CI Plus Specification v1.3.1 (2011-09)

Technical Specification

CI Plus Specification. Content Security Extensions to the Common Interface.

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Foreword

The DVB Common Interface specifications EN 50221 [7] and TS 101 699 [8], describe a system whereby a removable Conditional Access Module, given the appropriate rights, unscrambles protected content and routes it back to the Host over the same interface. The Common Interface connector is an industry standard PCMCIA slot. This means that potentially high value content is traversing a "standard" interface without any protection.

One of the aims of this specification is to address this problem. It is intended that this specification also clarifies some aspects of Common Interface behaviour that were undefined or ambiguous in the original specifications, EN 50221 DVB Common Interface Specification [7] and TS 101 699 Extensions to the Common Interface Specification [8].

The specification addresses some other requirements which have been identified by the market to make communication and interaction between the CA system, and the user, more uniform across different Host vendors and models.

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1 Scope

This specification addresses the concerns of service providers, CA operators and content owners about content protection after the conditional access protection has been removed. Specifically at the point where it leaves the CA module and re-enters the Host. To remove these concerns a strong and robust Content Control system is required to protect the content at this point.

This specification describes such a system, including all the rules for authentication, key generation and copy control information forwarding.

The domain of this system is the Common Interface CA Module to Host connection. It is not associated with a specific CA system and it is not intended to be extended beyond the Host. It is also not limited to any particular type of interface, however since the current base of implementations use PCMCIA slots, problems which might arise from the use of other interfaces have not been identified or addressed.

The mechanisms defined in this specification document are referred to as Common Interface Plus or CI Plus. This specification is based upon, and extends, the existing CI specifications; EN 50221 DVB Common Interface Specification [7] and TS 101 699 Extensions to the Common Interface Specification [8].

To provide optimum security in an environment containing individuals willing to spend time and effort in breaking such systems, the specification uses a collection of established, industry accepted and validated techniques, including device and message authentication and encryption.

Authentication between the CICAM and Host provides confirmation to the CICAM that it is operating with a legitimate Host; similarly that the Host is operating with a legitimate CICAM.

The specification uses shared private keys which are calculated by both the CICAM and Host separately and information passing over the interface is not sufficient for a third device to calculate this key. This process uses established, tried and tested methods which at the time of writing have no specific weaknesses.

This specification only applies to the reception of services which are controlled by a Conditional Access system and have been scrambled by the service provider. Services that are not controlled by a Conditional Access system are not covered by this specification.

This specification is intended to be used in combination with the appropriate certification process, and subject to conformance by the manufacturers to the CI Plus Robustness Rules [6] controlled by the selected Certification Authority.

This specification also provides a list of recommendations to clarify the DVB-CI standard further.

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3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

authentication: A procedure to securely confirm that a Host or CICAM has a genuine certificate and that the certificate has not been revoked. Also: a means to confirm securely that a message originated from a trusted source.

Authenticated: A quality resulting from the application of an Authentication procedure; securely confirmed.

bypass mode: A Host mode of operation where the TS input to the Host Demux is taken directly from the source (tuner) and not from the CICAM.

Carousel: Method for repeatedly delivering data in a continuous cycle. In this case, via an MPEG 2 Transport Stream.

CA-only: The CICAM mode of CA-descrambling EMI=00 content and returning it to the Host CC-unscrambled.

cached PIN: The PIN code that is sent in the record_start protocol.

controlled content: Controlled content means content that has been transmitted from the headend with (a) the Encryption Mode Indicator ("EMI") bits set to a value other than zero, zero (0,0), (b) the EMI bits set to a value of zero, zero (0,0), but with the RCT value set to one (1).

CICAM: Common Interface Conditional Access Module.

CICAM Certificate: The unique certificate issued to each CICAM and used for CICAM authentication. Parameter name: CICAM_DevCert.

Data Carousel: One of the two forms of carousel defined by DSM-CC, ISO 13818-6 [14], part of the MPEG 2 Specification.

Host: Any device that includes a CI Plus compliant CAM slot.

Host Certificate: The unique certificate issued to each Host device and used for Host authentication. Parameter name: Host_DevCert.

Encrypted: Data modified to prevent unauthorized access (compare with "scrambled").

Nonce: A randomly chosen value inserted in a message or protocol to protect against replay attacks.

pass-through: A Host mode of operation where the TS input to the Host Demux has previously passed through the CICAM from the source (tuner).

re-scramble: The CICAM mode of CA-descrambling and CC-scrambling content.

Secure Authenticated Channel: A secure communication path that exists between the Host and CICAM.

Scrambled: Content modified to prevent unauthorized access (compare with "encrypted").

trusted reception: Reception of SI data which has not been through a CICAM, i.e. bypass mode.

uncontrolled content: Uncontrolled content is content that is indicated by EMI value = 00.

viewing PIN: The PIN used to enable viewing of content in live or recording playback mode.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

E{K}(M)	Encryption of message 'M' using key 'K'
D{K}(M)	Decryption of message 'M' using key 'K'
P	Public key
Q	Private key
DQ	Device private key
DP	Device public key
A{K}(M)	Authentication of message 'M' with key 'K'
V{K}(M)	Verification of message 'M' with key 'K'
A ⊕ B	Bit-wise exclusive OR of 'A' and 'B'
A | B	Bit-wise OR of 'A' and 'B'
A || B	Concatenation of 'A' and 'B'
0x…	This prefix indicates a hexadecimal value follows.
0b…	This prefix indicates a binary value follows.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AES	Advanced Encryption Standard
APDU	Application Protocol Data Unit
APS	Analogue Protection System
ASN.1	Abstract Syntax Notation One
AV	Audio Video

BAT	Bouquet Association Table
bslbf	bit serial leftmost bit first
BSM	Basic Service Mode
CA	Conditional Access
CAM	Conditional Access Module
CAS	Conditional Access System
CBC	Cipher Block Chaining
CC	Content Control
CCK	Content Control Key
CI	Common Interface
CICAM	Common Interface Conditional Access Module
CICAM_ID	CICAM's unique identification number
CRL	Certificate Revocation List
CWL	Certificate White List
DES	Data Encryption Standard
DH	Diffie-Hellman
DOT	Digital Only Token
DSM-CC	Digital Storage Media – Command and Control
DTV	Digital Television
DVB	Digital Video Broadcast
ECB	Electronic Code Book
ECM	Entitlement Control Message
EIT	Event Information Table
EMI	Encryption Mode Indicator
EMM	Entitlement Management Message
FQDN	Fully Qualified Domain Name
FTA	Free-To-Air
HOST_ID	The Host device unique identification number
ICT	Image Constraint Token
IV	Initialisation Vector
LSB	Least Significant Bit
MAC	Message Authentication Code
mjdutc	Modified Julian Date UTC
MMI	Man Machine Interface
MPEG	Motion Pictures Experts Group
NIT	Network Information Table
PCMCIA	PC Memory Card International Association
PIN	Personal Identification Number
PMT	Programme Map Table
PPV	Pay-Per-View
PSI	Program Specific Information
RCT	Redistribution Control Token
RFC	Request For Comment
ROT	Root Of Trust (i.e. Trust Authority)
RSA	Rivest Shamir Adleman public key cryptographic algorithm
RSD	Revocation Signalling Data
RSM	Registered Service Mode
SAC	Secure Authenticated Channel
SAK	SAC Authentication Key
SDT	Service Descriptor Table
SEK	SAC Encryption Key
SHA	Secure Hash Algorithm
SIV	SAC Initialisation Vector
SOCRL	Service Operator Certificate Revocation List
SOCWL	Service Operator Certificate White List
SOPKC	Service Operator Public Key Certificate
SMS	Short Message Service (mobile phone)
SRM	System Renewability Message
SSAC	Single Source Authenticity Check
SSU	System Software Update

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TLF	Tag Length Format
TS	Transport Stream
TSC	Transport Scrambling Control
UCK	URI Confirmation Key
uimsbf	unsigned integer most significant bit first
URI	Usage Rules Information
UTC	Coordinated Universal Time
VOD	Video On Demand

3.4 Use of Words

The word *shall* is used to indicate mandatory requirements strictly to be followed in order to conform to the specification and from which no deviation is permitted *(shall* equals *is required to)*.

The word *should* is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required *(should* equals *is recommended that)*.

The word *may* is used to indicate a course of action permissible within the limits of the specification *(may* equals *is permitted to)*.

4 System Overview (informative)

4.1 Introduction

The Content Control system (CC System) described in this specification is intended to support a secure link for transport stream packets between one CICAM and a Host. This CC system specifies extensions to the DVB-CI specification to add protocol messages and features on both devices in order to protect selected content from being copied.

If the content (CA scrambled content or clear content) selected by the user does not require protection (i.e. no copy protection information in the transport stream related to this content) then both devices shall have behaviour fully compliant with DVB-CI EN 50221 [7] & TS 101 699 [8].

The end-to-end system overview is depicted in Figure 4.1. High value content may be protected from the head-end to the Host by the CA system. However, once the content has been demodulated and the CA system scrambling has been removed it is vulnerable to being copied as it travels across the Common Interface. It is the job of the Content Control system specified in this document to protect AV content while it is transferred across the Common Interface and passed to external AV interfaces.

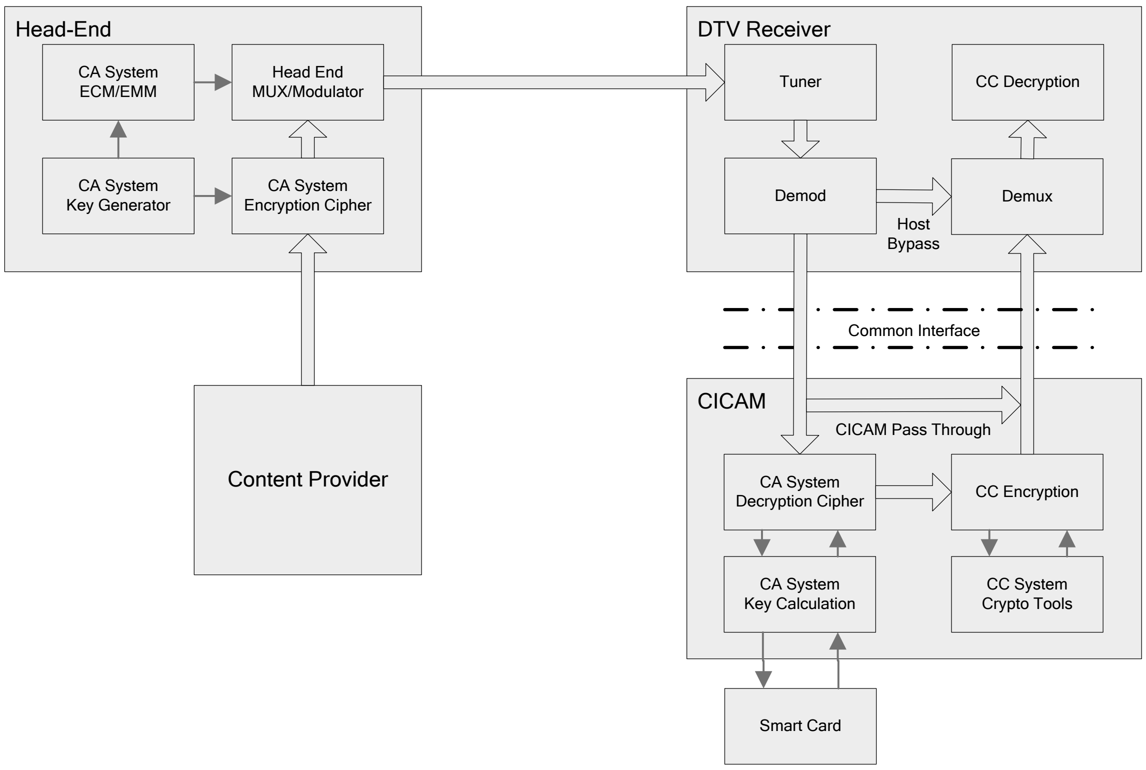


Figure 4.1: System Overview

4.2 Content Control System Components

For the purposes of this specification the Content Control (CC) system as a whole comprises the following components (see Figure 4.1):

- The DTV Receiver (Host)
- The CICAM
- The Head-end

Protection of the media before the CA system applies its scrambling is not considered in this specification. Likewise, apart from the propagation of Usage Rules Information (URI), what happens to the media after re-entering the Host and being decrypted is not considered in this specification.

The three aforementioned components are briefly described in the following sections:

4.2.1 Host

In the context of this specification the Host is a consumer electronics device that is used to receive and navigate the broadcast digital media. This device shall include one or more Common Interface slots which accept CICAMs.

Typically the Host device contains some form of tuner, a demodulator, a demultiplexer (Demux) and media decoders. These are pre-requisites for the reception of digital TV. For free-to-air material this is all that is required to receive and decode digital content, for content protected by a CA system then a CICAM is required.

DVB CICAMs that comply with EN 50221 [7] have no Content Control system to protect the descrambled content. Content where the CA system protection has been removed is passed to the Host unprotected. Hosts compliant with this specification may interoperate with CICAMs to provide a secure content control system to protect high value content which has been CA descrambled.

A Host is able to determine whether any CICAM inserted into the interface complies with only EN 50221 [7] or whether it additionally complies with this specification. A Host shall operate with both CI Plus and EN 50221 [7] CICAMs as outlined in Table 4.1. Free to view content shall never be impeded by CI Plus.

Table 4.1: CICAM and Host Interoperability (Informative)

		Host	
		CI	**CI Plus**
CICAM	**CI**	Default CI behaviour as described by EN 50221 [7].	Host shunning may optionally protect controlled content when signalled in the broadcast stream. Default CI behaviour as described by EN 50221 [7] if Host shunning is not activated by the broadcaster. Content decrypted by the CI CICAM is not re-encrypted on the Common Interface.
	CI Plus	Some controlled content may optionally be descrambled and passed to the Host under control of the CA System. Content decrypted by the CI Plus CICAM is not re-encrypted on the Common Interface.	Controlled content is not displayed unless the CICAM and Host have authenticated and the Host supports the encryption algorithm(s) as prescribed by CI Plus and required by the CICAM. Controlled content decrypted by the CICAM is re-encrypted on the Common Interface subject to the EMI value in the URI.

The Host includes a set of cryptographic tools and features that enable it to verify that any CICAM that has been inserted is both an authentic and trusted CICAM.

4.2.2 CICAM

The CICAM contains the consumer end of the CA system. It comprises a CA decryption cipher, optional smart card interface and software to enable decryption keys to be calculated using data from the received stream.

For non-CI Plus versions of the common interface the content is transferred to the Host in the clear across the CI connection leaving the content open to be intercepted and copied. This specification ensures any content that is signalled to be copy restricted is locally encrypted by the CICAM with a Content Control system before being passed to the Host.

In addition to the CA delivery protection system, CICAMs contain cryptographic tools and features which enable it to authenticate the trustworthiness of the Host it has been inserted into. If the CICAM authenticates with the Host it descrambles a broadcast service and applies Content Control encryption to the content.

4.2.3 Head-End

The head-end is where the CA system scrambles content using the CA system cipher. The head-end also introduces into the stream other CA specific information which enables the CICAM to descramble the content and to manage the subscriber access and entitlements.

4.3 Implementation Outline

The CICAM CC System consists of the following three operational elements:

- Host Authentication; based on the exchange of Host and CICAM certificates. Each device verifies the others certificate using signature verification techniques. The Host ID is checked by the CICAM (in a Basic Service Mode) against a revocation list and appropriate revocation action against compromised devices is taken. Optionally, further Service Operator specific checks may be undertaken in the Head-end (Registered Service Mode).

- Content Control; Content Control scrambling by the CICAM of content that requires protected transmission from the CICAM to the Host.
- Content Security; secure propagation of content usage rules from the CA system to the Host in order to enable the application of appropriate restrictions to any output connections.

The CICAM first CA-descrambles the content and then re-scrambles 'high value' content using the Content Control Key before delivery to the Host. A similar Content Control de-scrambling process occurs in the Host.

4.4 Device Authentication

The Content Control System requires authentication of the Host and CICAM prior to the CICAM descrambling any CA-scrambled content requiring Content Control. The CICAM requests the Host's certificate and the Host provides it. The Host requests the CICAM's certificate and the CICAM provides it.

Authentication is based on:

- The CICAM being able to verify the signature of the Host device certificate containing the Host ID.
- The Host being able to verify the signature of the CICAM certificate containing the CICAM ID.
- CICAM and Host proving they each hold the private key paired with the public key embedded in the certificate by signing a DH session key and sending it to the other device for signature verification.
- CICAM and Host proving that they can derive the authentication key.

4.5 Key Exchange and Content Encryption

The Content Control mechanism itself consists of four phases:

- Setup
- Key Derivation
- Content Encryption.
- Content encryption is subject to URI values, which are transferred securely by the Content Control mechanism.

Version 1.3 of this specification extends the Content Control with:

- Parental control (PIN code management)
- Entitlement binding to recordings, which are transferred securely by the Content Control mechanism.
- URI version 2 extending the retention limit and includes a Digital Only Token (DOT).

The CICAM and Host both contain algorithms for Diffie-Hellman (DH) key negotiation, SHA-256 hashing, DES and AES. The CICAM and Host also hold private keys and the corresponding public keys.

4.6 Enhanced MMI

CI Plus introduces a standardised presentation engine into the CI profile to present text and images on the Host display without necessitating any further extensions to the Application MMI. The presentation engine enables the CICAM to present information with the look and feel specified by the service operator rather than being constrained to the manufacturer High Level MMI.

Version 1.3 of this standard extends the Application Profile to include support for VOD applications.

It is mandatory for a Host to support the "CI Plus browser" application MMI which is described in Chapter 12. The existing High Level MMI resource requirements are described in Chapter 13.

4.7 CI Plus Extensions

CI Plus introduces some refinements of the existing DVB-CI resources in addition to some new resources which are described in Chapter 14, including:

- Provision for Low Speed communication over IP connections which may be used to support Conditional Access functions.
- CAM Software Upgrade facilitates the software upgrade of the CICAM in cooperation with the Host, standardising the CICAM and Host interaction. Host support of the software upgrade is mandatory.

The CI Plus security requirements and CI Plus extensions require faster transfers over the CI link which is dealt with in Annex G. Clarifications of DVB-CI use cases are specified in Annex E.

4.7.1 CI Plus 1.3 Extensions

CI Plus version 1.3 introduces some refinement of the existing CI Plus version 1.2 and DVB-CI resources in addition to some new resources which are described in Chapter 14, including:

- Extensions to the Low Speed Communication resource which removes some constraints of the previous version in order to improve throughput. The Low Speed Communication resource is mandatory for all Hosts that support an IP connection.
- The new Operator Profile resource provides a CI Plus standardised broadcast profile and uses the CICAM to translate any network private signalling into a uniform information structure allowing all CI Plus Host devices to perform a full installation and a channel listing of all of the services required by the Service Operator.
- Host control version 2 adds new commands for the CICAM to tune the Host to a service which is not part of the Host channel line-up. The service selected is based on the physical description of the Transport Stream that carries the service and the service identification.

5 Content Control Overview (normative)

The main aim of this specification is to protect the received content, after any CA system scrambling has been removed, as it passes across the Common Interface to the Host. This is performed by:

- Mutual authentication of CICAM and Host.
- Verification of Host and CICAM.
- Encryption key Calculation.
- Communication using a Secure Authenticated Channel.

These procedures are described in detail in this specification.

5.1 End to End Architecture

For the purposes of this specification the complete system comprises everything from the head-end to the Host including the CICAM. Anything upstream of the head-end is not in the scope of this specification. Any connection between the Host and another device is not considered in this specification. This specification does address the propagation of Usage Rules Information which the Host shall use when making media available on any relevant external interface.

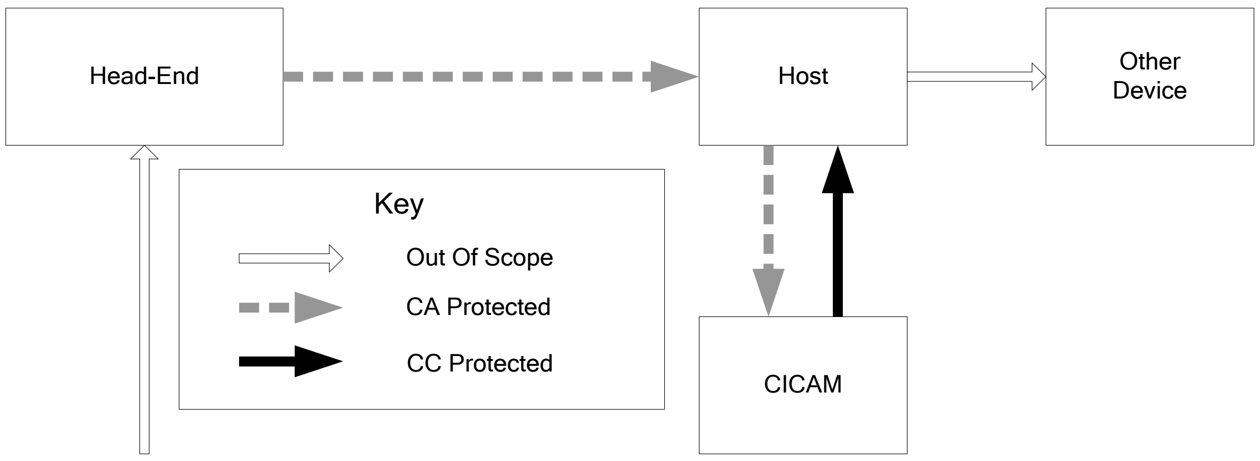


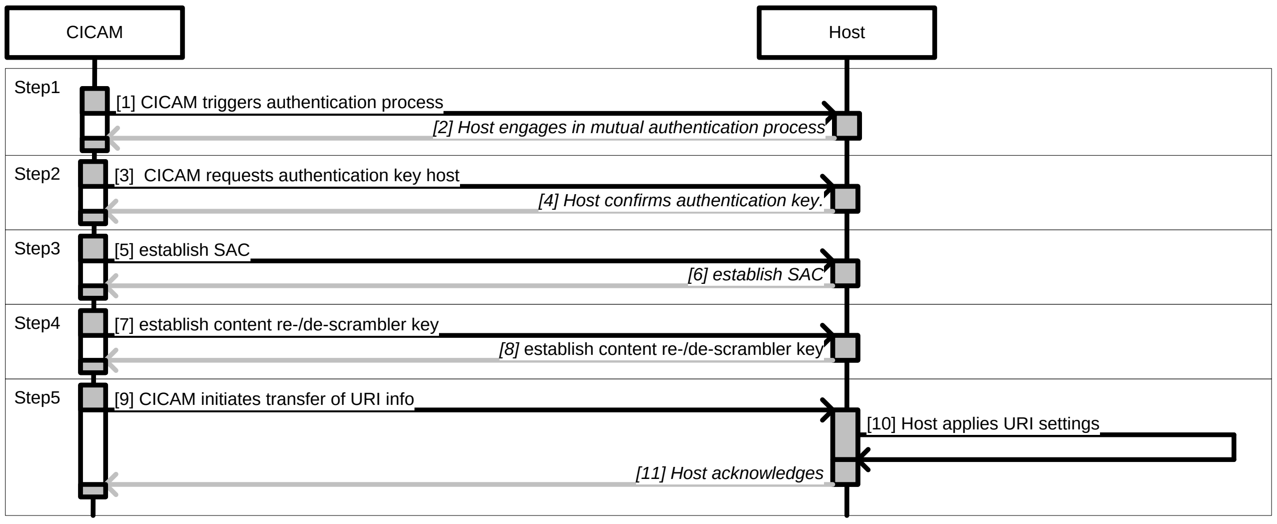
Figure 5.1: End-To-End Diagram Showing Scope of Protection Schemes

Figure 5.1 shows the end-to-end system and indicates the scope of the CA protection and Content Control system which is described in this specification. This specification addresses the interface between the CICAM and the Host which is protected by the CC system. This operates with the assistance of the CA system and a set of cryptographic tools to provide protection for the media passing to the Host. The Host, using a similar set of cryptographic tools, removes the protection and makes the content available to the Host decoder(s).

5.2 General Interface Behaviour

The start-up behaviour on power up is described in the document EN 50221 [7].

The CC resource, defined in this specification, is used to protect the content a) when it is in transit from the CICAM to the Host and b) if and when it is made available on external interface(s) of the Host. Multiple steps are involved in this process. The system components use the CC resource to start a mutual authentication process. When the CICAM and Host have mutually verified that they are communicating with legitimate CI Plus components, a Secure Authentication Channel (SAC) is initialised. The SAC is used to transfer messages that are authenticated and encrypted. The system components establish a common CC scramble/descramble key and exchange Usage Rules Information and optional license. The process is explained in Figure 5.2, while table 5.1 refers to sections in this specification that provide the detailed mechanisms.


CICAM
Host
Step1
[1] CICAM triggers authentication process
[2] Host engages in mutual authentication process
Step2
[3] CICAM requests authentication key host
[4] Host confirms authentication key.
Step3
[5] establish SAC
[6] establish SAC
Step4
[7] establish content re-/de-scrambler key
[8] establish content re-/de-scrambler key
Step5
[9] CICAM initiates transfer of URI info
[10] Host applies URI settings
[11] Host acknowledges

NOTE: This diagram does not suggest that any behaviour be specifically (un)synchronized / (un)blocked.

Figure 5.2: High Level Interface Behaviour (Informative)

The process is defined as described in Table 5.1:

Table 5.1: High Level Interface Behaviour (Normative)

No.	Description	Refer to
Start Authentication step #1 – certificate verification and DH key exchange		
1	**CICAM triggers authentication process.** The CICAM initiates the authentication process when there is no authentication key present from a previous successful binding. The authentication process is introduced in section 5.9. Refer to listed reference for full details.	Section 6
2	**Host engages in mutual authentication process.** The Host verifies the received protocol data to determine if it originated from a legitimate CICAM and engages in a mutual authentication process.	Section 6
Start Authentication step #2 – authentication key verification		
3 4	**CICAM requests authentication key Host.** The CICAM requests the authentication key (AKH) from the Host, in order to determine that both CICAM and Host have calculated the same key. The Host replies to this request with its computed authentication key.	Section 6
Start step #3 – establish SAC		
5 6	**Establish SAC.** After successful authentication, the CICAM and Host start to exchange data and compute key material for the encryption (SEK) and authentication (SAK) of messages that are to be transmitted over the SAC. Upon establishing the SAK and SEK keys, the CICAM shall synchronize with the Host to start using the new keys within a predefined timeout. The SAC is initialised using this key material.	Section 7
Start step #4 – establish CC key		
7 8	**Establish CC key.** After successful authentication, the CICAM may start computing the Content Control key (CC key). After successful initialisation of the SAC the CICAM may inform the Host to compute CC key. Upon establishing the CC key the CICAM shall synchronize with the Host to start using the new CC key within a predefined timeout. The (de)scrambler is initialised using this CC key. Note that this step may be performed repeatedly based on the maximum key lifetime setting.	Section 8
Start step #5 – transfer and exert copy control on content		
9	**CICAM initiates transfer of URI info and optional license.** The CICAM transfers the Usage Rules Information (URI) and optional license that matches the current copy control constraints on the selected service to the Host. Note that this step may be performed repeatedly during a programme event, based on the actual setting of the URI. See Note 2.	Section 5.7.4
10 11	**Host applies URI settings, associate the license recording and Host acknowledges.** After reception of the URI information the Host shall reply to the CICAM within a predefined timeout and then apply the copy control constraints to the external interfaces, as defined in the CI Plus Compliance Rules for Host Device [6].	Section 5.7.5.4
NOTE: 1. Refer to referenced sections for a detailed description of the mechanisms. 2. The URI version used shall have been negotiated see 5.7.5.1		

5.3 Key Hierarchy

A layered key hierarchy is used to implement content protection and copy control, as is shown in Figure 5.3.

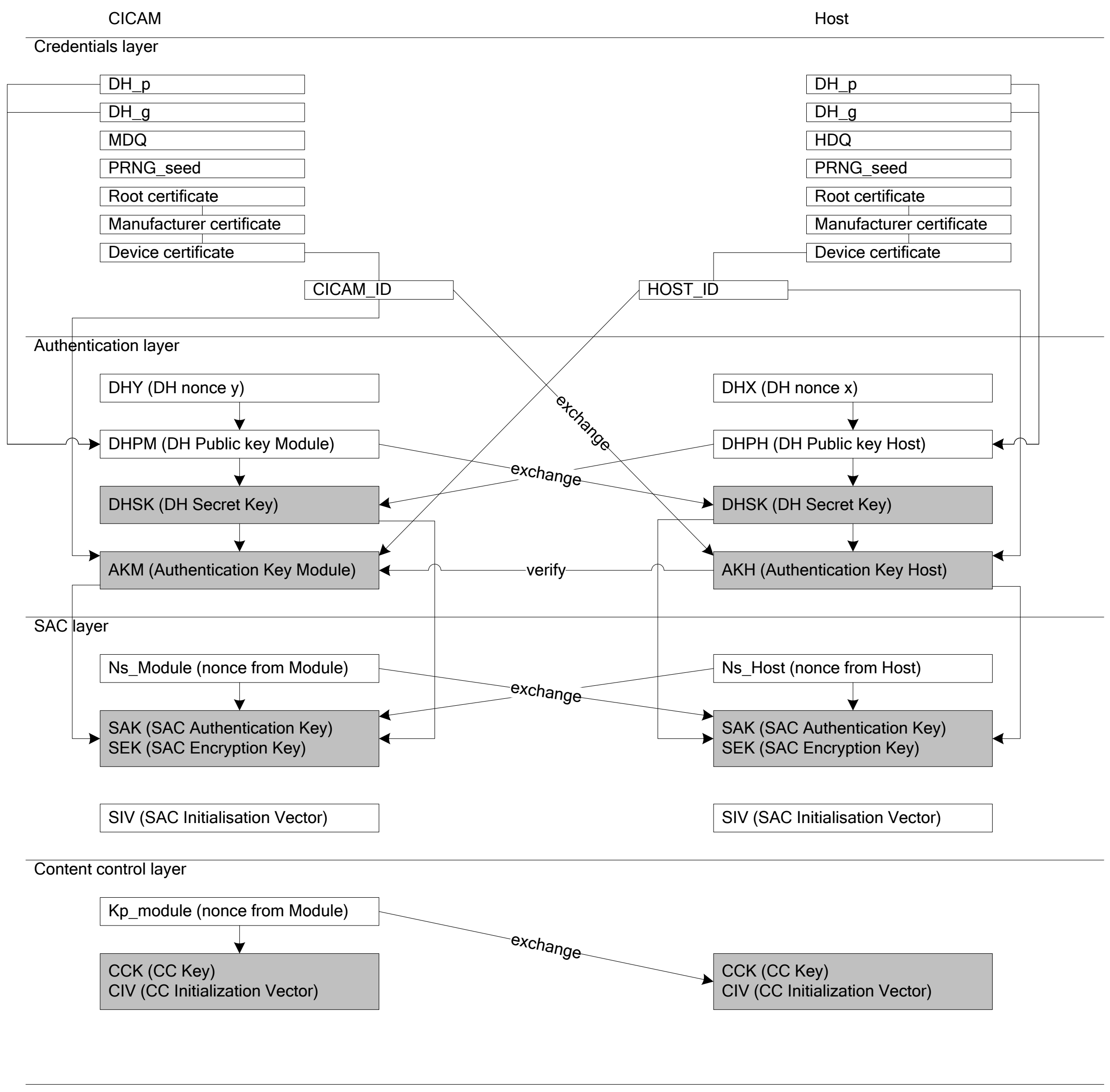


Figure 5.3: Key Hierarchy

Table 5.2: Key to the Credentials

Key	Description	Stored or Volatile	Exchanged or Keep Local
Root cert	Root certificate	stored (license constant)	keep local (not replaceable)
Brand cert	Brand certificate	stored (license constant)	exchange (not replaceable)
Device cert	Device certificate	stored (license constant)	exchange (not replaceable)
prng_seed	Per manufacturer seed for PRNG	stored (license constant)	keep local (not replaceable)
DH_p	Diffie-Hellman prime modulus	stored (license constant)	keep local
DH_g	Diffie-Hellman generator modulus	stored (license constant)	keep local
DH_q	Diffie-Hellman Sophie Germain constant	stored (license constant)	keep local
MDQ	Module Device Private key	stored (license constant)	keep local (not replaceable)
MDP	Module Device Public key	stored	exchange
HDQ	Host Device Private key	stored (license constant)	keep local (not replaceable)
HDP	Host Device Public key	stored	exchange
DHX	Diffie-Hellman nonce (exponent x)	volatile	keep local
DHY	Diffie-Hellman nonce (exponent y)	volatile	keep local
DHPM	Diffie-Hellman Public key Module	volatile	exchange
DHPH	Diffie-Hellman Public key Host	volatile	exchange
DHSK	Diffie-Hellman Secret Key	stored	keep local
AKM	Authentication Key Module	stored (on module)	keep local
AKH	Authentication Key Host	stored (on Host)	exchange (protected)
Ns_Module	Nonce SAC Module	volatile	exchange
Ns_Host	Nonce SAC Host	volatile	exchange
SEK	SAC Encryption Key	volatile	keep local
SAK	SAC Authentication Key	volatile	keep local
SIV	SAC Initialisation Vector	stored (license constant)	keep local
Kp	Key precursor	volatile	exchange (protected)
CCK	Content Control Key	volatile	keep local
CIV	CC Initialisation Vector	volatile	keep local

5.3.1 Keys on the Credentials Layer

There are a pair of public and private keys defined for the CICAM and for the Host. The CICAM has a Device Private key (MDQ) and the corresponding Device Public key (MDP) which is embedded in the CICAM's device certificate. The Host similarly carries HDQ and HDP. There is a unique certificate chain for both CICAM and Host. There are constants that are used in computations, such as the prime (DH_p) and generator (DH_g) for the Diffie-Hellman authentication process.

The data on the credential layer (such as keys, seeds, certificates and constants as suggested in table 5.2) are involved in operations on the authentication layer. The credential layer contains parameters that are not to be replaced. This specification does not specify the exact mechanisms used to protect the credentials, which is out of scope.

5.3.2 Keys on the Authentication Layer

The device public key, from the device certificate, and the device private key are involved in two operations. (Not shown in Figure 5.3):

1) Protect the parameter exchange during authentication. The authentication is based on Diffie-Hellman, which requires the CICAM and Host to exchange parameters which must be protected against alteration by a malicious source. Refer to section 6.1.2 for full details.

2) Verification of the certificate chain. The certificate chain contains information that is used in subsequent steps in the key hierarchy. The received certificates must be mutually verified, refer to section 9.4 and section 9 for full details.

The resultant keys for the authentication layer are the Diffie-Hellman Secret Key (DHSK) and the Authentication key (AKM for CICAM and AKH for Host). The CICAM requests the Authentication Key used by the Host. Refer to section 6 for details.

The DHSK and AKM or AKH are protected and managed by the authentication layer. Other layers (such as the SAC layer and the Content Control layer) may occasionally require these keys for calculation of their volatile secrets. The Authentication Layer passes the requested keys but the consuming layer shall not maintain or store them.

5.3.3 Keys on the SAC Layer

The SAC layer uses keys to authenticate and encrypt a message before it is transmitted. The receiving part uses the identical calculated keys to decrypt and verify a message. The SAC Authentication Key (SAK) is used to authenticate and verify a SAC message. Similarly the SAC Encryption Key (SEK) is used to encrypt and decrypt the SAC message payload. SAK and SEK are calculated together independently on CICAM and Host. SAK and SEK are both volatile short term secrets. Refer to section 7 for full details.

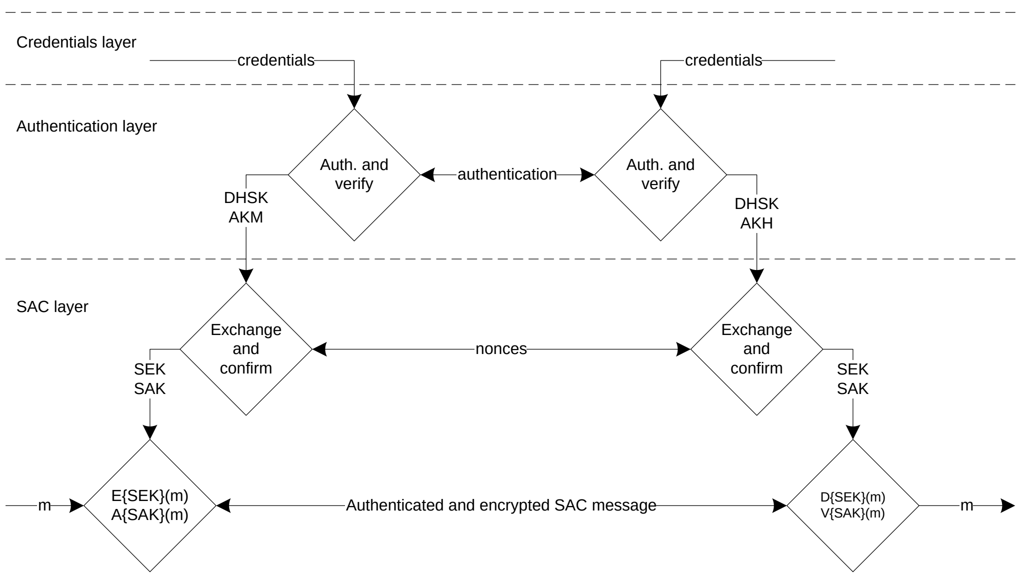


Figure 5.4: Keys on the SAC Layer

5.3.4 Keys on the Content Control Layer

The CC layer uses keys to scramble AV content before it is transmitted from CICAM to Host. The Content Control Key, CCK, (and if required CIV) are used to scramble AV. On the receiving side the Host uses the identical calculated keys to descramble the AV content. CCK (and if required CIV) are calculated together independently on the CICAM and Host. CCK (and if required CIV) are both volatile, short term secrets. Refer to section 8 for full details.

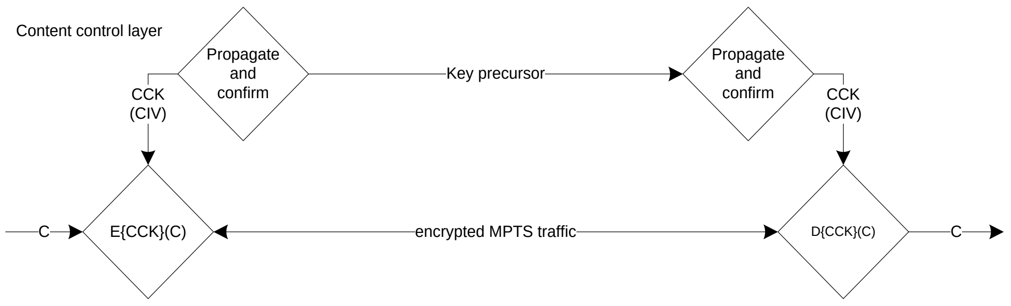


Figure 5.5: Keys on the CC Layer

5.4 Module Deployment

CICAMs may be deployed in a Basic Service Mode (BSM) or a Registered Service Mode (RSM). Basic Service Mode is mandatory, Registered Service Mode is optional. Registered Service Mode consists of three phases:

1) Certificate Verification & DH Key Exchange

2) Authentication Key Verification

3) Head-end Report Back

Both Service Modes support phase 1 and 2. Only the Registered Service Mode supports the third phase: Head-end Report Back (see Table 5.3).

Table 5.3: Supported Phases per Service Mode

Mode / Phases	Certificate Verification & DH Key Exchange	Authentication Key Verification	Head-end Report Back
Basic Service Mode	●	●	
Registered Service Mode	●	●	●

In Basic and Registered Service Mode, the CICAM may operate in two states:

- *Limited Operational*; EN 50221 [7] compatible mode. No services which require CI Plus protection are CA descrambled.
- *Fully Operational*; CI Plus compatible mode. All CI Plus protected services are CI Plus re-scrambled.

The next two sections explain both modes in more detail, the third section describes how errors are handled by the CICAM and the Host.

5.4.1 Deployment In Basic Service Mode

The Basic Service Mode defines the operation of the CICAM in a broadcast environment (i.e. no online bidirectional communication channel). The CICAM does not become operational immediately when inserted into the Host device and the power is applied; the following protocol has to be executed first:

- Power up Re-authentication (see section 6.3)
- Certificate Verification & DH Key Exchange (see section 6.2)
- Authentication Key Verification (see section 6.3)
- Secure Authenticated Channel (SAC) establishment (see section 7)
- Content Control (CC) key establishment (see section 8)

Figure 5.6 gives an overview of the authentication process in Basic Service Mode. At power up the CICAM first determines if the Host device is CI Plus compatible. A CI Plus compatible Host announces the CC resource during the resource manager protocol at start-up, see section 12.3 and EN 50221 [7] section 8.4.1.1 (2). Where the Host device is not compatible a descriptive error (see Figure 5.10) is given using the High-Level or Application MMI (3) and the CICAM becomes Limited Operational (10) (i.e. EN 50221 compatible). When the Host device is CI Plus compatible it checks if Power up Re-authentication is possible (4). Power up Re-authentication is possible when the CICAM has previously successfully bound with the Host device. On a successful binding then Certificate Verification and DH Key Exchange (5) and Authentication Key Verification (6) may be skipped, and the CICAM may start immediately with SAC establishment (7). After SAC establishment follows CC Key establishment (8). With the SAC and CC Key established the CICAM becomes fully operational (9).

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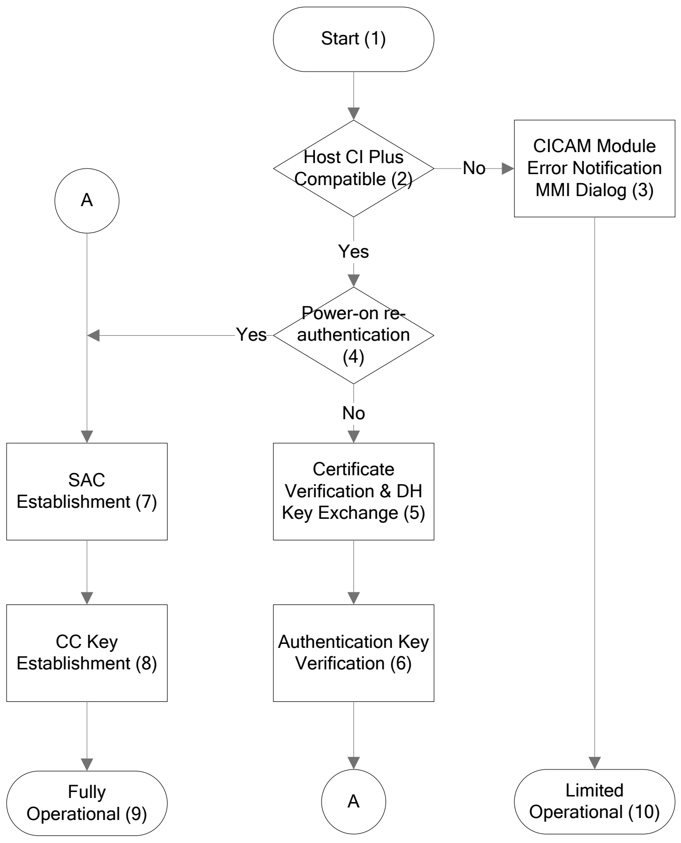

Start (1)
Host CI Plus Compatible (2)
No
CICAM Module Error Notification MMI Dialog (3)
A
Yes
Power-on re-authentication (4)
Yes
No
SAC Establishment (7)
Certificate Verification & DH Key Exchange (5)
CC Key Establishment (8)
Authentication Key Verification (6)
Fully Operational (9)
A
Limited Operational (10)

Figure 5.6: Authentication Process in Basic Service Mode

The SAC is used to communicate the content Usage Rules Information (URI) in a secure manner. The URI is associated with a service/event that is CA protected and conveys copy control information for analogue (APS) and digital (EMI) Host device outputs (see section 5.7.5.4). The Host device uses the default, and most restrictive, Usage Rules until the URI delivery protocol is concluded successfully (see section 5.7.5) and the event related Usage Rules are communicated to the Host device.

The CC Keys are used for the encryption of CI Plus protected services by the CICAM and for the decryption of CI Plus protected services by the Host device. The Host device deduces the CC Key as a result of a DH Key Exchange; no CC Key is transferred from the CICAM to the Host device. Figure 5.7 gives an overview of the SAC and CC Key establishment process, which are executed (3) and (5) when a key refresh (2) and (4) is required. If for some reason the SAC or CC Key can not be renewed (6) and (7) then the CICAM reverts to the Limited Operational State (8) otherwise its state remains Fully Operational (1).

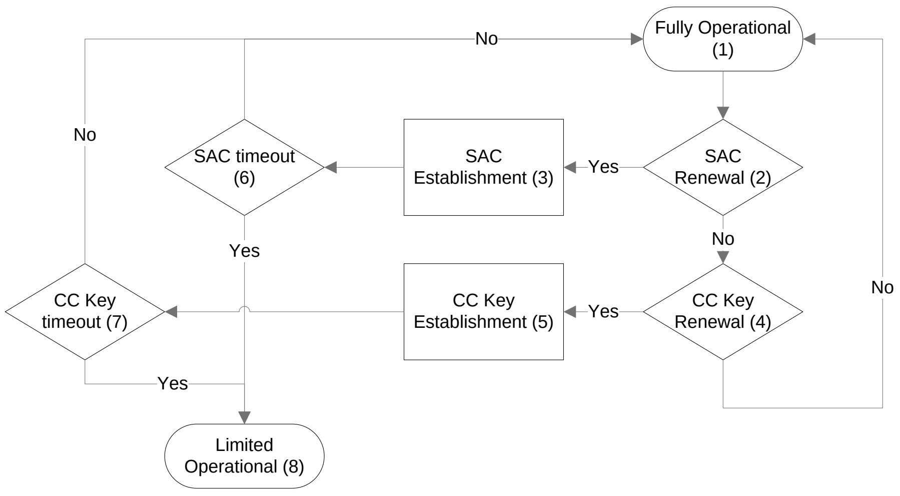


Figure 5.7: SAC and CC Key Renewal Process

Basic Service Mode supports the revocation of Host devices by means of a Certificate Revocation List (CRL) that is transmitted by the Head-end to the CICAM using a DSM-CC data carousel. In case of a Host device revocation, the CICAM informs the user that their Host device is black-listed using the Generic Error Reporting feature (see section 5.4.3).

In addition to the CRL, the Basic Service Mode supports a Certificate White List (CWL) that enables the Service Operator to revert a previous revocation of a single Host device. See section 5.5 for a detailed description of the CI Plus revocation mechanism.

5.4.2 Deployment in Registered Service Mode

Registered Service Mode is an extension of Basic Service Mode and is intended for networks that include a bi-directional communication channel from the CICAM to a network subscriber management system. To implement Registered Service Mode the CICAM may use the High Level or Application MMI to present instructions and registration data to the user to communicate back to the network subscriber management system.

The operational behaviour of Registered Service Mode is defined by the Service Operator and is outside the scope of this specification.

5.4.3 Generic Error Reporting

Errors may be detected and reported by either the CICAM or Host. When an error is detected by the CICAM then it shall use the High-Level or Application MMI to display a pre-defined error code. When the Host device detects an error then it may use some Host specific method to display the pre-defined error code. The error-code may be accompanied by descriptive text and shall be acknowledged by user interaction. Annex F defines standard error conditions and error codes.

Where the CICAM supports Registered Service Mode the CA Vendor or Service Operator may define a mapping between Action and Error Codes. The CA vendor or Service Operator shall determine the Action Codes supported in a Registered Service Mode and is out of scope of this specification.

An example of an Action Request Code mapping is 'invalid Host certificate', Annex F.1 defines this error condition as Error Code 16, which may be mapped to any Action Request Code by the CA Vendor or Service Operator. The resulting Notification Message provides information to the customer and may also provide instructions to call a service number.

5.5 Introduction to Revocation (informative)

The CI Plus specification includes revocation as a method to deal with Host devices whose security has been compromised. The specification distinguishes three mechanisms of revocation:

1) Host Service Shunning
2) Revocation by CAS
3) Host Revocation

Host Service Shunning is described in detail in section 10. The revocation by CAS is defined by a particular CAS and is out of scope for this specification. The remainder of this section describes the Host Revocation mechanism. The CI Plus CICAM Licensee Specification [33] and Supplementary CI Plus Specification for Service / Network Operators [37] specifies the requirements for Host Revocation implementation.

5.5.1 Host Revocation

Host Revocation is revocation by denial of service i.e. the CICAM ceases CI Plus operation, starving the Host device of CI Plus Content Control services. Host devices to revoke are listed in a Certificate Revocation List (SOCRL). The following revocation lists are defined for this purpose

- Service Operator Certificate Revocation List (SOCRL)
- Service Operator Certificate White List (SOCWL)

A SOCRL is created by the Root-of-Trust on request of a Service Operator specifically for their operation. Revocation is always tied to a specific Service Operator. A Host device may be revoked for one Service Operator and be functional for others. Host device revocation only applies to those services that are required by the Service Operator to be CI Plus protected (e.g. HD premium content) allowing other services (e.g. CA protected low value content) to remain accessible to the Host. Entries in the SOCWL undo a revocation defined in the SOCRL.

To ensure reception of a SOCRL by the CICAM, the SOCRL should be part of each Transport Stream (TS) that carries services belonging to the Service Operator. Where the TS contains services belonging to two or more Service Operators a SOCRL for each Service Operator must be added to the TS.

The exact rules for revoking a device are determined by the CI Plus license, and are therefore out-of-scope for this specification, see CI Plus Licensee Specification, [33].

The trust model for revocation identifies two entities: 1) the CICAM and 2) the Host device. The Host device is the target of revocation and is considered as untrusted. The following threats are considered:

1) Replay; the Host device may replay a SOCRL that does not contain its own identity.

2) Blocking; the Host device may prevent the SOCRL from reaching the CICAM.

3) Tampering; the Host device may change or remove a SOCRL entry that contains its identity.

The first threat is countered by adding a timestamp or counter to the SOCRL. The second threat is countered by defining a mandatory cycle constraint; the CICAM must receive a SOCRL within a pre-determined time-window (with a considerable grace-period to prevent race conditions). To prevent tampering the SOCRL is signed by the Service Operator's private RSA key and distributed by the Service Operator to CICAMs in their network. A CICAM can verify the integrity of an SOCRL using the RSA public key in the Service Operator's certificate. This certificate in turn is verified by the Root-of-Trust certificate (See chapter 9).

5.5.2 Revocation Granularity

The CI Plus specification supports different levels of revocation granularity:

1) Unique Host devices

2) Ranges of Host devices

3) Host devices of a certain Model-type

4) Host devices of a certain Brand

A Service Operator may use any of these granularities when requesting Host revocation. The SOCWL supports only single Host devices to be un-revoked from a revoked range. This feature may be used for testing individual devices from a device set that is revoked.

5.5.3 Revocation Signalling Data

The availability of a SOCRL, SOPKC (and SOCWL) in the network is indicated by the Revocation Signalling Data (RSD) information. The RSD shall carry:

1) Service Operator identity; identifies the provider of the CI Plus protected services, SOCRL and SOCWL.

2) SOCRL and/or SOCWL download information; contains the information that the CICAM requires to find the SOCRL and SOCWL in the Transport Stream. If no download information is specified then the Service Operator is not transmitting a SOCRL and SOCWL.

3) Latest SOCRL and/or SOCWL version numbers; the version numbers for the latest SOCRL and SOCWL instance that are currently broadcast.

4) SOCRL and SOPKC transmission timeouts; the SOCRL and SOPKC downloads have a transmission timeout and these values are conveyed by the RSD. Each of these files must be received before the timeout period has elapsed otherwise the CICAM becomes Limited Operational.

The RSD is protected against replay, blocking and tampering. Every CICAM has the capability to detect the RSD on the network. The CAS shall provide the CICAM with the capability to switch the detection of the RSD on or off, but the exact mechanism is out of scope for this specification and CAS specific. If the service operator switches detection of the RSD on, the RSD shall be present on the network and the RSD shall be transmitted repeatedly. The exact requirements and format of the RSD is defined in the Supplementary CI Plus Licensee Specification for Service / Network Operators [37].

The CICAM shall ensure that it has the latest versions of the RSD, SOCRL and SOCWL.

5.5.4 Transmission Timeout

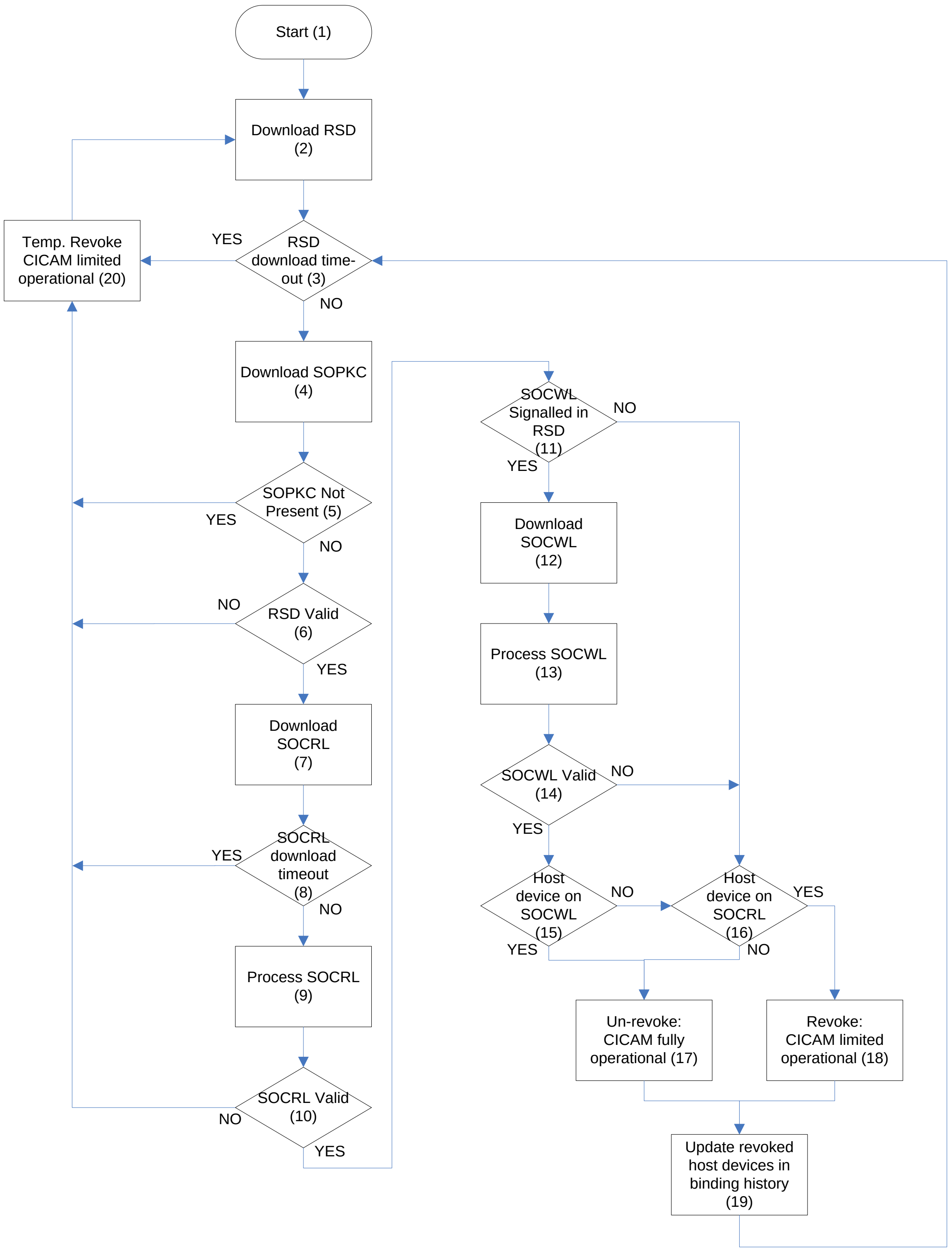
The cycle-time of the RSD should be significantly shorter than its transmission timeout to guarantee reception.

The SOCRL download has a transmission timeout and this value is conveyed by the RSD.

5.5.5 SOCRL and SOCWL Download Process

Download (using a carousel) of the SOCRL and SOCWL is executed according to Figure 5.8, which is informative and does not preclude other implementations. Each of the process steps is briefly discussed.

- **Start (1)**. The download of RSD may commence after the CICAM and Host have bound successfully.
- **Download RSD (2)**. The CICAM receives the RSD of the Service Operator.
- **RSD Download timeout (3)**. On a RSD transmission timeout the Host device is temporarily revoked (18). When the download has successfully completed, the CICAM determines if a SOCRL or, SOCRL and SOCWL should be downloaded.
- **Download SOPKC (4).** The CICAM downloads the SOPKC.
- **SOPKC Not Present (5).** If the SOPKC is not present, or invalid, then the Host is temporarily revoked (20).
- **RSD valid (6).** Using the SOPKC the CICAM shall determine that the RSD is valid. Refer to CI Plus Licensee Specification [33] for more details.
- **Download SOCRL (7)**. The CICAM compares the SOCRL version number' in the RSD with the 'version number' of a previously stored SOCRL. Where the RSD indicates a newer version, the SOCRL must be downloaded, similarly for the SOCWL. The location of the data carousel containing the SOCRL and SOCWL is found in the RSD.
- **SOCRL download timeout (8)**. On a SOCRL transmission timeout the Host is temporarily revoked (18). When the download has completed successfully, the CICAM processes the SOCRL (7).



Start (1)
Download RSD (2)
RSD download time-out (3)
YES
NO
Temp. Revoke CICAM limited operational (20)
Download SOPKC (4)
SOPKC Not Present (5)
YES
NO
RSD Valid (6)
NO
YES
Download SOCRL (7)
SOCRL download timeout (8)
YES
NO
Process SOCRL (9)
SOCRL Valid (10)
NO
YES
SOCWL Signalled in RSD (11)
NO
YES
Download SOCWL (12)
Process SOCWL (13)
SOCWL Valid (14)
NO
YES
Host device on SOCWL (15)
NO
YES
Host device on SOCRL (16)
YES
NO
Un-revoke: CICAM fully operational (17)
Revoke: CICAM limited operational (18)
Update revoked host devices in binding history (19)

Figure 5.8: SOCRL and SOCWL Download Flow Chart

- **Process SOCRL (9)**. When the SOCRL download has successfully completed, the CICAM verifies the digital signature of the SOCRL. The SOCRL is signed with the Service Operator credentials. The version number of the SOCRL and that specified in the RSD are checked for equality.
- **SOCRL Valid (10)**. The digital signature of the SOCRL is checked for authenticity and the version number of the SOCRL is equal to the version number that is contained in the RSD file otherwise the Host is temporarily revoked (20).

- **SOCWL Signalled in RSD (11)**. If no SOCWL is signalled in the RSD then the CICAM proceeds to check if the Host is in the SOCRL (16).
- **Download SOCWL (12)**. If a SOCWL is signalled in the RSD it is downloaded.
- **Process SOCWL (13)**. When the SOCWL has been successfully downloaded, the CICAM verifies the digital signature of the SOCWL. The SOCWL is signed with the Service Operator credentials.
- **SOCWL Valid (14)**. The following conditions shall be met in order to validate the SOCWL:
    - o The SOCWL digital signature over the SOCWL is valid
    - o The SOCWL 'version number' is equal to the ‘version number’ that is contained in the RSD

  Otherwise the SOCWL is considered invalid and ignored (16).
- **Host device on SOCWL (15)**. Where the Host that is currently bound to the CICAM is listed in the SOCWL then CI Plus protected services shall be un-revoked (17), otherwise the SOCRL is checked (16).
- **Host device on SOCRL (16)**. Where the Host that is currently bound to the CICAM is listed in the SOCRL then the Host shall be revoked (18), otherwise the Host device is not revoked (17).
- **Un-revoke: CICAM fully operational (17)**. The Host that is bound to the CICAM is not revoked, it is either on the SOCWL or is not listed on the SOCRL. Any existing (temporary) revocation is overruled or removed.
- **Revoke: CICAM limited operational (18)**. The Host that is bound to the CICAM is revoked; all CI Plus protected services remain CA scrambled until a SOCRL is received that does not contain an entry for the Host or a SOCWL is received that contains an entry for the Host. The revocation state overrules any temporary revocation state.
- **Update Revoked Host Device in Binding History (19)**. The CICAM maintains a list in non-volatile memory of Hosts that have successfully bound to the CICAM. This list must be updated:
    - o Where the Host is on the SOCWL then its entry in the binding history shall be updated by removing a revocation flag for the current Service Operator.
    - o Where the Host is on the SOCRL then its entry in the binding history shall be updated by setting a revocation flag for the current Service Operator.
    - o Each Host that is in the binding history for the current service operator shall be verified against the SOCRL (and SOCWL) and revocation flags adjusted appropriately.
- **Temporary Revoke: CICAM limited operational (20)**. As a result of a RSD transmission timeout, a SOCRL transmission timeout, an invalid SOCRL or SOPKC the CICAM temporarily revokes the Host by becoming limited operational. Any temporary revocation is removed when the RSD, SOPKC and SOCRL are all valid (10).

5.5.6 Denial of Service

The revocation process is based on a denial of service by the CICAM and is executed according to Figure 5.9, which is informative and does not preclude other implementations. Each of the process steps are briefly discussed.

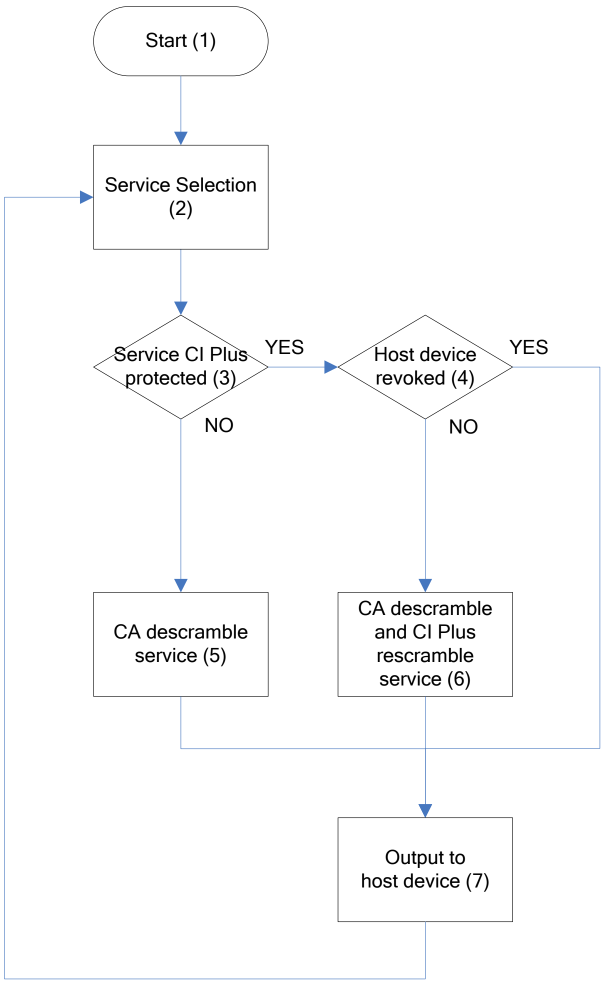

Start (1)
Service Selection (2)
Service CI Plus protected (3)
YES
NO
Host device revoked (4)
YES
NO
CA descramble service (5)
CA descramble and CI Plus rescramble service (6)
Output to host device (7)

Figure 5.9: Revocation by Denial of Services Flow Chart

- **Start**. After the CICAM and the Host have bound successfully, the descrambling of CA protected services and re-scrambling of CI Plus protected services may commence.
- **Service Selection**. The user selects a service and the Host tunes to the requested service. The CICAM first checks if the selected service is CI Plus protected before the CA protection may be removed (3).
- **Service CI Plus Protected**. The CICAM determines by means of the EMI value if the selected service is CI Plus protected. If CI Plus protection is required then the CICAM checks if the Host is not revoked (4) otherwise the CA protected service may be descrambled (5).
- **Host device revoked**. The CICAM uses the binding history to check if the Host to which it is bound, is flagged as (temporary) revoked. If the bound Host is revoked then the CA protected service is not descrambled otherwise the service is descrambled (6).
- **CA Descramble Service**. The selected service is CA descrambled but not CI Plus re-scrambled. The unprotected service is transmitted to the Host (7).
- **CA Descramble Service and CI Plus Re-scramble Service**. The selected service is a CI Plus protected service and the bound Host is not revoked, the service is first CA descrambled and then CI Plus re-scrambled. The CI Plus protected service is transmitted to the Host (7).
- **Output to Host device**. The CICAM may transmit the selected service to the bound Host for consumption. The service is either unencrypted (CA protection removed) or encrypted (CA protection removed but CI Plus protection is added).

5.6 (De)Scrambling of Content

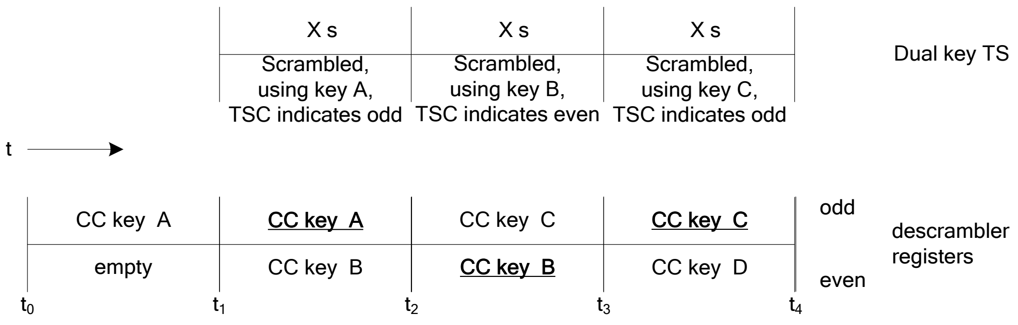
5.6.1 Transport Stream Level Scrambling

To protect high value content, a service provider may choose to "scramble" (encrypt) the content of the service elementary streams. The receiving device uses a descrambler to "descramble" (decrypt) the elementary streams so they may be consumed. The descrambler determines when to descramble by interrogating the transport scrambling control (TSC) bits in the TS packet as defined in Table 5.4

Table 5.4: Definition of Transport Scrambling Control Bits

Transport scrambling control bits	Description	Comment
00	No descrambling	Support required.
01	Scrambling with DEFAULT content key	Not supported by CICAM and Host.
10	Scrambling by the EVEN content key	Support required.
11	Scrambling by the ODD content key	Support required.
NOTE: Limitations to TS level scrambling adhere to ISO 13818-1 [13].		

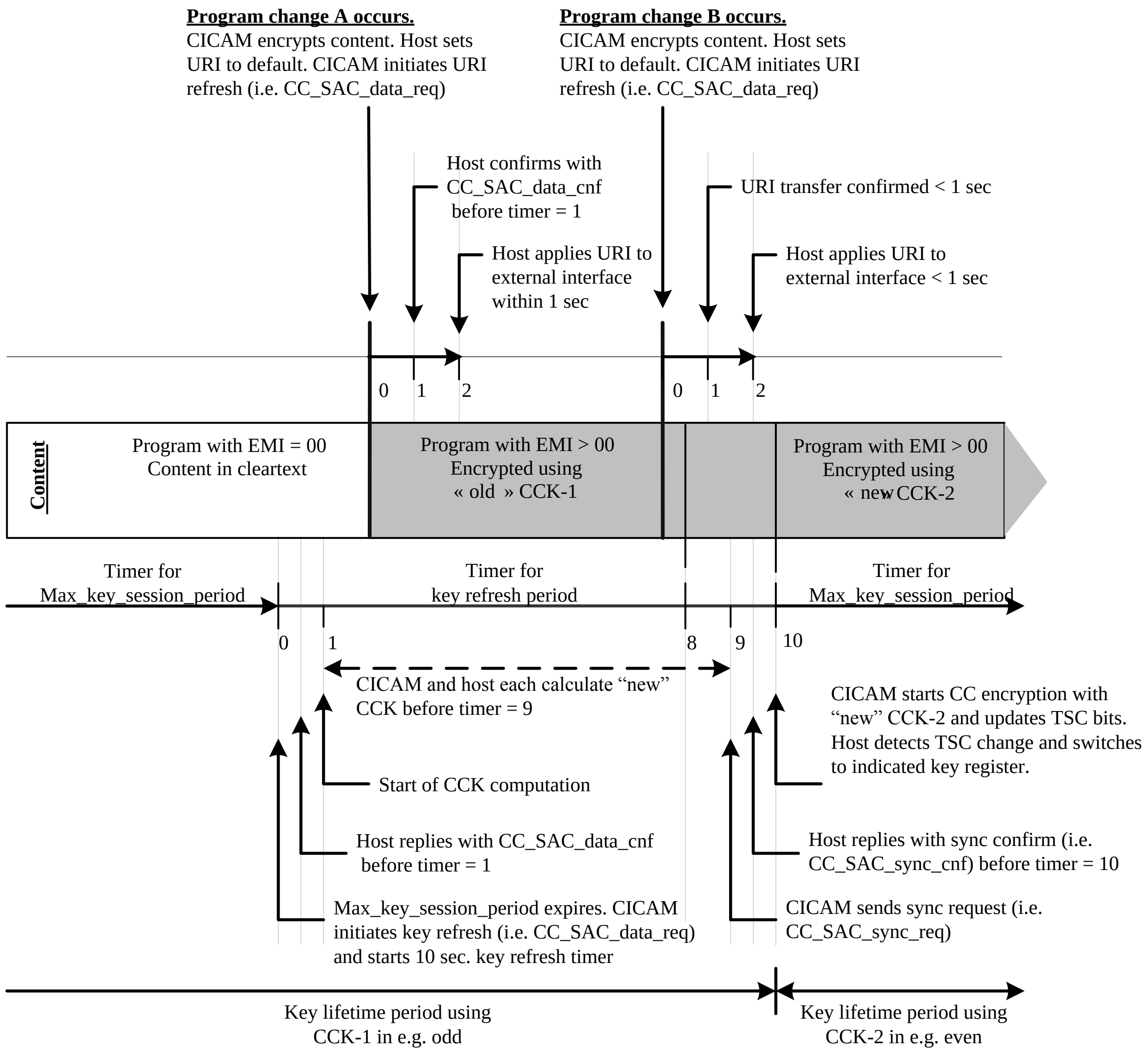
Dual-key descramblers use two registers to store two keys: the first register may contain the key the descrambler is currently using. During this key period the second register may be updated with a new key for the next keying period. To distinguish the registers they are identified as the odd and even key register. The TSC bits in the TS packet indicates if the descrambler is to use the key in the odd or even key register in order to descramble the TS packet and flips to the corresponding register when necessary. Refer to Figure 5.10 for details.



Key: active register is underlined.

Figure 5.10: Relation between Descrambler Registers and TS

The odd/even key refresh is signalled by the CICAM in the data request APDU, the Host knows in advance which descrambler register it has to store the Content Control Key (CCK) that the CICAM commands it to start computing. To determine if the Host has actually computed the CC key and loaded it into the requested register (odd or even) the CICAM and Host synchronize with each other; the CICAM initiates a sync request APDU which the Host has to confirm. If the key refresh timer expires the CICAM shall start using the new CC key (CCK) and modifies the TSC bits of the TS packet header. Directly after the CICAM changes the TSC value the Host shall detect the change and switch to the alternate key register. The URI protocol transfers the URI value to the Host. The URI indicates content restrictions. Refer to Figure 5.11 for details.


Program change A occurs.
CICAM encrypts content. Host sets URI to default. CICAM initiates URI refresh (i.e. CC_SAC_data_req)
Program change B occurs.
CICAM encrypts content. Host sets URI to default. CICAM initiates URI refresh (i.e. CC_SAC_data_req)
Host confirms with CC_SAC_data_cnf before timer = 1
Host applies URI to external interface within 1 sec
URI transfer confirmed < 1 sec
Host applies URI to external interface < 1 sec
0 1 2
0 1 2
Content
Program with EMI = 00 Content in cleartext
Program with EMI > 00 Encrypted using « old » CCK-1
Program with EMI > 00 Encrypted using « new» CCK-2
Timer for Max_key_session_period
Timer for key refresh period
Timer for Max_key_session_period
0 1 8 9 10
CICAM and host each calculate "new" CCK before timer = 9
CICAM starts CC encryption with "new" CCK-2 and updates TSC bits. Host detects TSC change and switches to indicated key register.
Start of CCK computation
Host replies with CC_SAC_data_cnf before timer = 1
Host replies with sync confirm (i.e. CC_SAC_sync_cnf) before timer = 10
Max_key_session_period expires. CICAM initiates key refresh (i.e. CC_SAC_data_req) and starts 10 sec. key refresh timer
CICAM sends sync request (i.e. CC_SAC_sync_req)
Key lifetime period using CCK-1 in e.g. odd
Key lifetime period using CCK-2 in e.g. even

Notes:

1. Refer to section 5.7.5 for details on the URI refresh protocol.
2. Refer to section 8.1 for details on the Content Control key refresh protocol.
3. Refer to section 11.3.1for details on the APDUs.
4. For the duration of a key lifetime period the CICAM re-scrambles all Elementary Streams under CC control with the same CCK and, where AES is chosen, IV.

Figure 5.11: Dual Key Refresh and URI Transfer

5.6.1.1 PES Level Scrambling

Where the service provider uses PES Level Scrambling of the elementary streams, i.e. the **PES_scrambling_control** bits of the **PES_packet** are non-zero, then any re-scrambling by the CICAM shall be re-applied at the Transport Stream level and the **PES_scrambling_control** field shall be set to Not Scrambled.

5.6.2 Scrambler/Descrambler Definition

5.6.2.1 Scrambling rules

This specification defines two scramblers for Transport Stream Output protection, DES and AES. Table 5.5 describes the mandatory Host and CICAM capabilities.

Table 5.5: Host and CICAM Capabilities

Scrambler option	CICAM	Host
DES-56-ECB	Mandatory	Mandatory for both SD and HD Hosts
AES-128-CBC	Optional	Mandatory for HD Hosts only.

The definition of SD and HD Hosts for the purposes of this document is specified in Annex D.

The Host and CICAM negotiate scrambler capabilities during certificate exchange. Each device determines the opposite device's scrambler capability, see 9.3.9.5. Both devices shall decide which cipher to use, see table 5.6.

If there is an existing binding, i.e. matching authentication keys, the previously negotiated cipher shall be used, see section 6.3.

Table 5.6: Scrambling Cipher Selection Rules

Module	Host	Decision	Comment
none	none	CC stopped and TS output for clear content.	**"**none**"** for either Host or module
DES	DES	Transport Steam Output re-scrambling utilizes DES.	
DES	AES	Transport Steam Output re-scrambling utilizes DES.	
AES	DES	Transport Steam Output re-scrambling may utilize DES.	See Note 3.
AES	AES	Transport Steam Output re-scrambling utilizes AES.	
Notes 1. The content owner could accept to use either DES or AES, meaning that a provider may make the technology choice to use DES or AES enabled CICAMs. 2. Transport Stream Output as defined in EN 50221 [7] 3. The CA System may decide that DES is not suitable and choose not to descramble the content.			

The CI Plus Content Control system adheres to the following scrambling rules:

- The Transport Stream packets of the Elementary Streams of the selected programme that are in the clear on the network side shall not be scrambled by the CI Plus Content Control and shall remain in the clear.
- Content that has been descrambled by the network CA system and where the CI Plus Content Control delivers a URI carrying EMI with value 0x00 shall not be re-scrambled by the CI Plus Content Control. In this case the Transport Stream packets of the Elementary Streams belonging to the selected programme that were scrambled on the network are passed to the Host in the clear.
- Content that has been descrambled by the network CA system and where the CI Plus Content Control delivers a URI carrying EMI with any other value than 0x00 are re-scrambled by the CI Plus Content Control. In this case the Transport Stream packets of the Elementary Streams belonging to the selected programme that were scrambled on the network are passed to the Host re-scrambled by CI Plus Content Control.
- The CI Plus Content Control shall always use the same scrambler cipher for all types of content (audio, video or some other component of the selected programme) and use the highest negotiated cipher.
- The CICAM shall only descramble, and possibly re-scramble, elementary streams that have been notified for descrambling in the CA_PMT according to EN 50221 [7] section 8.4.3.4.
- The CICAM is not obliged to pass content over a DES encrypted channel. i.e. it is at the service operators discretion whether to deliver high value HD (or SD) content over DES and may select to deliver the content to AES devices only, effectively disabling DES only devices for those services.

Apart from the rules defined in Table 5.9, the scrambling rules of SCTE41 [5], section 7.1.1 apply. In the case of conflict the rules above take precedence. (e.g. apart from DES the usage of AES is allowed and specified.)

5.6.2.2 Transport Stream Scrambling with DES

The payload of Transport Stream packets may be encrypted using DES-56 in ECB mode with residual blocks left in the clear. The DES scrambler and descrambler adheres to SCTE41 [5], Appendix B.

NOTE: There are differences in bit and byte numbering used in MPEG2 (see ISO 13818-1 [13]) and the specification of DES (see FIPS 46-3 [2]). The numbering system mapping is defined in ATSC Document A/70A [26], Annex A.

5.6.2.3 Transport Stream Scrambling with AES

The payload of Transport Stream packets may be encrypted using AES-128 in CBC mode with CC key and IV changing per key lifetime period and residual blocks left in the clear. Refer to FIPS 197 [4] for AES-128 and refer to NIST Special Publication 800-38A [25] for usage of AES-128 in CBC mode.

Encryption of the content is based on ATSC A/70A [26], Appendix D.3. The following section describes the AES scrambler and descrambler for this specification.

Figure 5.12 shows the high level format of a Transport Stream packet (see ISO 13818-1 [13]).

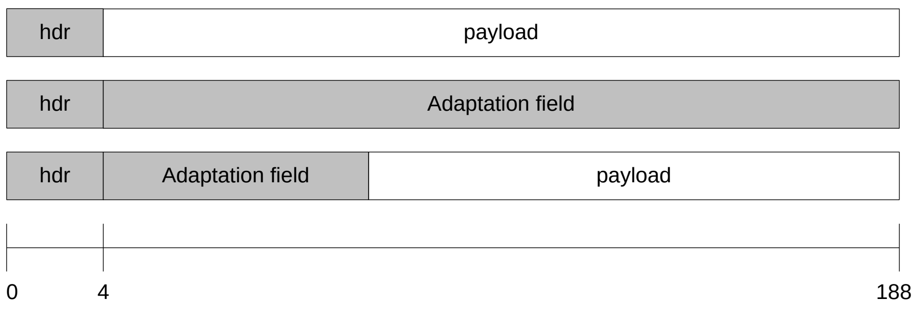


Figure 5.12: Transport Stream Packet

Transport Stream packets comprise a header (shaded grey) and payload field. Depending on the size of the adaptation field (grey), the length of the payload varies between 0 and 184 bytes. Only the payload is scrambled. The payload is segmented into blocks of 128 bits (16 bytes) and passed through the AES scrambling engine as described below.

5.6.2.3.1 Scrambling

An encryption function commonly defines ***b*** as clear text and its scrambled version ***s*** as cipher text. The AES encryption function is represented by ***s*** = $E_{AES\text{-}128\text{-}CBC}$\{CCK\}(***b***), where a Content Control Key (*CCK*, defined in section 8.1.4) is used to encrypt / scramble a binary block ***b*** of length equal to 128 bits (16 bytes). Encryption processes ***b*** into a block of the same size, ***s***.

When the clear text is larger than 128 bits the content is encrypted using AES in CBC mode (i.e. Cipher Block Chaining), using the following operation:

$$s(m) = E_{AES-128-CBC}\{CCK\}\left[b(m) \oplus s(m-1)\right] \qquad \text{Eq.5.1}$$

Where:

- *CCK* is the Content Control Key.
- *b(m)* represents the m^{th} block of 128 bits in the sequence, where *m* = 2..n. Encryption of the current block b*(m)* requires knowledge of the cipher text s*(m-1)* (i.e. the output of the previously scrambled block).

Notice that Equation (5.1) does not work for *m* = 1. For the first block (i.e. *m* = 1), the data for ***s***(0) does not exist. Therefore it is necessary to define an Initialization Vector (IV), which is used to compute the first scrambled block ***s***(0) with the following operation:

$$s(1) = E_{AES-128-CBC}\{CCK\}\left[b(1) \oplus IV\right] \qquad \text{Eq.5.2}$$

Where:

- *CCK* is Content Control Key and *IV* (CIV) is an initialization vector, as defined in section 8.1.4.

The appropriate vector ***IV*** shall be used at the beginning of a Transport Packet. The data payload of a TS packet is maximally 184 bytes long, the maximum number of blocks for encryption with AES-128-CBC is 11 (since residual blocks remain in the clear 184*8/128 is rounded to 11).

The Transport Stream packets of all selected elementary streams use the same key and initialisation vector. There are two special cases of residual blocks: terminating and solitary short blocks. Both blocks remain in the clear and do not require scrambling or descrambling.

5.6.2.3.2 Terminating short block:

Assume that a certain TS packet may be divided into *M* blocks: {***b***(1), ***b***(2), …., ***b***(*M*)}, a frequent occurrence is that the size of the last block is less than 128 bits. In this case, ***b***(*M*) is by definition a terminating short block. Refer to Figure 5.13 for details.

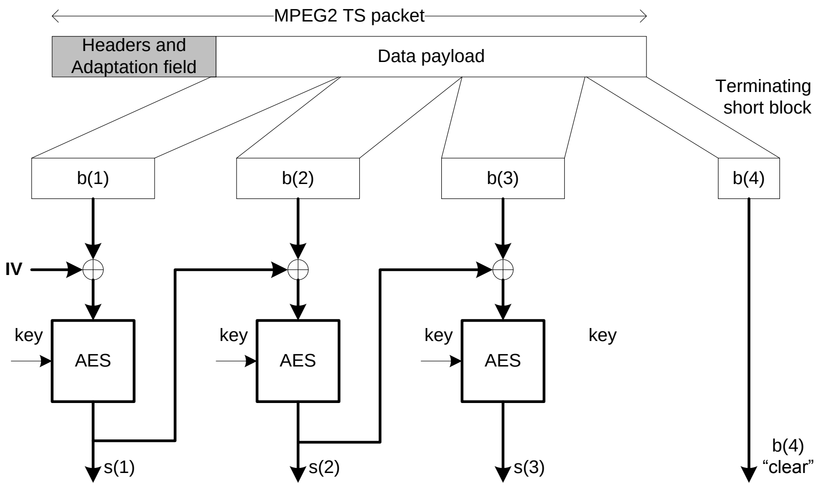


Figure 5.13: Scrambling of Data and Terminating Short Block

5.6.2.3.3 Solitary Short Block:

The second case, solitary short block, occurs when the TS packet to encrypt has only one block ***b***(1) and its size is less than 128 bits. Refer to Figure 5.14 for details.

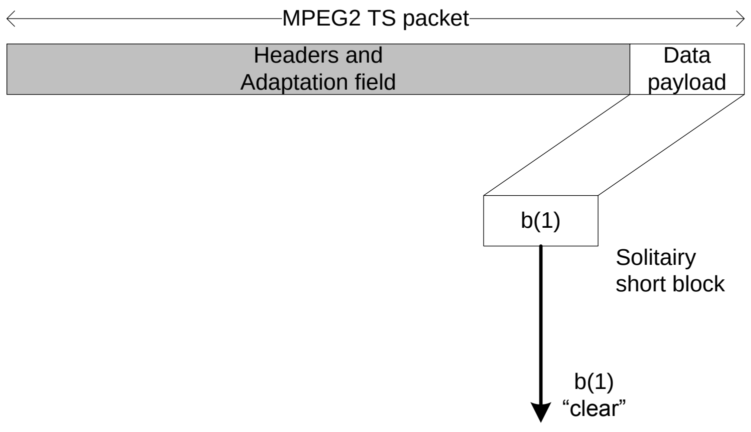


Figure 5.14: "Scrambling" of Solitary Short Block

5.6.2.3.4 Descrambling

Similar to scrambling above, the AES decryption function is represented by $\boldsymbol{b} = D_{AES\text{-}128\text{-}CBC}\{\text{CCK}\}(\boldsymbol{s})$, where a Content Control Key (*CCK,* defined in section 8.1.4) used to decrypt / descramble a binary block ***s*** of length equal to 128 bits (16 bytes). Decryption processes ***s*** into a block of the same size ***b***.

When the cipher block is larger than 128 bits the content is decrypted using AES-128 in CBC mode using following operation:

$$b(m) = D_{AES-128-CBC}\{CCK\}\left[s(m)\right] \oplus s(m-1) \qquad \text{Eq. 5.3}$$

Where:

- *CCK* is Content Control Key.
- *s(m)* represents the *m* th block of 128 bits in the sequence, where *m* = 2..n. Decryption of the current block s*(m)* requires knowledge of the cipher text s*(m-1)* (i.e. the previously scrambled block).

Equation 5.3 does not work for *m* = 1. For initialization we use following operation:

$$b(1) = D_{AES-128-CBC}\{CCK\}\left[s(1)\right] \oplus IV \qquad \text{Eq. 5.4}$$

Where:

- *CCK* is Content Control Key and *IV* (CIV) is an initialization vector, as defined in section 8.1.4.

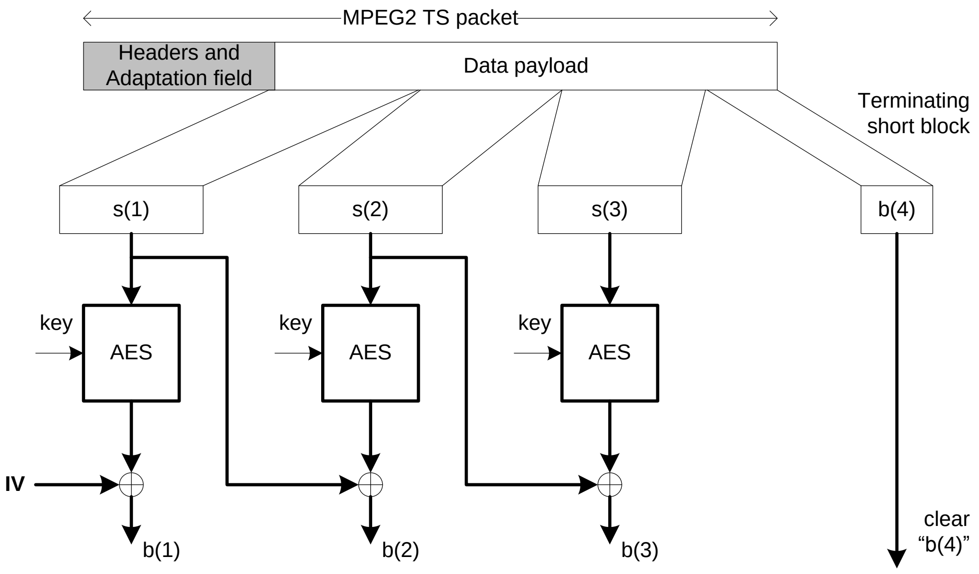


Figure 5.15: Descrambling of Data and Terminating Short Blocks

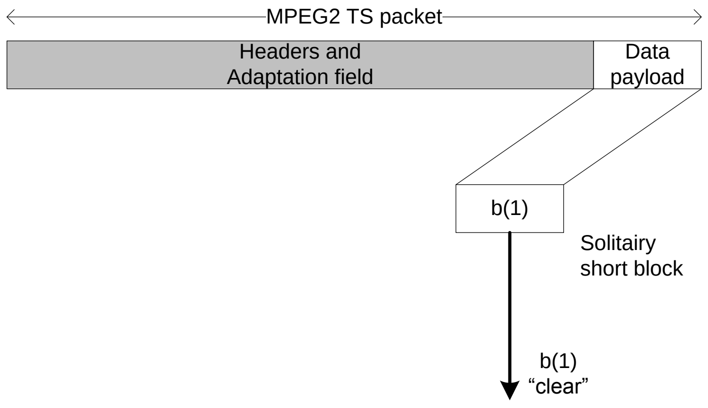


Figure 5.16: "Descrambling" Solitary Short Blocks

5.7 Copy Control Exertion on Content

5.7.1 URI Definition

The content provider and the content distributor determine Usage Rules Information (URI) values for each programme (i.e. service or event) off-line. The CA system delivers the URI securely from the network head-end to the CICAM. The CICAM passes URI to the Host using a SAC protocol. The Host uses the URI to control copy creation, analogue output copy control encoding, constrained image triggering and to set copy control parameters on Host outputs.

5.7.2 Associating URI with Content

The CA System shall securely associate the URI with content, i.e. a specific MPEG Service / Event. The URI is associated with the selected service via the 16-bit MPEG2 programme number, as specified in ISO 13818-1 [13].

All PIDs that belong to a programme (as indicated in the PMT) are associated with only one URI.

NOTE: content (i.e. MPEG2 events) covered by this specification shall not use a programme number with value 0 (zero).

5.7.3 URI transfer – Head-End to CICAM

The URI may be transmitted from the DVB head end to the CICAM in undisclosed ways. An example is to carry actual URI information and programme number information in an EMM or ECM message, protected by the network CA system. The exact transport mechanism used to carry the URI data from head-end to CICAM is out of scope for this specification.

5.7.4 URI transfer – CICAM to Host

Once the CICAM receives URI data this shall be transmitted from CICAM to Host via the URI message format. The URI message format is described in section 5.7.5.2.

The CICAM transfers the URI to the Host under different operating conditions using the following methods:

- When watching live content, using the URI transmission and acknowledgement protocol (See section 11.3.3.6)
- When recording content with EMI=1,1, using the License Exchange protocol (See section 11.3.4.1)
- When playing back recorded content which has a license, using the Playback License Exchange protocol (See section 11.3.4.2)

Immediately after power up or channel change, the Host shall use the initial default URI values shown below..

Table 5.7: Default Values for CI Plus URI Version 1

Field	Default Initial Value
protocol version	0x01
emi_copy_control_info	0b11
aps_copy_control_info	0b00
ict_copy_control_info	0b0
rct_copy_control_info	0b0
rl_copy_control_info	0b000000
reserved bits	0b0

Table 5.8: Default Values for CI Plus URI Version 2

Field	Default Initial Value
protocol version	0x02
emi_copy_control_info	0b11
aps_copy_control_info	0b00
ict_copy_control_info	0b0
rct_copy_control_info	0b0
dot_copy_control_info	0b0
rl_copy_control_info	0b00000000
reserved bits	0b0

After setting this initial default URI the Host shall start a 10-second timer. If the Host has not yet successfully completed the URI delivery protocol when the timer reaches ten (10) seconds, the Host shall change URI values to the Error Value which is the same as the initial default value except that the ICT bit is set to 0b1: in that case the Host shall apply Image Constraint as if the ICT bit was set to one. The URI after timeout is called the final default URI.

A CI Plus compliant device shall support URI version 0x01 and 0x02 and may ignore other URI versions. Any future URI version shall incorporate EMI and APS bits as defined in version 0x01.

Future URI versions shall not override existing bits in URI version 0x01. This means that future URI versions may add additional content restrictions, which a future device may support, as long as the content limitations are not made less restrictive. The settings of the EMI, APS and ICT bits shall always be respected.

The Host is expected to cache the URI whilst tuned to a given service regardless of the signal state, i.e. if the signal is lost due to antenna disconnection or the signal falling below the required minimum level then any previously received URI shall remain in force.

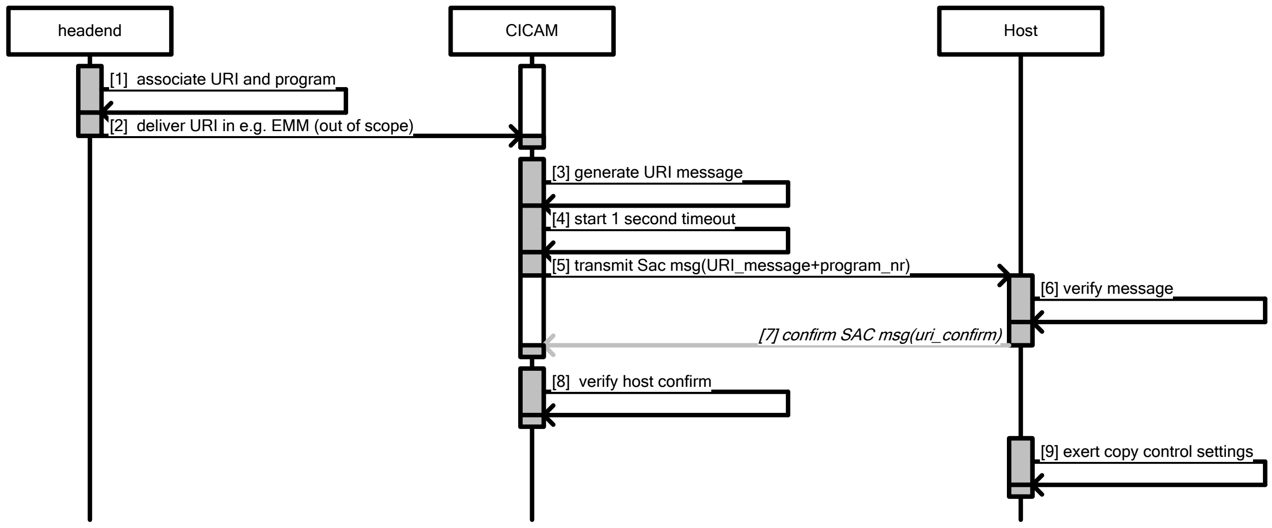
5.7.5 URI Refresh Protocol

The URI message delivered from the CICAM to the Host is protected by the SAC (refer to section 7). The CICAM and Host shall jointly execute the steps below, once for each transfer of the URI. Any failure of the steps described below shall result in a failed URI delivery. If the protocol is not completed successfully before the one second timeout expires the CICAM shall disable CA-descrambling and the Host shall set the URI to the default URI value until the URI refresh protocol successfully completes.

The CICAM shall send a URI to the Host only after the CICAM and Host have successfully bound and negotiated a shared Content Control Key (CCK). The CICAM shall initiate URI transfer to the Host on a CAS controlled service immediately after:

- the Host sends a ca_pmt to the CICAM, or
- the Programme Number changes on a tuned 'channel', or
- any change in the URI bits during a programme, or
- any change in the MPEG packet ID (PID) values that the CICAM is descrambling.

The exact process is explained in Figure 5.17.


headend
CICAM
Host
[1] associate URI and program
[2] deliver URI in e.g. EMM (out of scope)
[3] generate URI message
[4] start 1 second timeout
[5] transmit Sac msg(URI_message+program_nr)
[6] verify message
[7] confirm SAC msg(uri_confirm)
[8] verify host confirm
[9] exert copy control settings

Notes

1. This diagram does not suggest that any behaviour be specifically (un)synchronized / (un)blocked.
2. Steps 1 and 2 are shown for completeness, but are out of scope for this specification.
3. Refer to Figure 5.11 for an overview showing both URI refresh protocol and CCK refresh protocol.

Figure 5.17: URI Refresh Protocol (informative)

The process is defined as described in Table 5.9:

Table 5.9: URI Protocol Behaviour (normative)

No.	Description	Refer to
1	**Association of URI with programme.** The URI is associated with the content (DVB service or event). The exact process; including alternating URI values is out of scope.	
2	**Delivery of URI in e.g. EMM (out of scope).** The delivery of the URI is typically protected by the CA system to preserve the association between URI and programme number. The exact delivery process is out of scope.	
3	**CICAM generates URI message.** The CICAM calculates uri_confirm to authenticate Host acknowledgment of receipt (Note 5), as: $uri\_confirm = SHA_{256}(uri\_message \| UCK)$ where: • UCK = SHA_{256} (SAK) The value uri_confirm is locally kept for comparison in step 8. The CICAM shall generate a cc_sac_data_req APDU for the URI message, carrying: • the uri_message, • the program_number	Section 5.7.5.1
4	**CICAM starts 1 second timeout.** The CICAM starts a 1 second timeout in which the URI protocol has to complete. (Note 1)	Figure 5.15
5	**CICAM transmit SAC message with URI payload.** The CICAM transmits a SAC message with payload from step 3 and transmits this to the Host. (Note 2).	Section 7.3 and 11.3.1
6	**Host verifies message.** After the Host verifies the SAC message is correct, the Host extracts the URI value and programme number.	
7	**Host transmits SAC message with URI confirmation.** The Host checks it supports the URI version requested by the CICAM. The Host confirms URI delivery with the cc_sac_data_cnf APDU, carrying • uri_confirm and uses the SAC to transmit this to the CICAM. (Note 2) The Host calculates uri_confirm in an similar way to the CICAM in step 3 above. Failure to respond constitutes a failure of the copy protection system and sets the URI to the default value (Notes 3 & 4).	Section 7.3 and 11.3.1

8	**CICAM verifies Host confirm.** The CICAM compares the received uri_confirm from the Host with the value calculated in step 3 above. Failed equivalence constitutes a failure of the copy protection system and sets the URI to the default value (Notes 3 & 4).	
9	**Exert copy control settings** The Host shall control its outputs based on the valid URI immediately.	
Notes: 1. If the steps above are not completed before the one-second timeout expires the CICAM SHALL disable CA descrambling of copy protected content (i.e. EMI ≠ 0x0) for the associated MPEG programme until the URI delivery protocol completes successfully. When the protocol completes then the CICAM shall wait for one second before the URI protocol is reinitiated. 2. Refer to section 7.2 for an explanation how the URI protocol data is packed into a SAC message. 3. The Host shall apply the default URI settings. The default URI values are defined in section 5.7.4. 4. Refer to section 5.4.3 and Annex F for details on the generic error reporting mechanism. 5. Input is padded according to SHA-256. Refer to FIPS 180-3 [3]. It is advised that SHA implementations adhere to the SHS validation list. See SHS Validation List [11].		

5.7.5.1 URI Version Negotiation Protocol

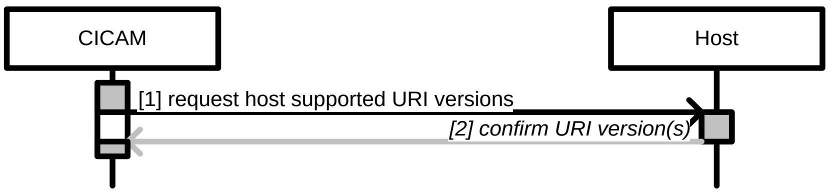

CICAM
Host
[1] request host supported URI versions
[2] confirm URI version(s)

Figure 5.18: URI Version Negotiation Protocol

The URI version negotiation is performed once after (re)initialisation of the SAC. The CICAM sends a message to the Host requesting the URI versions it is capable of supporting. The Host replies with a bitmask of the URI versions it supports. Refer to section 11.3.3.7.

The CICAM shall determine matching combinations of URI versions supported by both the CICAM and Host. The CICAM shall decide what URI version to use, the exact process is out of scope of this specification.

If no matching combinations of URI versions other than the default are found, the system shall use the default URI version.

5.7.5.2 Format of the URI message

The URI version 1 message syntax is defined in Table 5.10, version 2 syntax is shown in Table 5.11.

Table 5.10: URI Version 1 Message Syntax

Field	length	Mnemonic
`uri_message() {`		
`protocol_version`	8	uimsbf
`aps_copy_control_info`	2	uimsbf
`emi_copy_control_info`	2	uimsbf
`ict_copy_control_info`	1	uimsbf
`rct_copy_control_info`	1	uimsbf
`reserved for future use`	4	uimsbf
`rl_copy_control_info`	6	uimsbf
`reserved for future use`	40	uimsbf
`}`		

Table 5.11: URI Version 2 Message Syntax

Field	length	Mnemonic
`uri_message() {`		
`protocol_version`	8	uimsbf
`aps_copy_control_info`	2	uimsbf
`emi_copy_control_info`	2	uimsbf
`ict_copy_control_info`	1	uimsbf
`if (emi_copy_control_info == 00) {`		
`rct_copy_control_info`	1	uimsbf
`}`		
`else {`		
`reserved = 0`	1	uimsbf
`}`		
`reserved for future use`	1	uimsbf
`if (emi_copy_control_info == 11) {`		
`dot_copy_control_info`	1	uimsbf
`rl_copy_control_info`	8	uimsbf
`}`		
`else {`		
`reserved = 0x00`	9	uimsbf
`}`		
`reserved for future use`	40	uimsbf
`}`		

5.7.5.3 Coding And Semantics Of Fields

protocol_version: This parameter indicates the version of the URI definition and is defined in Table 5.12:

Table 5.12: Allowed Values for protocol_version

Contents	Meaning	Comment
0x00	Forbidden	not used in this specification
0x01	URI protocol version 1	specification to version 1.2
0x02	URI protocol version 2	specification version 1.3
0x03-0xFF	reserved for future use	
Note: A device made according to this version of the CI Plus specification shall understand value 0x02 and ignore URI messages that have a protocol_version value that it does not support.		

aps_copy_control_info: This parameter describes the Analogue Protection System (APS) bits which define the setting of analogue copy protection used on the analogue output, as explained in Table 5.13:

Table 5.13: Allowed Values for aps_copy_control

Contents	Value in Binary	Comment
0x0	00	Copy Protection Encoding Off
0x1	01	AGC Process On, Split Burst Off
0x2	10	AGC Process On, 2 line Split Burst On
0x3	11	AGC Process On, 4 line Split Burst On

emi_copy_control_info: This parameter describes the Encryption Mode Indicator (EMI) bits. The CI Plus system shall use the EMI bits to exert copy control permissions of digital and analogue outputs as explained in Table 5.14.

Table 5.14: Allowed Values for emi_copy_control

Contents	Value in Binary	Comment
0x0	00	Copying not restricted
0x1	01	No further copying is permitted
0x2	10	One generation copy is permitted
0x3	11	Copying is prohibited

ict_copy_control_info: This parameter describes the Image Constrained Trigger (ICT) bit. The Host shall use the ICT bit to control a constrained image quality on high definition analogue component outputs explained in Table 5.15.

Table 5.15: Allowed Values for ict_copy_control_info

Contents	Value in Binary	Comment
0x0	0	No Image Constraint asserted
0x1	1	Image Constraint required

rct_copy_control_info: This parameter describes the Encryption Plus Non-assert (RCT) bit. The Host shall use the RCT bit to trigger redistribution control on Controlled Content when the RCT value is set to a value of one (1) in combination with the EMI bits set to a value of zero, zero (0,0), which signals the need for redistribution control to be asserted on Controlled Content without the need to assert numeric copy control as explained in Table 5.16.

Table 5.16: Allowed Values for rct_copy_control_info

Contents	Value in Binary	Comment
0x0	0	No Redistribution Control asserted. Default.
0x1	1	Redistribution Control asserted

dot_copy_control_info: This parameter describes the Digital Only Token (DOT) bit. The Host shall use the DOT bit to control analogue video outputs as explained in Table 5.17. When the EMI bits are equal to (1,1) the CICAM may set the dot_copy_control_info bit to a value other than (0) to prohibit the output of analogue video content by the Host.

Table 5.17: Allowed Values for dot_copy_control_info

Contents	Value in Binary	Comment
0x0	0	No Digital Only Constraint asserted (default)
0x1	1	Digital Only Constraint asserted; output on analogue video outputs is prohibited.

rl_copy_control_info: This field describes the retention limit of the recording and/or time-shift of content from the time that it is retained. Figure 5.19 shows how the retention limit is applied. The default rl_copy_control_info bits in the URI message shall always be filled with the default retention limit value 0x00 except when the EMI bits are set to a value of one, one (1,1). When EMI is (1,1) the CICAM may set the rl_copy_control_info bits to a value other than 0x00 (zero) to override the default 90 minutes retention limit, other values may signal a retention limit in hours or days. When EMI is (1,1) and the CICAM has not received information from the network then the default rl_copy_control_info value in the URI message is filled with the default retention limit value 0x00.

Table 5.18: URI Version1 Allowed Values for rl_copy_control_info

Contents	Value in Binary	Comment
0x00	000000	Default retention limit of 90 minutes applies
0x01	000001	Retention limit of 6 hours applies
0x02	000010	Retention limit of 12 hours applies
0x03-0x3F	000011-111111	Retention limit of 1-61 multiples of 24 Hrs applies as signalled by bits

Table 5.19: URI Version 2 Allowed Values for rl_copy_control_info

Contents	Value in Binary	Comment
0x00	00000000	Default retention limit of 90 minutes applies
0x01	00000001	Retention limit of 6 hours applies
0x02	00000010	Retention limit of 12 hours applies
0x03-0xFE	00000011-11111110	Retention limit of 1-252 multiples of 24 Hrs applies as signalled by bits
0xFF	11111111	Unlimited retention period.

If the CICAM receives rl_copy_control_info from the network which is for a higher URI version than the Host can support, the CICAM shall use the highest rl_copy_control_info value capable for the matching URI version.

For Example:

Network rl_copy_control_info = 0xf0 (237 days)

Host with URIv2 rl_copy_control_info = 0xf0 (237 days)

Host with URIv1 rl_copy_control_info = 0x3f (61 days)

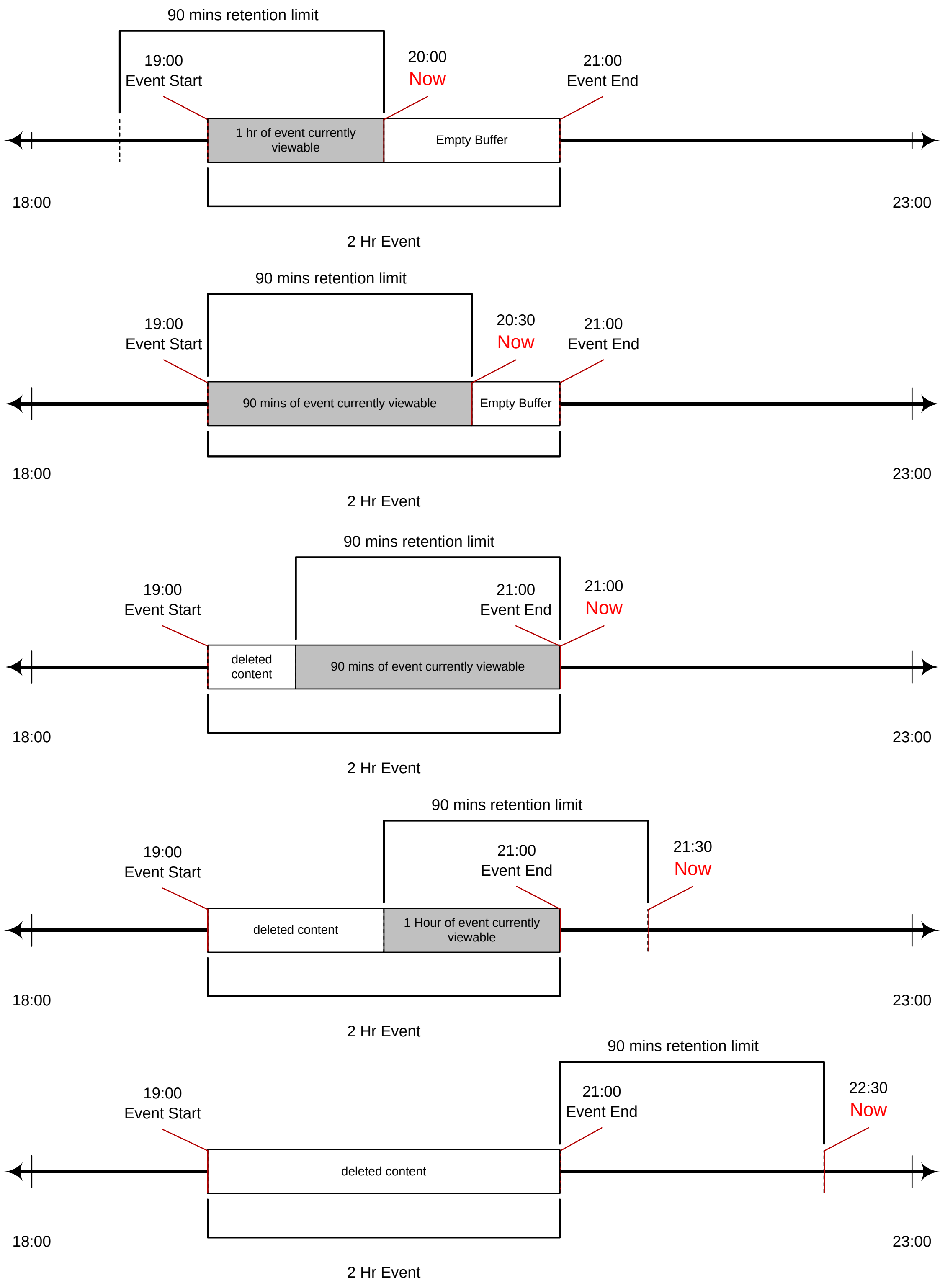


Figure 5.19: Example of a Retention Time Limit of 90 mins

5.8 Modes Of Operation

Hosts and CICAMs that meet this specification shall be completely compatible with the Common Interface specified in EN 50221 [7] and TS 101 699 [8]. A DVB CICAM inserted into a CI Plus Host shall function as normal. The Host shall recognise that it is DVB CI and use the resources that it has. If a CI Plus CAM is inserted into a DVB CI Host, the Host shall recognise it as a valid DVB CI device and function normally. Table 5.20 describes the various operating modes of CICAMs and Hosts.

Table 5.20: Operating Modes of CICAM and Host

Host	CICAM	State	EMI>0	EMI=0
CI Plus	DVB CI		DVB CI (Note 1)	DVB CI
DVB CI	CI Plus		No Descrambling (Note 2)	DVB CI (Note 4)
CI Plus	CI Plus	Authenticated	Descramble + CC (Note 4)	Descramble
CI Plus	CI Plus	SAC Failed	No Descrambling	DVB CI (Note 4)
CI Plus	CI Plus	CCK Failed	No Descrambling	DVB CI (Note 4)
CI Plus	CI Plus	CICAM Revoked	No Descrambling	No Descrambling
CI Plus	CI Plus	Host Revoked	CICAM Pass-through (Note 3)	CICAM Pass-through (Note 3)
CI Plus	CI Plus	Authentication Failed	No Descrambling	No Descrambling

Notes:
1. Only if CI Plus descriptor absent in SDT_{Actual}.
2. CICAM shall detect EMI >0 and shall not descramble.
3. Content is passed through the CICAM un-altered.
4. The service operator and CAS may choose under what Content Control conditions to descramble content to a DVB CI device

5.8.1 Host Operation with Multiple CICAMs

A CI Plus compliant Host may support a maximum of 5 CI Plus slots. Each slot may contain either a DVB CICAM or a CI Plus CAM. All combinations are allowed. There may be additional slots that support DVB CI only.

For a single tuner Host the TS shall be daisy-chained through each inserted CICAM. See Figure 5.20. For dual-tuner systems, there is no need for daisy-chaining and it's up to the Host manufacturer to route the two TS in a suitable way.

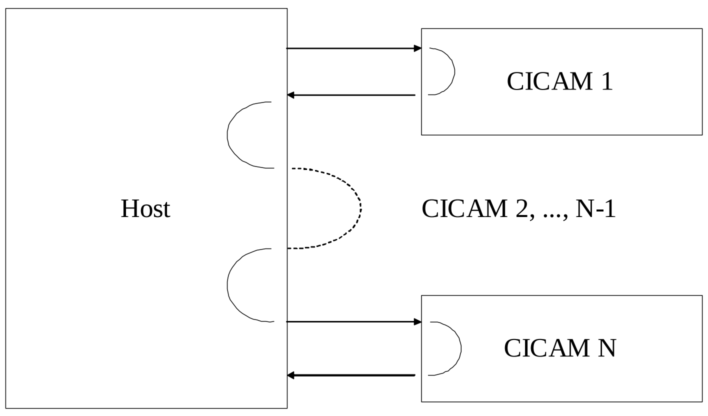


Figure 5.20: Daisy Chaining Of Transport Stream Through CICAMs

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The Host and single CICAM shall be able to descramble one service, and possibly re-scramble it according to this specification. A situation where two or more modules descramble a different service of the TS may be optionally performed by the Host and CICAM.

When a CICAM is plugged in, the Host starts the communication with the CICAM as described in EN 50221 [7]. The CICAM opens the sessions required for its operation. The Host remembers the corresponding slot number for each open session. When more than one CICAM is present during start-up of the Host, the Host may initialize the CICAMs one by one, i.e. it may delay initialization of the next CICAM until the previous one is complete.

At start-up, a CI Plus CAM first performs the verification of the Host's Authentication Key (AKH). If this succeeds, the complete authentication protocol may be skipped. Section 6.3 explains this procedure. When a CICAM tries to open a session to a resource, the Host may be busy for various reasons. A CICAM shall accept a response "resource busy" when it tries to open a session.

Compliant CICAMs shall fully support the CA resource as defined in EN 50221 [7]. When a service is to be descrambled, the Host may send a ca_pmt command with ca_pmt_cmd_id query to all inserted CICAMs. Each CICAM checks if it can descramble the service. For this check, the CICAM refers to private data from the CA system. After receiving the ca_pmt_reply from each CICAM, the Host may select one to descramble by sending a ca_pmt with ca_pmt_command_id set to ok_descrambling to this CICAM. A CICAM that is not selected for descrambling shall pass the TS unaltered.

A CI Plus CAM shall not send a URI transmission unless it has been selected by the Host for descrambling the current service.

CICAMs shall support Host implementations where multiple slots share the same address, data and some control lines. Each CICAM shall check its Card Enable #1 pin (CE1# pin) before acting on any signals on the shared bus.

When a module requests a CC key recalculation while the Host is running a CC key recalculation with another module, the Host may indicate that it is busy.

When a CICAM encounters data in the TS which is not understood, it shall relay the TS unaltered.

5.8.2 Single CICAM with Multiple CA System Support

5.8.2.1 Introduction

This section defines how a single CICAM with multiple CA Systems and multiple smartcard readers shall operate with the CI Plus requirements.

5.8.2.2 CICAM Device Certificates

The CICAM shall have only one Device Certificate; the certificate is not dependent on the number of CA Systems supported by the CICAM.

5.8.2.3 CCK Refresh

The CCK is independent of the CA System; the CA System is responsible for controlling the CCK refresh.

At CICAM start-up the CCK is created as defined in section 8.1.4.

Only one CA System shall be active at any one time, only the active CA System shall control the CCK refresh command. CCK refresh is defined in section 8.1.2.

5.8.2.4 Host revocation

Revocation of the Host shall only be performed by the active CA system.

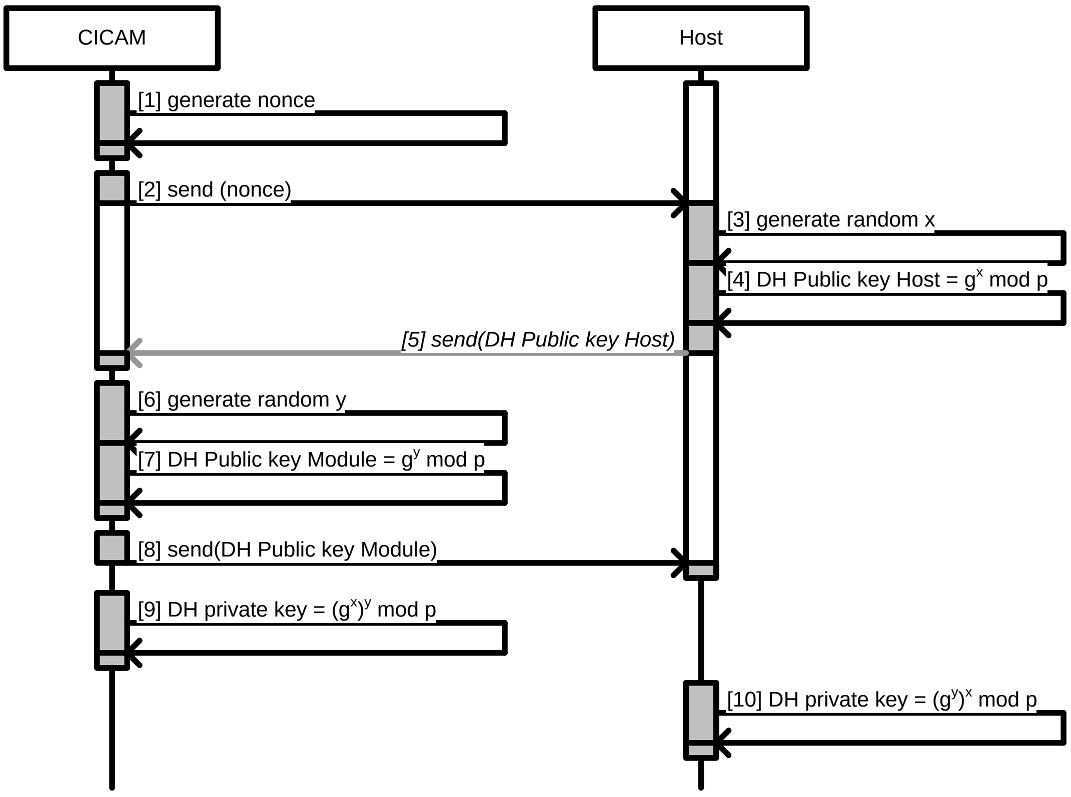
5.9 Authentication Overview

The CI Plus specification requires mutual authentication of both the Host and CICAM. Before the CICAM may start descrambling CA protected content, the Host and CICAM shall pass an authentication procedure, which is based on successfully completing the following:

- CICAM requests and Host provides its certificate chain. CICAM verifies the signature of the Host device certificate that contains HOST_ID and the CICAM verifies the signature of the Host Brand certificate.
- Host requests and CICAM provides its certificate chain. Host verifies the signature of the CICAM device certificate that contains the CICAM_ID and the Host verifies the signature of the CICAM Brand certificate.
- CICAM and Host prove they possess the private key corresponding with the public key embedded in the certificate by signing a DH public key, together with other protocol data, and sending it to the other device for signature validation.
- CICAM and Host prove that they can derive the authentication key.

This process is described in detail in section 6.

The mutual authentication mechanism is based on Diffie-Hellman (DH). Refer to PKCS #3 [31] for a detailed explanation of DH. The CI Plus authentication protocol utilizes a 3 pass protocol, applied to the standard DH algorithm for key agreement. A simplified explanation of the 3 pass DH is given in Figure 5.21.


CICAM
Host
[1] generate nonce
[2] send (nonce)
[3] generate random x
[4] DH Public key Host = g^x mod p
[5] send(DH Public key Host)
[6] generate random y
[7] DH Public key Module = g^y mod p
[8] send(DH Public key Module)
[9] DH private key = (g^x)^y mod p
[10] DH private key = (g^y)^x mod p

NOTE: This diagram does not suggest that any behaviour be specifically (un)synchronized / (un)blocked

Figure 5.21: Diffie-Hellman Three Pass Process (informative)

Note that both sides compute a DH private key. Each side computes the key starting with a different private values (e.g. x and y) and end up with the same secret (DH private) key.

Several measures are taken to protect the DH parameters in transit between the CICAM and Host:

- The CICAM starts the communication by sending a nonce to the Host. This nonce shall be covered by the complete protocol and used in signatures for parameter exchange in the protocol.
- The CICAM and Host shall mutually exchange their stored device and brand certificates which are created by the ROT. The Host shall verify the signature of the opposite certificate.
- The CICAM and Host shall mutually exchange protocol parameters protected with a signature using the public / private key framework from the certificates. The sender shall create a signature on all exchanged protocol parameters using its private key and the Host shall positively verify a signature using the opposite public key received from its certificate.

Refer to section 6 for a detailed description of the exact authentication mechanisms.

5.10 Content License Exchanges

When an item of content to be recorded has a URI with EMI = “1,1”, the CICAM has the option to provide a license at the time of recording. The Host shall associate this license with the item of content for the lifetime of the recording. If a license exists for an item of content, the license shall be checked by the original CICAM when the content is played back to determine if the Host still has entitlement rights to the content. The content license checking requires that the CICAM and Host securely transfer licenses to each other over the Common Interface. On recording, the license supplied by the CICAM contains CAS specific data that is stored by the Host and is associated with the recorded content. On playback of the recorded content then the associated license is transferred back to the original CICAM that created the license without any change. The CICAM evaluates the license and returns a playback status in addition to a new license and playback URI which replaces the existing content license. The Host is required to return the license to the CICAM which originally issued the license; the Host uses the CICAM_ID to identify the CICAM used for recording and for subsequent playback.

The licenses are always exchanged via the SAC using the cc_sac_data_req and cc_sac_data_cnf APDUs, see sections 11.3.1.3 and 11.3.1.4.

5.10.1 Record Start Protocol

The Host shall signal the start of a CA protected service recording to the CICAM with the Record Start protocol using the SAC, see section 11.3.4.4 for protocol details. This exchange informs the CICAM of the current operating mode of the Host and optionally allows the Host to provide the CICAM PIN. The CICAM may cache the CICAM PIN for unattended recording or timeshift. The CICAM PIN shall only be used to enable uninterrupted recording when a future parental control event may occur. The CICAM PIN shall not be used to enforce parental control on playback and live viewing where the user shall be asked to enter the CICAM PIN by means of the MMI.

The Host may initiate a Record Start protocol on a FTA service in anticipation that the service may change to CA protected service later. The CICAM should not expect another Record Start protocol at any future transition between FTA and CA protected.

5.10.2 Content License Exchange on Record

If a license is required to be associated with an item of content, then at the start of recording the CICAM sends the Host a license using the SAC. This license exchange process uses the CICAM to Host License Exchange Protocol, see section 11.3.4.1 for more detail. The URI which accompanies the license shall be applied immediately and supersedes any previous URI.

5.10.3 Content License Exchange on Check

The Host may determine the current state of a content license associated with a recording by using the License Check Exchange Protocol, see section 11.3.4.3. The Host shall send the message to the CICAM that originally issued the license. The License Check Exchange Protocol is provided for Host information only and is not used for evaluating playback rights.

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The CICAM responds to the License Check Exchange with status information of the license. The status information provides information on content availability and may be used when displaying a recording library. The status information includes a play_count which is an 8-bit field containing the remaining number of plays that the user is entitled to.

5.10.4 Content License Exchange on Playback

On playback of content which has an associated license then the Host shall send the license to the original content recording CICAM for evaluation. The license is sent to the CICAM securely on the SAC using the Playback License Exchange Protocol, see section 11.3.4.2. The CICAM processes the license to establish whether it still has rights to play the content. A new license and URI are returned to the Host to replace the originals in case the information contained has changed, e.g. play count. The Playback License Exchange Protocol is performed while playing the content to ensure that playback start is not delayed. If the Playback License Exchange response is not OK, or the response takes longer than 10 seconds, then the playback shall be stopped. The URI which accompanies the license in the Playback License Exchange Protocol shall be applied immediatly.

5.10.5 Content License and Timeshifting

The Host is not required to store or exchange the content licenses when buffering content for timeshift, e.g. live-pause (90 minute retention). However, if the Host subsequently changes the buffered content into a recording, it shall associate the received licenses with the item of content for the lifetime of the recording.
Note: This implies that if timeshifting is implemented with the ability to convert the timeshift buffer into a recording then all content licenses received during the timescale of the buffer contents must be retained until the buffer contents are no longer able to be converted into a recording.

5.10.6 Record Stop Protocol

The Host shall signals the end of a recording using the Record Stop Protocol using the SAC, see section 11.3.4.6. For every Record Start Protocol for a given program_number the Host shall execute a corresponding Record Stop Protocol. e.g. on a channel change the Host shall send a Record Stop Protocol for the current service, initiate a tune to the new location and then send Record Start Protocol for the new service.

5.11 Parental Control

For Free-To-Air services age rating for content may be signalled with the DVB parental rating descriptor. The Host may optionally offer a mechanism for:

- Setting a maximum age rating of content above which a PIN is required to be entered before viewing.
- For entering the PIN that will authorise the exception to this limit. For the purposes of this document this PIN will be referred to as the Host PIN.

For CA protected services the age rating may be delivered via the CA system or in the broadcast stream using the DVB parental_rating descriptor. On CA protected services the derivation of parental control is out of scope of this specification and is determined by the CAS and/or CICAM. The CICAM may offer a menu item to set the PIN that authorises an exception. For the purposes of this document this will be referred to as the CICAM PIN. The exact method used for the delivery of the age rating in this case is out of scope of this specification.

CI Plus version 1.3 adds features to the Content Control resource to enable these two potential parental control systems to be handled as one for the convenience of the user. The parental control for CA protected services is handled as normal depending on the CICAM PIN capabilities. The CICAM informs the Host of the minimum age rating where it starts to handle PIN code management; this allows the Host to exert parental control when the Host rating is set to a lower level than the CICAM rating. For FTA services, when the Host determines that the current content has an age rating that exceeds the user age threshold, then the Host may pass PIN entry control to the CICAM with a cc_PIN_MMI_req() message containing the Host FTA PIN code (depending on the reported CICAM PIN capabilities). The CICAM then creates an MMI prompting the user to enter the PIN. The CICAM compares the PIN entered with the CICAM PIN and the Host PIN passed in the message and if the user entered PIN matches with either then the content is allowed to be viewed.

During normal viewing the user may be asked to enter a PIN code to continue viewing a service or event. This may occur on service selection or at the start of a new event. In the normal course of events the viewer will enter the correct PIN and continue to watch the service or event. The video and audio shall be unavailable until the correct PIN is entered.

During recording or timeshifting of CA protected content the aforementioned behaviour would cause unacceptable blank periods where the content is not being descrambled for the recording and therefore could not be viewed during playback. CI Plus version 1.3 specifies a record start protocol whereby the Host passes the PIN to the CICAM which shall be cached by the CICAM (depending on the CICAM PIN capabilities) in case it is required during the recording. To ensure that this mechanism is not misused the CICAM shall clear any stored cached PIN codes at the end of the recording.

Within the scope of this specification the Host and CICAM PINs are assumed to be numerical digits 0-9 and shall be no longer than 8 digits.

Within the context of parental control the term AV includes all associated elementary stream components that may be presented to the viewer. e.g. “AV blanking” means the Host shall disable the presentation of audio, video, subtitles, etc.

The Host must abide by the parental control rules defined in the CI Plus Device Interim License Agreement [6].

5.11.1 CICAM PIN Capabilities

The Content Control resource PIN provides features that allow for different levels of PIN management by the CICAM. The CICAM reports its capabilities in response to a capabilities request from the Host. The CICAM may offer no PIN code management at all or may report the capability to handle PIN code management for CAS controlled content, the capability to handle PIN code management for both CAS controlled and Free-To-Air content.

The cc_PIN capabilities APDUs, see section 11.3.2.1, enables the Host to determine how any PIN code parental controls for programme events and services are to be managed. The resource shall be interpreted and implemented by all Host devices.

The PIN capabilities are sent to the Host using cc_PIN_capabilities_reply() APDU. This APDU is sent in response to a cc_PIN_capabilities_req() from the Host. The cc_PIN_capabilities_reply() APDU is also sent to the Host whenever the PIN capabilities change including when the effective age rating at which the CAM starts managing the PIN code is changed in the CICAM.

The PIN capabilities APDU contains information allowing the CICAM to inform the Host as to how any PIN is being handled ensuring that the Host does not interfere with the operation. The APDU contains a time and date of the last PIN change which enables the Host to determine if any outstanding scheduled recordings require a new PIN code.

The CICAM PIN capability is defined in the following sections.

5.11.1.1 No CICAM PIN Capabilities

The CICAM does not perform any parental rating on any services (FTA and CAS). The Host may optionally provide a mechanism to do parental rating at the discretion of any user parental rating setting. The Host provides a native user interface for PIN entry.

5.11.1.2 CICAM PIN Capabilities for CA Services Only

The CICAM does not perform any rating management on FTA services. The CICAM performs the CAS PIN code management for services that the CICAM is capable of descrambling (e.g. matching CA_system_ID). The CICAM shall use a high level or application MMI message to get the PIN from the user. The Host shall ignore any PIN code management from a CICAM which is not capable of descrambling the content. The Host may optionally do parental rating on FTA services at the discretion of the user setting a parental rating and CA services if the parental rating set in the Host is lower than the rating provided in the CICAM PIN capabilities, in which case the Host provides a native user interface for PIN entry.

5.11.1.3 CICAM PIN Capabilities for CA and FTA Services

The Host may request the CICAM to display a MMI screen for FTA services and CA services where the parental rating set in the Host is lower than the rating provided in the CICAM capabilities. The Host does not need to provide a native user interface for PIN entry and may use the CICAM to perform PIN entry. The CICAM shall not indiscriminately show a PIN MMI unless explicitly requested by the Host on FTA services. The CICAM confirms the PIN entered is correct with the CICAM PIN or the Host PIN sent in the cc_PIN_MMI_req() before returning the status in the cc_PIN_reply(). The CICAM performs the CAS PIN management and shall use a high level or application MMI message to get the PIN from the user.

5.11.1.4 CICAM PIN Capabilities for CA Services Only (cached PIN)

The CICAM does not perform any rating management on FTA services. The CICAM performs the CAS PIN code management and shall use the High-Level or Application MMI to get the PIN from the user. The Host may optionally perform parental rating, at the discretion of the user setting a parental rating, on both FTA services and CA services when the parental rating set in the Host is lower than the rating provided in the CICAM PIN capabilities, in which case the Host provides a native display for PIN entry.

The Host may use the Record Start Message to provide the CICAM with the CICAM PIN. In this case the CICAM shall use the cached PIN code for enabling uninterrupted recording. The viewing PIN provided by the user via the MMI shall be used for control of the live viewing of the content and shall not interrupt any ongoing recording.

Moving to a timeshift or watch and buffer mode, if the cached PIN was entered incorrectly (via the record start) then the viewing PIN shall replace the cached PIN.

5.11.1.5 CICAM PIN Capabilities for CA and FTA Services (cached PIN)

The Host may request the CICAM to display a MMI screen for FTA services and CA services where the parental rating set in the Host is lower than the rating provided in the CICAM capabilities. The Host does not need to provide a native interface for PIN entry and uses the CICAM MMI. The CICAM shall not indiscriminately show a PIN MMI unless explicitly requested by the Host on FTA services. The CICAM confirms the PIN entered is correct after comparison with the CICAM PIN and/or the Host PIN sent in the cc_PIN_MMI_req() before returning the status in the cc_PIN_reply(). The CICAM performs the CAS PIN management and shall use the High-Level or Application MMI message to get the PIN from the user.

The Host may use the Record Start Message to provide the CICAM with the CICAM PIN. In this case the CICAM shall use the cached PIN code for enabling uninterrupted recording. The viewing PIN provided by the user via the MMI shall be used for control of the live viewing of the content and shall not interrupt any ongoing recording.

Moving to a timeshift or watch and buffer mode, if the cached PIN was entered incorrectly (via the record start) then the viewing PIN shall replace the cached PIN.

5.11.2 CICAM PIN code

The CICAM may offer the management of a PIN code and age rating value to provide parental controlled access to content. The CAS may obtain the requirement for a PIN directly from the CAS system (e.g. ECM) or by using SI information in the broadcast stream such as the DVB parental_rating_descriptor.

In an unattended recording mode the entry of a PIN code may be required and the cc_PIN_cmd() is used to pass the PIN code to the CICAM at the point the user booked a recording event to confirm the PIN is correct. The cc_PIN_cmd() is used for unattended recording or timeshift. The CICAM shall acknowledge the PIN code using a cc_PIN_reply().

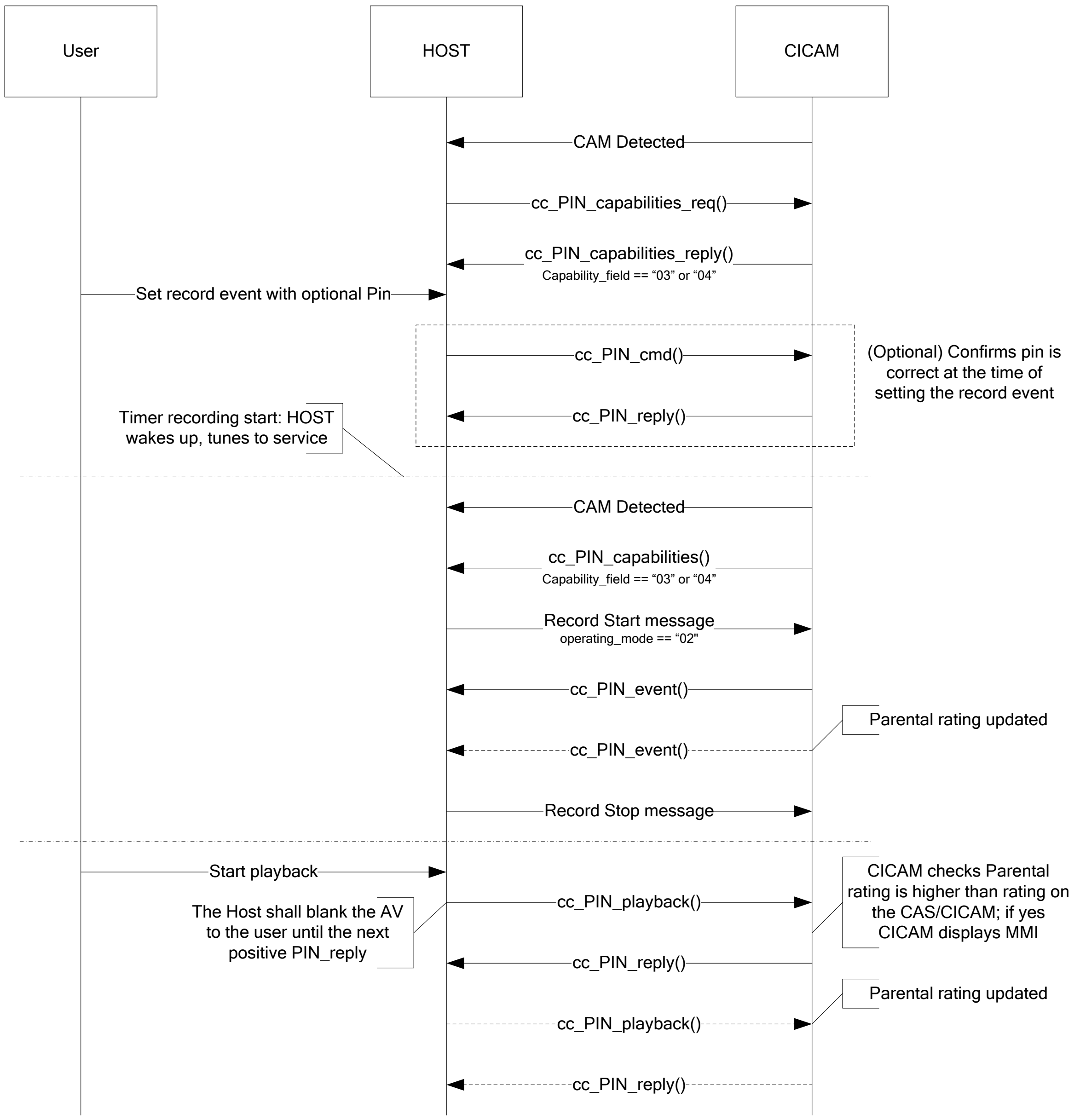

User
HOST
CICAM
CAM Detected
cc_PIN_capabilities_req()
cc_PIN_capabilities_reply()
Capability_field == "03" or "04"
Set record event with optional Pin
cc_PIN_cmd()
(Optional) Confirms pin is correct at the time of setting the record event
cc_PIN_reply()
Timer recording start: HOST wakes up, tunes to service
CAM Detected
cc_PIN_capabilities()
Capability_field == "03" or "04"
Record Start message
operating_mode == "02"
cc_PIN_event()
Parental rating updated
cc_PIN_event()
Record Stop message
Start playback
CICAM checks Parental rating is higher than rating on the CAS/CICAM; if yes CICAM displays MMI
The Host shall blank the AV to the user until the next positive PIN_reply
cc_PIN_playback()
cc_PIN_reply()
Parental rating updated
cc_PIN_playback()
cc_PIN_reply()

Figure 5.22: Unattended Record Sequence Diagram (Informative)

To start a recording a PIN code may be required to start the CICAM descrambling, in this case the Record Start SAC message may be used to pass the PIN code to the CICAM with no user interaction. The CICAM shall provide the PIN to the CAS if the PIN is required to descramble the recorded program and acknowledge the PIN code using the cc_PIN_event() containing the parental control rating for users during playback. If the parental rating for the program changes the Host is not required to resend the PIN and the CICAM provides the PIN to the CAS and sends an updated cc_PIN_event() to the Host.

When the Host stops an unattended recording the Host sends a Record Stop message, the CICAM stops using the cached PIN for descrambling the content.

During playback, Figure 5.22 shows that the CICAM receives a cc_PIN_playback() APDU when the Host encounters a ‘pin_event’ in the recording. Depending on the Operator requirements or local legislation, the CICAM determines if parental control should be enforced. In the case that the CICAM decides parental control does not have to be enforced the CICAM sends a cc_PIN_reply() APDU with a status of “PIN code correct” or “Video Blanking Not Required”. The Host blanks the AV for the period between the ‘pin_event’ in the recording and receiving a cc_PIN_reply() APDU with a status of “PIN code correct” or “Video Blanking Not Required”, this may cause a flicker. The flicker may be prevented by scheduling the cc_PIN_playback() APDU one or more seconds early thereby allowing the CICAM sufficient time to send the cc_PIN_reply() APDU before the actual ‘pin_event’ is encountered in the recording. If the ‘pin_event’ in the recording is encountered before the cc_PIN_reply() APDU is received by the Host then the Host shall blank the AV until the cc_PIN_reply() APDU is received with “PIN code correct” or “Video Blanking Not Required”.

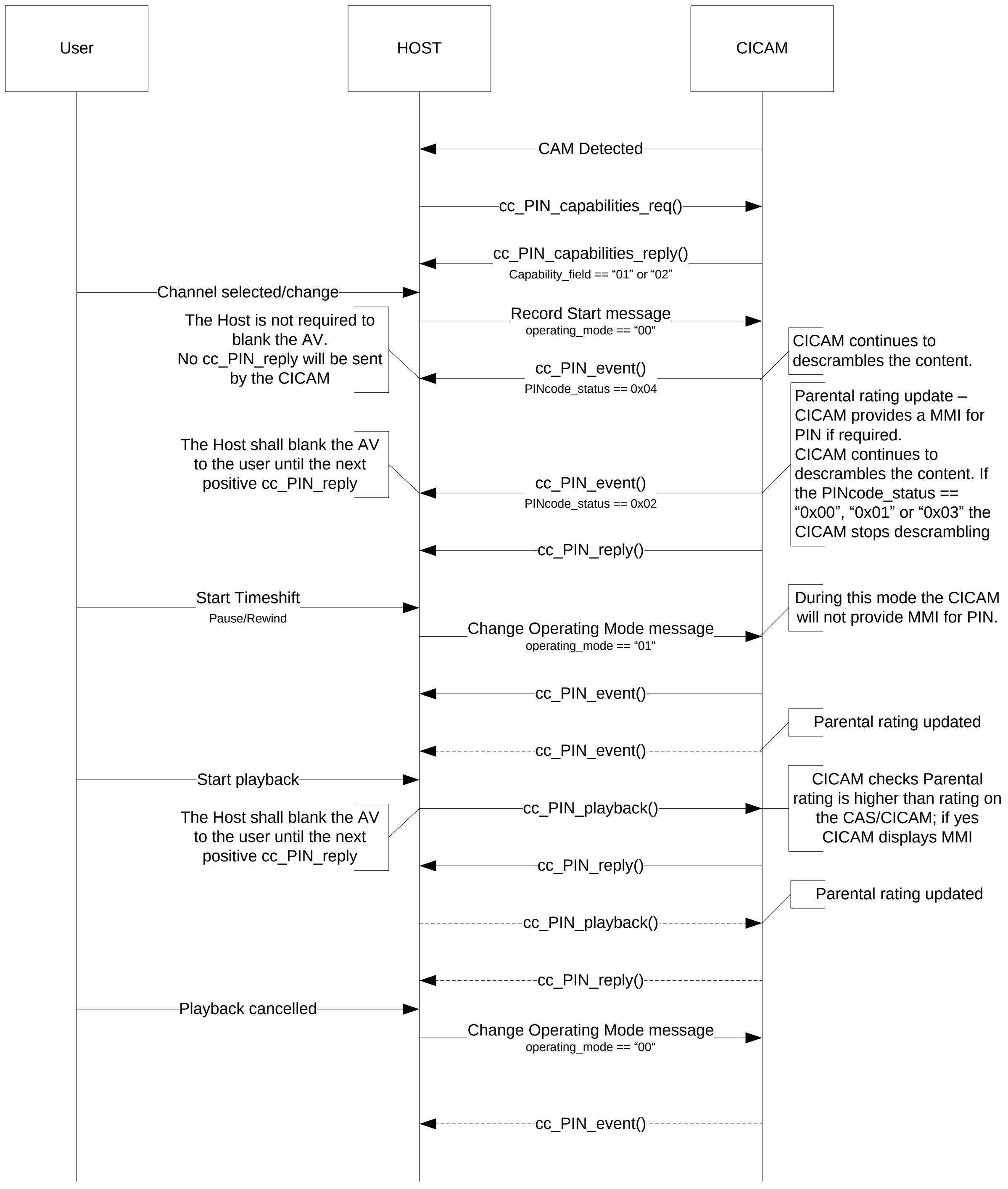

User
HOST
CICAM
CAM Detected
cc_PIN_capabilities_req()
cc_PIN_capabilities_reply()
Capability_field == “01” or “02”
Channel selected/change
Record Start message
operating_mode == “00”
The Host is not required to blank the AV. No cc_PIN_reply will be sent by the CICAM
CICAM continues to descrambles the content.
cc_PIN_event()
PINcode_status == 0x04
Parental rating update – CICAM provides a MMI for PIN if required. CICAM continues to descrambles the content. If the PINcode_status == “0x00”, “0x01” or “0x03” the CICAM stops descrambling
The Host shall blank the AV to the user until the next positive cc_PIN_reply
cc_PIN_event()
PINcode_status == 0x02
cc_PIN_reply()
Start Timeshift
Pause/Rewind
During this mode the CICAM will not provide MMI for PIN.
Change Operating Mode message
operating_mode == “01”
cc_PIN_event()
Parental rating updated
cc_PIN_event()
Start playback
CICAM checks Parental rating is higher than rating on the CAS/CICAM; if yes CICAM displays MMI
The Host shall blank the AV to the user until the next positive cc_PIN_reply
cc_PIN_playback()
cc_PIN_reply()
Parental rating updated
cc_PIN_playback()
cc_PIN_reply()
Playback cancelled
Change Operating Mode message
operating_mode == “00”
cc_PIN_event()

Figure 5.23: Timeshift Sequence Diagram (Informative)

At playback the Host shall send the cc_PIN_playback() APDU with the age rating supplied by the CICAM on a cc_PIN_event() when the recording was made to the CICAM which originally sent the cc_PIN_event(). The CAS checks the rating and requests a high level or application MMI to obtain the PIN information, if required, before returning a cc_PIN_reply() to the Host. The CICAM responds to the Host with the cc_PIN_reply() to confirm if the Host may continue playback of the recording.

Figure 5.23 shows that during the viewing of live broadcasted content the Host receives a cc_PIN_event() APDU after which it blanks the AV. It is not necessary for the Host to pro-actively blank the AV when the

PINcode status field in the cc_PIN_event() APDU is equal to '0x04' (Video blanking not required). The 'PIN event' must be stored with the associated content for the possible enforcement of parental control during playback.

If the Host stops recording it shall send a Record Stop message. The CICAM shall stop using the cached PIN to descramble the content. If the previously entered viewing PIN was correct this shall be used to allow the viewer to watch the content with no interruption. If the previously entered viewing PIN was incorrect then the CICAM shall enforce the appropriate parental control.

5.11.3 Host PIN code

The Host PIN code is a private PIN code normally managed by the Host and end-user only. The Content Control resource allows the CICAM PIN code to be used by the Host to present age rated Free-To-Air content. Host PIN code management is a optional feature that may or may not be implemented by a Host manufacturer.

On a Free-To-Air service, if the Host determines that the parental control rating of the service is higher than the rating set by the user then the Host sends the cc_PIN_MMI_req() with the Host PIN to the CICAM to use a high level or application MMI message to get the PIN from the user. The CICAM confirms the PIN entered matches the CICAM PIN or the PIN sent in the cc_PIN_MMI_req() before returning the cc_PIN_reply(). Figure 5.24 is provided for informative purposes:

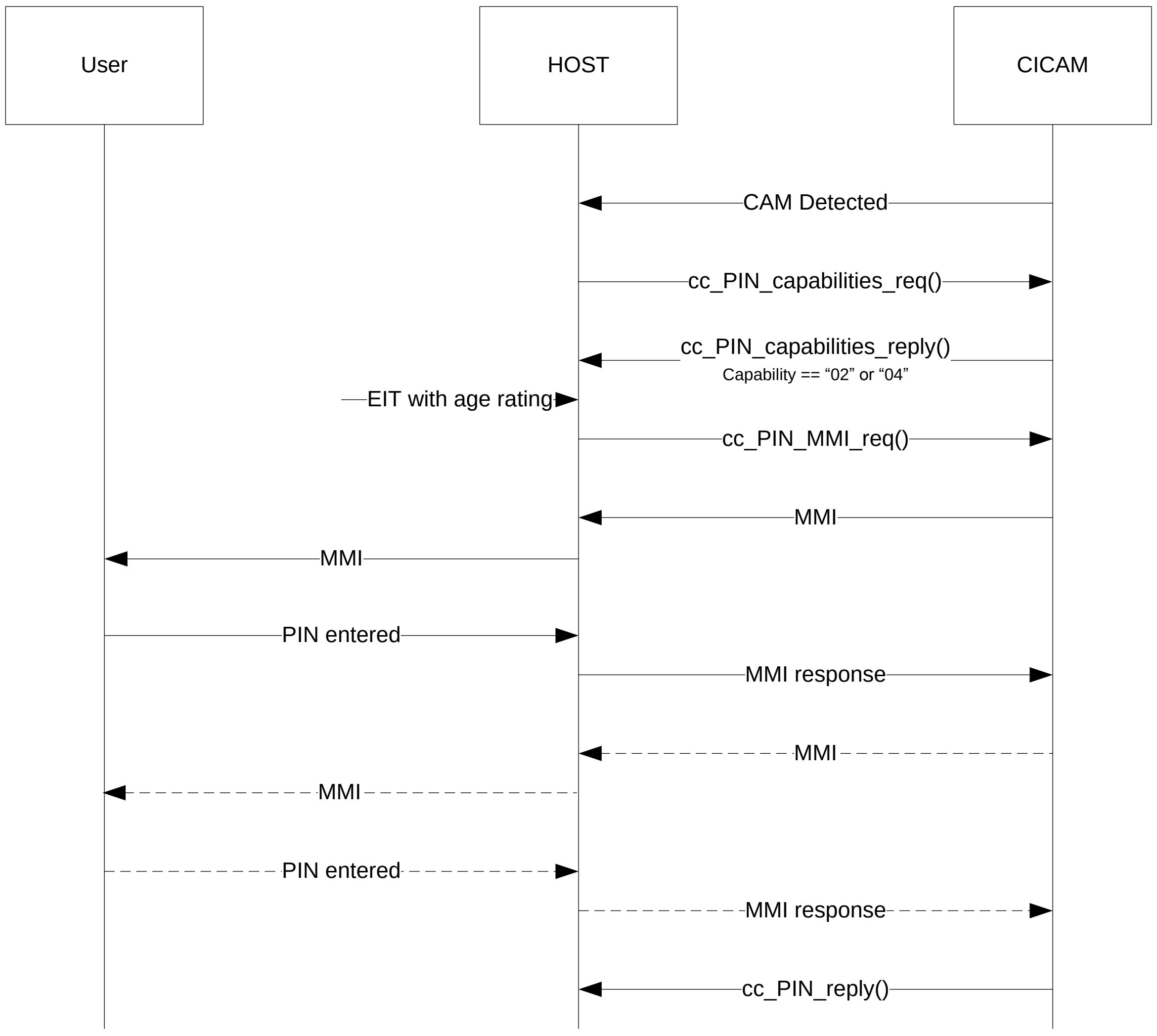


Figure 5.24: Free to Air PIN (Informative)

5.11.4 Notification that a PIN is required

The cc_PIN_event() APDU is sent by the CICAM to notify the Host that a PIN is required to descramble the recorded program and to provide the parental rating for use during playback and the time at which it has changed. If the parental rating of the program changes the Host is not required to resend the PIN and the CICAM provides the PIN to the CAS and sends an updated cc_PIN_event().

The CICAM shall send the cc_PIN_event() APDU to the Host whenever the parental rating changes, this includes the transition from when a PIN is required to when a PIN is no longer required. i.e. parental rating has been removed. The CICAM shall send a rating of 0x00 (parental rating undefined) to inform the Host that the PIN is no longer required.

CICAMs with a CA_system_ID that does not match that of the program to be recorded shall not send cc_PIN_event(). Hosts shall ignore cc_PIN_events() from any CICAM where the CA_system_ID does not match the currently selected service. The CICAM shall not send a cc_PIN_event() APDU when the Host is not recording i.e. the Host has not completed the Record Start Protocol.

CICAMs with a CA_system_ID that matches that of the program to be recorded but are not able to descramble the program to record (e.g. No Rights available) shall send a cc_PIN_event() with the status "Error - Content still CA scrambled".

CICAMs with a CA_system_ID that matches that of the program to be recorded but are not able to descramble due to incorrect PIN entry shall send a cc_PIN_event() with the status "Error - Bad PIN code".

5.11.5 Transfer of Parental Rating to CICAM

In recorded content the point at which parental rating changes, e.g. at event boundaries, is indicated by the cc_PIN_event() which is stored with the content, see section 11.3.2.4. During playback when the parental rating of the content changes the Host sends a cc_PIN_playback() to the CICAM, see section 11.3.2.5.

The Host is required to return the cc_PIN_playback() to the CICAM which originally descrambled the content; the Host uses the CICAM_ID to identify the CICAM used for descrambling and subsequent playback. When playback is attempted and the CICAM is not present or not responding then the Host shall continue to blank the parental controlled content until such time that the original CICAM is again present in the Host and is able to process the PIN playback request.

5.11.6 PIN Code Caching

The Host may provide the capability to store a PIN to be used as part of a record start message so that the CICAM is able to continue descrambling the content on encountering parental rating control. The Host shall only use this cached PIN for recording or confirming the cached PIN for a future record event.

The Host shall not reveal the cached PIN to the user in any form e.g. via the native UI or menu.

5.12 Recording and Playback

This section discusses the recording storage and subsequent playback requirements of a Host that records CI Plus protected content using the Content Control resource. The Host is always required to honour the URI settings, Parental Control (PIN) notifications and Content License.

The URI, License and PIN changes shall be accurately stored with the programme content such that each transition may be accurately reproduced by the Host on subsequent playback matching the events with the original delivery content position. The PIN notification contains a time stamp and may be accurately aligned with the stream. The URI and License do not contain a time stamp and shall be aligned with the content based on their reception time at the Host.

The Host shall not aggregate Licenses or PINs. The Content Control protection of Licenses, URIs and PINs shall apply from the position in the stream where the protection was applied in the recording until the next protection position in the recording or the end of the stream. The scope of each content protection component is defined as follows:

- A URI extends from the reported position to the next URI reported position, or to the end of the recording, in a forwards direction.
- A License extends from the reported position to the next URI or License reported position, or to the end of the recording, in a forwards direction.
- A PIN extends from the reported position to the next PIN reported position, or to the end of the recording, in a forwards direction.

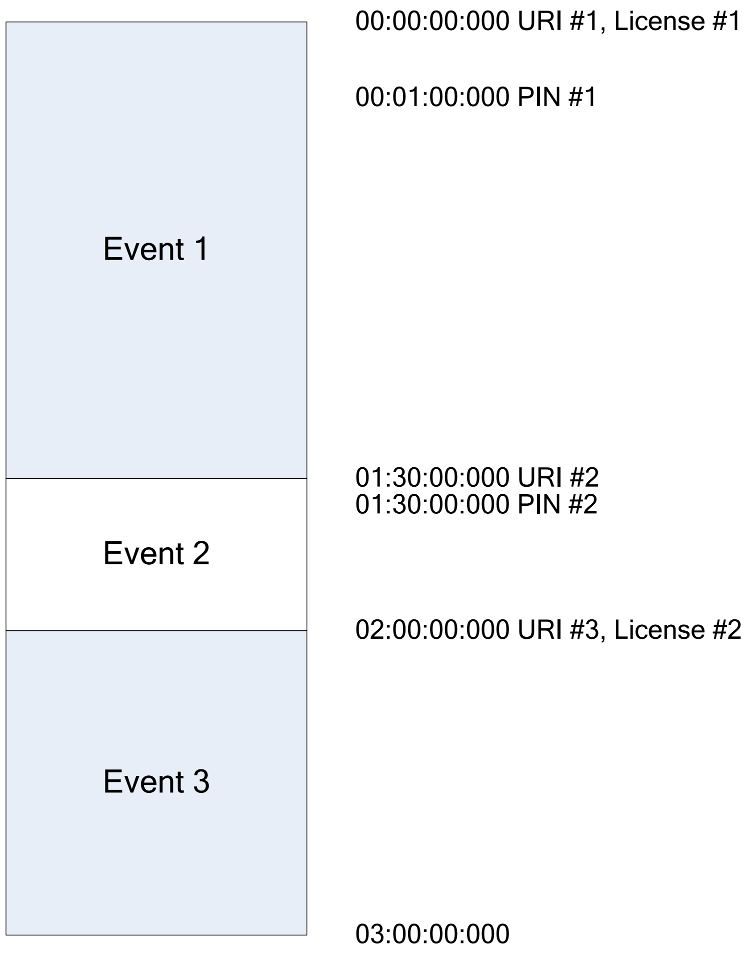


Figure 5.25: Example recording sequence

Any of the aforementioned transitions may occur at any time in the recording as shown in Figure 5.25 which depicts a time, rather than event based, recording.

The content in Figure 5.25 is protected as follows, where URI#n is a change in the URI, License#n is the content license and PIN#n is a parental control event where the parental rating has changed. For the purposes of the example then we assume that the recording spans three events, typically we would expect a single event to be recorded.

Event#1: is content that is license protected with License#1 and URI#1 there is a parental control PIN#1 one minute into the recording.

Event#2: is content that is not licence protected and has URI#2, there is a parental control PIN#2 in effect.

Event#3: is content that is licence protected with License#2 and URI#3 and there is a parental control PIN#2 in effect.

It should be noted that License#1 and License#2 may be the same or a different license. Whilst in a recording mode then the URI and License are dispatched together in a single message. The Host does not interpret the license and simply returns it on a playback operation at the appropriate time in the stream when a new license block is entered.

5.12.1 Playback Session

On playback of a recording the Host shall effectively include the concept of a session. On playing a recording then the session shall be opened, the session is not closed until the playback is stopped, a pause does not constitute a session close. A session may be closed by the Host as a result of the content retention time limit being exceeded, at which point the content protected by the retention time limit is made inaccessible.

Licenses are consumed, typically as encountered, during the playback. Consumption of a License requires a license exchange with the CICAM and the License and URI associated with the recording are exchanged with a new License and URI to be associated with the recording replacing each of the existing stored values. A license is only consumed once in the context of a playback session, irrespective of the user navigation moving between different license blocks that have already been consumed in the current session.

A parental rating (PIN) transition in the recording requires the Host to remove all displayable components of the recording (i.e. blank video, mute audio, disable subtitles, etc.) until a PIN valid is acquired from the CICAM, via the user, when the content may be restored. A PIN exchange must be performed with the CICAM when crossing any PIN event in the recording in either a forward or backward direction if the content is to be displayed. The CICAM (Service Operator) may reduce user interaction within the context of a playback once a valid PIN has been entered and any further PIN requests from the Host should ideally not invoke a user interaction provided that the parental rating of the first PIN entry is not exceeded, the exact operation of the CICAM is determined by the Service Operator and country regulations.

Navigation in a forwards and backwards direction in the recording requires the Host to honour all the License, URI and PIN constraints at each transition point in the recording. When moving in a backwards direction then the Host is required to re-evaluate the constraints when crossing a constraint event in the recording, this requires the Host to find the previous transition type and appropriately apply the constraint. Within the context of a playback session, on encountering a:

PIN Constraint: a PIN exchange shall be performed with the CICAM

License Constraint: each license is exchanged with the CICAM only once in a playback session, at first encounter. On any subsequent encounter of a successfully exchanged license, there is no requirement to exchange that license with the CICAM again.

URI Constraint: the URI shall be applied as described in section 5.7.

The URI returned from a CICAM license exchange may change the existing recorded License and URI and shall be associated with the content at the same position as the original, displacing the existing License and URI. The new URI shall be used immediately for playback. The new URI may alter the retention time limit which shall be applied in a similar way to the recording process, taking into consideration the length of the material when viewed with a normal playback time. e.g. Consider a 2 hour (120 minute) programme that changes its retention limit from 30 days to 90 minutes. At the instant the URI is changed then the first byte of the recorded material at the URI transition has a new retention time limit of 90 minutes, the last byte of the 120 minute recorded event has a retention time limit of 120+90 or 210 minutes. A URI that exists without a License is not re-presented to the CICAM on playback and is not replaced in the recording.

Where a recording has multiple URIs with different retention limit values then the Host is required to manage the retention limits of each URI region according to the CI Plus License Agreement [6]. The Host may choose to handle each URI region retention limit separately or apply the most restrictive retention limit to the whole of the material. In either case the Host shall not exceed the stated retention limit for any URI region. The exact method by which the Host manages different retention times within a single recording is implementation specific, but in all cases must be managed according to the CI Plus License Agreement.

A Host is not obliged to remove recording content from storage which has exceeded its play count. If the Service Operator requires the content to be removed once it has been viewed on playback, when a transition from a play count of one to zero occurs, then the retention limit should be set appropriately through the playback URI to force the Host to remove the content once the retention time limit has been exceeded.

5.13 SRM Delivery

The CICAM may receive System Renewability Messages (SRM) data files, as specified in [34]. SRM data files perform the function of blacklist for HDCP [34]. These SRM data files are to be applied to the HDCP function of a Host, subject to the Host deploying a HDCP output in source or repeater mode.

The implementation of a HDCP function in a CI Plus Host shall be in compliance with the CI Plus Licensee Specification [33]. A CI Plus Host requiring SRM files shall accept these files if the CICAM initiates the transfer of those SRM files.

5.13.1 Data file transfer protocol

This section describes the mandatory protocol to transfer SRM data files from CICAM to Host. The responsibility of CI Plus is to transfer the SRM data files safely. The correct application of SRM files is part of the HDCP function and out of scope of the CI Plus specification.

5.13.1.1 Initialisation and message overview

The process is explained in figure 5.26:

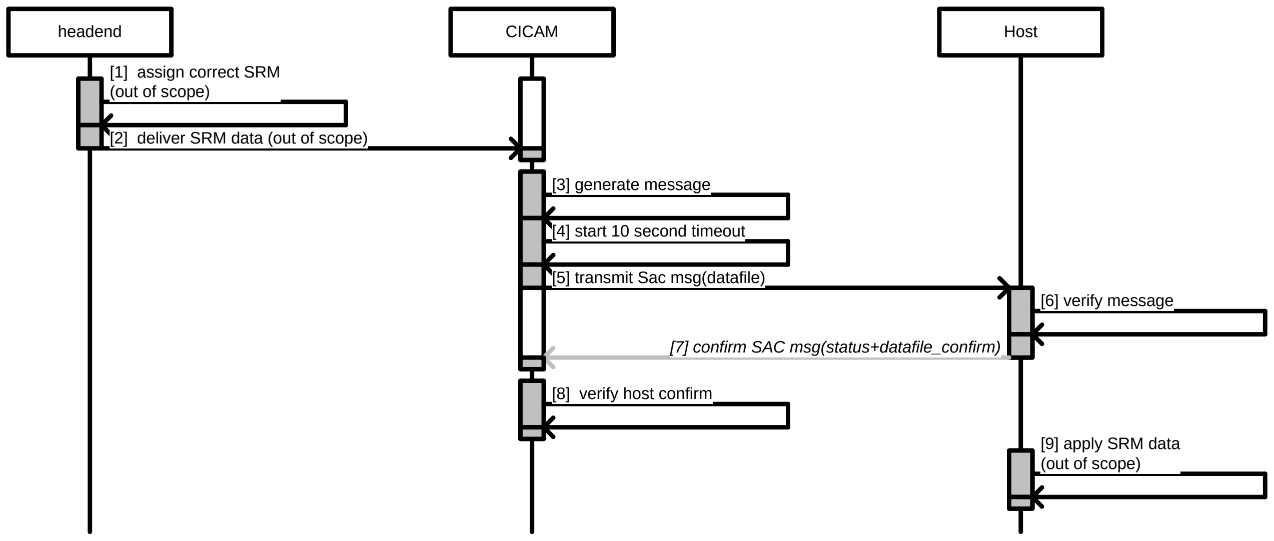

headend
CICAM
Host
[1] assign correct SRM (out of scope)
[2] deliver SRM data (out of scope)
[3] generate message
[4] start 10 second timeout
[5] transmit Sac msg(datafile)
[6] verify message
[7] confirm SAC msg(status+datafile_confirm)
[8] verify host confirm
[9] apply SRM data (out of scope)

Figure 5.26: Delivery of SRM data files

Table 5.21: SRM Data file Transfer Protocol Behaviour (normative)

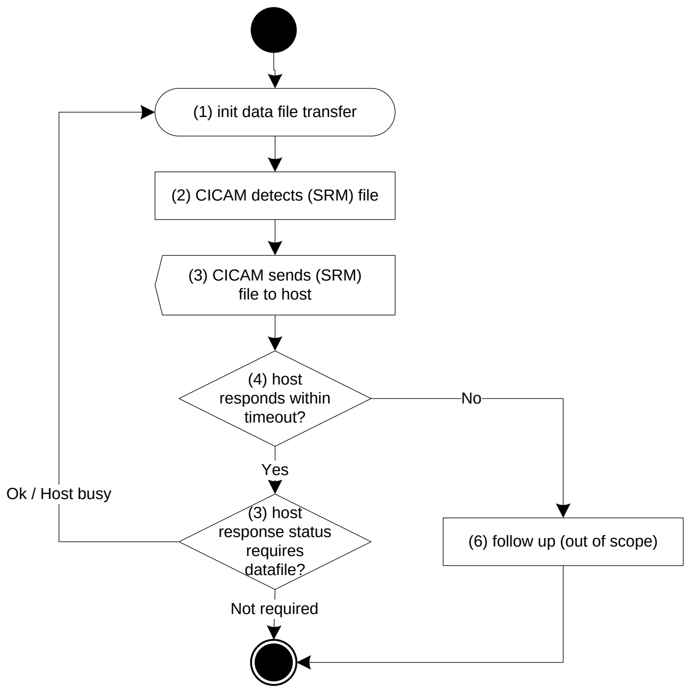
No.	Description	Refer to
1	**Assign correct SRM (out of scope).** The correct SRM is assigned to the CICAM Host combination. The exact process is out of scope.	
2	**Delivery of SRM (out of scope).** The delivery of the SRM is typically protected by the CA system or delivered to the CICAM by other means (for example: preloading). The exact delivery process is out of scope.	
3	**CICAM generates message.** The CICAM calculates datafile_confirm to authenticate Host acknowledgment of receipt (Note 3), as: $$datafile\_confirm = SHA_{256}(datafile \parallel UCK)$$ where: • datafile is the SRM file. • UCK = SHA_{256} (SAK). The value datafile_confirm is locally kept for comparison in step 8. The CICAM shall generate a cc_sac_data_req APDU for the (SRM) data file message, carrying: • the SRM data file (datatype_id = srm_data).	Section 11.3.5
4	**CICAM starts 10 second timeout.** The CICAM starts a 10 second timeout in which the SRM data transfer protocol has to complete. (Note 1)	
5	**CICAM transmit SAC message with SRM datafile payload.** The CICAM transmits a SAC message with payload from step 3 and transmits this to the Host. (Note 2).	Section 7.3 and 11.3.1
6	**Host verifies message.** After the Host verifies the SAC message is correct, the Host extracts the SRM data file. The Host may pass the SRM data file to the consuming function, which is out of scope (in this case HDCP).	Section 7.4
7	**Host transmits SAC message with SRM data file confirmation.** The Host calculates the datafile_confirm in exactly the same way as the CICAM did in step 3. The Host confirms SRM data file delivery with the cc_sac_data_cnf APDU, carrying • datafile_confirm (datatype_id = datatransfer_confirm) • status and uses the SAC to transmit this to the CICAM. (Note 2) Failure to respond constitutes a failure of the data file transfer (Note 1).	Section 7.3, 11.3.1 and 11.3.5

8	**Verify Host confirm.** The CICAM compares the received datafile_confirm from the Host with the value calculated in step 3 above. Failed equivalence constitutes a failure of the data file transfer and may be followed up by the CICAM. (Note 1)	
9	**Apply SRM data (out of scope).** The application of the SRM data file is out of scope.	
Notes: 1. If the steps above are not completed before the 10 second timeout expires the CICAM shall consider that the data file transfer failed. Any subsequent actions from the CICAM are out of scope. 2. Refer to section 7.2 for an explanation how the SRM data is packed into SAC message. 3. Input is padded according to SHA-256. Refer to FIPS 180-3 [3]. It is advised that SHA implementations adhere to the SHS validation list. See SHS Validation List [11].		

5.13.2 Data transfer conditions

The CICAM starts initiating a data file transfer the first time it detects a SRM data file. In case the Host is not requiring this file, it may notify this in the confirmation message, and the CICAM shall refrain from sending subsequent SRM data files. In any case the Host shall follow up with a confirmation to detect message deletion. When the Host indicated that it received the SRM data file, the CICAM shall refrain from sending identical files multiple times.

Figure 5.27 explains the CICAM operation for data file transfer.


(1) init data file transfer
(2) CICAM detects (SRM) file
(3) CICAM sends (SRM) file to host
(4) host responds within timeout?
No
Yes
Ok / Host busy
(3) host response status requires datafile?
(6) follow up (out of scope)
Not required

Note: timeout is defined as 10 seconds.

Figure 5.27: CICAM sided overview of data files delivery conditions (informative)

6 Authentication Mechanisms

6.1 CICAM Binding and Registration

CICAM binding and registration is performed in three steps:

Verification of Certificates & DH Key Exchange.

Verification of Authentication Key.

Optional Report Back to Service Operator (Registered Service Mode only).

These steps are described in the following sections.

6.1.1 Verification of Certificates & DH Key Exchange

The Host and CICAM start the authentication protocol by exchanging the Host certificate chain, CICAM certificate chain, signed data and Diffie-Hellman public keys. Before authentication is complete the CICAM is authorized only for programmes with EMI data set to a value of 00 (copying allowed).

The CICAM verifies the signatures contained in the Host certificate chain and the signature on the Diffie-Hellman public key. This is a mutual authentication protocol and the Host shall verify the signatures contained in the CICAM certificate chain along with the signature on the Diffie-Hellman public key. The DHPH is protected by the Host with a signature that involves the Host's HDQ. The CICAM side verifies the received DHPH with the HDP of the Host, which it obtains from the Host device certificate. The DHPM is protected in an identical way, using the MDQ for signing and the MDP for verification.

If the Host certificate chain verifies together with the signature on the Diffie-Hellman public key, the HOST_ID shall be extracted from the Host device certificate. Similarly, if the CICAM certificate chain verifies together with the signature on the Diffie-Hellman public key, the CICAM_ID shall be extracted from the CICAM device certificate.

If the certificate or signature verification fails the CICAM shall not remove the network CA (i.e. shall not decrypt the network CA from the incoming TS) even if the subscriber would otherwise be authorized to receive the service. The CICAM attempts to display an error message using the MMI resource on the Host, see section 5.4.3 for details about the error messages and EN 50221 [7], section 8.6 for an explanation of the MMI resource. If the Host is temporarily unable to service the request for an MMI dialogue, the CICAM keeps retrying until the Host is free.

6.1.2 Verification of Authentication Key

The CICAM and Host derive a long-term Authentication Key from data exchanged between the CICAM and Host during the first phase of the authentication procedure. The authentication key is computed from the DH private key together with unique data from this particular binding, the HOST_ID and CICAM_ID (refer to section 6.2.3.4 for details).

The CICAM sends a request message to the Host to request the Authentication Key derived by the Host. The Host follows this with a confirm message which includes the requested authentication key. After reception the CICAM compares the received authentication key with the one it previously stored. If the CICAM comparison is successful the Host has proved that it derived the same authentication key and the CICAM accepts that Host as legitimate allowing communication. Both sides store the derived authentication key in non-volatile memory so that it is available for computation of key material for the SAC and the CC. Refer to section 7 (SAC) and section 8 (Content Control Key) for details.

If a matching Authentication key has not been received within 5 seconds of the request message, the CICAM shall not remove the network CA (i.e. shall not decrypt the incoming TS), even if the subscriber would otherwise be authorized to receive the service.

6.1.3 Report Back to Service Operator

When the system is deployed in Registered Service Mode the CICAM may initiate an MMI "registration" message, allowing an exchange of information between the CICAM and the service operator. The exact mechanism is not in the scope of this specification.

6.1.4 CC System Operation

Figure 6.1 explains how the 3-step authentication is integrated into the overall CC operation. This is informative and other implementations of network related components are possible. The 3-step authentication process is mandatory.

The CICAM Content Control System (CC) shown in Figure 6.1 comprises the following basic steps:

1) The CC resource shall be provided by the Host and any attempt by modules to provide a CC resource shall be ignored by the Host's resource manager. The Host shall support one session of the CC resource for each CI slot. During the profile inquiry process (see Figure 6.1 and Figure 6.2) the Host shall report that a Content Control resource is available. If the resource is not reported this constitutes a failure of the Content Control system and the system shall continue at step (13).

2) A session to the Content Control resource shall be opened by the CICAM, section 11.3. If a valid session is not successfully opened the Content Control system shall be considered failed. The CICAM shall send a cc_open_req APDU to the Host. The Host shall respond with a cc_open_cnf APDU within 5 seconds (see section 6.2.1).

   Failure to respond to this request within 5 seconds constitutes a failure and the system shall continue at step (14).

   The cc_system_id_bitmask in the Host response shall include CC version 1, see section 11.3.1.2. If the cc_system_id_bitmask does not include CC version 1 the system shall continue at step (13).

3) The CICAM checks if there is an authentication key stored in non-volatile memory. If the CICAM contains a valid authentication key (AKM) it shall request the Host to send its authentication key (AKH). If the CICAM does not have a valid AKM then the CICAM and Host shall continue with step (6).

4) The CICAM requests the Host to send its authentication key (AKH). The Host shall respond with its AKH within 5 seconds. If the AKH is not available, then it shall transmit a value of all zeros. A value of all zeros shall be recognized by the CICAM as an invalid AKH.

5) The CICAM shall compare its stored AKM with the received AKH. If the authentication keys match then a previous authentication has been completed successfully and the certificates are considered valid. The DH Secret Key (DHSK) and authentication keys (AKM/AKH) computed on both sides are then preserved, the key material for the SAC (SAK and SEK) and the Content Control Key (CCK) are independently (re)generated and synchronized on both sides. The system shall then continue with step 10). If the authentication keys do not match then the system is required to authenticate and shall continue with step (6). Note that Host behaviour for multiple modules and multiple slots is defined in section 6.3.

6) The CICAM triggers the start of the DH protocol and certificate exchange. The exact DH based authentication protocol is described in Figure 6.2 step (1).

7) If the DH protocol completed successfully, the system shall continue at step (8). Any failure in the completion of the DH protocol constitutes a failure of the Content Control system and the system shall continue at step (11).

8) The CICAM shall request the Host to confirm its authentication key (AKH) within 5 seconds.

9) The CICAM shall compare its authentication key AKM with the received AKH. If they are not equal, this constitutes a failure of the Content Control system (see section 6.1.1) and the system shall continue at step (11). If they are equal, then the CICAM and Host concludes the Diffie-Hellman operation completed successfully and shall store the derived authentication keys (DHSK and AKM/AKH) into non-volatile memory.

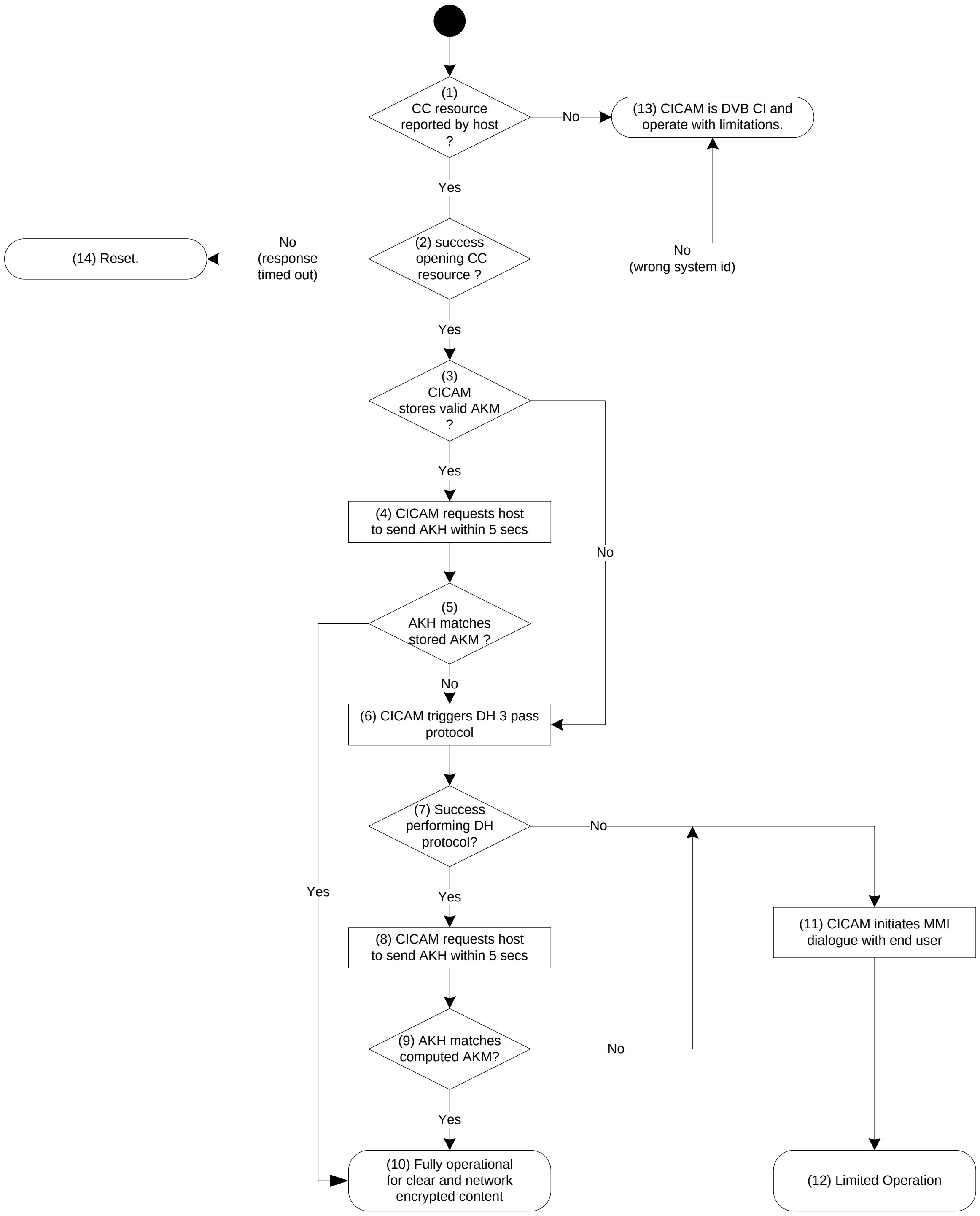

(1) CC resource reported by host ?
No
(13) CICAM is DVB CI and operate with limitations.
Yes
(2) success opening CC resource ?
No (response timed out)
(14) Reset.
No (wrong system id)
Yes
(3) CICAM stores valid AKM ?
Yes
(4) CICAM requests host to send AKH within 5 secs
No
(5) AKH matches stored AKM ?
No
(6) CICAM triggers DH 3 pass protocol
(7) Success performing DH protocol?
No
Yes
Yes
(8) CICAM requests host to send AKH within 5 secs
(11) CICAM initiates MMI dialogue with end user
(9) AKH matches computed AKM?
No
Yes
(10) Fully operational for clear and network encrypted content
(12) Limited Operation

Figure 6.1: Overview of CICAM and Host in the CC Operation (Informative)

10) The system is fully operational to process clear and CA encrypted content provided that the user has the necessary entitlements and after successful computation of the SAC (see section 7) and CC keys (see section 8) the Host will be able to display content.

11) The CICAM initiates a dialogue indicating a failure to authenticate.

12) The system is limited to processing only clear content.

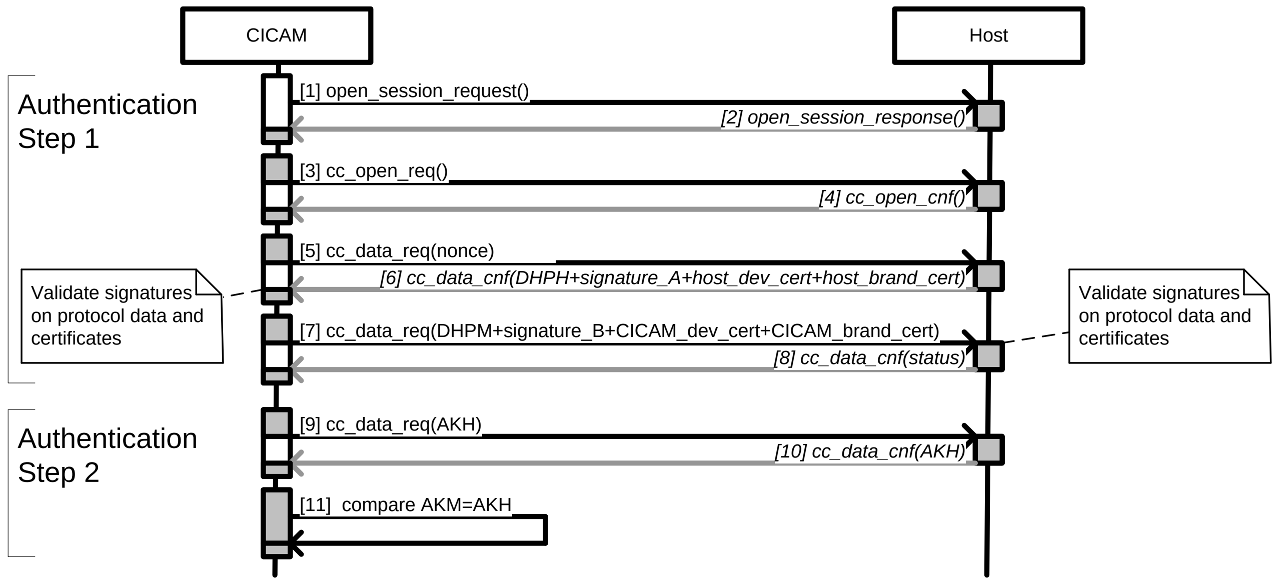
6.2 Authentication Protocol

Section 6.2.1 explains the authentication protocol messages exchanged over the external interfaces. Section 6.2.2 explains the authentication conditions. Section 6.2.3 explains the authentication protocol local verification and key computations.

The CICAM should not attempt authentication until the date has been obtained by both the CICAM and Host to ensure that certificates can be verified. E.g. this may be accomplished using the date and time resource, see EN 50221 [7], section 8.5.2.

6.2.1 Initialisation and Message Overview

Authentication is performed in three steps:


CICAM
Host
Authentication Step 1
[1] open_session_request()
[2] open_session_response()
[3] cc_open_req()
[4] cc_open_cnf()
[5] cc_data_req(nonce)
[6] cc_data_cnf(DHPH+signature_A+host_dev_cert+host_brand_cert)
Validate signatures on protocol data and certificates
[7] cc_data_req(DHPM+signature_B+CICAM_dev_cert+CICAM_brand_cert)
[8] cc_data_cnf(status)
Validate signatures on protocol data and certificates
Authentication Step 2
[9] cc_data_req(AKH)
[10] cc_data_cnf(AKH)
[11] compare AKM=AKH

NOTE: This diagram does not suggest that any behaviour be specifically (un)synchronized / (un)blocked. This diagram also assumes that the CICAM does not store a valid AKM.

Figure 6.2: Authentication Exchange Sequence Diagram (Informative)

The process is defined as described in Table 6.1:

Table 6.1: Authentication Exchange (normative)

No.	Description	Refer to
1	The CICAM shall open a session to the Content Control resource	Section 11.3
2	The Host shall confirm with a session response. Failure to open a valid session constitutes a failure of the Content Control system.	Section 11.3
3	The CICAM shall send a cc_open_req APDU to the Host.	Section 11.3.1.1
4	The Host shall confirm with the cc_open_cnf APDU, carrying: • cc_system_id_bitmask	Section 11.3.1.2
5	The CICAM shall send a cc_data_req APDU to the Host, carrying: • a nonce (i.e. auth_nonce). • Requests for datatype IDs to be delivered by Host as listed in referenced subsection.	Section 11.3.3.2
6	The Host shall confirm with the cc_data_cnf APDU, carrying: • DH public key of the Host (DHPH, refer to section 6.2.3.2), • the signature A (refer to section 6.2.3), • the Host brand certificate (Host_BrandCert, refer to section 9.2), • the Host device certificate (Host_DevCert, refer to section 9.2). Failure to respond with a cc_data_cnf constitutes a failure of the Content Control system; this may occur when the Host failed to verify the received CICAM data (see Note 2).	Section 11.3.3.2
7	The CICAM shall follow up with an cc_data_req APDU, carrying: • DH public key of the CICAM (DHPM, refer to section 6.2.3.2), • the signature B (refer to section 6.2.3), • the CICAM brand certificate (CICAM_BrandCert, refer to section 9.2), • the CICAM device certificate (CICAM_DevCert, refer to section 9.2). • requests for datatype IDs to be delivered by Host as listed in referenced subsection. Failure to respond with cc_data_req constitutes a failure of the Content Control system; this may occur when the CICAM failed to verify the received Host data (see Note 2).	Section 11.3.3.2
8	The Host shall confirm with the cc_data_cnf APDU, carrying: • the status of the Host. Failure to respond with cc_data_cnf constitutes a failure of the Content Control system; this may occur when the Host failed to verify the received CICAM data (see Note 2).	Section 11.3.3.2
9	The CICAM shall send a cc_data_req APDU to the Host to request the Host authentication key (AKH, refer to section 6.2.3.4), carrying: • request for datatype ID of AKH (as specified in Annex H.1).	Section 11.3.3.3
10	The Host shall confirm with the cc_data_cnf APDU, carrying: • AKH, either valid or filled with 0 (zero, indicating "invalid") (refer to section 6.2.3.4). Failure to respond within 5 seconds with cc_data_cnf constitutes a failure of the Content Control system (see Note 2).	Section 11.3.3.3

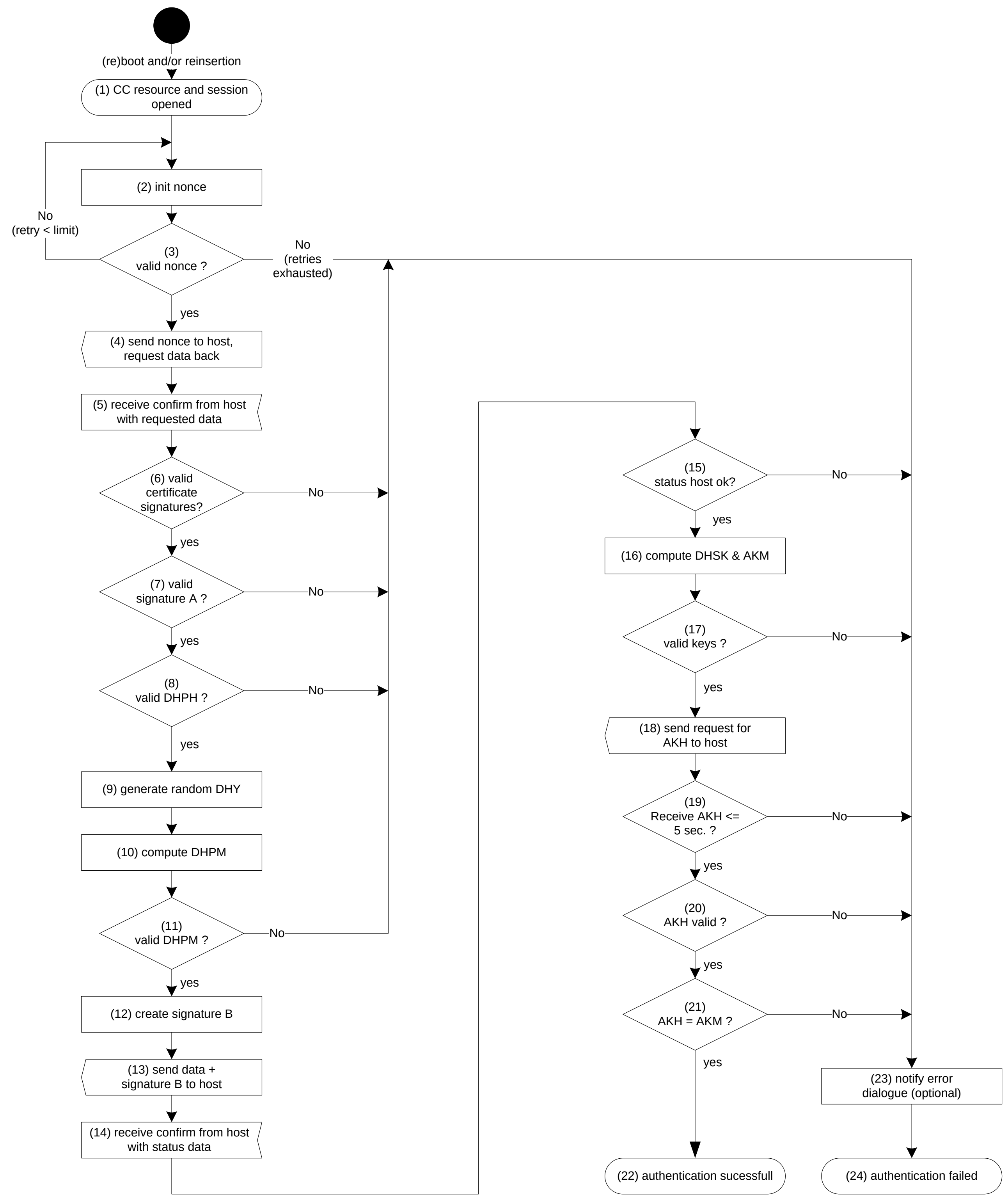
11	The CICAM shall compare the AKH with the newly computed AKM. If they fail to match this constitutes in a failure of the Content Control system (see Note 2).	
Note 1. Refer to Annex H for an overview of the parameters involved. 2. Behaviour on failure of the Content Control System is defined in Section 6.1 and Figure 6.1, step 11. Refer to section 5.4.3 and Annex F for details on the generic error reporting mechanism.		

6.2.2 Authentication Conditions

The following limits are defined in this section:

Table 6.2: Authentication Exchange (normative)

Limit	Description	Defined as
Nonce retry	Maximum number of CICAM retries to create a valid nonce	3


(re)boot and/or reinsertion
(1) CC resource and session opened
(2) init nonce
No (retry < limit)
(3) valid nonce ?
No (retries exhausted)
yes
(4) send nonce to host, request data back
(5) receive confirm from host with requested data
(6) valid certificate signatures?
No
yes
(7) valid signature A ?
No
yes
(8) valid DHPH ?
No
yes
(9) generate random DHY
(10) compute DHPM
(11) valid DHPM ?
No
yes
(12) create signature B
(13) send data + signature B to host
(14) receive confirm from host with status data
(15) status host ok?
No
yes
(16) compute DHSK & AKM
(17) valid keys ?
No
yes
(18) send request for AKH to host
(19) Receive AKH <= 5 sec. ?
No
yes
(20) AKH valid ?
No
yes
(21) AKH = AKM ?
No
yes
(23) notify error dialogue (optional)
(22) authentication sucessfull
(24) authentication failed

Note: Retry limit defined in Table 6.2

Figure 6.3: CICAM sided overview of authentication conditions (Informative)

The CICAM authentication conditions shown in Figure 6.3 are described below:

Note: Refer to Table 6.3 for details on the computations and to Table 6.1 for details on the message exchange.

1) CC resource and session shall be opened before the CICAM starts the authentication procedure.

2) The CICAM initializes a protocol nonce "auth_nonce".

3) The auth_nonce shall be a valid length as listed in Annex H, Table H.1. If this is not the case the CICAM retries until it reaches the retry limit (Refer to Table 6.2). If the retry limit is reached the authentication fails and the CICAM continues at step 23.

4) The CICAM sends the auth_nonce to the Host and requests data back in the confirmation message.

5) The CICAM waits until it receives the confirmation from the Host carrying the requested parameters.

6) The CICAM verifies that the certificates received from the Host are valid by checking the SSAC. Otherwise the authentication fails and the CICAM continues at step 23.

7) The CICAM verifies that the signature A received from the Host is valid by checking the SSAC. Otherwise the authentication fails and the CICAM continues at step 23.

8) The CICAM verifies that the DHPH key received from the Host is valid by checking length according to Annex H, Table H.1 and value according to control check in section 6.2.3.2. Otherwise the authentication fails and the CICAM continues at step 23.

9) The CICAM generates a random nonce DHY for use in the DH computations.

10) The CICAM computes a DH public key DHPM.

11) The CICAM checks that the computed key DHPM is valid by checking length according to Annex H, Table H.1 and value according to control check in section 6.2.3.2. Otherwise the authentication fails and the CICAM continues at step 23.

12) The CICAM creates a unique signature B for the data to be exchanged with the Host.

13) The CICAM sends the protocol data to the Host with a request to receive the status of the Host.

14) The CICAM waits until it receives a confirmation from the Host with its status.

15) The CICAM checks if the status of the Host is OK. Otherwise the authentication fails and the CICAM continues at step 23.

16) The CICAM computes the DHSK and AKM keys.

17) The CICAM checks if the DHSK and AKM are valid according to sections 6.2.3.3 and 6.2.3.4. Otherwise the authentication fails and the CICAM continues at step 23.

18) The CICAM requests the Hosts AKH key.

19) The CICAM shall receive the Host response within 5 seconds. Otherwise the authentication fails and the CICAM continues at step 23.

20) The CICAM checks that the response contains a valid AKH key. If the key is all zeros then the AKH is considered invalid and the authentication fails, the CICAM continues at step 23.

21) The CICAM checks the received AKH from the Host matches the AKM of the CICAM. Otherwise the authentication fails and the CICAM continues at step 23.

22) The CICAM completes the authentication successfully.

23) The CICAM may initiate an authentication failed MMI dialogue.

24) Authentication failed.

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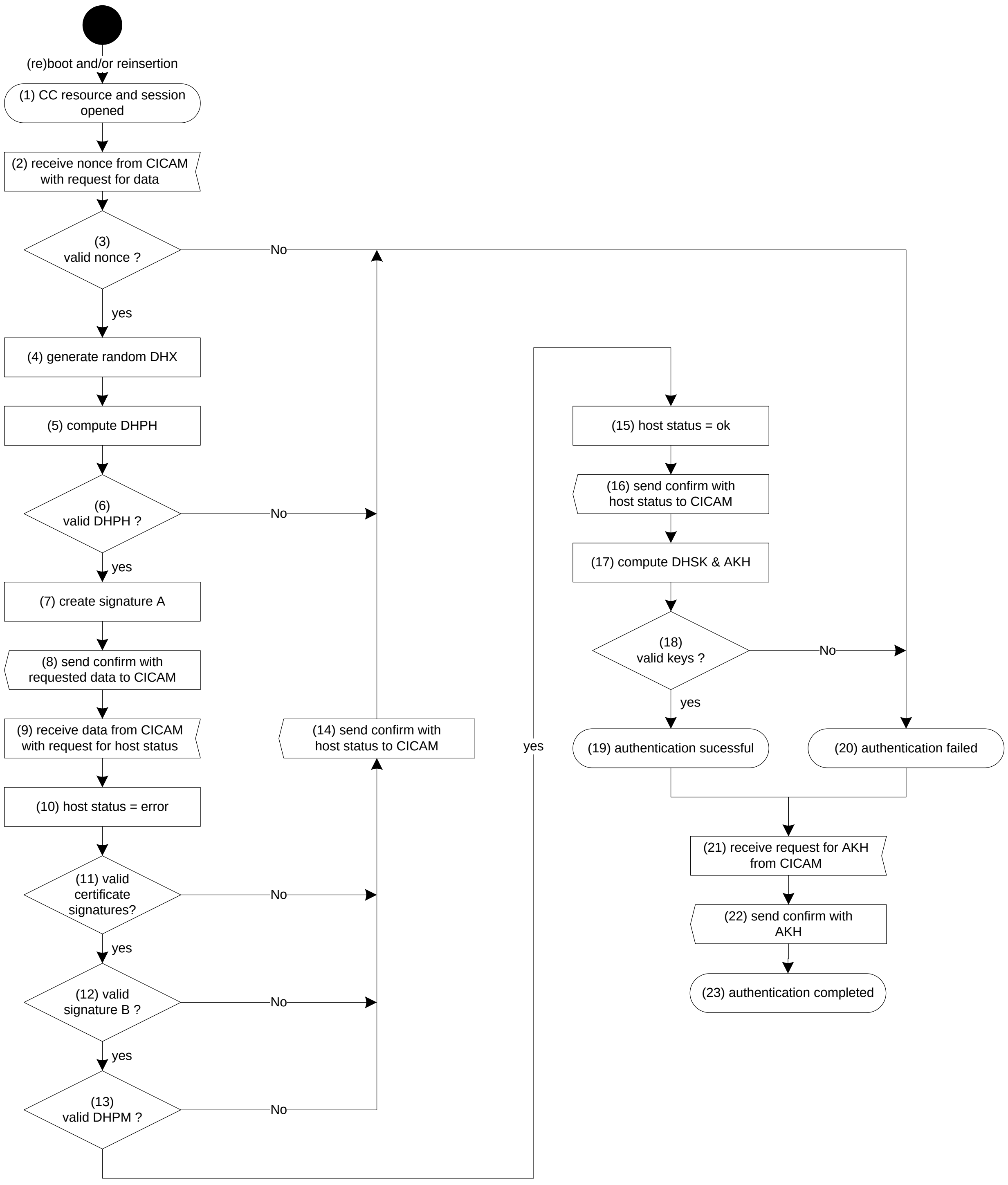

(re)boot and/or reinsertion
(1) CC resource and session opened
(2) receive nonce from CICAM with request for data
(3) valid nonce ?
No
yes
(4) generate random DHX
(5) compute DHPH
(6) valid DHPH ?
No
yes
(7) create signature A
(8) send confirm with requested data to CICAM
(9) receive data from CICAM with request for host status
(10) host status = error
(11) valid certificate signatures?
No
yes
(12) valid signature B ?
No
yes
(13) valid DHPM ?
No
(14) send confirm with host status to CICAM
yes
(15) host status = ok
(16) send confirm with host status to CICAM
(17) compute DHSK & AKH
(18) valid keys ?
No
yes
(19) authentication sucessful
(20) authentication failed
(21) receive request for AKH from CICAM
(22) send confirm with AKH
(23) authentication completed

Figure 6.4: Host sided overview of authentication conditions (Informative)

The Host authentication conditions shown in Figure 6.4 are described below:

Note: Refer to Table 6.2 for details on the computations and to Figure 6.2 for details on the message exchange.

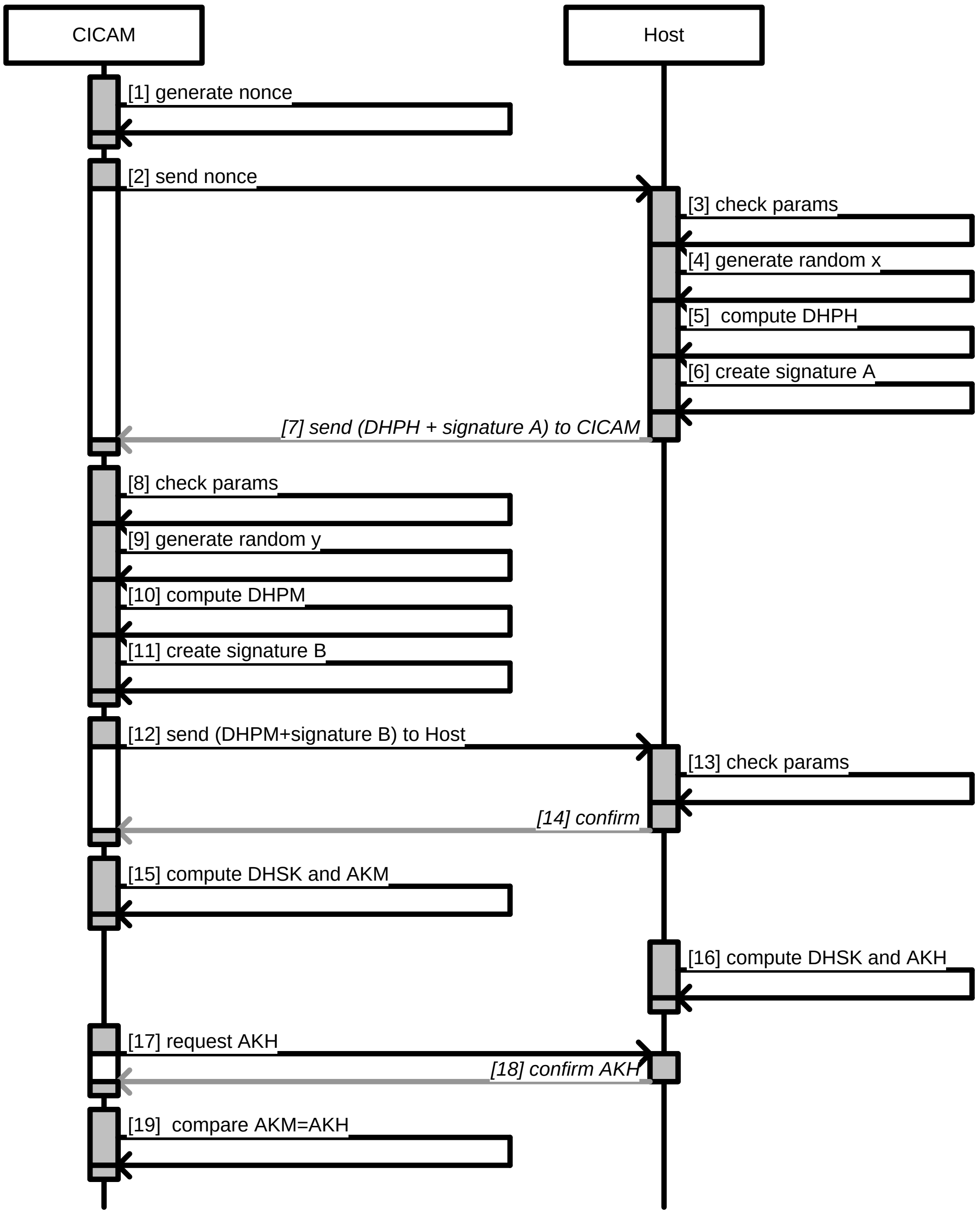
1) CC resource and session are opened successfully.

2) The Host receives a nonce from the CICAM.

3) The Host checks if the received nonce is valid as listed in Annex H, Table H.1. This nonce is used throughout the authentication protocol.
4) The Host generates a random nonce DHX for use in the DH computations.
5) The Host computes a DH public key DHPH.
6) The Host checks that the computed key DHPH is of valid by checking length according to Annex H, Table H.1 and value according to control check in section 6.2.3.2.
7) The Host creates a unique signature A for the data that is to be exchanged with the CICAM.
8) The Host sends the protocol data to the CICAM.
9) The Host waits for response from the CICAM carrying the required parameters to complete the authentication.
10) The Host sets Host status to error.
11) The Host verifies the certificates received from the CICAM are valid by checking the SSAC.
12) The Host verifies that the signature B received from the CICAM is valid by checking the SSAC.
13) The Host verifies that the DHPM key received from the CICAM is valid by checking length according to Table H.1 and value according to control check in section 6.2.3.2.
14) The Host sends a confirmation with the local status.
15) The Host sets Host status to ok.
16) The Host sends local status as confirmation.
17) The Host computes the DHSK and AKH keys.
18) The Host checks if the DHSK and AKH are of valid according to sections 6.2.3.3 and 6.2.3.4.
19) Valid keys shall mean the Host authentication is successful but not yet completed.
20) Invalid keys or any other error during the authentication protocol shall mean the authentication has failed.
21) The Host receives a request from the CICAM to report the Host AKH key.
22) The Host shall confirm with the value of the AKH. An invalid AKH key is filled with all zeros. Note that the CICAM may retry, repeating steps 21 and 22.
23) The authentication is complete.

6.2.3 Authentication Key Computations

If a matching authentication key is not found (see section 6.1.2) the system performs an authentication session as described in Figure 6.5.



NOTE: This diagram does not suggest that any behaviour be specifically (un)synchronized / (un)blocked.

Figure 6.5: Authentication Key Material Computation Sequence Diagram (Informative)

The process is defined as described in Table 6.3:

Table 6.3: Authentication Key Material Computation (Normative)

No.	Description	Refer to
0	On start-up the Host performs checks if the DH parameters are valid.	Section 6.2.3.1
1	The CICAM shall generate a random nonce of 256 bits (auth_nonce), which is included in the signature of exchanged parameters of the 3 pass DH protocol. The nonce shall be generated by a suitable PRNG.	Annex A
2	The CICAM shall send the auth_nonce to the Host using the appropriate APDU message.	Section 11.3.2.2
3	The Host shall check that the received auth_nonce parameter is the correct size (256 bits).	Annex A
4	The Host shall generate a random value for DH exponent x. The value x (DHX) shall be generated by a suitable PRNG.	Annex A
5	The Host shall compute the DH public key of the Host (DHPH).	Section 6.2.3.2
6	The Host shall create a signature A over the auth_nonce and DHPH, so that: $$message\_A = (version \mid\mid msg\_label \mid\mid auth\_nonce \mid\mid DHPH)$$ $$signature\_A = RSASSA-PSS-SIGN(HDQ, message\_A)$$ where: • RSASSA-PSS shall be used as referred in Note 2 below. • HDQ is the device private key, as defined in Section 5.3. • version = 0x01 and msg_label = 0x2. • Auth_nonce is identical to value received in step 3.	Annex I
7	The Host shall send the signature A and the DHPH key, together with the Host brand certificate and the Host device certificate to the CICAM.	Section 11.3.3.2
8	The CICAM shall check the received parameters as follows: a) CICAM shall verify signature on the certificates. b) CICAM shall verify the signature A, so that: $$message\_A = (version \mid\mid msg\_label \mid\mid auth\_nonce \mid\mid DHPH)$$ $$RSASSA-PSS-VERIFY(HDP, message\_A, signature\_A) = TRUE$$ where: • RSASSA-PSS shall be used as referred in Note 2 below. • HDP is the device public key received in step 7. • Version = 0x01 and msg_label = 0x2. • Auth_nonce is identical to the value generated in step 1. • DHPH is identical to the value received in step 7. • TRUE means ‘valid signature’ c) The CICAM shall verify that: $$1 < DHPH < DH\_p \text{ and } DHPH^{DH-q} \bmod DH\_p = 1$$	Section 9.4

9	The CICAM shall generate a random value for DH exponent y. The value y (DHY) shall be generated by a suitable PRNG.	Annex A
10	The CICAM shall compute the DH public key of the CICAM (DHPM).	Section 6.2.3.2
11	The CICAM shall create a signature B over the DHPM key and the exchanged parameters auth_nonce and DHPH, so that: $message\_B = (version \| \| msg\_label \| \| auth\_nonce \| \| DHPH \| \| DHPM)$ $signature\_B = RSASSA-PSS-SIGN(MDQ, message\_B)$ where: • RSASSA-PSS shall be used as referred in Note 2 below. • MDQ is the device private key, as defined in Section 5.3. • version = 0x01 and msg_label = 0x3. • Auth_nonce is identical to value received in step 1.	Annex I Section 5.3
12	The CICAM sends the signature B and the DHPM key, together with the CICAM brand certificate and the CICAM device certificate to the Host using the appropriate APDU message.	Section 11.3.3.2
13	The Host shall check the received parameters as follows: a) Host shall verify signature on the certificates. b) Host shall verify the signature B, so that: $message\_B = (version \| \| msg\_label \| \| auth\_nonce \| \| DHPH \| \| DHPM)$ $RSASSA-PSS-VERIFY(MDP, message\_B, signature\_B) = TRUE$ where: • RSA shall be used as referred in Note 2 below. • MDP is the device public key received in step 12. • Version = 0x01 and msg_label = 0x3. • Auth_nonce is identical to value received in step 3. • DHPH is identical to the value generate in step 5. • DHPM is identical to the value received in step 10. • TRUE means 'valid signature' c) The Host shall verify that: $1 < DHPM < DH\_p$ and $DHPM^{DH\_q} \bmod DH\_p = 1$ d) The Host shall confirm the CICAM brand identifier is present in the certificate and is an integer in the range 1..65535	Section 9.4
14	The Host shall confirm it is ready by sending a status using the appropriate APDU message.	Section 11.3.3.2
15	The CICAM shall compute and store the DHSK key. The CICAM shall compute and store the AKM key.	Section 6.2.3.3 Section 6.2.3.4

16	The Host shall compute and store the DHSK key. The Host shall compute and store the AKH key.	Section 6.2.3.3 Section 6.2.3.4
17	The CICAM shall start the authentication verification (step 2 in the authentication process) by sending a request for the current authentication key AKH to the Host using the appropriate APDU message.	Section 11.3.3.3
18	The Host confirms the request from step 17 and sends the AKH to the CICAM using the appropriate APDU message.	Section 11.3.3.3
19	The CICAM shall check if the AKH received from the Host matches the AKM computed by the CICAM. Failure to match constitutes a failure of the authentication protocol (see Note 3).	
Notes: 1: Refer to Annex H for an overview of parameters involved. 2: RSA is used for SSAC authentication and verification as described in Annex I. The data fields in the signature are concatenated utilizing the tag length format described in Annex J. 3: Failure of the Content Control System is defined in Section 6.1 and Figure 6.1. Refer to section 5.4.3 and Annex F for details on the generic error reporting mechanism.		

6.2.3.1 Diffie Hellman Parameters

The Diffie Hellman parameters and their requirements are not defined in this document and can be found in the CI Plus Licensee Specification [33].

6.2.3.2 Calculate DH Public Keys (DHPH and DHPM)

The Diffie Hellman public keys (DHPH and DHPM) are volatile and shall be deleted after completion of the authentication protocol.

The Host shall compute its Diffie Hellman public key as follows:

$$DHPH = DH\_public\_Key_{Host} = g^{x} \bmod p \qquad \text{Eq.6.1}$$

The CICAM shall compute its Diffie Hellman public key as follows:

$$DHPM = DH\_public\_Key_{Module} = g^{y} \bmod p \qquad \text{Eq. 6.2}$$

Where:

- Exponent x (DHX) and exponent y (DHY) are random and generated by a PRNG as defined in Annex A. The exponents DHX and DHY shall be kept local and secret and shall be deleted after completion of the authentication protocol. The value of g and p are defined in the CI Plus Licensee Specification [33].

After computation of a DH public key following checks shall be performed:

- check if $1 < DH\_public\_key < DH\_p \wedge DH\_public\_key^{DH\_q} \bmod DH\_p = 1$.

NOTE: refer to Annex H for an overview of parameters involved.

6.2.3.3 Calculate DH Keys (DHSK)

The Diffie Hellman secret key (DHSK) shall be stored in non-volatile memory. The key shall be computed as follows:

$$DHSK = DH\_private\_Key_{Host} = (DHPM)^{x} \bmod DH\_p \equiv (DHPH)^{y} \bmod DH\_p = DH\_private\_Key_{Module} \qquad \text{Eq. 6.3}$$

6.2.3.4 Calculate Authentication Key (AKH and AKM)

The Authentication key AKH/AKM shall be used for the SAC key (refer to section 7.1.3) and Content Control Key (CCK) calculation (refer to section 8.1.4). The authentication key generation occurs only once (per Host-CICAM pair) when the CICAM and Host are first connected. The resulting authentication keys (AKM for CICAM and AKH for Host) shall be stored in non-volatile memory. The keys shall be computed as follows:

$$AKM \equiv AKH = SHA_{256}(\mathrm{CICAM\_ID}||\mathrm{Host\_ID}||\mathrm{DHSK}) \qquad \text{Eq. 6.4}$$

Input parameters shall adhere to Table 6.4.

Table 6.4: Input Parameters in Key Computation

Key or variable	Size (bits)	Comments	Refer to
DHSK	2048	The complete DH secret from the authentication process.	Section 6.2.3.3
HOST_ID	64	Generated by the ROT and included in the X.509 certificate of the Host.	Section 9.3.6
CICAM_ID	64	Generated by the ROT and included in the X.509 certificate of the CICAM.	Section 9.3.6
Notes: 1. Input is padded according to SHA-256. Refer to FIPS 180-3 [3]. It is advised that SHA implementations adhere to the SHS validation list. See SHS Validation List [11]. 2. Refer to Annex H for overview of parameters involved.			

6.3 Power-Up Re-Authentication

After establishing the CC session, CICAM and Host perform the Authentication Key Verification protocol to check if there is an existing binding between the two devices and re-authentication is unnecessary.

The authentication context contains the data required for Authentication Key Verification and start-up without full authentication. This comprises of:

- AKM / AKH
- DHSK
- CICAM ID / Host ID
- CICAM Brand ID used for host service shunning
- scrambler algorithm that was negotiated during the binding

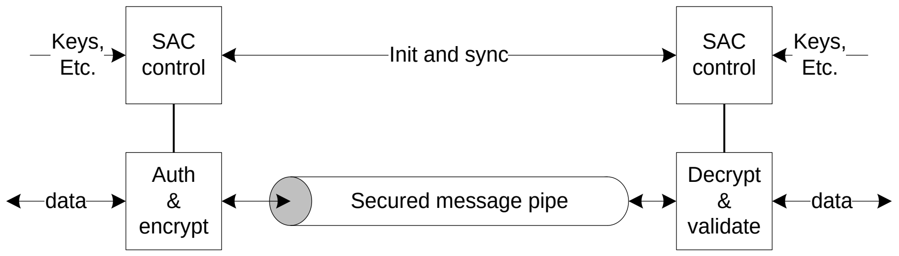
A Host shall store 5 authentication contexts. A CICAM shall support at least one authentication context, it may support more.

If the CICAM has a valid authentication context, it requests the AKH from the Host and checks if the received AKH matches with the AKM in its authentication context. If there is no match the CICAM shall retry until a match is found or the maximum of 5 attempts has been made. The Host goes through its authentication contexts and sends back the corresponding AKHs. When there is a match, the fast authentication is finished and Host and CICAM continue with SAC establishment. When the Host does not have another valid authentication context it replies with the AKH value filled with zeros. When receiving this invalid AKH the CICAM stops retrying and starts the authentication protocol.

Implementations on the CICAM and the Host should try to minimize the cases where a full authentication is required.

7 Secure Authenticated Channel

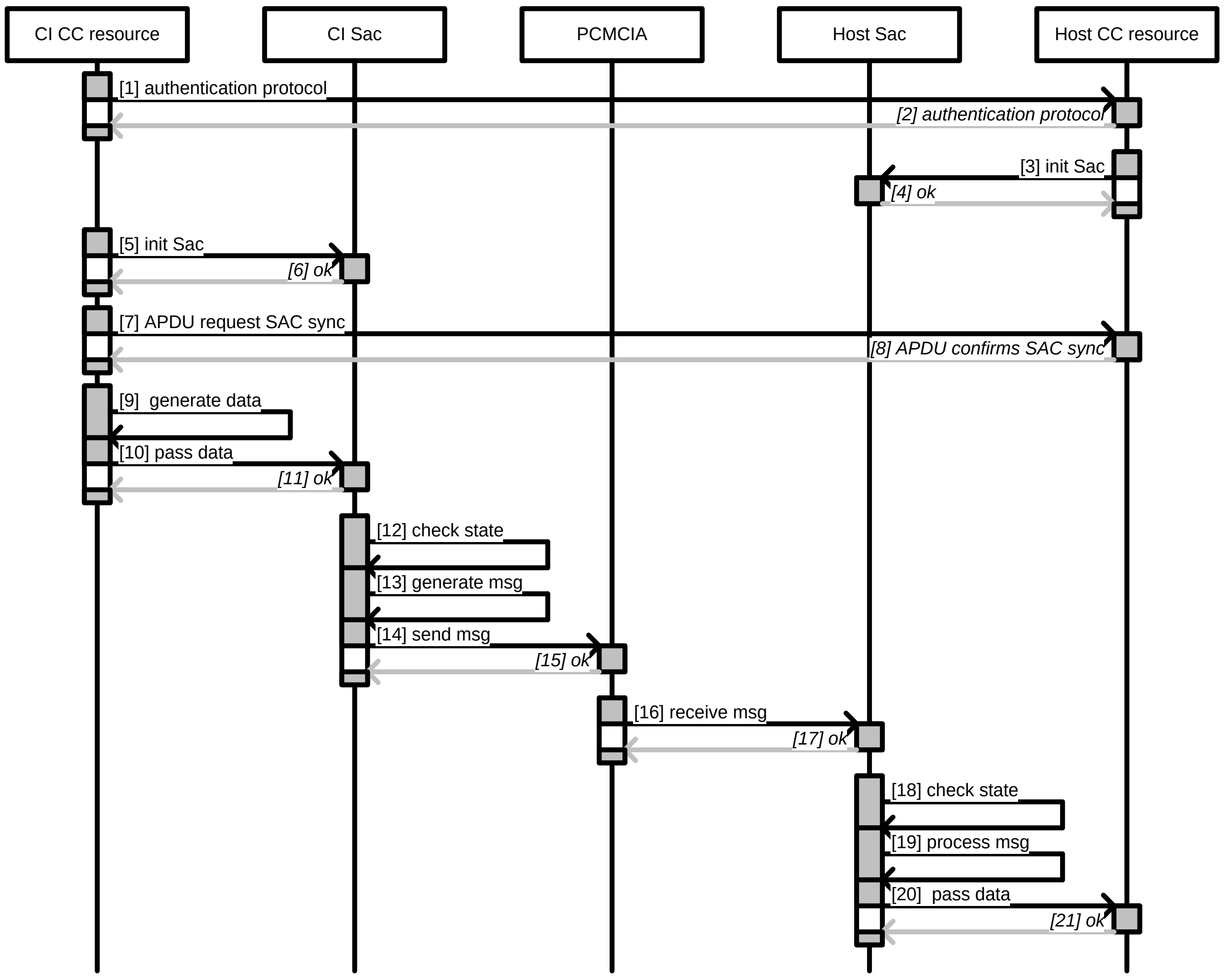
The CI SAC encrypts and decrypts data such as APDUs into SAC messages. A contextual high level diagram is shown in Figure 7.1:



NOTE: The CI SAC may send and receive messages in both directions.

Figure 7.1: Contextual Overview of CI SAC (informative)

Figure 7.2 is provided for informative purposes:



NOTE: This diagram does not suggest that any behaviour be specifically (un)synchronized / (un)blocked.

Figure 7.2: CI SAC Sequence Diagram (informative)

The process is defined as described in Table 7.1:

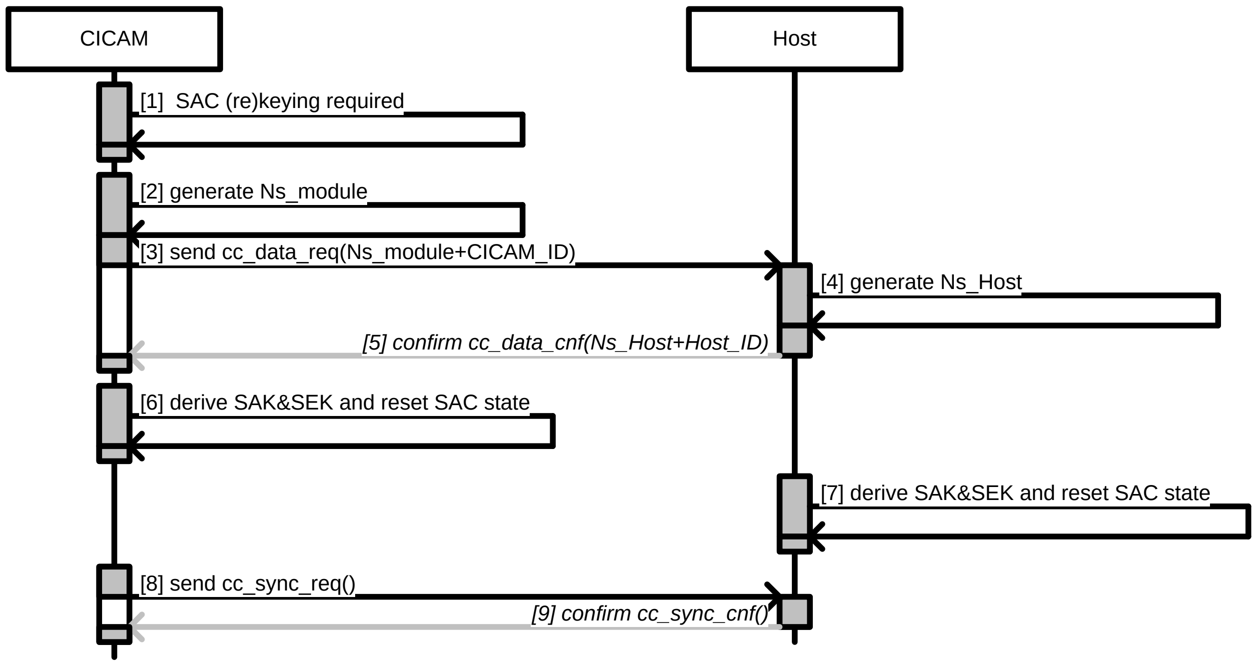
Table 7.1: Contextual Overview of the CI SAC (normative)

No.	Description	Refer to
1 2	**Authentication protocol.** The CICAM and Host shall successfully complete the mutual authentication protocol.	Section 6.2
3 .. 6	**Init SAC.** The SAC shall be initialized on the CICAM and the Host. This concerns key material derivation and (re)setting the initial SAC state.	Section 7.1.1
7 8	**Request SAC sync and confirm SAC sync.** If the CICAM has correctly initialized the CI SAC, the CICAM shall issue an APDU to synchronize with the Host. After successful confirmation, both sides may start to use the SAC.	Section 7.1.1
9 .. 15	**Generating and transmitting SAC message.** The SAC message is generated for the payload, by adding a message header, authentication field and optionally encrypting.	Section 7.3
16 .. 21	**Receiving and validating SAC message.** Upon reception of the SAC message it shall be validated and if valid its payload may be processed further.	Section 7.4
Notes: 1. The CI SAC may send and receive messages in both directions. 2. Refer to section 7.5 for an explanation how the SAC is integrated into CI Plus architecture. 3. Refer to Tables 11.28 and 11.30 for an overview of the messages that are exchanged through the SAC.		

7.1 CI SAC Operation

7.1.1 SAC Initialisation

This section specifies in detail how the SAC is initialized. Figure 7.3 is provided for informative purposes:


CICAM
Host
[1] SAC (re)keying required
[2] generate Ns_module
[3] send cc_data_req(Ns_module+CICAM_ID)
[4] generate Ns_Host
[5] confirm cc_data_cnf(Ns_Host+Host_ID)
[6] derive SAK&SEK and reset SAC state
[7] derive SAK&SEK and reset SAC state
[8] send cc_sync_req()
[9] confirm cc_sync_cnf()

NOTE: This diagram does not suggest that any behaviour be specifically (un)synchronized / (un)blocked.

Figure 7.3: SAC Key Material Computation Sequence Diagram (informative)

The process is defined as described in Table 7.2:

Table 7.2: SAC Key Computation (normative)

No.	Description	Refer to
1	When the CICAM detects that a (re)keying of the SAC is required, the CICAM shall start the process of SAC initialisation. The exact conditions for (re)keying are specified in the referenced subsection.	Section 7.1.2
2	The CICAM shall generate a nonce used in SAC key material computation.	Section 7.1.3
3	The CICAM shall send a cc_data_req APDU to the Host, carrying the following parameters: • nonce Ns_module. • CICAM_ID as extracted from the CICAM device certificate.	Section 11.3.3.5
4	The Host shall generate a nonce used in SAC key material computation.	Section 7.1.3
5	The Host shall confirm receipt of the cc_data_request APDU from the CICAM by sending the cc_data_cnf APDU to CICAM, carrying the following parameters: • nonce Ns_Host. • HOST_ID, extracted from the Host device certificate. Failure to respond with cc_data_cnf constitutes a failure of the copy control system.	Section 11.3.3.5
6	The CICAM shall check that the received HOST_ID is equal to the previously stored HOST_ID (See Note 2). If they are the same the CICAM may start to compute the SAK and SEK and (re)set the SAC state.	Section 7.1.3
7	The Host shall check that the received CICAM_ID is equal to the previously stored CICAM_ID (See Note 2). If they are the same the Host may start computing the SAK and SEK and shall (re)set the SAC state.	Section 7.1.3
8	The CICAM shall send a cc_sync_req APDU to the Host, indicating a SAK refresh. When the CICAM has initialized the scrambler, the CICAM shall send a synchronization request to the Host, indicating that the CICAM is ready to start using the SAC.	Section 11.3.3.5
9	The Host shall confirm with a cc_sync_cnf APDU to the CICAM indicating that it is ready to start using the SAC. Failure to respond with cc_sync_cnf constitutes a failure of the copy control system. See Note 3.	Section 11.3.3.5
Notes: 1. Refer to Annex H for an overview of the parameters involved in this protocol. 2. Previous HOST_ID / CICAM_ID is stored in the 'Authentication Context'. Refer to Section 6.3 3. Refer to section 5.4.3 and Annex F for details on the generic error reporting mechanism.		

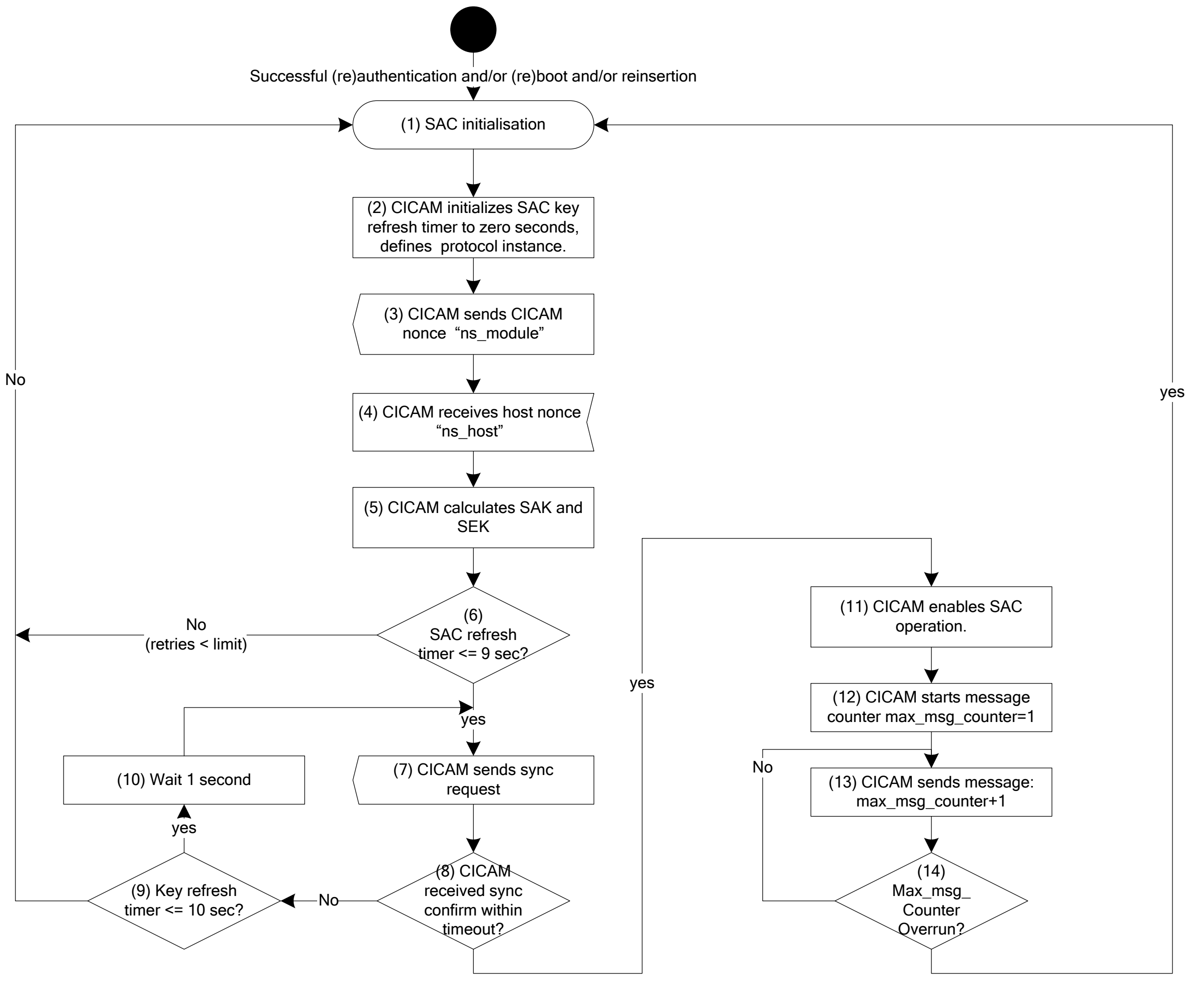
7.1.2 SAC (re)keying Conditions

The SAC key refresh is initiated by the CICAM, whereas the Host is passively replying. The SAC key refresh shall be triggered under any of the following conditions:

- On reboot; when (re)boot is completed successfully and there is a valid AKM stored in memory.
- On (re) insertion of a CICAM; when a CICAM is re-inserted in a Host and there is a valid AKM stored in memory.
- On (re)authentication; when there is no valid AKM stored in memory the authentication session is (re)initiated, resulting in successful completion (i.e. valid AKM) of the subsequent (re) authentication session.

- On message counter overrun.

Figure 7.4 explains the CICAM operation for SAC key refresh.

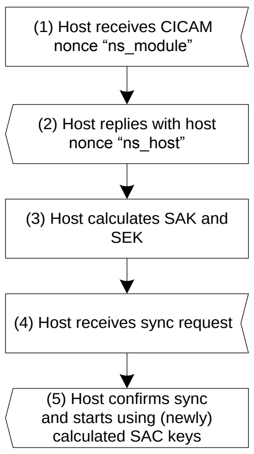


Successful (re)authentication and/or (re)boot and/or reinsertion
(1) SAC initialisation
(2) CICAM initializes SAC key refresh timer to zero seconds, defines protocol instance.
(3) CICAM sends CICAM nonce "ns_module"
(4) CICAM receives host nonce "ns_host"
(5) CICAM calculates SAK and SEK
(6) SAC refresh timer <= 9 sec?
No (retries < limit)
yes
(7) CICAM sends sync request
(8) CICAM received sync confirm within timeout?
No
(9) Key refresh timer <= 10 sec?
yes
(10) Wait 1 second
No
yes
(11) CICAM enables SAC operation.
(12) CICAM starts message counter max_msg_counter=1
(13) CICAM sends message: max_msg_counter+1
(14) Max_msg_ Counter Overrun?
No
yes

Note: The retry limit is defined as value 3 and applies to subsequent failures of the SAC protocol in step 6.

Figure 7.4: Flow Chart – CICAM SAC Key Refresh Session

Figure 7.5 explains the Host operation for SAC key refresh.



(1) Host receives CICAM nonce "ns_module"
(2) Host replies with host nonce "ns_host"
(3) Host calculates SAK and SEK
(4) Host receives sync request
(5) Host confirms sync and starts using (newly) calculated SAC keys

Figure 7.5: Flow Chart – Host SAC Key Refresh Session

7.1.3 SAC Key Computation

The SAC requires two keys for operation: the SAC Authentication Key (SAK) and the SAC Encryption Key (SEK). Computation of SAK and SEK proceeds in two steps:

- Key seed calculation.
- SEK and SAK key derivation.

These are defined as follows:

Step 1: Key Seed calculation.

The Key Seed Ks is 256 bits long and shall be used for the computation of the key material Km. The process to calculate Ks shall be performed on the Host and CICAM.

The Key Seed Ks shall be calculated on the Host as follows:

$$Ks_{host} = \mathrm{SHA}_{256}(\mathrm{DHSK}\,||\,\mathrm{AKH}\,||\,\mathrm{Ns\_host}\,||\,\mathrm{Ns\_module}) \qquad \text{Eq. 7.1}$$

On the CICAM the Key Seed Ks shall be calculated as follows:

$$Ks_{CICAM} = \mathrm{SHA}_{256}(\mathrm{DHSK}\,||\,\mathrm{AKM}\,||\,\mathrm{Ns\_host}\,||\,\mathrm{Ns\_module}) \qquad \text{Eq. 7.2}$$

Where:

- $Ks_{CICAM} \equiv Ks_{host}$
- Input parameters are defined in Table 7.3:

Table 7.3: Input Parameters in Key Computation

Key or variable	Size (bits)	Comments	Refer to
DHSK	128	The LSB bits of the DH secret from the authentication process. See note 3.	Section 6.2.3.3
AKH / AKM	256	The authentication keys from the authentication process.	Section 6.2.3.4
Ns_Host	64	Random nonce of 64 bits generated by the Host and transmitted by the Host to the CICAM.	Annex A
Ns_module	64	Random nonce of 64 bits generated by the CICAM and transmitted by the CICAM to the Host.	Annex A
Notes: 1. Input is padded according to SHA-256. Refer to FIPS 180-3 [3]. It is advised that SHA implementations adhere to the SHS validation list. See SHS Validation List [11]. 2. The requirements on the random number generator for Ns_Host and Ns_module are given in Annex A. 3. DHSK is truncated from 1024 to 128 bits.			

Step 2: Key Material computation.

The Key Material Km is 256 bits long and shall used for the derivation of the SEK and SAK. The Key Material Km shall be calculated as follows:

$$SEK, SAK = f - SAC(Ks) \qquad \text{Eq. 7.3}$$

Note: The function f-SAC is not defined in this document and is obtained from the CI Plus Licensee Specification [33].

7.1.4 SAC error codes and (re) set SAC state

The SAC re-keying conditions are explained in following Figure 7.6.

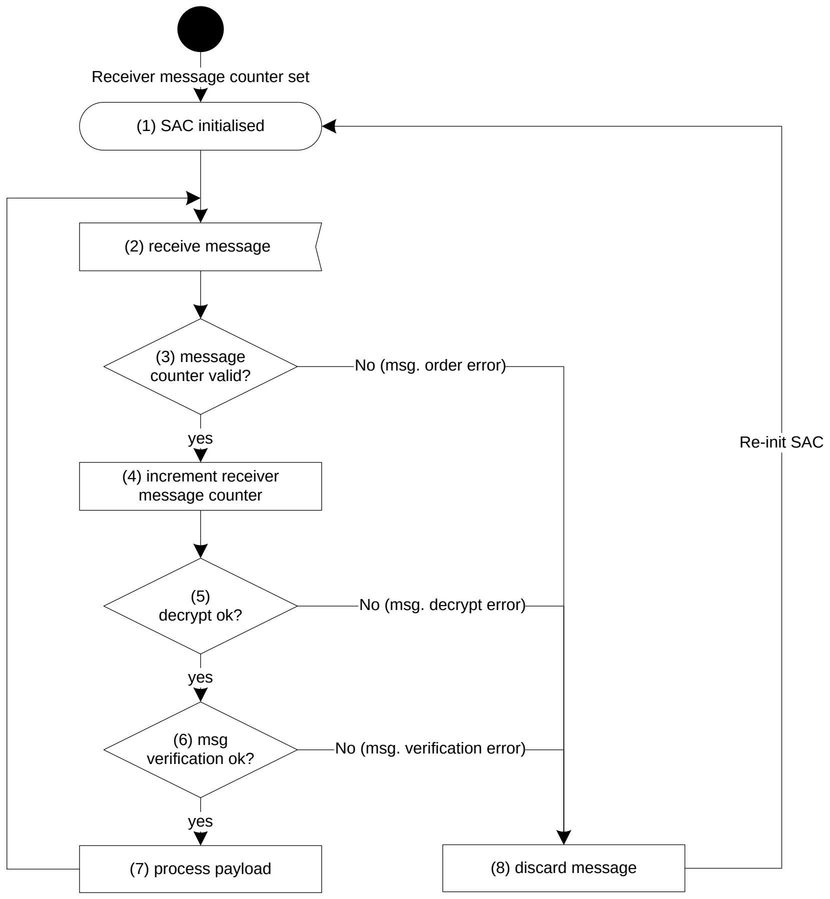
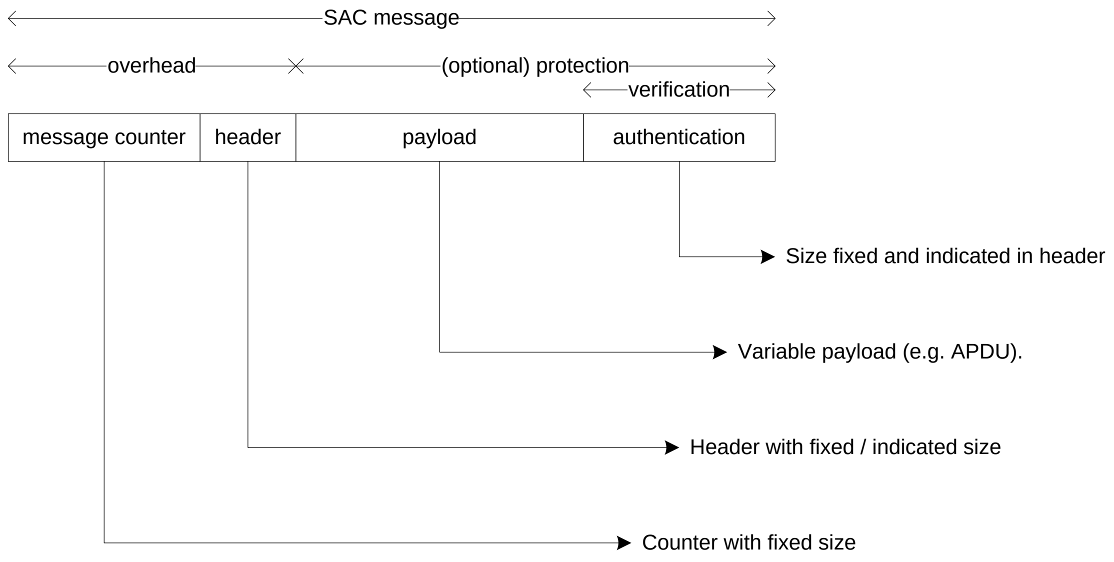


Figure 7.6: SAC state handling

7.2 Format of the SAC Message

A data message that is delivered as payload to the CI SAC shall be transformed into a SAC message as follows:



Note: The SAC authenticates first and then encrypts.

Figure 7.7: SAC Message Composition

The detailed SAC message syntax is defined in Table 7.4.

Table 7.4: SAC Message Syntax

Field	No. of Bits	Mnemonic
`message() {`		
`   message_counter`	32	uimsbf
`   /* message header starts here */`		
`   protocol_version`	4	uimsbf
`   authentication_cipher_flag`	3	uimsbf
`   payload_encryption_flag`	1	bslbf
`   encryption_cipher_flag`	3	uimsbf
`   reserved for future use`	5	bslbf
`   length_payload`	16	uimsbf
`   /* message header ends here */`		
`   /* message body starts here */`		
`   if (payload_encryption_flag == MSG_FLAG_TRUE) {`		
`      encrypted_payload`	length_payload * 8 + 128	bslbf
`   } else if (payload_encryption_flag == MSG_FLAG_FALSE) {`		
`      payload`	length_payload * 8	bslbf
`      authentication`	128	bslbf
`   }`		
`   /* message body ends here */`		
`}`		

7.2.1 Constants

The message defines the constants as defined in Table 7.5.

Table 7.5: Constants in SAC Message

Name	Value
MSG_FLAG_FALSE	0
MSG_FLAG_TRUE	1

7.2.2 Coding and Semantics of Fields

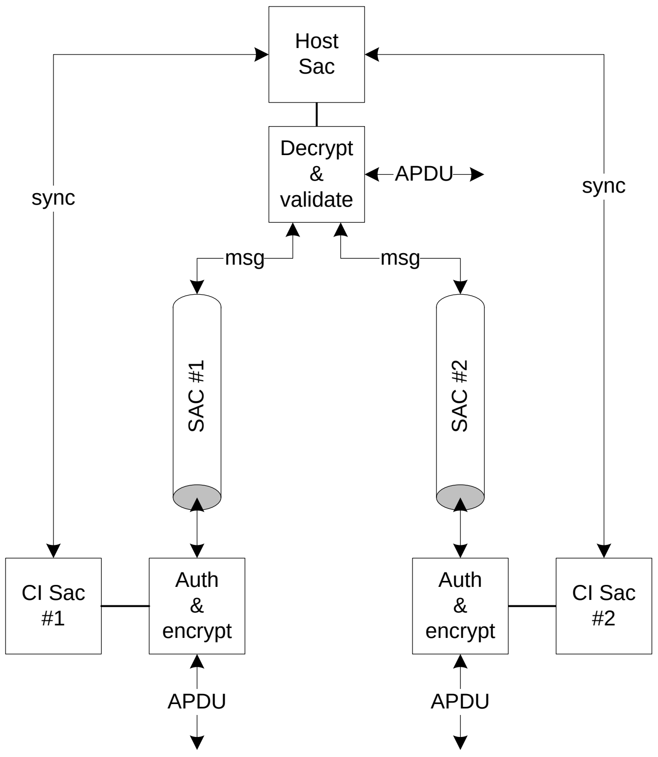
message_counter: A data message requires a unique counter. The usage of this field is explained in section 7.4.1.

protocol_version: This parameter indicates the protocol version of this message. The device shall ignore messages that have a protocol_version number it does not support. In this version of the specification the value of the protocol_version of this message shall be set to 0x0.

authentication_cipher_flag: This parameter is indicates the cipher that is used to generate the authentication field as defined in Table 7.6.

Table 7.6: Allowed Values for authentication_cipher_flag

Contents	Meaning	Comment
0x0	AES-128-XCBC-MAC	XCBC-MAC mode as described in RFC 3566 [20] (Note2)
0x1-0x7	reserved for future use	
Notes 1. A device adhering to this version of the specification shall interpret value 0x0 and ignore messages that have an authentication_cipher_flag value that it does not support. 2. With the exception that the 128 bit MAC output is not truncated and remains 128 bits.		



NOTE: The CI SAC may send and receive messages in both directions

Figure 7.8: Multiple Modules

payload_encryption_flag: This parameter indicates if the payload is encrypted. The value 1 indicates encryption of the payload and 0 that the message payload is not encrypted. A device adhering to this version of the specification shall interpret the value 1 and ignore messages with other unsupported payload_encryption_flag values.

encryption_cipher_flag: This parameter indicates the cipher that is used to encrypt the message payload as defined in Table 7.7.

Table 7.7: Allowed Values for encryption_cipher_flag

Contents	Meaning	Comment
0x0	AES-128 in CBC mode	AES-128 according to FIPS 197 [4] in CBC mode according to 800-38A [25]
0x1-0x7	reserved for future use	
Note: A device adhering to this version of the specification shall interpret value 0x0 and ignore messages that have an encryption_cipher_flag value that it does not support.		

length_payload: This parameter is the length of the payload message in bytes including optional padding, excluding the authentication length, for both encrypted and non-encrypted payloads.

encrypted_payload: this field contains the encrypted data consisting of the message payload, padding if required and authentication. Refer to section 7.3.2 for a description of this field.

payload: this field carries the unencrypted message payload (e.g. input data such as an APDU).

authentication: this field carries the authentication of the message. Refer to section 7.3.1 for a description of the authentication procedure. This field may be encrypted as signalled by "payload_encryption_flag"; refer to section 7.3.2 for details.

7.3 Transmitting SAC Messages

A data message that is delivered to the CI SAC shall be processed as follows:

1) Check the message_counter for exhaustion and update the message_counter. Refer to section 7.4.1 for details.

2) Compute the authentication of the message. Refer to section 7.3.1 for details.

3) Concatenate the authentication and payload and (optionally) encrypt the message. Refer to section 7.3.2 for details.

4) Construct the final message: (message_counter || header || result from step 3). Refer to section 7.2 for details.

5) Transmit the message.

NOTE: If any of these steps fail, the message and state (e.g. keyset, counter, etc.) shall be destroyed and an error shall be produced. Refer to section 7.1.4 for details.

7.3.1 Message Authentication

A data message on the CI SAC is protected with an authentication field. The authentication field is computed as follows:

$$authentication = MAC\{SAK\}(length(header\_h_i) \,||\, i \,||\, header\_h_i \,||\, payload\_p_i) \quad \text{Eq. 7.4}$$

Where:

- MAC is the algorithm indicated by the authentication_cipher_flag, refer to section 7.2.2.
- SAK a 128 bit key, as defined in section 7.1.3.
- The authentication is performed over the entire message, with the exception of the authentication field. The parameters used in the computation of the authentication field are defined in Table 7.8.

Table 7.8: Parameters in MAC Computation

Parameter	length	Type
length_h_i	8	uimsbf
i	32	uimsbf
header_h_i	length_h_i * 8	bslbf
payload_p_i	y * 8	bslbf

i – This field contains the message_counter value from the message. Refer to section 7.2.2 for a description of this field.

length_h_i – this parameter is the length of the header in bytes.

header_h_i – this parameter represents the header of the message, see Table 7.4.

payload_p_i – this parameter contains the payload of the message. For computation of the authentication field, the original unencrypted payload shall be used.

7.3.2 Message Encryption

A flag indicates if the payload is encrypted or not. If a SAC message requires encryption, the data is encrypted as follows:

$$encrypted\_payload_i = E\{SEK, SIV\}(payload\_p_i \,||\, authentication\_a_i) \quad \text{Eq. 7.5}$$

Where:

- E is the algorithm indicated by the encryption_cipher_flag, refer to section 7.2.2.
- SEK is a 128 bit key. Refer to section 7.1.3 for details.
- SIV is fixed, 128 bits long and a license constant, refer to the CI Plus Licensee Specification [33]. The SIV must be used at the beginning of each SAC message.
- Authentication a_i shall be computed as described in section 7.3.1.

NOTE: If payload_p_i $\neq$ any multiple of the block cipher size (i.e. 128 bits) the message is padded by adding a 1 (one) bit and then 0 (zeros) bits until the block size is filled. If the payload is not encrypted then padding is not applied.

7.4 Receiving SAC Messages

A data message received by the CI SAC shall be processed as follows:

1) First check that the received message contains the correct message_counter and protocol_version. Refer to section 7.4.1 for details.

2) If payload_encryption_flag = 1, decrypt the encrypted message payload. Refer to section 7.4.2 for exact details.

3) Re-compute the authentication field and verify the integrity of the message. Refer to section 7.4.3 for details.

NOTE: If any of these steps fail, the message and state (e.g. keyset, counter, etc.) shall be destroyed and an error shall be produced. Refer to section 7.1.4.

7.4.1 Message Counter State

The receiving device (CICAM or Host) shall locally maintain a secure message counter for received messages to track the message number of the last message received. On receiving a message from the CI SAC the Host shall update the state of the receiver_message_counter. The receiver_message_counter is 32 bits (as is the message counter field of the message).

Any new message number shall have a strictly increased message number i. The first message shall use number 0x1, the second 0x2, and so on. The receiver shall not accept messages which are out of order.

Correct message number: $(i = receiver\_message\_counter + 1)$

Incorrect message number: $(i \leq receiver\_message\_counter) \vee (i > receiver\_message\_counter + 1)$

An incorrect message number produces a "message order error"; this shall be handled as explained in section 7.1.4

Message limitations:

The number of messages is limited to 2^{32}-1 messages. Where the message number overflows the devices shall stop using the current keys and negotiate new keys (refer to section 7.1.2). The message number, *i*, wraps back to 0x1 (not zero).

NOTE: The CICAM is the only device that is able to decide and initiate follow up actions upon message counter exhaustion. The behaviour is specified in section 7.1.4.

7.4.2 Message Decryption

A data message on the CI SAC may be encrypted. The decryption is as follows:

$$payload\_p_i \,||\, authentication\_a_i = D\{SEK, SIV\}(encrypted\_payload_i) \qquad \text{Eq. 7.6}$$

Where:

- D is the algorithm indicated by the encryption_cipher_flag, refer to section 7.2.2.
- SEK is a 128 bit key. Refer to section 7.1.3 for details.
- SIV is fixed, 128 bits long and a license constant, refer to the CI Plus Licensee Specification [33]. The SIV shall be used at the beginning of each SAC message.
- An incorrect decryption of a message produces a "message decrypt error"; this shall be handled as explained in section 7.1.4

NOTE: authentication_a_i shall be split from payload_p_i where the length of authentication_a_i may be inferred from the value of the authentication_cipher_flag.
The original SAC input data = resulting payload_p_i – authentication_ a_i.
If payload_$p_i \neq$ a multiple of the block cipher size (i.e. 128 bit) the message is padded by adding a 1 (one) and then 0 (zeros) until the block size is filled. If the payload is not encrypted then padding is not applied.

7.4.3 Message Verification

A data message on the CI SAC contains an authentication field. The authentication shall be validated as follows:

$$authentication\_a_i' = MAC\{SAK\}(length(header\_h_i) \,||\, i \,||\, header\_h_i \,||\, payload\_p_i) \quad \text{Eq. 7.7}$$

Where:

- MAC is the algorithm indicated by the authentication_cipher_flag, refer to section 7.2.2.
- SAK a 128 bit key, as defined in section 7.1.3.
- For a description of the remaining parameters refer to section 7.3.1.

NOTE: If the calculated authentication_a_i is not equal to authentication_a_i derived from the decrypted message (in case payload_encryption_flag = 1), or if the calculated a_i is not equal to the authentication field contained in the message (in case payload_encryption_flag =0), the received message m shall be discarded and a message verification error shall be generated and handled as defined in section 7.1.4.

7.5 SAC Integration into CI Plus

The SAC is designed as a multiple purpose protocol and is integrated into the CC resource as explained in Figure 7.9.

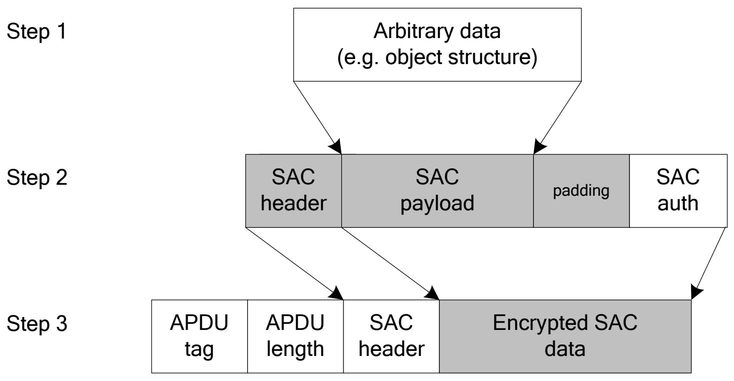


Figure 7.9: SAC message integration

Table 7.9: Data encapsulation into a SAC Message

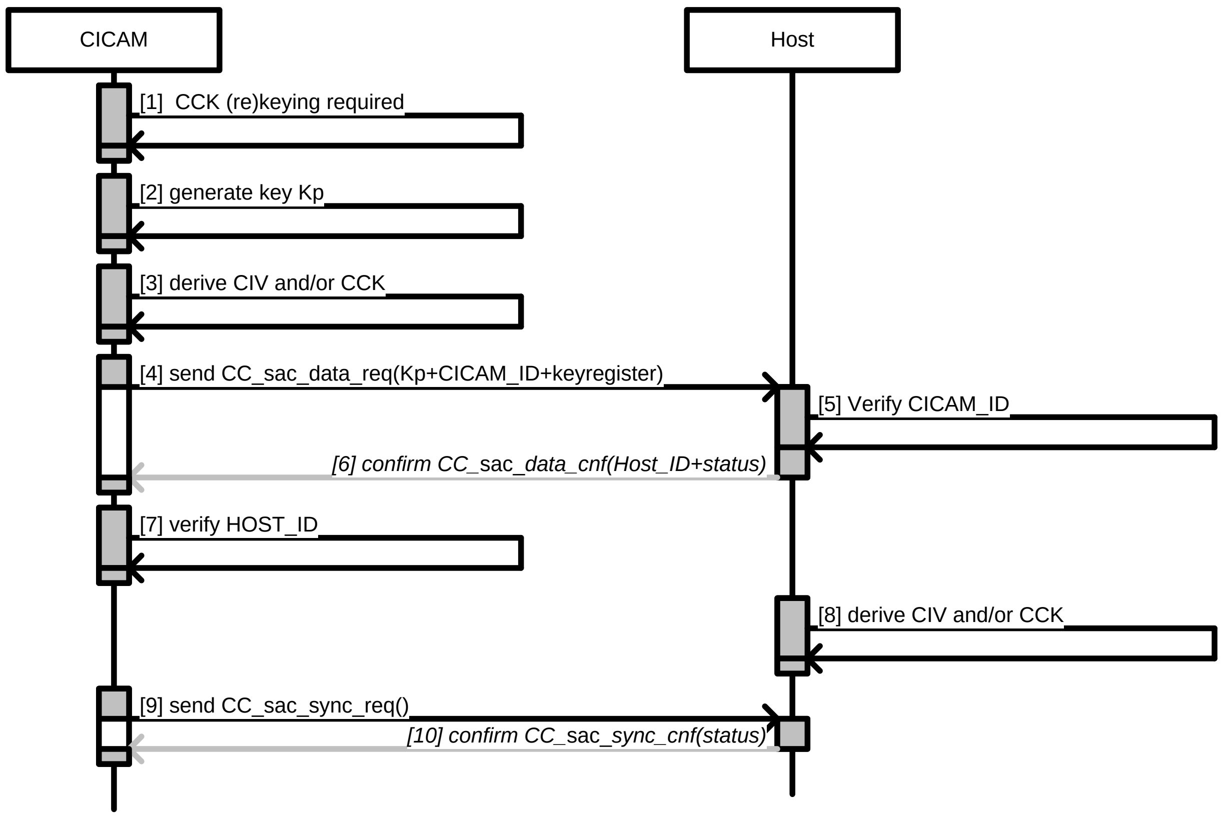
No.	Description	Refer to
1	The system collects the data objects that forms the SAC payload.	Section 11.3.1.7
2	The system authenticates the complete SAC message, comprising the SAC header, SAC payload and padding (if required).	Section 7.3
3	The SAC payload and SAC authentication are encrypted. The encrypted SAC data is appended with the SAC header and the APDU tag and APDU length.	Section 7.5
Note: Refer to Table 11.10 for messages that are transmitted through the SAC		

8 Content Key Calculations

8.1 Content Control Key refresh protocol

8.1.1 Initialization and message overview

The following Figure 8.1 is provided for informative purpose:


CICAM
Host
[1] CCK (re)keying required
[2] generate key Kp
[3] derive CIV and/or CCK
[4] send CC_sac_data_req(Kp+CICAM_ID+keyregister)
[5] Verify CICAM_ID
[6] confirm CC_sac_data_cnf(Host_ID+status)
[7] verify HOST_ID
[8] derive CIV and/or CCK
[9] send CC_sac_sync_req()
[10] confirm CC_sac_sync_cnf(status)

NOTE : This diagram does not suggest that any behaviour be specifically (un)synchronized / (un)blocked.

Figure 8.1: CCK material computation sequence diagram

The process is defined as described in Table 8.1.

Table 8.1: CCK Computation (normative)

No.	Description	Refer to
1	When the CICAM detects that a refresh of the CCK is required, the CICAM shall start the process of CCK initialisation. The exact conditions for (re)keying are specified in the referenced subsection.	Section 8.1.2
2	The CICAM generates a nonce to generate Kp as follows:. $$Kp = SHA_{256}(nonce)$$	Section Annex A.1
3	The CICAM may immediately start to compute the CIV and/or CCK.	Section 8.1.4
4	The CICAM shall send a cc_sac_data_req APDU to the Host, carrying the following parameters: • Kp. • CICAM_ID as extracted from the CICAM device certificate. • selection for odd or even register.	Section 11.3.3.4
5	The Host shall check that the received CICAM_ID is equal to the previously stored CICAM_ID (See Note 5). If they are the same the Host may start computing the CIV and/or CCK. A CICAM_ID verification failure shall constitute in a response of ”no CC support”.	Section 8.1.4
6	The Host shall confirm with the cc_sac_data_cnf APDU to CICAM, carrying the following parameters: • HOST_ID as extracted from the Host device certificate. Failure to respond with cc_data_cnf constitutes a failure of the copy control system.	Section 11.3.3.4
7	The CICAM shall check that the received HOST_ID is equal to the previously stored HOST_ID (See Note 5). If they are the same the CICAM may use the computed CCK and CIV. A Host answer of CC_no support or a HOST_ID verification failure constitutes a failure of the copy control system. See Note 6.	Section 8.1.4
8	The Host may compute the CIV and/or CCK.	Section 8.1.4
9	The CICAM shall send a cc_sac_sync_req APDU to the Host, indicating a CCK refresh. When the CICAM has completed initializing the scrambler, the CICAM shall send a synchronization request to the Host. This informs the Host that the CICAM is ready to start using the newly computed CCK.	Section 11.3.3.4
10	The Host shall use the cc_sac_sync_cnf APDU to confirm to the CICAM to indicate that it is ready to start using the newly computed CCK. Failure to respond with cc_sac_sync_cnf constitutes a failure of the copy control system. See Note 6.	Section 11.3.3.4

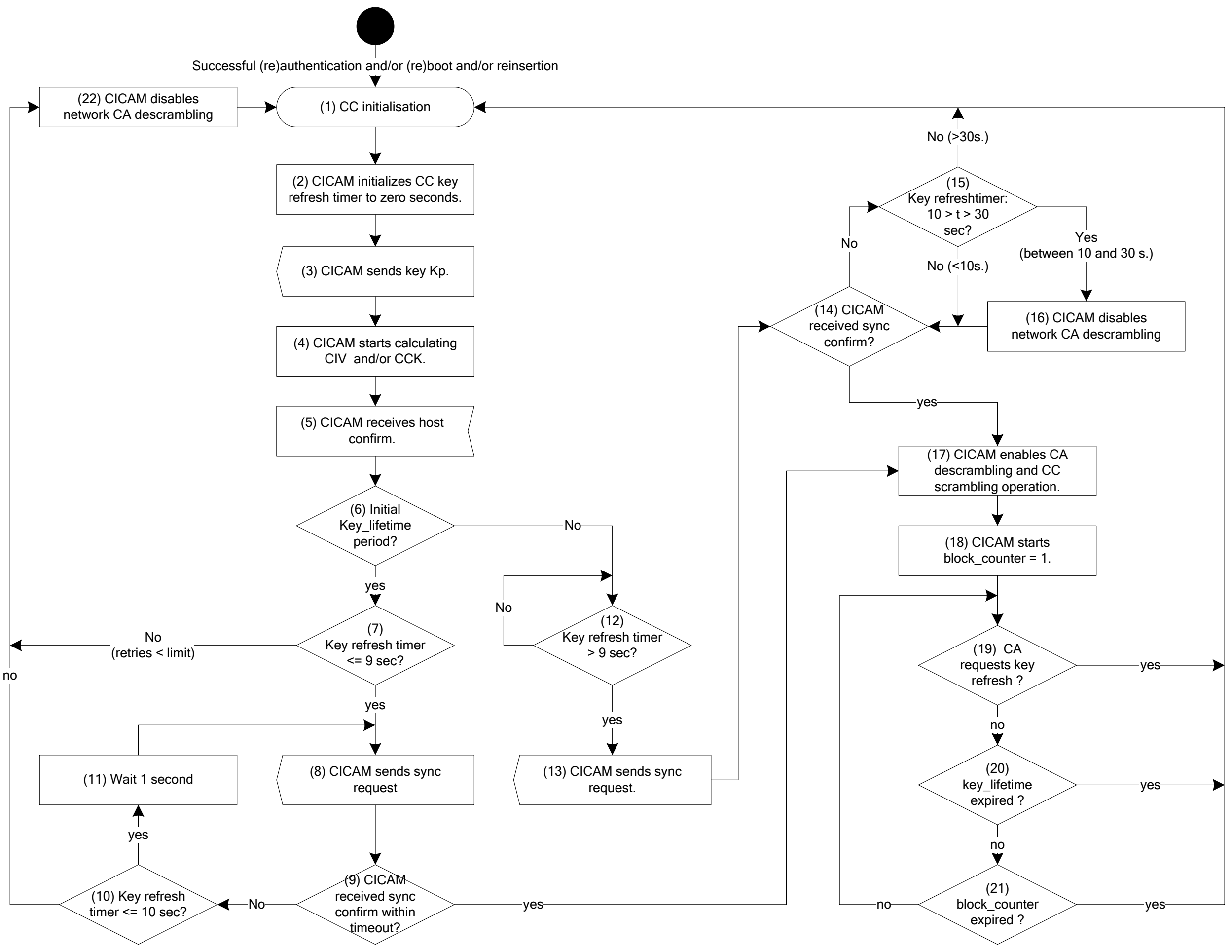
Notes:
1. Once computed, the new key material shall be stored in the appropriate register of the (de)scrambler. Refer to section 5.6 for details.
2. The conditions for CCK refresh are specified in section 8.1.2.
3. Refer to Annex H for an overview of parameters involved.
4. The APDUs that are required in the CCK refresh protocol shall be sent via the SAC; refer to section 7.
5. Previous HOST_ID / CICAM_ID is stored in the 'Authentication Context'. Refer to Section 6.3
6. Refer to section 5.4.3 and Annex F for details on the generic error reporting mechanism.

8.1.2 Content Control Key re-keying conditions

The Content Control Key (CCK) refresh is initiated by the CICAM, whereas the Host is passively replying. The CCK refresh shall be triggered under any of the following conditions:

- After both the authentication and the SAC initialisation process have successfully completed.
- When triggered at the discretion of the CAS.
- When triggered periodically (maximum key lifetime parameter). See Section 8.1.3.
- When block counter limit is overrun (only for AES mode).
- At every reboot.
- At every reset of the CICAM.

The following Figure 8.2 explains the CICAM operation for CCK refresh.


Successful (re)authentication and/or (re)boot and/or reinsertion
(22) CICAM disables network CA descrambling
(1) CC initialisation
(2) CICAM initializes CC key refresh timer to zero seconds.
(3) CICAM sends key Kp.
(4) CICAM starts calculating CIV and/or CCK.
(5) CICAM receives host confirm.
(6) Initial Key_lifetime period?
No
yes
(7) Key refresh timer <= 9 sec?
No (retries < limit)
no
yes
(11) Wait 1 second
yes
(8) CICAM sends sync request
(9) CICAM received sync confirm within timeout?
No
yes
(10) Key refresh timer <= 10 sec?
No
(12) Key refresh timer > 9 sec?
yes
(13) CICAM sends sync request.
No (>30s.)
(15) Key refreshtimer: 10 > t > 30 sec?
No
Yes (between 10 and 30 s.)
No (<10s.)
(14) CICAM received sync confirm?
(16) CICAM disables network CA descrambling
yes
(17) CICAM enables CA descrambling and CC scrambling operation.
(18) CICAM starts block_counter = 1.
(19) CA requests key refresh ?
yes
no
(20) key_lifetime expired ?
yes
no
(21) block_counter expired ?
no
yes

NOTES: 1. The key refresh timer is the timeout upon computing a new CCK; refer to Figure 5.15 for details.
2. The key lifetime is described in Section 8.1.3
3. The block counter limit is defined in Table 8.2
4. The initial key_lifetime is defined as the first key lifetime period (i.e. CCK computation) after SAC (re)initialisation.
5. Start of CC scrambling operation is subject to any URI data associated with the selected service.

Figure 8.2: CICAM operation for CCK refresh (informative)

Table 8.2: Scrambler Block Counter Limits

Scrambler Selection	Block Counter Limit	Comment
DES	N/A	not used
AES	2^{32}	
Note: The block counter limit is the number of cipher blocks that have been processed since the refresh of the CCK.		

Figure 8.3 explains the Host operation for CCK refresh.

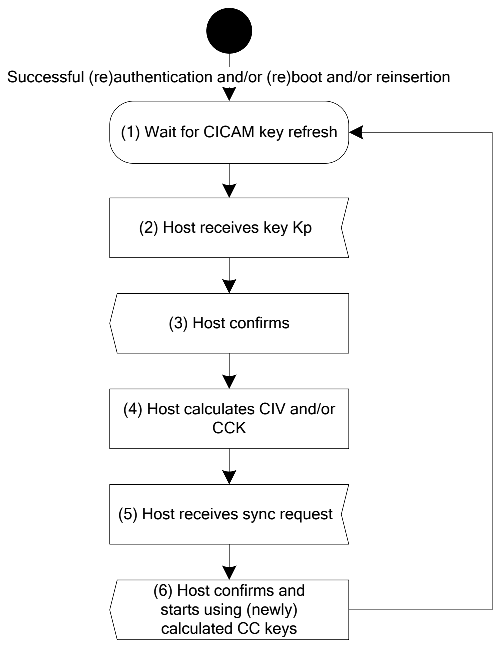

Successful (re)authentication and/or (re)boot and/or reinsertion
(1) Wait for CICAM key refresh
(2) Host receives key Kp
(3) Host confirms
(4) Host calculates CIV and/or CCK
(5) Host receives sync request
(6) Host confirms and starts using (newly) calculated CC keys

Figure 8.3: Host operation for CCK refresh (informative)

8.1.3 Content Key Lifetime

The maximum key lifetime parameter is controlled by the CA system, which is out of scope of this specification. The countdown from this value is maintained by the CICAM which triggers the CCK refresh process.

The countdown proceeds ONLY whilst the CICAM is scrambling content. This ensures that the Content Key is not recalculated when it is not being used.

8.1.4 Content Control Key Computation (CCK)

The scrambler requires a content key (and an IV if required) for its operation: the Content Control Key (CCK) and a Content Initialization Vector (CIV). Computation of CCK (and CIV) proceeds in two steps:

- Key precursor calculation.
- CCK and CIV key derivation.

These are defined as follows:

Step 1: Key precursor calculation.

The Key Precursor Kp is 256 bits long and shall be used for the computation of Km. The process to calculate Kp shall be performed on the CICAM.

The Key Precursor Kp shall be calculated on the CICAM as follows:

$$Kp = \mathrm{SHA}_{256}(\mathrm{nonce}) \qquad \text{Eq. 8.1}$$

Where:

- Input parameters are defined in Table 8.3.

Table 8.3: Input Parameters in Key Computation

Key or variable	Size (bits)	Comments	Refer to
nonce	256	Random nonce of 256 bits generated by the CICAM.	Annex A
Notes: 1. Input is padded according to SHA-256. Refer to FIPS 180-3 [3]. It is advised that SHA implementations adhere to the SHS validation list. See SHS Validation List [11]. 2. The requirements on the random number generator for the nonce are given in Annex A			

Step 2: Key Material computation.

The Key Material Km is 256 bits long and is used for the derivation of the Content Control Key (CCK). The Key Material Km is calculated as follows:

$$CCK, CIV = f - CC(Kp) \qquad \text{Eq. 8.2}$$

Note: the function f-CC is not defined in this document and may be obtained from the CI Plus Licensee Specification [33].

After successful authentication the system will have determined whether the AES or DES cipher will be used to protect the CA-unscrambled content returning to the Host (refer to section 6). The Content Control Key (CCK) and Initialisation Vector (CIV) are derived from the Key Material (Km) in different ways for the AES-128 scrambler and for the DES-56 scrambler.

8.1.5 Content Key for DES-56-ECB Scrambler.

The DES-56 Content Key (CCK_{DES}) is 64 bits. The CCK material from the f-CC is padded with parity bits in the same way as SCTE41 [5], Appendix B into the resultant CCK_{DES}. The CCK_{DES} shall be changed as specified in section 5.6.1.

When DES is used, the CCK shall be used to descramble a TS packet as follows:

$$clear\_packet = D_{DES-56-ECB}\{CCK_{DES}\}(Ts\_Packet) \qquad \text{Eq. 8.3}$$

NOTE: Refer to section 5.6.2.2 for the detailed specification of the DES (de)scrambler.

8.1.6 Content Key and IV for AES-128-CBC Scrambler.

The AES-128 Content Key (CCKAES) is 128 bits long. When AES is used, the CCK and CIV are applied to AES to descramble a TS packet as follows:

$$clear\_packet = D_{AES-128-CBC}\{CCK_{AES}\}\{CIV\}(Ts\_Packet) \qquad \text{Eq. 8.4}$$

Where:

- The CCK_{AES} shall change as specified in section 5.6.1. Additionally, the CCK_{AES} shall be changed after processing 2^{32} AES blocks.
- The CIV is fixed for every key lifetime period and shall change when the CCK changes. The current CIV shall be re-used at the start of every MPEG2 TS packet.

NOTE: Refer to section 5.6.2.3 for the detailed specification of the AES (de)scrambler.

9 PKI and Certificate Details

9.1 Introduction

The authentication between a CI Plus Host and module includes the exchange of certificates. A device certificate of a Host or module serves three purposes:

- prove that the device is compliant with the CI Plus specification
- provide an RSA public key of the device. This key is used for verification of the device's Diffie-Hellman public key during the authentication protocol, see Figure 6.2 and Table 6.1
- convey the device scrambler capabilities

Each service provider that broadcasts CI Plus services has a Service operator certificate. This certificate is used by the CICAM to verify the integrity of revocation lists that it receives from the broadcast.

9.2 Certificate Management Architecture

The CI Plus trust hierarchy is organized as a tree structure with a single Root of Trust (ROT). There is only one tree for all participants in CI Plus, See Figure 9.1.

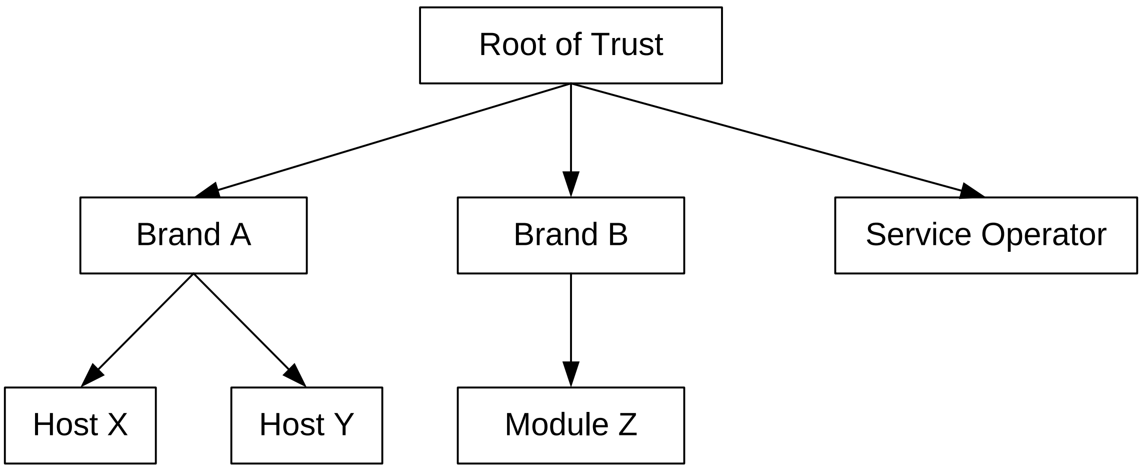


Figure 9.1: Certificate Hierarchy Tree

There are four different types of certificates.

- Root certificate
  - issued by the ROT
  - self-signed
  - only one root certificate exists for all of CI Plus
- Brand certificate
  - issued by the ROT
  - signed with the private key of the root certificate
  - one certificate of this type exists for each brand (or manufacturer)
- Device certificate
  - issued by the ROT

  - signed with the private key of the brand certificate
  - each single device has a unique device certificate
- Service operator certificate
  - issued by the ROT
  - signed with the private key of the root certificate
  - one certificate of this type exists for each service operator

Each certificate contains a public key for which there is a corresponding private key.

Each Host and module device shall integrate the following certificate related information at manufacturing time.

- the CI Plus root certificate
- the brand certificate
- the device certificate
- the private key corresponding to the device certificate (MDQ or HDQ, see Table 5.2)

The service operator certificate is broadcast and unlike other certificates it does not have to be integrated into the Host or CICAM at manufacture.

9.3 Certificate Format

All CI Plus certificates are based on the Internet Profile of X.509, defined in RFC 3280 [19]. The Multimedia Home Platform (MHP) Specification 1.0.3, TS 101 812 [9], section 12.11 provides a good overview of certificate encoding.

For informational purposes, the ASN.1 definition of an X.509 certificate, taken from RFC 3280 [19], section 4.1, is reproduced below:

```
Certificate ::= SEQUENCE {
     tbsCertificate     TBSCertificate,
     signatureAlgorithm AlgorithmIdentifier,
     signatureValue BIT STRING }

TBSCertificate ::= SEQUENCE {
     version        [0]   EXPLICIT Version DEFAULT v1,
     serialNumber         CertificateSerialNumber,
     signature            AlgorithmIdentifier,
     issuer               Name,
     validity             Validity,
     subject              Name,
     subjectPublicKeyInfo SubjectPublicKeyInfo,
     issuerUniqueID [1]   IMPLICIT UniqueIdentifier OPTIONAL,
                          -- If present, version MUST be v2 or v3
     subjectUniqueID[2]   IMPLICIT UniqueIdentifier OPTIONAL,
                          -- If present, version MUST be v2 or v3
     extensions     [3]   EXPLICIT Extensions OPTIONAL
                          -- If present, version MUST be v3
}

Version ::= INTEGER { v1(0), v2(1), v3(2) }

CertificateSerialNumber ::= INTEGER

Validity ::= SEQUENCE {
    notBefore Time,
    notAfter Time }

Time ::= CHOICE {
     utcTime UTCTime,
     generalTime GeneralizedTime }

UniqueIdentifier ::= BIT STRING
```

```
SubjectPublicKeyInfo ::= SEQUENCE {
     algorithm AlgorithmIdentifier,
     subjectPublicKey BIT STRING }

Extensions ::= SEQUENCE SIZE (1..MAX) OF Extension

Extension ::= SEQUENCE {
     extnID OBJECT IDENTIFIER,
     critical BOOLEAN DEFAULT FALSE,
     extnValue OCTET STRING }
```

This section explains the fields and extensions that are used in the CI Plus specification.

9.3.1 version

CI Plus implementations shall use X.509 version 3.

9.3.2 serialNumber

Each certificate shall include a unique serial number which shall be assigned by the issuer of the certificate.

9.3.3 signature

All certificates use RSASSA-PSS signatures as defined in PKCS1v2.1 [1], section 8.1.1.

Table 9.1: Certificate Signature Algorithm

Parameter	Value
hashAlgorithm	SHA-1
maskGenAlgorithm	MGF1 using SHA-1
saltLength	20 bytes
trailerField	one byte: 0xbc

The corresponding ASN.1 object identifiers are:

```
id-RSASSA-PSS OBJECT IDENTIFIER ::= { pkcs-1 10 }

pkcs-1 OBJECT IDENTIFIER ::= {
       iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) 1 }


rSASSA-PSS-Default-Params RSASSA-PSS-Params ::= {
       sha1Identifier, mgf1SHA1Identifier, 20, 1}

sha1Identifier AlgorithmIdentifier ::= { id-sha1, NULL }

id-sha1 OBJECT IDENTIFIER ::= {
       iso(1) identified-organization(3) oiw(14) secsig(3) algorithms(2) 26 }

mgf1SHA1Identifier AlgorithmIdentifier ::= { id-mgf1, sha1Identifier }
```

9.3.4 issuer

CI Plus certificates (like all other X.509 certificates) use an X.501 [22] distinguished name in the issuer field. Table 9.2 shows the issuer field for the different certificate types.

Table 9.2: Certificate Issuer

Certificate type	Issuer
Root certificate	C: <country where the ROT is located> ST: <state where the ROT is located> L: <city where the ROT is located> O: <name of the ROT> OU: <department of the ROT that is responsible for CI Plus certificates> OU: "test" or "production" CN: "CI Plus Root CA certificate"
Brand certificate	C: <country where the ROT is located> ST: <state where the ROT is located> L: <city where the ROT is located> O: <name of the ROT> OU: <department of the ROT that is responsible for CI Plus certificates> OU: "test" or "production" CN: "CI Plus Root CA certificate"
Device certificate	C: <country where the brand is located> ST: <state where the brand is located> L: <city where the brand is located> O: <name of the brand> OU: "test" or "production" CN: "CI Plus ROT for" <name of the brand>
Service operator certificate	C: <country where the ROT is located> ST: <state where the ROT is located> L: <city where the ROT is located> O: <name of the ROT> OU: <department of the ROT that is responsible for CI Plus certificates> OU: "test" or "production" CN: "CI Plus Root CA certificate"

The X.501 attributes used by CI Plus are Country (C), State (ST), Location (L), Organization Name (O), Organizational Unit Name (OU) and Common Name (CN). Please note that the same attribute may appear in a name multiple times.

The ASN.1 encoding of an X.501 distinguished name is defined in RFC 3280 [19], section 4.1.2.4. All attribute values may be encoded as PrintableString or UTF8String.

9.3.5 validity

The validity of the certificate must exceed the expected lifetime of the device. The CI Plus specification does not include a method to replace root, brand or device certificates. A service operator certificate is received via the broadcast and may be easily updated; its lifetime may be considerably shorter than that of the other certificates.

Definition of the exact lifetimes for the certificates is out of scope of this specification.

The time in the fields notBefore and notAfter shall be encoded as UTC Time and shall include seconds, i.e. the format is YYMMDDHHMMSSZ. The year field shall be interpreted as 20YY.

9.3.6 subject

The subject is an X.501 [22] distinguished name and uses the same encoding as the issuer field.

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Table 9.3: Certificate Subject

Certificate type	Subject
Root certificate	C: <country where the ROT is located> ST: <state where the ROT is located> L: <city where the ROT is located> O: <name of the ROT> OU: <department of the ROT that is responsible for CI Plus certificates> OU: "test" or "production" CN: "CI Plus Root CA certificate"
Brand certificate	C: <country where the brand is located> ST: <state where the brand is located> L: <city where the brand is located> O: <name of the brand> OU: "test" or "production" CN: "CI Plus ROT for" <brand name>
Device certificate	C: <country where the brand is located> ST: <state where the brand is located> L: <city where the brand is located> O: <name of the brand> OU: <product name> (optional) OU: "test" or "production" CN: <device ID>
Service operator certificate	C: <country where the operator is located> ST: <state where the operator is located> L: <city where the operator is located> O: <name of the operator> OU: "test" or "production" CN: <service operator ID>

The device ID is a hexadecimal number that consists of 16 digits. To store this number in an X.501 Common Name (CN) attribute, it must be converted into a string. Each digit is represented by the corresponding ASCII code, i.e. 1 is written as 0x31 and 7 as 0x37. For the hexadecimal digits A to F, uppercase letters are used (hex values 0x41 to 0x46).

For details about the content of the device ID, refer to the CI Plus Licensee Specification [33].

The service operator ID is a hexadecimal number that consists of 16 digits. It is encoded in the same way as the device ID. The service operator ID is used for linking a service operator certificate to the Revocation Signalling Data file (RSD), see section 3.1.4 of CI Plus Supplementary Specification [37].

9.3.7 subjectPublicKeyInfo

The algorithm is RSA using the ASN.1 object identifier

```
rsaEncryption OBJECT IDENTIFIER ::= { pkcs-1 1}

pkcs-1 OBJECT IDENTIFIER ::= {
   iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) 1 }
```

The parameters field shall have ASN.1 type NULL.

The RSA key's public exponent shall be 65537 == 0x10001, the modulus length shall be 2048 bits. Refer to RFC 3280 [19], section 4.1.2.7 for encoding of the public key.

9.3.8 issuerUniqueID and subjectUniqueID

The issuerUniqueID and subjectUniqueID parameters are defined in RFC 3280 [19], section 4.1.2.8. CI Plus certificates shall not use unique identifiers.

9.3.9 extensions

Certificates for CI Plus use some standard extensions as defined in RFC 3280 [19] and two private extensions that are specific to CI Plus. The following table lists the mandatory extensions for each certificate type:

Table 9.4: Certificate Extensions

Certificate Type	Mandatory Extensions
Root certificate	key usage subject key identifier basic constraints
Brand certificate	key usage subject key identifier authority key identifier basic constraints
Device certificate	key usage authority key identifier basic constraints scrambler capabilities CI Plus info (optional) CICAM brand identifier (CICAM only)
Service operator certificate	key usage authority key identifier basic constraints

All other extensions may be used as defined in RFC 3280 [19] and they shall not be marked as critical. CI Plus compliant Hosts and CICAMs may ignore these extensions when parsing and verifying a certificate.

9.3.9.1 Subject Key Identifier

The subject key identifier shall be calculated according to proposal (1) in RFC 3280 [19], section 4.2.1.2.

9.3.9.2 Authority Key Identifier

The Authority Key Identifier extension is defined in RFC 3280 [19], section 4.2.1.1. The keyIdentifier field shall be calculated according to proposal (1) in RFC 3280 [19], section 4.2.1.2.

9.3.9.3 Key usage

The key usage extension is defined in RFC 3280 [19], section 4.2.1.3 and shall always be present and marked as critical. The value of KeyUsage depends on the certificate type as shown in Table 9.5.

Table 9.5: Key Usage Values for Certificate Types

Certificate Type	Key Usage
Root certificate	keyCertSign crlSign
Brand certificate	keyCertSign
Device certificate	digitalSignature
Service operator certificate	cRLSign digitalSignature

9.3.9.4 Basic constraints

The basic constraints extension is defined in RFC 3280 [19], section 4.2.1.10. The values shall be set as follows:

Table 9.6: Extension Fields

Certificate Type	cA	pathLenConstraint
Root certificate	True	1
Brand certificate	True	0
Device certificate	False	-
Service operator certificate	False	-

9.3.9.5 Scrambler capabilities

Scrambler capabilities is a private extension for CI Plus, it shall be present in each device certificate and marked as critical. The ASN.1 definition is defined as

```
id-pe-scramblerCapabilities OBJECT IDENTIFIER ::= { id-pe 25 }
id-pe ::= {
   iso(1) identified-organization(3) dod(6) internet(1) security(5)
   mechanisms(5) pkix(7) 1 }

ScramblerCapabilities ::= SEQUENCE {
     capability   INTEGER (0..MAX),
     version      INTEGER (0..MAX) }
```

The following values are supported for capability

Table 9.7: Capabilities Supported

Value	Meaning
0	DES
1	DES and AES
all others	reserved for future use

The version field is used to further distinguish different scrambler capabilities. See the CI Plus Licensee Specification [33] for further details.

9.3.9.6 CI Plus info

The optional CI Plus info private extension conveys additional information about a CI Plus device. This extension shall be present in a device certificate only and shall not be declared as critical.

This is its ASN.1 definition

```
id-pe-ciplusInfo OBJECT IDENTIFIER ::= { id-pe 26 }
id-pe ::= {
   iso(1) identified-organization(3) dod(6) internet(1) security(5)
   mechanisms(5) pkix(7) 1 }

CiplusInfo ::= BIT STRING
```

The content of CiplusInfo is undefined by this specification and may be used by future profile extensions.

9.3.9.7 CICAM brand identifier

The CICAM brand identifier private extension conveys the identity of the CICAM manufacturer in the CI Plus device certificate which should be matched with the broadcast stream for the Host shunning mechanism (See section 10.1.1). This extension shall not be declared as critical. The extension shall be present in a CICAM device certificate.

The ASN.1 definition is defined as:

```
id-pe-cicamBrandId OBJECT INDENTIFIER ::= { id-pe 27 }
id-pe ::= {
   iso(1) identified-organization(3) dod(6) internet(1) security(5)
   mechanisms(5) pkix(7) 1 }
```

CicamBrandId ::= INTEGER (1..65535)

9.3.10 signatureAlgorithm

This field is identical to signature, see section 9.3.3

9.3.11 signatureValue

This field is defined in RFC 3280 [19], section 4.1.1.3

9.4 Certificate Verification

During the authentication process (see section 6), the chains of certificates are exchanged and each device verifies the opposite's chain. This section explains the verification process.

The CI Plus Root Certificate is stored in each device, during the authentication process, only the brand and the device certificate are exchanged, the root certificate is never exchanged by any device.

9.4.1 Verification of the brand certificate

The following steps must be performed in order to verify the brand certificate.

1) Check that the Issuer of the brand certificate is identical to the Subject of the root certificate.
2) Check that the validity period of the brand certificate includes the current date and time.
3) Check that each mandatory extension listed in section 9.3.9 exists and the values are valid. Check that no other extension is marked as critical.
4) Verify that the KeyIdentifier in the brand certificate's authority key identifier extension is identical to the KeyIdentifier in the root certificate's subject key identifier extension.
5) Verify the certificate's signature by using the RSASSA-PSS verification described in RSA PKCS#1 [1], section 8.1.2.

Table 9.8: Brand Certificate verification

Parameter	Value
signer's RSA public key	subjectPublicKeyInfo of the Root Certificate
message to be verified	TBSCertificate of the brand certificate (see RFC 3280 [19], section 4.1)
signature to be verified	signatureValue of the brand certificate

9.4.2 Verification of the device certificate

When the brand certificate is determined to be valid, the device certificate is checked. The process is similar to the brand certificate verification.

1) Check that the Issuer of the device certificate is identical to the Subject of the brand certificate.
2) Check that the validity period of the device certificate includes the current time.
3) Check that each extension listed in section 9.3.9 exists and their values are valid values listed there. Check that no other extension is marked as critical.
   Check that the CICAM brand identifier extension is present in the CICAM device certificate and that it contains valid values according to section 9.3.9.7.

   Note: Although this extension is not marked critical certificate verification shall fail if this extension is not present or contains an invalid value.
4) Verify that the KeyIdentifier in the device certificate's authority key identifier extension is identical to the KeyIdentifier in the brand certificate's subject key identifier extension.
5) Verify the certificate's signature by using the RSASSA-PSS verification described in PKCS#1 v2.1 [1], section 8.1.2.

Table 9.9: Device Certificate verification

Parameter	Value
signer's RSA public key	subjectPublicKeyInfo of the brand certificate
message to be verified	TBSCertificate of the device certificate (see RFC3280 [19], section 4.1)
signature to be verified	signatureValue of the device certificate

6) Ensure that the device certificate has not been revoked, this is only performed by the CICAM on checking the Host certificate.

7) Verify that the device ID (which is part of the Subject field) contains a valid value. See Annex B for details.

Details about revocation list checking can be found in the CI Plus Licensee Specification [33].

9.4.3 Verification of the service operator certificate

To verify a service operator certificate, received from the broadcast, the following steps must be performed:

1) Check the Issuer of the service operator certificate is identical to the Subject of the root certificate.

2) Check the validity period of the service operator certificate includes the current date and time.

3) Check that each mandatory extension listed in section 9.3.9 exists and the values are valid. Check that no other extension is marked as critical.

4) Verify that the KeyIdentifier in the service operator certificate's authority key identifier extension is identical to the KeyIdentifier in the root certificate's subject key identifier extension.

5) Verify the certificate's signature by using the RSASSA-PSS verification described in RSA PKCS#1 [1], section 8.1.2.

Table 9.10: Service Operators Certificate verification

Parameter	Value
signer's RSA public key	subjectPublicKeyInfo of the Root certificate
message to be verified	TBSCertificate of the service operator certificate (see RFC3280 [19], section 4.1)
signature to be verified	signatureValue of the service operator certificate

6) Verify that the numerical representation of the service operator ID in the Subject matches the service_operator_identity of the Revocation Signalling Data (RSD) file on the current multiplex.

10 Host Service Shunning

Host Service Shunning allows the Service Operator to inform the Host of services that require CI Plus protection allowing the Host to prevent the display of content when the CICAM is not CI Plus conformant. Host Service Shunning ensures that DVB CICAMs are not able to display content on services where they are not permitted.

10.1 CI Plus Protected Service Signalling

The CI Plus Protected Service Signalling is carried in the Service Description Table (SDT_{Actual}) for the actual multiplex, as specified in EN 300 468 [10]. A CI Plus protected service is signalled by the inclusion of a CI Plus private data specifier and private ci_protection_descriptor in the service descriptor loop of SDT_{Actual}. The descriptor defines whether the service is CI Plus enabled and may optionally constrain the Host to operate with a specific brand of CI Plus CICAM.

The CI Plus Protection Service Signalling is a quasi-static state attribute of the service and shall not change on an event basis. A service may switch between clear and scrambled on an event basis. Host Service Shunning checking is operative on all services, both FTA and CA scrambled, when any CICAM is present in a Host device ensuring that service shunning broadcast signalling is always honoured.

10.1.1 CI Protection Descriptor

The CI protection descriptor (See Table 10.1) provides a means of indicating the CI operating mode required by a service. It shall be inserted at most once in the service descriptor loop of the $\mathrm{SDT}_{\mathrm{Actual}}$ and shall be preceded by a CI Plus private data specifier descriptor according to EN 300 468 [10].

Table 10.1: CI protection descriptor

Syntax	No. of bits	Mnemonic
`ci_protection_descriptor(){`		
`descriptor_tag`	8	uimsbf
`descriptor_length`	8	uimsbf
`free_ci_mode_flag`	1	bslbf
`match_brand_flag`	1	bslbf
`reserved_future_use`	6	bslbf
`if(match_brand_flag == 1) {`		
`number_of_entries`	8	uimsbf
`for(i=0; i<n; i++) {`		
`cicam_brand_identifier`	16	uimsbf
`}`		
`}`		
`for(i=0; i<n; i++) {`		
`private_data_byte`	8	uimsbf
`}`		
`}`		

10.1.1.1 CI Protection Descriptor

descriptor_tag: The descriptor_tag for the ci_protection_descriptor is 0xCE.

descriptor_length: The descriptor length is an 8-bit field specifying the total number of bytes of the data portion of the ci_protection_descriptor following the byte defining the value of this field.

free_ci_mode_flag: This is a 1-bit field identifying the CI operating mode. When set to "0", indicates that all of the component streams of the service do not require CI Plus protection. When set to "1", indicates that all of the component streams of the service require CI Plus protection if they are not transmitted in the clear on the broadcast network.

match_brand_flag: This is a 1-bit field signifying that the descriptor includes a list of cicam_brand_identifiers. When set to "0", indicates that this service has no chosen CICAM brands. When set to "1", indicates that this service has chosen to set CICAM brands. The match_brand_flag is only interpreted when the free_ci_mode_flag is set to "1".

reserved_future_use: Reserved bits shall be "1".

number_of_entries: This field specifies the number of cicam_brand_identifiers that are contained in the brand identifier loop. When match_brand_flag field has been set to 1, the number_of_entries shall be $\neq 0$.

cicam_brand_identifier: This is a 16-bit field that identifies the CICAM brands that may be used with the service.

When no CICAM brand identifiers are present, any CI Plus CICAM may be used with the Host. When one or more CICAM brand identifiers are specified, the Host shall only operate with a CI Plus CICAM device whose Device Certificate cicamBrandId matches the cicam_brand_identifier. If none of the cicam_brand_identifiers present are matched with the CICAM device certificate then the CICAM shall be shunned for this service. The cicam_brand_identifier value 0x0000 is reserved and shall not be used.

private_data_byte: This is included for future extensions to Host Service Shunning. For this version of the specification is undefined and if present shall be ignored.

10.1.1.2 Private Data Specifier Descriptor

The Private Data Specifier descriptor (see EN 300 468 [10], Private Data Specifier descriptor) shall precede the ci_protection_descriptor in the SDT_{Actual} descriptor loop. The private data specifier value is defined in the CI Plus Licensee Specification [33].

10.2 Trusted Reception

The Host shall have only two CICAM transport stream routing modes:

1) by-pass mode; the MPEG-2 TS shall be routed directly to the Host demux.

2) pass-through mode; the MPEG-2 TS shall be routed through the CICAM to the Host demux.

There are two trusted reception modes for receiving SDT_{Actual}. The first is where one or more non CI Plus CICAMs are inserted in the Host; in this case the Host shall receive the MPEG2 TS in by-pass mode to determine if CI Plus protection is required for this service. This is required because the data path through the non CI Plus CICAM is not trusted.

The second is where the Host only has a CI Plus CICAMs inserted; in this case the Host may trust the MPEG2 TS being received from the CI Plus CICAM and pass-through mode may be used.

While receiving an MPEG-2 TS in one of the two trusted reception modes, the Host shall attempt to acquire the SDT_{Actual}. If the Host receives the MPEG-2 TS but the SDT_{Actual} is not acquired, after 5 seconds the Host may switch to service shunning in-active. The Host shall be in receipt of a valid MPEG-TS before starting the 5 second timer to determine if SDT_{Actual} is absent.

The conceptual hardware operation for Host by-pass and CICAM pass-through modes is depicted in Figure 10.1 which considers the transport stream source as switchable under Host control. The figure is informative and other hardware solutions may be used that produce the same effect.

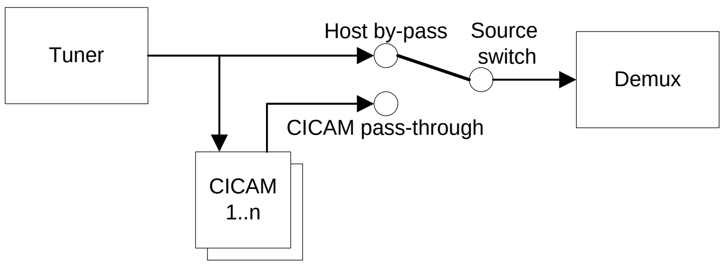


Figure 10.1: Conceptual bypass operation (Informative)

The CI Plus Protected Service signalling of a service is quasi-static and the CI Plus state may be cached by the Host. The Host shall periodically re-confirm the CI Plus service state by inspection of SDT_{Actual} using a trusted reception mode.

If the Host caches the CI Plus Protected Service signalling, it shall only cache it for a maximum of 7 days after which the data shall be deleted and renewed by appropriate acquisition of SDT_{Actual}. The 7-day cache implies that a Host may take up to 7 days to react to a change in the broadcast network CI Plus state.

10.3 CI Plus Protection Service Mode

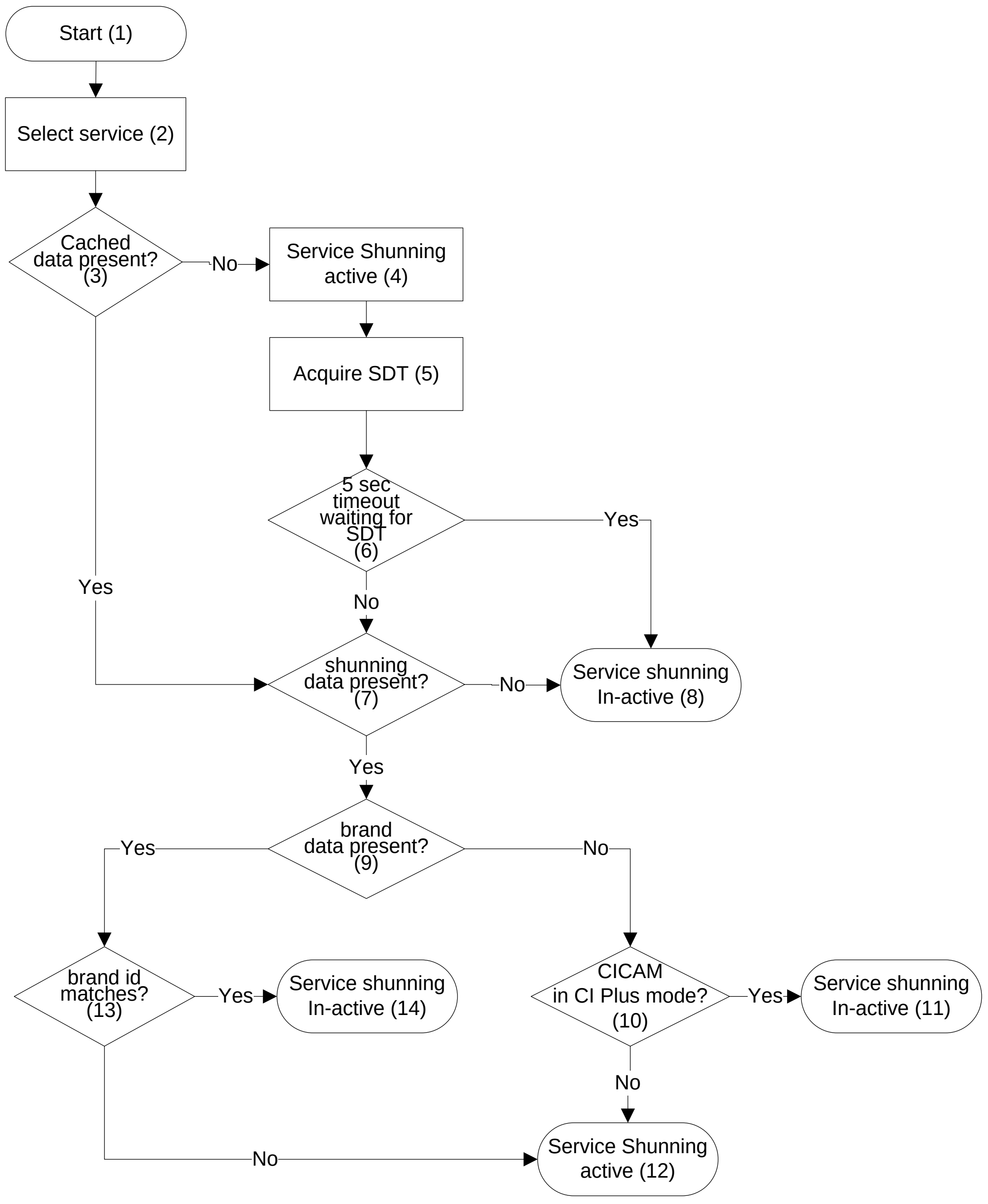
The CI Plus Protected Service modes are defined as:

Table 10.2: CI Plus Protected Service modes

Signalling	CICAM-type	Service Shunning Operating Mode
ci_protection_descriptor absent (See note 1)	DVB CI and CI Plus	in-active
ci_protection_descriptor present and free_CI_mode is "0"	DVB CI and CI Plus	in-active
ci_protection_descriptor present and free_CI_mode is "1"	DVB CI	active
ci_protection_descriptor present, free_CI_mode is "1" and match_brand_flag = "0" or number_of_entries = "0"	CI Plus	in-active
ci_protection_descriptor present, free_CI_mode is "1", match_brand_flag = "1" and number_of_entries ≠ "0" and CICAM brand identifier not matched	CI Plus	active
ci_protection_descriptor present, free_CI_mode is "1", match_brand_flag = "1" and number_of_entries ≠ "0" and CICAM brand identifier matched	CI Plus	in-active
Notes: 1. Failure to acquire the $\text{SDT}_{\text{Actual}}$ in a trusted reception mode then the Host may assume that the ci_protection_descriptor is absent and shall assume an in-active service shunning operating mode.		

10.4 Service Shunning

Each time the Host device selects any service the Host device shall use the stream or cached CI Plus state from $\text{SDT}_{\text{Actual}}$ to determine how the CICAM shall operate with the selected service. An informative overview of the operation is shown in Figure 10.2, caching may be optionally implemented by the receiver.


Start (1)
Select service (2)
Cached data present? (3)
No
Service Shunning active (4)
Acquire SDT (5)
5 sec timeout waiting for SDT (6)
Yes
No
Yes
shunning data present? (7)
No
Service shunning In-active (8)
Yes
brand data present? (9)
Yes
No
brand id matches? (13)
Yes
Service shunning In-active (14)
CICAM in CI Plus mode? (10)
Yes
Service shunning In-active (11)
No
Service Shunning active (12)
No

Note1: Check at step (7): is CI_protection descriptor absent or (if present) is field "free_ci_mode_flag" = 1?

Note2: Check at step (9): is field "match_brand_flag" = 1 and is field "brand_identifier_length" > 0 (zero)?

Figure 10.2: Shunning Operation

Whenever the Host is operational (1) and selects any service (2). The Host checks if the cached CI Plus Protected Service signalling data is present (3). If not the Host prepares for a Host shunning check and shall not instruct the CICAM to descramble the service (4). The Host switches to a trusted reception mode and acquires SDT_{Actual} and determines the Host shunning state using the CI Protection descriptor if present (5). The Host attempts to acquire the SDT_{Actual}, if the SDT_{Actual} is not acquired after 5 seconds then service shunning is In-active (8). The Host checks whether the service shunning state is active (7). If the CI_protection_descriptor is absent or (if present) the free_CI_mode_flag is set to "0" then Service Shunning is In-active (8). If the CI protection descriptor is present and free_CI_mode_flag is set to "1" then the Host shall continue to check if brand data is present (9). If the match_brand_flag is set to "0" or the list_length is set to 0 (zero) then the Host determines that the brand data is absent and continues to check if the CICAM operating in a CI Plus mode (10). If the CICAM is operating in CI Plus mode then Service shunning is In-active for the service (11), the CICAM is operating in a non CI Plus mode then service shunning is activated for the service (12). However, if in step 9 the match_brand flag is "1" and list length is not equal to "0" the Host checks if the identifier of the CICAM and a cicam_brand_identifier signalled by the service match (13), if the identifiers do not match then service shunning is Active (12). If a cicam_brand identifier does match the CICAM then service shunning is In-active (14).

10.4.1 Service Shunning In-active

Service Shunning In-active is the condition where the active or current CICAM is allowed to descramble the service. In this case the service may allow DVB CICAMs or the current CICAM is CI Plus conformant and the brand_identifier matches the service operating requirements (if applicable). See Figure 10.2 for more on service shunning in-active.

Whilst in a Service Shunning in-active operating mode the Host is required to appropriately reacquire $\text{SDT}_{\text{Actual}}$ from the broadcast stream to obtain the CI Plus operating state if any cached CI Plus status is older than 7-days, this may require the Host to interrupt the currently viewed service.

10.4.2 Service Shunning Active

Service Shunning Active is the condition where the active or current CICAM is not allowed to descramble the service. In this case the CICAM may not be CI Plus compliant or the CICAM brand does not match the service signalling. Service shunning may also be temporarily activated while the Host performs trusted SDT acquisition and acquires the CI Protection descriptor for the selected service. See Figure 10.2 for more on service shunning active.

Service Shunning Active shall be implemented by the Host initiating by-pass mode. If the TS is still routed to the CICAM in this mode the Host shall not send a CA_PMT to the CICAM.

When the shunning state changes from "active" to "inactive", the Host shall immediately send a CA_PMT to the CICAM.

11 Command Interface

This section explains the new resources in CI Plus. Changes to the existing application information resource are also included in this section.

11.1 Application Information resource

11.1.1 Application Information Version 3

Application Information Resource version 3 (see Table L1 in Annex L for resource ID) adds new commands for CICAM reset and Host PCMCIA bus data rate limits.

11.1.2 Request CICAM Reset

When a condition occurs that requires the CICAM to request a physical CICAM reset, it shall send a request_cicam_reset APDU.

11.1.2.1 request_cicam_reset APDU

On receipt of this request, the Host shall physically reset the CICAM within 10 seconds. After sending the request_cicam_reset command the CICAM shall not send any other APDUs to the Host.

Table 11.1: Request CICAM Reset APDU Syntax

Syntax	No. of bits	Mnemonic
`request_cicam_reset() {`		
`   request_cicam_reset_tag`	24	uimsbf
`   length_field() = 0`		
`}`		

request_cicam_reset_tag: The value for this tag may be found in Table L.1 in Annex L.

length_field: Length of APDU payload in ASN.1 BER format, see EN 50221 [7], chapter 8.3.1.

Note: The CICAM may also request that the physical interface be re-initialized using the IIR bit of the status register. Support for the IIR bit is optional in CI Plus and is explained in the following section.

11.1.2.2 Reset request using the IIR bit

An additional bit called IIR (initialize interface request) is added to the status register, see Table 11.2 below. The CICAM sets this bit to request a physical interface reset. After setting the IIR bit, the CICAM shall not send any other APDUs to the Host. The CICAM clears the IIR bit when the Host sets the RS bit during the reset.

Table 11.2: Status Register including IIR

Bit	7	6	5	4	3	2	1	0
	DA	FR	R	IIR	R	R	WE	RE

Note: DA, FR, WE and RE bits are unchanged, see EN 50221 [7], annex A.2.2.1.

11.1.3 Data rate on the PCMCIA bus

The CI Plus specification supports two different data rates on the PCMCIA bus: 72 Mbit/s and 96 Mbit/s. CICAMs must support 96 Mbit/s. Hosts must support 72 Mbit/s, support for 96 Mbit/s is optional.

11.1.3.1 data_rate_info APDU

The Host sends a data_rate_info APDU to inform the CICAM about the maximum data rate it supports. Typically, a data_rate_info APDU is sent after the initial application_info_enq and application_info messages. The CICAM must not exceed an output data rate of 72 Mbit/s until it has received a data_rate_info message from the Host. If data_rate_info APDU is not sent by the Host then the maximum data rate supported by the Host is 72Mbit/s.

Table 11.3: data_rate_info APDU Syntax

Syntax	No. of bits	Mnemonic
`data_rate_info() {`		
`   data_rate_info_tag`	24	uimsbf
`   length_field() = 1`		
`   data_rate`	8	uimsbf
`}`		

data_rate_info: The value for this tag is 0x9F8024.

data_rate: This value specifies the maximum PCMCIA data rate supported by the Host. Table 11.4 lists the possible values.

Table 11.4: possible values for data_rate

maximum PCMCIA data rate	value
72 Mbit/s	00
96 Mbit/s	01
reserved	other values

11.2 Host Language and Country resource

The Host uses the Host language and country resource to inform the CICAM about its current language and country settings. The CICAM may set its menu language to reflect the Host's setting.

The Host language and country resource is provided by the Host. The resource shall support one session per CICAM. The resource ID for the Host language and country resource is listed in Table L.1, Annex L.

11.2.1 Host Language and Country resource APDUs

The following APDUs are used by the Host language and country resource. They are explained in detail in subsequent sections.

Table 11.5: Host Language & Country APDUs

APDU Name	Direction
`Host_country_enq`	CICAM → HOST
`Host_country`	CICAM ← HOST
`Host_language_enq`	CICAM → HOST
`Host_language`	CICAM ← HOST

11.2.1.1 Host_country_enq APDU

The CICAM sends this APDU to the Host to query the current country setting. The Host replies with a Host_country APDU.

Table 11.6: Host_country_enq APDU syntax

Syntax	No. of bits	Mnemonic
`Host_country_enq() {`		
`   Host_country_enq_tag`	24	uimsbf
`   length_field() = 0`		
`}`		

Host_country_enq_tag: see Table L.1, Annex L.

11.2.1.2 Host_country APDU

This APDU is sent by the Host to inform the CICAM about the Host's current country setting. It is sent in response to a Host_country_enq from the CICAM.

The Host also sends this APDU asynchronously on a change in its country setting.

On opening a Host language and country resource, the Host sends one Host_country APDU to the CICAM conveying the current Host setting.

Table 11.7: Host_country APDU syntax

Syntax	No. of bits	Mnemonic
`Host_country() {`		
`   Host_country_tag`	24	uimsbf
`   length_field() = 3`		
`   iso_3166_country_code`	24	bslbf
`}`		

Host_country_tag: see Table L.1, Annex L.

iso_3166_country_code: This field contains the current Host country setting. The country code is a 24-bit field that identifies the Host country using 3 uppercase characters as specified by ISO 3166-1 alpha 3, [17]. Each character is coded as 8-bits according to ISO 8859-1 [15].

NOTE: The Host may pass a country code that the CICAM does not support or recognise, it is up to the CICAM how to handle this condition. The CICAM may use the MMI to select a suitable alternative.

11.2.1.3 Host_language_enq APDU

The CICAM sends this APDU to the Host to query the current language setting. The Host replies with a Host_language APDU.

Table 11.8: Host_language_enq APDU syntax

Syntax	No. of bits	Mnemonic
`Host_language_enq() {`		
`Host_language_enq_tag`	24	uimsbf
`length_field() = 0`		
`}`		

Host_language_enq_tag: see Table L.1, Annex L.

11.2.1.4 Host_language APDU

This APDU is sent by the Host to inform the CICAM about the Host's current language setting. It is sent in response to a Host_language_enq from the CICAM.

The Host also sends this APDU asynchronously on a change in its language setting.

On opening the Host language and country resource, the Host sends one Host_language APDU to the CICAM conveying the current Host language setting.

Table 11.9: Host_language APDU syntax

Syntax	No. of bits	Mnemonic
`Host_language() {`		
`Host_language_tag`	24	uimsbf
`length_field() = 3`		
`iso_639.2_language_code`	24	bslbf
`}`		

Host_language_tag: see Table L.1, Annex L.

iso_639.2_language_code: This field contains the current Host language preference setting. This is a 24-bit field that identifies the language using 3 lowercase characters as specified by ISO 639 Part 2 [18]. Both ISO 639-2/B and ISO 639-2/T may be used. Each character is coded into 8-bits according to ISO 8859-1 [15].

NOTE: The Host may pass a language code that the CICAM either does not support or recognise, it is up to the CICAM how to handle this condition. The CICAM may use the MMI to select a suitable alternative.

11.3 Content Control resource

The Content Control (CC) resource implements the security protocols of CI Plus such as authentication, key calculation and URI transmission.

The CC resource is provided by the Host. The CICAM may request a session to the CC resource only if the Host announced the CC resource during the resource manager protocol (see EN 50221 [7], section 8.4.1.1). The Host shall support only one session to the CC resource per CI Plus slot.

The resource ID for the CC resource is listed in Table L.1, Annex L.

11.3.1 Content Control resource APDUs

This section describes the general structure of each APDU that is part of the CC resource. Section 5 explains how the messages are used to implement the security protocols of CI Plus.

Table 11.10 gives an overview of the APDUs used by the CC resource.

Table 11.10: Content Control APDU Tag Values

APDU_Tag	Direction	APDU used for
`cc_open_req`	CICAM → HOST	Host capability evaluation
`cc_open_cnf`	CICAM ← HOST	Host capability evaluation
`cc_data_req`	CICAM → HOST	Authentication Auth key verification SAC key calculation
`cc_data_cnf`	CICAM ← HOST	Authentication Auth key verification SAC key calculation
`cc_sync_req`	CICAM → HOST	SAC key calculation
`cc_sync_cnf`	CICAM ← HOST	SAC key calculation
`cc_sac_data_req`	CICAM ←→ HOST	CC key calculation URI transmission and acknowledgement URI version negotiation SRM transmission and acknowledgement Content license exchange
`cc_sac_data_cnf`	CICAM ←→ HOST	CC key calculation URI transmission and acknowledgement URI version negotiation SRM transmission and acknowledgement Content license exchange
`cc_sac_sync_req`	CICAM → HOST	CC key calculation
`cc_sac_sync_cnf`	CICAM ← HOST	CC key calculation
`cc_PIN_capabilities_req`	CICAM ← HOST	Host requests PIN capabilities of CICAM
`cc_PIN_capabilities_reply`	CICAM → HOST	CICAM PIN capabilities reply
`cc_PIN_cmd`	CICAM ← HOST	Passing PIN code to CICAM
`cc_PIN_reply`	CICAM → HOST	Returning PIN code status
`cc_PIN_event`	CICAM → HOST	Notifying the Host that PIN is required
`cc_PIN_playback`	CICAM ← HOST	Providing a playback PIN to the CICAM
`cc_PIN_MMI_req`	CICAM ← HOST	Request for PIN dialogue

The general structure of an APDU is described in EN 50221 [7], section 8.3.1. An APDU starts with a 24 bit tag followed by a length field coded as ASN.1 BER.

The tag values of the Content Control resource APDUs are given in Table L.1, Annex L.

11.3.1.1 cc_open_req APDU

This APDU is sent by the CICAM to request the bitmask of the CC system IDs supported by the Host.

Table 11.11: cc_open_req message APDU syntax

Syntax	No. of bits	Mnemonic

`cc_open_req() {`
`  cc_open_req_tag`
`  length_field()=0`
`}`
	24	Uimsbf

cc_open_req_tag: see Table L.1, Annex L.

11.3.1.2 cc_open_cnf APDU

The Host sends this APDU to the CICAM to inform it about the CC system ID it supports.

Table 11.12: cc_open_cnf message APDU syntax

Syntax	No. of bits	Mnemonic
`cc_open_cnf() {`		
`   cc_open_cnf_tag`	24	uimsbf
`   length_field()`		
`   cc_system_id_bitmask`	8	bslbf
`}`		

cc_open_cnf_tag: see Table L.1, Annex L.

cc_system_id_bitmask: Each of the 8 bits indicates support for one CC system ID. The CICAM may choose the highest common version supported at both ends. The least significant bit is for system ID 1, there is no system ID 0.

This specification describes CC system ID 1, irrespective of the content of the cc_resource version. Host and CICAMs shall always perform a bitwise check on this field rather than a simple comparison.

11.3.1.3 cc_data_req APDU

A cc_data_req message is used by the CICAM to transfer protocol related data to the Host and to request a response from the Host. The data to be sent and requested for each protocol is explained in section11.3.3. cc_data_req which is used for data that does not have to be authenticated or encrypted. For data that shall be authenticated or encrypted a cc_sac_data_req is used.

Table 11.13: cc_data_req message APDU syntax

Syntax	No. of bits	Mnemonic
`cc_data_req() {`		
`   cc_data_req_tag`	24	uimsbf
`   length_field()`		
`   cc_system_id_bitmask`	8	bslbf
`   send_datatype_nbr`	8	uimsbf
`   for (i=0; i<send_datatype_nbr; i++) {`		
`      datatype_id`	8	uimsbf
`      datatype_length`	16	uimsbf
`      data_type`	8*datatype_length	bslbf
`   }`		
`   request_datatype_nbr`	8	uimsbf
`   for (i=0; i<request_datatype_nbr; i++) {`		
`      datatype_id`	8	uimsbf
`   }`		
`}`		

cc_data_req_tag: see Table L.1, Annex L.

cc_system_id_bitmask: see section 11.3.1.2.

send_datatype_nbr: the number of data items included in this message.

datatype_id: see Table H.1, Annex H, for possible values.

datatype_length: this value is the length of data_type to send in bytes.

data_type: this field is used for contents of the datatype_id.

request_datatype_nbr: the number of data items that the Host shall include in its response.

datatype_id: the list of data items requested in the Host's response, see Table H.1, Annex H.

11.3.1.4 cc_data_cnf APDU

A cc_data_cnf message is sent by the Host to transfer protocol related data to the CICAM. The exact data is specified with the protocols in section 5.

cc_data_cnf is used for data that does not have to be authenticated or encrypted. If this is required, a cc_sac_data_cnf shall be used.

Table 11.14: cc_data_cnf APDU syntax

Syntax	No. of bits	Mnemonic
`cc_data_cnf() {`		
`cc_data_cnf_tag`	24	uimsbf
`length_field()`		
`cc_system_id_bitmask`	8	bslbf
`send_datatype_nbr`	8	uimsbf
`for (i=0; i<send_datatype_nbr; i++) {`		
`datatype_id`	8	uimsbf
`datatype_length`	16	uimsbf
`data_type`	8*datatype_length	bslbf
`}`		
`}`		

cc_data_cnf_tag: see Table L.1, Annex L.

cc_system_id_bitmask: see section 11.3.1.2.

send_datatype_nbr: the number of data items included in this message.

datatype_id: see Table H.1 (annex H) for possible values.

datatype_length: the length of the piece of data in bytes.

data_type: this field is used for contents of the datatype_id.

11.3.1.5 cc_sync_req APDU

This APDU object is issued by the CICAM at the end of a key calculation to signal that it is ready to use the newly calculated key.

Table 11.15: cc_sync_req APDU syntax

Syntax	No. of bits	Mnemonic
`cc_sync_req() {`		
`cc_sync_req_tag`	24	uimsbf
`length_field()=0`		
`}`		

cc_sync_req_tag: see Table L.1, Annex L.

11.3.1.6 cc_sync_cnf APDU

This APDU is the Host's response to a cc_sync_req, it signals that the Host has finished its key calculation. For details, see section 11.3.2 below.

Table 11.16: cc_sync_cnf APDU syntax

Syntax	No. of bits	Mnemonic
`cc_sync_cnf() {`		
`cc_sync_cnf_tag`	24	uimsbf
`length_field()=1`		
`status_field`	8	uimsbf
`}`		

cc_sync_cnf_tag: see Table L.1, Annex L.

status_field: This byte returns the status of the Host. Table 11.17 lists the possible values.

Table 11.17: Possible values for status_field

status_field	Value
OK	0x00
No CC Support	0x01
Host Busy	0x02
Authentication failed	0x03
CICAM Busy	0x04
Recording Mode error	0x05
Reserved	0x06-0xFF

11.3.1.7 cc_sac_data_req APDU

This APDU is used by the Host and CICAM to send protocol specific data and to request a response. In contrast to a cc_data_req, the data contained in this message is authenticated and encrypted. The SAC encapsulates the input data as specified in Table 11.19 as payload in the SAC message.

Table 11.18: cc_sac_data_req APDU syntax

Syntax	No. of bits	Mnemonic
`cc_sac_data_req() {`		
`  cc_sac_data_req_tag`	24	uimsbf
`  length_field()`		
`  sac_message()`		
`}`		

cc_sac_data_req_tag: see Table L.1, Annex L.

sac_message: The format of this message is defined in section 7, Figure 7.7 and Table 7.4.

The payload_encryption_flag shall be 1.

The payload of this SAC message is defined in Table 11.19. For more details, see section11.3.3.

Table 11.19: cc_sac_data_req payload

Syntax	No. of bits	Mnemonic
`cc_system_id_bitmask`	8	bslbf
`send_datatype_nbr`	8	uimsbf
`for (i=0; i<send_datatype_nbr; i++) {`		
`  datatype_id`	8	uimsbf
`  datatype_length`	16	uimsbf
`  data_type`	8*datatype_length	bslbf
`}`		
`request_datatype_nbr`	8	uimsbf
`for (i=0; i<request_datatype_nbr; i++) {`		
`  datatype_id`	8	uimsbf
`}`		

cc_system_id_bitmask: see section 11.3.1.2.

send_datatype_nbr: the number of data items included in this message.

datatype_id: see Table H.1, Annex H, for possible values.

datatype_length: the length of the data in bytes.

data_type: the message data.

request_datatype_nbr: the number of data items that the Host shall include in its response to this message.

datatype_id: the list of data items requested in the Host's response, see Table H.1, Annex H.

11.3.1.8 cc_sac_data_cnf APDU

This message is used by the Host and CICAM to send protocol specific data in response to cc_sac_data_req() when the data has to be authenticated and encrypted. Section 7 has a detailed description of the protocol data carried in each message. The SAC encapsulates the input data as specified in Table 11.21 as payload in the SAC message.

Table 11.20: cc_sac_data_cnf APDU syntax

Syntax	No. of bits	Mnemonic
`cc_sac_data_cnf() {`		
`  cc_sac_data_cnf_tag`	24	uimsbf
`  length_field()`		
`  sac_message()`		
`}`		

cc_sac_data_cnf_tag: see Table L.1, Annex L.

sac_message: The format of this message is defined in section 7, Figure 7.7 and Table 7.4.

The payload_encryption_flag shall be 1.

The payload of the SAC messages is specified in Table 11.21. For more details, see section11.3.3.

Table 11.21: cc_sac_data_cnf payload

Syntax	No. of bits	Mnemonic
`cc_system_id_bitmask`	8	bslbf
`send_datatype_nbr`	8	uimsbf
`for (i=0; i<send_datatype_nbr; i++) {`		
`  datatype_id`	8	uimsbf
`  datatype_length`	16	uimsbf
`  data_type`	8*datatype_length	bslbf
`}`		

cc_system_id_bitmask: see section 11.3.1.2.

send_datatype_nbr: the number of data items included in this message.

data_type_id: see Table H.1, Annex H, for possible values.

datatype_length: the length of this piece of data in bytes.

data_type: the actual data.

11.3.1.9 cc_sac_sync_req APDU

This APDU is used during CC key calculation. The CICAM sends this to indicate that it has finished calculating the new CC key.

Table 11.22: cc_sac_sync_req APDU syntax

Syntax	No. of bits	Mnemonic
`cc_sac_sync_req() {`		
`  cc_sac_sync_req_tag`	24	uimsbf
`  length_field()`		
`  sac_message()`		
`}`		

cc_sac_sync_req_tag: see Table L.1, Annex L.

sac_message: The format of this message is defined in section 7, Figure 7.7 and Table 7.4.

The payload_encryption_flag shall be 1.

The payload of this SAC message is empty.

11.3.1.10 cc_sac_sync_cnf APDU

This APDU is used during CC key calculation. The Host uses this to respond to a cc_sac_sync_req from the CICAM.

Table 11.23: cc_sac_sync_cnf APDU syntax

Syntax	No. of bits	Mnemonic
`cc_sac_sync_cnf() {`		
`  cc_sac_sync_cnf_tag`	24	uimsbf
`  length_field()`		
`  sac_message()`	8	uimsbf
`}`		

cc_sac_sync_cnf_tag: see Table L.1, Annex L.

sac_message: The format of this message is defined in section 7, Figure 7.7 and Table 7.4.

The payload_encryption_flag shall be 1.

The payload of this SAC message is a status field. Possible values for status_field are listed in Table 11.27.

Table 11.24: cc_sac_sync_cnf Status

status_field	Value
OK	0x00
No CC Support	0x01
Host Busy	0x02
Not Required	0x03
Reserved	0x04-0xFF

11.3.2 Content Control Resource PIN APDUs

This section specifies the Content Control resource PIN APDUs which offers the capability of PIN entry, confirmation of PIN for unattended recording and PIN entry for play back at a later date.

11.3.2.1 cc_PIN_capabilities APDUs

The cc_PIN capabilities APDU enables the Host to determine how parental control PIN codes for FTA and CICAM (CAS controlled) content are to be managed.

Table 11.25: cc_PIN_capabilities_req APDU Syntax

Syntax	No. of bits	Mnemonic
`cc_PIN_capabilities_req() {`		
`  cc_PIN_capabilities_req_tag`	24	uimsbf
`  length_field() = 0`		
`}`		

cc_PIN_capabilities_req_tag: see Table L.1 in Annex L.

The cc_PIN_capabilities_reply is returned in response to the cc_PIN_capabilities_req and shall also be sent to the Host unsolicited whenever the PIN capabilities change including when the effective age rating at which the CICAM starts managing the PIN code is changed in the CICAM.

Table 11.26: cc_PIN_capabilities_reply APDU Syntax

Syntax	No. of bits	Mnemonic
`cc_PIN_capabilities_reply() {`		
`   cc_PIN_capabilities_reply_tag`	24	uimsbf
`   length_field()`		
`   capability_field`	8	uimsbf
`   pin_change_time_utc`	40	bslbf
`   rating`	8	uimsbf
`}`		

cc_PIN_capabilities_reply_tag: see Table L.1 in Annex L.

capability_field: this byte returns the capability code of the CICAM management, see Table 11.27.

Table 11.27: capability_field Values

capability_field	Value
CICAM has no capability to handle PIN	0x00
CICAM only handles CAS controlled content PIN	0x01
CICAM handles both CAS controlled content PIN and non CAS controlled content PIN	0x02
CICAM only handles CAS controlled content PIN (with CICAM cached PINs)	0x03
CICAM handles both CAS controlled content PIN and non CAS controlled content PIN (with CICAM cached PINs)	0x04
Reserved	0x05-0xFF

The interpretation of the capability_field values are described in more detail in section 5.11.1.

pin_change_time_utc: returns the time when the CICAM PIN was last changed. This is a 40-bit field which specifies the date and time in MJD and UTC when the PIN was last changed (See start_time field of the EIT in EN 300 468 [10]). This field is encoded as 40-bits giving the 16 LSBs MJD followed by 24-bits coded as 6 digits in 4-bit BCD. This field shall be specified as zero if the PIN is not handled or when it has never been changed. The Host may use the 'change time' to warn the end-user that any unattended recording programmed may fail when it was programmed before and scheduled after the time indicated by the pin_change_time_utc field.

rating: This 8-bit field is coded as DVB rating (3+years). Rating is defined in EN 300 468 [10] parental rating descriptor. This is the current rating as set in the CICAM. This field allows the Host to exert parental control when the Host rating is set at a lower level than the CICAM rating. The Host may use the cc_PIN_MMI_req() APDU for this purpose depending on the CICAM PIN capabilities. The CICAM shall not request a PIN entry for an age rating less than this value.

11.3.2.2 cc_PIN_cmd APDU

The cc_PIN_cmd() APDU is used by the Host to send the CICAM PIN to the module. The CICAM PIN is validated by the CICAM and a cc_PIN_reply() APDU is sent back to the Host. The Host uses the reply to check if its cached CICAM PIN is correct.

Table 11.28: cc_PIN_cmd APDU Syntax

Syntax	No. of bits	Mnemonic
`cc_PIN_cmd() {`		
`   cc_PIN_cmd_tag`	24	uimsbf
`   length_field()`		
`   for (i=0; i<n; i++) {`		
`      PINcode_data_bytes`	8	uimsbf
`   }`		
`}`		

cc_PIN_cmd_tag: see Table L.1 in Annex L.

PINcode_data_bytes: payload for the PIN code, one byte is used for each pin code digit in ASCII format.

11.3.2.3 cc_PIN_reply APDU

The cc_PIN_reply() APDU is used to inform the Host that either the CICAM PIN entered by the user is correct or incorrect.

Table 11.29: cc_PIN_reply APDU Syntax

Syntax	No. of bits	Mnemonic
`cc_PIN_reply() {`		
`cc_PIN_reply_tag`	24	uimsbf
`length_field()`		
`PINcode_status_field`	8	uimsbf
`}`		

cc_PIN_reply_tag: see Table L.1 in Annex L.

PINcode_status_field: this byte returns the status of the PIN code CICAM management, see Table 11.30.

Table 11.30: PINcode_status_field Values

PINcode_status_field	Value
Error - Bad PIN code	0x00
Error - CICAM Busy	0x01
PIN code correct	0x02
PIN code unconfirmed	0x03
Video Blanking Not Required	0x04
Error - Content still CA scrambled	0x05
Reserved	0x06-0xFF

Where the status values are defined as follows:

Error - Bad PIN code: the PIN entered by the end-user is incorrect. When this status is received as part of a cc_PIN_event() the PIN code used for recording is incorrect and the CICAM may not descramble the content. When this status is received as part of a cc_PIN_reply() the PIN code used for viewing is incorrect and the Host shall continue blanking the AV.

Error - CICAM Busy: the CICAM is busy.

PIN code correct: the PIN entered by the end-user is correct. When this status is received as part of a cc_PIN_event() the PIN code used for recording is correct and the CICAM continues descrambling the content. When this status is received as part of a cc_PIN_reply() the PIN code entered by the user is correct and the Host should stop blanking the AV.

PIN code unconfirmed: when multiple CA Systems are present and it is not known which would be used for the event to be recorded. This error response occurs when the Host sends a cc_PIN_cmd() to the CICAM when booking a recording if the CA system associated with the event is not known. The Host may optionally inform the user that the PIN code used to book the recording has not been verified by the CICAM. This status may also be used by a CICAM which does not support cached PIN to notify a PIN event when it is unable to confirm the PIN sent in the record start protocol.

Video blanking not required: confirms that a PIN is not required by the CICAM to view the content, e.g. the Host is not required to blank the AV for CAS Controlled content. The cc_PIN_event() should be stored with the associated content for enforcement of parental control during playback. When the CICAM sends this status it shall not display a PIN related MMI.

Error - Content still CA scrambled: this status value is only received via the cc_PIN_event() APDU. This error response occurs when the CICAM is not able to descramble the content, meaning that the content is not available for playback. The Host may use this status to inform the user of the recoding failure and is not requred to store this PIN event with the content.

11.3.2.4 cc_PIN_event APDU

The cc_PIN_event() APDU is sent by the CICAM for CA protected content only and performs two operations:

- To notify the Host of a parental rating change.
- To confirm the validity of the PIN sent in the record start protocol.

The CICAM shall send the cc_PIN_event() APDU to the Host whenever the parental rating changes, this includes the transition where a PIN is required and a PIN is no longer required. i.e. parental rating has been removed. The CICAM shall send a rating of 0x00 to inform the Host that the PIN is no longer required. If the CICAM has reported a PIN capability of '0', during the cc_PIN_capabilities exchange, see section 11.3.2.1, then the CICAM shall not send cc_PIN_event() APDUs to the Host.

The contents of the cc_PIN_event() shall be "recorded" with the content to identify changes in parental rating. To ensure that the Host is able to accurately place parental control boundaries on playback then the CICAM determines the time of the boundary and passes the time to the Host. The time is defined as UTC and positions the PIN event at an absolute point in time within the live broadcast. The UTC time of reception of the APDU by the Host is different from the UTC time contained within the APDU. On playback then the Host is required to process the parental control at the content position specified by the time contained within the PIN event.

Table 11.31: cc_PIN_event APDU Syntax

Syntax	No. of bits	Mnemonic
`cc_PIN_event() {`		
`cc_PIN_event_tag`	24	uimsbf
`length_field()`		
`program_number`	16	uimsbf
`PINcode_status_field`	8	uimsbf
`rating`	8	uimsbf
`pin_event_time_utc`	40	uimsbf
`pin_event_time_centiseconds`	8	uimsbf
`private_data`	8x15	uimsbf
`}`		

cc_PIN_event_tag: see Table L.1 in Annex L.

program_number: the program number of the associated Record Start protocol for this recording.

PINcode_status_field: This 8-bit field returns the status of the previously submitted PIN code as defined in Table 11.30.

rating: This 8-bit field is coded as DVB rating (3+years). Rating is defined in EN 300 468 [10] parental rating descriptor. It represents the rating of the broadcasted content item that triggered the cc_PIN_event() APDU.

pin_event_time_utc: This field returns the time when the parental rating changed requiring the entry of a PIN. This is a 40-bit field which specifies the date and time in MJD and UTC when the parental rating changed (See start_time field of the EIT in EN 300 468 [10]). This 40-bit field is coded as 16-bits giving the 16 LSBs of MJD followed by 24 bits coded as 6 digits in 4-bit BCD.

pin_event_time_centiseconds: This field contains the fractional part (seconds/100) of the time of the change in parental rating requiring the entry of a PIN.

private_data: These private data bytes provide the CICAM with the option to include additional CAS specific information stored with the parental control rating in the recording. The private_data is returned to the CICAM on playback using the cc_PIN_playback() APDU.

11.3.2.5 cc_PIN_playback APDU

This APDU is sent to the CICAM during the playback of a recording when the Host encounters a recorded PIN event, i.e. the parental rating of the content has changed.

Table 11.32: cc_PIN_playback APDU Syntax

Syntax	No. of bits	Mnemonic
`cc_PIN_playback() {`		
`   cc_PIN_playback_tag`	24	uimsbf
`   length_field()`		
`   rating`	8	uimsbf
`   private_data`	8x15	uimsbf
`}`		

cc_PIN_ playback_tag: see Table L.1 in Annex L.

rating: This 8-bit field is coded as DVB rating (3+years). Rating is defined in EN 300 468 [10] parental rating descriptor.

private_data: These bytes contain the private data that was delivered to the Host in the cc_PIN_event() APDU.

11.3.2.6 cc_PIN_MMI_req APDU

This APDU is sent to the CICAM to request a MMI for PIN entry. The PINcode_data_bytes loop allows the Host to provide the Module with either the FTA PIN (managed by the Host) or the CICAM PIN (managed by the CICAM). The result of the PIN entry is returned to the Host by the cc_PIN_reply() APDU. See section 5.11.3.

Table 11.33: cc_PIN_MMI_req APDU Syntax

Syntax	No. of bits	Mnemonic
`cc_PIN_MMI_req() {`		
`   cc_PIN_MMI_req_tag`	24	uimsbf
`   length_field()`		
`   for (i=0; i<n; i++) {`		
`      PINcode_data_bytes`	8	uimsbf
`   }`		
`}`		

cc_PIN_MMI_req_tag: see Table L.1 in Annex L.

PINcode_data_bytes: Payload for the PIN code, one byte is used for each pin code digit in ASCII format.

11.3.3 Content Control Protocols

This section explains the payload of the APDUs for each security protocol of CI Plus.

11.3.3.1 Host Capability Evaluation

After the session to the CC resource has been established, the CICAM requests the bitmask of the CC system IDs that the Host supports. It should be noted that the Host advertises supported versions of the Content Control resource using the resource manager and the CICAM shall use the highest available Content Control resource signalled by the Host when establishing a CC session.

Table 11.34: Host Capability Evaluation

Step	Action	APDU	Content
1	CICAM requests the Host's CC system ID bitmask	cc_open_req	
2	Host sends its CC system ID bitmask	cc_open_cnf	cc_system_id_bitmask: • bit 0 set indicates support for CI Plus

11.3.3.2 Authentication

Authentication is described in section 6.2 and an overview is shown in Figure 6.2, it uses cc_data_req and cc_data_cnf messages.

Table 11.35: Authentication

Step	Action	APDU	Content		
1	CICAM sends a nonce to the Host	cc_data_req	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	19 (nonce)	256 bits
			request_datatype_nbr = 4		
			i	datatype_id	
			0	13 (DHPH)	
			1	17 (Signature_A)	
			2	15 (Host_DevCert)	
			3	7 (Host_BrandCert)	
2	Host sends a nonce, its DH public key, signature, Host Device Certificate Data and Host Brand Certificate	cc_data_cnf	send_datatype_nbr = 4		
			i	datatype_id	
			0	13 (DHPH)	2048 bits
			1	17 (Signature_A)	2048 bits
			2	15 (Host_DevCert)	variable length
			3	7 (Host_BrandCert)	variable length
3	CICAM sends DH public key, signature, CICAM Device Certificate Data and CICAM Brand Certificate	cc_data_req	send_datatype_nbr = 4		
			i	datatype_id	datatype_len
			0	14 (DHPM)	2048 bits
			1	18 (Signature_B)	2048 bits
			2	16 (CICAM_DevCert)	variable length
			3	8 (CICAM_BrandCert)	variable length
			request_datatype_nbr = 1		
			30	status_field	
4	Host sends a confirmation	cc_data_cnf	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	30 (status_field) (see Note 2)	8 bits
Notes 1. Refer to Annex H for an overview of the parameters involved. 2. The Host may set this to OK or Authentication failed, see Table 11.17.					

11.3.3.3 Authentication Key verification

Authentication Key Verification is performed at start-up and after completing the authentication protocol (see sections 6.2 and 11.3.3.2). The CICAM checks if both sides have the same stored authentication key (AKH and AKM).

Table 11.36: Authentication Key Verification

Step	Action	APDU	Content		
1	CICAM requests the authentication key from the Host	cc_data_req	request_datatype_nbr = 1		
			i	datatype_id	
			0	22 (AKH)	
2	Host sends its authentication key	cc_data_cnf	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	22 (AKH)	256 bits
Note: Refer to Annex H for an overview of the parameters involved.					

11.3.3.4 CC key calculation

This protocol is used for calculating new CC key material, see section 8 for details.

All messages of this protocol are protected by the SAC.

Table 11.37: CC key calculation

Step	Action	APDU	Content		
1	CICAM sends CICAM_ID and a nonce	cc_sac_data_req	send_datatype_nbr = 3		
			i	datatype_id	datatype_len
			0	6 (CICAM_ID)	64 bits
			1	12 (Kp)	256 bits
			2	28 (key register)	8 bits
			request_datatype_nbr = 2		
			i	datatype_id	
			0	5 (HOST_ID)	
			1	30 (Status_field)	
2	Host responds with HOST_ID and a nonce	cc_sac_data_cnf	send_datatype_nbr = 2		
			i	datatype_id	datatype_len
			0	5 (HOST_ID)	64 bits
			1	30 (Status_field) (see Note 2)	8 bits
3	CICAM tells the Host that is has finished calculating the new CC key.	cc_sac_sync_req			
4	Host tells the CICAM that is has finished calculating the new CC key.	cc_sac_sync_cnf	Status_field (see Table 11.17)		
Notes: 1: Refer to Annex H for an overview of the parameters involved. 2: Host may set this to OK or Host Busy or No_CC_support, see Table 11.17. 3: All sac messages are encrypted and authenticated.					

11.3.3.5 SAC key calculation

This protocol is performed when new key material must be calculated for the SAC, see Figure 7.3.

Table 11.38: SAC key calculation

Step	Action	APDU	Content		
1	CICAM sends CICAM_ID and a nonce	cc_data_req	send_datatype_nbr = 2		
			i	datatype_id	datatype_len
			0	6 (CICAM_ID)	64 bits
			1	21 (Ns_module)	64 bits
			request_datatype_nbr = 2		
			i	datatype_id	
			0	5 (HOST_ID)	
			1	20 (Ns_Host)	
2	Host responds with HOST_ID and a nonce	cc_data_cnf	send_datatype_nbr = 2		
			i	datatype_id	datatype_len
			0	5 (HOST_ID)	64 bits
			1	20 (Ns_Host)	64 bits
3	CICAM tells the Host that it has finished calculating the new SAC key material.	cc_sync_req			
4	Host tells the CICAM that it has finished calculating the new SAC key material.	cc_sync_cnf	status_field (see Table 11.20)		
Note: Refer to Annex H for an overview of the parameters involved.					

11.3.3.6 URI transmission and acknowledgement

This protocol transmits a set of Usage Rules Information (URI) and receives the Host's acknowledgement, see section 5.7.5.

Table 11.39: URI transmission and acknowledgement

Step	Action	APDU	Content		
1	CICAM sends the URI to the Host	cc_sac_data_req	send_datatype_nbr = 2		
			i	datatype_id	datatype_len
			0	25 (uri_message)	64 bits
			1	26 (program_number)	16 bits
			request_datatype_nbr = 1		
			i	datatype_id	
			0	27 (uri_confirm)	
2	Host sends a acknowledgement to the CICAM	cc_sac_data_cnf	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	27 (uri_confirm)	256 bits
Notes: 1: Refer to Annex H for an overview of the parameters involved. 2: All SAC messages are encrypted and authenticated.					

11.3.3.7 URI version negotiation

After the SAC keys have been calculated, the CICAM requests a list of URI versions that the Host supports. The Host sends back a version bitmask. Each bit corresponds to one version which is set when the version is supported; the least significant bit indicates support for version 1. The next most significant bit indicates support for version 2. For more details, see section 5.7.4.

Table 11.40: URI version negotiation

Step	Action	APDU	Content		
1	CICAM requests the bitmask of supported URI versions from the Host	cc_sac_data_req	request_datatype_nbr = 1		
			i	datatype_id	
			0	29 (uri_versions)	
2	Host sends the bitmask of supported URI versions	cc_sac_data_cnf	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	29 (uri_versions)	256 bits
Notes: 1: Refer to Annex H for an overview of the parameters involved. 2: All SAC messages are encrypted and authenticated.					

11.3.4 Content License Exchange

When an item of content to be recorded has a URI with an EMI value of 0b11, the CICAM optionally provide one or more licenses during the recording. The Host shall associate this license with the item of content for the lifetime of the recording. If a license exists for an item of content, the license shall be checked by the original CICAM when the content is played back to see if the entitlements rights still exist to view the content. A license supplied by the CICAM contains CAS specific data which is stored by the Host with the content. When the content item is played back then the Host shall transfer the license back to the original CICAM without any change.

The licenses are always exchanged via the SAC using the protocols below.

11.3.4.1 CICAM to Host License Exchange Protocol

If a license is required to be associated with an item of content then at the start of recording the CICAM sends the Host the license using the SAC. The process uses the CICAM to Host License Exchange protocol and is shown below including the response.

The message exchange shall be performed in accordance with a URI Protocol behaviour of section 5.7.5. The CICAM shall set a 1 second timeout and the Host shall confirm the URI and license within the timeout, failure to respond constitutes a failure of the copy protection system and the CICAM shall disable CA descrambling of copy protected content (i.e. EMI != 0,0) for the associated MPEG program until the protocol completes successfully. When the protocol completes then the CICAM shall wait for one second before the exchange is re-initiated.

The Host shall exert the URI copy control settings of the message and control its outputs based on the valid URI immediately.

Table 11.41: CICAM to Host License Exchange Protocol

Step	Action	APDU	Content		
1	CICAM supplies the Host with content license	cc_sac_data_req	send_datatype_nbr = 3 or 4		
			i	datatype_id	datatype_len
			0	26 (program_number) (see note 3)	16 bits
			1	34 (license_status) (see note 4)	8 bits
			2	25 (uri_message)	64 bits
			3	33 (cicam_license)	variable
			request_datatype_nbr = 1		
			i	datatype_id	
			0	35 (license_rcvd_status)	
2	Host confirms receipt	cc_sac_data_cnf	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	35 (license_rcvd_status)(see note 5)	8 bits

Notes:
1: Refer to Annex H for an overview of the parameters involved.
2: All SAC messages are encrypted and authenticated.
3: The program_number matches the Record Start message's program_number.
4: Table 11.45 contains the allowed values and meaning of this field.
5. Table 11.42 contains the allowed values and meaning of this field.

Table 11.42: license_rcvd_status Values

license_rcvd_status	Value
OK	0x00
Host Busy	0x01
Invalid Data	0x02
Host Error	0x03
Reserved	0x04-0xFF

11.3.4.2 Playback License Exchange Protocol

When an item of content which has a license associated with it, at played back, the Host must supply the CICAM with the original license. The CICAM processes the license to establish whether the Host still has rights to play the content. A new license and URI are returned to the Host to replace the original URI and license values in the recording in case the information contained has changed, e.g. play count. The Host shall exert the URI copy control settings of the message and control its outputs based on the valid URI immediately.

The size of the cicam_license and Host_license shall be identical. i.e. the playback license received from the CICAM shall be identical in size to the original Host_license that was sent to the CICAM on playback.

Table 11.43: Playback License exchange protocol

Step	Action	APDU	Content		
1	HOST supplies the CICAM license	cc_sac_data_req	send_datatype_nbr = 2		
			i	datatype_id	datatype_len
			0	26 (program_number)	16 bits
			1	36 (Host_license)	variable
			request_datatype_nbr = 4		
			i	datatype_id	
			0	26 (program_number)	
			1	34 (license_status)	
			2	25 (uri_message)	
			3	33 (cicam_license)	
2	CICAM response with new license and new URI	cc_sac_data_cnf	send_datatype_nbr = 4		
			i	datatype_id	datatype_len
			0	26 (program_number)	16 bits
			1	34 (license_status) (see note 3)	8 bits
			2	25 (uri_message)	64 bits
			3	33 (cicam_license)	variable

Notes:
1: Refer to Annex H for an overview of the parameters involved.
2: All SAC messages are encrypted and authenticated.
3: Table 11.45 contains the allowed values and meaning of this field.

11.3.4.3 License Check Exchange Protocol

When the Host needs to interrogate the CICAM about the current status of a content license associated with a recording it follows the protocol below.

The response from the CICAM contains information regarding the status of the license sent in the request. The response is for information only, e.g. to provide more detail on content availability when displaying a recording library.

Table 11.44: License check exchange protocol

Step	Action	APDU	Content		
1	HOST supplies the CICAM license	cc_sac_data_req	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	36 (Host_license)	variable
			request_datatype_nbr = 2		
			i	datatype_id	
			0	34 (license_status)	
			1	37 (play_count)	
2	CICAM response with license status and play count	cc_sac_data_cnf	send_datatype_nbr = 2		
			i	datatype_id	datatype_len
			0	34 (license_status) (see note 3)	8 bits
			1	37 (play_count)	8 bits

Notes:
1: Refer to Annex H for an overview of the parameters involved.
2: All SAC messages are encrypted and authenticated.
3: Table 11.45 contains the allowed values and meaning of this field.

Table 11.45: license_status Values

license status	Value
OK	0x00
Descrambling not possible, no entitlement (record only)	0x01
Descrambling not possible, undefined error (record only)	0x02
Entitlement rights expired (playback & status check)	0x03
Play count exceeded (playback & status check)	0x04
Retention limit exceeded (playback & status check)	0x05
Invalid license (playback & status check)	0x06
Reserved	0x07-0xFF

11.3.4.4 Record Start Protocol

The Host signals the start of a CA protected service recording to the CICAM via the protocol below using the SAC. This exchange also informs the CICAM of the current operating mode of the Host.

Where the CICAM has PIN capabilities or EMI = 1,1 then no CA protected content shall be recorded until the Record Start protocol, described below, has completed successfully with a record_start_status value of 'OK'.

Where the CICAM does not support PIN capabilities and in addition, EMI != 1,1 or the Host is buffering the content the record start status may be ignored by the Host. In this case the Host may record the content but may experience parental control interruptions.

Where the Host is in a "Unattended_Recording" or "Watch_and_Buffer" operating mode then the PINcode_data parameter is used to provision the CICAM with the CICAM PIN. The CICAM PIN shall only be used to enable uninterrupted recording when a future parental control event may occur. The CICAM PIN shall not be used to enforce parental control on playback and live viewing; in such a case the user shall be asked to enter the CICAM PIN by means of the High-Level or Application MMI.

Table 11.46: Record Start Protocol

Step	Action	APDU	Content		
1	Host informs CICAM of start of recording.	cc_sac_data_req	send_datatype_nbr = 2 or 3		
			i	datatype_id	datatype_len
			0	38 (operating_mode)	8 bits
			1	26 (program_number)	16 bits
			2	39 (PINcode data)	variable (optional)
			request_datatype_nbr = 1		
			i	datatype_id	
			0	40 (record_start_status)	
2	CICAM sends a acknowledgement to the Host	cc_sac_data_cnf	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	40 (record_start_status) (see note 4)	8 bits
Notes: 1: Refer to Annex H for an overview of the parameters involved. 2: All SAC messages are encrypted and authenticated. 3: Table 11.47 defines the allowed values of operating mode. 4: Table 11.17 defines the allowed values of this field .					

Table 11.47: operating_mode Values

operating_mode	Value
Watch_and_Buffer	0x00
Timeshift	0x01
Unattended _Recording	0x02
Reserved	0x03-0xFF

The operating modes are described as follows:

Watch_and_Buffer – the user is watching live content that is also being recorded. At reception of the Record Start message the CICAM shall cache the CICAM PIN in order to allow for uninterrupted recording when the parental control rating changes. The CICAM shall continue to display a MMI requesting the user to enter the CICAM PIN when parental control is required to be enforced. The CICAM shall continue to descramble if the cached CICAM PIN is correct and the Host shall Blank the video and audio upon the reception of the cc_PIN_event() where the PINcode_status_field equals “0x00” until the next cc_PIN_reply() APDU where the PINcode_status_field equals “0x02”.

Timeshift – the user is watching previously recorded content while the Host continues recording the live content. The CICAM shall not provide a MMI for CICAM PIN entry and shall use the cached CICAM PIN to continue to descramble the content for the purpose of uninterrupted recording. The Host shall use the cc_PIN_playback() APDU while watching buffered recorded content to inform the CICAM of the parental control rating of the content being played back. The Host shall blank the video and audio until reception of cc_PIN_reply() APDU where PINcode_status_field equals “0x02”.

Unattended_Recording – the user has programmed the Host to record content in an unattended mode. Prior to programming the recording the Host may validate the cached CICAM PIN using cc_PIN_cmd() APDU. At the start of the recording the Host includes the CICAM PIN in the Record Start message to the CICAM. During the recording the CICAM informs the Host of the parental control rating using the cc_PIN_event() APDU for use at play back by the Host.

11.3.4.5 Change Operating Mode Protocol

The message protocol below is used when the Host changes the operating mode and is comparable to the Record Start message. The Change Operating Mode message is used in use-cases where no new License is required by the Host, e.g. when the operation mode changes from “Watch_and_Buffer” to “Timeshift”.

Table 11.48: Change Operating Mode Protocol

Step	Action	APDU	Content		
1	Host informs CICAM of change of operating mode.	cc_sac_data_req	send_datatype_nbr = 2		
			i	datatype_id	datatype_len
			0	38 (operating_mode)	8 bits
			1	26 (program_number)	16 bits
			request_datatype_nbr = 1		
			i	datatype_id	
			0	41 (mode_change_status)	
2	CICAM sends a acknowledgement to the Host	cc_sac_data_cnf	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	41 (mode_change_status)	8 bits
Notes: 1: Refer to Annex H for an overview of the parameters involved. 2: All SAC messages are encrypted and authenticated. 3: Table 11.47 defines the allowed values of operating mode. 4: Table 11.17 defines the allowed values of this field.					

11.3.4.6 Record Stop Protocol

The Host uses this protocol to inform the CICAM that the recording has stopped and that all PIN related information cached by the CICAM shall be deleted.

Table 11.49: Record Stop Protocol

Step	Action	APDU	Content		
1	Host informs CICAM recording has stopped.	cc_sac_data_req	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	26 (program_number)	16 bits
			request_datatype_nbr = 0		
			i	datatype_id	
			0	42 (record_stop_status)	
2	CICAM sends a acknowledgement to the Host	cc_sac_data_cnf	send_datatype_nbr = 1		
			i	datatype_id	datatype_len
			0	42 (record_stop_status) (see note 3)	8 bits
Notes: 1: Refer to Annex H for an overview of the parameters involved. 2: All SAC messages are encrypted and authenticated. 3: Table 11.17 defines the allowed values of this field.					

11.3.5 SRM file transmission and acknowledgement

This datafile transfer protocol transmits data files such as SRM data files and receives the Host status and acknowledgement. This protocol utilises the CI Plus SAC APDUs to send the data files from the CICAM to the Host. The data file is identified by a datatype_id (refer to Table H.1 in Annex H for the datatype_id indicating an SRM file). Details are explained in table 11.50.

Table 11.50: SRM data file transmission and acknowledgement

Step	Action	APDU	Content		
1	CICAM sends the SRM to the Host	cc_sac_data_req	send_datatype_nbr = 1		
			i	datatype_id	
			0	31 (srm_data)	
			request_datatype_nbr = 2		
			i	datatype_id	
			0	30 (status_field)	
			1	32 (datatransfer_confirm)	
2	Host sends a acknowledgement to the CICAM	cc_sac_data_cnf	send_datatype_nbr = 2		
			i	datatype_id	datatype_len
			0	30 (status_field) (See Note 3)	8 bits
			1	32 (datatransfer_confirm)	256 bits
Notes: 1: Refer to Annex H for an overview of parameters involved. 2: All SAC messages are encrypted and authenticated. 3: Host may set this to OK, Host Busy or Not Required, see Table 11.24.					

11.4 Specific Application Support

CI Plus offers a Specific Application Support (SAS) resource similar to the one defined in the OpenCable™ Specifications, CableCARD™ Interface 2.0 Specification [27]. This resource offers a transparent pipe that allows an application on the Host to access functionality on the CICAM.

For the SAS resource to be useful, a protocol has to be defined on top of this transparent pipe. Each of these protocols is assigned a private_Host_application_ID to uniquely identify it.

The SAS resource is applicable to the MHP CA APIs permitting a data exchange between the MHP Application environment and the CAS resident on the CICAM as depicted in Figure 11.2.

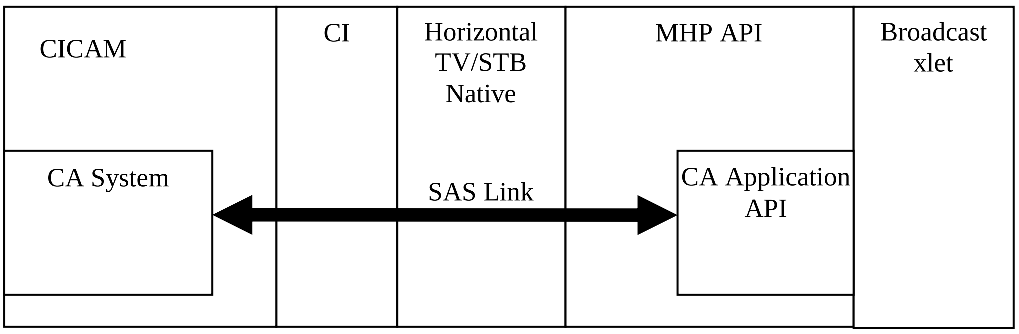


Figure 11.1 Example Application Environment for SAS

The SAS resource message protocol for the MHP CA API is defined in Annex M.

The SAS resource APDU and message syntax of the OpenCable™ Specifications, CableCARD™ Interface 2.0 Specification [27], section 9.17, shall be defined and used by this profile.

The CICAM shall open a SAS session at start-up. When the Host requires a connection to an application part on the CAM, it sends a SAS_connect_rqst() APDU according to section 9.17.1 of [27] to an unused SAS session. This APDU includes the requested private_Host_application_ID. If the CICAM supports the requested application id, it associates this SAS session with the application id and sends a SAS_connect_cnf() APDU in response. The CICAM shall then open another SAS session for subsequent connects by the Host so that at least one open SAS session is available that is not associated with an application id.

The Host shall keep track of the associations between each SAS session and an application id. When the Host wants to connect to an application id, it shall use an open SAS session that is not yet associated to an application id.

A CICAM may support multiple clients connected to the same application id at the same time.

11.4.1 Application Life-cycle

Each Host application that requires access to the SAS resource shall create a new SAS connection and the application life-cycle of the SAS resource is defined as follows:

1) Application starts up on the Host.
2) Host application initiates a connection to the SAS session with a SAS_connect_rqst() APDU when a connection is required.
3) CICAM processes the request and responds with a SAS_connect_cnf() APDU.
    - If the connection was accepted then the CICAM shall create a new SAS session ready for any subsequent new connection.
    - If the connection was not accepted then the session remains open ready for a subsequent connection request.
4) Host application and CICAM communication via the connected SAS session.
5) The Host application terminates and the SAS session is closed by the Host.

11.4.2 Data Transfer

For data transfer CI Plus only uses the asynchronous mode as defined in the OpenCable Interface Specification 2.0 [27], Synchronous mode is not supported.

12 CI Plus Application Level MMI

12.1 Scope

TS 101 699 [8] section 6.5 specifies the concept of an application domain MMI. The Application Domain MMI enables an unspecified presentation engine to be used (if present) potentially enabling a sophisticated CICAM application presentation and interaction to be realised when compared with the conventional High Level Application MMI.

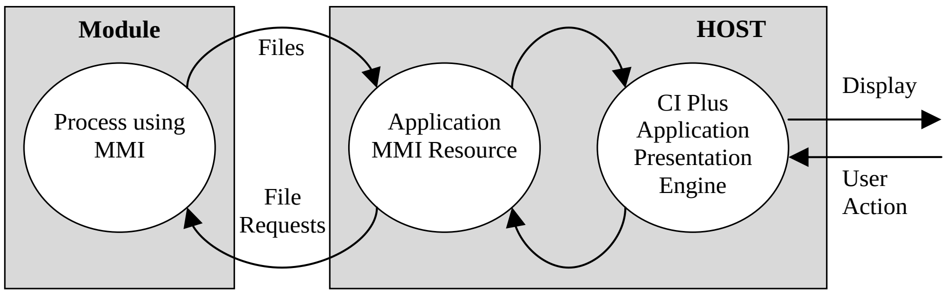


Figure 12.1: Operation of the application MMI resource and CI Plus Presentation Engine

This section specifies the CI Plus Application profile to be implemented in a CI Plus Host and identifies the minimum functionality that the Host shall support.

The inclusion of a mandatory standard CI Plus presentation engine enables the module to present text and graphics on the Host display without necessitating any further extensions to the MMI resources which might otherwise constrain the module application. The scope of a conformant CI Plus Host is depicted in Figure 12.2. The CI Plus presentation engine enables the module to present information with the look and feel specified by the service operator rather than being constrained to the High Level MMI for which there is limited presentation control and interaction.

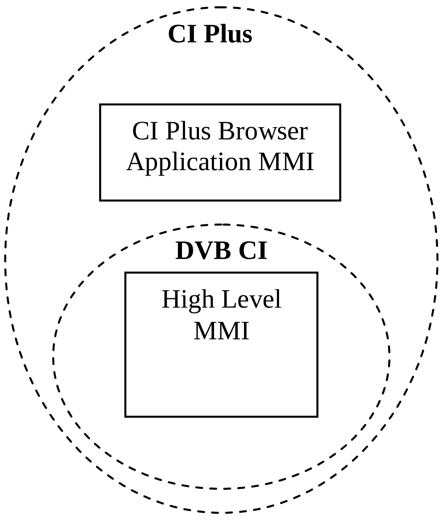


Figure 12.2: Scope of CI Plus

The CI Plus Application MMI is based on the UK-DTT MHEG-5 [23] engine specification and is subset to provide sufficient functionality to enable a module application to present text and graphics with minimal control over the broadcast stream. All content to the CI Plus presentation engine shall be supplied to the Host directly from the CICAM through the Application MMI resource; the CICAM itself may optionally source file data internally from the CICAM and/or directly from the broadcast stream.

The CI Plus Application MMI may operate in a Host that supports other application environments e.g. MHEG-5, MHP, etc. The Host implementation of the CI Plus Application MMI may elect to support the interface using any existing MHEG-5 application environment or with a separate implementation instance. The CI Plus

Application MMI shall take precedence over any existing application environment and may optionally be presented on the Host native graphics plane, application plane or another display plane that may exist between the Host display and application, this is shown as a number of conceptual planes in Figure 12.3.

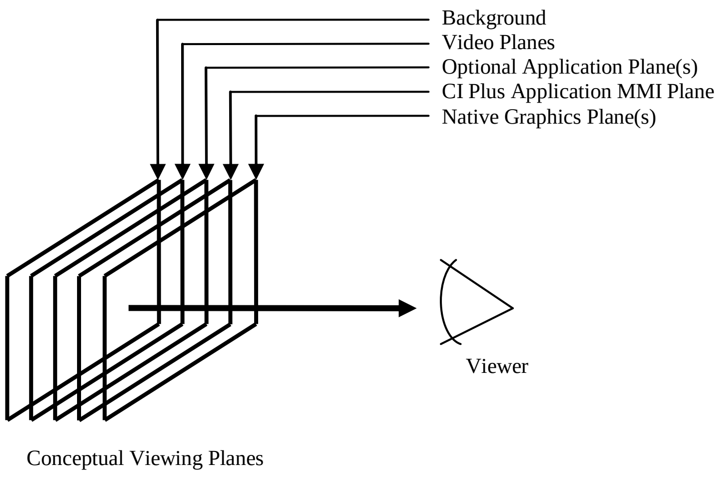

Background
Video Planes
Optional Application Plane(s)
CI Plus Application MMI Plane
Native Graphics Plane(s)
Viewer
Conceptual Viewing Planes

Figure 12.3: Conceptual Display Planes (Informative)

Figure 12.3 is informative only and includes both logical and physical planes, the Host implementation shall determine the most suitable physical mapping for a given Host architecture. The Application MMI shall support full video transparency enabling text and graphics to be overlaid over the video (and possibly any native application). The Application MMI has a native SD resolution of 720x576 pixels and shall be scaled to full screen to match the current video aspect ratio in both SD and HD environments.

It is mandatory for the Application MMI to provide limited control over the MPEG decoders which enable the broadcast video and audio of the current service to be presented, additionally a full frame I-frame may be used to provide rich graphics backgrounds. The MMI Application may deny the application MMI control of the MPEG decoder if a resource conflict results.

The Application MMI profile includes an optional extension for dynamically loadable TrueType and OpenType outline fonts which permit international character sets to be used by the application. Dynamically loadable fonts may not be available in all Hosts and the application may check the Host support from within the application.

CI Plus specification v1.3 extends the Application MMI which includes feature support for VOD type applications.

12.2 Application MMI Profile

The CI Plus Application shall conform with the MHEG-5 profile version 1.06 [D-Book 5.0, Sections 12-18][23] with some reduced functionality for a CI Plus compliant Host.

12.2.1 Application Domain

This specification is an *application domain* in the terms set out in Annex D of ISO 13522-5 [16] and D-Book 5.0 [23], Section 13. The CI Plus *application domain* is referred to "CIEngineProfile1".

12.2.2 Set of Classes

The set of classes is defined in D-Book 5.0 [23], 13.3 with the exceptions stated in Table 12.1:

Table 12.1: Class exceptions to D-Book 5.0

Class	Notes
Font	Required (see note)
Dynamic Line Art	Not Required
HyperText	Not Required
Note: See D-Book [23] and Section 12.5.1 Downloadable Fonts.	

Receivers may optionally support "Not Required" classes but they shall not be used by a CI Plus Application unless referenced in the context of a different application domain or the application has confirmed the class exists.

12.2.3 Set of Features

The set of features is defined in D-Book 5.0 [23], section 13.4 with the following exceptions in Table 12.2:

Table 12.2: CIEngineProfile1 GetEngineSupport behaviour exceptions to D-Book 5.0

Feature	Notes
Caching	Not Required
Video Scaling	Not Required
Scene Aspect Ratio	Not Required
UniversalEngineProfile	Shall adhere to D-Book and also support the CI Plus profile value

A full MHEG profile typically includes the stream object providing control of the audio and video components. To maintain the current video and audio an application typically creates a stream object containing active audio and video set to the default components. The application may then change the component tags to select the audio and video components. For the CI Plus profile the application is only allowed to use the default audio and video components. The CI Plus application is allowed to stop and start the stream in order to display an I-frame if it has permission using the resident program *RequestMPEGDecoder*.

The default components are taken to be whatever components are currently active on the receiver. The loading of a CI Plus application with default components set shall not change them. The current components may have been set by another application environment, such as MHP, and shall not be interfered with by the CI Plus application.

12.2.3.1 CI Plus Engine Profile

UniversalEngineProfile shall respond with a true response to a string argument of "`CIPLUS001`" which identifies the MHEG engine as being CI Plus Profile 1 compliant.

12.2.3.2 Not required features

Features identified as not required in this profile may be optionally implemented by Hosts conforming to this profile. This permits the CI Plus profile to co-exist with other MHEG-5 broadcast profiles.

CI Plus Applications shall not use any features identified as not required unless the application first checks that they are supported by the engine using the UniversalEngineProfile() or any other standard method to determine the capabilities of the environment.

The engine may only provide optional features from another profile(s) which have been certified i.e. features of the New Zealand MHEG profile may be active if the Host is certified for New Zealand.

12.2.3.3 Stream Objects

The application shall start with the default components active by specifying a stream object containing active audio and video objects set to the default component. Should the CI Plus application wish to stop the stream then it shall first gain permission using the resident program *RequestMPEGDecoder*, see section 12.3.6.

Permission from *RequestMPEGDecoder* is required as other application environments may be running that are currently using the MPEG decoder.

Any application that does not start with an active stream object with default components shall behave in an undefined way.

Any attempt to stop the video object or the whole stream without permission shall behave in an undefined way.

Once permission has been granted, control of the MPEG decoder shall persist according to the normal resident application rules or until the CI Plus application releases it using *RequestMPEGDecoder*. Before releasing the MPEG decoder the application shall return the MPEG decoder to its normal state by removing any I-frame from the screen and restarting the stream objects with default audio and video component tags.

This mechanism ensures that the application operates in a predictable manner even if another application environment is active.

The CI Plus profile does not require stream objects to generate stream events.

12.2.3.4 RTGraphics / Subtitles

On launching the CI Plus Application MMI the subtitle state shall be determined from the CICAM Request Start message defined in section 12.6.2. Where subtitling is stopped to enable the launch of the CI Plus Application MMI then subtitling shall be re-enabled automatically when the CI Plus Application terminates.

12.2.4 GetEngineSupport

The GetEngineSupport "feature" strings of D-Book 5.0 [23] section 13.4.1 with the exception in table 12.3:

Table 12.3: GetEngineSupport "feature" strings

String		Constraint
Standard	**Short**	
MultipleAudioStreams(N)	MAS(N)	May return "true" for N≤1
MultipleVideoStreams(N)	MVS(N)	May return "true" for N≤1
VideoScaling(CHook,X,Y)[a]	VSc(CHook,X,Y)[a]	May return "false" for all combinations of CHook, X & Y
VideoDecodeOffset(CHook,Level)	VDO(CHook,Level)	May return "false" for all combinations of CHook, X & Y
DownloadableFont(CHook)	DLF(CHook)	Shall return "true" for the values of CHook that are supported by the Font class. Shall return "false" for all other values of N

12.3 Content Data Encoding

The content data encoding is defined in D-Book 5.0 [23], section 13.5 with exceptions defined in this and subsequent sections.

12.3.1 Content Table

In CIEngineProfile1 the table 13.7 will be as per D-Book 5.0 [23] with the following exception:

Table 12.4: Content Table

Attribute	Permissible Values
Font	See 12.5.1 "Downloadable Fonts"

12.3.2 Stream "memory" formats

In *CIEngineProfile1* there is no requirement for stream memory formats, D-Book 5.0 [23] section 13.5.3.

12.3.3 User Input

The CI Plus Application shall have input focus and display priority if the CI Plus Application MMI co-exists with any other application engine (i.e. running simultaneously).

The UK Profile authoring requirement to always start in user input register 3 in the first scene shall not apply to the CI Plus application.

12.3.4 Engine Events

The minimum set of engine events that the engine shall support is defined in D-Book 5.0 [23] section 13.8, with the exception that the following EngineEvents are not required by *CIEngineProfile1*.

Table 12.5: CIEngineProfile1 EventData exceptions to D-Book 5.0

EventData	Value	Notes
VideoPrefChanged	6	Not Required
NetworkBootInfo	9	Not Required

12.3.5 Protocol Mapping and External Connection

The protocol mapping and external connections of D-Book 5.0 [23] section 13.9 with the exception that Stream Actions and Stream Events are not required by *CIEngineProfile1*.

12.3.6 Resident Programs

The Resident Programs of D-Book 5.0 [23] section 13.10 with the exception of the following Resident Programs that are not required by *CIEngineProfile1*.

Table 12.6: CIEngineProfile1 Resident Program exceptions to D-Book 5.0

Resident Program	Name	Notes
SI_TuneIndex	Tin	Not Required
SI_TuneIndexInfo	TII	Not Required
GetBootInfo	GBI	Not Required
VideoToGraphics	VTG	Not Required
SetWidescreenAlignment	SWA	Not Required
SetSubtitleMode	SSM	Not Required
RequestMPEGDecoder	RMD	Note: Call only, See section 12.3.6.1.

12.3.6.1 RequestMPEGDecoder

Requests exclusive access to a MPEG decoder and video plane to display I-frames. The MPEG decoder shall be available when no other application environment is active.

Synopsis RMD(result)

Arguments

in/out/ in-out	type	name	comment
in	GenericBool	request	If 'true' then the MHEG application is requesting exclusive use of the MPEG decoder and video plane. If 'false' it is releasing use of said decoder.
output	GenericBool	result	If request is 'true' then: • If the result is 'true' then I-frames may be used and shall remain available until the application exits, a new application starts (See D-Book 5.0 [23] section 13.10.12) or *RequestMPEGDecoder* is invoked again with request='false'. • If the result is false then the MPEG decoder is not available and I-frames may not be used. If request is 'false' then: • result shall be 'false', the MPEG decoder is not available and I-frames may not be used.

Description If the CI Plus application requires to stop the broadcast stream and display an I-frame then it must first get permission to use the MPEG decoder. When the application has finished with the MPEG decoder it may release it by calling *RequestMPEGDecoder* with request='false' however the application must have removed any I-frames from the display and restarted the stream with default components otherwise the results will be unpredictable.

12.4 Engine Graphics Model

The *graphics plane* is used to represent all visible's except MPEG I-frames. The CI Application menu shall have a drawing area of 720x576 pixels. The *graphics plane* shall match the current video resolution and aspect ratio. Where high definition video is present then the graphics plane shall be scaled to match the current video resolution and aspect ratio.

The CI Plus Graphics plane shall be above the video(s) and any subtitling plane. Any intermediate planes separating the CI Plus graphics plane and video (and subtitle) plane may optionally be disabled or made transparent. i.e. in an application environment the application graphics plane may be visible if the CI Plus Application display includes transparency.

The minimum colour palette and colour space representation is defined by D-Book 5.0 [23], section 14. It is recommended that truecolour with a minimum of 16 bits is implemented.

12.4.1 LineArt and Dynamic LineArt

LineArt and Dynamic LineArt shall not be required by *CIEngineProfile1*, as defined in D-Book 5.0 [23], section 14.5.

12.4.2 PNG Bitmaps

PNG bitmaps shall conform to D-Book 5.0 [23], section 14.7.

12.4.3 MPEG Stills

MPEG stills or I-frames shall conform to D-Book 5.0 [23], section 14.8.

12.4.4 User Input

The User Input is defined in D-Book 5.0 [23], section 13.6. A CI Plus initiated application may start in any register group setting including Register Group 5.

12.4.5 High definition graphics model.

High definition receivers (i.e. ones that are capable of decoding and presenting HD resolution video) shall observe the Engine Graphics Model defined in clause 12.4 and 12.4.1 to 12.4.4 with the exceptions specified by the HDGraphicsPlaneExtension and HDVideoExtension as defined in ETSI MHEG [38] clause 12.11 and related clauses.

12.4.5.1 Discovery

CI Plus applications shall be able to determine the graphics capability of the receiver to which they are delivered. Hosts supporting the HD graphics model shall support the “HDExtension” (“HDE”) GetEngineSupport feature string as defined in ETSI MHEG [38] clause 11.4.1.

12.5 Engine Text

CIEngineProfile1 has full conformance with D-Book 5.0 [23], section 15. except as documented in the following sections. These replace sections 15.3.1 and 15.3.1.1 in D-Book 5.0.

The character repertoire of *CIEngineProfile1* shall minimally be the character repertoire of *UKEngineProfile1* when the resident font is used. The MHEG application may use other characters that are available in an alternative character set after first confirming the presence of the character set in `rec://font/xxx`, where xxx is the required character set.
CIEngineProfile1 has a font attribute class of "`rec://font/CI1`".

Downloaded fonts may have a wider character repertoire and all characters in a downloaded font shall be supported.

12.5.1 Downloadable Fonts

Receivers may optionally support downloadable fonts using the MHEG-5 Font class. Support is indicated by a positive response to *DownloadableFont* for the supported content hook. Only receiver fonts may be referenced by name, downloaded fonts shall be referenced as an MHEG-5 Font object. The receiver shall support all characters in a downloaded font and will not be limited to a country specific engine profile. The set of supported characters in any receiver embedded font file may be limited to a country specific set of characters.

A receiver supporting Downloadable fonts shall minimally reserve 256K bytes of memory for dynamically loaded fonts. Asian fonts, such as Chinese, require the receiver to reserve significantly more font resource memory. CI Plus enabled receivers deployed in these areas shall determine the CI Plus memory requirement based on the broadcast requirements of the local region.

Where downloadable fonts are supported by a Host then the Host is only required to support the download of a single font. A Host may optionally support more than one downloadable font.

12.5.1.1 OpenType Fonts

The CHook value of 10 is defined as being an OpenType® font meeting version 1.4 of the OpenType specification with TrueType™ outlines and as published on the following web sites:

<http://www.microsoft.com/typography/otspec/default.htm>

<http://partners.adobe.com/asn/tech/type/opentype/index.jsp>

TrueType Collections are not supported in this profile. A font file is considered to contain a single font. This single font will be referenced as the default font style 'plain'. Where downloadable fonts are supported receivers are required to support the following tables:

- tables related to TrueType outlines
- the kern table (format ‘0’ horizontal kerning only).

Support for tables that are not required is optional.

For OpenType fonts, the following table defines the values to be used for the font metrics parameters referenced in D-Book 5.0 [23], section 15.5 "Text Rendering".

Table 12.7: OpenType font parameters

Parameter name	Obtained from
metricsResolution, outlineResolution	unitsPerEm field, defined in the Font Header ('head') table
advanceWidth, charSetWidth	advanceWidth values, defined in the Horizontal Metrics ('htmx') table. see note
xMin, yMin, yMax	defined in the Font Header ('head') table
Kern	value, defined in the Kerning ('kern') table
Note: for monospaced fonts, only a single advance width may be defined.	

12.5.1.2 Presentation

When a text object references a downloaded font the object shall be presented as defined in D-Book 5.0 [23] section 14.10, "Appearance of Visible objects during content retrieval" until successful download of the font or font download fails. Should the font download fail the receiver shall use the receivers default built-in font instead. When the receivers built-in font is used the text object shall be rendered using the rules for that font including the receivers defined Character repertoire.

12.5.1.3 Defensive Response

Font downloads may fail and applications may request invalid or unsupported features and characteristics. In order to handle these events in a predictable and robust manner receivers shall implement the following measures:

- The receiver shall use its inbuilt font in place of the download font when:
  - The requested font is unavailable
  - The content hook is unrecognised
  - The font attributes are invalid

When the receiver font is used then the text box shall be rendered as though the receiver font had been specified.

- The only supported font style is 'plain'. If any other font style is specified it shall be treated as 'plain'.
- If the requested font size is not supported by the font then the next smaller size shall be used. If the required font is smaller than the smallest available, then the smallest available size shall be used.

12.6 CI Application Life Cycle

This section covers the application life cycle. D-Book 5.0 [23] section 16 shall not be interpreted unless specifically stated in this section.

12.6.1 Application Life Cycle

The Application Life Cycle is the method by which the CI application is signalled to launch or terminate.

12.6.1.1 Launching and Terminating the CI Plus Application

The CI Plus Application for a *CIEngineProfile1* only Host shall be explicitly introduced by the CICAM by a **RequestStart**. The Host may respond with a *API busy* response if it is unable to honour the request and the CICAM may retry the request later.

CICAM applications may terminate for a number of reasons and the exit condition shall be reported to the CICAM as follows:

- They execute a "Quit" action.

- They are killed by the Host following a channel change.
- They are killed because the CI module generates a RequestStart or AppAbortRequest message.
- The CI Plus Application cannot be presented when subtitles or RTGraphics are enabled.

The CI file system is mounted by activity of the CI module. The current output state of the video, audio and optionally any other application, shall remain unchanged. Optionally the subtitles may be disabled and the application launched and presented. The application graphics shall be scaled to match the current video screen resolution.

12.6.2 Interaction with DVB Common Interface Module

The interaction with the DVB Common Interface Module shall adhere to D-Book 5.0 [23], section 16.11. The Application Domain Identifier "`CIMHEGP1`" (0x43494d4845475031) shall be used in the **RequestStart** message to identify that the required application domain is *CIEngineProfile1*.

The Application Domain Identifier may be optionally qualified with arguments that define the requirements of the CI Plus Application environment. The options are specified at the end of the Application Domain Identifier separated by a semi-colon (`;`) i.e. *<applicationDomainIndentifier>*[**;***<option1>***;***<option2>***;***…***;***<option#>*] where the options are defined as follows:

Table 12.8: Application Domain Identifier Launch Options

Name	Option Value	Notes
SSM RTGraphics State	SSM=0	Subtitles (RTGraphics) shall be disabled before the CI Plus Application is started, subtitles shall be returned to their existing running state when the CI Plus Application terminates.
	SSM=1	Subtitles (RTGraphics) shall be displayed when enabled by any user preference, if the CI Plus Application and subtitles are not able to co-exist then the CI Plus Application shall not start.
	SSM=2	Subtitles (RTGraphics) shall optionally be displayed when enabled by any user preference, if the CI Plus Application and subtitles are not able to co-exist then subtitles shall be disabled and the CI Plus Application shall launch. Where the subtitle state temporarily over-rides the user preference and are disabled then the existing subtitle state shall be restored when the application terminates. This option is the default state that shall be assumed when the SSM option is omitted from the application domain specifier.

12.6.2.1 MHEG Broadcast Profile

Where the broadcast profile of a given country supports a broadcast MHEG environment then the CICAM may be tailored to a specific broadcast profile and start with the Application Domain Identifier of that profile rather than the CI profile. See D-Book 5.0 [23], section 16.11.3.2. The broadcast profile application life cycle may be honoured which may allow:

- A CI application is introduced by the CI module.
- A CI application is optionally introduced by a broadcast application.

i.e. The CICAM may use the broadcast profile MHEG rather than the CI Plus Application environment for an operator specific CI Plus Application. The CICAM may continue to use the CI Plus Application MMI for CICAM specific menus and messages.

12.6.2.2 MHP Broadcast Profile

Where the broadcast profile supports MHP then the CI Plus Application MMI shall take priority over the MHP application environment and shall have input focus. The MHP graphics plane may be either be temporarily removed or the CI Plus Application MMI shall appear in front of it. As the CI Plus Application MMI is considered to be an extension of the native OSD then it is acceptable to present the CI Plus output on the native Host graphics plane as an alternative to the native graphics interface (OSD).

12.6.2.3 File Request and Acknowledge

The maximum size of a file request or acknowledge FileNameLength is not specified, but shall be suitable for the CI Plus browser memory resource.

12.6.2.4 Persistent Storage

The CI Plus engine shall minimally provide 1024 bytes of data as D-Book [23] section 16.7. Persistent Storage may be implemented in volatile memory.

12.6.3 Host Resource Model

As D-Book 5.0 [23] sections 16.8 and 16.9 with the following limitations.

12.6.3.1 Memory Resource

Receivers shall minimally provide 512Kbytes of RAM for the CI Plus Application. Where the engine supports High Definition graphics then the receiver shall minimally provide 1MByte of RAM for the CI Plus Application. Where the engine supports downloadable fonts then the receiver shall provide an additional 256kbytes of RAM for font handling as defined in 12.5.1.

12.6.3.2 Link Recursion Behaviour

The CI Plus engine shall allow at least 128 concurrent Actions and at least 1024 ElementaryActions pending processing.

12.6.3.3 Timer Count and Granularity

The CI Plus engines shall allow at least 4 concurrent MHEG-5 timers to be active with an accuracy of +/-10ms. When more than 4 timers are active then the accuracy may degrade in a platform specific manner.

Receivers shall support timer durations up to at least 1 hour.

12.6.3.4 Application Stacking

Application stacking is as section 16.9 of D-Book 5.0 except the application stack shall be capable of holding references to at least 5 applications.

12.7 Name Mapping

12.7.1 Names within the Host

The names in a *CIEngineProfile1* Host comprise:

Table 12.9: CI Profile Names within the Host

Name	Notes
rec://font/CI1	Identifies the built in font other font names may exist but are not mandated by *CIEngineProfile1*. This font is defined for Western Europe and shall be identical to UK-DTT "UK1".
ram://<name>	Name space for persistent storage.

12.7.2 Name Space Mapping

When an application starts then it is assumed that a MMI session with the a DVB CI Module has been established and the CI file system may be used to retrieve file objects containing *CIEngineProfile1* MHEG-5 objects or data content such as text and bitmaps.

The MHEG object files are either Scene, Application or content data of an Ingredient object, where each Scene, Application object or content data is stored in a separate file.

12.7.3 MHEG-5 Object References

The MHEG-5 object reference rules of D-Book 5.0 [23] section 18.3.1 apply with the exception of DSM-CC objects.

12.7.4 Mapping Rules for GroupIdentifier and ContentReference

The mapping rules for GroupIdentifier and ContentReference of D-Book 5.0 [23] section 18.3.2 apply with the following caveats:

12.7.4.1 Case sensitivity

The CI file system provides case sensitive file names.

12.7.4.2 Structure of file references

"`DSM:`" and "~" (the shorthand of "`DSM:`") are not required in *CIEngineProfile1*. The CI root file system is referenced as "`CI:`".

12.7.4.3 Caching

The default cache behaviour of "`CI:`" content is 'caching not allowed' (CCP0) and by default all file references are requested via the CI interface. There is no requirement for a *CIEngineProfile1* to support ContentCachPriority (CCP) with the CI file system.

A Host may optionally perform caching of the CI file system and may interpret the ContentCachePriority and GroupCachingPriority which shall be used in accordance with D-Book [23]. Any Hosts implementing a caching mechanism shall support the same cache behaviour as specified in the MHEG object carousel profile, except the words “broadcast stream” and “broadcast carousel” are replaced by “CI file system”. Caching may be performed using either the Application MMI resource v1 or v2 for greater efficiency (see 14.5).

The Content or Group Cache Priority shall be interpreted and applied to the CI file system according to Table 12.10.

Table 12.10: CICAM Caching Behaviour

Cache Priority	Semantics	Cache Retrieval Method
Even values (excluding zero)	Even non-zero values of cache priority (2, 4, 6, etc.) indicate that the object may be fetched from the local cache without reference to the CICAM. The value hints that the data is static and the higher the value the more useful the data is to cache. Any content that is persistently cached through MHEG sessions shall be considered dirty on starting any new MHEG session and shall be reacquired using RequestType = FileHash or RequestType = File.	Use locally cached content if available and not stale (or dirty)
Odd values	Odd values of cache priority (1,3,5, etc., including 127, the default) indicate that the Host must verify that the content is current before using data from the cache. The higher the value the more useful the data is to cache. Note: To verify that the content is current then a File request must be sent to the CICAM i.e. the cache is only useful for Hosts that support FileHash type requests.	RequestType=FileHash or RequestType=File
Zero	This is the default when no CICAM cache is implemented. Caching is not allowed for this content, cached copies of the data, if present, shall be invalidated and shall be explicitly retrieved from the CICAM with RequestType=File. RequestType=FileHash shall not be used for CPP0.	RequestType=File

12.8 VOD extensions

The Application MMI extends the engine features to support the requirements of CI Plus Specification v1.3 and includes additional resident programs to support VOD applications. VOD is provided using Host Control v2 and a VOD application requires an enhanced key capture mechanism and a control for graphics display hiding. The VOD extensions are a requirement for all Hosts implementing this (CI Plus) specification v1.3 or greater.

12.8.1 Resident Programs

The Resident Programs shall additionally include those listed in Table 12.11.

Table 12.11: CI Plus VOD Resident Program extensions

Resident Program	Name	Notes
TestInputMask	TIM	VOD key handling – DTG White paper
SuppressMHEGGraphics	SMG	VOD display control – CI Plus v1.3 Extension

An application may test for the presence of the VOD extensions by testing for the existence of the SMG resident program.

12.8.1.1 Test Input Mask

The input key handling shall be extended with the Input Mask Extensions that provide the Application MMI with access to the video control keys, this is detailed in document "DTG MHEG Spec Group White Paper: MHEG InputMaskExtensions".

The `InputEventMask` shall be provided in the Scene class.

The Elementary Action `SetInputMask (NewInputMask)` shall be supported.

12.8.1.2 Suppress MHEG Graphics

The SuppressMHEGGraphics resident program provides a control to toggle between the display of subtitles and application graphics on Hosts that only support a single graphics plane. The resident program allows the subtitles to be presented while an application continues to execute, in addition, allows subtitles to be suspended and the application graphics to be restored to the application environment. Invocation of this resident programme, on a Host that supports the simultaneous display of subtitles and MHEG graphics, does not guarantee that the graphics plane is removed from the display and it is the responsibility of the application to remove all visible objects.

Synopsis `SMG(GraphicsState)`

Arguments

In/out	Type	Name	comment
in	GenericBool	GraphicsState	If true then the Application MMI has relinquished the graphics plane and subtitles may be displayed when enabled. The graphics plane may be suppressed. If false then the Application MMI requires the graphics plane and subtitles shall be stopped and control of the graphics plane shall return to the Application MMI by the end of the resident program call.

Description On Hosts that support the simultaneous display of the Application MMI and subtitles this resident programme shall have no effect. The Application MMI is not required to hide graphical objects and graphical objects may remain visible.

On Hosts that do not support the simultaneous display of the Application MMI and subtitles then where the Application MMI was launched with SSM=2 and the Application MMI is displayed then the graphics plane shall be disconnected from the Application MMI and shall be used to present subtitles, when subtitles are enabled and present in the stream. The application may lose the graphics plane when SuppressMHEGGraphics(true) is invoked even if subtitles are not enabled. When SuppressMHEGGraphics(false) is invoked then subtitles shall be stopped and the graphics plane shall be returned to the application.

The resident program may be used by an application as follows:

1. Application MMI is launched with SSM=2 on a receiver that does not support the simultaneous display of application and subtitles. The user has enabled subtitles and subtitles are present in the stream.
2. The application starts and subtitles are suppressed.
3. The user navigates through the application and selects an option where no graphics are required (i.e. the screen is transparently filled). The application hides all visible graphics components and calls SuppressMHEGGraphics(true).
4. The graphics plane is disconnected from the application environment and subtitles are presented. There is likely to be a short delay in subtitle presentation as the subtitle decoder is started.
5. The application continues to receive key presses and is able to communicate and load files from the CICAM.
6. The user performs an action that requires the application to become visible. The application calls SuppressMHEGGraphics(false). When the resident program returns subtitles are hidden and the graphics plane is restored to the application. The application may make graphical components visible and they shall appear.

Legacy products will not support the SuppressMHEGGraphics() resident program and subtitles will remain disabled while the application runs.

12.9 MHEG-5 Authoring Rules & Guidelines

The authoring rules defined in D-Book 5.0 [23] section 19 apply but shall adhere to the CI Plus limits i.e. applications are restricted to 512 K bytes. Noted that HD applications may be larger but the application shall have determined that the engine supports HD before attempting to increase the application size up to 1Mbyte.

CI Plus Applications shall be authored with consideration that they may be deployed in SD or HD environments where the application graphics plane shall be subject to scaling.

The CICAM shall consider the subtitles (RTGraphics) state when launching a CI Plus Application. For some Host implementations it may not be possible for the CI Plus Application and subtitles to co-exist at the same time, in this case subtitles shall take priority where the CICAM attempts to install a background CI Plus Application, enabling the user to maintain subtitles.

It is the applications responsibility to ensure that the downloadable font support is available on the Host when used. OpenType fonts that use optional tables should be avoided by application authors as the results will vary from receiver to receiver. The application shall only use a single downloadable font.

The font may fail to download. Should this occur then text that uses characters not in the receiver default character set will be rendered incorrectly. The application should defend against this, for example by monitoring the ContentAvailable event from the font object before activating the text object.

Text shall always be rendered left to right, top to bottom. In regions where the text flow is right to left then the CI Plus Application engine will not word wrap correctly. MHEG applications may be authored with right justification and the text authoring should insert manual line feeds at appropriate points to ensure correct text flow and presentation.

CI Plus applications may exist in environments where they may compete with other application environments for use of the MPEG decoder so while the use of I-Frames is desirable for CI Plus applications they may not always be available. It is not intended for CI Plus applications to interfere with the broadcast stream. Care shall be taken by the application author to ensure predicable results, in order to ensure this CI Plus applications shall follow these rules:

- The application shall always start with an active stream with an original-content of "rec://svc/cur". This stream object shall have a multiplex of one audio object and one video object. Both the audio and video objects shall have a component tag of -1. The video object shall have an orignalBoxSize 720 wide and 576 high. The video object shall have an XYPosition of 0,0.

- The application shall not specify a scene aspect ratio.

- The application shall not change the position, scale or decode offset of the live video, however the application may change the position, scale and decode offset of I-Frames.

- Before stopping the stream object representing the broadcast stream the CI Plus application shall obtain permission from the resident program RequestMPEGDecoder (section 12.3.5.1). Once permission has been granted it remains granted for the duration of the resident program as defined in D-Book 5.0 section 13.01.12 or until the CI Plus application releases permission.
- Applications should not request use of the MPEG decoder more than necessary. If RequestMPEGDecoder has returned false then it is likely to return false if it is called again.
- Once the broadcast stream object has been stopped an I-Frame may be presented.
- The CI Plus application may relinquish permission to use the MPEG decoder, before doing so, the CI Plus application shall ensure the MPEG decoder is in the same state as it was before permission to use MPEG decoder was granted. Any I-Frame shall be removed from the display and a stream object for the broadcast stream started.

Any CI Plus application that does not follow these rules risks unpredictable behaviour.

While the initial scene of the application may start in any valid input register mode it is strongly recommended that it starts in input register 3. Starting in input register 5, for example, has the generally undesirable effect of restricting the users ability to change channel.

Application authors should take section 14.7 of D-Book 5.0 into consideration when producing PNGs. Removing unused chunks from a PNG and reducing the colour depth can have a significant impact on the file size and thus application load time.

13 CI Plus Man-Machine Interface Resource

13.1 Low Level MMI

The low level MMI is optional and not required by the CI Plus implementation.

13.2 High Level MMI

This specification does not change the EN 50221 [7] section 8.6, High level MMI, but extends the specification with an additional requirement:

- The Host shall be able to display 40 characters and 5 lines in addition of title, subtitle and bottom line.

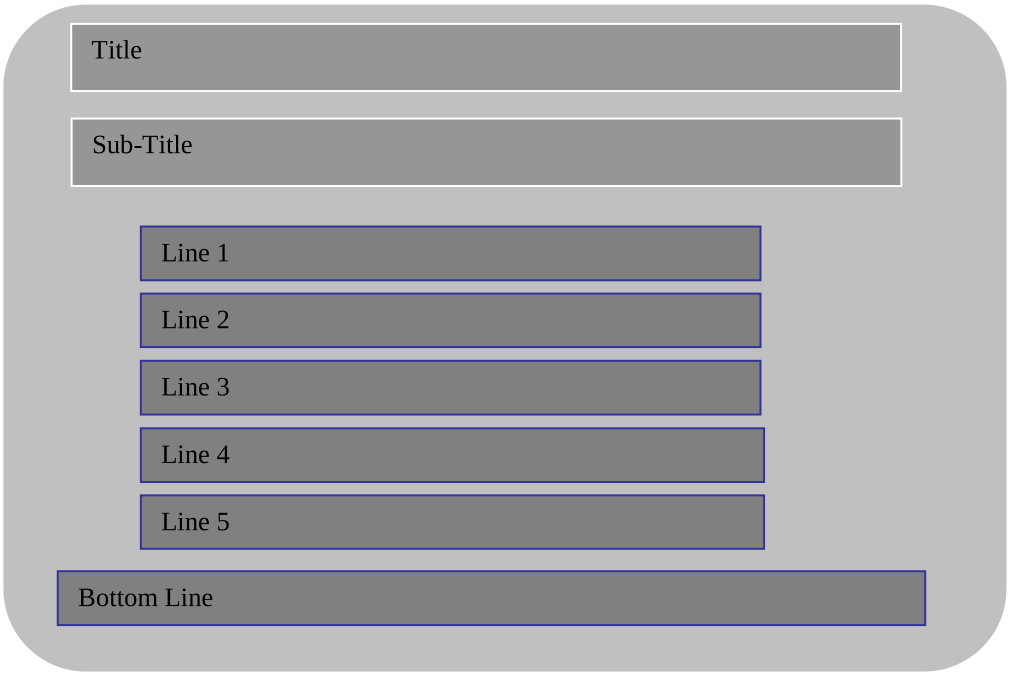


Figure 13.1: High Level MMI Presentation

13.3 MMI Resources Association

The following table shows the MMI capabilities of the Host and CICAM on the DVB CI and CI Plus profiles.

Table 13.1: MMI Resource HOST / CICAM DVB-CI Version

		Host	
		DVB-CI	**CI Plus**
CICAM	**DVB-CI**	- High level MMI: Mandatory - Low level MMI: optional	- High level MMI: Mandatory - Appl. MMI "CI Plus browser": Optional
	CI Plus	- High level MMI: Mandatory	- High level MMI: Mandatory - Appl. MMI "CI Plus browser": Mandatory

The High Level MMI and Application MMI are mutually exclusive and the CICAM shall not attempt to open a session to both resources at the same time. Where the CICAM attempts to open both resources simultaneously then the Host behaviour is undefined.

13.4 CICAM Menu

The following recommendation is made in respect to the CICAM menu on the Host.

- The maximum number of levels to access the CICAM menu is less than 3.

14 Other CI Extensions

14.1 Low Speed Communication Resource Version 3

Version 3 of the Low Speed Communication changes the messages and the protocol in order to increase data throughput.

- The maximum size of send and receive buffers is increased to 2048 bytes.

- Host and CICAM use a fixed buffer pool of 16 buffers in each direction.
- Multiple buffer acknowledgement.
- Multiple buffer availability notification which is not acknowledged.

The minimum bit rate supported shall be 1 Mbps.

14.1.1 comms_cmd Modification

The changes in the comms_cmd() APDU are related to the Set_Params command. The buffer_size is now encoded as a 16-bit value. The buffer_size and reception_timeout both have default values.
The CICAM shall send a Set_Params command only when the network side is not connected or when a network connection is established and no payload data has been transmitted yet.

Table 14.1: Comms Cmd Object coding

Syntax	No. of bits	Mnemonic
`comms_cmd() {`		
`   descriptor_tag`	24	uimsbf
`   length_field()`		
`   comms_command_id`	8	uimsbf
`   if (comms_command_id == Connect_on_Channel) {`		
`      connection_descriptor()`		
`      retry_count`	8	uimsbf
`      timeout`	8	uimsbf
`   }`		
`   if (comms_command_id == Set_Params)`		
`      buffer_size`	16	uimsbf
`      reception_timeout`	8	uimsbf
`   }`		
`   if (comms_command_id == Get_Next_Buffer){`		
`      comms_phase_id`	8	uimsbf
`   }`		
`}`		

buffer_size: The maximum size, expressed in bytes, of the buffers exchanged in both directions. The maximum value of buffer_size is 2048. The default value for the buffer size, when no Set_Params command has been sent, shall be 254 bytes.

reception_timeout: A reception timeout value, expressed in units of 10ms. If the Host has received one or more bytes in the current buffer and the timeout has elapsed with no further bytes received, then the buffer is sent to the CICAM. If the buffer fills to the limit set by the buffer_size parameter with no timeout then the buffer is sent immediately. The default value for reception_timeout is 10, i.e.100ms. A reception_timeout of 0 is illegal and shall not be used.

14.1.2 comms_reply Modification

With version 3 of the LSC resource, the Host shall not acknowledge availability of a buffer before sending it to the CICAM. As a consequence, the Host shall never send comms_reply() with the comms_reply_id set to 05 (the former comms_reply_id of Get_Next_Buffer_Ack).

The comms_reply_id values are defined in Table 14.2.

Table 14.2: comms_reply_id

comms_reply_id	id_value
Connect_Ack	0x01
Disconnect_Ack	0x02
Set_Params_Ack	0x03
Status_Reply	0x04
Reserved	0x05
Send_Ack	0x06
Reserved	Other values

The syntax of the comms_reply() message is unchanged from Table 54 of EN 50221 [7]. Zero (0x00) is the standard OK return value, 0xff is the non-specific error. See Annex E.14.

The comms_reply() return value for Set_Params_Ack is 0 when the Host accepts the buffer size requested by the CICAM or 0xfe (buffer too big) when the Host cannot handle send and receive buffers of the size requested by the CICAM. In this case, the buffer size and timeout remain unchanged and the CICAM may resend a Set_Params command with a smaller buffer size.

Set_Params_Ack shall return 0xff when the CICAM requested a reception_timeout of 0. The previous reception_timeout shall not be changed in this case. Set_Params_Ack shall return 0xff in response to a Set_Params command that was sent after a network connection was established and data has been transferred.

14.1.3 CICAM Flow Control

With version 3 of the Low Speed Communication resource, the CICAM uses a fixed number of 16 buffers.

The availability of a set of consecutive buffers is indicated to the Host by issuing Get_Next_Buffer with the comm_phase_id set to the identifier of the last buffer of the buffer set. The set of buffers is defined as the last Get_Next_Buffer comm_phase_id plus one (modulo 16), or zero when no Get_Next_Buffer has been issued from session opening or connect on channel, to the current Get_Next_Buffer comm_phase_id, inclusive.

When received data is available from the channel, the Host shall use the comms_rcv APDU with the comm_phase_id set to the last comms_rcv APDU comm_phase_id plus one (modulo 16), or zero when no comms_rcv APDU has been issued from session opening or connect on channel. The buffer corresponding to the comm_phase_id is considered as no longer available until the CICAM issues a Get_Next_Buffer APDU describing a set of buffers which includes the said buffer.

The Host shall stop issuing comms_rcv APDU when all the buffers available have been used. The Host shall wait until the CICAM indicates availability of a new set of buffers before issuing a comms_rcv APDU, if required.

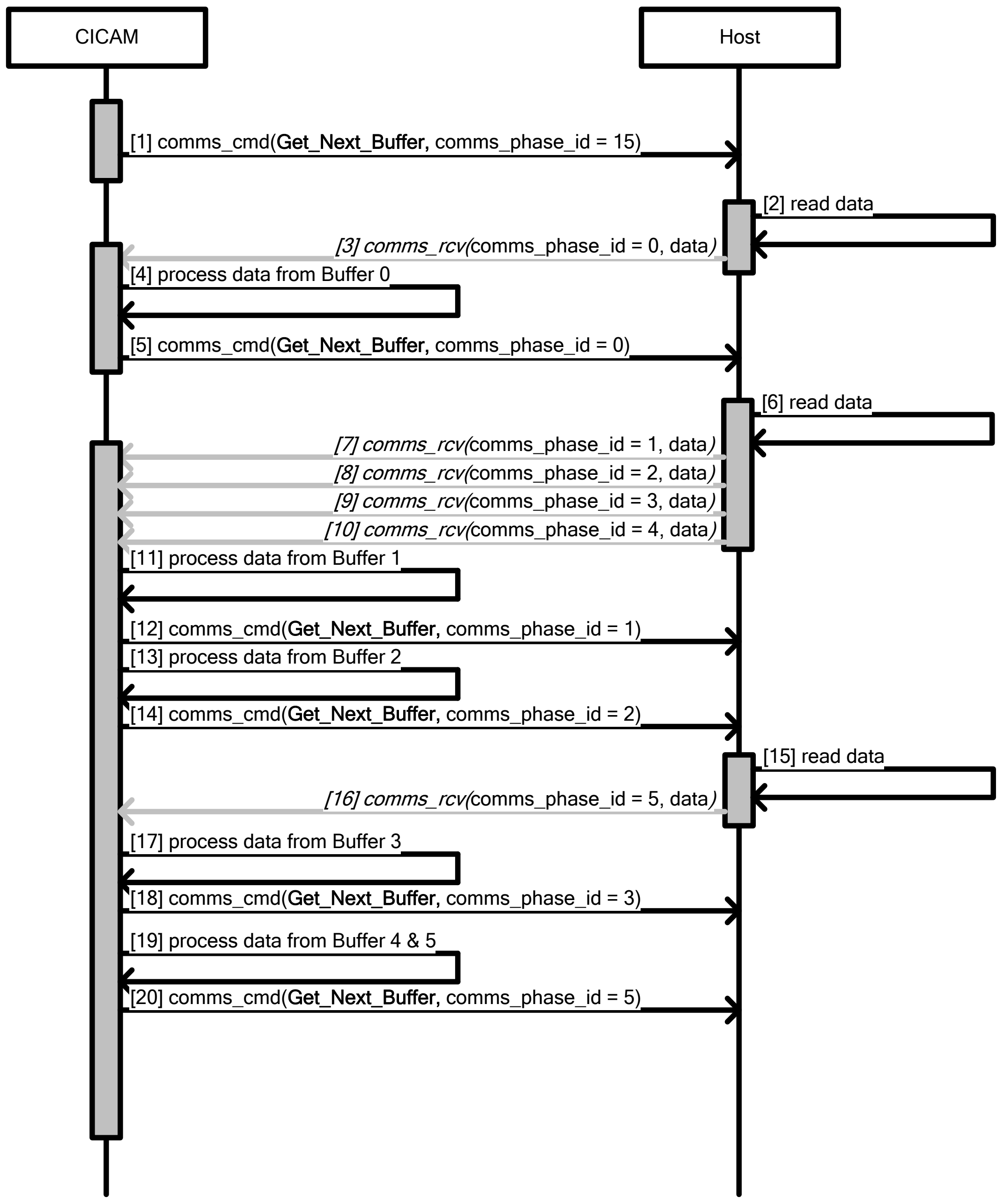

CICAM
Host
[1] comms_cmd(Get_Next_Buffer, comms_phase_id = 15)
[2] read data
[3] comms_rcv(comms_phase_id = 0, data)
[4] process data from Buffer 0
[5] comms_cmd(Get_Next_Buffer, comms_phase_id = 0)
[6] read data
[7] comms_rcv(comms_phase_id = 1, data)
[8] comms_rcv(comms_phase_id = 2, data)
[9] comms_rcv(comms_phase_id = 3, data)
[10] comms_rcv(comms_phase_id = 4, data)
[11] process data from Buffer 1
[12] comms_cmd(Get_Next_Buffer, comms_phase_id = 1)
[13] process data from Buffer 2
[14] comms_cmd(Get_Next_Buffer, comms_phase_id = 2)
[15] read data
[16] comms_rcv(comms_phase_id = 5, data)
[17] process data from Buffer 3
[18] comms_cmd(Get_Next_Buffer, comms_phase_id = 3)
[19] process data from Buffer 4 & 5
[20] comms_cmd(Get_Next_Buffer, comms_phase_id = 5)

Figure 14.1: CICAM Flow Control (Informative)

The Table 14.3 indicates availability of each of the 16 buffers, after several steps of the above flow control figure.

Table 14.3: Buffer availability in example flow figure

Buffer Id	STEPS								
	[1]	[3]	[5]	[10]	[12]	[14]	[16]	[18]	[20]
0	**O**	X	O	O	O	O	O	O	O
1	O	**O**	**O**	X	O	O	O	O	O
2	O	O	O	X	X	O	O	O	O
3	O	O	O	X	X	X	X	O	O
4	O	O	O	X	X	X	X	X	O
5	O	O	O	**O**	**O**	**O**	X	X	O
6	O	O	O	O	O	O	**O**	**O**	**O**
7	O	O	O	O	O	O	O	O	O
8	O	O	O	O	O	O	O	O	O
9	O	O	O	O	O	O	O	O	O
10	O	O	O	O	O	O	O	O	O
11	O	O	O	O	O	O	O	O	O
12	O	O	O	O	O	O	O	O	O
13	O	O	O	O	O	O	O	O	O
14	O	O	O	O	O	O	O	O	O
15	O	O	O	O	O	O	O	O	O

“O” means buffer available for the Host.

“X” means buffer not available for the Host.

The next available buffer to be used by the Host for data reception is marked with a bold “**O**”.

The transfer steps shown in Figure 14.1 are described below:

1) After a connection is successfully established on the channel, the CICAM issues Get_Next_Buffer with comms_phase_id set to 15, to indicate to the Host that Buffers 0 to 15 may be filled .
2) The Host receives data on the channel.
3) The Host sends the received buffer using the Comms Rcv object with comms_phase_id set to 0.
4) The CICAM processes buffer 0.
5) The CICAM issues Get_Next_Buffer with comms_phase_id set to 0, to indicate to the Host that Buffer 0 may be filled.
6) The Host receives data on the channel.
7) The Host sends part of the received data using the Comms Rcv object with comms_phase_id set to 1.
8) The Host sends part of the received data using the Comms Rcv object with comms_phase_id set to 2.
9) The Host sends part of the received data using the Comms Rcv object with comms_phase_id set to 3.
10) The Host sends part of the received data using the Comms Rcv object with comms_phase_id set to 4.
11) The CICAM processes buffer 1.
12) The CICAM issues Get_Next_Buffer with comms_phase_id set to 1, to indicate to the Host that Buffer 1 may be filled.
13) The CICAM processes buffer 2.
14) The CICAM issues Get_Next_Buffer with comms_phase_id set to 2, to indicate to the Host that Buffer 2 may be filled.
15) The Host receives data on the channel.

16) The Host sends the received buffer using the Comms Rcv object with comms_phase_id set to 5.

17) The CICAM processes buffer 3.

18) The CICAM issues Get_Next_Buffer with comms_phase_id set to 3, to indicate to the Host that Buffer 3 may be filled.

19) The CICAM processes buffers 4 and 5.

20) The CICAM issues Get_Next_Buffer with comms_phase_id set to 5, to indicate to the Host that Buffers 4 and 5 may be filled.

14.1.4 Host Flow Control

With version 3 of the Low Speed Communication resource, the Host shall accept up to 16 buffers before flow control is activated by the CICAM.

When the CICAM has to send data to the channel, the CICAM uses a comms_send APDU with comms_phase_id set to the last comms_send APDU comm_phase_id plus one (modulo 16), or zero when no comms_send APDU has been issued from session opening or connect on channel.

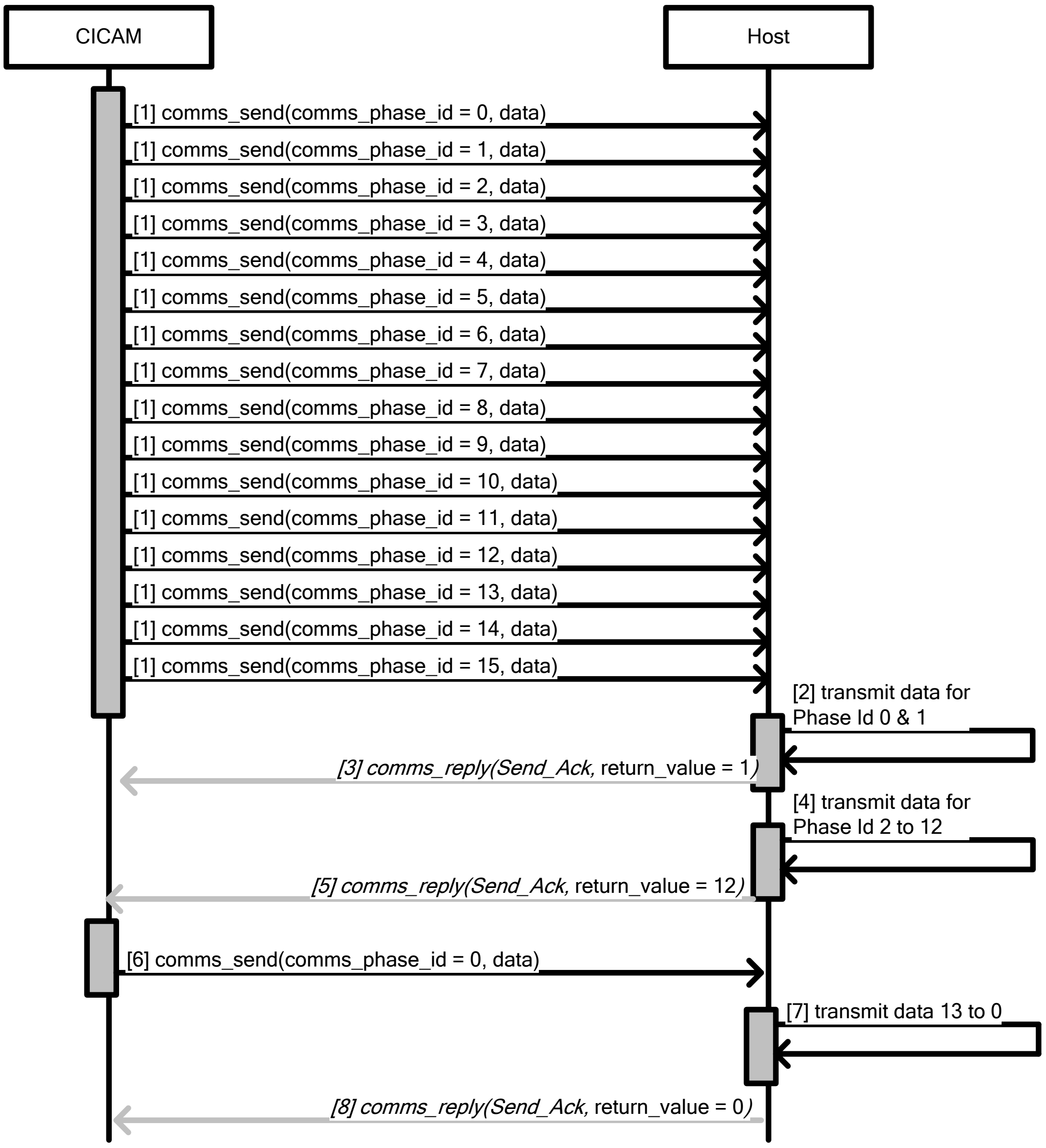

CICAM
Host
[1] comms_send(comms_phase_id = 0, data)
[1] comms_send(comms_phase_id = 1, data)
[1] comms_send(comms_phase_id = 2, data)
[1] comms_send(comms_phase_id = 3, data)
[1] comms_send(comms_phase_id = 4, data)
[1] comms_send(comms_phase_id = 5, data)
[1] comms_send(comms_phase_id = 6, data)
[1] comms_send(comms_phase_id = 7, data)
[1] comms_send(comms_phase_id = 8, data)
[1] comms_send(comms_phase_id = 9, data)
[1] comms_send(comms_phase_id = 10, data)
[1] comms_send(comms_phase_id = 11, data)
[1] comms_send(comms_phase_id = 12, data)
[1] comms_send(comms_phase_id = 13, data)
[1] comms_send(comms_phase_id = 14, data)
[1] comms_send(comms_phase_id = 15, data)
[2] transmit data for Phase Id 0 & 1
[3] comms_reply(Send_Ack, return_value = 1)
[4] transmit data for Phase Id 2 to 12
[5] comms_reply(Send_Ack, return_value = 12)
[6] comms_send(comms_phase_id = 0, data)
[7] transmit data 13 to 0
[8] comms_reply(Send_Ack, return_value = 0)

Figure 14.2: Host Flow Control with 16 buffers (Informative)

The acknowledgement of transmission through the channel of a set of consecutive buffers is indicated by the Host by issuing a comms_reply APDU with comms_reply_id=Send_Ack and the return_value set to the identifier of the last buffer of the buffer set. The set of buffers acknowledged for transmission is defined as the last comms_reply APDU with comms_reply_id=Send_Ack return_value plus one (modulo 16), or zero when no comms_reply APDU with comms_reply_id= Send_Ack has been issued from session opening or connect on channel, to the current comms_reply return_value, inclusive.

The CICAM shall stop issuing the comms_send APDU when all the buffers that have been sent to Host for transmission to the channel are not acknowledged. The CICAM shall wait until the Host acknowledges transmission of a new set of buffers before issuing further comms_send APDU, if required.

The transfer steps shown in Figure 14.2 are described below:

1) After a connection is successfully established on the channel, the CICAM sends 16 buffers to the Host with comms_phase_id from 0 to 15.
2) The Host transmits the buffer 0 and 1 (with comms_phase_id = 0 and comms_phase_id = 1).
3) The Host sends to the CICAM a comms_reply with comms_reply_id= Send_Ack and return_value = 1 to acknowledge the transmission of the set of buffers from comms_phase_id = 0 to comms_phase_id = 1.
4) The Host transmits the buffers 2 to 12.
5) The Host sends to the CICAM a comms_reply with comms_reply_id = Send_Ack and return_value = 0 to acknowledge the transmission of the set of buffers from comms_phase_id = 2 to comms_phase_id = 12.
6) The CICAM fills the buffer 0 and send it to the Host with comms_phase_id = 0.
7) The Host transmits the buffers 13 to 0.
8) The Host sends to the CICAM a comms_reply with comms_reply_id = Send_Ack and return_value = 0 to acknowledge the transmission of the set of buffers from comms_phase_id = 13 to comms_phase_id = 0.

14.1.5 Requirement for Buffers

- Buffers of up to 2048 bytes in length shall be supported in both directions. The CICAM may select a buffer size lower than 2048 if required by sending a Set_Params command.
- The Host shall accept up to 16 buffers sent by the CICAM before flow control takes place.
- The maximum number of message bytes in comms_send() is 2048 bytes.
- The maximum number of message bytes in comms_rcv() is 2048 bytes.

14.1.6 Disconnection Behaviour

When a disconnection is initiated by the network endpoint, the Host shall transmit all pending receive buffers to the CICAM and shall then send an unsolicited comms_reply() see last paragraph of EN 50221 [7] section 8.7.1.5. The Low Speed Communication session remains open and the CICAM may request another connection.

14.1.7 Data transfer

In order to transfer payload data between the CICAM and a network endpoint via the Host, an exchange of APDUs between the Host and the CICAM is required as follows.

The CICAM breaks down its payload into chunks of buffer_size bytes. Buffers that are completely filled are sent with a comms_send_more() APDU, the last (partial or full) buffer shall be sent with comms_send_last(). A CICAM shall not send a partially filled buffer in a comms_send_more() APDU.

The Host sends payload data received from the network to the CICAM using the comms_rcv_more() or comms_rcv_last() APDUs. The Host breaks down its payload into chunks of buffer_size bytes. Buffers that are completely filled are sent with a comms_rcv_more() APDU immediately. A partially filled buffer on a timeout or a close of the network endpoint shall be sent with a comms_rcv_last() APDU.

The Host delivers a byte stream from the network to the CICAM that is packetized into comms_rcv_more() and comms_rcv_last() APDUs. The CICAM shall interpret the payload as a byte stream and shall not rely on the payload size of APDUs or on the comms_rcv_more() / comms_rcv_last() tag for interpreting the payload. If an application requires the splitting of the received payload byte stream into messages and the detection of message boundaries, this mechanism shall be provided by the protocol that runs on top of the LSC resource.

14.2 Low Speed Communication IP Extension

The low-speed communications resource class as defined in EN 50221 [7] is enhanced to provide bi-directional communications over an IP connection. This may be used to support Conditional Access functions and may be used in conjunction with interactive services. Version 2 and above of the low-speed communications resource supports an IP connection.

The Host IP stack shall comply with the following standards:

RFC768 (UDP)

RFC793 (TCP)

RFC791 (IPv4)

Support for IPv6 and IPv4 multicast is optional on the Host.

IPv4 multicast implementations shall comply with RFC1112 (IGMPv1). IPv6 support on the Host shall be compliant to RFC2460 (IPv6) and RFC4443 (ICMPv6).

For all multicast connections, the protocol_type in the IP descriptor shall be UDP.

If the IP descriptor in the CICAM's comms_cmd APDU contains an invalid value or the requested connection type is not available on the Host, the Host shall reject the connection attempt. This is performed by responding with a comms_reply APDU with comms_reply_id set to Send_Ack and return_value set to 0 (see EN 50221, section 8.7.1.5)

The Host supports only one connection per session, but the Host may support several sessions in parallel.

The communication messages are the same as described in EN 50221 [7] section 8.7.

The contents of the payload shall be in Network Byte Order.

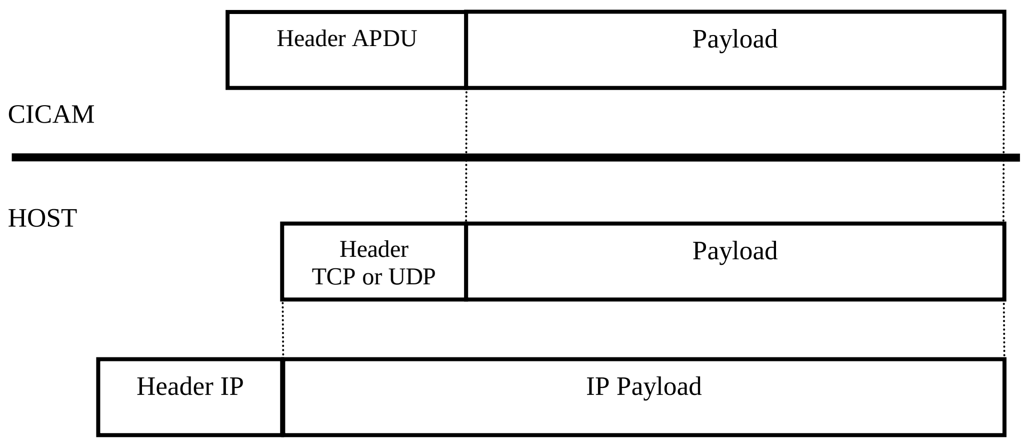


Figure 14.3: Transport packet format

On a TCP connection, the host may dispatch the payloads of a comms_send_more() or comms_send_last() APDUs to the network immediately since TCP provides buffering and reliable transport. No data shall be lost when using TCP.

On a UDP connection, the host shall buffer all incoming comms_send_more() payloads until it receives a comms_send_last() or the size of all buffered payloads exceeds the size of all available send buffers. It shall then write the data to the network in one step.

The host may read TCP data from the network in chunks of any length that is suitable for relaying the data in comms_rcv_more() and comms_rcv_last() APDUs.

When reading UDP data from the network, the host should ensure that it reads complete datagram's and no data is discarded during the read. Each datagram read in this way should be split into comms_rcv_more() and comms_rcv_last() APDUs.

14.2.1 Comms Cmd Modification

A new connection type is added to the connection descriptor object to provide the parameters for an IP connection over the low speed communication resource.

Table 14.4: Connection Descriptor object coding

Syntax	No. of bits	Mnemonic
`connection_descriptor() {`		
`  connection_descriptor_tag /* see EN 50221 [7] */`	24	uimsbf
`  length_field()`		
`  connection_descriptor_type`	8	uimsbf
`  if (connection_descriptor_type == SI_Telephone_Descriptor) {`		
`    telephone_descriptor() /* see EN 300 468 [10] */`		
`  }`		
`  if (connection_descriptor_type == Cable_Return_Channel_Descriptor) {`		
`    channel_id`	8	uimsbf
`  }`		
`  if (connection_descriptor_type == IP_Descriptor) {`		
`    IP_descriptor()`		
`  }`		
`  if (connection_descriptor_type == Hostname_descriptor) {`		
`    Hostname_descriptor()`		
`  }`		
`}`		

The "connection_descriptor" table is modified to include the descriptor type for the IP connection.

Table 14.5: Connection Descriptor Type

connection_descriptor_type	Type value
SI_Telephone_Descriptor	01
Cable_Return_Channel_Descriptor	02
IP_Descriptor	03
Hostname_descriptor	04
All other values reserved	

14.2.1.1 Comms Cmd IP_descriptor

The IP descriptor syntax is specified in Table 14.7

Table 14.6: IP Descriptor

Syntax	No. of bits	Mnemonic
`IP_descriptor() {`		
`descriptor_tag`	8	uimsbf
`descriptor_length`	8	uimsbf
`IP_protocol_version`	8	uimsbf
`IP_address`	128	uimsbf
`destination_port`	16	uimsbf
`protocol_type`	8	uimsbf
`}`		

descriptor_tag: the descriptor_tag for the IP_descriptor is 0xCF.

descriptor_length: the descriptor length is an 8-bit field specifying the total number of bytes of the data portion of the IP_descriptor following the byte defining the value of this field.

IP_protocol_version: this field defines the IP protocol version.

Table 14.7: Protocol Versions

IP_Protocol_version	Type value
reserved	0x00
IPv4	0x01
IPv6	0x02
All other values reserved	0x03-0xFF

IP_address: this field defines the IP address destination. In IPv4 the 12 first bytes are equal to "0".

destination_Port: this field defines the destination port to be use by the Host. The reception port is managed by the Host.

protocol_type: this field is used to define the protocol to use; UDP or TCP.

Table 14.8: Protocol Types

protocol_type	Type value
reserved	0x00
TCP	0x01
UDP	0x02
All other values reserved	0x03-0xFF

14.2.1.2 Comms Cmd Hostname_descriptor

Table 14.9: Hostname Descriptor

Syntax	No. of bits	Mnemonic
`hostname_descriptor() {`		
`descriptor_tag`	8	uimsbf
`descriptor_length`	8	uimsbf
`protocol_type`	8	uimsbf
`destination_port`	16	uimsbf
`for (i=0; i<n; i++) {`		
`hostname_byte`	8	uimsbf
`}`		
`}`		

descriptor_tag: the descriptor_tag for the hostname_descriptor is 0xCD.

descriptor_length: the descriptor length is an 8-bit field specifying the total number of bytes of the data portion of the hostname_descriptor following the byte defining the value of this field.

protocol_type: this field is used to define the protocol to use; UDP or TCP.

destination_Port: this field defines the destination port to be use by the Host. The reception port is managed by the Host.

hostname_byte: data bytes making up the Host name, i.e. FQDN. Refer to RFC1123 [40], section 2.1.

14.2.2 Low-Speed Communications Resource Types Modification

New values of Low-speed communications resources types are added to support the IP connection.

9	8	7	6	5	4	3	2	1	0
device type								device no.	

Figure 14.4: Communications Resource Type Structure

The device type field is defined in Table 14.10.

Table 14.10: Communications Device Types

Description	Value
Modems	0x00-0x3F
Serial Ports	0x40-0x4F
Cable return channel	0x50
reserved	0x51-0x5F
IP connection	0x60
reserved	0x61-0xFF
NOTE: Table supersedes 8.8.1.1 in EN 50221 [7]	

The device no. shall be zero for device type IP connection.

14.3 CAM Upgrade Resource and Software Download

14.3.1 Introduction

CICAM software is becoming increasingly complex, in order to guarantee the functionality and security of a CICAM in the field a software upgrade may be necessary. The firmware upgrade may be available on the network using information contained in one or more transport streams.

DVB CICAMs are currently able to perform a software upgrade but the existing specification does not provide any standardised interface between the Host and CICAM to coordinate a software download. This specification introduces a standardised method of handling a CICAM software upgrade enabling the CICAM to negotiate with the Host and CA System to effect an upgrade.

The resource interface is mandated by this specification and ensures that the software upgrade is not left to proprietary methods of signalling. This section defines the signalling and synchronisation between the CICAM and Host, the actual carriage and signalling of the CICAM software upgrade is not defined by this specification and may use standardised broadcast software upgrade schemes such as DVB-SSU or a proprietary delivery mechanism defined by the Operator or CA provider.

The CAM upgrade may initiate a tune operation by the Host under CICAM control as part of the upgrade process using either the Host control tune() APDU or Host control tune_broadcast_req() APDU. The tune() and tune_broacast_req() APDUs are mandated by this specification.

14.3.2 Principles

The CICAM upgrade process considers different requirements from:

- CA provider.
- Service operator.
- Host (TV or recording device).

A typical conditional access CICAM provides two different modes of software upgrade operation called "delayed" and "immediate" satisfying different requirements of the CA System:

Immediate mode is used when a software upgrade is required immediately. The CICAM ceases to process CA protected services until an upgrade has successfully completed.

Delayed mode is used when a software upgrade may be deferred. The CICAM continues to process CA protected services and allows the upgrade to be rescheduled to occur at a more appropriate time. This may be determined automatically by the Host, minimising service interruption, or explicitly controlled by the user. A delayed software upgrade may be determined by a version number difference or some other CA System criteria.

The CICAM shall not make any request for a software upgrade unless a CA service has been selected by a ca_pmt. The CICAM may be on a transponder that carries or signals software upgrade availability, unless a CA service is currently selected the CICAM shall not initiate any upgrade interaction. The CICAM may silently proceed to download the upgrade provided that there is no interruption to the transport stream and with the knowledge that the transponder may be changed at any time.

14.3.3 CAM Upgrade Process

The basic software upgrade process is shown in Figure 14.5 as a sequence of steps:

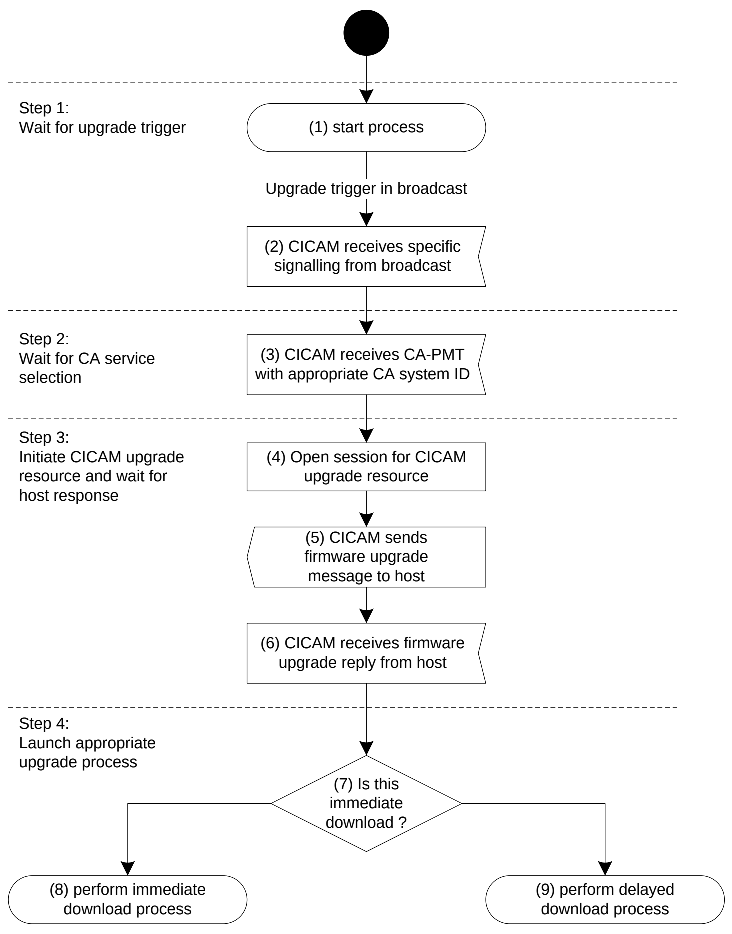

Step 1:
Wait for upgrade trigger
(1) start process
Upgrade trigger in broadcast
(2) CICAM receives specific signalling from broadcast
Step 2:
Wait for CA service selection
(3) CICAM receives CA-PMT with appropriate CA system ID
Step 3:
Initiate CICAM upgrade resource and wait for host response
(4) Open session for CICAM upgrade resource
(5) CICAM sends firmware upgrade message to host
(6) CICAM receives firmware upgrade reply from host
Step 4:
Launch appropriate upgrade process
(7) Is this immediate download ?
(8) perform immediate download process
(9) perform delayed download process

Figure 14.5: CAM Upgrade Process

The process is defined as follows:

1) Wait for a trigger signalling the availability of a new software upgrade for the CICAM. The CA System and service operator determines how the Head-end system signals firmware upgrade availability to the CICAM which shall be recognised in the broadcast.

2) Wait for the Host to perform a service selection to the CA Service, determined by the CA System Id in the current ca_pmt.

3) The CAM_upgrade resource is opened and the CICAM informs the Host of the software upgrade availability including the upgrade mode. The CICAM waits for the Host reply to determine how the upgrade shall proceed.

4) The Host response and download mode determines how the CICAM shall process the software download which may be initiated.

14.3.3.1 Delayed Process

When a delayed upgrade is requested by the head-end, the delayed process is launched as soon as the CICAM receives a response from the Host.

According to the Host response, the CICAM has the following states:

If the Host's response is "No" then CICAM closes the CAM_upgrade session and the CAM_upgrade process is stopped.

If the Host's response is "Yes" then CICAM optionally opens a session on DVB Host Control to send a Tune request message and to perform the software download on the CICAM

If the Host's response is "Ask" then the CICAM displays an MMI dialogue to inform the End User about this CAM upgrade availability. The CICAM launches or stops the software download process depending on the user's feedback (accept or decline).

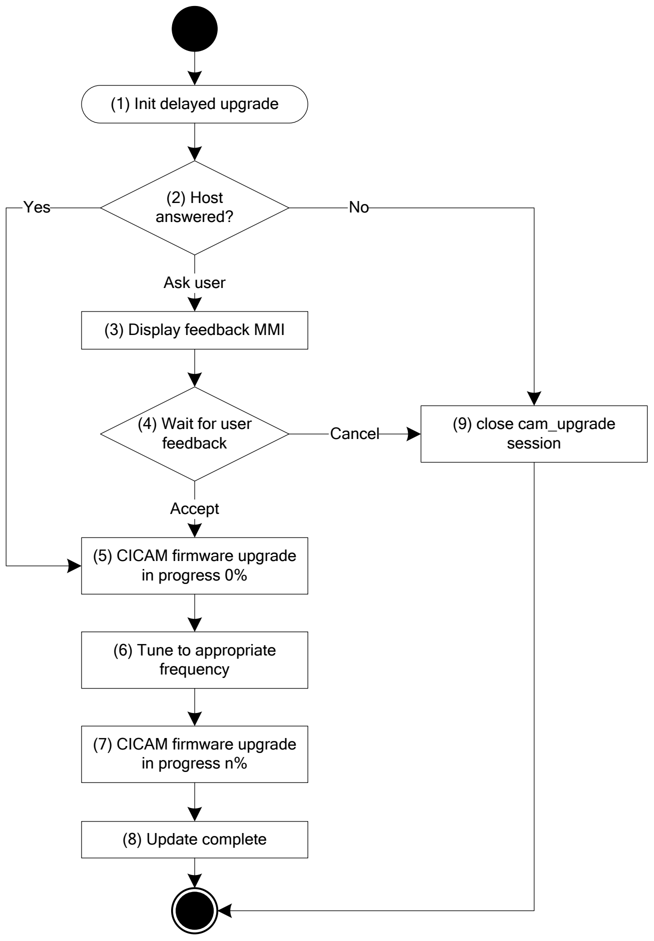

(1) Init delayed upgrade
(2) Host answered?
Yes
No
Ask user
(3) Display feedback MMI
(4) Wait for user feedback
Cancel
(9) close cam_upgrade session
Accept
(5) CICAM firmware upgrade in progress 0%
(6) Tune to appropriate frequency
(7) CICAM firmware upgrade in progress n%
(8) Update complete

Figure 14.6: Delayed process

14.3.3.2 Immediate Process

When an immediate upgrade is requested by the head-end the CICAM stops CA descrambling until the upgrade has been successfully acquired and installed, an outline of the process is shown in Figure 14.7.

The CICAM notifies the Host of the upgrade using the CAM_upgrade resource and awaits the response which is processed as follows.

When the Host reply is "Yes" the CICAM initiates a software upgrade process immediately. This may require that the CICAM opens a session to the Host Control Tune resource to perform a tuning operation to acquire the upgrade.

When the Host reply is "Ask" the CICAM displays a MMI dialogue to inform the user about the upgrade availability and request permission to perform the upgrade. The CICAM shall either continue with the upgrade or stop the process depending on the user response (accept or decline). When the upgrade has been stopped the user may only tune away to another FTA service as no CA services are descrambled. When the user has accepted the upgrade then the Host shall allow the software upgrade to complete, optionally displaying a progress indicator. User intervention shall be disabled until the upgrade has completed.

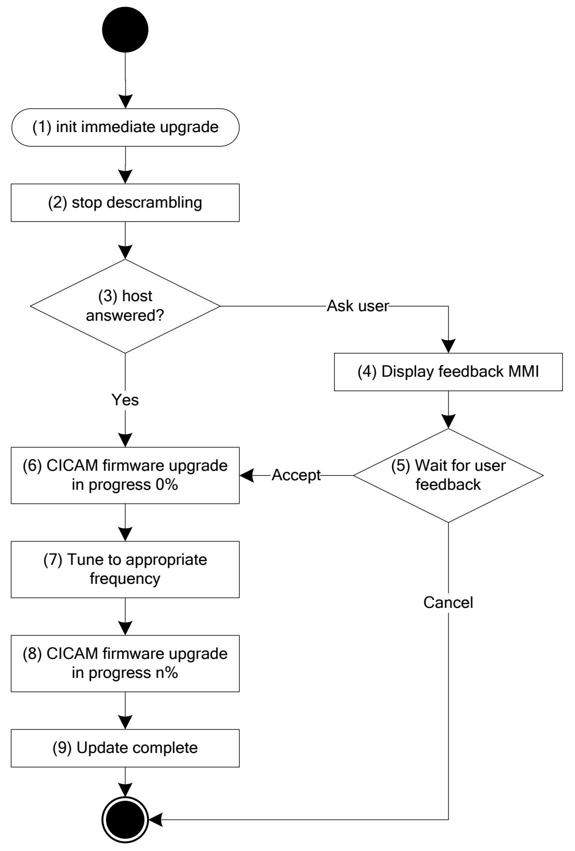

(1) init immediate upgrade
(2) stop descrambling
(3) host answered?
Ask user
(4) Display feedback MMI
Yes
(5) Wait for user feedback
Accept
(6) CICAM firmware upgrade in progress 0%
(7) Tune to appropriate frequency
Cancel
(8) CICAM firmware upgrade in progress n%
(9) Update complete

Figure 14.7: Immediate Process

14.3.4 CAM Upgrade Protocol

14.3.4.1 Delayed mode

For a delayed upgrade, the CICAM waits for the Host to select a CA Service with a ca_pmt which includes a CA descriptor with a matching upgrade CA system ID. When such a service is selected the CICAM opens the CAM upgrade resource, if it is not already open, and sends a cam_firmware_upgrade APDU to initiate a delayed upgrade process.

The Host shall respond to the request with a cam_firmware_upgrade_reply including a status in the "answer" parameter, the operating mode of the Host is likely to determine the response i.e. user control or unattended. The CICAM shall use the Host answer to determine how to proceed with the upgrade process.

If the upgrade has been accepted the CICAM shall first send a cam_firmware_upgrade_progress message indicating that a software upgrade process has started. The CICAM may then use the DVB Host Control APDUs to send one or more tune() or tune_broadcast() requests to locate and select the download service, the progress of the download shall then be communicated every 20 seconds with cam_firmware_upgrade_progress messages. When the upgrade process has completed then the CICAM sends a cam_firmware_upgrade_complete APDU.

If the upgrade is not accepted it may be re-attempted next time the Host selects a CA Service with a ca_pmt which includes a CA descriptor with a matching upgrade CA system ID. The CICAM shall not re-attempt an upgrade before this time. The CICAM may choose to delay an upgrade attempt until some later time when the Host again selects a CA Service with a ca_pmt which includes a CA descriptor with a matching upgrade CA system ID.

The cam_firmware_upgrade_complete APDU indicates to the HOST whether a CICAM reset is required to finish the upgrade process. On receipt of the cam_firmware_upgrade_complete APDU, the Host shall perform any requested reset and may regain control of the tuner.

The Host shall prevent user interaction from affecting the download as soon as the first cam_firmware_upgrade_progress APDU has been received until a cam_firmware_upgrade_complete. If the Host does not receive a cam_firmware_upgrade_progress APDU for a period of 60 seconds then it may assume that the CICAM has failed and attempt recovery of the Host.

The delayed upgrade sequence is shown in Figure 14.8.

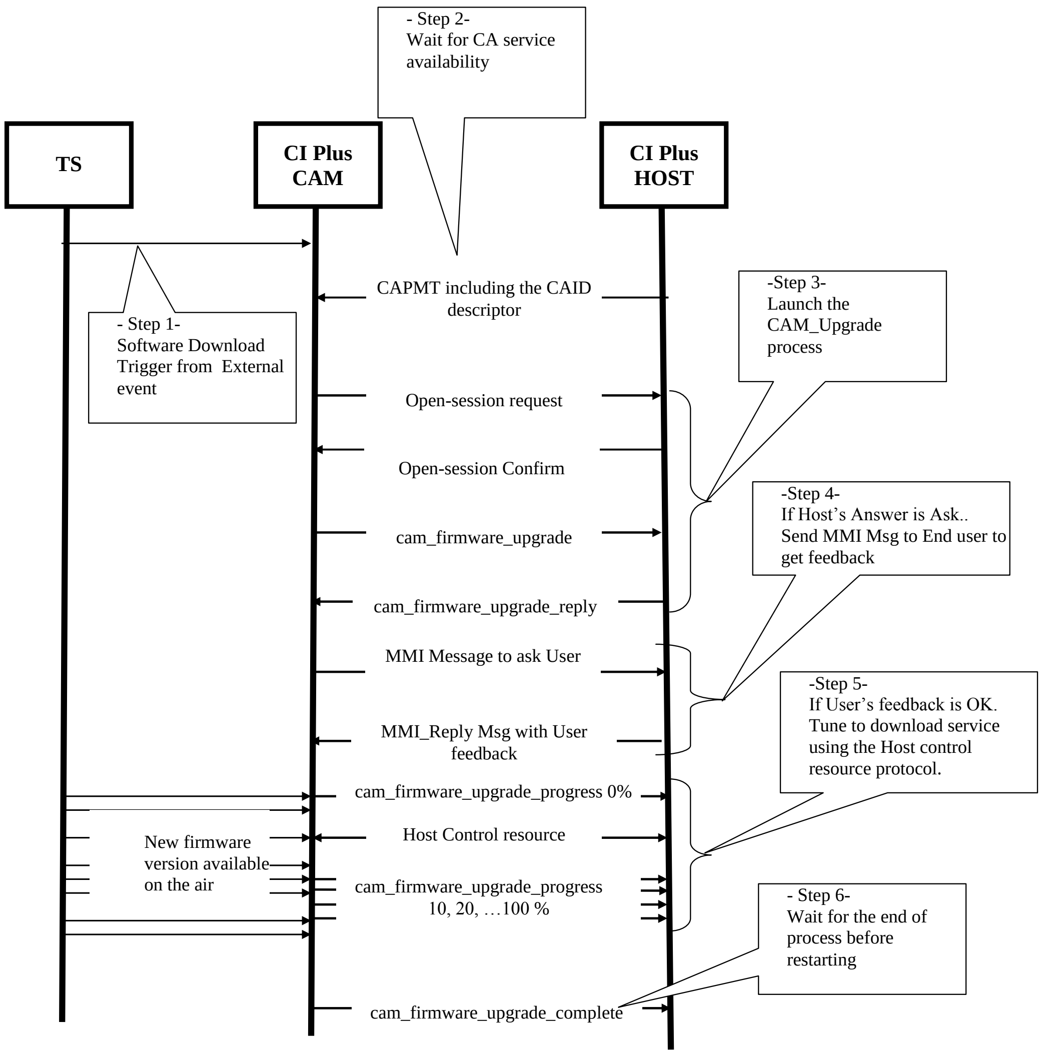

- Step 2-
Wait for CA service availability
TS
CI Plus CAM
CI Plus HOST
CAPMT including the CAID descriptor
-Step 3-
Launch the CAM_Upgrade process
- Step 1-
Software Download Trigger from External event
Open-session request
Open-session Confirm
-Step 4-
If Host's Answer is Ask.. Send MMI Msg to End user to get feedback
cam_firmware_upgrade
cam_firmware_upgrade_reply
MMI Message to ask User
-Step 5-
If User's feedback is OK. Tune to download service using the Host control resource protocol.
MMI_Reply Msg with User feedback
cam_firmware_upgrade_progress 0%
Host Control resource
New firmware version available on the air
cam_firmware_upgrade_progress 10, 20, …100 %
- Step 6-
Wait for the end of process before restarting
cam_firmware_upgrade_complete

Figure 14.8: Delayed Upgrade protocol

14.3.4.2 Immediate mode

For an immediate upgrade, the CICAM shall block the descrambling of all CA System Id services until the new firmware upgrade has been installed. When a user selects a CA scrambled service, the CICAM opens the CAM upgrade resource, if it is not already open, and sends a cam_firmware_upgrade APDU to initiate an immediate upgrade process.

On receipt, the Host responds with a cam_firmware_upgrade_reply indicating the Host availability with the "answer" parameter. Depending on the response from the Host the CICAM shall either stop the upgrade negotiation or proceed to initiate the upgrade process.

If the upgrade has been accepted the CICAM shall first send a cam_firmware_upgrade_progress message indicating that a software upgrade process has started. The CICAM may then use the DVB Host Control APDUs to send one or more tune() requests to locate and select the download service, the progress of the download shall then be communicated every 20 seconds with cam_firmware_upgrade_progress messages. When the upgrade process has completed then the CICAM sends a cam_firmware_upgrade_complete APDU.

If the upgrade is not accepted it may be re-attempted next time the Host selects a CA Service with a ca_pmt which includes a CA descriptor with a matching upgrade CA system ID. The CICAM shall not re-attempt an upgrade before this time. The CICAM may choose to delay an upgrade attempt until some later time when the Host again selects a CA Service with a ca_pmt which includes a CA descriptor with a matching upgrade CA system ID.

The cam_firmware_upgrade_complete APDU indicates to the HOST whether a CICAM reset is required to finish the upgrade process. On receipt of the cam_firmware_upgrade_complete APDU, the Host shall perform any requested reset and may regain control of the tuner.

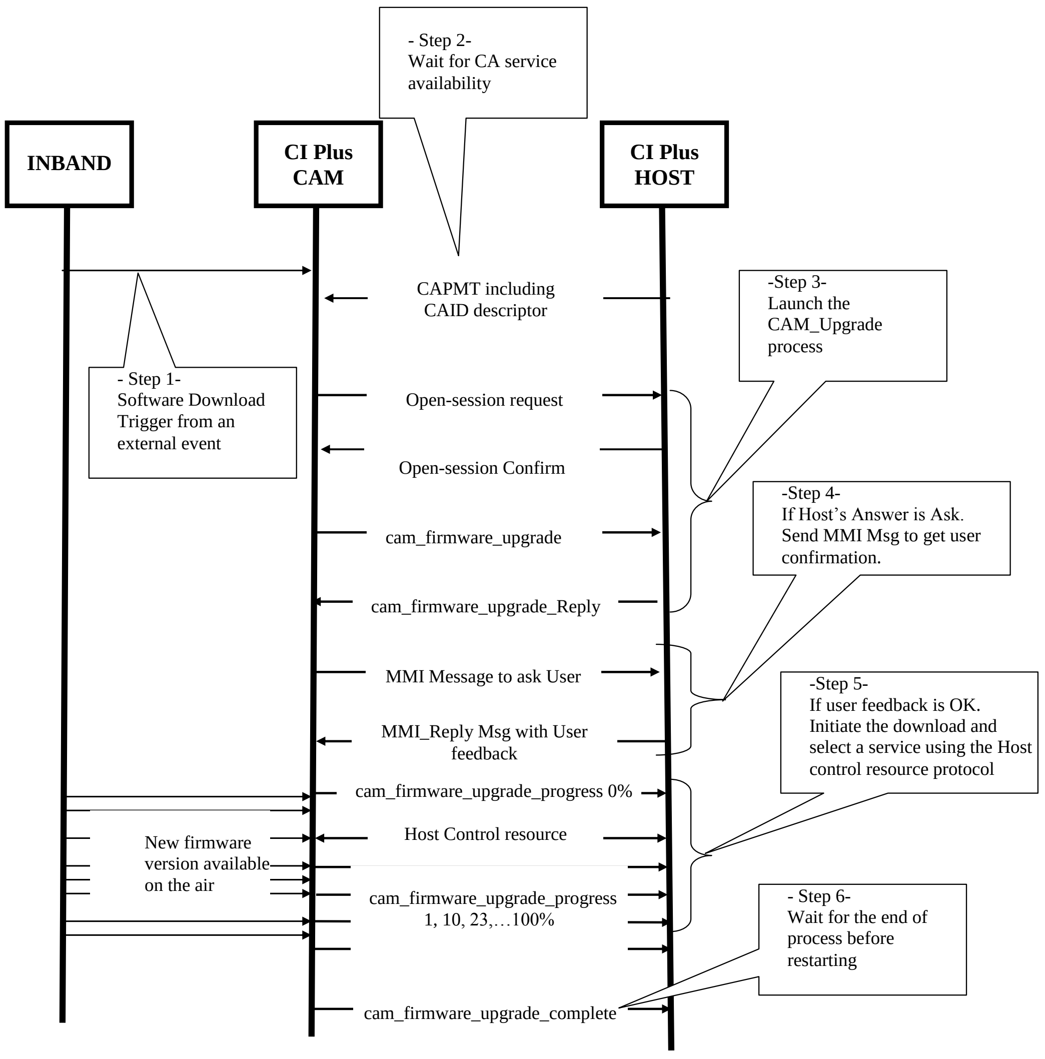

- Step 2- Wait for CA service availability
INBAND
CI Plus CAM
CI Plus HOST
CAPMT including CAID descriptor
-Step 3- Launch the CAM_Upgrade process
- Step 1- Software Download Trigger from an external event
Open-session request
Open-session Confirm
-Step 4- If Host's Answer is Ask. Send MMI Msg to get user confirmation.
cam_firmware_upgrade
cam_firmware_upgrade_Reply
MMI Message to ask User
-Step 5- If user feedback is OK. Initiate the download and select a service using the Host control resource protocol
MMI_Reply Msg with User feedback
cam_firmware_upgrade_progress 0%
Host Control resource
New firmware version available on the air
cam_firmware_upgrade_progress 1, 10, 23,…100%
- Step 6- Wait for the end of process before restarting
cam_firmware_upgrade_complete

Figure 14.9: Immediate Upgrade protocol

The Host shall prevent user interaction from affecting the download as soon as the first cam_firmware_upgrade_ progress APDU has been received until a cam_firmware_upgrade_complete. If the Host does not receive a cam_firmware_upgrade_progress APDU for a period of 60 seconds then it may assume that the CICAM has failed and attempt recovery of the CICAM.

14.3.4.3 Upgrade Interruption

The CICAM upgrade process may be interrupted for a number of reasons:

- CICAM Reset.
- Power off.

CICAM Reset
A CICAM upgrade process, irrespective of the mode, shall be fully reinitiated when the CA system ID service is selected.

Power Off / Recovery
The Host and CICAM may be subject to a power off event at any time during the upgrade operation, The CICAM shall be able to recover and initiate a upgrade on selection of a CA system ID service. The CICAM shall not recover the upgrade that causes any interruption to the transport stream or user (via MMI Messages) while not on a CA system ID service.

14.3.4.4 Reset Implementation

When CICAM has completed a firmware upgrade, it shall send the cam_firmware_upgrade_complete APDU with the appropriate reset type.

14.3.4.5 Host Operation

1) The Host shall support the CAM_upgrade resource and DVB Host Control Resource management.

2) The Host operating mode shall determine the return status to the CICAM through the cam_firmware_ upgrade_reply message.

3) The Host response to the cam_firmware_upgrade_reply message shall respect Table 14.12.

Table 14.11: Host upgrade response states

	Delayed Process	Immediate Process
User Mode	ASK	ASK
Unattended Mode	NO	YES
Service Mode	YES	YES

4) In a normal operating mode (user mode), the answer shall be ASK (0x02). This implies that the user is going to watch a CA service and the CICAM provides an indication to the user of the upgrade availability.

5) In an unattended mode (i.e. recording), in a delayed upgrade the response is likely to be NO (0x00) allowing the recording to continue without interruption, any upgrade would be postponed to a later more convenient time. For an immediate upgrade then the response shall be YES (0x01) where the upgrade would be initiated as soon as possible and may result in part of any programme being missed.

6) In a service mode (i.e. Host software upgrade, network evolution etc.) the response may be YES (0x01) for all types of upgrade process and the CICAM may start the upgrade process immediately.

7) The CICAM shall manage progress notifications to the user making use of the MMI.

8) The Host shall manage the CICAM reset on completion of the upgrade and the Host shall resume normal operation with the CICAM in all respects, including timeout and reset operation.

14.3.4.6 Upgrade Cancellation

If the CICAM cancels a firmware upgrade, then it shall send a cam_firmware_upgrade_complete APDU with the reset type set to 0x02 "no reset required".

14.3.5 CAM_Upgrade Resource

The CAM_Upgrade resource enables the CICAM to coordinate the CICAM software upgrade process with the Host. The messages allow the CICAM to initiate a download with some agreement from the Host device, communicate the progress of the upgrade and finally indicate completion. The Host is provided with knowledge of the upgrade urgency enabling the Host to determine when user intervention is required depending on its current operating mode.

14.3.5.1 CAM_Upgrade Resource APDUs

The CICAM opens the CAM_Upgrade resource when a firmware upgrade is required. The CAM_Upgrade resource supports the following objects:

Table 14.12: CAM_Upgrade APDUs

CAM Upgrade APDU	Direction
`cam_firmware_upgrade`	CICAM → HOST
`cam_firmware_upgrade_reply`	CICAM ← HOST
`cam_firmware_upgrade_progress`	CICAM → HOST
`cam_firmware_upgrade_complete`	CICAM → HOST

14.3.5.2 cam_firmware_upgrade APDU

The CICAM shall transmit the cam_firmware_upgrade APDU to the Host to inform it about the upgrade process mode required by the CA system or system operator. The object includes information of the download urgency and estimated completion time.

Table 14.13: Firmware Upgrade Object Syntax

Syntax	No. of bits	Mnemonic
`cam_firmware_upgrade() {`		
`cam_firmware_upgrade_tag`	24	uimsbf
`length_field()`		
`upgrade_type`	8	uimsbf
`download_time`	16	uimsbf
`}`		

cam_firmware_upgrade_tag: see Table L.1 in Annex L.

upgrade_type: this parameter identifies the type of CAM firmware upgrade requested:

0x00: Delayed Upgrade mode.

0x01: Immediate Upgrade mode.

download_time: The time in seconds, estimated to complete the firmware upgrade process. If the value is 0x0000 then the duration is unknown.

14.3.5.3 cam_firmware_upgrade_reply APDU

The Host response to the cam_firmware_upgrade APDU. The CICAM shall not start the download operation until it receives this reply.

Table 14.14: Firmware Upgrade Reply APDU Syntax

Syntax	No. of bits	Mnemonic
`cam_firmware_upgrade_reply() {`		
`cam_firmware_upgrade_reply_tag`	24	uimsbf
`length_field()`		
`answer`	8	uimsbf
`}`		

cam_firmware_upgrade_reply_tag: see Table L.1 in Annex L.

answer: The Host's answer has the following possible values:

- 0x00 means NO.
- 0x01 means YES.
- 0x02 means ASK the user. The CICAM shall open a MMI dialogue to get feedback from the user.
- 0x03-0xFF Reserved for future use.

14.3.5.4 cam_firmware_upgrade_progress APDU

After the CICAM has initiated its upgrade, it transmits the cam_firmware_upgrade_progress() APDU to the Host to inform it about the software download progress. This message shall be sent periodically, every 20 seconds, from the CICAM to Host. The Host uses this object to ensure that the CICAM remains operational during a software upgrade process. The CICAM shall ensure that the percentage value increases at least once every 60s until the upgrade complete is issued otherwise the CICAM may be subject to a reset by the Host.

Table 14.15: Firmware Upgrade Progress APDU Syntax

Syntax	No. of bits	Mnemonic
`cam_firmware_upgrade_progress() {`		
`  cam_firmware_upgrade_progress_tag`	24	uimsbf
`  length_field()`		
`  download_progress_status`	8	uimsbf
`}`		

cam_firmware_upgrade_progress_tag: see Table L.1 in Annex L.

download_progres_status: The percentage value of the CAM upgrade progress, in the range 0 to 100 (i.e. a percentage complete).

14.3.5.5 cam_firmware_upgrade_complete APDU

When the CICAM has completed its upgrade, it transmits the cam_firmware_upgrade_complete() APDU to the Host. The object informs the Host that the upgrade has completed and whether the CICAM requires a reset. Any Host Control resources used during the upgrade process shall be closed by the CICAM before issuing this object.

Table 14.16: Firmware Upgrade Complete APDU Syntax

Syntax	No. of bits	Mnemonic
`cam_firmware_upgrade_complete() {`		
`  cam_firmware_upgrade_complete_tag`	24	uimsbf
`  length_field()`		
`  reset_request_status`	8	uimsbf
`}`		

cam_firmware_upgrade_complete_tag: see Table L.1 in Annex L.

reset_request_status: This contains the status of the reset for the CICAM.

Table 14.17: reset_request_status types

Value	Interpretation
0x00	PCMCIA reset requested – The Host sets the RESET signal active then inactive.
0x01	CI Plus CAM reset requested – Host sets the RS flag and begins interface initialisation
0x02	No reset required – Normal Operation continues
0x03 – 0xFF	reserved
Note: If the CICAM wishes to cancel the firmware upgrade, it may send the cam_firmware_upgrade_complete APDU with no reset requested. Normal operation shall continue if the Host receives this APDU.	

14.4 Application MMI Resource

The Application MMI Resource, TS 101 699 [8], is extended to permit an exchange of file and data in both directions, this permits status information to be returned from the application domain to the module. These extensions shall only be used by the CI Plus Application Domain to transfer file or private data pipe information. The Application MMI resource version remains at 1 and the CI Plus extensions define the file naming conventions that shall be used in the CI Plus Application Domain "CIEngineProfile1".

14.4.1 File Naming Convention

The Host shall always include “CI://” at the start of any file name used during Application MMI resource file operations to ensure interoperability with existing CICAMs. Any path included in a file name shall be fully resolved, it shall not contain relative path components e.g. “**..**”. To ensure interoperability with existing Hosts, the CICAM shall resolve any of the following MHEG file references:

- `/myDir/myFile`
- `//myDir/myFile`
- `/myFile`
- `//myFile`
- `CI:/myDir/myFile`
- `CI://myDir/myFile`
- `CI:/myFile`
- `CI://myFile`

14.4.2 FileRequest

The FileRequest message is extended (see Table 14.18) to allow the transmission to the module of either a file request as defined in TS 101 699 [8] or to establish a private data pipe between the Host and the module.

Applications may perform asynchronous file requests of type File and multiple FileRequests may be issued by the Host without waiting for a FileAcknowledge (i.e. the file requests are not serialised). The CICAM shall queue the requests and return a FileAcknowledge for each FileRequest. The CICAM shall minimally be capable of managing 8 outstanding FileRequests at any one time.

For messages of type File the FileResponse shall return the data as soon as it becomes available which may result in FileResponse messages being received in a different order than originally requested. Messages of type Data shall preserve order and shall be handled sequentially by the CICAM and return a FileAcknowlegde in the same order as the FileRequest.

Table 14.18: FileRequest Message

Syntax	No. of bits	Mnemonic
`FileReq() {`		
`   FileReqTag`	24	uimsbf
`   length_field()`		
`   RequestType`	8	bslbf
`   if (RequestType == 0) {`		
`      for (i=0; i<(n-1); i++) {`		
`         FileNameByte`	8	bslbf
`      }`		
`   }`		
`   if (RequestType == 1) {`		
`      for (i=0; i<(n-1); i++) {`		
`         DataByte`	8	bslbf
`      }`		
`   }`		
`}`		

RequestType: An 8-bit field that defines the type of request being made by the Host. The RequestType values are defined in Table 14.19.

Table 14.19: FileRequest RequestType values

RequestType	Value
File	0x00
Data	0x01
Reserved for future use	0x02-0xff

FileNameByte: A byte of the filename requested.

DataByte: A byte of the data to be sent to the Module.

14.4.3 FileAcknowledge

The FileAcknowledge is extended (see Table 14.20) to permit the module to return either the requested file bytes or data pipe to the Host for CI Plus Application MMI messages.

Table 14.20: FileAcknowledge Message

Syntax	No. of bits	Mnemonic
`FileAck() {`		
`   FileAckTag`	24	uimsbf
`   length_field()`		
`   Reserved`	7	bslbf
`   FileOK`	1	bslbf
`   RequestType`	8	bslbf
`   if (RequestType == File) {`		
`      FileNameLength`	8	uimsbf
`      for (i=0; i<FileNameLength; i++) {`		
`         FileNameByte`	8	bslbf
`      }`		
`      FileDataLength`	32	uimsbf
`      for (i=0; i<FileDataLength; i++) {`		
`         FileDataByte`	8	bslbf
`      }`		
`   }`		
`   if (RequestType == Data) {`		
`      for (i=0; i<(n-1); i++) {`		
`         DataByte`	8	bslbf
`      }`		
`   }`		
`}`		

FileOK: A 1-bit field is set to "1" if the file is available or this is an acknowledgement response to a **FileRequest** message with a **RequestType** of data, otherwise it shall be "0".

RequestType: An 8-bit field that defines the type of request being made by the Host. The RequestType values are defined in Table 14.21.

Table 14.21: FileAcknowledge RequestType Values

RequestType	Value
File	0x00
Data	0x01
Reserved for future use	0x02-0xff

FileNameLength: The number of bytes in the filename.

FileNameByte: The name of the file requested by the Host. This allows the Host to asynchronously request multiple file transfers before the acknowledgement is received as the acknowledgment identifies the file of the original request. The file name returned shall be the same as that supplied in the original FileRequest.

FileDataLength: The length of the contents of the file in bytes.

FileDataByte: A byte of the file data that has been retrieved. Note that APDUs are NOT limited to 65535 bytes. See Annex E.9.

DataByte: A byte of the data that has been sent to the Host.

14.4.4 AppAbortRequest

The Host or the module may pre-empt the CI Plus application domain which may be torn down immediately without waiting for a **AppAbortAcknowledge**. The Host shall send an **AppAbortRequest** APDU to the CICAM when the application closes, this includes, but is not limited to, when the application engine is denied permission to start by the Host, application fails to start, application exits through an error or when the application naturally exits. The AppAbortRequest abort codes for the CI Plus Application domain are defined in Table 14.22.

A CICAM is recommended to explicitly terminate any existing running application with a **AppAbortRequest** before starting a new application with **RequestStart** as the order of a **AppAbortRequest** (existing application closing) and **RequestStartAck** (new application starting) cannot be guaranteed by the Host.

Table 14.22: Application Abort Codes

AbortReqCode	Meaning
0x00	Reserved for future use.
0x01	User Cancel – The user has initiated termination of the application domain.
0x02	System Cancel – The system has pre-empted the application domain to perform another task.
0x03-0xff	Reserved for future use.

14.5 Application MMI Resource v2

The Application MMI Resource, TS 101 699 [8] protocol is extended to permit the caching of content in the Host device to speed up CI application execution. These extensions shall only be used by the CI Plus Application Domain to transfer file or private data pipe information with version 2 of the Application MMI resource.

The caching mechanism is provided by a new RequestType called FileHash which allows the Host to compute a MD5 hash of the file content and enables the Host to request a file from the CICAM with both the filename and a Host computed content hash. On receiving the FileHash request the CICAM uses the file hash to determine if the file content has changed, if the CICAM computed file hash is the same as the hash in the request message then the file content is not returned to the Host and an indication is provided in the response message that the file content remains unchanged. If the file hash is different then the CICAM returns the new file contents.

This file hash mechanism allows the communication bandwidth between the Host and the CICAM to be reduced when existing content has already been acquired thereby speeding up the application execution.

The Application MMI Resource v2 also includes a mechanism for the RequestType to be extended in the future without necessitating a version increment of the resource.

A CICAM is required to support v1 and v2 of the Application MMI Resource. A Host is required to support the Application MMI resource v1 and may optionally support v2 in addition to v1. Unless otherwise stated, the behaviour of Application MMI resource v1 is identical to Application MMI resource v2 for RequestType File and Data.

14.5.1 FileRequest v2

The FileRequest message is extended (see Table 14.23) to included support for hashed file transfers The syntax is identical to version 1 for RequestType File and Data.

Applications may perform asynchronous file requests of type File and FileHash. Multiple FileRequests may be issued by the Host without waiting for a FileAcknowledge (i.e. the file requests are not serialised). The CICAM shall queue the requests and return a FileAcknowledge for each FileRequest. The CICAM shall minimally be capable of managing 8 outstanding FileRequests at any one time.

For messages of type File and FileHash the FileResponse shall return the data as soon as it becomes available which may result in FileResponse messages being received in a different order than originally requested. Messages of type Data shall preserve order and shall be handled sequentially by the CICAM and return a FileAcknowlegde in the same order as the FileRequest.

Table 14.23: FileRequest Message

Syntax	No. of bits	Mnemonic
`FileReq() {`		
`   FileReqTag`	24	uimsbf
`   length_field()`		
`   RequestType`	8	bslbf
`   if (RequestType == File) {`		
`      for (i=0; i<(n-1); i++) {`		
`         FileNameByte`	8	bslbf
`      }`		
`   }`		
`   if (RequestType == Data) {`		
`      for (i=0; i<(n-1); i++) {`		
`         DataByte`	8	bslbf
`      }`		
`   }`		
`   if (RequestType == FileHash) {`		
`      FileHash`	128	bslbf
`      for (i=0; i<(n-17); i++) {`		
`         FileNameByte`	8	bslbf
`      }`		
`   }`		
`}`		

RequestType: This 8-bit field defines the type of request being made by the Host. The RequestType values are defined in Table 14.24. The Host shall not send any request type other than File (0x00), Data (0x01) or FileHash (0x02) unless compatibility with the CICAM has been confirmed, refer to section 14.4.4, Request Type Discovery v2.

Table 14.24: RequestType values

RequestType	Description	Value
File	A file is being requested without any version control.	0x00
Data	A data item is being requested,	0x01
FileHash	A file is being request with a hashed version field.	0x02
ReqTypes	A list of supported RequestType is being requested	0x03
Reserved for future use	Reserved for future use	0x04-0x7f
User defined	User defined	0x80-0xff

FileNameByte: A byte of the filename requested or a data pipe byte to send to the module. The interpretation of the byte is determined by the RequestType.

DataByte: A byte of the data to be sent to the module.

FileHash: This 128-bit field is set to the MD5 hash of the contents of the file on the Host with the filename sent as part of this message. The MD5 algorithm is as defined in RFC 1321.

14.5.2 FileAcknowledge v2

The FileAcknowledge is extended (see Table 14.25) to permit the module to return either the requested file bytes or data pipe to the Host for CI Plus Application MMI messages. An extended status of the original request is included in v2 of the response.

Table 14.25: FileAcknowledge Message

Syntax	No. of bits	Mnemonic
`FileAck() {`		
`   FileAckTag`	24	uimsbf
`   length_field()`		
`   Reserved_zero`	6	bslbf
`   RequestOK`	1	bslbf
`   FileOK`	1	bslbf
`   RequestType`	8	uimsbf
`   if (RequestType == File) ||`		
`      (RequestType == FileHash) {`		
`      FileNameLength`	8	uimsbf
`      for (i=0; i<FileNameLength; i++) {`		
`         FileNameByte`	8	bslbf
`      }`		
`      FileDataLength`	32	uimsbf
`      for (i=0; i<FileDataLength; i++) {`		
`         FileDataByte`	8	bslbf
`      }`		
`   }`		
`   if (RequestType == Data) {`		
`      for (i=0; i<(n-1); i++) {`		
`         DataByte`	8	bslbf
`      }`		
`   }`		
`        if (RequestType == ReqTypes) {`		
`      for (i=0; i<(n-1); i++) {`		
`         ReqTypeByte`	8	uimsbf
`      }`		
`   }`		
`}`		

Reserved_zero: This 6-bit field is reserved for future use and shall be set to zero.

RequestOK: This 1-bit field is interpreted in the context of a **RequestType** only according to Table 14.26. The field shall be set to "0" when the field value is unused.

Table 14.26: RequestOK status Values

Request Type	Request	RequestOK=0	RequestOK=1
0x00	File	Unused, field value ignored.	
0x01	Data	Unused, field value ignored.	
0x02	FileHash	The request failed the file was not found or the request was invalid.	The request succeeded, the **FileOK** field indicates whether the file has changed or not.
0x03	ReqTypes	Unused, field value ignored.	
0x04-0xff	Reserved	Unused, field value ignored.	

FileOK: This 1-bit field is interpreted in the context of a **RequestType** only according to Table 14.27. The field shall be set to "0" when the RequestType is unknown.

Table 14.27: FileOK status Values

Request Type	Request	FileOK=0	FileOK=1
0x00	File	The file was not found or is not available.	The requested file is available and the contents are included in this acknowledgement message.
0x01	Data	The data was not found or is not available.	This is a successful acknowledgement response and data contents may be included in this acknowledgement message.
0x02	FileHash	When **RequestOK**=1 the file contents have not changed and match the file hash. When **RequestOK**=0 the request failed.	The file contents have changed and do not match the requested file hash. The new file contents are included in this acknowledgement message.
0x03	ReqTypes	An error occurred during the request.	This is a successful acknowledgement response and the message contains a list of supported RequestTypes of the CICAM.
0x04-0xff	Reserved	Command unknown or failed.	Reserved shall not be set

RequestType: This 8-bit field defines the type of request being made by the Host. The RequestType values are defined in Table 14.24.

FileNameLength: The number of bytes in the filename.

FileNameByte: The name of the file requested by the Host. The return of the requested file name allows the Host to asynchronously request multiple file transfers before the acknowledgement is received as the acknowledgment identifies the file of the original request. The file name returned shall be the same as that supplied in the original FileRequest.

FileDataLength: The length of the contents of the file in bytes. This field shall be set to zero on a RequestType of FileHash when the file exists on the CICAM and the host FileHash is identical to the file hash of the CICAM i.e. where the return status information is RequestOK=1 and FileOK=0.

FileDataByte: A byte of the file data that has been retrieved. Note that APDUs are NOT limited to 65535 bytes. See Annex E.12.

DataByte: A byte of the data that has been sent to the Host.

ReqTypeByte: This 8-bit field contains the supported RequestType of the CICAM. Each RequestType supported by the CICAM shall be included in the response and shall be presented in ascending numerical order.

14.5.3 RequestType Discovery v2

Version 2 of the Application MMI resource allows the Host to query the RequestTypes that are supported by the CICAM to allow additional RequestTypes to be added to the Application MMI resource without necessitating a version increment of the resource. A Host shall only use RequestTypes File, Data, FileHash and ReqTypes. RequestTypes other than File, Data, FileHash and ReqTypes may only be used by the Host after first querying the CICAM to confirm the presence of the required RequestType. The RequestType may not be used by the Host if it is not reported by the CICAM. A CICAM shall be robust in the presence of a unknown RequestType and shall always return a FileOK status of “0".

To query the CICAM supported RequestTypes then the Host sends a FileRequest() message with a RequestType ReqTypes (0x03). The CICAM shall respond with a FileAcknowledge() message with a RequestType ReqTypes (0x03), FileOK field set to "1" and the ReqTypeByte field shall include each RequestType that is supported by the CICAM sorted in ascending order. i.e. if the CICAM supports File, Data, FileHash and ReqTypes then the ReqTypeByte field shall be 4 bytes long and contain the bytes 0x00, 0x01, 0x02 and 0x03.

EXAMPLE: 4 bytes (hex) `00010203` CICAM supports the 4 basic resource v2 types of File (0x00), Data (0x01), FileHash (0x02) and ReqTypes (0x03) only.

5 bytes (hex) `0001020304`	CICAM supports 5 protocols. The basic resource v2 types of File (0x00), Data (0x01) , FileHash (0x02) and ReqTypes (0x03) in addition to a yet undefined type 0x04.

14.6 DVB Host Control resource

14.6.1 DVB Host Control Version 2

The DVB Host Control resource class as defined in EN 50221 [7] is enhanced so that it is no longer limited to tuning to a DVB triplet known by the Host (Host Control **version 1**). See Annex E.16 for clarification of Host Control version 1 Tune behaviour. Version 2 of this resource adds new commands for the CICAM to address another type of tuning operation:

- **Host Control 2**: Request the Host to tune to a service which is not part of the Host channel line-up (the service has not been detected by the Host during service discovery), the service selected is based on:
    - The physical description of the Transport Stream that carries the service.
    - The service identification (e.g. service_id).

14.6.2 DVB Host Control Version 2 APDUs

The DVB Host Control Version 2 resource supports the following objects:

Table 14.28: DVB Host Control Version 2 APDUs

DVB Host Control Version 2 APDU	Direction
`tune`	CICAM → HOST
`replace`	CICAM → HOST
`clear_replace`	CICAM → HOST
`ask_release`	CICAM ← HOST
`tune_broadcast_req`	CICAM → HOST
`tune_reply`	CICAM ← HOST
`ask_release_reply`	CICAM → HOST

14.6.2.1 tune_broadcast_req APDU

The CICAM sends this APDU to request the Host to tune to a service, based on the physical description of the transport stream that carries the service and the service identification. The Host replies with tune_reply() APDU.

Table 14.29: tune_broadcast_req APDU Syntax

```
Syntax                              No. of bits   Mnemonic
tune_broadcast_req() {
   tune_broadcast_req_tag               24         uimsbf
   length_field()
   reserved                              7         uimsbf
   pmt_flag                              1         uimsbf
   service_id                           16         uimsbf
   reserved                              4         uimsbf
   descriptor loop_length               12         uimsbf
   for (i=0; i<N; i++) {
      descriptor()
   }
   if (pmt_flag==1) {
      program_map_section()
   }
}
```

pmt_flag: The pmt_flag is a 1-bit field indicating whether the tune_broadcast_req contains a PMT. A value of "0" indicates that the request does not contain a PMT and that the Host shall fetch the PMT of the service service_id from the Transport Stream. A value of "1" indicates that the request contains a PMT which shall be used by the Host to perform elementary stream selection.

service_id: This is a 16-bit field which serves as a label to identify the required service from any other service within the tuned Transport Stream. This is the same as program_number in the PMT. If the service_id is zero then the pmt_flag shall also be zero and the Host shall tune to the frequency but shall not select a service, a ca_pmt will not be sent.

descriptor_loop_length: This 12-bit field gives the total length in bytes of the following descriptors loop.

descriptor(): The descriptors are coded as defined in EN 300 468 DVB Specification for Service Information (SI) in DVB Systems [10]. Table 14.34 indicates which descriptors may be available in the loop.

program_map_section():A Program Map Table as specified in ISO/IEC 13818-1.
The program_number in the PMT shall be identical to the service_id specified in the tune_broadcast_req() APDU. On a mismatch of these values then the tune shall fail and the tune_reply() shall return status 0x04, “bad or missing parameters”. The Host shall only use this program_map_section() if the CICAM sending the APDU has already been authenticated, otherwise the tuning request shall be ignored and the tune_reply() shall return status 0x04, “bad or missing parameters”.

14.6.2.2 tune_reply APDU

This APDU is the Host response to a tune_broadcast_req() or tune() as defined in section 8.5.1.1 of EN 50221 [7]. It provides the CICAM with the status of the tune request.

Table 14.30: tune_reply APDU Syntax

Syntax	No. of bits	Mnemonic
`tune_reply () {`		
`tune_reply_tag`	24	uimsbf
`length_field()`		
`status_field`	8	uimsbf
`}`		

status_field: This 8-bit field specifies the tuning status according to Table 14.31.

Table 14.31: tune_reply status values

status_field	Value
Status OK – Successful tuning (see note 1)	0x00
Error - Unsupported delivery system descriptor	0x01
Error - Tuner not locking	0x02
Error - Tuner Busy	0x03
Error - Bad or missing parameters. (see note 2)	0x04
Error - Service not found	0x05
Error – undefined	0x06
Reserved	0x07-0xFF
Notes: 1: Following a successful tuning operation the Host shall return a ca_pmt() extracted from the applicable PMT. 2: If a mandatory descriptor is missing in the tune request, then this error shall be returned. Mandatory descriptors are listed in Table 14.34.	

14.6.2.3 ask_release APDU

Host Control version 2 uses the ask_release() APDU. The syntax of this APDU is exactly as defined in section 8.5.1.4 of EN 50221 [7] and its behaviour is altered to enable the CICAM to retain control of the tuner if required. On receiving a ask_release APDU the CICAM may query the user to confirm the action using the high level or application MMI. The CICAM replies to the Host with the tuner release status with the ask_release_reply APDU.

14.6.2.4 ask_release_reply APDU

This APDU is the CICAM reply to a ask_release(). This APDU indicates whether the CICAM confirms or not that the tuner shall be released and the session closed.

Table 14.32: Tune Release Reply APDU Syntax

Syntax	No. of bits	Mnemonic
`ask_release_reply() {`		
`ask_release_query_tag`	24	uimsbf
`length_field()`		
`release_reply`	8	uimsbf
`}`		

release_reply: This 8-bit field gives the tuning status according to Table 14.33.

Table 14.33: Tune Release Reply values

release_reply	Value
Release OK – Host regains control of the tuner	0x00
Release Refused – CICAM retains control of the tuner	0x01
Reserved	0x02-0xFF

14.6.3 PMT Management

For Video-on-demand (VOD) deployments, typically in cable networks, then the VOD components are delivered on the broadcast channel as elementary stream components only and the broadcast channel may not deliver PSI and SI components. In this scenario then the PMT shall be delivered by the CICAM in the APDU and is constructed from information retrieved by the CICAM from the broadcast head-end equipment, typically via the Low Speed Communications resource.

Application authors of any VOD application shall note that in the absence of any SI in the stream then the tuning operation incurs a 5 second delay while a Host shunning check is performed to acquire the SDT actual which will fail and time out. The Host check for the SDT cannot be disabled as this compromises the security afforded by the Host on a network.

When the CICAM requests the tuning on a broadcast channel it may provide the PMT of the service within the APDU. The APDU PMT shall be used by the Host and the Host shall not attempt to acquire a PAT or PMT from the broadcast network.

14.6.4 Descriptors

The tune_broadcast_req() APDU contains a loop of descriptors which are used by the Host to provide information about the tuned service.

When the CICAM requests the Host to tune with tune_broadcast_req() the CICAM shall provide the Host with a single tuning location delivered by one or more delivery system descriptors. If the descriptor loop contains more than one tuning location the Host shall consider the first one and ignore the rest.

The CICAM may optionally provide the Host with additional information about the requested tuned service. The information provided may be used by the Host in order to provide the user with service and event description. e.g. to populate the channel banner and info dialogues. The exact mechanism by which the Host delivers this information into its DVB stack is not specified, and is receiver specific, the Host could for example construct an internal EIT_{pf} with this information for the currently selected service.

Table 14.34 specifies the list of DVB descriptors that may appear in the descriptor loop of a tuner request.

Table 14.34: descriptors allowed in tune_broadcast_req APDU

Descriptor	DVB Tag Value	Comment
terrestrial_delivery_system_descriptor	0x5A	Mandatory descriptors; a single destination frequency shall be specified by delivery system descriptor suitable for the current network.
T2_delivery_system_descriptor	0x7F, 0x04 See Note	
satellite_delivery_ system_descriptor	0x43	
S2_satellite_delivery_system_descriptor	0x79	
cable_delivery_ system_descriptor	0x44	
C2_delivery_system_descriptor	0x7F, 0x0D See Note	
service_descriptor	0x48	Additional optional information for the receiver to describe the service.
short_event_descriptor	0x4D	
component descriptor	0x50	
parental_rating_descriptor	0x55	
content_descriptor	0x54	
Note: The T2_delivery_system_descriptor and the C2_delivery_system_descriptor are extended DVB descriptors, see EN 300 468 [10], sections 6.2.16 and 6.3.		

14.6.5 Host Tuning protocol

Figure 14.10 provides an overview of the Host behaviour upon reception of a DVB Host Control Version 2 tune request.

1) The Host receives a tune_broadcast_req().

2) The Hosts checks the availability and consistency of the parameters. If one or more parameters is not consistent or is missing then the Host continues at step 10.

3) The Host checks that the delivery system is supported. If the delivery system descriptor is not supported then the Host continues to step 11.

4) The Host tunes the tuner passing through the described transport stream.

5) The Host confirms that the tuning operation is successful and a valid signal is received. If the tuning failed then the Host continues to step 12.

6) If the service_id is zero then the Host does not search for a PMT and continues to step 14. If the service_id is not zero then the Host continues to step 7.

7) The Host determines if a PMT was passed in the request, if the PMT is not present then is shall be acquired from the broadcast stream. If a PMT is not available then the Host continues to step 13.

8) The Host sends the tune_reply() to the CICAM with status 0x00 (OK).

9) The Host uses the PMT in order to select the elementary streams.

10) The Host sends a ca_pmt() to the CICAM.

11) The Host sends a tune_reply() with status 0x04 (Bad or missing parameters).

12) The Host sends a tune_reply() with status 0x01 (Unsupported delivery system descriptor).

13) The Host sends a tune_reply() with status 0x02 (tuner not locking).

14) The Host sends a tune_reply() to the CICAM with status 0x00 (OK).

15) The Host acquires the PAT from the transport stream. On acquiring the PAT the Host locates the PMT PID matching the program_number with the service_id field in the tune_broadcast_request APDU. The corresponding PMT is then acquired from the transport stream.

16) The Host checks that the PMT has been successfully loaded. If the PMT is not loaded then the Host continues to step 15.

17) The Host sends a tune_reply() with status 0x05 (service not found).

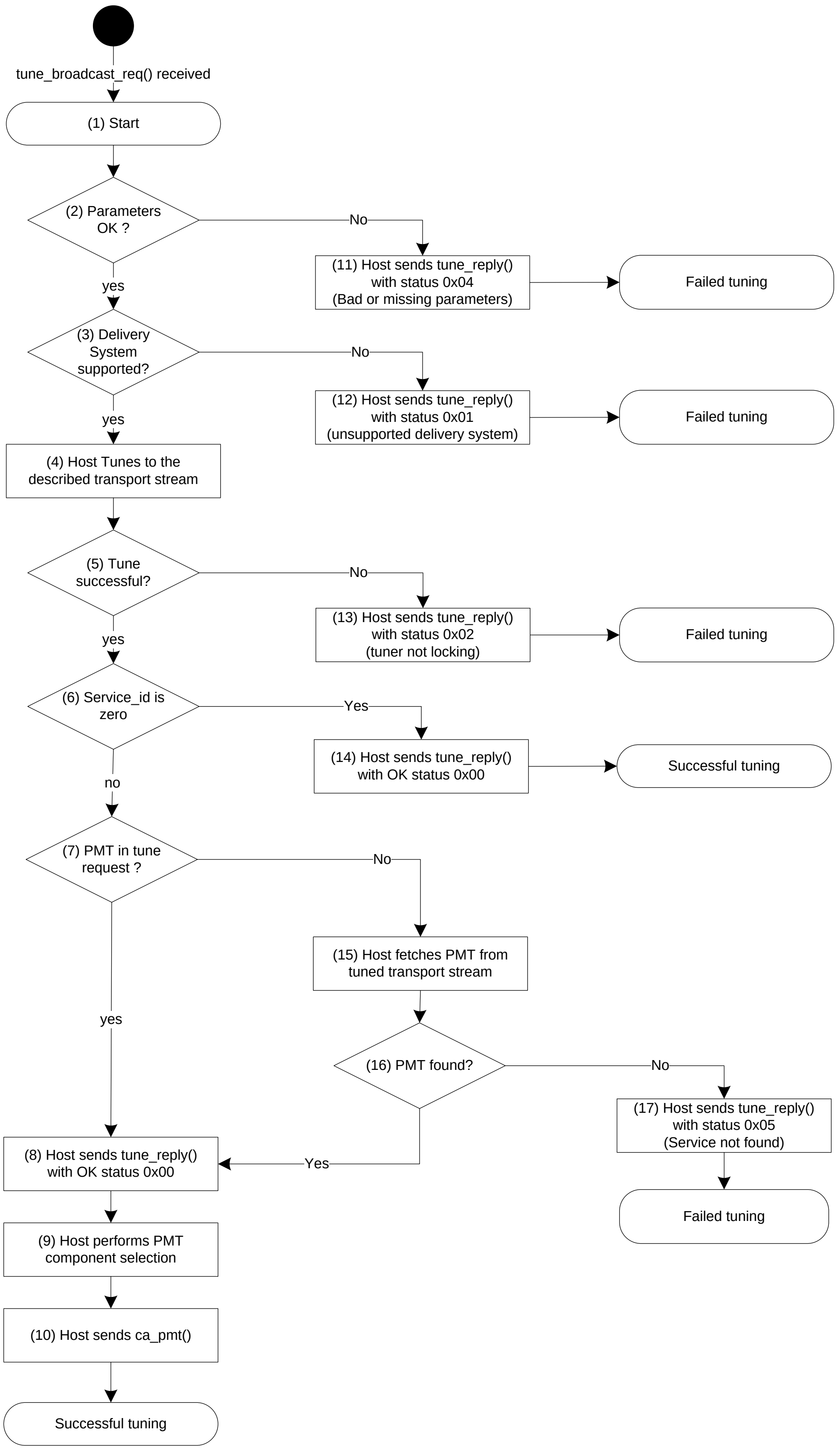

tune_broadcast_req() received
(1) Start
(2) Parameters OK ?
No
(11) Host sends tune_reply() with status 0x04 (Bad or missing parameters)
Failed tuning
yes
(3) Delivery System supported?
No
(12) Host sends tune_reply() with status 0x01 (unsupported delivery system)
Failed tuning
yes
(4) Host Tunes to the described transport stream
(5) Tune successful?
No
(13) Host sends tune_reply() with status 0x02 (tuner not locking)
Failed tuning
yes
(6) Service_id is zero
Yes
(14) Host sends tune_reply() with OK status 0x00
Successful tuning
no
(7) PMT in tune request ?
No
(15) Host fetches PMT from tuned transport stream
yes
(16) PMT found?
No
(17) Host sends tune_reply() with status 0x05 (Service not found)
Failed tuning
Yes
(8) Host sends tune_reply() with OK status 0x00
(9) Host performs PMT component selection
(10) Host sends ca_pmt()
Successful tuning

Figure 14.10: Tuning process with Host Control Version 2 (informative)

14.6.6 Host Control release requests

When a session is opened with the DVB Host Control resource and the Host detects user interaction which would result in tuning to another service, the Host shall seek permission from the CICAM to release the tuner for Host use.

Figure 14.11 provides an overview of the Host behaviour when it detects user interaction while a DVB Host control session is opened.

1) The CICAM has opened a session with the DVB Host Control resource.

2) The Hosts detects user interaction that would normally result in tuning to a new service.

3) The Host sends a ask_release() to the CICAM to request that the tuner is released.

4) The Host receives an ask_release_reply() from the CICAM in response to the query.

5) The Host checks whether the CICAM accepts the ask_release(). This may involve the CICAM use of MMI to query the user. If the CICAM does acknowledge, then the Host goes to step 6). If the CICAM does not acknowledge, then the Host goes back to step 1).

6) The Host receives a close session from the CICAM.

7) The Host tunes to the user selected service.

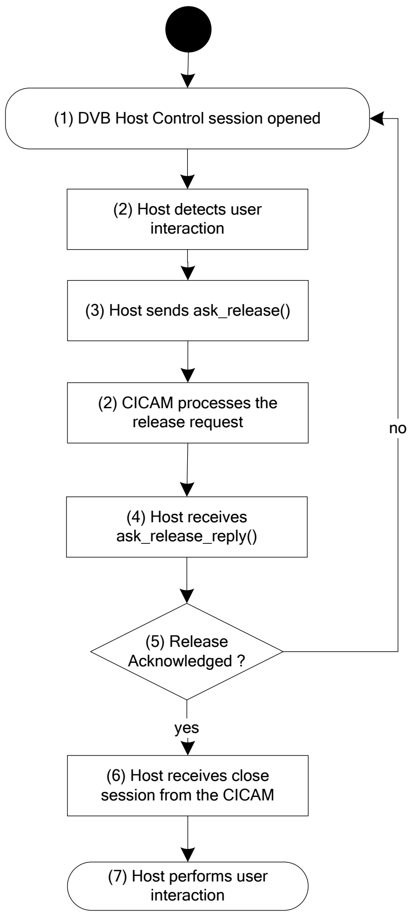

(1) DVB Host Control session opened
(2) Host detects user interaction
(3) Host sends ask_release()
(2) CICAM processes the release request
no
(4) Host receives ask_release_reply()
(5) Release Acknowledged ?
yes
(6) Host receives close session from the CICAM
(7) Host performs user interaction

Figure 14.11: Tuning process with Host Control Version 2

14.7 Operator Profile

14.7.1 Introduction

The broadcast profiles in the vertical market segment are typically encumbered by the deployment of existing proprietary receivers that utilise private signalling to convey information from the broadcast Head-end to the receivers in the field. As an established network then it is very difficult for the service operator to modify the network to cater for the introduction of horizontal market receiver devices using the Common Interface without disturbing the network and the existing receiver base.

The private signalling on these networks requires that horizontal market receivers are tailored to understand any proprietary signalling before they are able to be utilised on the network. Analysis of this private signalling reveals that proprietary signalling is most diverse at the higher levels in the network profile while the signalling at the service level and PSI level is generally consistent with standardised DVB signalling. The higher level networking signalling of the network typically includes strict controls on the channel list and logical channel numbering which may be based, in part, on the subscription and entitlement rights purchased by the user.

The Operator Profile resource attempts to resolve the network and receiver interoperability issues by providing a CI Plus standardised broadcast profile and uses the CICAM to translate the network private signalling into a uniform information structure allowing all CI Plus Host devices to perform a full installation and a channel listing of all of the services required by the Service Operator.

14.7.2 Operational Overview

The Operator Profile resource enables the delivery of a Network Information Table (NIT) through the CICAM which is used in preference to any broadcast network NIT. The NIT delivery mechanism enables the CICAM to transform private network information and service operator specific signalling into a single format that is delivered in a NIT that may be universally understood by all CI Plus Host devices that conform to this version of the specification.

Service operators in the vertical market are unlikely to be able to significantly alter their existing SI/PSI signalling because of legacy receivers that may already be deployed in the network. The Operator Profile resource provides a mechanism for the higher level SI signalling to be configured, re-packaged and delivered to a CI Plus Host locally without affecting the existing broadcast signalling of the network. Full control over the NIT is provided by a CICAM NIT messaging mechanism which allows the broadcast SDT to be partially reconfigured from the NIT using the ciplus_service_descriptor. Some adjustment of the broadcast PSI and EIT within the network may be required to allow full compatibility with a CI Plus Host, this generally means fuller conformance with the standard DVB specifications. The operational behaviour of the existing network may be provided to the Host via the operator_info() APDU which defines the operational environment allowing the Host to compensate for operational variations in the different networks.

The Operator Profile resource provides two different modes of operation depending on the profile_type which is defined as follows:

- profile_type = 0 – A non-profiled CICAM for a DVB network that follows normal DVB SI rules. The network service list is determined from the broadcast Service Information by the Host. This profile allows the CICAM to collect entitlement rights information. Additional information about the network behaviour may be defined and conveyed to the Host in the resource.
- profile_type = 1 – Profiled operation where the Host constructs a local channel list explicitly for the service operator and the CICAM delivers an alternative CICAM NIT to the Host which defines the network. The Host does not interrogate the broadcast network to determine the logical channel line up.

Figure 14.12 shows the conceptual operation of the Operator Profile resource when running in a CICAM NIT delivery mode.

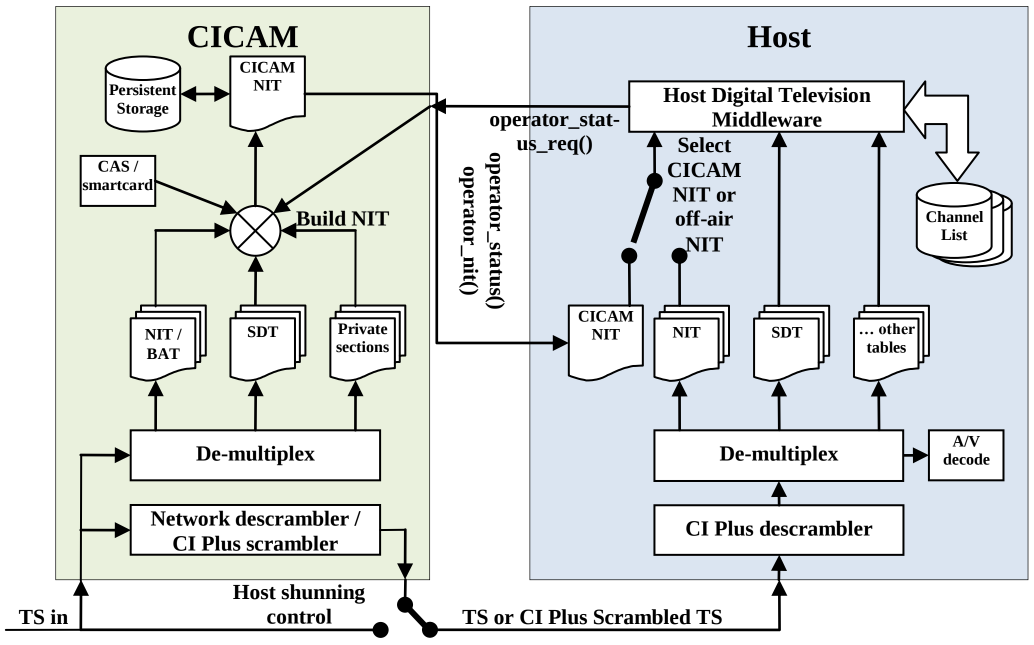


Figure 14.12: Conceptual operation of the Operator Profile resource (Informative)

The transport stream TS in passes through the CICAM and is descrambled under Host control according to the ca_pmt(). Optionally, the Service Information (SI) of the network is demultiplexed by the CICAM and used to construct a new CICAM NIT which is passed to the Host via the *operator_status()* and *operator_nit()* APDUs. The tables used by the CICAM to construct the CICAM NIT are determined by the service operator and may be derived from the broadcast stream NIT, BAT, SDT or any other private table sections appearing on the network. Entitlement rights of the CAS/Smartcard and *service_type* from the *operator_search_start()* APDU are used to determine which services may appear in the CICAM NIT. The CICAM NIT is a quasi-static structure and is stored in persistent storage within the CICAM once the table has been built. The table is maintained by the CICAM by monitoring the network in addition to the CAS/Smartcard entitlement rights and passing any changes to the Host by managing the version number of the CICAM NIT.

The Host provides a dedicated channel list for each CICAM profile to which it has attached. Whilst operating on a CICAM profile channel list then the CICAM NIT is always used in preference to any broadcast NIT which is ignored. The CICAM NIT information is used to construct the channel list for the attached CICAM profile. Changes in the profile are sent to the Host with an asynchronous *operator_status()* APDU which contains version information of any updated CICAM NIT with a new table section version number and operates in the same way as a NIT table section update in a conventional broadcast network.

The CICAM NIT fully describes the services appearing in the service operator channel list and sufficient information is present in the CICAM NIT to enable the Host to build a complete channel list. The Host is not required to interrogate the broadcast NIT, BAT or SDT for channel list construction or maintenance and all information is provided in the CICAM NIT. The CICAM is required to construct and maintain the CICAM NIT using the latest channel list information which may require the CICAM to monitor the SI tables of the network dynamically.

Within the context of a CICAM profile then the native Electronic Programme Guide of the Host may be used to display programme event information of the profile acquired through EIT_{sch} information from each multiplex, acquired from the same multiplex when fully cross carried or acquired by tuning to a dedicated barker channel. EIT_{sch} may be delivered in a scrambled form across the network.

The CICAM and Host shall strictly adhere to the broadcast profile that is defined in Annex N to ensure full interoperability with all CI Plus devices.

14.7.3 Host Operator Profile Handling

The CICAM Operator Profile resource with a non-zero profile_type requires the Host to create a separate logical channel list for the service operator with a label described by the profile_name field of the operator_info() APDU. A selection mechanism shall be provided by the Host to move into different channel lists as shown in Figure 14.13 where a CICAM has reported a profile with profile name "`CICAM network 1`".

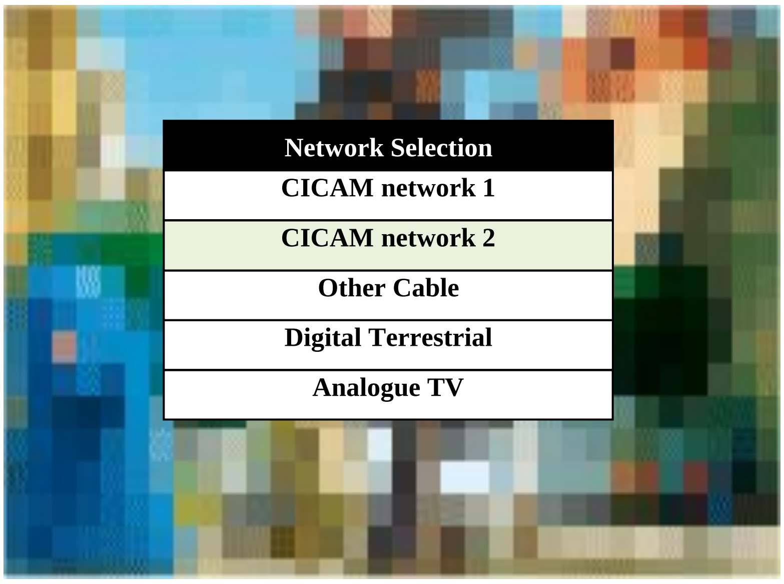


Figure 14.13: Example Network Selection User Interface with 2 CICAMs

The exact Host mechanism by which the different network profiles are selected, manipulated and finally deleted is not defined by this specification. The installation procedure of a new CICAM advertising an Operator Profile shall ideally be simple for the user and the Host shall automatically initiate and guide the user through the installation procedure when a new CICAM with a profile that may be supported and populated is inserted into the Host.

The Host shall retain the network profile of the CICAM until such time that the CI Plus CICAM authentication pairing is removed or the user explicitly removes the profile. The Host shall retain the profile through a CICAM un-plug operation allowing a limited number of different CICAMs to be cycled without losing the stored channel list information.

The CICAM Operator Profile information shall comprise an independent logical channel list which shall honour the NIT signalling of the CICAM network for profile_type 1. A mechanism shall be provided by the Host to move from one Operator Profile to another.

14.7.4 Operator Profile Resource exchange

This section describes the APDU exchange between the Host and the CICAM.

14.7.4.1 Initialisation

The operator_status() APDU shall be automatically reported at start up by the CICAM and shall contain the profile information cached in the CICAM which shall be made available immediately. If the CICAM is un-initialised then the initialised_flag shall be "0" to indicate that an immediate search operation is required to initialise the CICAM.

14.7.4.1.1 Non-profile CICAM

A CICAM that reports profile_type zero (0) does not support a separate logical channel list and operates as a conventional DVB CICAM and is considered to be non-profiled. The Host is expected to understand the information that is broadcast on the network and either the network is fully DVB conformant or the Host has been specifically customised to operate with the network, the operator_info() APDU provides some information to the Host about the network environment.

The CICAM flags are interpreted in an identical way to a profiled CICAM and the CICAM may request a tune etc. which may be used to acquire information from the network and control the Host. Typically the CICAM starts in an initialised state as there is no additional information to be propagated to the Host.

14.7.4.1.2 Profiled CICAM

A CICAM that reports profile_type one (1) requires Host support for an operator profile and the Host is expected to create a separate logical channel list for the service operator according to the rules outlined in Annex N.

The Host shall ideally automatically install the profile on insertion of CICAM and build the logical channel list with minimal user intervention. The profile and logical channel list shall be persistent in both the CICAM and the Host and shall not be automatically erased if the CICAM or SmartCard is removed on a temporary basis. It is suggested that the profile is retained until the user explicitly deletes it or any CI Plus authentication pairing between the CICAM and the Host is discarded.

The CICAM shall retain the profile information in persistent memory (including the CICAM NIT or information to rebuild the CICAM NIT). The CICAM shall ensure that the caching update mechanism is robust and is able to support a power-off operation at any stage in the writing operation without losing any existing cached information until the new information has been completely written. This prevents the profile information from being lost and randomly reverting to an un-initialised state.

14.7.4.1.3 Profile Discovery

A profiled CICAM is likely to start in an un-initialised state and the Host is required to determine the delivery system of the CICAM. This may be determined by querying the CICAM as shown in Figure 14.14.

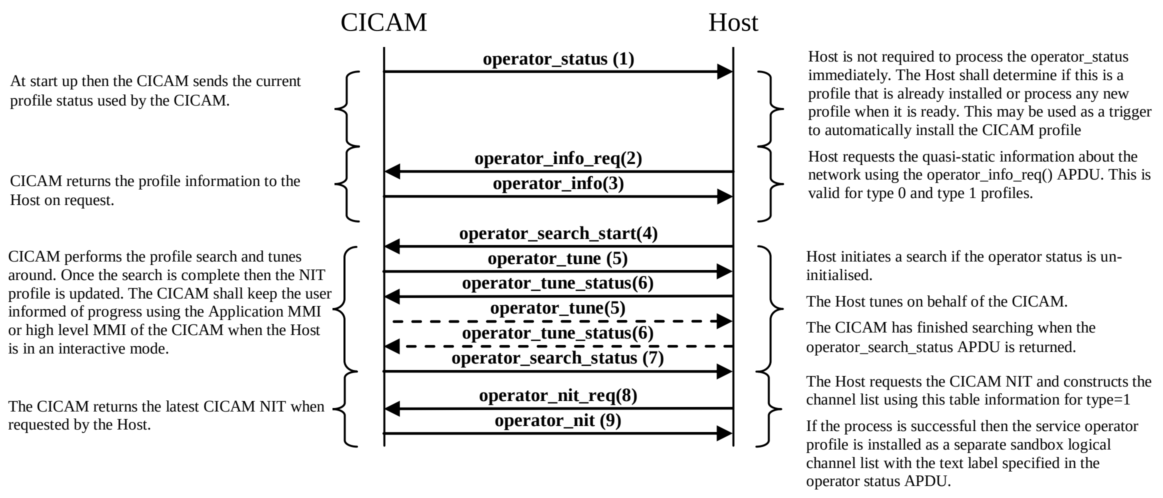

CICAM
Host
operator_status (1)
At start up then the CICAM sends the current profile status used by the CICAM.
Host is not required to process the operator_status immediately. The Host shall determine if this is a profile that is already installed or process any new profile when it is ready. This may be used as a trigger to automatically install the CICAM profile
operator_info_req(2)
operator_info(3)
CICAM returns the profile information to the Host on request.
Host requests the quasi-static information about the network using the operator_info_req() APDU. This is valid for type 0 and type 1 profiles.
operator_search_start(4)
operator_tune (5)
operator_tune_status(6)
operator_tune(5)
operator_tune_status(6)
operator_search_status (7)
CICAM performs the profile search and tunes around. Once the search is complete then the NIT profile is updated. The CICAM shall keep the user informed of progress using the Application MMI or high level MMI of the CICAM when the Host is in an interactive mode.
Host initiates a search if the operator status is un-initialised.
The Host tunes on behalf of the CICAM.
The CICAM has finished searching when the operator_search_status APDU is returned.
operator_nit_req(8)
operator_nit (9)
The CICAM returns the latest CICAM NIT when requested by the Host.
The Host requests the CICAM NIT and constructs the channel list using this table information for type=1
If the process is successful then the service operator profile is installed as a separate sandbox logical channel list with the text label specified in the operator status APDU.

Figure 14.14: Profile Discovery APDU sequence

1. The CICAM reports the current profile on opening the session.
2. The Host queries the CICAM for the general profile information for the service operator and the network using a operator_info_req() APDU.
3. The CICAM reports the profile information to the Host in the operator_info() APDU. The version number of the operator information is maintained in the operator_status() APDU and the Host may detect a change in the information from the version number without interrogating the Operator Profile information again.
4. The Host installs the profile, if the profile is uninitialised then a profile search is initiated to search for the profile information using the operator_search_start () APDU.
5. On receiving an operator_search_start () APDU then the CICAM shall direct the Host tuning operations and display the on-going search status via the CICAM MMI. The CICAM may request zero or more tune operations to the required multiplex(es) with a operator_tune() APDU.
6. On receipt of a operator_tune() then the Host tunes to the required multiplex and acknowledges the tune with a operator_tune_status() APDU that contains the status of the tune. If the CICAM requires the Host to find the next digital location then the CICAM may issue another operator_tune() APDU

which performs a channel search using the locations described in the APDU and is acknowledged by the Host with a operator_tune_status() APDU when the search completes.

7. Once the CICAM has completed the profile search then any NIT is internally updated on the CICAM with the new network information and the NIT version is updated. The operator_search_status() APDU is sent and shall include the status and any new NIT version number. The error_flag is set appropriately if the system_descriptor of the search is not supported. Any Application or high level MMI shall be removed before the operator_search_status() APDU is sent.
8. If the profile search has no errors then the Host may install the profile based on the CICAM NIT information, the Host shall request the NIT using the operator_nit_req() APDU.
9. The CICAM shall return the latest version of the NIT to the Host with the operator_nit() APDU.

If the profile cannot be found by the CICAM then the initialised_flag and error_flag shall be set in any operator_status_body() indicating that the Operator Profile is in error. The error_flag for a failed profile search shall be persistent. The error_flag shall only be cleared by a Host initiated operator search or reset or by some other external interaction with the CICAM e.g. MMI option to reset or CICAM detection that it has been unplugged and re-plugged.

14.7.4.1.4 Start-up Considerations

The Operator Profile session shall be opened within 30 seconds of power-on of the CICAM to afford the Host an opportunity to include the Operator Profile in any installation procedure. A profiled CICAM should advertise the presence of an Operator Profile in the CIS information to inform the Host that an Operator Profile is present and the Host may then wait for the CICAM to create the Operator Profile resource before proceeding with any installation process.

On first installation then it is likely that the Operator Profile resource should be processed before the Host and CICAM are able to connect to the network and subsequently acquire the time and date. The CICAM shall ensure that any Content Control resource authentication procedure is only initiated once the CICAM and Host have both acquired a valid date and time. i.e. the Operator Profile resource is processed before any Content Control authentication is performed.

14.7.4.2 Moving between profiles

The Host is required to inform the CICAM when it enters and leaves a profile_type 1 environment. A Host enters a operator environment by sending a operator_status_req() APDU, the CICAM may assume that the Host is actively running in the profile until a operator_exit() APDU is received. On entering the operator profile environment then the following behaviour is required:

- The CICAM shall actively maintain the operator profile environment.
- The CICAM may assume that transport streams passing through the CICAM are part of the operator profile environment.
- The Host shall maintain the profile environment using the operator_status() APDU.

The Host may leave an operator profile for another profile or any of its private channel lists. When the Host leaves the profile then the following behaviour is required:

- The CICAM shall not assume that transport streams passing through the CICAM are part of the operator profile environment.
- The CICAM shall continue to handle the ca_pmt() and descramble content when it is able to.
- The Host is not required to maintain the profile environment or process the operator_status() APDU.

The Host may subsequently return to the operator profile environment again by issuing a operator_status_req() APDU. The APDU sequence is depicted in Figure 14.15.

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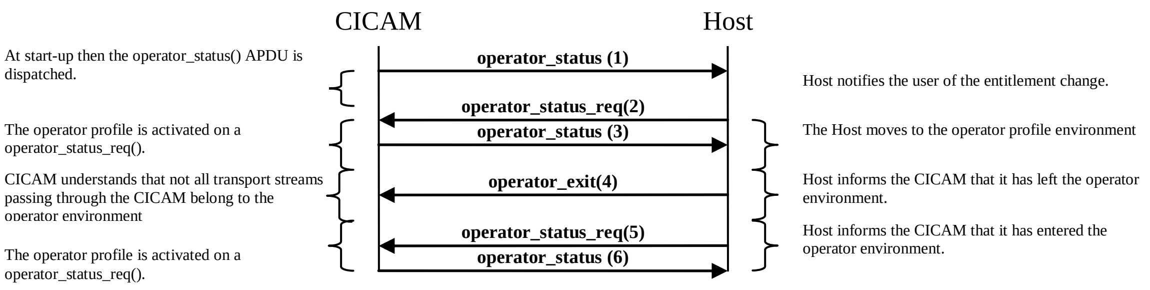
CICAM
Host
At start-up then the operator_status() APDU is dispatched.
operator_status (1)
Host notifies the user of the entitlement change.
operator_status_req(2)
The operator profile is activated on a operator_status_req().
operator_status (3)
The Host moves to the operator profile environment
CICAM understands that not all transport streams passing through the CICAM belong to the operator environment
operator_exit(4)
Host informs the CICAM that it has left the operator environment.
operator_status_req(5)
Host informs the CICAM that it has entered the operator environment.
The operator profile is activated on a operator_status_req().
operator_status (6)

Figure 14.15: Entering and Leaving a profiled environment

The behaviour of the system is defined as follows:

1. The CICAM reports the operator_status() APDU automatically at start-up.
2. The Host moves into the operator profile environment and sends a operator_status_req() APDU.
3. The CICAM is operating within the operator profiled environment and acknowledges the Host with a operator_status() APDU.
4. The Host leaves the operator profile environment, by sending a operator_exit() APDU, and may be operating in a different operator profile or with a different delivery system using a different channel list.
5. The Host moves back to the operator profiled environment and sends a operator_status_req() APDU.
6. The CICAM is again operating within the operator profiled environment and acknowledges the Host with a operator_status() APDU.

14.7.4.3 Entitlement Change

The entitlement_change_flag of the operator_status_body() is set when the CAS entitlement has changed. A change in entitlement may be signalled as a result of the user updating their subscription. A change in subscription may make more/less services accessible and may require an update to the Host channel list. On detecting a change in entitlement then the Host updates the channel list where necessary and then acknowledges the CICAM that the entitlement has been processed when the CICAM shall clear the entitlement change flag. The entitlement_change_flag shall not be used to simply indicate a change in the service line-up. A change in the service line-up is indicated by a change in the nit_version field of the operator_status_body() which the Host shall process in the same manner as a NIT table update in a conventional broadcast network.

The entitlement_change_flag shall be processed by the Host as quickly as practically possible so to install any new services corresponding to the entitlement change. This may require notifying the user that an entitlement change has occurred and then immediately passing tuning control to the CICAM to acquire the service line up changes form the network.

The flag states of the operator_status_body() indicate how the Host should process the entitlement change.

14.7.4.3.1 Simple entitlement change

In the simple case then the entitlements are updated, which may entail a change to the CICAM NIT table. The Host updates the channel list with any CICAM NIT change and then acknowledges the CICAM that the entitlement has been processed. The APDU exchange is shown in Figure 14.16.

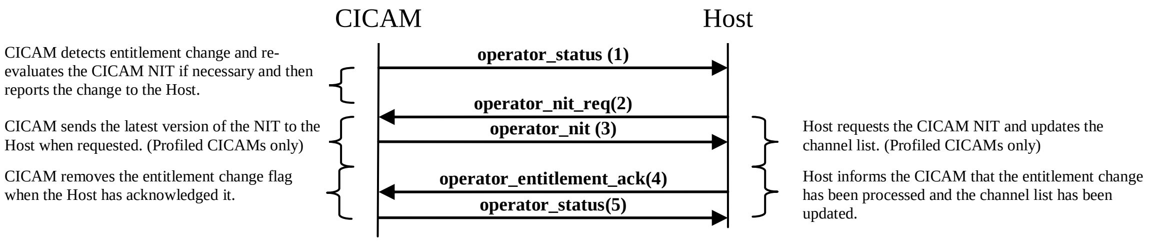
CICAM
Host
CICAM detects entitlement change and re-evaluates the CICAM NIT if necessary and then reports the change to the Host.
operator_status (1)
operator_nit_req(2)
CICAM sends the latest version of the NIT to the Host when requested. (Profiled CICAMs only)
operator_nit (3)
Host requests the CICAM NIT and updates the channel list. (Profiled CICAMs only)
CICAM removes the entitlement change flag when the Host has acknowledged it.
operator_entitlement_ack(4)
operator_status(5)
Host informs the CICAM that the entitlement change has been processed and the channel list has been updated.

Figure 14.16: Simple Entitlement Change APDU sequence

The behaviour of the system is described as follows:

1. The CICAM detects a change in the entitlement rights and updates the NIT if necessary. The change is reported in an operator_status() APDU with the entitlement_change_flag field set. The refresh_request_flag may be unset indicating that the CICAM has already captured the entitlement change and the NIT is ready, no search is required.
2. The CICAM NIT of a profiled CICAM may have changed, indicated by a version number update, and if so the Host prepares to update the channel list by requesting the new CICAM NIT from the CICAM (this may require permission from the user to process the entitlement change immediately).
3. A profiled CICAM then sends the new CICAM NIT to the Host. The Host processes the CICAM NIT and updates the channel list.
4. The Host processes the entitlement change and acknowledges the CICAM by sending a operator_entitlement_ack().
5. On receiving a operator_entitlement_ack() to clear the entitlement request then the CICAM clears the entitlement_change_flag and acknowledges the change of state with a new operator_status() APDU.

Note that the CICAM may not require an update to the CICAM NIT and the CICAM may signal an entitlement change without updating the CICAM NIT version.

14.7.4.3.2 Entitlement change where a search is required

An entitlement change may sometimes require the CICAM to search the network to acquire a new service line up change, in this case the CICAM may signal the entitlement change with a refresh request together in the same APDU i.e. entitlement_change_flag=1 and refresh_request_flag=1. If the tuning operation is urgent then the CICAM may signal the refresh_request_flag=2 indicating that the entitlement cannot be processed until the Host has issued a search. The APDU exchange is shown in Figure 14.17.

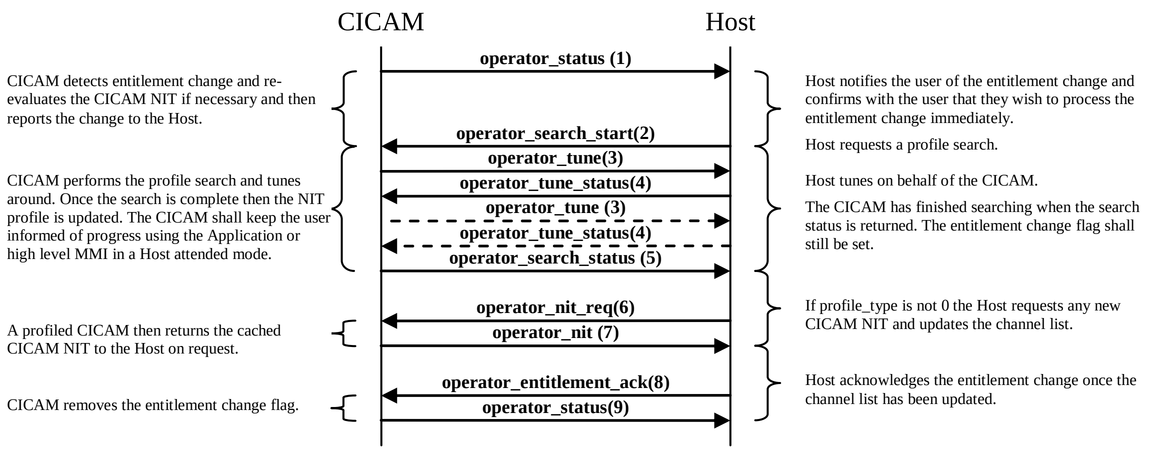
CICAM
Host
operator_status (1)
CICAM detects entitlement change and re-evaluates the CICAM NIT if necessary and then reports the change to the Host.
Host notifies the user of the entitlement change and confirms with the user that they wish to process the entitlement change immediately.
operator_search_start(2)
Host requests a profile search.
operator_tune(3)
operator_tune_status(4)
CICAM performs the profile search and tunes around. Once the search is complete then the NIT profile is updated. The CICAM shall keep the user informed of progress using the Application or high level MMI in a Host attended mode.
Host tunes on behalf of the CICAM.
operator_tune (3)
operator_tune_status(4)
The CICAM has finished searching when the search status is returned. The entitlement change flag shall still be set.
operator_search_status (5)
operator_nit_req(6)
If profile_type is not 0 the Host requests any new CICAM NIT and updates the channel list.
operator_nit (7)
A profiled CICAM then returns the cached CICAM NIT to the Host on request.
operator_entitlement_ack(8)
Host acknowledges the entitlement change once the channel list has been updated.
operator_status(9)
CICAM removes the entitlement change flag.

Figure 14.17: Search Entitlement Change APDU sequence

The behaviour of the system is described as follows:

1. The CICAM detects the change in the entitlement rights but is not able to determine if the channel list is altered by the change without scanning the network. The change is reported in an operator_status() APDU and the entitlement_pending_flag is set and the refresh_request_flag is set to 1 or 2 depending on the urgency of a network search.
2. The Host informs the user about the entitlement change, if the refresh_request_flag is set to 1 then the user may be given an option to process the entitlement change immediately where the refresh_request_flag is 2 then the requirement to interrogate the network is more urgent then the user may be not given any options to install later. When the Host is ready to process the entitlement change a search is initiated to start the network scan and a operator_search_start() APDU is sent and control effectively moves to the CICAM.
3. On receiving a operator_search_start() then the CICAM may request one or more tune operations to the required multiplex(es) with a operator_tune () APDU. In a Host attended mode then the CICAM shall keep the user informed of progress using the Application or high level MMI.
4. On receipt of a operator_tune () then the Host tunes to the required multiplex and acknowledges the tune with a operator_tune_status() APDU that contains the status of the tune request.

5. Once the CICAM has completed the search then any cached NIT is updated with the new network information, the version number updated and a operator_search_status() APDU is sent to the Host. The entitlement_change_flag field shall remain set as the entitlement change has not been acknowledged by the Host. Any Application or high level MMI shall be removed prior to sending the search status.
6. On receipt of the operator_search_status() APDU the Host determines if the NIT has changed using the nit_version field. If the NIT version has been updated then the Host may request the new CICAM NIT using the operator_nit_req() APDU.
7. The CICAM returns the updated NIT to the Host with the operator_nit() APDU and the Host updates the channel list if the CICAM NIT has changed.
8. Once the channel list has been updated then the entitlement change is acknowledged to the CICAM by sending a operator_entitlement_ack() APDU.
9. On receiving a operator_entitlement_ack() to clear the entitlement request then the CICAM clears the entitlement_change_flag and acknowledges the change of state with a new operator_status() APDU.

14.7.4.4 Tuning and Scanning

There are a number of different tuning and scanning scenarios which are required by the operator profile, all tuning scenarios are explicitly initiated by the Host using the operator_search_start() APDU. The Host may choose to initiate a tuning sequence as a result of:

- A tune explicitly solicited by the CICAM with the refresh_request_flag in the operator_status_body() of a operator profile APDU.
- An unsolicited search by the Host, typically as part of the Host receiver network maintenance performed in a stand-by state etc.

It is highly recommended that the Host provides the CICAM with an opportunity to update itself from the network on at least a weekly basis as part of any Host initiated maintenance cycle by initiating an unsolicited search operation. The CICAM may communicate a recommended date and time to perform a background scan using a timed refresh request.

The CICAM has the capability to notify the Host that it requires a tune using the refresh_request_flag in the operator_status_body() component of an APDU. The urgency of the tune request is determined from the state of this field.

- Advanced warning (1) informs the Host that a tune is required in the near future. This notification should not affect the user and shall ideally be serviced at the next opportune moment of the Host i.e. a back ground scan when the user enters stand-by etc.
- Urgent request (2) informs the Host that an immediate tune is required. This is only signalled by the CICAM in cases where some parts of the network or content, in the case of type 0 profiles, are not accessible until the tune is performed. The Host is strongly recommended to initiate an immediate tune after confirmation from the user.
- Timed request (3) informs the Host that a scheduled search is requested at a time and date in the future. The Host shall perform the scheduled search if it is able to (i.e. is not powered off). If the search has been missed then the CICAM shall not unnecessarily force the Host to perform an immediate scan but ideally reschedule for a later date. This prevents unnecessary interruptions for the user.

A tune operation is considered more urgent if the entitlement_pending_flag is set in conjunction with the refresh_request_flag as this indicates that the entitlement rights have been updated and a tune operation is required to re-evaluate that entitlement. The Host may, in this case, choose to inform the user of an entitlement change and request permission to initiate an immediate search to re-evaluate the network.

The refresh_request_flag may be set and cleared as part of the normal running of the system (i.e. when the user is watching a service) as information is received from the current multiplex which may cause a pending request to be added or removed if information updates have been received from the network.

14.7.4.4.1 Profile Search

A profile search APDU exchange is shown in Figure 14.18.

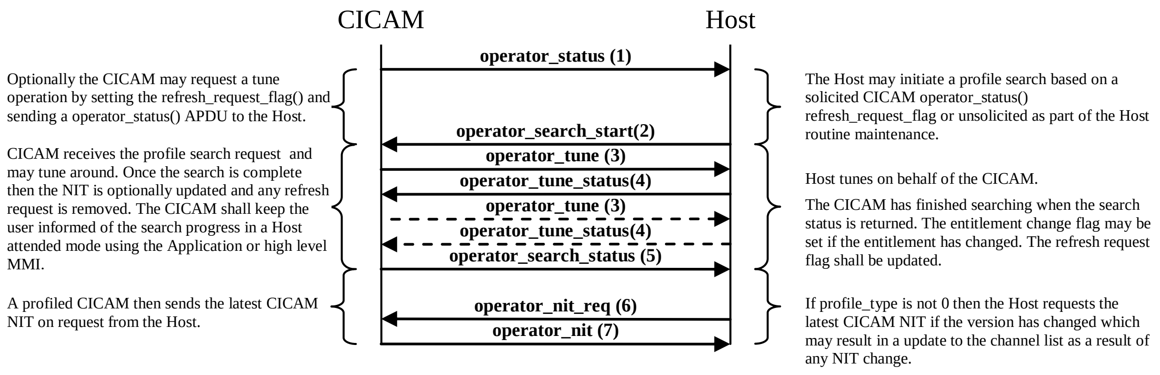
CICAM
Host
operator_status (1)
Optionally the CICAM may request a tune operation by setting the refresh_request_flag() and sending a operator_status() APDU to the Host.
The Host may initiate a profile search based on a solicited CICAM operator_status() refresh_request_flag or unsolicited as part of the Host routine maintenance.
operator_search_start(2)
operator_tune (3)
operator_tune_status(4)
operator_tune (3)
operator_tune_status(4)
operator_search_status (5)
CICAM receives the profile search request and may tune around. Once the search is complete then the NIT is optionally updated and any refresh request is removed. The CICAM shall keep the user informed of the search progress in a Host attended mode using the Application or high level MMI.
Host tunes on behalf of the CICAM.
The CICAM has finished searching when the search status is returned. The entitlement change flag may be set if the entitlement has changed. The refresh request flag shall be updated.
operator_nit_req (6)
operator_nit (7)
A profiled CICAM then sends the latest CICAM NIT on request from the Host.
If profile_type is not 0 then the Host requests the latest CICAM NIT if the version has changed which may result in a update to the channel list as a result of any NIT change.

Figure 14.18: Profile search APDU sequence

The behaviour of the system is described as follows:

1. The CICAM optionally detects the change in the network that requires it to perform a search operation. The priority of the search request is determined and the refresh_request_flag is set to the appropriate value for that search priority. The change is reported in an operator_status() APDU and the refresh_request_flag is set to a non-zero value depending on the urgency of a tune.
2. When the Host is ready to process the profile search then the operator_search_start() APDU is sent to the CICAM and control of the tuner and MMI is effectively passed to the CICAM.
3. On receiving a operator_search_start() with a profile search then the CICAM requests one or more tune operations to the required multiplex(es) with a operator_tune () APDU. The progress of the search shall be conveyed to the user using the Application or high level MMI where the Host is attended.
4. On receipt of a operator_tune () APDU then the Host tunes to the required multiplex and acknowledges the tune with a operator_tune_status() APDU that contains the status of the tune.
5. Once the CICAM has completed the profile search then any NIT is updated within the CICAM with the new network information, the CICAM NIT version is updated and a operator_search_status() APDU is sent to the Host. The refresh_request_flag is reset. Any Application or high level MMI shall be removed.
6. If the NIT version has changed in the operator_status_body() then the Host may request the new CICAM NIT table with the operator_nit_req() APDU.
7. On receipt of the operator_nit_req() APDU then the CICAM returns the latest cached CICAM NIT sections to the Host in a operator_nit() APDU. The Host may use the CICAM NIT to update the channel list.

14.7.4.4.2 Tuning Requests

The CICAM may only initiate a tuning request operator_tune () APDU in response to the Host operator_search_start() APDU. Once the search has been initiated then the CICAM is permitted to initiate multiple tuning requests. The tune operation may:

- Move to an explicit delivery system location.
- Request the Host to perform a scanning tune from based on a list of delivery system locations.

The explicit tune requires the Host to move the tuner to the location specified by the delivery_system_descriptor, the Host is not required to select any service on this multiplex. Multiple tuning locations may be specified and the Host shall process the locations sequentially in the order specified in the APDU until a valid signal is found when it completes the tune request.

Within the context of a CICAM search then the Host shall allow the CICAM to use other APDUs to acquire information including, but not exclusively, the Low Speed Communications resource. The CICAM shall ensure that other APDUs opened in the context of the search are closed before the search completes. The CICAM is not permitted to use the software upgrade APDU in the context of a search.

The operator_tune() APDU command may also be used by the CICAM for service discovery and requires the Host to scan the network sequentially using the delivery system descriptors to find a location that carries a signal. The Host command completes when the next carrier is found or the list is exhausted. The Host returns information about the tuned location to the CICAM. The information returned by the Host in any delivery system descriptor definition shall be accurate as this information may be used to construct the CICAM NIT.

The Host completes a tuning request by sending a operator_tune_status() APDU to the CICAM which contains information on the status of the tune operation. The Host shall return a delivery_system_descriptor which shall be fully and accurately populated describing the currently tuned location, some values of the system_delivery_descriptor may be derived from the tuner parameter signalling information carried in the actual signal. The signal strength and quality information from the network interface shall be included in the APDU expressed as a percentage relative values which should not be interpreted literally by the CICAM. The Host shall not report non-viable signals to the CICAM as being present, the Host may report a frequency location where a data carrier is detected by the network interface but the signal does not contain a valid transport stream i.e. the Host is not required to determine that the signal actually carries a valid transport stream.

During a tuning operation then the CICAM shall be robust against data fluctuations and noise on the transport stream bus. The Host may choose to, but is not required to, disconnect the transport stream interface for the duration of a tune operation to further increase the robustness of the system. Where the transport stream is disconnected by the Host for the duration of the tune then it shall be reconnected before issuing the operator_tune_status() APDU to the CICAM.

The CICAM shall keep the user informed of the search progress in a Host attended mode using the MMI, ideally the CICAM shall present an option to cancel in the MMI. If the user chooses to cancel the scan, the CICAM shall cancel the tune and send an operator_search_status() to the Host with error_flag set to 0x3.

The Host may cancel the tune by sending a operator_search_cancel(), the CICAM shall cancel the tune and send an operator_search_status() to the Host with the error_flag set to 0x3.

14.7.4.4.3 CAM Upgrade Consideration

A CICAM firmware upgrade APDU sequence shall not be initiated in the middle of a operator_search_start() sequence until the CICAM returns the final operator_search_status() acknowledgement.

Where the Host initiates a periodical maintenance search in a stand-by mode, where the Host is unattended, then the Host is required to provide the CICAM with a window of opportunity to make further Host requests. A grace period of 30s after receipt of the operator_search_status() acknowledgement shall be provided by the Host allowing the CICAM sufficient time to initiate a firmware upgrade APDU request before the Host returns to any deep stand-by mode.

14.7.5 Operator Profile Resource

The Operator Profile resource enables the CICAM to coordinate the profile management with the Host. The messages allow the CICAM to acquire and maintain the operator profile information with some agreement from the Host device. The Host is informed of changes to the operator environment including changes in the service line up and is advised when the CICAM needs to search the network to acquire the very latest information. The CICAM is provided with the facility to tune and scan a network to acquire network information which is facilitated by the Host.

The Host is only required to support a single Operator Profile session per CICAM. Where a CICAM has a capability to support a multitude of different profiles then the CICAM shall determine which profile to map to the session. The exact mechanism by which the CICAM determines the active profile to map is unspecified; ideally the CICAM shall determine this automatically using the broadcast information, entitlement rights etc.

14.7.5.1 Operator Profile Resource APDUs

The CICAM opens the operator_profile resource immediately from start up and the resource remains open in order to deliver any subsequent changes to the profile information.

Table 14.35: Operator Profile APDUs

Operator Profile APDU	Direction	Description
`operator_status_req`	HOST → CICAM	Enter profile and/or request current profile information.
`operator_status`	CICAM → HOST	The current profile status information.
`operator_nit_req`	HOST → CICAM	Request the current CICAM NIT sections.
`operator_nit`	CICAM → HOST	The current CICAM NIT sections.
`operator_info_req`	HOST → CICAM	Request the Operator information
`operator_info`	CICAM → HOST	The Operator information
`operator_search_start`	HOST → CICAM	Host permission to initiate a network search.
`operator_search_cancel`	HOST → CICAM	Cancel the current network search.
`operator_search_status`	CICAM → HOST	CICAM notification that the search has completed.
`operator_exit`	HOST → CICAM	The Host has left the service operator profile.
`operator_tune`	CICAM → HOST	Request to tune to a specific multiplex location.
`operator_tune_status`	HOST → CICAM	Host tune request has completed.
`operator_entitlement_ack`	HOST → CICAM	Confirmation that entitlement change has been enacted.

14.7.5.2 operator_status_req APDU

The Host sends this APDU to the CICAM when entering the service operator profile and to query the current operator profile status. The CICAM replies with a operator_status() APDU. When the CICAM receives the operator_status_req() then it may assume that the Host is operating in the operator profile context until such time that a operator_exit() APDU is received when no further asynchronous operator profile APDU updates may be reported to the Host until such time that the Host enters the profile again with a operator_status_req() APDU.

Table 14.36: operator_status_req APDU syntax

Syntax	No. of bits	Mnemonic
`operator_status_req() {`		
`   operator_status_req_tag`	24	uimsbf
`   length_field()`		
`}`		

Where the fields are defined as follows:

operator_status_req_tag: See Table L.1 in Annex L.

14.7.5.3 operator_status APDU

This APDU is sent by the CICAM to inform the Host about the CICAMs current operator profile settings. It is sent in response to a operator_status_req() or operator_entitlement_ack() APDUs from the Host. The CICAM also sends this APDU asynchronously on opening of the session or when there is a change in the operator_status_body() that must be enacted by the Host.

The operator_status_body() should be considered to be quasi-static and contains information which represents the operational state of the operator_profile session. The CICAM shall only send an operator_status APDU when the operational state of the session changes.

On opening the Operator Profile resource the CICAM sends one operator_status () APDU to the Host conveying the current profile setting.

Table 14.37: operator_status APDU syntax

Syntax	No. of bits	Mnemonic
`operator_status() {`		
`   operator_status_tag`	24	uimsbf
`   length_field()`		
`   operator_status_body()`		
`}`		

Where the operator_status_body() is defined as defined in Table 14.38. The operator_status_body() conveys information about the state of the CA system in the context of CA services which are controlled by the CICAM. The operator_status_body() contains flags and values that may cause the Host to perform some action. As a general rule the Host and CICAM shall be sympathetic to the type of the currently selected service as follows:

- A Free-to-air service
    - The CICAM shall not change the refresh_request_flag setting to urgent.
    - The Host shall not unnecessarily interrupt or prevent the viewer from viewing the current service. The Host shall process any urgent or expired timed request at the earliest opportunity following the event when the user is not unnecessarily interrupted from viewing the current service. The Host may choose to inform the user that the CA System requires some action and allow the user to decide if this operation may be undertaken immediately or shall be deferred. Any action, urgent or otherwise, may be deferred to prevent viewer interruption e.g. deferred until the next channel change.
- A CA Service not owned by the operator profile CICAM – As Free-to-air service.
- A CA Service owned by the operator profile CICAM
    - The CICAM may change the resfresh_request_flag to any setting including urgent.
    - The Host shall action the change of the refresh_request_flag to urgent immediately which is likely to interrupt the viewing of the current service. An outstanding urgent refresh_request_flag setting shall be actioned immediately on selection of the CA service.

Table 14.38: operator_status_body syntax

Syntax	No. of bits	Mnemonic
`operator_status_body() {`		
`info_version`	3	uimsbf
`nit_version`	5	uimsbf
`profile_type`	2	uimsbf
`initialised_flag`	1	bslbf
`entitlement_change_flag`	1	bslbf
`entitlement_valid_flag`	1	bslbf
`reserved`	1	bslbf
`refresh_request_flag`	2	uimsbf
`error_flag`	4	uimsbf
`delivery_system_hint`	4	bslbf
`refresh_request_date`	16	uimsbf
`refresh_request_time`	8	uimsbf
`}`		

Where the fields are defined as follows:

operator_status_tag: See Table L.1 in Annex L.

info_version: This 3-bit field is an identifier that uniquely identifies the version of the profile information contained in the operator_info() APDU. The profile information version shall be incremented by 1, wrapping to 0, when the profile information changes and the Host is required to re-evaluate the profile container. The profile information version shall only be incremented on gross profile changes including a profile name change, profile type change etc. This field shall not be incremented on a nit_version change or any changes in the status flags e.g. initialised_flag, refresh_request_flag, etc.

nit_version: This 5-bit field is only interpreted in the context of a non-zero profile and is set to the current version number of the NIT delivered by the CICAM. The Host shall monitor this field and shall respond to any change in the same manner as a NIT table update in a conventional broadcast network.

If the CICAM is not delivering a NIT then the field shall be zero and shall not be interpreted by the Host.

profile_type: This 2-bit field identifies the type of CICAM profile, the CICAM profiles are identified in Table 14.39.

Table 14.39: profile_type values

Value	Description
0	The CICAM does not support any profiles and descrambles elementary streams as per DVB CI.
1	Profile is a private network that uses a CICAM NIT and has a private profile logical channel list.
2-3	Reserved for future use.

initialised_flag: This 1-bit field contains the status of the profile initialisation for the specified profile. A value of "0" indicates that the profile has not been determined by the CICAM and the Host shall initiate an operator_search_start(). A value of "1" indicates that the profile has been determined by the CICAM. When this flag is clear other flags of the operator status body shall not be interpreted by the Host.

entitlement_change_flag: This 1-bit field shall be set when an entitlement change has occurred which has not been acknowledged by the Host. A value of "0", the default, indicates that there are no entitlement changes pending, a value of "1" indicates that an unacknowledged entitlement change is pending.

entitlement_valid_flag: This 1-bit field shall be set when the entitlement is valid, the field is provided for information only. A value of "1" indicates that entitlement rights have been gained and are valid. A value of "0" indicates that there are no entitlement rights.

refresh_request_flag: This 2-bit field shall be set when the CICAM requires a tuning operation to visit another multiplex in order to acquire further information about the profile or to check entitlement rights etc. The refresh_request_flag shall be set to zero when the CICAM no longer requires a tuning operation.

The CICAM may only request a single refresh request which may be deferred, urgent or scheduled. The Host is required to action the last received refresh request discarding any previous request.

Table 14.40: refresh_request_flag values

Value	Description
0	The default state, indicates that the CICAM does not need to interrogate the network and is up to date.
1	Advance warning to the Host that something in the network has changed and the CICAM requires the Host to tune in order to perform an update check when convenient. The request shall be deferred until the Host is ready to do the search without interrupting the user.
2	Urgent request from the CICAM that the network needs to be interrogated in order to acquire information. An urgent request shall only be notified where the CICAM does not have full functional capability until the network has been interrogated. The Host shall initiate a profile search as soon as possible. A Host on a Free-to-air or CA service not associated with the CICAM that owns the operator profile is not required to process this flag immediately when processing the request will interrupt or prevent the user from viewing the current service.
3	Scheduled refresh request from the CICAM that the network needs to be interrogated at a specific update time. The Host shall initiate a profile search at or after the specified time. This may require the Host to automatically wake from standby at the specified time to initiate the search. If the search slot is missed, for example if the receiver is powered off at the mains or the user is viewing a service at the scheduled time, then the Host shall initiate an operator search request as soon as possible after the event. Where there is an outstanding expired schedule refresh request then the CICAM shall wait for the Host to initiate an operator search before rescheduling for a later time. The scheduled refresh requires that the Host shall invoke the operator search on or as soon as possible after the event has expired. When the operator profile search is invoked by the Host then the CICAM may perform the search and/or reschedule another search for a later time/date by updating the refresh request fields.

The state of the refresh_request_flag (and time/date) shall be updated by the CICAM to reflect the next refresh state required by the CICAM on completion of any operator search operation. The Host is notified of the new refresh request flag setting in addition to the other flags of the operator_status_body() in the operator_search_status() APDU.

error_flag: This 4-bit field contains the status of the current active profile. The bits of the field shall be set according to Table 14.41.

Table 14.41: error_flag values

Value	Description
0	There are no errors.
1	Profile error. The CICAM has encountered an error and cannot acquire the profile, no profile information is cached.
2	Unsupported delivery system. The CICAM does not support the delivery system descriptor(s) reported by the Host.
3	Cancelled. The operator search has been interrupted and is incomplete.
4-15	Reserved for future use.

delivery_system_hint: This 4-bit field contains a hint of the delivery systems supported by the Operator Profile and provides the Host with an assessment of the CICAM profile. This field shall be interpreted as a bitmask and shall be set according to Table 14.42. This field shall not be set to zero.

Table 14.42: delivery_system_hint values

Bit	Description
0b0001	This is a cable network and may be DVB-C and/or DVB-C2
0b0010	This is a satellite network and may be DVB-S and/or DVB-S2
0b0100	This is a terrestrial network and may be DVB-T and/or DVB-T2
0b1000	Reserved for future use.

The CICAM may support multiple delivery systems which shall result in multiple bits of this field being set. If the Host does not support any of the reported delivery systems then the profile may be ignored by the Host.

refresh_request_date: This 16-bit field indicates the date of the next scheduled refresh cycle requested by the CICAM. The date is specified as UTC Modified Julian Date (MJD) as defined in EN 300 468 [10], Annex C. A value of 0x0000 indicates that no schedule refresh is requested.

refresh_request_time: This 8-bit field indicates the time of a scheduled refresh cycle requested by the CICAM. The time is specified in UTC as an integer value in 6 minute intervals from midnight and is valid in the range 0..239. This field is only interpreted when the refresh_request_date is non-zero. When the refresh_request_flag is zero then this field shall also be zero.

EXAMPLE:	0	00:00 – Midnight
	44	04:24 – 24 minutes past 4 in the morning.
	239	23:54 – 6 minutes to midnight.

14.7.5.4 operator_nit_req APDU

The Host sends this APDU to the CICAM to query the current Network Information Table (NIT). The CICAM replies with an operator_nit APDU returning the CICAM NIT to the Host.

Table 14.43: operator_nit_req APDU syntax

Syntax	No. of bits	Mnemonic

operator_nit_req() {
  operator_nit_req_tag
  length_field()
}
	24	uimsbf

Where the fields are defined as follows:

operator_nit_req_tag: See Table L.1 in Annex L.

14.7.5.5 operator_nit APDU

The CICAM sends this APDU to the Host in response to a operator_nit_req() APDU. The ADPU, if successful, contains the latest CICAM NIT sections.

Table 14.44: operator_nit APDU syntax

Syntax	No. of bits	Mnemonic
`operator_nit () {`		
`operator_nit_tag`	24	uimsbf
`length_field()`		
`nit_loop_length`	16	uimsbf
`for (i=0; i<N; i++){`		
`nit_section_byte`	8	uimsbf
`}`		
`}`		

Where the fields are defined as follows:

operator_nit_tag: See Table L.1 in Annex L.

nit_loop_length: This 16-bit field specifies the length in bytes of the following NIT section field containing the CICAM NIT sections. The field may be zero (0) if there is no NIT.

nit_section_byte: A loop of one or more Network Information Table (NIT) sections that fully describe the network. A NIT shall only be provided where the broadcast Network and/or Bouquet information is to be ignored and is prepared by the CICAM. The NIT sections shall respect the broadcast signalling rules and shall be a maximum size of 1024 bytes, shall appear in ascending section number order and shall each contain a valid CRC-32. The NIT first loop may be split over multiple sections and shall adhere to the DVB splitting rules. The NIT second loop may be split over multiple sections, the sections shall be sequentially numbered sections and the appropriate delivery_system_descriptors and private data specifiers shall appear in each section.

When the NIT is returned to the Host then the NIT version shall typically match the version number in the last reported operator_status() APDU. The NIT version shall only be different when the NIT has been updated and the CICAM has not yet dispatched the operator_status() APDU containing the latest nit_version information.

The CICAM NIT shall contain all of the information that the Host requires to construct and maintain the logical channel list of the operator profile. The Host is not required to interrogate the broadcast Service Information (SI) for construction or maintenance of the profile channel list.

The first loop of the NIT may optionally contain a network name in a network_name_descriptor in addition to CI Plus private descriptors to provide an indication of the broadcast network operation and to assign content text labels. The first loop may also optionally include other broadcast signalling information such DVB-SSU which shall be signalled in accordance with the DVB standards.

The second loop of the NIT shall contain system_delivery_descriptor(s) accurately specifying the network location of the multiplex in addition to one or more ciplus_service_descriptor(s) describing the text label and service type of each service to be included in the profiled logical channel list. Services are assigned a logical channel number and may be hidden.

The Host shall always honour private descriptor scope. The Host is not obliged to interpret any other private descriptors encountered in any loop of the NIT and shall ignore and skip over any unknown descriptors.

Refer to Annex N for full profile information.

14.7.5.6 operator_info_req APDU

The Host sends this APDU to the CICAM to query the operator information. The CICAM replies with a operator_info() APDU returning the quasi-static operator information to the Host.

Table 14.45: operator_info_req APDU syntax

Syntax	No. of bits	Mnemonic
`operator_info_req() {`		
`   operator_info_req_tag`	24	uimsbf
`   length_field()`		
`}`		

Where the fields are defined as follows:

operator_info_req_tag: See Table L.1 in Annex L.

14.7.5.7 operator_info APDU

The CICAM sends this APDU to the Host in response to a operator_info_req() APDU. The APDU contains important information for the Host for the correct interpretation and representation of the configuration of the SI in the multiplexes of the network. It is important that any information provided in the APDU accurately matches the actual network operation otherwise the behaviour of the Host may be adversely affected. The information in this APDU shall be considered as quasi-static. The operator_info APDU is only interpreted for profile type 1 and type 0 for DVB-C/C2 networks. The operator_info APDU for type 0 is optionally interpreted for DVB-T/T2 and DVB-S/S2 networks.

Table 14.46: operator_info APDU syntax

Syntax	No. of bits	Mnemonic
`operator_info () {`		
`   operator_info_tag`	24	uimsbf
`   length_field()`		
`   reserved`	4	bslbf
`   info_valid`	1	bslbf
`   info_version`	3	uimsbf
`   if (info_valid == 1) {`		
`      cicam_original_network_id`	16	uimsbf
`      cicam_identifier`	32	uimsbf
`      character_code_table`	8	uimsbf
`      if (character_code_table == 0x1f) {`		
`         encoding_type_id`	8	uimsbf
`      }`		
`      else if (character_code_table == 0x10) {`		
`         second_byte_value`	8	uimsbf
`         third_byte_value`	8	uimsbf
`      }`		
`      sdt_running_status_trusted`	1	uimsbf
`      eit_running_status_trusted`	1	uimsbf
`      eit_present_following_usage`	2	uimsbf
`      eit_schedule_usage`	3	uimsbf
`      extended_event_usage`	1	bslbf
`      sdt_other_trusted`	1	bslbf
`      eit_event_trigger`	1	bslbf
`      reserved`	6	bslbf
`      ISO_639_language_code`	24	bslbf
`      profile_name_length`	8	uimsbf
`      for (i=0; i< profile_name_length; i++) {`		
`         profile_name_byte;`	8	uimsbf
`      }`		
`   }`		
`}`		

Where the fields are defined as follows:

operator_info_tag: See Table L.1 in Annex L.

info_valid: this 1-bit field, when set to "1", indicates that the operator information is present. This bit shall only be set to "1" when the operator information accurately reflects the contents of the broadcast network.

info_version: This 3-bit field is an identifier that uniquely identifies the version of the profile information contained within this APDU. The profile information version shall be incremented by 1, wrapping to 0, when the profile information changes and the Host is required to re-evaluate the profile container. The profile information version shall only be incremented on gross profile changes including a profile_name change, profile_type change etc.

cicam_original_network_id: This 16-bit field unambiguously identifies the original_network_id identity of the service operator according to the allocations found in ETSI TS 101 162 [32]. This may differ from the original_network_id reported in the network due to the historical evolution of the network.

cicam_identifier: This 32-bit field identifies a particular hardware instance of the CICAM. The cicam_identifier shall be unique enough to be used in conjunction with the CICAM_original_network_id to link a CICAM with an operator profile. For example, the value may be constructed using any of the following:

- hash of the CICAM_ID
- hash of the serial number of the CICAM device
- hash of the serial number field of the CICAM device certificate
- value determined by the CICAM manufacturer

The chances of two CICAMs with the same identity should be greater than 1 in 10^9. The Host may use this field value in conjunction with other information about the CICAM to associate a profiled channel list to a given CICAM.

character_code_table: This 8-bit field identifies the default character set encoding that has been used on the network where the network operator has deviated from the DVB character encoding format defined by ETSI EN 300 468 [10], Annex A. The default is `0x00` representing the DVB Character code table 00 – Latin alphabet defined by the superset of ISO/IEC 6937. Where a non-zero character_code_table value has been specified by this field then all of the text fields of the network, including text fields in the CI Plus private descriptors of the NIT, which do not start with non-spacing, non-displayed data shall assume the character code specified by this and/or its associated fields.

encoding_type_id: This 8-bit field qualifies the character_code_table field when set to `0x1f` and indicates the encoding scheme of the string according to the allocations found in ETSI TS 101 162 [32].

second_byte_value: This 8-bit field qualifies the character_code_table field when set to `0x10` and is the first byte of the 16-bit value used to specify the character code table as defined in ETSI EN 300 468 [10], Annex A, Table A.4.

third_byte_value: This 8-bit field qualifies the character_code_table field when set to `0x10` and is the second byte of the 16-bit value used to specify the character code table as defined in ETSI EN 300 468 [10], Annex A, Table A.4.

sdt_running_status_trusted: This 1-bit field is a hint to the Host that identifies if the *running_status* field of the SDT is accurate, is trustable and may be interpreted by the Host. When the field is set to "1" then the SDT running status is trusted and the Host may indicate services that are not in a active running state. When the field is set to "0" then the SDT running status shall be interpreted to be always in a running state. The default Host operation is "0".

eit_running_status_trusted: This 1-bit field is a hint to the Host that identifies if the *running_status* field of the EIT is accurate, is trusted and may be interpreted by the Host. When the field is set to "1" then the EIT running status is trusted and correctly indicates whether services are in an active running state. When the field is set to "0" then the Host shall assume that the EIT running status is always in an active running state. The default Host operation is "0".

eit_present_following_usage: This 2-bit field describes the operating state of the $EIT_{present/following}$ event information in the network according to the values in Table 14.47. The default Host operation is acquisition from the local multiplex (1).

Table 14.47: EIT present/following operation values

Value	Description
0	The EIT table is not present.
1	The EIT table is present on the network. The EIT table is not fully cross carried and is delivered on the multiplex containing the service only. The Host is required to scan around the network to acquire the complete set of EIT information. Networks that are partially cross carried shall use this setting.
2	The EIT table is present on the network and is fully cross carried. The Host may remain on the same multiplex to acquire the complete set of EIT information.
3	Reserved for future use.

eit_schedule_usage: This 3-bit field describes the operating state of the EIT scheduled event information in the network according to the values in Table 14.48. The default Host operation is acquisition from the local multiplex (1) or Barker channel operation (3) when a EPG service linkage is present.

Table 14.48: EIT schedule operation values

Value	Description
0	The EIT table is not present.
1	The EIT table is present on the network. The EIT table is not fully cross carried and is delivered on the multiplex containing the service only. The Host is required to scan around the network to acquire the complete set of EIT information. Networks that are partially cross carried shall use this setting.
2	The EIT table is present on the network and is fully cross carried. The Host may remain on the same multiplex to acquire the complete set of EIT information.
3	The EIT table is present on the network and is available from a barker channel. The Host is required to move to the Barker channel to acquire a complete set of EIT information. The location of the barker channel(s) is indicated by a linkage descriptor with linkage_type 0x02 (EPG Service) in the 1st loop of the NIT.
4	The Electronic Programme Guide information is delivered using an application.
5-7	Reserved for future use.

extended_event_usage: This 1-bit field identifies how extended event information is presented and identifies whether the short_event_descriptor (`0x4d`) and extended_event_descriptor (`0x4e`) text fields are used mutually exclusively. The values are defined in Table 14.49.

Table 14.49: EIT extended event semantics values

Value	Description
0	The text of the extended_event_descriptor is different from the short_event_descriptor and shall be concatenated together to provide extended event information.
1	The text of the extended_event_descriptor includes the text of the short_event_descriptor and the descriptors are used mutually exclusively. The short_event_descriptor is used on its own to provided a short description only, the extended_event_descriptor is used on its own to provide a fuller text description.

sdt_other_trusted: This 1-bit field identifies the trusted state of SDT_{other} tables in the network. The field shall be set to "1" when the SDT is fully cross carried across the network and may be trusted by the Host for accurate state information. The default is "0" and information in SDT_{actual} is trusted only.

eit_event_trigger: This 1-bit field identifies if the $EIT_{p/f}$ event transition across the network is accurate enough to be used for event based recording. When the field is set to "1" then the $EIT_{p/f}$ event transition (when $EIT_{following}$ becomes $EIT_{present}$) is accurately transitioned and may be used as a trigger to start and stop recording of an event. When the field is "0" then the $EIT_{p/f}$ transition is inaccurate and the Host may use another mechanism to ensure that the whole event is recorded e.g. addition of a 5min lead-in and trailer time before and after the event signalled time.

$EIT_{p/f}$ trigging requires that the service operator accurately aligns the broadcast content with the event delivery and only allows events to transition when the programme content changes. This requires the service operator to hold the current event when a programme is running late and to transition to the next event when a programme is running early.

ISO_639_language_code: This 24-bit field identifies the default language code of unlabelled text fields and elementary stream components. The default language code shall be used by the Host to perform component and text selection in the absence of any explicit signalling from the service operator. Language codes which are undefined (including ‘und’ or ‘qaa’) shall be assumed to be the default language code specified by this field.

profile_name_length: This 8-bit field specifies the length in bytes of the following text field describing the profile name. For profile_type=1 this field shall always be non-zero and contain a valid profile name. The field may be zero (`0`) if there is no profile name.

profile_name_byte: This is a 8-bit field, a string of "char" fields specifies the profile name. Text information is coded using the character sets and methods defined in ETSI EN 300 468 [10], Annex A. The profile name shall be used to label a profile and shall be used in preference to any network name found in any broadcast information or CICAM NIT.

14.7.5.8 operator_search_start APDU

The Host sends this APDU to the CICAM to initiate a profile search sequence. On issuing the APDU then the Host relinquishes control and passes that control (MMI and tuning) to the CICAM. Within the context of a search then the CICAM shall control the user interface through the Application or High level MMI and may take control of the Host tuner in order to move within the Network to acquire profile information. When the CICAM has completed the search then it shall respond to the Host with a operator_search_status() APDU.

Table 14.50: operator_search_start APDU syntax

Syntax	No. of bits	Mnemonic
`operator_search_start() {`		
`   operator_search_start_tag`	24	uimsbf
`   length_field()`		
`   unattended_flag`	1	bslbf
`   service_type_loop_length`	7	uimsbf
`   for (i=0; i<N; i++) {`		
`      service_type`	8	uimsbf
`   }`		
`   delivery_capability_loop_length`	8	uimsbf
`   for (i=0; i<N; i++) {`		
`      delivery_capability_byte`	8	uimsbf
`   }`		
`   application_capability_loop_length`	8	uimsbf
`   for (i=0; i<N; i++) {`		
`      application_capability_byte;`	8	uimsbf
`   }`		
`}`		

operator_search_start_tag: See Table L.1 in Annex L.

unattended_flag: This 1-bit field specifies whether the Host is operating in an unattended mode (i.e. the user is not present). A value of "1" indicates that the user is not present and the Host is not able to service any interactive requests. When the Host is unattended then the CICAM shall refrain from using the High Level or Application MMI which cannot be serviced. A value of "0" indicates that the user is present and interactive displays may be utilised by the CICAM.

service_type_loop_length: This 7-bit field specifies the number of bytes immediately following this field defining the list of service_type’s the Host is able to present.

service_type: This 8-bit field specifies the type of service the Host is able to present. The service type values are defined by the service_type field in the service_descriptor described in EN 300 468 [10].

EXAMPLE:	`0x0102`	MPEG-2 television (0x01) and MPEG-1, Layer-II radio (0x02) services supported.
	`0x01020c`	MPEG-2 television (0x01), MPEG-1, Layer-II radio (0x02) and data

	services identified by the application_capability_byte field (0x0c) supported.
`0x0102030a16`	MPEG-2 television (0x01), MPEG-1, Layer-II radio (0x02), Teletext (0x03), Advanced codec radio (0x0a) and Advanced codec SD video (0x16) services supported
`0x0102030a101619`	MPEG-2 television (0x01), MPEG-1, Layer-II radio (0x02), Teletext (0x03), Advanced codec radio (0x0a), MHP (0x10), Advanced codec SD (0x16) and HD (0x19) video services supported.

delivery_capability_loop_length: This 8-bit field specifies the length in bytes of the delivery_capability loop.

delivery_capability_byte: This 8-bit field describes the delivery system(s) which are supported by the Host. Each delivery system supported by the Host is described by the EN 300 468 [10] delivery system descriptor descriptor_tag, any extended descriptor shall be preceded by the extended descriptor tag (`0x7F`). A Host may choose to advertise all supported delivery system descriptors or the delivery system descriptors applicable to the current operational mode of the Host.

EXAMPLE:	`0x43`	DVB-S. A Host with a satellite tuner only.
	`0x4379`	DVB-S and DVB-S2. A Host with a satellite tuner supporting S and S2.
	`0x5a7f0444`	DVB-T, DVB-T2 and DVB-C. A Host with a multi-functional hybrid terrestrial and cable tuner.

application_capability_loop_length: This 8-bit field specifies the length in bytes of the application_capability loop.

application_capability_byte: This 8-bit field describes zero or more applications that are supported by the Host. Each application natively supported by the Host is described by ETSI TS 101 162 [32] data_broadcast_id value of 16-bits, multiple application environments are advertised by including multiple 16-bit values corresponding to each supported application environment. A Host shall only advertise those applications types which it is able to present. The versions of the application profiles are not specified and there is no guarantee that a Host is able to support the version of any application environment.

EXAMPLE:	`0x00f0`	Host supports broadcast MHP
	`0x0106`	Host supports broadcast MHEG-5 profile
	`0x01230107`	Host supports broadcast HbbTV and Open TV

14.7.5.9 operator_search_cancel APDU

The Host sends this APDU to the CICAM to cancel a profile search sequence. On issuing the APDU then the Host requests the CICAM to terminate the current profile search and responds with a operator_search_status() APDU. The CICAM should attempt to stop the current profile search as quickly as possible, e.g. without waiting for any outstanding operator_tune_status().

Table 14.51: operator_search_cancel APDU syntax

Syntax	No. of bits	Mnemonic

`operator_search_cancel() {`
`   operator_search_cancel_tag`
`   length_field() = 0`
`}`
	
	24
		
		uimsbf

Where the fields are defined as follows:

operator_search_cancel_tag: See Table L.1 in Annex L.

14.7.5.10 operator_search_status APDU

This APDU is sent by the CICAM to inform the Host that the profile search has been completed or cancelled. The APDU content is identical to a operator_status() APDU with the exception of the APDU tag.

At the end of the operator search then the CICAM shall set the flag settings in the operator_status_body() to accurately reflect the current CICAM state e.g. the refresh_request_flag shall be cleared or initialised with the next search request. The Host shall process the operator_search_status() APDU as an indication that the search has terminated and shall additionally process all of the flags of the operator_status_body() to ascertain the current state of the operator profile. The CICAM shall not issue a operator_status() APDU in addition to a operator_search_status() APDU at the end of the search.

Table 14.52: operator_search_status APDU syntax

Syntax	No. of bits	Mnemonic
`operator_search_status() {`		
`   operator_search_status_tag`	24	uimsbf
`   length_field()`		
`   operator_status_body()`		
`}`		

Where the fields are defined as follows:

operator_search_status_tag: See Table L.1 in Annex L.

operator_status_body(): See Table 14.38 in section 14.7.5.3.

14.7.5.11 operator_tune APDU

The CICAM sends this APDU to the Host to request a tuning operation in the context of the operator_search_start() APDU under Host control when a profile search operation is requested. The APDU shall not be used for tuning outside of this context. The Host replies with a operator_tune_status() APDU when the tune operation has been completed. The APDU enables the CICAM to perform a direct tuning operation.

The Host is required to tune to the location specified by the delivery_system_descriptor field and to leave the transport stream of this location passing through the CICAM. Multiple locations may be specified by this APDU and the Host shall attempt to tune to each location in the order that they are presented in the APDU until the Host locates a valid data carrier signal when the search is terminated without processing any more of the locations and a operator_tune_status() APDU is returned to the CICAM identifying the multiplex that has been found.

The Host shall count the descriptors processed in the APDU descriptor loop and is required to return the descriptor number of the next unprocessed descriptor to the CICAM in the operator_tune_status() APDU on completion of the tune. The descriptor count commences from 0 which identifies the first descriptor of the loop.

The Host processing of the tune request is depicted in the following pseudo code:

```
// Initialise
tuner_information = not found;
desc_num = 0;

// Loop over all of the descriptors in the APDU
while (descriptor[desc_num] is present in descriptor loop) {
   current_location_info = descriptor [desc_num];
   desc_num++;
   while (descriptor [desc_num] present and additionally describes the current_location) {
      current_location_info += descriptor [desc_num];
      desc_num++;
   }

   // Check the tuning parameters quit if these descriptors are not supported and
   // the CICAM may then re-build the list excluding this delivery location.
   if (current_location_info has bad parameters OR is invalid OR is not supported) {
      current_location_info = descriptor information + error codes.
      break;
   }

   // All of the descriptors that identify this tuning location have been found.
```

```
    // Initiate a tune.
    tune_status = tune (current_location_info);

    // If a data carrier is found then save the tuner information and quit loop.
    if (tune_status == signal present AND signal viable AND is a data carrier) {
       tuner_information = current tuner location information;
       break;
    }
}

// If nothing has been found we have reached the end of the loop
if (tuner_information == not found) {
    desc_num = 0xff;
}

// Stay at the tuned location and send the tune status back to the CICAM.
send APDU operator_tune_status (desc_num, tuner_information)
```

The Host shall utilise any hardware assistance of the tuner to speed up the search and may skip over tuner locations without initiating an explicit tune operation if the tuner location is considered to have been previously searched by the hardware. This Host optimisation relies on the CICAM correctly grouping similar tuning requests such that the Host is able to identify and trivially discard these locations.

Table 14.53: operator_tune APDU syntax

Syntax	No. of bits	Mnemonic
`operator_tune () {`		
`   operator_tune_ tag`	24	uimsbf
`   length_field()`		
`   reserved`	4	bslbf
`   descriptor_loop_length`	12	uimsbf
`   for (i=0; i<N; i++) {`		
`      descriptor()`	8	uimsbf
`   }`		
`}`		

Where the fields are defined as follows:

operator_tune_tag: See Table L.1 in Annex L.

length_field(): The APDU shall be limited to a maximum of 2048 bytes which allows 157 system_delivery_descriptors with a length of 13 bytes.

descriptor_loop_length: This 12-bit field specifies the length in bytes of the descriptor() loop that follows this field.

descriptor(): A loop of delivery system descriptors that describes the location of the CICAM tune request. The descriptor loop shall contain one or more delivery system descriptors which are all from the same delivery system. The CICAM shall produce a complete and optimal tuner parameter set in the delivery descriptor i.e. frequencies shall be grouped etc. The Host shall attempt to tune to each specified location and locate a viable signal with appropriate data carrier indication, as soon as the Host locates a carrier location, or the end of the descriptor list is reached, then the tune operation is stopped and the status is reported to the CICAM with a operator_tune_status() APDU.

14.7.5.12 operator_tune_status APDU

The Host sends this APDU to the CICAM in response to a operator_tune () or APDU operation after the Host has tuned to the requested location.

Table 14.54: operator_tune_status APDU syntax

Syntax	No. of bits	Mnemonic
`operator_tune_status() {`		
`   operator_tune_status_tag`	24	uimsbf
`   length_field()`		
`   descriptor_number`	8	uimsbf
`   signal_strength`	8	uimsbf
`   signal_quality`	8	uimsbf
`   status`	4	uimsbf
`   descriptor_loop_length`	12	uimsbf
`   for (i=0; i<N; i++) {`		
`      descriptor()`	8	uimsbf
`   }`		
`}`		

Where the fields are defined as follows:

operator_tune_status_tag: See Table L.1 in Annex L.

descriptor_number: This 8-bit field identifies the next unprocessed descriptor number in the operator_tune() APDU which has not been processed by the Host, a value of 0xff indicates that the Host has reached the end of the table. The descriptors are counted from 0, the descriptor_number handling is described in the introductory text for the operator_tune() APDU.

Table 14.55: status values

Value	Description
0	The tuning operation was successful and the Host has successfully tuned to the requested location; the tuner is locked and a digital signal is available. The transport stream shall be passing through the CICAM. The descriptor_number field shall be the next unprocessed descriptor number. The signal_strength field shall be non-zero. The signal_quality_field shall be non-zero. The descriptors() field shall contain the delivery_system_descriptor(s) that describe the current fully qualified tuning location. This may be slightly different from the original CICAM delivery descriptor if the information has been corrected by the Host tuner information.
1	The delivery system descriptor is not supported by the Host. The descriptor_number field shall be the next unprocessed descriptor number. The signal_strength field shall be 0. The signal_quality_field shall be 0. The descriptor_loop shall contain the descriptor(s) that are not supported
2	The delivery system descriptor parameters are invalid. The descriptor_number field shall be the next unprocessed descriptor number. The signal_strength field shall be 0. The signal_quality_field shall be 0. The descriptor_loop shall contain the descriptor(s) that are invalid.
3	The tuning operation failed. The Host has successfully tuned to the requested location and no signal is present. The descriptor_number field shall be `0xff` as the descriptor list will have been exhausted. The signal_strength field shall be 0. The signal_quality_field shall be 0. The descriptor_loop_length shall be 0.
4-15	Reserved for future use.

Where the Host reports an unknown or illegal delivery_system_descriptor then the Host shall stop the search and return the erroneous system_delivery_descriptor to the CICAM. The CICAM may then re-build the tuning list with a new set of tuning locations which shall exclude descriptors of a similar type if the search is to continue.

signal_strength: This 8-bit field specifies the signal strength as a percentage value in the range 0 to 100, where 0 represents no signal and 100 is a full strength signal. Note that an indication of signal strength is not a measure of signal quality and the signal_quality field shall be interrogated to assess the signal quality.

signal_quality: This 8-bit field specifies the quality of the signal as a percentage value in the range 0 to 100, where 0 represents a signal with no viable quality and 100 is a perfect signal.

status: This 4-bit is the status of the tune request. The status values are defined in Table 14.54.

descriptor_loop_length: This 12-bit field specifies the length in bytes of the descriptor() loop that follows this field.

descriptor(): A loop of delivery system descriptors that describes the currently tuned location of the Host that is passing through the CICAM or descriptors causing an error. The descriptor loop shall contain a single delivery system location only, which may be described by one or more descriptors.

14.7.5.13 operator_entitlement_ack APDU

The Host sends this APDU to the CICAM to acknowledge that any change in the entitlement has been processed by the Host, which may have resulted in a change in the logical channel list etc. The CICAM shall send a operator_status() APDU in response to the command with the entitlement_change_flag field cleared.

Table 14.56: operator_entitlement_ack APDU syntax

Syntax	No. of bits	Mnemonic
`operator_entitlement_ack() {`		
`   operator_entitlement_ack_tag`	24	uimsbf
`   length_field()`		
`}`		

Where the fields are defined as follows:

operator_entitlement_ack_tag: See Table L.1 in Annex L.

14.7.5.14 operator_exit APDU

The Host sends this APDU to the CICAM to inform the CICAM that the Host has left a profile_type=1 environment and is operating in a different channel list or context. Any transport stream passing through the CICAM may not originate from the operator profile environment until such time that the Host returns to the operator environment signified with a operator_status_req() APDU.

Table 14.57: operator_exit APDU syntax

Syntax	No. of bits	Mnemonic
`operator_exit() {`		
`   operator_exit_tag`	24	uimsbf
`   length_field()`		
`}`		

Where the fields are defined as follows:

operator_exit_tag: See Table L.1 in Annex L.

Annex A (normative): Random Number Generator

A.1 Random Number Generator Definition

The random number generator is used to generate following random numbers in this specification:

Table A.1: random numbers

Field	Length (bits)	Comment
DHX	2048	Diffie Hellman exponent "x"
DHY	2048	Diffie Hellman exponent "y"
Kp	256	CICAM's key precursor to Host for CCK
Ns_Host	64	Host's challenge to CICAM for SAC
Ns_Module	64	CICAM's challenge to CICAM for SAC
Auth_nonce	256	nonce in authentication protocol

The random number generator shall adhere to either of the following:

1) The PRNG described in SCTE 41 [5], section 4.6.

NOTE: The uniquely generated seed value is prng_seed in this specification. Unless explicitly noted otherwise, the seed values shall be treated as highly confidential as described in the CI Plus Licensee Specification [33]. It is advised that SHA implementations adhere to the SHS validation list, refer to SHS Validation List [11].

2) An AES based algorithm inspired by ANSI X 9.31 [12] illustrated in Figure A.1 and described below:

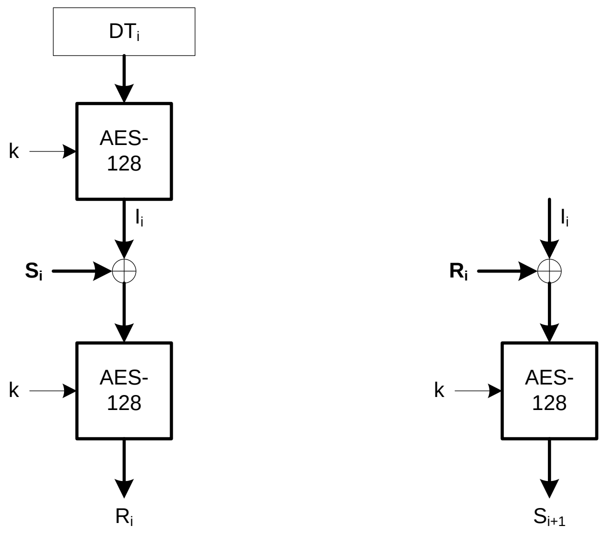

Figure A.1: AES Based PRNG Example

In Figure A.1, k is a 128-bit constant value, DT_i is a 128 bit value that is updated on each iteration (e.g. date/time vector or monotonic counter) and s is a seed value. The CICAM and the Host shall each have a uniquely generated seed value S.

NOTE: Unless explicitly noted otherwise, the values k and S shall be treated as highly confidential as described in the license agreement.

The combination of fixed value k and initial seed value S_0 shall be unpredictable and unique per licensed product. The seed generator for S_0 shall comply with SP800-22b [36]. If there is no seed generator for S_0, then S shall be maintained in a non-volatile register, in which case a source of entropy is not required. Additionally DT must be ensured to be non-repeating only until the next time the licensed product is re-started.

The 128 bit random values R_i (i=0,1….) are generated as follows:

$$I_i = E_{AES-128}\{k\}(DT_i) \qquad \text{Eq. A.1}$$

$$R_i = E_{AES-128}\{k\}(I_i \oplus S_i) \qquad \text{Eq. A.2}$$

$$S_{i+1} = E_{AES-128}\{k\}(I_i \oplus R_i) \qquad \text{Eq. A.3}$$

For random numbers that are not an exact multiple of the AES block size the last AES block is truncated LSB to the length specified in Table A.1.

Annex B (normative): Device ID Protocol

B.1 Device ID Specification

Note: The Device ID format is not defined in this document and may be obtained from the CI Plus Licensee Specification [33].

Annex C (normative): Checksum Algorithms

C.1 Checksum Algorithms

This section is deprecated. Communication between the CICAM and the service operator is not within scope of this specification.

Annex D (normative): SD and HD capabilities

D.1 SD and HD Definitions

In this specification the definition for an SD device or an HD device is not specified. A HD device is a device that can process and decode HD signals passed through the Common Interface. This could mean for example that the HD device conforms to the HD TV logo of the EICTA. Several countries or continents have different definitions of logo programs, other logo definitions may apply to conform to the capability to process HD signals.

Annex E (normative): Clarification of DVB-CI Use Cases

E.1 Initialisation

E.1.1 Specification

PCMCIA standard defines in volume 2, section 4.4.6 that the Host has to wait 5s for the ready signal to be set. As a reminder, a specification extract is shown below in italic.

A card that requires more than 20 ms for internal initialization before access shall negate READY until it is ready for initial access, a period of time which is not to exceed five seconds following the time at which the RESET signal is negated (or if no RESET is implemented, VCC is stable).

E.1.2 Requirement

The Host shall explicitly check for the READY signal until it is set by the module or until a timeout of 5s has expired.

E.2 CA_PMT in Clear

E.2.1 Specification

DVB-CI specifications define in the "Guidelines for Implementation and Use of the Common Interface for DVB Decoder Applications (R206-001:1998)" [24] that the Host has to send the ca_pmt object even when the selected programme is in the clear. As a reminder, the specification extract is shown below in italic.

CA_PMT is sent by the Host even when a programme in clear is selected by the user (typically a programme for which there are no CA_descriptor in the PMT). In this case, the Host shall issue a CA_PMT without any CA_descriptors (i.e.: CA_PMT with program_info_length == 0 and ES_info_length == 0).

E.2.2 Requirement

Hosts shall send the CA_PMT even when selected programme is in the clear (FTA).

E.3 CA_PMT Clear to Scrambled / Scrambled to Clear

E.3.1 Specification

It has been defined in Guidelines for Implementation and Use of the Common Interface for DVB Decoder Applications (R206-001 [24]; section 9.5.6.2):

Switch from scrambled to unscrambled and vice-versa.

- When one programme switches from scrambled to clear, there are several possibilities:

    1. This change is not signalled in the PMT, but only in the TSC field of the packet header or in the PES_SC field of the PES header. In this case, there is no reason for the Host to send a new CA_PMT to remove the programme from the list. The programme remains selected and the Host keeps on sending CA_PMT when the version_number of the PMT evolves.

    2. This change results in a modification of the PMT. In this case, a CA_PMT is issued by the Host.

- When one programme switches from clear to scrambled, there are several possibilities:
    1. This change is not signalled in the PMT, but only in the TSC field of the packet header or in the PES_SC field of the PES header. In this case, the Host does not send a new CA_PMT. The CA application must detect that switch.
    2. This change results in a modification of the PMT (e.g.: CA_descriptors are removed). In this case, a CA_PMT is issued by the Host.

NOTE: In both cases it is recommended that the CA application attempt to create a user dialogue to inform the user.

E.3.2 Recommendation

The CA application shall not create a user dialogue when not necessary.

E.4 PMT Update and New CA_PMT

E.4.1 Specification

It has been described in R206-001 [24] (section 9.5.5.1) that:

If the Host wants to update a CA_PMT of one of the programmes of the list it sends a CA_PMT with ca_pmt_list_management == update. This happens when the Host detects that the version_number or the current_next_indicator of the PMT has changed. The CA application in the module then checks whether this change has consequences in the CA operations or not. It also happens when the list of elementary streams of a selected programme changes (e.g.: the user has selected another language). In this case, the Host has to resend the whole list of elementary streams of that updated programme.

E.4.2 Recommendation

When the PMT version is changed, the CA_PMT_Update object shall be used in order to avoid a black screen.

E.5 Spontaneous MMI

E.5.1 Specification

It has been defined in Guidelines for Implementation and Use of the Common Interface for DVB Decoder Applications R206-001 [24] (section 9.5.6.1):

CA applications currently not active for any current programmes selected by the user may create MMI sessions for user dialogue, for example to warn of an impending PPV event on another programme previously purchased by the user.

E.5.2 Resolution

Display all MMI messages sent by the CICAM. Do not allow automatic MMI closing, allow the user to close the MMI.

The CICAM shall deal with situations when the Host is busy and cannot service the CICAM's request to display a spontaneous MMI message. In this case, the Host returns an open_session_response object with session_status F3 (resource busy) when the module tries to open the MMI session. The module may retry opening an MMI session until the Host is able to open the session but it must take into account that some messages become obsolete when the current service is changed (e.g. a spontaneous MMI message saying "you are not allowed to watch this programme").

E.6 Transport Stream to CICAM

E.6.1 Specification

DVB-CI specifications define in EN 50221 [7] (section 5.4.3) that a transport stream connection has to be established if the module is found as DVB conformant. As a reminder, a specification extract is shown below in italic.

When a module is not connected the Transport Stream Interface shall bypass the module, and the Command Interface to that module shall be inactive. On connection of a module, the Host shall initiate a low-level initialisation sequence with the module. This will carry out whatever low-level connection establishment procedures are used by the particular Physical Layer, and then establish that the module is a conformant DVB module. If successfully completed, the Host shall establish the Transport Stream connection by inserting the module into the Host's Transport Stream path. It is acceptable that some Transport Stream data is lost during this process.

E.6.2 Resolution

Always send the transport stream to the CICAM when it has been initialized.

E.7 Profile Reply

E.7.1 Specification

DVB-CI specifications define in EN 50221 [7] (section 8.4.1.1) that when a profile enquiry is sent by Host or module, a profile reply has to be sent by module or Host. As a reminder, a specification extract is shown below in italic.

When a module is plugged in or the Host is powered up one or perhaps two transport connections are created to the module, serving an application and/or a resource provider.

The first thing an application or resource provider does is to request a session to the Resource Manager resource, which is invariably created as the Resource Manager has no session limit. The Resource Manager then sends a Profile Enquiry to the application or resource provider which responds with a Profile Reply listing the resources it provides (if any). The application or resource provider must now wait for a Profile Change object. Whilst waiting for Profile Change it can neither create sessions to other resources nor can it accept sessions from other applications, returning a reply of 'resource non-existent' or 'resource exists but unavailable' as appropriate.

E.7.2 Recommendation

Reply to profile enquiry object.

E.8 Operation on a Shared Bus

E.8.1 Background

In many setups, a PCMCIA slot shares address and data lines with other devices such as a second PCMCIA slot or a flash memory chip. Each device will have its own Chip Enable line that is negated when the current access refers to this particular device. For a PCMCIA slot, this Chip Enable line is connected to the CICAM's Chip Enable #1 (CE1#) pin, Chip Enable #2 (CE2#) is ignored.

E.8.2 Recommendation

The CICAM shall check its CE1# pin and make sure it is low before processing any data from the bus. When Chip Enable #1 (CE1#) pin is high, the CICAM shall not send any data or change its internal state based on signals from the bus.

E.9 Maximum APDU Size

EN 50221 [7] section 7 states:

The objects are coded by means of a general Tag-Length-Value coding derived from that used to code ASN.1 syntax.

And later in this section:

Any value field length up to 65535 can thus be encoded by three bytes.

ASN.1 Basic Encoding Rules (BER) allow for the encoding of lengths using more than three bytes. Using the long form a length value may occupy a maximum of 127 bytes giving an encoded length which is 128 bytes long that may represent a length of greater than 10^{305} bytes.

The second fragment of EN 50221 text is in fact an example of how one can use three bytes to encode a length. One could equally give the example of using four bytes which could encode a length of up to 16 777 216 bytes.

E.10 Host Control resource

E.10.1 Specification

The Host Control resource 00 20 00 4x is mandatory for a CI Plus Host to support, it allows the CICAM tune away to another service for CAM upgrade as specified in section 14.3 and support Video on Demand (VoD) type applications as specified in section 14.6.1.

E.10.2 Recommendation

Host Control shall only be used when the User interacts with the CICAM allowing the CICAM to tune away to another service (i.e. CAM upgrade and MMI).

E.11 CA-PMT Reply

E.11.1 Specification

DVB-CI specifications define in EN 50221 [7] (section 8.4.3.5). This object is always sent by the application to the Host after reception of a ca_pmt object with the ca_pmt_cmd_id set to 'query'. It may also be sent after reception of a ca_pmt object with the ca_pmt_cmd_id set to 'ok_mmi' in order to indicate to the Host the result of the MMI dialogue. e.g. 'descrambling_possible'; if the user has purchased the content, or 'descrambling not possible (because no entitlement)'; if the user has not purchased the content.

E.11.2 Recommendation

The CICAM shall always send a ca_pmt_reply when the ca_pmt object is sent with the ca_pmt_cmd_id set to 'query' and shall not start descrambling until the Host sends a ca_pmt with ca_pmt_cmd_id set to 'ok_descrambling'.

E.12 CC and CP Resource

E.12.1 Specification

The CC resource in CI plus offers enhanced Content Control using the URI as defined in section [5.7], the extensions in DVB TS 101 699 [8], section 6.6, offers the CP resource for Content Control. Both of these resources are used to control the distribution of content and shall never be opened at the same time.

E.12.2 Recommendation

The CICAM shall not open a session to both the CC resource and the CP resource at the same time. The Host shall reply 'session not opened, resource exists but unavailable (0xf1)'

E.13 Physical Requirements

E.13.1 Data Interface

EN 50221 [7] section 5.4.2.5 states:

All interfaces shall support a data rate of at least 58 Mb/s averaged over the period between the sync bytes of successive transport packets.

This specification increases this data rate requirement. CICAMs conforming to this specification shall support 96 Mb/s. Hosts conforming to this specification shall have sufficient bandwidth for their network interfaces. Refer to section 11.1.3 for further information on the CI Plus data rate requirements.

E.13.2 Command Interface

EN 50221 [7] section 5.4.2 states:

The Command Interface shall transfer commands as defined by the appropriate Transport Layer part of this specification in both directions. The data rate supported in each direction shall be at least 3.5 Megabits/sec.

This requirement shall still hold for this specification.

E.14 Low-Speed Communication comms reply object

E.14.1 Specification

In section 8.7.1.5 of EN 50221 [7] the return_value in the description of the Comms Reply object coding is categorised by the mnemonic “uimsbf”. However, in the text of the specification is states that return_value contains negative values to indicate an error and specifically a value of -1 for non-specific errors.

E.14.2 Recommendation

It is recommended that the eight bit return_value field in a comms_reply APDU should be interpreted as a signed “two’s complement” value.

E.15 High-Level MMI Text Object Coding

E.15.1 Specification

Section 8.6.5.1 of EN 50221 [7] states that Text information is coded using the character sets and methods described in EN 300 468 [10] and that text sent by the application may include such control characters as are defined by [10] to provide indication of how the display is to be presented.

The Host may render any text object without a preceding character table selection byte as Table 00 – Latin Alphabet as shown in EN 300 468 [10] Annex A1, Figure A.1, which may not be what the CICAM wants.

E.15.2 Recommendation

It is recommended that the CICAM always includes the preceding character table selection byte to ensure that the correct character table is used by the Host. See EN 300 468 [10] Annex A.

E.16 DVB Host Control Tune Object

E.16.1 Specification

Section 8.5.1.1 of EN 50221 [7] describes how the Host Control resource allows a CICAM to instruct the Host to tune to another location. The new location is defined by a combination of network_id, original_network_id, transport_stream_id and service_id. The behaviour of the receiver when some of these values are zero and any method of setting a wild card value is not described.

E.16.2 Recommendation

It is recommended that the network_id shall not be used. A value of zero (0) shall be considered a wild card or don’t care value. It is recommended that there shall be only two valid combinations of tuning parameters and wild card values. The valid combinations are shown in Table E.1.

Table E.1: Valid combinations of DVB Host Control Tune object parameters

network_id	transport_stream_id	original_network_id	service_id	Action
0	TSID	ONID	SID	Tune to a service, service must exist
0	TSID	ONID	0	Tune to a multiplex, Host does not select service, a ca_pmt will not be sent by the Host.
Note: It is assumed that the receiver has the desired location already referenced in its service list so that the actual tuning parameters may be found. The Host service list may only contain services interpreted by the Host i.e. Television and Radio services only.				

E.17 Conditional Access Support

E.17.1 Specification

EN 50221 [7], section 8.4.3.4 states:

The CA PMT contains all of the CA_descriptors of the selected programme. If several programmes are selected, the Host sends several CA PMT objects to the application. The CA_PMT only contains CA_descriptors. All other descriptors must be removed from the PMT by the Host.

R206-001:1998 [24], section 9.5.5 Description of the feature, states:

If simulcrypt techniques are in use then an entry for one programme in the PMT may contain CA descriptors for more than one CA ID. In this case the CA_PMT object will contain all the CA descriptors in use, that is, the receiver will not attempt to select on the basis of the CA ID(s) advertised by a particular CA application.

E.17.2 Host Requirement

On selection of a service to be descrambled, the Host is required to process ALL CA_descriptors appearing in both the first descriptor loop (Program Stream Loop) and second descriptor loops (Elementary Stream Loop) of the PMT. Multiple CA_descriptors with different CA_system_ID's may be present in either or both loops.

The Host shall pass all CA_descriptors appearing in the PMT to the CICAM in the ca_pmt using the corresponding program level and/or elementary stream level loops, with the exception that the Host may optionally discard any CA_descriptors that do not match any of the CA_system_id's advertised by the CICAM in the ca_info() APDU.

The Host is recommended to, but not obliged to, to maintain the same CA_descriptor and Elementary Stream ordering of the PMT in the ca_pmt.

E.17.3 CICAM Requirement

The CICAM shall include all CA_system_IDs that it supports in the ca_info() APDU when requested by the Host.

The CICAM shall be robust in the presence of multiple CA_descriptors which may appear in any order. The CICAM shall be robust in the presence of CA_descriptors that do match any CA_system_id(s) of the CICAM and shall ignore the CA_descriptors if they are not supported by the CICAM.

The CICAM shall be robust with respect to the order of Elementary Streams and shall be able to descramble correctly signalled and CA supported elementary streams irrespective of their order in the ca_pmt.

E.18 Resource Version Handling

E.18.1 Specification

En 50221 [7], section 8.4.1.1 Resource Management Protocol states:

When it has asked for profiles on all transport connections and received Profile Replies the host builds a list of available resources. Where two or more resources match in both class and type the host keeps the one with the highest version number in its list.

E.18.2 Requirement

Where a Host supports multiple versions of the same resource then the highest version number of the resource is reported by the Host ONLY. Lower versions of the resource shall be supported by the Host but are not reported in the profile_reply() APDU.

The CICAM may request a lower version of the resource than reported by the Host which is discussed in section E.19.

E.19 Open Session Request

E.19.1 Specification

En 50221 [7], section 7.2.6.1 Open Session Request states:

This object is issued by the module to the host in order to request the opening of a session between the module and one resource provided either by the host or by a module. The resource_identifier must match in both class and type a resource that the host has in its list of available resources. If the version field of the supplied resource identifier is zero, then the host will use the current version in its list. If the version number in the request is less than or equal to the current version number in the host's list then the current version is used. If the requested version number is higher than the version in the host's list, then the host will refuse the request with the appropriate return code.

E.19.2 Specification Correction

In a change to the EN 50221 [7] specification then the paragraph is revised as follows:

This object is issued by the module to the host in order to request the opening of a session between the module and one resource provided either by the host or by a module. The resource_identifier must match in both class and type a resource that the host has in its list of available resources. If the version field of the supplied resource identifier is zero, then the host will use the current version in its list. ***If the version number in the request is equal to the current version number in the host's list then the current version is used. If the version number in the request is less than the current version number in the host's list then the Host shall use the version number requested by the CICAM.*** *If the requested version number is higher than the version in the host's list, then the host will refuse the request with the appropriate return code.*

This requires that the Host shall always support all lower versions of an advertised resource.

E.19.3 Recommendation

The CICAM is recommended not to use a resource identifier version field value of zero and shall specify the highest version number of the resource that is supported by the CICAM.

The CICAM shall never request a version number that it is not able to fully support and shall not return the version number advertised by the Host unless it is fully supported.

E.20 CA PMT Provision

E.20.1 Background

Omission of the Host to send a CA PMT on each and every service change causes issues on the CICAM including:

1) Pay Per Time (PPT) is not counted correctly (as no notification of service change),
2) Parental control is not always enforced when re-entering a protected service.
3) Application MMI is not restarted.

E.20.2 Specification

EN 50221 [7] 8.4.3.3 CA_PMT states:

The host may decide to send the CA PMT to all connected CA applications or preferably only to the applications supporting the same CA_system_id value as the value given in the CA_descriptor of the selected elementary streams (ES).

EN 50221 [7], section 8.4.3.4 states:

The receiver sends a new CA PMT or a new list of CA PMT to the Application when:
• the user selects another programme
• a 'tune' command selects another service (see 8.5.1.1)
• the version_number changes
• the current_next_indicator changes

E.20.3 Host Recommendation

The Host should send a new CA PMT on every service change and on change of the version_number or current_next_indicator to all connected CA applications that are actively descrambling.

E.21 CICAM evaluation of CA_descriptors

E.21.1 Specification

EN50221:1997 [7], section 8.4.3.4 CA_PMT states:

The CA_descriptor(s) at elementary_stream level is (are) valid for the elementary_stream only. If, for one elementary_stream, CA_descriptor(s) exist at programme level and at elementary_stream level, only the CA_descriptor(s) at elementary_stream level are taken into account.

ITU-T J.96:2001 [39], section 6.2.3 Modes 2 and 3 states:

One CA_descriptor may be present in PMT at program level, giving an ECM_pid for all components of the program. Additional CA_descriptors may be present at component level. In this case, it supersedes the value which has been specified at program level, only for the concerned component.

E.21.2 CICAM Requirement

Within the ca_pmt() APDU; CA_descriptors that are available at the component level (ES) for a given component that may be descrambled by the CICAM then any CA_descriptors at the program level shall be ignored for this component.

E.22 CA Support session closing behaviour

E.22.1 Specification

EN-50221:1997 [7], section 8.4.3 Conditional Access Support states:

The session is then kept open for periodic operation of the protocol associated with the CA PMT and CA PMT Reply objects.

R206-001:1998 [24], - 9.5.5.1. General rules, and 9.5.6.1. General rules states:

In case of repetitive errors, it may also close the CA support session and re-open it.

If the session to the CA support resource closes down, the CA application should attempt to open another session.

E.22.2 Host Requirement

The Host shall support the closing and reopening of the CA support session.

E.22.3 CICAM Requirement

If the current session of the CA support resource is closed, the CICAM shall try to reopen it.

E.23 ca_pmt commands

E.23.1 Specification

EN50221 [7] lists several ca_pmt_cmd_id values. The influence the way a ca_pmt from the host is interpreted by the CICAM.

E.23.2 CICAM Requirement

A CICAM shall support all ca_pmt_cmd_id values listed in EN 50221 [7], section 8.4.3.4. When the CICAM receives a ca_pmt with ca_pmt_cmd_id set to *query* for a program or elementary stream, the CICAM shall send a ca_pmt_reply to the host and shall not start descrambling and shall not display any MMI.

E.24 Open Session Response

E.24.1 Specification

The host sends an open_session_response() SPDU in response to an open_session_request() by the CICAM.

The open_session_response() contains a status value according to EN 50221 [7], table 7.

E.24.2 CICAM Requirement

The CICAM shall process all status values in EN 50221 [7], table 7.

A CICAM shall be robust if the Host returns the status "session not opened, resource busy". In this case, it is recommended that the CICAM retry opening the session until the Host is able to service the request.

E.25 Character Coding

E.25.1 Specification

With respect to EN50221 [7] specification, section 8.6.2.3 Display Reply and a change to the R206-001[24], section 9.8.5 Output character codes.

E.25.2 Host Requirement

The Host shall respond to a display_control() APDU of types get_display_character_table_list (02) and get_input_character_table_list (03).

E.25.3 Host Recommendation

A Host is recommended to reply with all of the character codes required by the base profile of the country or region or network for which the Host is currently configured. The Host may optionally include all other character code tables that are supported by the High Level MMI which might not be required for the Hosts current configuration.

In the case where the network requires only the default character set (ISO/IEC 6937) then the Host shall respond to the display_control() APDU request with a display_reply() APDU and the character_table_byte loop shall be zero length indicating that the default character set is supported.

Example:

Country/Region	**character_table_byte**	**Character Tables**
France, Germany, …	`{0x01}`	ISO/IEC 6937 and ISO/IEC 8859-9
United Kingdom	`{}`	ISO/IEC 6937 only
Nordig	`{0x01, 0x05, 0x10, 0x00, 0x01, 0x10, 0x00, 0x04, 0x10, 0x00, 0x0f}`	ISO/IEC 6937, ISO/IEC 8859-9, ISO/IEC 8859-9, ISO/IEC 8859-1, ISO/IEC 8859-4, ISO/IEC 8859-15

Annex F (normative) Error Code Definition and Handling

F.1 Error Codes

Table F.1: ARC Error Codes

Error Code$^+$	Error condition	Error detected by	Host action	CI Plus Module action	Comments
00	None	N/A	None	None	
01	Module Revoked	CICAM	None	CICAM goes to pass-through mode (note 1)	
02	Host Revoked	CICAM		- CICAM goes to pass-through mode (Note 1) - a revocation notification message is displayed.	
03	SAC Failed	CICAM/Host		- If EMI>0 CICAM goes to pass-through mode, otherwise switches to DVB CI mode - a response error notification message is displayed.	The service operator and CAS may choose under what conditions to descramble when operating in DVB CI mode.
04	CCK Failed	CICAM/Host		- If EMI>0 CICAM goes to pass-through mode, otherwise switches to DVB CI mode - a response error notification message is displayed.	The service operator and CAS may choose under what conditions to descramble when operating in DVB CI mode.
05	CICAM Firmware Upgrade Failed - Bootloader	CICAM	None	Recommended: - CICAM retries the download 2 times - a response error notification message is displayed.	
06	CICAM Firmware Upgrade Failed - Location Error	CICAM	None	Recommended: - CICAM retries the download 2 times. - a response error notification message is displayed.	

Error Code+	Error condition	Error detected by	Host action	CI Plus Module action	Comments
07	CICAM Firmware Upgrade Failed - Image Signature Error	CICAM	None	Recommended: - CICAM retries the download 2 times - a response error notification message is displayed.	
08	Authentication Failed - Retries Exhausted	CICAM	None	CICAM goes to pass-through mode	
09	Authentication Failed - Signature Verification Failed	CICAM/Host	Host stops the CICAM.	CICAM goes to pass-through mode	
10	Authentication Failed - Auth Key Verification Failed	CICAM/Host	Host stops the CICAM.	CICAM goes to pass-through mode	
11	Authentication Failed - Key Computation Failed	CICAM/Host	Host stops the CICAM.	CICAM goes to pass-through mode	
12	Authentication Failed - DH Failed	CICAM/Host	Host stops the CICAM.	CICAM goes to pass-through mode	
13	CICAM Certificate Invalid - Syntax Incorrect	Host	Host stops the CICAM.	None	
14	CICAM Certificate Invalid - Expired	Host	Host goes to DVB-CI mode. (Note 2)	None	
15	CICAM Certificate Invalid - Signature Verification Failed	Host	Host stops the CICAM.	None	
16	Host Certificate Invalid - Syntax Incorrect	CICAM	None	- CICAM goes to pass-through mode - a response error notification message is displayed.	
17	Host Certificate Invalid - Expired	CICAM	None	- CICAM goes to DVB-CI mode (Note 3) - a response error notification message is displayed.	
18	Host Certificate Invalid - Signature Verification Failed	CICAM	None	- CICAM goes to pass-through mode - a response error notification message is displayed.	
19	Service Operator Certificate Invalid - Syntax Incorrect	CICAM	None	- CICAM goes to DVB-CI mode (Note 3) - a response error notification message is displayed.	
20	Service Operator Certificate Invalid - Expired	CICAM	None	- CICAM goes to DVB-CI mode (Note 3) - a response error notification message is displayed.	
21	Service Operator Certificate Invalid - Signature Verification Failed	CICAM	None	- CICAM goes to DVB-CI mode (Note 3) - a response error notification message is displayed.	

Error Code[+]	Error condition	Error detected by	Host action	CI Plus Module action	Comments
22	CICAM Requires Update	CICAM	None	- CICAM goes to pass-through mode - a response error notification message is displayed.	
23 – 127	Reserved for CI Plus	CICAM	None	- a response error notification message is displayed.	
128 – 255	Private Use for Service Operator	CICAM	None	- a response error notification message is displayed.	
NOTE: 1: The CICAM relays the transport stream unaltered and does not descramble any services (CI Plus or DVB-CI services). 2: The Host behaves like a DVB-CI compliant Host. 3: The CICAM descrambles only services that require no CI Plus protection (DVB-CI fallback mode)					

Annex G (normative): PCMCIA Optimizations

The PC-Card based physical layer for DVB-CI is described in EN 50221 [7], annex A. In CI Plus, more data has to be transferred over the command interface than in DVB-CI. The following section defines changes to the DVB-CI physical layer in order to increase throughput on the command interface. Please note that these changes do not affect the transport stream interface.

G.1 Buffer Size

The buffer size for sending and receiving data on the command interface is negotiated during initialisation of the command interface, see EN 50221 [7], annex A.2.2.1.1.

A CI Plus compliant device shall provide a minimum buffer size of 1024 bytes but it can be up to 65535 bytes.

G.2 Interrupt Mode

The CI Plus uses interrupt driven operation on the command interface outlined in R206-001 [24]. A CICAM may assert IREQ# when it has data to send or when it is ready to receive data from the Host, i.e. when it sets the DA bit or the FR bit in the status register.

Two additional bits are defined in the command register to control the occasions when the CICAM actually triggers an interrupt.

Table G.1: Command Register

7	6	5	4	3	2	1	0
DAIE	FRIE	R	R	RS	SR	SW	HC

Table G.2: Interrupt Enable Bits

DAIE	when this bit is set, the module asserts IREQ# each time it has data to send
FRIE	when this bit is set, the module asserts IREQ# each time it is free to receive data

The default values at start-up are 0 for both bits. Before setting DAIE or FRIE to 1, the Host shall ensure that the CICAM is CI Plus compliant.

A CI Plus compliant CAM shall announce interrupt support in the Card Information Structure (CIS). The CIS contains one CISTPL_CFTABLE_ENTRY for each interface the PC-Card supports. A CI Plus CAM uses the same PC card custom interface as a DVB-CI CAM and therefore the same CISTPL_CFTABLE_ENTRY. Table G.3 explains the changes in the CISTPL_CFTABLE_ENTRY to indicate interrupt support. See PC Card Standard Volume 4 [30], section 3.3.2 for a complete explanation of the CFTABLE_ENTRY and its components.

Table G.3: Changes to CISTPL_CFTABLE_ENTRY

TPCE_FS (feature selection byte)	set bit 4 (IRQ) to 1 this indicates that a TPCE_IR entry is present
TPCE_IR	only one byte is used for the TPCE_IR set bit 5 (Level) to 1, all other bits to 0

The CICAM uses level-triggered interrupts. To signal an interrupt, the CICAM asserts the IREQ# line by setting it to low. The line is kept asserted until the Host acknowledges that the interrupt is being serviced. The acknowledgement is given implicitly by a read or write operation on the bus. Pulsed interrupts are not supported in CI Plus.

When the Host receives an interrupt from the CICAM, it checks its settings for DAIE and FRIE and the CICAM's DA and FR bits in the status register in order to determine the cause of the interrupt. The Host must be prepared to find both FR and DA set to 0. This may occur if the CICAM signalled that it is free to receive data but it has become busy and reclaimed the free buffer before the interrupt was serviced.

If the interrupt was triggered because the CICAM has data available, the Host performs a module to Host transfer as described in EN 50221 [7], annex A.2.2.1.3. If the interrupt signals that the CICAM is free to receive data, the Host may perform a Host to module transfer according to EN 50221 [7], annex A.2.2.1.2.

In interrupt mode if the CICAM requests a reset (i.e. setting the IIR bit in the status register) it can assert the FR bit in the status register to cause an interrupt and assert the IREQ# signal.

Support for interrupt handling is mandatory in both the Host and CICAM. See R206-001 [24], section 4.3.3 for further information about interrupt driven operation.

A CI Plus module shall always be capable of operating with polling operation even though interrupt support is mandatory. The module will raise an interrupt and wait for the Host to initiate a data transfer; the Host may poll regularly without checking for an interrupt, the actual transfer of data is not changed.

G.3 CI Plus Compatibility Identification

A CI Plus CICAM (and optionally any other CICAM that is not necessarily CI Plus but is able to operate correctly in a CI Plus Host) shall declare CI Plus compatibility in the CIS information. A CICAM shall declare CI Plus compatibility in the CISTPL_VERS_1 tuple. Within the TPLLV1_INFO a CI Plus compliant CICAM shall include a CI Plus compatibility string declaration in one of the two lines for Additional Product Information.

The compatibility string shall strictly adhere to the following BNF definition:

```
<compatibility>          ::= "$compatible[" <compatibility_sequence> "]$"
<compatibility_sequence> ::= <compatibility_item> { " " <compatibility_item> }
<compatibility_item>     := <label> "=" [<compatibility_flag>] <identity>
<compatibility_flag>     ::= "-"|"+"|"*"
<label>                  ::= <word>
<identity>               ::= <word>
<word>                   ::= <char> {<char>}
<char>                   ::= "a"-"z"|"A"-"Z"|"0"-"9"|"."|"_"
```

Where the fields are defined as follows:

<compatibility>: the compatibility string is used to indicate the start and end of the compatibility information. The string is delimited by the dollar ($) character which shall appear at both the start and end of the compatibility string enclosure. The enclosed string commences with the case insensitive key word **compatible** followed by a square bracket with no spaces i.e. "**$compatible[**". The <compatibility_sequence> shall immediately follow the square bracket and shall be terminated with a closing square bracket "**]**". The string may appear once only in either one of the two lines for Additional Product Information. The string may be preceded or followed by other text characters.

<compatibility_sequence>: a space separated string of <compatibility_item>'s, a single space only shall separate each <compatibility_item>.

<label>: a character string that identifies the compatibility that is supported. The label shall comprise the uppercase or lowercase alphabetic characters "a" to "z" and "A" to "Z", numeric's "0" to "9", period character (".") and underscore ("_"). For CI Plus compatibility then the label is defined as the case insensitive string "ciplus".

<identity>: a character string that qualifies the compatibility of the given label.

<compatibility_flag>: an optional character that identifies the compatibility of the item with the associated label as defined in Table G.4.

Table G.4: Compatibility Flag

Character	Description
- (Minus)	The CICAM is not compatible with the <identity>
+ (Plus)	The CICAM is compatible with the given <identity> only. This is the default when omitted.
* (Asterisk)	The CICAM is compatible with all versions up to and including the <identity>.

Where a label appears in the compatibility string with multiple compatibility settings then the compatibility string set shall be fully evaluated for the label before being applied. In the example "label=*4 label=-2" then "label" is valid for the set of values {0,1,3,4} only and the value 2 is excluded.

All components of the compatibility string are defined as case insensitive and a Host processing the CIS compatibility string shall perform case insensitive parsing. As an example the following Additional Product Information strings are considered to be compatibility equivalent:

```
"Some text $compatible[acme=+this ciplus=1 acme=-that]$ more text"
"Some text $COMPATIBLE[Acme=+This CIPLUS=1 Acme=-that]$ more text"
"Some text $CoMpAtIbLe[AcMe=+ThIs CIplus=1 aCmE=-tHaT]$ more text"
```

A CICAM shall not under any circumstances advertise compatibility with CI Plus at a given version unless that CICAM has been fully tested with a CI Plus Host at that specified version. It is mandatory for a CI Plus CICAM to indicate its CI Plus compatibility status in the CIS information.

A CI Plus Host may optionally process the CIS compatibility information. A CI Plus Host that processes the compatibility information and determines that the CICAM is not CI Plus compatible may optionally omit advertising CI Plus resources or refrain from using specific CI Plus APDUs. Removal of the CI Plus specific APDUs minimises interoperability issues with CICAMs that are not CI Plus compatible. It is mandatory for a CI Plus Host to advertise its CI Plus specific resources to a compatible CICAM irrespective of whether the module is actually a CI Plus CICAM.

G.3.1 CI Plus Identification

A CI Plus CICAM shall declare support for CI Plus with the <label> "ciplus". For the <label> "ciplus" then the <identity> shall be a decimal integer version number comprising one or more decimal digits. For this version of the specification then the <identity> shall be "1". The version shall remain at 1, irrespective of the specification version, until such time that there is an APDU or functional incompatibility which shall force the version number to be increased by 1.

For a CICAM that is compatible with the CI Plus specification then the <label> and <compatibilty_item> shall be defined as "ciplus=1". A typical compatibility string for a CI Plus CICAM (or a CICAM that has been tested with a CI Plus Host) shall be:

```
$compatible[ciplus=1]$
```

The compatibility information may appear with other information embedded in the string, a complex string example might be:

```
"Some text $compatible[acme=+this ciplus=1 acme=-that]$ more text"
```

Where the CICAM is compatible with "acme=this" but is not compatible with "acme=that" and is also compatible with CI Plus specification 1.2 ("ciplus=1").

A later revision of the CI Plus specification may require the CI Plus identification number to be incremented and a CICAM that is compatible with versions 1 and 2 of the identifier would advertise compatibility as follows:

```
$compatible[ciplus=*2]$
```

indicating that the CICAM is compatible with identity 1 CI Plus Specification and identity 2 (some later version of the specification). All Hosts that interpret the CIS information shall process the compatibility flag.

G.3.2 Additional CI Plus Feature Identification

A CICAM shall declare support for additional CI Plus features in the CIS information e.g. Operator Profile Resource.

The compatibility string shall strictly adhere to the BNF definition defined in G.3.

For a CICAM that is compatible with the additional CI Plus features <label> and <compatibilty_item> shall be defined as "ciprof=int". A typical compatibility and features string for a CICAM which supports the additional CI Plus features shall be:

```
$compatible[ciplus=1 ciprof=int]$
```

Where int is defined as a 32-bit unsigned integer which may be expressed as an unsigned decimal integer using the digits 0..9 or as a hexadecimal integer which shall be prefixed with 0x and include the digits 0..9 and characters a..f. The hexadecimal notation shall be case insensitive i.e. 0x4ac or 0X4AC or 0x4Ac are all valid.

The ciprof identity is interpreted as a bit mask as follows:

Table G.5: Features Bit Mask

Features (resources)	bit mask	Note
Operator Profile Resource	`0x00000001`	See section 14.7.4.1.4
Reserved	`0x00000002 – 0x80000000`	

Examples of compatibility and features might be:

```
$compatible[ciplus=1 ciprof=1]$

$compatible[ciplus=1 ciprof=0x4401]$

$compatible[ciplus=*22 ciprof=116893]$

$compatible[ciplus=*3 ciprof=0x890a4401]$
```

A CICAM shall not under any circumstances advertise CI Plus feature unless the CICAM has been fully tested with a CI Plus Host. It is mandatory for a CI Plus CICAM to indicate its CI Plus compatibility and features in the CIS information.

A CI Plus Host may optionally process the CIS additional CI Plus Features information.

When the ciprof string is omitted from the CIS information then the Host shall assume that none of the features that are known are supported, unless otherwise determined by the Host when full communication with the CICAM has been initiated.

It is recommended that the ciprof label is placed after the ciplus label in the string.

G.3.2.1 Operator Profile Resource (Bit 0 – 0x00000001)

The operator profile resource bit when set to "1" indicates that the CICAM supports an active operator profile. This bit is set to "0" when there is no operator profile on the CICAM or the operator profile has not been advertised in advance.

The Host device may optionally interpret this bit to determine if an operator profile is present and may wait for the CICAM to create the operator profile APDU before continuing with any installation process. When the bit is zero then the CICAM may still have an operator profile present however it may not be possible for the Host to install the profile in any initial installation procedure as it was not advertised early enough. In such an event then the operator profile shall be installed by the Host in a separate installation procedure following the initial installation.

Annex H (normative): Credential Specification

H.1 Parameters Exchanged in APDUs

Table H.1: Input Parameters in Computations (exchanged in APDUs)

Key or variable	Size (bits)	Comments	datatype id
Reserved	-	-	1
Reserved	-	-	2
Reserved	-	-	3
Reserved	-	-	4
HOST_ID	64	Generated by the ROT and included in the X.509 certificate.	5
CICAM_ID	64	Generated by the ROT and included in the X.509 certificate.	6
Host_BrandCert	Note 1	Host Brand Certificate	7
CICAM_BrandCert	Note 1	CICAM Brand Certificate	8
Reserved	-	-	9
Reserved	-	-	10
Reserved	-	-	11
Kp	256	CICAM's key precursor to Host for CCK	12
DHPH	2048	DH Public Key Host	13
DHPM	2048	DH Public Key module/CICAM	14
Host_DevCert	Note 1	Host Device Certificate Data	15
CICAM_DevCert	Note 1	CICAM Device Certificate Data	16
Signature_A	2048	The signature of Host DH public key	17
Signature_B	2048	The signature of CICAM DH public key	18
auth_nonce	256	Random nonce of 256 bits generated by the CICAM and transmitted by the CICAM to the Host for use in the authentication protocol.	19
Ns_Host	64	Host's challenge to CICAM for SAC	20
Ns_module	64	CICAM's challenge to Host for SAC	21
AKH	256	Authentication Key Host	22
AKM	256	Authentication Key Module/CICAM	23
Reserved	-	-	24
uri_message	64	Data message carrying the Usage Rules Information.	25
program_number	16	MPEG program number.	26
uri_confirm	256	Hash on the data confirmed by the Host.	27
key register	8	(uimsbf) 0 = even, 1 = odd, other values not supported.	28
uri_versions	256	Bitmask expressing the URI versions that can be supported by the Host. Format is ' uimsbf'	29
status_field	8	Status field in APDU confirm messages.	30
srm_data	Note 2	SRM for HDCP	31
srm_confirm	256	Hash on the data confirmed by the Host.	32
cicam_license	variable	License from CICAM associated with content (Note 3)	33
license status	8	Current status of the content license	34
license_rcvd_status	8	Status from the exchange of content license	35
Host_license	variable	License for which the Host requires current status. (Note 3)	36
play_count	8	Remaining Play Count	37
operating_mode	8	Record operating mode	38
PINcode data	variable	CICAM PIN code one byte for each pin code digit	39
record_start_status	8	CICAM status after a record_start protocol	40
mode_change_status	8	CICAM status after a change operating mode protocol	41
record_stop_status	8	CICAM status after a record_stop protocol	42
Notes: 1. Certificate lengths are of variable size. 2. SRMs for HDCP are defined in HDCP specification, [34]. First generation SRMs shall not exceed 5 kilobytes. 3. Licenses must not be zero length and shall be padded to the next byte boundary. Licenses shall be no larger than 1024 bytes.			

Annex I (normative): Use of PKCS#1

I.1 RSA Signatures under PKCS#1

RSA signatures shall be constructed using the implementation guidelines of RSA PKCS#1 [1].

The scheme is RSA + SHA1. There are two choices specified in RSA PKCS#1 [1] as they are RSASSA-PSS and RSASSA-PKCS1-V1_5. RSASSA-PSS shall be used to sign and validate messages.

The signatures shall be 2048 bits long.

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Annex J (normative): Tag Length Format

J.1 Tag Length Format

A tag length format (TLF) is defined to identify the items in the signatures of the authentication protocol (see section 6). An item in the signature is identified by following syntax:

<tag> <length><signature_item>

<tag> - this is a field of 8 bits with a unique value (uimsbf) for the data item as specified in Table J.1. The tag is encoded as binary value. The following tag values are defined and shall be used.

Table J.1: Tag and length definition

tag value (8 bits)	tag name	Comment	length (16 bits)
0x00	version	version of the protocol (value is fixed to 0x01 for this version of the specification)	8
0x01	msg_label	message label	8
0x02	auth_nonce	authentication nonce	256
0x03	DHPM	DH Public key CICAM Module	2048
0x04	DHPH	DH Public key Host	2048
0x05-0xFF	reserved	reserved for future use	N/A

<length> - this is a field of 16 bits (uimsbf) to express the length of the actual data item in the signature in bits. The length is encoded as binary value with min 0 and max 2^{16} -1.

<signature_item> - this field carries the actual data item in the signature.

Example; following signature:

<version 1> + <msg_label 02> + <auth_nonce> + <DHPH>

would encode as explained in Table J.2:

Table J.2: Example

Item	Encoding

<version>	0000 0000
	0000 0000 0000 1000
	0000 0001

<msg_label 02>	0000 0001
	0000 0000 0000 1000
	0000 0010

<auth_nonce>	0000 0010 0000 0001 0000 0000 (followed by 256 bits of random data)
<DHPH>	0000 0100 0000 1000 0000 0000 (followed by 2048 bits of random data)

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Annex K (normative): Electrical Specification

K.1 Electrical Specification

This Annex reiterates the electrical requirements for CI Plus Host and CICAM. There are no new electrical requirements for CI Plus. This information is extracted from EN 50221 [7], PCM CIA Volume 2 [28] and PCM CIA Volume 3 [29].

K.1.1 General Information

DVB compliant Hosts shall accept any forms of PCMCIA module without damage to either the Host or PCMICA module and determine that it is not a CICAM. Similarly CICAM may be plugged into a PCMCIA socket on any other system without damage to either the Host or CICAM and the usability of the CICAM in that system will be determined.

K.1.2 Connector Layout

Common Interface physical layer uses PC Card Type I and II physical form factor which is defined in PCMCIA 8.0 Volume 3 Physical Specification [29]. The interface specifies a connector with 68 pins. At power up just after Reset the pin assignment of the CICAM is shown in Table L.1 which is an abstract of the 16 bit PC Card signal definition as defined in the PCMCIA Electrical specification [28]. When the CICAM is configured as the DVB-CI variant during the initialisation process, the following pin reassignments are made is shown in Table L.2

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Table K.1: Common Interface pin assignment before Personality Change

Pin assignment before personality change								
Pin	**Signal**	**I/O**	**Comment**		**Pin**	**Signal**	**I/O**	**Comment**
1	GND		Ground		35	GND		
2	D3	I/O	Data Bit 3		36	CD1#		Card Detect 1
3	D4	I/O	Data Bit 4		*37*	*D11*	*I/O*	*High Z*
4	D5	I/O	Data Bit 5		*38*	*D12*	*I/O*	*High Z*
5	D6	I/O	Data Bit 6		*39*	*D13*	*I/O*	*High Z*
6	D7	I/O	Data Bit 7		*40*	*D14*	*I/O*	*High Z*
7	CE1#	I	Card Enable 1		*41*	*D15*	*I/O*	*High Z*
8	A10	I	Address Bit 10		*42*	*CE2#*	*I*	*Card Enable 2*
9	OE#	I	Output Enable		43	VS1#	O	Voltage Sense 1
10	A11	I	Address Bit 11		*44*	*RFU*		
11	A9	I	Address Bit 9		*45*	*RFU*		
12	A8	I	Address Bit 8		*46*	*A17*	*I*	*High Z*
13	A13	I	Address Bit 13		*47*	*A18*	*I*	*High Z*
14	A14	I	Address Bit 14		*48*	*A19*	*I*	*High Z*
15	WE#	I	Write Enable		*49*	*A20*	*I*	*High Z*
16	Ready	O	Ready		*50*	*A21*	*I*	*High Z*
17	VCC		Supply		51	VCC		Supply
18	VPP1		Program Voltage1		52	VPP2		Program Voltage2
19	*A16*	*I*	*High Z*		*53*	*A22*	*I*	*High Z*
20	*A15*	*I*	*High Z*		*54*	*A23*	*I*	*High Z*
21	A12	I	Address Bit 12		*55*	*A24*	*I*	*High Z*
22	A7	I	Address Bit 7		*56*	*A25*	*I*	*High Z*
23	A6	I	Address Bit 6		*57*	*VS2#*	*O*	*Voltage Sense 2*
24	A5	I	Address Bit 5		58	RESET	I	Card Reset
25	A4	I	Address Bit 4		59	WAIT#	O	Extend Bus Cycle
26	A3	I	Address Bit 3		*60*	*RFU*		
27	A2	I	Address Bit 2		61	REG#	I	Register Select
28	A1	I	Address Bit 1		*62*	*BVD2*	*O*	
29	A0	I	Address Bit 0		*63*	*BVD1*	*O*	
30	D0	I/O	Data Bit 0		*64*	*D8*	*I/O*	*High Z*
31	D1	I/O	Data Bit 1		*65*	*D9*	*I/O*	*High Z*
32	D2	I/O	Data Bit 2		*66*	*D10*	*I/O*	*High Z*
33	*WP*	*O*	*Write Protect*		67	CD2#		Card Detect 2
34	GND				68	GND		

Notes:
1. "I" indicates signals input to the CICAM.
2. "O" indicates signals output from the CICAM.
3. Uses the least significant byte of the data bus. 16 bit read and writes are not supported.
4. Data signals D8 – D15 shall not be available as data lines.
5. Address Lines A15 – A25 shall not be available as address lines.
6. Signals BVD1 BVD2 shall remain "High" during initialization phase.
7. CE2# shall be ignored and interpreted by the module as being in the "High" state.
8. Signals shown in *grey* are non used signals on the CICAM in this personality.
9. The following items apply to all signals marked with High Z. Signals marked as input indicated with "I", shall not be actively driven by the Host and kept in High Z state except the signals pulled up / down by the Host according to Tables K5, K6 and K7.
10. The following items apply to all signals marked with High Z. Signals marked as output indicated with "O", shall not be actively driven by the CICAM and kept in High Z state except the signals pulled up / down by the Host according to Tables K5, K6 and K7.
11. All signals that are not active (*greyed* out) should be ignored at the input end.

Table K.2: Common Interface pin assignment after Personality Change

Pin assignment after personality change								
Pin	**Signal**	**I/O**	**Comment**		**Pin**	**Signal**	**I/O**	**Comment**
1	GND		Ground		35	GND		
2	D3	I/O	Data Bit 3		36	CD1#		Card Detect 1
3	D4	I/O	Data Bit 4		37	MDO3	O	MP data out 3
4	D5	I/O	Data Bit 5		38	MDO4	O	MP data out 4
5	D6	I/O	Data Bit 6		39	MDO5	O	MP data out 5
6	D7	I/O	Data Bit 7		40	MDO6	O	MP data out 6
7	CE1#	I	Card Enable 1		41	MDO7	O	MP data out 7
8	A10	I	Address Bit 10		42	CE2#	I	Card Enable 2
9	OE#	I	Output Enable		43	VS1#	O	Voltage Sense 1
10	A11	I	Address Bit 11		44	IORD#	I	I/O read
11	A9	I	Address Bit 9		45	IOWR#	I	I/O write
12	A8	I	Address Bit 8		46	MISTRT	I	MP in start
13	A13	I	Address Bit 13		47	MDI0	I	MP data in 0
14	A14	I	Address Bit 14		48	MDI1	I	MP data in 1
15	WE#	I	Write Enable		49	MDI2	I	MP data in 2
16	IREQ#	O	Interrupt Request		50	MDI3	I	MP data in 3
17	VCC		Supply		51	VCC		Supply
18	VPP1		Program Voltage1		52	VPP2		Program Voltage2
19	MIVAL	I	MP invalid		53	MDI4	I	MP data in 4
20	MCLKI	I	MP clock input		54	MDI5	I	MP data in 5
21	A12	I	Address Bit 12		55	MDI6	I	MP data in 6
22	A7	I	Address Bit 7		56	MDI7	I	MP data in 7
23	A6	I	Address Bit 6		57	MCLKO	O	MP clock output
24	A5	I	Address Bit 5		58	RESET	I	Card Reset
25	A4	I	Address Bit 4		59	WAIT#	O	Extend Bus Cycle
26	A3	I	Address Bit 3		60	INPACK#	O	In Port Ack.
27	A2	I	Address Bit 2		61	REG#	I	Register Select
28	A1	I	Address Bit 1		62	MOVAL	O	MP out valid
29	A0	I	Address Bit 0		63	MOSTRT	O	MP out start
30	D0	I/O	Data Bit 0		64	MDO0	O	MP data out 0
31	D1	I/O	Data Bit 1		65	MDO1	O	MP data out 1
32	D2	I/O	Data Bit 2		66	MDO2	O	MP data out 2
33	IOIS16#		16 bit I/O		67	CD2#		Card Detect 2
34	GND				68	GND		
Notes: 1. IOIS16# is never asserted. 2. CE2# is ignored by the CICAM and is pulled up to Vcc by the Host. 3. INPACK# is optional for Hosts with single CI slots, mandatory for CICAMS								

K.1.3 Configuration Pins

K.1.3.1 Card Detection Pins

- Card Detect pins (CD1# and CD2#) are used by the Host to detect the presence of a CICAM.
- Both Card Detect pins are placed at opposite ends of the connector in order to detect correct insertion.
- The Host shall provide a 10KΩ or larger pull up resistor to "Vcc" on each of the Card Detect pins. This Vcc is not the same Vcc as used to supply the CICAM.
- The CICAM shall tie both of the Card Detect pins to "GND".

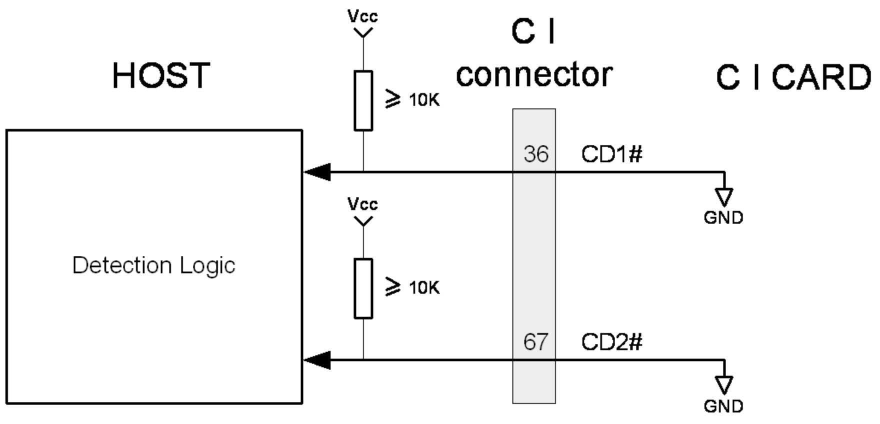

Figure K.1: Card Detect Mechanism

- Host shall only report valid insertion when both Card Detect pins are asserted.
- Card Detect pins shall not be interconnected between CICAMs.
- If the Host senses only one Card Detect pin asserted, it may notify the user one of the following conditions:

  The CICAM has not been inserted correctly or completely.

  The card inserted is of a type not supported by the common interface.

K.1.3.2 Voltage Sense Pins And Socket Key

- Following the PCMCIA version 8 specifications, voltage sense pins are used to configure supply voltage levels.
- CI Plus Host shall support 5V and optionally 3.3V.
- CI Plus CICAM shall support 5V supply only.
- Voltage sense pin VS1# may be connected to GND or left open on the CICAM due to previous demand.
- VS1# pins shall not be interconnected between CICAMs.
- Socket Key for the Host is of 5V type.

K.1.3.3 Function Of VPP1 And VPP2

- CICAMs are allowed to use pins VPP1 and VPP2 as power pins.
- The CICAM is not allowed to short pin VPP1 to VPP2.
- The CICAM is not allowed to short pin VPP1 or VPP2 to VCC.
- When pins VPP1 and VPP2 are used as power pins they have to follow the power up/down conditions and sequence that are valid for the VCC pins.
- CICAM must not derive more than 30% of the consumed power via the VPP pins and not more than 15% for each VPP pin.
- VPP pins shall not be interconnected between CICAMs.

K.1.4 Power Supply Specifications

K.1.4.1 5V DC Supply Specification

Table K.3: Card supply characteristics for 5V indication

Common Interface Card DC Characteristics				
Supply Name	**Min**	**Max**	**Unit**	**Remark**
Vcc	4.75	5.25	V	See 1.
Vpp	4.75	5.25	V	See 1.
Icc + Ipp	-	300	mA	See 2.
Ipp		50	mA	valid per VPP pin
Icc + $Ipp_{power\ up}$		100	mA	See 4.
Icc + Ipp_{peak}		500	mA	See 3.
P_{total}		1.5	W	See 2.

Notes:
1. "Vcc" is the voltage indication for the VCC pins and "Vpp" is the voltage indication for the VPP1 and VPP2 pins. When indicated with 5V it demands that the card functions properly in the specified supply voltage range.
2. Total long term power dissipation of a single common interface card must not exceed Ptotal.
3. Short term peak current are allowed but not longer than 1ms
4. Maximum current consumption directly after power up and reset and during the configuration access.

Table K.4: Host supply characteristics for 5V indication

Host DC Characteristics				
Supply Name	**Min**	**Max**	**Unit**	**Remark**
Vcc	4.75	5.25	V	See 1.
Vpp	4.75	5.25	V	See 1.
Icc	330		mA	See 2.
Ipp	55		mA	
Icc + $Ipp_{\mathbf{peak}}$	500		mA	See 3.

Notes:
1. "Vcc" or "Vpp" indicated with 5V meet the specification under all static load conditions that does not pass load limits with the remark that the Host is not in a power up/down state.
3. It is recommended that the Host is able to provide the minimal peak load for duration of at least 1ms.
4. Current load requirements are based on a single card. Hosts that support multiple cards shall provide the current load requirements times the number of card slots.

K.1.4.2 Host Supply Power Up Timing Diagram

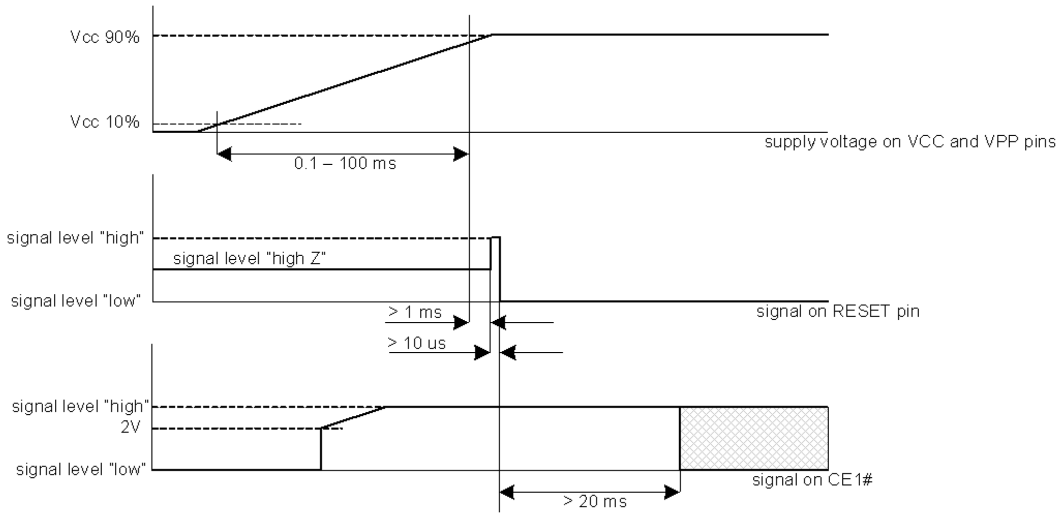

Figure K.2: Host supply power up timing diagram

K.1.4.3 Host Supply Power Down Timing Diagram

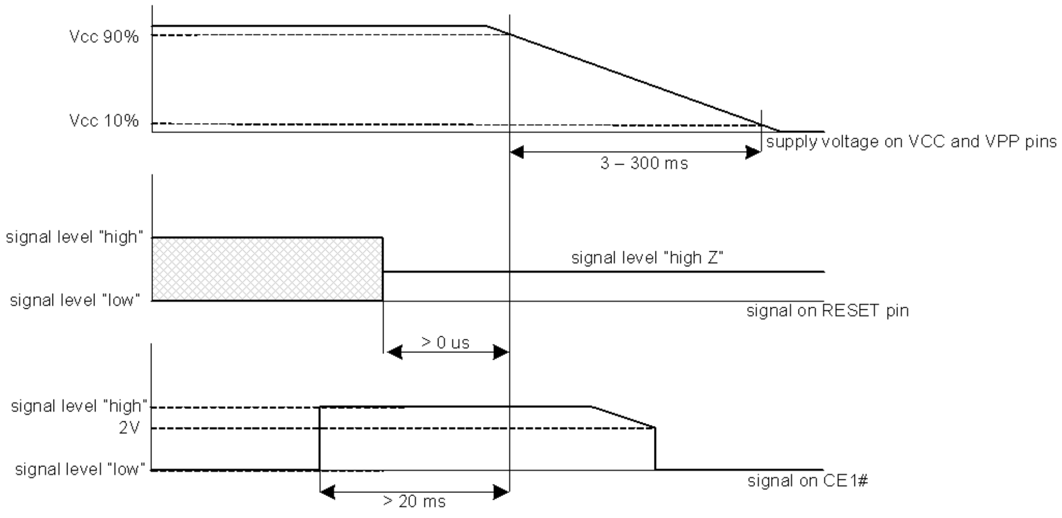

Figure K.3: Host supply power down timing diagram

K.1.5 Signal Level Specifications

K.1.5.1 Pull Up/Pull Down And Capacitive Load Requirements

Table K.5: Load requirements control signals

Load requirements control signals			
Signal Name	**Card**	**Host**	**Remark**
CE1# CE2# REG# IORD# IOWR#	Pull up to "Vcc" ≥10KΩ Must be sufficient to keep inputs inactive when pins are not connected at the Host.		
	Capacitive Load ≤ 50pF		
OE# WE#	Pull up to VCC ≥10KΩ		
	Capacitive Load ≤ 50pF		
RESET	Pull up to VCC ≥100KΩ		
	Capacitive Load ≤ 50pF		

Table K.6: Load requirements status signals

Load requirements status signals			
Signal Name	**Card**	**Host**	**Remark**
READY INPACK# WAIT# WP = IOIS16#		Pull up to VCC ≥10KΩ	
		Capacitive Load ≤ 50pF	

Table K.7: Load requirements address and data signals

Load requirements address and data signals			
Signal Name	**Card**	**Host**	**Remark**
A[14:0]	Pull down to GND ≥100KΩ		
	Capacitive Load ≤ 100pF		
D[7:0]	Pull down to GND ≥100KΩ		
	Capacitive Load ≤ 50pF		

Table K.8: Load requirements MPEG input signals

Load requirements MPEG input signals			
Signal Name	**Card**	**Host**	**Remark**
MDI[7:0] MISTRT MICLK MIVAL	Pull down to GND ≥100KΩ		
	Capacitive Load between 5 and 25pF		

Table K.9: Load requirements MPEG output signals

Load Requirements MPEG Output Signals			
Signal Name	**Card**	**Host**	**Remark**
MDO[7:0] MOCLK MOVAL	Pull down to GND ≥100KΩ		
	Capacitive Load ≤ 50pF		
NOTE: The load requirements are applicable for each single card.			

K.1.5.2 DC Specification For Signals With 5V Supply

Table K.10: DC specifications for signals with 5V supply

Name	Parameter	min	max	units
VIH = "high"	input high voltage	2.4	"Vcc" + 0.25	V
VOH = "high"	output high voltage	2.8	"Vcc"	V
VIL = "low"	input low voltage	0.0	0.8	V
VOL = "low"	output high voltage	0.0	0.5	V
IIH control signal	input high current for defined max. load conditions per card see K.1.5.1.		150	µA
IOH control signal	output high current drive capacity Host for defined max. load conditions	300		µA
IIL control signal	input low current for defined max. load conditions per card see K.1.5.1.		700	µA
IOH control signal	output high current drive capacity Host for defined max. load conditions	1400		µA
IIH status signal	input high current for defined max. Host load conditions see K.1.5.1.		100	µA
IOH status signal	output high current drive capacity per card for defined max. load conditions	100		µA
IIL status signal	input low current for defined max. Host load conditions see K.1.5.1.		400	µA
IOH status signal	output high current drive capacity per card for defined max. load conditions	400		µA
IIH data and address signal	input high current for defined max. load conditions for each card and Host see K.1.5.1.		150	µA
IOH data and address signal	output high current drive capacity Host for defined max. load conditions	300		µA
IIL data and address signal	input low current for defined max. load conditions per card see K.1.5.1.		450	µA
IOH data and address signa**l**	output high current drive capacity Host for defined max. load conditions	1600		µA
1. All specifications are valid for each individual signals. 2. While 0V is recommended min. for VIL, allowable absolute min. limit for VIL is -0,5V undershoot.				

K.1.6 Common Interface Signal Description

K.1.6.1 Common Interface CPU Related Signals

The Common Interface specification is derived from the PC card specification. The Common Interface is a variant of the PC Card with the differences as described in this section.

Just **after reset and before configuration and personality change** the pin out is shown in Table K.1. In this mode CICAM shall behave as a memory only device. This mode does not support I/O cycles.

After personality change the pin out is shown in Table K.2. In this mode CICAM supports I/O cycles and attribute memory cycles.

Attribute Memory is used for storing CICAM identification and configuration information and shall not require a large address space. To access attribute memory signal REG# is kept active. Attribute memory support by Hosts and CICAM is mandatory. After personality change the CICAM shall provide at least the Configuration Option Register address.

Common Memory is the collective name for a variety of different memory types like SRAM, MaskROM, OTPROM, (E)EPROM and FLASH. Common memory support by the Host is optional. The CICAM shall not implement common memory.

I/O support by Host and CICAM is mandatory after personality change. CICAM shall support the Configuration Option Register. Host support for registers other than the Configuration Option Register is optional.

Address Lines A[14 : 0]:

- Before personality change the following items apply.
- The Host shall provide a full 32kByte A[14:0] address space to the CICAM.
- The CICAM shall decode at least 12 bits of addresses A[11:0].
- Due to the byte mode operation of the CICAM access to odd addresses are not supported and the Host shall not access odd addresses.
- After personality change the following items apply.
- The Host shall provide at least 4 address locations in I/O mode A[1:0] starting at 00h.
- The CICAM shall decode the 4 address locations in I/O mode using address lines A[1:0] and shall ignore address lines A[14:2] in I/O mode.
- For attribute memory access the Host and the CICAM shall support the same address range as before the personality change.
- Multiple CICAMs may share the same Address lines.

Data Lines D[7:0]:

- Data Lines D[7:0] constitutes the bidirectional data bus.
- Data lines must turn to "high Z" when not enabled.
- The most significant bit is D[7], least significant bit is D[0].
- Multiple CICAMs may share the same Data lines.

Card Enable CE2# and CE1#:

- CE1# (in diagrams named CE#) is enabled on even addresses only.
- CE2# is ignored by the CICAM and interpreted as always being "high".
- CE1# is active for attribute memory access and I/O access.
- Host may never assert CE1# lines to more than one CICAM at the same time.
- CE2# and CE1# shall not be interconnected between CICAM.

Output Enable OE#:

- OE# is used to read data from the CICAM's attribute memory.
- Hosts must negate OE# during memory write and I/O read and write operation.
- Multiple CICAMs may share the same OE#.

Write Enable WE#:

- WE# is used to write date to the CICAM's attribute memory.
- Multiple CICAMs may share the same WE#.

Interrupt Request IREQ#:

- IREQ# is available after personality change.
- IREQ# is asserted to indicate to the Host that the CICAM requires Host software service.
- The Host must support one IREQ# input per Common Interface slot. Support for more than one IREQ# per slot is optional.
- It is recommended to route IREQ# to one of the standard interrupt inputs when the Host is a PC compatible computer. In this case it must be guaranteed that the interrupt is not occupied by the Host itself.
- The interrupt shall be level dependant.

Attribute Memory Select REG#:

- In case of memory read or write cycle, access is limited to attribute memory when REG# is asserted.
- In case of I/O read and write cycle, REG# is asserted.
- Multiple CICAMs cards may share the same REG#.

Input Output Read IORD#:

- IORD# is supported after personality change.
- IORD# is asserted during I/O read action from CICAM into the Host.
- Multiple CICAMs may share the same IORD#.

Input Output Write IOWR#:

- IOWR# is supported after personality change.
- IOWR# is asserted during I/O write action from Host into the CICAM.
- Multiple CICAMs may share the same IOWR#.

Extend Bus Cycle WAIT#:

- WAIT# is asserted by the CICAM to delay completion of memory or I/O read or write cycles.
- WAIT# shall not be interconnected between CICAMs.

Input Port Acknowledge INPACK#:

- INPACK# is active low.
- INPACK# is asserted by the CICAM when the card is selected to respond to an I/O read cycle and can handle the response.
- This signal is used by the Host to control the enable of any input data buffer between CICAM and Host system data bus D[7:0].
- INPACK# must be inactive until the card has passed personality change.
- INPACK# shall not be interconnected between CICAMs.

K.1.6.2 MPEG Transport Stream Related Signals

This section describes the signal definitions of the MPEG stream ports of the Common Interface. The Common Interface replaces the signals as defined in Table K.1 with the signals as defined in Table L2 after personality change to enable the port signals as required for the MPEG transport stream. Before personality change the MPEG stream related signals are not defined and the Host shall keep these signals in "High Z" state. In a multiple CICAM configuration, the MPEG stream signals may be daisy chained via the socket on the Host.

The MPEG stream part of the Common Interface has signals as defined below.

MPEG Data Input MDI[7:0]:

- MPEG stream data lines MDI[7:0] constitutes the input data bus.
- The most significant bit is MDI[7], least significant bit is MDI[0].
- CICAM may connect the MPEG stream data input to the MPEG stream data output taking the timing specifications into account.

MPEG Input Start MISTRT:

- This signal is active to indicate the first byte of a MPEG Transport Packet on MDI[7:0].
- CICAM may connect MISTRT to MOSTRT taking the timing specifications into account.

MPEG Input Valid MIVAL:

- This signal is active to indicate valid byte of a MPEG Transport Packet on MDI[7:0].
- In a phase that the interface is clocked continuously it is required to have and use this signal for non valid data identifications between and within MPEG Transport Packet transfers.
- CICAM may connect MIVAL to MOVAL taking the timing specifications into account.

MPEG Input Clock MCLKI:

- This signal is a continuously running clock input after personality change under the condition the transport stream redirection switch is set to module pass through. "leading to the condition that the transport stream is routed through the CICAM".
- It is recommended that MCLKI shall have a continuous frequency clock related to the data rate of the transport stream being received.
- CICAM may connect MCLKI to MCLKO taking the timing specifications into account. MCLKO is in that case the buffered version of MCLKI with a small delay.

MPEG Data Output MDO[7:0]:

- MPEG stream data lines MDO[7:0] constitutes the output data bus.
- The most significant bit is MDO[7] , least significant bit is MDO[0].

MPEG Output Start MOSTRT:

- This signal is active to indicate the first byte of a MPEG Transport Packet on MDO[7:0].

MPEG Output Valid MOVAL:

- This signal is active to indicate valid byte of a MPEG Transport Packet on MDO[7:0].
- In a phase that the interface is clocked continuously it is required to have and use this signal for non valid data identifications between and within MPEG Transport Packet transfers.

MPEG Output Clock MCLKO:

- This signal is a continuously running clock output after personality change under the condition the transport stream redirection switch is set to module pass through. "leading to the condition that the transport stream is routed through the CICAM".
- Multiple CICAMs may interconnect MCLKO of one card with MCLKI of the other consecutive card taking the timing specifications into account.

K.1.6.3 MPEG Clock Timing Considerations.

- To ease EMC design on the Common Interface it is recommended to fulfil the minimum specification of 5ns for rise and fall time for clock signals MCLKI and MCLKO.

- Due to potential cumulative distortion for chaining of clocks through at least 2 cascaded CICAMs and to keep clock reshaping and buffering economically attractive and still meet the timing requirements at max clock speed it is recommended to fulfil the maximum specification of 20ns for rise and fall time for clock signals MCLKI and MCLKO.

The fall time is defined as the transition time from Vh_{min} to Vl_{max} as defined in section K.1.5.

- The rise time is defined as the transition time from Vl_{max} to Vh_{min} as defined in section K.1.5.
- Hosts that buffer the one's Common Interface MCLKO to pass to the next Common Interface MCLKI shall not produce a cumulative absolute difference between rise and fall time of more than 20ns.
- To fulfil the rise and fall time requirements the next addition to the requirements in section K.1.5 are made. The capacitive load presented to MCLKO shall be between 10pF and 50pF. The capacitive load presented to MCLKI shall be between 5pF and 25pF.
- It is recommend not to use simple clock shapers in combination with multiple CICAMs that pass MCLKO from one CICAM via a buffer on the Host to MCLKI of the next CICAM.

K.1.7 Timing Specifications

For a detailed description of the signals and bus see section K.1.6.1.

K.1.7.1 Common Interface Attribute Memory Read Diagram

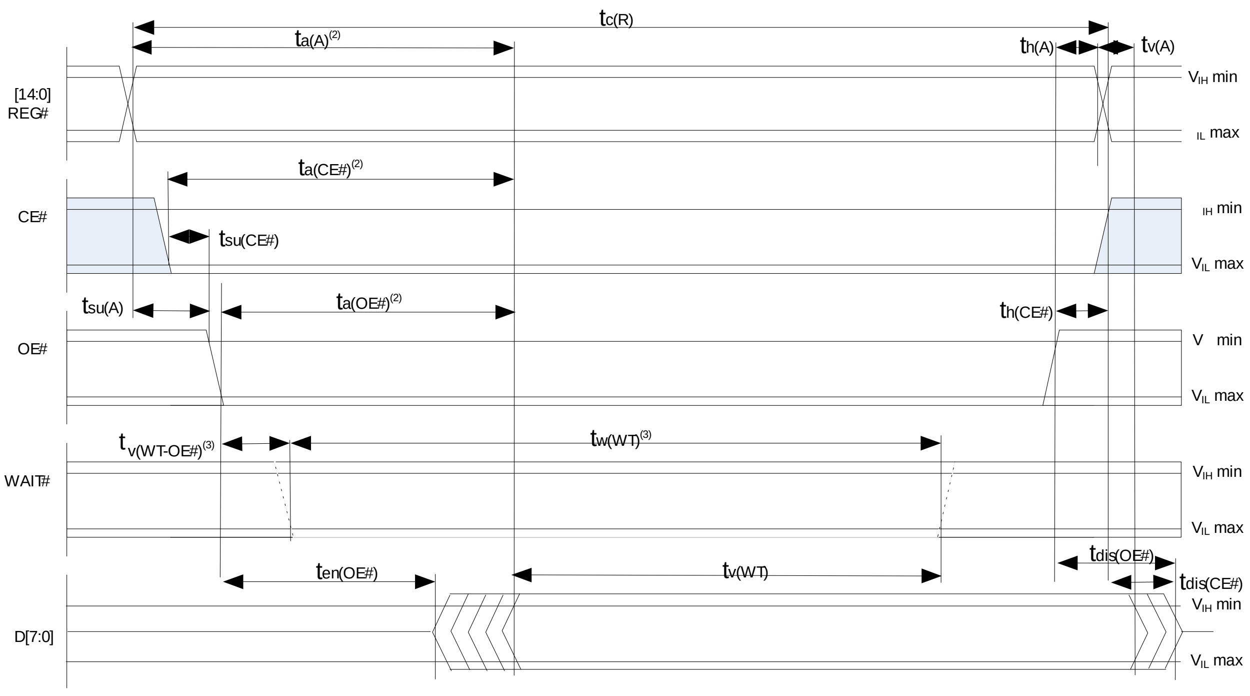

Figure K.4: Attribute Memory Read Timing Diagram

Table K.11: Attribute Memory Read Timing Specifications

Item	Symbol	300 ns	
		min	max
Read Cycle Time	$t_{c}R$	300	
Address Access Time	$t_{a}(A)$		300
Card Enable Access Time	$t_{a}(CE\#)$		300
Output Enable Access Time	$t_{a}(OE\#)$		150
Output Disable Time from OE#	$t_{dis}(OE\#)$		100
Output Enable Time from OE#	$t_{en}(OE\#)$	5	
Data valid from Add Change	$t_{v}(A)$	0	
Address Setup Time [1]	$t_{su}(A)$	100	
Address Hold Time [1]	$t_{h}(A)$	35	
Card Enable Setup Time [1]	$t_{su}(CE\#)$	0	
Card Enable Hold Time [1]	$t_{h}(CE\#)$	35	
WAIT# valid from OE# [1]	$t_{v}(WT\text{- }OE\#)$		100
WAIT# Pulse Width [6]	$t_{w}(WT)$		12 µs
Data Setup for WAIT# Released	$t_{v}(WT)$	0	
1. These timings are specified for Hosts and CICAM which support the WAIT# signal.			
2. All timings in ns when not explicitly mentioned.			

K.1.7.2 Common Interface Attribute Memory Write Diagram

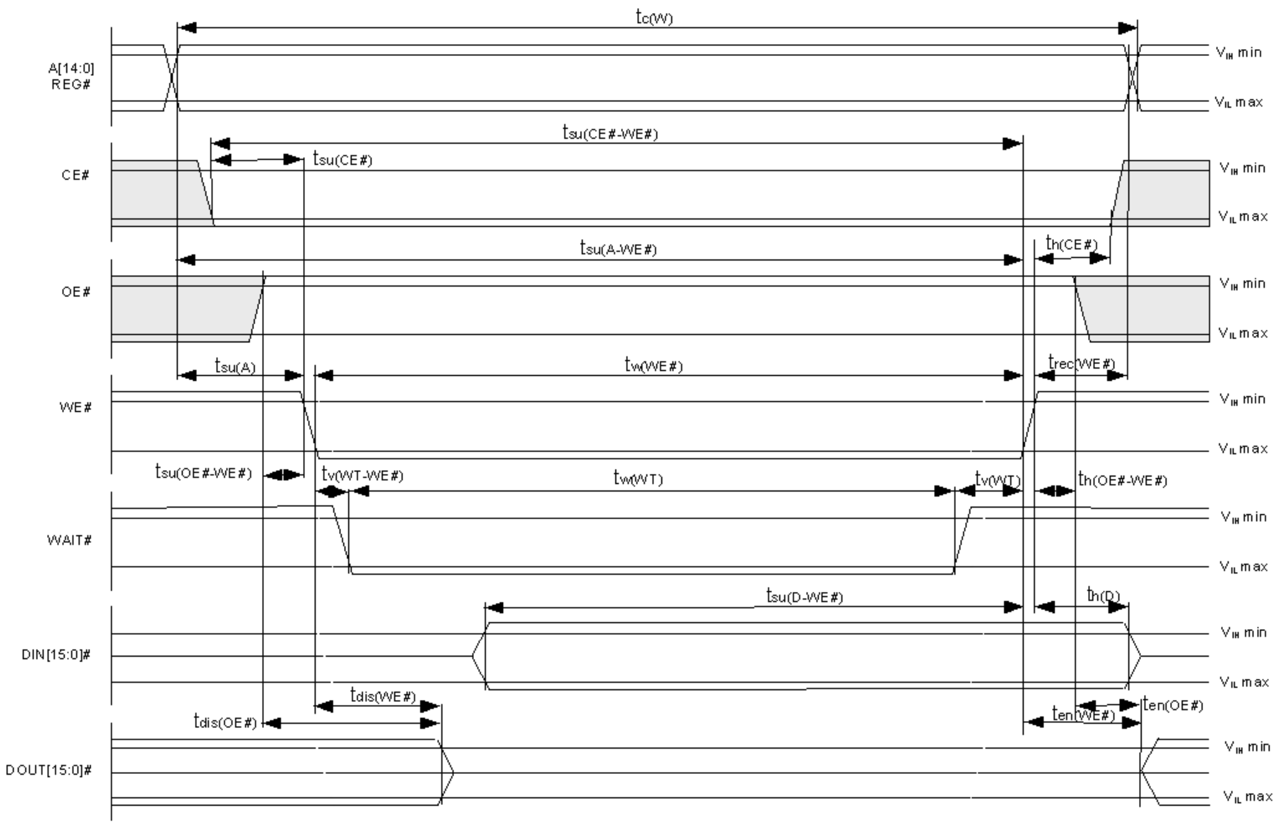

Figure K.5: Attribute Memory Write Timing Diagram

Table K.12: Attribute Memory Write Timing Specifications

Item	Symbol	250 ns	
		min	max
Write Cycle Time	t_c(W)	250	
Write Pulse Width	t_w(WE#)	150	
Address Setup Time [1]	t_{su}(A)	30	
Address Setup Time for WE# [1]	t_{su}(A-WE#)	180	
Card Enable Setup Time for WE#	t_{su}(CE#-WE#)	180	
Data Setup Time for WE#	t(D-CE#)	80	
Data Hold Time	t_h(D)	30	
Write Recover Time	t_{rec}(WE#)	30	
Output Disable Time from WE#	t_{dis}(WE#)		100
Output Disable Time from OE#	t_{dis}(OE#)		100
Output Enable Time from WE#	t_{en}(WE#)	5	
Output Enable Time from OE#	t_{en}(OE#)	5	
Output En. Setup from WE#	t_{su}(OE#-WE#)	10	
Output Enable Hold from WE#	t_h(OE#-WE#)	10	
Card Enable Setup Time [2]	t_{su}(CE#)	0	
Card Enable Hold Time [2]	t_h(CE#)	20	
WAIT# Valid from WE# [2]	t_v(WT-WE#)		35
WAIT# Pulse Width [4]	t_w(WT)		12 µs
WE# High from WAIT# released [3]	t_v(WT)	0	

Notes:
1. The REG# signal timing is identical to address signal timing.
2. These timings are specified for Hosts and cards which support the WAIT# signal.
3. These timings specified only when WAIT# is asserted within the cycle.
4. All timings measured at the CI card. Skews and delays from the system driver/receiver to the CI card must be accounted by the system.
6. All timings in ns when not explicitly mentioned.

K.1.7.3 Common Interface I/O Read Timing

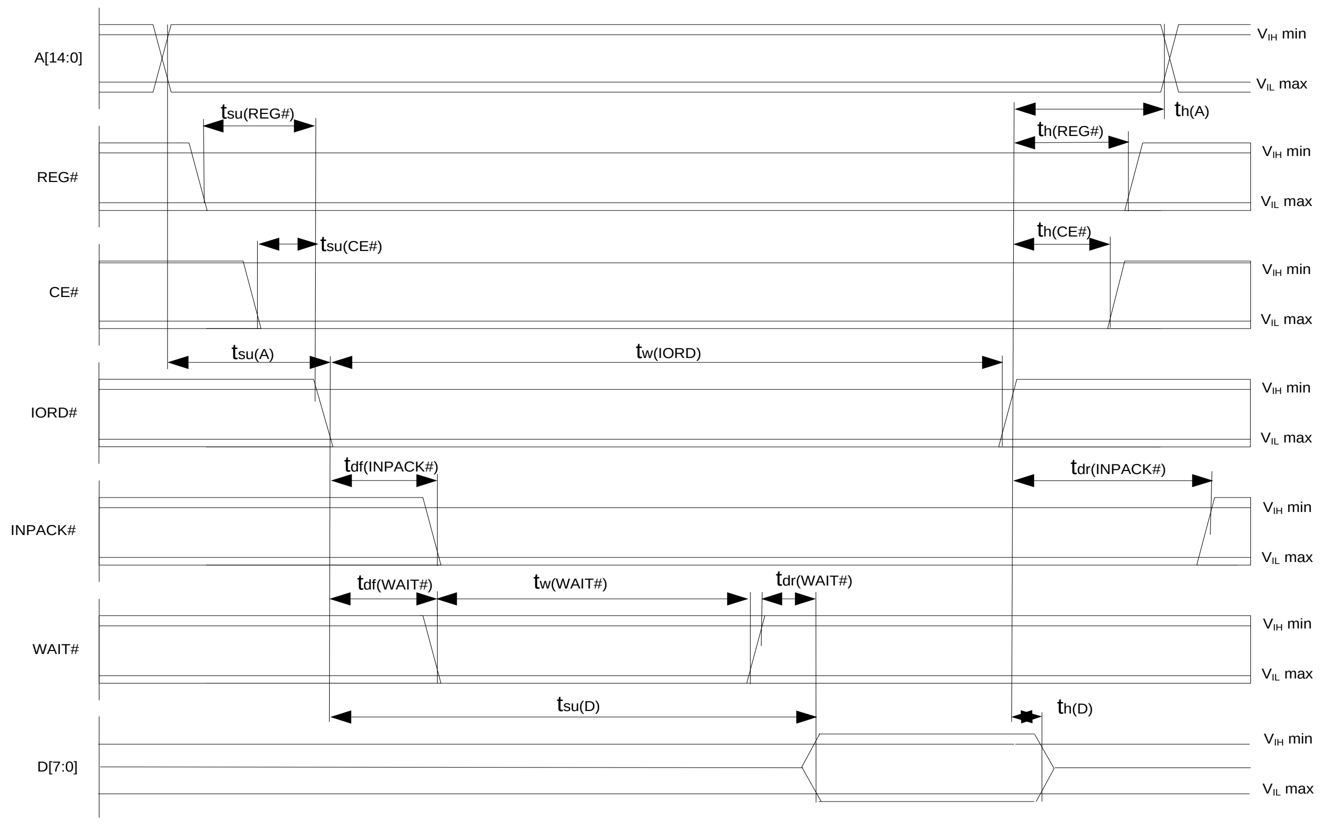

Figure K.6: I/O Read Timing Diagram

Table K.13: I/O Read Timing Specifications

Item	Symbol	min	max
Data Delay after IORD#	t_{su}(D)		100
Data Hold following IORD#	t_h(D)	0	
IORD# Width Time	t_w(IORD)	165	
Address Setup before IORD#	t_{su}(A)	70	
Address Hold following IORD#	t_h(A)	20	
CE# Setup before IORD#	t_{su}(CE#)	5	
CE# Hold following IORD#	t_h(CE#)	20	
REG# Setup before IORD#	t_{su}(REG#)	5	
REG# Hold following IORD#	t_h(REG#)	0	
INPACK# Delay Falling from IORD#	$_{df}$(INPACK#)	0	45
INPACK# Delay Rising from IORD#	$_{dr}$(INPACK#)		45
WAIT# Delay Falling from IORD#	t_{df}(WAIT#)		35
Data Delay from WAIT# Rising	t_{dr}(WAIT#)		0
WAIT# Width Timing	t_w(WAIT#)		12000
NOTE: All timings in ns.			

K.1.7.4 Common Interface I/O Write Timing

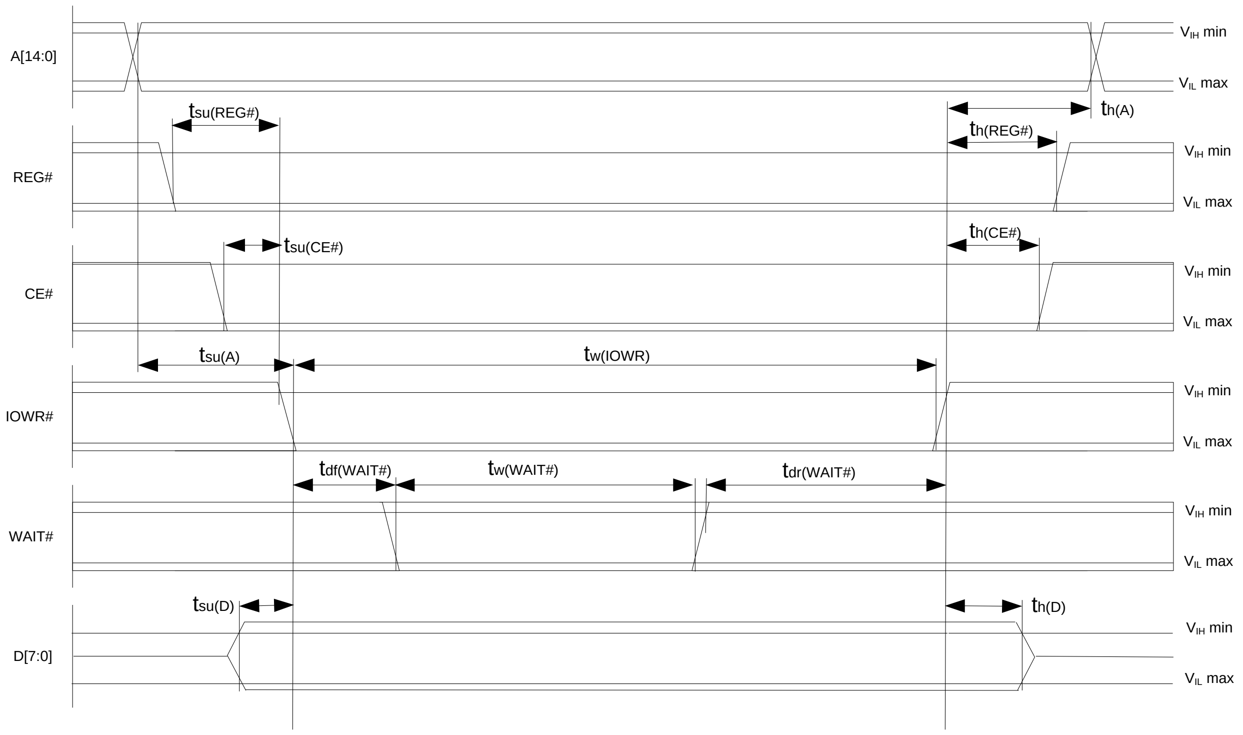

Figure K.7: I/O Write Timing Diagram

Table K.14: I/O Write Timing Specifications

Item	Symbol	min	Max
Data Delay before IOWR#	t_{su}(D)	60	
Data Hold following IOWR#	t_h(D)	30	
IOWR# Width Time	t_w(IOWR)	165	
Address Setup before IOWR#	t_{su}(A)	70	
Address Hold following IOWR#	t_h(A)	20	
CE# Setup before IOWR#	t_{su}(CE#)	5	
CE# Hold following IOWR#	t_h(CE#)	20	
REG# Setup before IOWR#	t_{su}(REG#)	5	
REG# Hold following IOWR#	t_h(REG#)	0	
WAIT# Delay Falling from IOWR#	t_{df}(WAIT#)		35
IOWR# High from WAIT# High	t_{dr}(WAIT#)	0	
WAIT# Width Timing	t_w(WAIT#)		12000
NOTE: All timings in ns.			

K.1.7.5 Common Interface MPEG Signal Timing

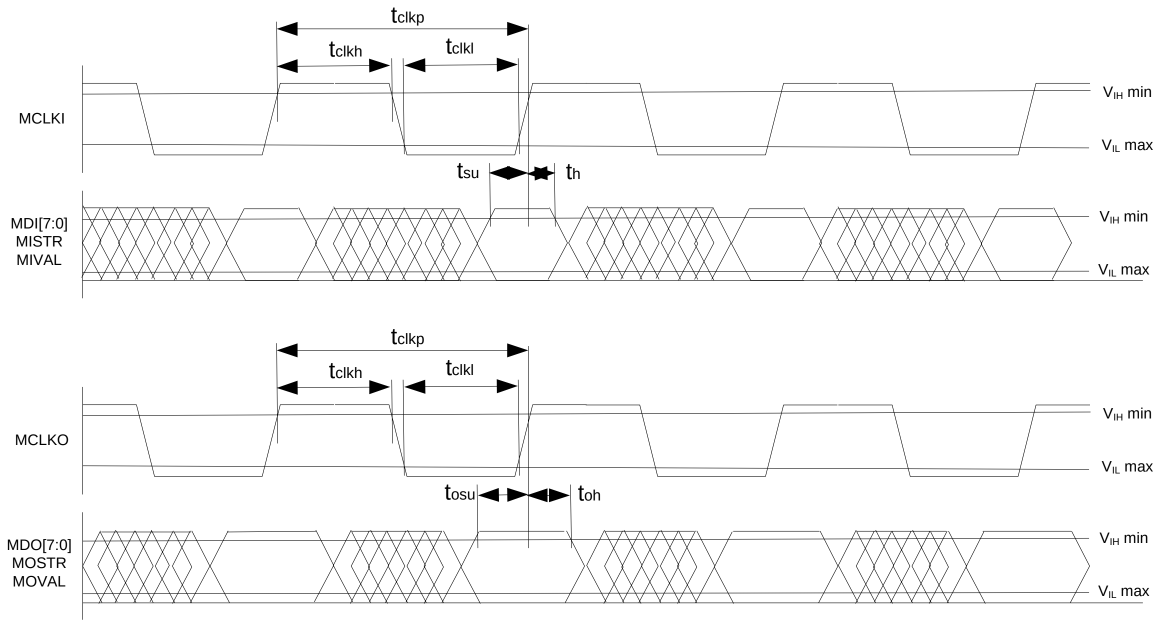

Figure K.8: MPEG Stream Signals Timing Diagram

Table K.15: MPEG Stream Signals Timing Specifications

Item	Symbol	Minimum Timings	
		72 MBits/s	96 MBits/s
Clock Period	t_{clkp}	111	83
Clock High Time	t_{clkh}	40	20
Clock Low Time	t_{clkl}	40	20
Input Data Setup Time	t_{su}	15	10
Input Data Hold Time	t_h	10	10
Output Data Setup Time	t_{osu}	20	10
Output Data Hold Time	t_{oh}	15	10
NOTE: All timings in ns.			

Annex L (normative): Resource Summary

L.1 Resource IDs

There are two different versions of Resource IDs. Version 1 is defined in EN 50221 [7], section 8.2.2, version 2 is defined in TS 101 699 [8] section 4.1. In version 1, the resource_type is 10 bits. Version 2 splits this field into 4 bits resource_type and 6 bits resource_instance. The resource_instance is identical to the module_id described in TS 101 699 [8], section 4.2.

The resource_instance is used to distinguish between different implementations of the same resource provided by the Host and by CICAMs that need to co-exist. This concept is only applicable to the resources listed in TS 101 699 [8], section 4.2. A Host supporting one of these resources has to implement resource manager version 2 and negotiate a module_id with each CICAM.

For all resources not listed in TS 101 699 [8], section 4.2, resource ID version 1 is used. All resources defined in this specification use resource ID version 1. Such resources may be handled by resource manager version 1 or 2.

The resource_id_type (see EN 50221 [7], section 8.8.2) is set to 0 for all resources to indicate that they are public resources.

L.2 Resource Summary

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Table L.1: Resource Summary

Resource					Application Object		Direction			
Name	**Resource Identifier**	**class**	**type**	**vers.**	**APDU Tag**	**Tag value**	**Host**	**CAM**	**Mandatory**	**Spec**
Resource Manager	00 01 00 41	1	1	1	profile_enq	9F 80 10	←→		Yes (version 1 or version 2 may be used), see section L.1)	EN 50221
					profile	9F 80 11	←→			
					profile_change	9F 80 12	←→			
	00 01 00 42	1	1	2	profile_enq	9F 80 10	←→			TS 101 699
					profile	9F 80 11	←→			
					profile_change	9F 80 12	←→			
					module_id_send	9F 80 13	←			
					module_id_command	9F 80 14	→			
Application Information	00 02 00 41	2	1	1	application_info_enq	9F 80 20	→		Yes	EN 50221
					application_info	9F 80 21	←			
					enter_menu	9F 80 22	→			
	00 02 00 42	2	1	2	application_info_enq	9F 80 20	→		Yes	TS 101 699
					application_info	9F 80 21	←			
					enter_menu	9F 80 22	→			
	00 02 00 43	2	1	3	application_info_enq	9F 80 20	→		Yes	CI Plus
					application_info	9F 80 21	←			
					enter_menu	9F 80 22	→			
					request_cicam_reset	9F 80 23	←			
					data_rate_info	9F 80 24	→			
Conditional Access Support	00 03 00 41	3	1	1	ca_info_enq	9F 80 30	→		Yes	EN 50221
					ca_info	9F 80 31	←			
					ca_pmt	9F 80 32	→			
					ca_pmt_reply	9F 80 33	←			
Host Control	00 20 00 41	32	1	1	tune	9F 84 00	←		Yes	EN 50221
					replace	9F 84 01	←			
					clear_replace	9F 84 02	←			
					ask_release	9F 84 03	→			
	00 20 00 42	32	1	2	tune	9F 84 00	←		Yes	CI Plus 1.3
					replace	9F 84 01	←			

					clear_replace	9F 84 02	←		
					ask_release	9F 84 03	→		
					tune_broadcast_req	9F 84 04	←		
					tune_reply	9F 84 05	→		
					ask_release_reply	9F 84 06	←		
Date-Time	00 24 00 41	36	1	1	date_time_enq	9F 84 40	←	Yes	EN 50221
					date_time	9F 84 41	→		
MMI	00 40 00 41	64	1	1	close_mmi	9F 88 00	→	High level only	EN 50221
					display_control	9F 88 01	←		
					display_reply	9F 88 02	→		
					text_last	9F 88 03	←		
					text_more	9F 88 04	←		
					keypad_control	9F 88 05	←		
					keypress	9F 88 06	→		
					enq	9F 88 07	←		
					answ	9F 88 08	→		
					menu_last	9F 88 09	←		
					menu_more	9F 88 0A	←		
					menu_answ	9F 88 0B	→		
					list_last	9F 88 0C	←		
					list_more	9F 88 0D	←		
					subtitle_segment_last	9F 88 0E	←		
					subtitle_segment_more	9F 88 0F	→		
					display_message	9F 88 10	←		
					scene_end_mark	9F 88 11	←		
					scene_done	9F 88 12	←		
					scene_control	9F 88 13	→		
					subtitle_download_last	9F 88 14	←		
					subtitle_download_more	9F 88 15	→		
					flush_download	9F 88 16	←		
					download_reply	9F 88 17	←		
low-speed comms.	00 60 xx x1	96		1	comms_cmd	9F 8C 00	←	Yes for v1.3 where Host IP	EN 50221
					connection_descriptor	9F 8C 01	←		
					comms_reply	9F 8C 02	→		

					comms_send_last	9F 8C 03	←	support exists	
					comms_send_more	9F 8C 04	←		
					comms_rcv_last	9F 8C 05	→		
					comms_rcv_more	9F 8C 06	→		
	00 60 xx x2	96		2	comms_cmd	9F 8C 00	←	Yes for v1.3 where Host IP support exists	CI Plus
					connection_descriptor	9F 8C 01	←		
					comms_reply	9F 8C 02	→		
					comms_send_last	9F 8C 03	←		
					comms_send_more	9F 8C 04	←		
					comms_rcv_last	9F 8C 05	→		
					comms_rcv_more	9F 8C 06	→		
	00 60 xx x3	96		3	comms_cmd	9F 8C 00	←	Yes for v1.3 where Host IP support exists	CI Plus 1.3
					connection_descriptor	9F 8C 01	←		
					comms_reply	9F 8C 02	→		
					comms_send_last	9F 8C 03	←		
					comms_send_more	9F 8C 04	←		
					comms_rcv_last	9F 8C 05	→		
					comms_rcv_more	9F 8C 06	→		
Content Control	00 8C 10 01	140	64	1	cc_open_req	9F 90 01	←	Yes	CI Plus
					cc_open_cnf	9F 90 02	→		
					cc_data_req	9F 90 03	←		
					cc_data_cnf	9F 90 04	→		
					cc_sync_req	9F 90 05	←		
					cc_sync_cnf	9F 90 06	→		
					cc_sac_data_req	9F 90 07	←		
					cc_sac_data_cnf	9F 90 08	→		
					cc_sac_sync_req	9F 90 09	←		
					cc_sac_sync_cnf	9F 90 10	→		
	00 8C 10 02	140	64	2	cc_open_req	9F 90 01	←	Yes	CI Plus 1.3
					cc_open_cnf	9F 90 02	→		
					cc_data_req	9F 90 03	←		
					cc_data_cnf	9F 90 04	→		
					cc_sync_req	9F 90 05	←		

					cc_sync_cnf	9F 90 06	→		
					cc_sac_data_req	9F 90 07	←		
					cc_sac_data_cnf	9F 90 08	→		
					cc_sac_sync_req	9F 90 09	←		
					cc_sac_sync_cnf	9F 90 10	→		
					cc_PIN_capabilities_req	9F 90 11	→		
					cc_PIN_capabilities_reply	9F 90 12	←		
					cc_PIN_cmd	9F 90 13	→		
					cc_PIN_reply	9F 90 14	←		
					cc_PIN_event	9F 90 15	←		
					cc_PIN_playback	9F 90 16	→		
					cc_PIN_MMI_req	9F 90 17	→		
Host Language & Country	00 8D 10 01	141	64	1	Host_country_enq	9F 81 00	←	Yes	CI Plus
					Host_country	9F 81 01	→		
					Host_language_enq	9F 81 10	←		
					Host_language	9F 81 11	→		
CAM_Upgrade	00 8E 10 01	142	64	1	cam_firmware_upgrade	9F 9D 01	←	Yes	CI Plus
					cam_firmware_upgrade_reply	9F 9D 02	→		
					cam_firmware_upgrade_progress	9F 9D 03	←		
					cam_firmware_upgrade_complete	9F 9D 04	←		
Operator Profile	00 8F 10 01	143	64	1	operator_status_req	9F 9C 00	→	Yes	CI Plus 1.3
					operator_status	9F 9C 01	←		
					operator_nit_req	9F 9C 02	→		
					operator_nit	9F 9C 03	←		
					operator_info_req	9F 9C 04	→		
					operator_info	9F 9C 05	←		
					operator_search_start	9F 9C 06	→		
					operator_search_status	9F 9C 07	←		
					operator_exit	9F 9C 08	→		
					operator_tune	9F 9C 09	←		
					operator_tune_status	9F 9C 0A	→		
					operator_entitlement_ack	9F 9C 0B	→		
					operator_search_cancel	9F 9C 0C	→		

SAS	00 96 10 01	150	64	1	SAS_connect_rqst	9F 9A 00	→	No	CI Plus
					SAS_connect_cnf	9F 9A 01	←		
					SAS_data_rqst (see note 1)	9F 9A 02	←→		
					SAS_data_av (see note 1)	9F 9A 03	←→		
					SAS_data_cnf (see note 1)	9F 9A 04	←→		
					SAS_server_query (see note 1)	9F 9A 05	←→		
					SAS_server_reply (see note 1)	9F 9A 06	←→		
					SAS_async_msg	9F 9A 07	←→		
Application MMI	00 41 00 41	65	1	1	RequestStart	9F 80 00	←	Yes	TS 101 699
					RequestStartAck	9F 80 01	→		
					FileRequest	9F 80 02	→		
					FileAcknowledge	9F 80 03	←		
					AppAbortRequest	9F 80 04	←→		
					AppAbortAck	9F 80 05	←→		
	00 41 00 42	65	1	2	RequestStart	9F 80 00	←	No for Host Yes for CICAM	CI Plus 1.3
					RequestStartAck	9F 80 01	→		
					FileRequest	9F 80 02	→		
					FileAcknowledge	9F 80 03	←		
					AppAbortRequest	9F 80 04	←→		
					AppAbortAck	9F 80 05	←→		
Note 1: The synchronous SAS APDUs are not used by this specification.									

Annex M (normative): MHP Application Message Format

M.1 Background (Informative)

This Annex describes the MHP application message format that facilitates the connection between the CA system that exists on the CICAM and the MHP application interface defined by TS 102 757 [35]. In considering the message format then the architecture differences of an integrated receiver containing no conditional access system and a receiver containing an integrated CA system have been considered. An architectural overview of the different environments is presented.

M.1.1 Embedded CAS Environment (Informative)

An embedded CAS environment is depicted in Figure M.1 and is perhaps the simplest environment for Conditional Access application environment. In this case the manufacturer has control of the middleware on the receiver and works with the CA provider allowing the MHP component to be connected to the CA system. Interoperability issues between the CA system and the MHP application API may be resolved by the manufacturer.

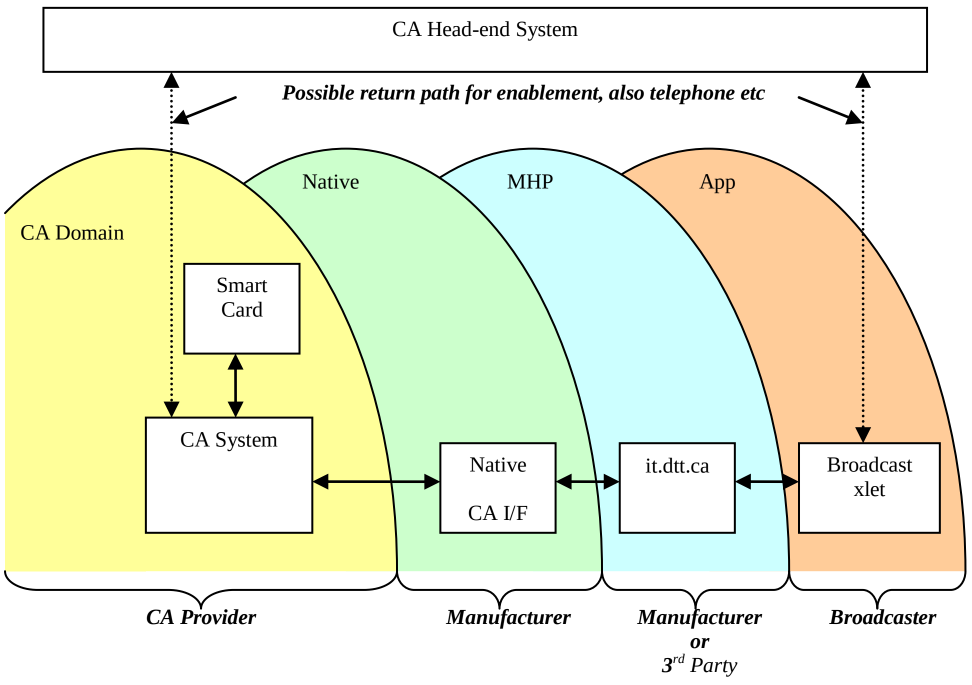

Figure M.1: Embedded CAS Environment

M.1.2 CI CAS Environment (Informative)

Within a CI CAS environment then the architecture of the system differs as there is no tight coupling of the CA system and complete ownership may not lie with the manufacturer, as depicted in Figure M.2. A CAS-less receiver does not include the CA subsystem and relies on a Conditional Access Module (CAM) on the Common Interface (CI) to perform the CA services and de-scrambling. A CAS-less receiver has no knowledge of the CA system with which it is interfacing, relying instead on the Common Interface protocol[4,3] to effect the CA services and descrambling (possibly using the High Level MMI resource of the CI).

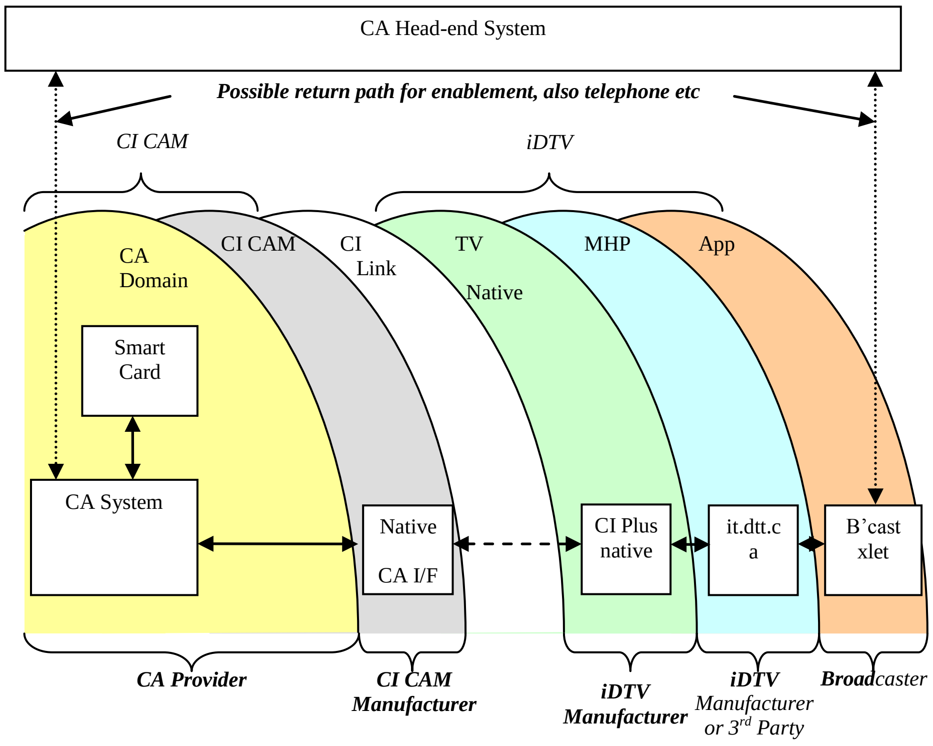

Figure M.2: CICAM CAS Environment

In this environment then the CICAM Manufacturer has knowledge of the CA interfaces, the DTV Manufacturer does not, therefore Pay-per-view and CA information has to be passed through the CI to the application environment and presented at the application interface. For a manufacturer to realise `it.dtt.ca` then the Common Interface has to provide all of the information as new CI messages which are understood by the native TV environment. This requires that there is a CA information CI resource which is known to MHP enabled receivers and CI CA information enabled CICAMs.

M.1.3 Use of SAS for MHP Support (Informative)

The SAS resource has been selected as the data transfer APDU resource to move data between the CICAM and Host (and vice versa). This resource provides better control of asynchronous transfers than the DVB CA pipeline resource. Figure M.3 depicts a conceptual view of the connection between the CICAM and the Host.

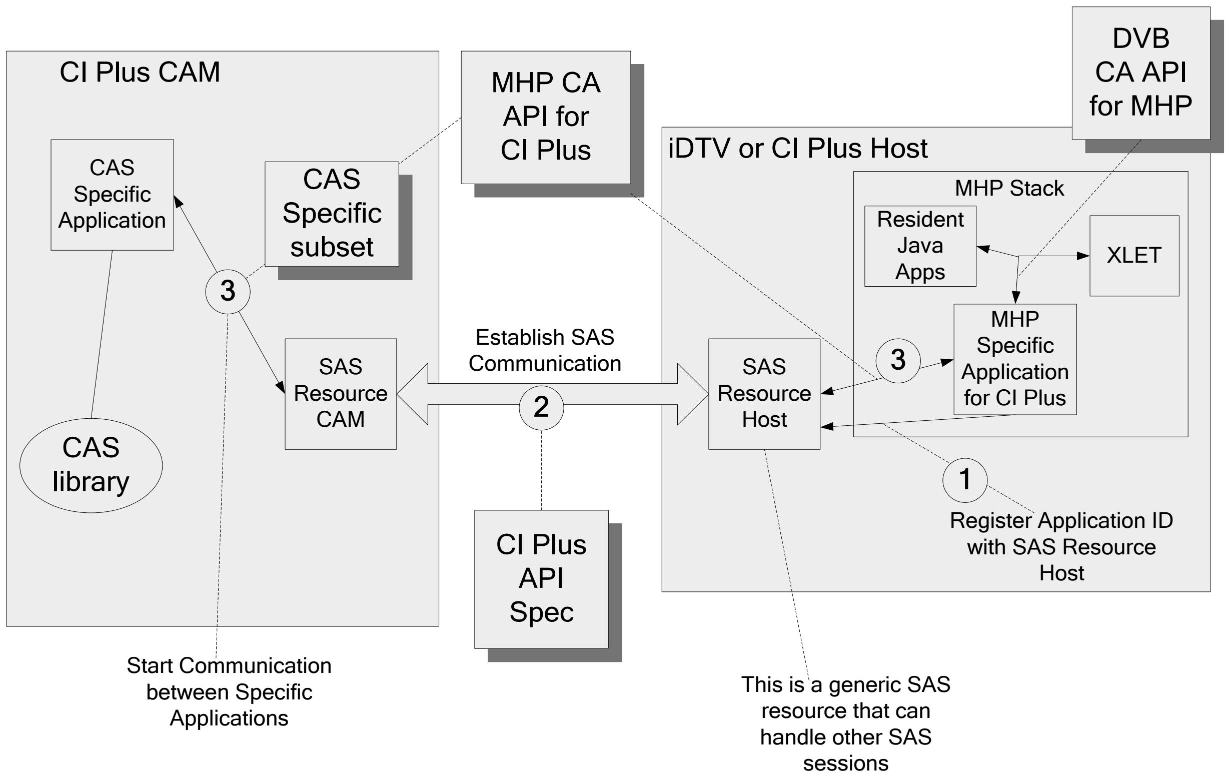
CI Plus CAM
CAS Specific Application
CAS Specific subset
CAS library
3
SAS Resource CAM
MHP CA API for CI Plus
Establish SAS Communication
2
CI Plus API Spec
DVB CA API for MHP
iDTV or CI Plus Host
MHP Stack
Resident Java Apps
XLET
MHP Specific Application for CI Plus
3
SAS Resource Host
1
Register Application ID with SAS Resource Host
Start Communication between Specific Applications
This is a generic SAS resource that can handle other SAS sessions

Figure M.3: CA system and MHP connectivity through SAS

Where:

- The `private_Host_application_ID` shall be predefined for MHP environments.
- The `Open_Session_Request/Response` and `SAS_Connect_Request/cnf` are used to establish communication session.
- Thereafter the `SAS_async_msg()` is used to send data asynchronously between the specific applications in Host and CICAM.

Additionally,

- The MHP CA API implementation must be processed by the MHP SAS application in the event that the CICAM is used for CAS (or to the embedded CA if local CAS is selected).
- The SAS MHP application shall map between the MHP CA API and the MHP CA API for CI Plus as specified in this Annex.
- The SAS MHP messages shall support the full MHP CA API superset. Private Data that is CA vendor specific shall be passed transparently through the interface in a defined way and is unambiguously specified in the MHP CA API for CI Plus.
- The SAS MHP Application in the CAM is a subset according to the requirements for a particular CAS.

M.1.4 Key Decisions (Informative)

The key decisions in defining the MHP application link are outlined below:

- SAS is selected for data transport over the Common Interface.
- The CA system link does not need to be encrypted.
- A common message format over SAS is required to map the CA system to the MHP API.
- The CICAM and Host manufacturers are to implement the message formatting. i.e. Host manufactures couple to `ita.dtt.ca`, CICAM manufacturers couple to the CA system API.
- The messages shall encapsulate all of the requirements of `ita.dtt.ca` and do not require use of other CI resources for information.

M.2 Message Format (Normative)

This section describes the MHP `it.dtt.ca` [35] message format. A MHP enabled CICAM and Host shall support all messages.

M.2.1 Session Establishment

The application domain on the CICAM shall open a SAS session. The Host shall request a connection for the MHP application using the `SAS_connect_rqst()` APDU to the CICAM establishing a connection between the application and the CA system. The connection shall be established with a 64-bit `private_Host_application_ID` of `"itdttca\0"` which has the hexadecimal value of `0x6974647474636100`.

The CICAM shall respond with a `SAS_connect_cnf()` APDU and set the `SAS_session_status` field to define the connection status.

M.2.2 Session Operation

The application API shall operate in asynchronous mode only to query and exchange data using the `SAS_async_msg()` which is reproduced in Table M.1.

Table M.1: SAS_Async_Message APDU syntax

Syntax	No. of bits	Mnemonic
`SAS_async_msg() {`		
`    SAS_async_msg_tag`	24	uimsbf
`    length_field()`	*	
`    message_nb`	8	uimsbf
`    message_length`	16	uimsbf
`    message_byte()`	8 * message_length	
`}`		

Semantics for the `SAS_async_msg()` APDU syntax are defined by the OpenCableTM Specifications, CableCardTM Interface 2.0 [27, 9.17.8] with the following qualifications:

message_nb: The message number that is generated from a 8-bit cyclic counter, the Host and CICAM shall maintain their own message counter numbers which shall be incremented by 1 on each message sent. The counter shall wrap from 255 to 0.

The `message_byte()` field for each message shall take the general form specified in Table M.2 where the message data may be broken into a number of records containing the same or different types of data identified by the `datatype_id`.

Table M.2: General message_byte() syntax

Syntax	No. of bits	Mnemonic
`message_byte() {`		
`    command_id`	8	uimsbf
`    ca_system_id`	16	uimsbf
`    transaction_id`	32	uimsbf
`    send_datatype_nbr`	8	uimsbf
`    for (i=0; i<send_datatype_nbr; i++) {`		
`        datatype_id`	8	uimsbf
`        datatype_length`	16	uimsbf
`        data_type()`	8 * datatype_length	bslbf
`    }`		
`}`		

Semantics for the general `message_byte()` syntax:

command_id: This is a 8-bit value that identifies the message type and shall be either a command or a response. The field values are defined in Table M.3. The command identity space is generally divided into two parts, a command is even, while the response to a command is the even command identity plus 1.

Table M.3: Message Command Identities

Command_id	Identity	Direction	Description
reserved	0x00		Reserved for future use.
reserved	0x01		Reserved for future use.
CMD_ATR_GET_REQUEST	0x02	H → M	A request sent by the Host to query the SmartCard ATR information.
CMD_ATR_GET_RESPONSE	0x03	H ← M	A response to a ATR Get Request Message by the CICAM detailing the ATR information of the smart card in the given slot or with the given identity.
CMD_CANCEL_REQUEST	0x04	H ← M H → M	A request sent by either the Host or the CICAM to cancel a request with a specified transaction identity, the command (if it exists) will be cancelled and the command returns a failed status.
CMD_CANCEL_RESPONSE	0x05	H ← M H → M	A response to a Cancel Request Message, the cancel response is ONLY dispatched if no transaction_id exists that needs to be cancelled.
CMD_CAPABILITIES_REQUEST	0x06	H → M	Queries the CICAM for information on the CAS systems supported.
CMD_CAPABILITIES_RESPONSE	0x07	H ← M	Response from the CICAM to a CMD_CAPABILITIES_REQUEST message informing the Host of the CA system information.
CMD_HISTORY_GET_REQUEST	0x08	H → M	A request sent by the Host to get the history information.
CMD_HISTORY_GET_RESPONSE	0x09	H ← M	A response to a History Get Request Message by the CICAM detailing the product information of the event.
CMD_HISTORY_SET_REQUEST	0x0a	H → M	A request sent by the Host to set the history information.
CMD_HISTORY_SET_RESPONSE	0x0b	H ← M	A response to a History Set Request Message by the CICAM.
CMD_NOTIFICATION_DISABLE	0x0c	H → M	Disable asynchronous event notifications from the CICAM.
CMD_NOTIFICATION_ENABLE	0x0d	H → M	Enable asynchronous event notifications from the CICAM.
CMD_PARENTAL_LEVEL_GET_REQUEST	0x0e	H → M	A request from the Host to query the current parental control level.
CMD_PARENTAL_LEVEL_GET_RESPONSE	0x0f	H ← M	A response from the CICAM to retrieve the current parental control level in response to a CMD_PARENTAL_LEVEL_GET_REQUEST.

Command_id	Identity	Direction	Description
CMD_PARENTAL_LEVEL_SET_REQUEST	0x10	H → M	A request from the Host to modify the current parental control level.
CMD_PARENTAL_LEVEL_SET_RESPONSE	0x11	H ← M	A response from the CICAM to modify the parental control level in response to a CMD_SET_PARENTAL_LEVEL_REQUEST.
CMD_PIN_CHECK_REQUEST	0x12	H → M	A request sent by the Host to check the Pin information.
CMD_PIN_CHECK_RESPONSE	0x13	H ← M	A response to a Set PIN Request Message by the CICAM confirming the correct PIN code.
CMD_PIN_GET_REQUEST	0x14	H → M	Queries the CICAM for status information on the Personal Identification Numbers (PIN).
CMD_PIN_GET_RESPONSE	0x15	H ← M	A response message from the CICAM to a CMD_PIN_STATUS_REQUEST message conveying the status information of the PINs.
CMD_PIN_SET_REQUEST	0x16	H → M	A request sent by the Host to change the current Pin information.
CMD_PIN_SET_RESPONSE	0x17	H ← M	A response to a PIN Set Request Message by the CICAM detailing the PIN information held by the CA system.
CMD_PRIVATE_DATA_REQUEST	0x18	H ← M H → M	A request sent by either the Host or the CICAM to exchange private information.
CMD_PRIVATE_DATA_RESPONSE	0x19	H ← M H → M	A response to a Private Data Request Message.
CMD_PRODUCT_GET_REQUEST	0x1a	H → M	A request sent by the Host to query the current product information.
CMD_PRODUCT_GET_RESPONSE	0x1b	H ← M	A response to a Product Get Request Message by the CICAM detailing the product information of the event.
CMD_PURCHASE_CANCEL_REQUEST	0x1c	H → M	A request sent by the Host to cancel a purchase an event.
CMD_PURCHASE_CANCEL_RESPONSE	0x1d	H ← M	A response to a Purchase Get Request Message by the CICAM detailing the product information of the event.
CMD_PURCHASE_SET_REQUEST	0x1e	H → M	A request sent by the Host to purchase an event.
CMD_PURCHASE_SET_RESPONSE	0x1f	H ← M	A response to a Purchase Set Request Message by the CICAM detailing the product information of the event.
CMD_RECHARGE_REQUEST	0x20	H → M	A request sent by the Host to recharge the wallet with monies.
CMD_RECHARGE_RESPONSE	0x21	H ← M	A response to a Recharge Request Message by the CICAM detailing the outcome of the recharge event.
CMD_SLOT_GET_REQUEST	0x22	H → M	A request sent by the Host to query the slot information.
CMD_SLOT_GET_RESPONSE	0x23	H ← M	A response to a Slot Get Request Message by the CICAM detailing the slot information of the smart card in the given slot.
CMD_SMARTCARD_GET_REQUEST	0x24	H → M	A request sent by the Host to query the SmartCard information.
CMD_SMARTCARD_GET_RESPONSE	0x25	H ← M	A response to a SmartCard Get Request Message by the CICAM detailing the smart card information of the smart card in the given slot or with the given identity.
CMD_SMARTCARD_SET_REQUEST	0x26	H → M	A request sent by the Host to set the user data information on the SmartCard.
CMD_SMARTCARD_SET_RESPONSE	0x27	H ← M	A response to a SmartCard Set Request Message by the CICAM detailing the smart card information of the smart card in the given slot or with the given identity.
CMD_WALLET_GET_REQUEST	0x28	H → M	A request sent by the Host to get the wallet information.
CMD_WALLET_GET_RESPONSE	0x29	H ← M	A response to a Wallet Get Request Message by the CICAM.
CMD_PRODUCT_INFO_GET_REQUEST	0x30	H → M	A request sent by the Host to query the current product status information.

Command_id	Identity	Direction	Description
CMD_PRODUCT_INFO_GET_RESPONSE	0x31	H ← M	A response to a Product Info Get Request Message by the CICAM detailing the product status information.
	0x32-0x3f		Reserved for future use.
CMD_ACCESS_EVENT	0x40	H ← M	An event message from the CICAM to notify a listener about a CA module status changes regarding the access, descrambling and purchasing periods.
CMD_CREDIT_EVENT	0x42	H ← M	An event message from the CICAM on a change of state of the wallet credit.
CMD_MESSAGE_EVENT	0x44	H ← M	An event message from the CICAM notifying a new information message.
CMD_PIN_REQUEST_EVENT	0x46	H ← M	An event from the CICAM indicating that a PIN entry is required.
CMD_PIN_RESPONSE_EVENT	0x47	H → M	A response from the Host to the CICAM to a Pin Request Event Message which includes the requested PIN code
CMD_PRIVATE_DATA_EVENT	0x48	H ← M H → M	A request sent by either the Host or the CICAM to exchange private information, no acknowledgement is required.
CMD_PRODUCT_EVENT	0x4a	H ← M	An event message from the CICAM on a change of product status.
CMD_PURCHASE_HISTORY_EVENT	0x4c	H ← M	An event message from the CICAM on a change to the purchase history.
CMD_RECHARGE_EVENT	0x4e	H ← M	An event message from the CICAM indicating that a recharge event has completed.
CMD_SLOT_EVENT	0x50	H ← M	An event message from the CICAM on a change of card status, this message shall be sent asynchronously whenever the card status changes.
CMD_SMARTCARD_EVENT	0x52	H ← M	An event message from the CICAM on a change of card status.
	0x54-0x7f		Reserved for future use.
	0x80-0xff		User defined.

ca_system_id: This is a 16-bit integer that identifies the CA system being queried, this may be 0 when querying the CICAM or transmitting a non-CA specific message.

transaction_id: A 32-bit value, generated by the sender of a data request message, that is returned in any corresponding reply (response) message to that request. The **transaction_id** allows any asynchronous request for information to be paired with any response that returns information. There are no constraints on the value of this field.

send_datatype_nbr: The number of data type items included in the message.

datatype_id: The type of the data contained in the data type loop, the values are defined in Table M.4.

Table M.4: Data Type Identities

Datatype Identity	datatype id	Description
	0	Reserved.
`dtid_access_event`	31	Information about the access to services from the CA system.
`dtid_byte_data()`	1	Generic byte data.
`dtid_cas_information()`	2	Identifies the CA provider and information about the CA system.
`dtid_cicam_information()`	3	Identifies the CICAM supplier and information about the CICAM system.
`dtid_credit_event()`	4	Notification status about the wallet and credit from the CA system.
`dtid_error_status`	5	Error status information.
`dtid_history()`	6	A history or message record.
`dtid_history_event()`	7	Notification status about a change in the purchase history status or arrival of a new message from the CA system.
`dtid_history_request()`	8	A history information request.
`dtid_numeric_index()`	9	A numeric index or integer value.
`dtid_object_identity()`	10	A CA system assigned object identity or handle.

Datatype Identity	datatype id	Description
`dtid_parental_level()`	11	A parental level.
`dtid_pin_code()`	12	A PIN code.
`dtid_pin_event()`	13	Notification status from the CA system requesting that the PIN code should be entered.
`dtid_pin_information()`	14	Information about the PIN code.
`dtid_product()`	15	A product record.
`dtid_product_event()`	16	Notification status about the product from the CA system.
`dtid_product_info()`	30	Product status information record.
`dtid_product_request()`	17	A product information request.
`dtid_purchase()`	18	A purchase record.
`dtid_recharge()`	19	A recharge request.
`dtid_recharge_event()`	20	Notification status about a recharge from the CA system.
`dtid_service_id()`	21	A service identity, specified as a DVB locator.
`dtid_slot()`	22	Identifies the state of a smart card slot in the system.
`dtid_slot_event()`	23	Notification status about a card event from the CA system.
`dtid_smartcard()`	24	Smart card information.
`dtid_smartcard_event()`	25	Notification status about a smart card event from the CA system.
`dtid_smartcard_request()`	26	A smart card information request.
`dtid_user_data()`	27	User data.
`dtid_wallet()`	28	A wallet record.
`dtid_wallet_id()`	29	A wallet identity.
	32-127	Reserved for future use.
	128-255	User defined.

datatype_length: The value of the *datatype* field in bytes.

data_type(): The datum contents identified by the `datatype_id` of length `datatype_length` bytes. The data type loop shall only contain the specified data type, but may contain multiple records of the same type, the number of records may be determined by computation of the `datatype_length` field.

M.3 Message Components

This section describes the format of standard components that are used in the message definitions. These are fragments of data described as byte sequences which are referenced by the communication messages themselves. The basic constructs represent common constructs that are used in the CI messages. They are used as a short hand field definition rather than repeating a definition of a common construct.

M.3.1 Money

Money represents a quantity of money and includes the currency type and amount. The general form of any monetary value shall be conveyed in the form as show in Table M.5.

Table M.5: Money field syntax

Syntax	No. of bits	Mnemonic
`money() {`		
`currency`	24	bslbf
`num_of_decimals`	3	uimsbf
`sign`	1	bslbf
`decimals`	20	uimsbf
`}`		

Semantics for the money() syntax are:

currency: A string of 3 characters representing the currency as defined by ISO 4217. The currency is specified as three upper case characters e.g. `EUR`, `GBP`, `USD`, etc.

num_of_decimals: The number of decimal places of this currency.

sign: The sign of the decimal value indicating a positive or negative value. "0" is positive, "1" is negative.

decimals: The value of this currency specified as a unsigned 20-bit integer. Currency units may be determined by using the `num_of_decimals` field.

When the field is undefined then all bits of the money() block shall be "1" (i.e. `0xffffffffffff`).

M.3.2 Time

This 40-bit field contains the time in Universal Time, Coordinated (UTC) and Modified Julian Date (MJD) as defined in EN 300 468 [10], Annex C. The general form of any time value shall be conveyed in the form show in Table M.6.

Table M.6: Time field syntax

Syntax	No. of bits	Mnemonic
`time() {`		
`   mjd`	16	uimsbf
`   utc`	24	bslbf
`}`		

Semantics for the time() block are:

mjd: 16-bit Modified Julian Date, refer to EN 300 468 [10], Annex C.

utc: Universal Time, Coordinated (UTC) coded as 6 digits in 4-bit Binary Coded Decimal (BCD).

If the time is undefined then all bits of the time block are set to "1" (i.e. `0xffffffffff`).

M.3.3 Duration

This is a 24-bit field that contains a duration specified in hours, minutes and seconds. The general form of any duration value shall be conveyed in the form show in Table M.7.

Table M.7: Duration field syntax

Syntax	No. of bits	Mnemonic
`duration() {`		
`   elapsed`	24	bslbf
`}`		

Semantics for the duration() block are:

elapsed: The elapsed time coded as 6 digits in 4-bit Binary Coded Decimal (BCD) - this is the same format as the `utc` field in `date()`.

If the duration is undefined then all bits of the duration field are set to "1" (i.e. `0xffffff`).

M.3.4 String

A string field represents a variable length string up to 255 characters in length. The general form of any string shall be conveyed in the form show in Table M.8.

Table M.8: String field syntax

Syntax	No. of bits	Mnemonic
`string() {`		
`   length`	8	uimsbf
`   for (i=0; i<length; i++) {`		
`      char`	8	bslbf
`   }`		
`}`		

Semantics for the string() block are:

length: This 8-bit field specifies the length in bytes of the character forming the text string.

char: This is an 8-bit field. A string of `char` fields specify the string text. Text information is coded using the character sets and methods described in EN 300 468 [10] Annex A.

M.3.5 Lstring

A long string field represents a variable length string which may exceed 255 characters and is typically used for a long description or detailed information. The general form of any long string shall be conveyed in the form show in Table M.9.

Table M.9: Long string field syntax

Syntax	No. of bits	Mnemonic
`lstring() {`		
`   length`	16	uimsbf
`   for (i=0; i<length; i++) {`		
`      char`	8	bslbf
`   }`		
`}`		

Semantics for the lstring() block are:

length: This 16-bit field specifies the length in bytes of the character forming the text string.

char: This is an 8-bit field. A string of `char` fields specify the string text. Text information is coded using the character sets and methods described in EN 300 468 [10] Annex A.

M.3.6 Locator

A locator represents a DVB reference to a service or programme event. The general form of any locator shall be conveyed in the form show in Table M.10.

Table M.10: Locator field syntax

Syntax	No. of bits	Mnemonic
`locator() {`		
`   string_indicator`	1	bslbf
`   if (string_flag == 1) {`		
`      length`	7	uimsbf
`      for (i=0; i<length; i++) {`		
`         char`	8	bslbf
`      }`		
`   }`		
`   else {`		
`      tsid_indicator`	1	bslbf
`      sid_indicator`	1	bslbf
`      event_indicator`	1	bslbf
`      reserved_zero`	1	bslbf
`      num_components`	3	uimsbf
`      original_network_id`	16	uimsbf
`      if (tsid_indicator == 1) {`		
`         transport_stream_id`	16	uimsbf
`      }`		
`      if (sid_indicator == 1) {`		
`         service_id`	16	uimsbf
`      }`		
`      for (i=0; i<num_components; i++) {`		
`         component_tag`	8	uimsbf
`      }`		
`      if (event_indicator == 1) {`		
`         event_id`	16	uimsbf
`      }`		
`      path_segments`	*	string()
`   }`		
`}`		

Semantics for the locator() block are:

string_indicator: This 1-bit flag indicates the use of a DVB locator string format when set to "1" and indicates a binary field format when set to "0". In CI Plus then the binary format is the preferred transmission format and this field should always be "0", the string format shall only be used where the locator cannot be represented in a binary format.

length: This 7-bit field specifies the length in bytes of the DVB locator string.

char: This is an 8-bit field. A string of `char` fields specify the string text. Text information is coded using the character sets and methods described in EN 300 468 [10] Annex.

tsid_indicator: This 1-bit flag indicates that the locator includes the `transport_stream_id` when set to "1". If the field is "0" then the transport stream identity is not specified.

sid_indicator: This 1-bit flag indicates that the locator includes a `service_id` when set to "1". If the field is "0" then the service identity is not specified.

event_indicator: This 1-bit flag indicates that the locator includes a `event_id` when set to "1". If the field is "0" then the event identity is not specified.

num_components: This 3-bit flag identifies the number of component tags that are specified in the locator, this may be 0 when no components are present.

original_network_id: This 16-bit field specifies the label identifying the `network_id` of the originating delivery system of the information service indicated.

transport_stream_id: This is a 16-bit field that defines the transport stream containing the service indicated. This field may be optionally omitted.

service_id: This is a 16-bit field which uniquely identifies an information service within a transport stream. The `service_id` is the same as the `program_number` in the corresponding PMT. This field may be optionally omitted.

component_tag: This 8-bit field identifies an elementary stream component, the `component_tag`'s have no specific order. This field may be optionally omitted.

event_id: This 16-bit field contains the identification number of the described programme event in the EIT. This field may be optionally omitted.

path_segments: The text path segments of the DVB locator as defined in IETF RFC 2396.

M.3.7 Pin Code

A Personal Identification Number, or PIN, is a 4 digit access code which enables access to some services of the CA system and/or programme content. The general form of the pin code shall be conveyed in the form show in Table M.11.

Table M.11: PIN code syntax

Syntax	No. of bits	Mnemonic
`pin_code()`	16	uimsbf

Semantics for the pin_code() block are:

pin_code: This is a 16-bit field containing a 4-digit, 4-bit BCD, PIN code. When the value is undefined (i.e. not set) then the value of the field bits shall be all "1"s i.e. `0xffff`. When the PIN code is secret and not available then the value of the field shall be `0xfffe`.

EXAMPLE: A pin-code of 1234 is coded as `0x1234`.

EXAMPLE: A pin-code that is not defined or active shall be coded as `0xffff`.

EXAMPLE: A pin-code that is set and is secret shall be coded as `0xfffe`.

M.3.8 Parental Control Level

The parental control level describes the level of access available to the content. The general form of the field shall be conveyed in the form show in Table M.12.

Table M.12: Parental Control Level syntax

Syntax	No. of bits	Mnemonic
`parental_level()`	8	uimsbf

Semantics for the parental_level() are:

parental_level: The parental control level setting of the CA system. The values are shown in Table M.13.

Table M.13: Parental Control Values

Value	Mnemonic	Description
`0x00`	n/a	Reserved for future use.
`0x01`	PARENTAL_CONTROL_STRICT_MODE	Strict mode requires an extra PIN input for viewing all PPV events except those rated for any audience.
`0x02`	PARENTAL_CONTROL_INTERMEDIATE_MODE	Intermediate mode an extra PIN input for viewing PPV events rated *restricted* and *adult only* content with no PIN for all other types of event.
`0x03`	PARENTAL_CONTROL_PERMISSIVE_MODE	An extra PIN input for viewing PPV events rated *adults only* and no PIN for all other events.
`0x04-0x7f`	n/a	Reserved for future use.
`0x80-0xff`	n/a	User defined.

M.3.9 Properties

The Properties conveys generic information comprising a loop of names each with an associated data string. The general form of the properties shall be conveyed in the form show in Table M.14.

Table M.14: Properties field syntax

Syntax	No. of bits	Mnemonic
`properties() {`		
`num_properties`	8	uimsbf
`for (i=0; i<num_properties; i++) {`		
`name`	*	string()
`data`	*	lstring()
`}`		
`}`		

Semantics for the properties() block are:

num_properties: The number of properties described by the properties loop.

name: The name of the property.

data: The data associated with the property. The string content shall be interpreted in the context of *name*.

M.4 Message Types

The different message types are identified in the following sections:

M.4.1 ATR Get Request Message

A request sent by the Host to query the SmartCard ATR information. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_ATR_GET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.15.

Table M.15: ATR Get Request Message Data Types

Data Type Identity	Description
`dtid_smartcard_request()`	The card or slot to query.

M.4.2 ATR Get Response Message

A response to a ATR Get Request Message by the CICAM detailing the ATR information of the smart card in the given slot or with the given identity. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_ATR_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in a `atr_get_request_message()`.

data_type(): The data type fields associated with this response are shown in Table M.16.

Table M.16: ATR Get Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_data_byte()`	The data associated with the ATR.

M.4.3 Cancel Request Message

A request sent by either the Host or the CICAM to cancel a request with a specified transaction identity, the command (if it exists) shall be cancelled and the command returns a failed status. If there is no such request then a CMD_CANCEL_RESPONSE shall be sent. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_CANCEL_REQUEST`

ca_system_id: The identity of the CA system.

transaction_id: The request/response command to cancel.

data_type(): The data type fields associated with this request are shown in Table M.17.

Table M.17: Cancel Request Message Data Types

Data Type Identity	Description
`dtid_user_data()`	One or more private data fields.

M.4.4 Cancel Response Message

A response to a Cancel Request Message, the cancel response is ONLY dispatched if no **transaction_id** exists that needs to be cancelled. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_CANCEL_RESPONSE`

ca_system_id: The `ca_system_id` received in a `cancel_request_message()`.

data_type(): The data type fields associated with this request are shown in Table M.18.

Table M.18: Cancel Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.

M.4.5 Capabilities Request Message

A Host request for general information about the CA provider(s) and CA version numbers for all CA systems supported by the CICAM in addition to information about the CICAM itself. The CICAM shall respond with a `CAS_Response_Message()`. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_CAPABILITIES_REQUEST`

ca_system_id: The CA system to query, a value 0x0000 shall return all CA systems supported by the CICAM, a non-zero value queries information for a specific CA provider only.

data_type(): The data is ignored and shall be zero.

M.4.6 Capabilities Response Message

A response to a `CAS_request_message()` by the CICAM detailing the CA provider(s) and CA version numbers for all CA system supported by the CICAM. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_CAPABILITIES_RESPONSE`

ca_system_id: The `ca_system_id` received in a `CAS_request_message()`.

data_type(): The data type fields associated with this response are shown in Table M.19.

Table M.19: Capabilities Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_cas_information()`	One or more data blocks providing general information about the CA system(s) available on the CICAM. A single block shall be used for each CA system supported by the device.
`dtid_cicam_information()`	A single data block that provides information about the CICAM itself.

M.4.7 History Get Request Message

A request sent by the Host to get the history information. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_HISTORY_GET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.20.

Table M.20: History Get Request Message Data Types

Data Type Identity	Description
`dtid_history_request()`	One or more items specifying the history required.

M.4.8 History Get Response Message

A response to a History Get Request Message by the CICAM detailing the product information of the event. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_HISTORY_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in a `history_get_request_message()`.

data_type(): The data type fields associated with this response are shown in Table M.21.

Table M.21: History Get Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_history()`	The history information, there may be multiple history items. Multiple history items shall be delivered in list order whereby the first item of any list shall be index 0. The history items shall be delivered in a order that matches the original request.

M.4.9 History Set Request Message

A request sent by the Host to set the history information. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_HISTORY_SET_REQUEST`

ca_system_id: The identity of the CA system to modify.

data_type(): The data type fields associated with this request are shown in Table M.22.

Table M.22: History Set Request Message Data Types

Data Type Identity	Description
`dtid_history ()`	One or more items specifying the updated history, the first item shall represent index 0 when a list is being replaced. If the history status is delete then the history is deleted.

M.4.10 History Set Response Message

A response to a History Set Request Message by the CICAM. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_HISTORY_SET_RESPONSE`

ca_system_id: The `ca_system_id` received in a `history_get_request_message()`.

data_type(): The data type fields associated with this response are shown in Table M.23.

Table M.23: History Set Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_history()`	The revised history information, there may be multiple history items. Multiple history items shall be delivered in list order whereby the first item of any list shall be index 0.

M.4.11 Notification Enable/Disable Request Message

A request from the Host to CICAM to enable or disable asynchronous event notification on the change of state of the CA system and its associated environment. No response shall be returned to this command. On enabling notifications then the CICAM shall immediately notify the Host of the current status by sending event messages reflecting the current state of CA system, thereafter event messages shall only be dispatched on a change of state until such time that the notifier is disabled or the SAS session is closed.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_NOTIFICATION_ENABLE_REQUEST`, `CMD_NOTIFICATION_DISABLE_REQUEST`

ca_system_id: The identity of the CA system for which events are required.

data_type(): None.

M.4.12 Parental Level Get Request Message

A request from the Host to query the current parental control level.

command_id: `CMD_PARENTAL_LEVEL_GET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): None.

M.4.13 Parental Level Get Response Message

A response from the CICAM to retrieve the current parental control level.

command_id: `CMD_PARENTAL_LEVEL_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in a Parental Level Get Request Message.

data_type(): The data type fields associated with this response are shown in Table M.24.

Table M.24: Parental Level Get Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_parental_level()`	The current parental level information assigned to the system.

M.4.14 Parental Level Set Request Message

A request from the Host to modify the current parental control level.

command_id: `CMD_PARENTAL_LEVEL_SET_REQUEST`

ca_system_id: The identity of the CA system to modify.

data_type(): The data type fields associated with this request are shown in Table M.25.

Table M.25: Parental Level Set Request Message Data Types

Data Type Identity	Description
`dtid_parental_level()`	The new parental to assigned to the CA system.
`dtid_pin_code()`	The optional PIN code required by the CA system to authorise the change in parental level when required.

M.4.15 Parental Level Set Response Message

A response from the CICAM to modify the parental control level.

command_id: `CMD_PARENTAL_LEVEL_SET_RESPONSE`

ca_system_id: The `ca_system_id` received in the Parental Level Set Request Message.

data_type(): The data type fields associated with this response are shown in Table M.26.

Table M.26: Parental Level Set Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_parental_level()`	The new parental level information assigned to the system.

M.4.16 Pin Check Request Message

A request sent by the Host to check the Pin information. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_PIN_CHECK_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.27.

Table M.27: Pin Check Request Message Data Types

Data Type Identity	Description
`dtid_pin_information()`	The PIN information to check, the pin_code field shall contain the password to check. No PIN information shall be changed in the CA System as a result of this message.

M.4.17 Pin Check Response Message

A response to a Set PIN Request Message by the CICAM detailing the PIN information held by the CA system. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PIN_CHECK_RESPONSE`

ca_system_id: The `ca_system_id` received in the Pin Check Request Message.

data_type(): The data type fields associated with this response are shown in Table M.28.

Table M.28: PIN Check Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.

M.4.18 Pin Get Request Message

A `pin_request_message()` sent by the Host to enquire about the current PINs held by the CA system. The CICAM responds with the `pin_response_message()` containing PIN information. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PIN_GET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data is ignored and shall be zero.

M.4.19 Pin Get Response Message

A response to a `PIN_request_message()` by the CICAM detailing the PIN information held by the CA system. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PIN_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in the Pin Get Request Message.

data_type(): The data type fields associated with this response are shown in Table M.29.

Table M.29: Pin Get Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_pin_information()`	The PIN code information. One or more PIN codes may be returned.

M.4.20 Pin Set Request Message

A request sent by the Host to change the current Pin information. The CAS may not allow all fields of the PIN information to be modified under application control and shall apply the changes to those fields that are permitted by the CAS. i.e. The CAS may ignore field settings that it is not prepared to change under application control. The application may determine the changed state in any PIN response message. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_PIN_SET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.30.

Table M.30: Pin Set Request Message Data Types

Data Type Identity	Description
`dtid_pin_information()`	The updated PIN information and shall contain the existing PIN code.
`dtid_pin_code()`	If the PIN is being changed then an authorisation PIN may be required to enable the change of PIN code and shall be transmitted as a separate block.

M.4.21 Pin Set Response Message

A response to a PIN Set Request Message by the CICAM detailing the PIN information held by the CA system. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PIN_SET_RESPONSE`

ca_system_id: The `ca_system_id` received in a Pin Set Request Message.

data_type(): The data type fields associated with this response are shown in Table M.31.

Table M.31: PIN Set Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_pin_information()`	Contains the updated PIN information. The returned information reflects the current PIN information and the field settings may not exactly match the original request if the CA system does not allow update of some of the fields.

M.4.22 Private Data Request Message

A request sent by either the Host or the CICAM to exchange private information. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_PRIVATE_DATA_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.32.

Table M.32: Private Data Request Message Data Types

Data Type Identity	Description
`dtid_user_data()`	One or more private data fields.

M.4.23 Private Data Response Message

A response to a Private Data Request Message. The Semantics for the CAS_response_message() syntax are:

command_id: CMD_PRIVATE_DATA_RESPONSE

ca_system_id: The ca_system_id received in a Private Data Request Message.

data_type(): The data type fields associated with this request are shown in Table M.33.

Table M.33: Private Data Response Message Data Types

Data Type Identity	Description
dtid_error_status()	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
dtid_user_data()	One or more private data fields.

M.4.24 Product Get Request Message

A request sent by the Host to query the current product information. The Semantics for the CAS_request_message() syntax are:

command_id: CMD_PRODUCT_GET_REQUEST

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.34.

Table M.34: Product Get Request Message Data Types

Data Type Identity	Description
dtid_product_request()	The product to query.

M.4.25 Product Get Response Message

A response to a Product Get Request Message by the CICAM detailing the product information of the event. The Semantics for the CAS_response_message() syntax are:

command_id: CMD_PRODUCT_GET_RESPONSE

ca_system_id: The ca_system_id received in a Product Get Request Message.

data_type(): The data type fields associated with this response are shown in Table M.35.

Table M.35: Product Get Response Message Data Types

Data Type Identity	Description
dtid_error_status()	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
dtid_product()	The product data, multiple products maybe returned in a single or multiple datatype blocks.

M.4.26 Product Info Get Request Message

A request sent by the Host to query the current product status information. The Semantics for the CAS_request_message() syntax are:

command_id: CMD_PRODUCT_INFO_GET_REQUEST

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.36.

Table M.36: Product Get Request Message Data Types

Data Type Identity	Description
`dtid_object_identity()`	The product identifier to query, multiple product identifiers may be included in a single info request.

M.4.27 Product Info Get Response Message

A response to a Product Info Get Request Message by the CICAM detailing the product status information of the event. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_INFO_PRODUCT_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in a Product Get Request Message.

data_type(): The data type fields associated with this response are shown in Table M.37.

Table M.37: Product Get Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_product_info()`	Current information about the product, multiple product information may be returned. Information is only returned for products that exist.

M.4.28 Purchase Cancel Request Message

A request sent by the Host to cancel a purchase an event. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_PURCHASE_CANCEL_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.38.

Table M.38: Purchase Set Request Message Data Types

Data Type Identity	Description
`dtid_purchase ()`	The identity of the item to cancel.

M.4.29 Purchase Cancel Response Message

A response to a Purchase Get Request Message by the CICAM detailing the product information of the event. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PURCHASE_CANCEL_RESPONSE`

ca_system_id: The `ca_system_id` received in a Purchase Cancel Request Message.

data_type(): The data type fields associated with this response are shown in Table M.39.

Table M.39: Purchase Cancel Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_purchase()`	The purchase information.

M.4.30 Purchase Set Request Message

A request sent by the Host to purchase an event. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_PURCHASE_SET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.40.

Table M.40: Purchase Set Request Message Data Types

Data Type Identity	Description
`dtid_purchase ()`	The identity of the item to purchase.

M.4.31 Purchase Set Response Message

A response to a Purchase Set Request Message by the CICAM detailing the product information of the event. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PURCHASE_SET_RESPONSE`

ca_system_id: The `ca_system_id` received in the Purchase Set Request Message.

data_type(): The data type fields associated with this response are shown in Table M.41.

Table M.41: Purchase Set Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_purchase()`	The purchase data.
`dtid_product()`	The product data associated with the purchase.

M.4.32 Recharge Request Message

A request sent by the Host to recharge the wallet with monies. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_RECHARGE_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.42.

Table M.42: Recharge Request Message Data Types

Data Type Identity	Description
`dtid_recharge ()`	The recharge request information.

M.4.33 Recharge Response Message

A response to a Recharge Request Message by the CICAM detailing the outcome of the recharge event. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_RECHARGE_RESPONSE`

ca_system_id: The `ca_system_id` received in the Recharge Request Message.

data_type(): The data type fields associated with this response are shown in Table M.43.

Table M.43: History Set Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_wallet()`	The updated wallet data.
`dtid_recharge()`	Contains the original transaction information, including the recharge value.

M.4.34 Slot Get Request Message

A request sent by the Host to query the slot information. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_SLOT_GET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.44.

Table M.44: Slot Get Request Message Data Types

Data Type Identity	Description
`dtid_numeric_index()`	The identity number of the slot to query. If the numeric index is not present then all slots shall be assumed.

M.4.35 Slot Get Response Message

A response to a Slot Get Request Message by the CICAM detailing the slot information of the smart card in the given slot. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_SLOT_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in the Slot Get Request Message.

data_type(): The data type fields associated with this response are shown in Table M.45.

Table M.45: Slot Get Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_slot()`	The slot information, multiple blocks may be present if there are multiple slots in the CICAM.

M.4.36 SmartCard Get Request Message

A request sent by the Host to query the SmartCard information. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_SMARTCARD_GET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.46.

Table M.46: SmartCard Get Request Message Data Types

Data Type Identity	Description
`dtid_smartcard_request()`	The smart card to query.

M.4.37 SmartCard Get Response Message

A response to a SmartCard Get Request Message by the CICAM detailing the smart card information of the smart card in the given slot or with the given identity. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_SMARTCARD_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in the Smart Card Request Message.

data_type(): The data type fields associated with this response are shown in Table M.47.

Table M.47: Smartcard Get Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_smartcard()`	One or more data blocks containing the smart card information.

M.4.38 SmartCard Set Request Message

A request sent by the Host to set the user data information on the SmartCard. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_SMARTCARD_SET_REQUEST`

ca_system_id: The identity of the CA system to modify.

data_type(): The data type fields associated with this request are shown in Table M.48.

Table M.48: SmartCard Set Request Message Data Types

Data Type Identity	Description
`dtid_smartcard_request()`	The smart card to query.
`dtid_wallet_id()`	The identity of the new wallet to set as current. If this block is omitted then the current wallet shall remain unchanged.
`dtid_user_data()`	the user data to write to the smart card if the user data is to be updated. If this block is omitted then the user data shall remain unchanged.

M.4.39 SmartCard Set Response Message

A response to a SmartCard Get Request Message by the CICAM detailing the smart card information of the smart card in the given slot or with the given identity. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_SMARTCARD_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in the SmartCard Set Request Message.

data_type(): The data type fields associated with this response are shown in Table M.49.

Table M.49: SmartCard Set Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.

M.4.40 Wallet Get Request Message

A request sent by the Host to get the wallet information. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_WALLET_GET_REQUEST`

ca_system_id: The identity of the CA system to query.

data_type(): The data type fields associated with this request are shown in Table M.50.

Table M.50: Wallet Get Request Message Data Types

Data Type Identity	Description
`dtid_wallet_id()`	The wallet to query, multiple wallet identity data types may be present if information on a number of different wallets is required in a single request.

M.4.41 Wallet Get Response Message

A response to a Wallet Get Request Message by the CICAM. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_WALLET_GET_RESPONSE`

ca_system_id: The `ca_system_id` received in a Wallet Get Request Message.

data_type(): The data type fields associated with this response are shown in Table M.51.

Table M.51: History Set Response Message Data Types

Data Type Identity	Description
`dtid_error_status()`	The status of the request on a failure or when there is no information available, the status information may be optionally included with an OK status or may be omitted in the response and success shall be assumed.
`dtid_wallet()`	The requested wallet data, multiple wallet data types may be present if multiple wallets were originally requested. The wallets shall appear in the same order as they were requested.

M.5 Event Types

The different event message types are identified in the following sections, an event is generally distinguished from a request / response message type as it is unsolicited and generally does not require a response.

M.5.1 Access Event Message

An event message from the CICAM on a change of access to the broadcast material, this message shall be sent asynchronously whenever the access status changes. No response shall be returned. The message shall only be transmitted when notifications are enabled.

The Access Event may be used to notify a listener about a CA module status changes regarding the access, descrambling and purchasing periods. Under some circumstances, a single event in the CA system may result in multiple CAAccessEvents being posted. For example, successful purchase of a current program could result in both ACCESS_DESCRAMBLING_BEGIN and ACCESS_GRANTED.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_ACCESS_EVENT`

ca_system_id: The identity of the CA system generating the event.

data_type(): The data type fields associated with this request are shown in Table M.52.

Table M.52: Access Event Message Data Types

Data Type Identity	Description
`dtid_access_event()`	The access status. Multiple events may be included in a single or multiple data type blocks.

M.5.2 Credit Event Message

An event message from the CICAM on a change in credit, this message shall be sent asynchronously whenever the purchase credit state changes. No response shall be returned. The message shall only be transmitted when notifications are enabled.

The credit event may be used to notify a listener about a credit status changes regarding wallet recharge etc.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_CREDIT_EVENT`

ca_system_id: The identity of the CA system performing the credit charge.

data_type(): The data type fields associated with this request are shown in Table M.53.

Table M.53: Credit Event Message Data Types

Data Type Identity	Description
`dtid_credit_event()`	The credit status. Multiple events may be included in a single or multiple data type blocks. This data type block shall appear before any associated datatype information associated with the event.
`dtid_wallet()`	The wallet associated with the credit change.
`dtid_smartcard()`	The Smart Card associated with the credit change.

M.5.3 Message Event Message

An event message from the CICAM on a new message from the service operator, this message shall be sent asynchronously. No response shall be returned. The message shall only be transmitted when notifications are enabled.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_MESSAGE_EVENT`

ca_system_id: The identity of the CA system generating the event.

data_type(): The data type fields associated with this request are shown in Table M.54.

Table M.54: Message Event Message Data Types

Data Type Identity	Description
`dtid_history_event()`	The new message status. This data type block shall appear before any associated datatype information associated with the event.
`dtid_history()`	The message information.
`dtid_smartcard()`	The Smart Card associated with the message event.

M.5.4 Pin Request Event Message

An event from the CICAM indicating that a PIN entry is required, this message shall be sent asynchronously. A pin code response may be optionally returned to the Smart Card. The message shall only be transmitted when notifications are enabled.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PIN_REQUEST_EVENT`

ca_system_id: The identity of the CA system generating the event.

data_type(): The data type fields associated with this request are shown in Table M.55.

Table M.55: PIN Request Event Message Data Types

Data Type Identity	Description
`dtid_pin_event()`	The PIN code request. This data type block shall appear before any associated datatype information associated with the event.
`dtid_pin_information()`	The PIN information.

M.5.5 Pin Request Response Message

A response from the Host to the CICAM to a Pin Request Event Message which includes the requested PIN code. The response may be optionally sent by the Host and shall use the same **transaction_id** to return the PIN code. This is the only event message for which a response may be returned.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PIN_RESPONSE_EVENT`

ca_system_id: The identity of the CA system as defined in the Pin Request Event Message requesting a PIN.

data_type(): The data type fields associated with this request are shown in Table M.56.

Table M.56: PIN Response Event Message Data Types

Data Type Identity	Description
`dtid_pin_information()`	The PIN information. A valid PIN code shall be included in the `pin_code` field.

M.5.6 Private Data Event Message

An event sent by either the Host or the CICAM to exchange private information, no acknowledgement is required. The Semantics for the CAS_request_message() syntax are:

command_id: `CMD_PRIVATE_DATA_EVENT`

ca_system_id: The identity of the recipient CA system.

data_type(): The data type fields associated with this request are shown in Table M.57.

Table M.57: Private Data Event Message Data Types

Data Type Identity	Description
`dtid_user_data()`	One or more private data fields.

M.5.7 Product Event Message

An event message from the CICAM on a change of product status, this message shall be sent asynchronously whenever the product state changes. No response shall be returned. The message shall only be transmitted when notifications are enabled.

The product Event may be used to notify a listener about a CA programme status changes regarding the Pay-per-View start, stop and product list changes.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PRODUCT_EVENT`

ca_system_id: The identity of the CA system generating the event.

data_type(): The data type fields associated with this request are shown in Table M.58.

Table M.58: Product Event Message Data Types

Data Type Identity	Description
`dtid_product_event()`	The product status. Multiple events may be included in a single or multiple data type blocks. This data type block shall appear before any dtid_product() associated with the event.
`dtid_product()`	The product associated with the event. Multiple products may be included in a single or multiple data type blocks. The programmes relate to the last dtid_product_event() included in the data type field.

M.5.8 Purchase History Event Message

An event message from the CICAM on a change to the purchase history, this message shall be sent asynchronously whenever the history state changes. No response shall be returned. The message shall only be transmitted when notifications are enabled.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_PURCHASE_HISTORY_EVENT`

ca_system_id: The identity of the CA system generating the event.

data_type(): The data type fields associated with this request are shown in Table M.59.

Table M.59: Purchase History Event Message Data Types

Data Type Identity	Description
`dtid__history_event()`	The purchase history status. This data type block shall appear before any associated datatype information associated with the event.
`dtid_history()`	The history associated with the purchase history change.
`dtid_smartcard()`	The Smart Card associated with the purchase history event.

M.5.9 Recharge Event Message

An event message from the CICAM indicating that a recharge event has completed, this message shall be sent asynchronously. No response shall be returned. The message shall only be transmitted when notifications are enabled.

The CA product Event may be used to notify a listener about recharge transactions.

The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_RECHARGE_EVENT`

ca_system_id: Th identity of the CA system generating the event.

data_type(): The data type fields associated with this request are shown in Table M.60.

Table M.60: Recharge Event Message Data Types

Data Type Identity	Description
`dtid_recharge_event()`	The recharge status. This data type block shall appear before any associated datatype information associated with the event.

M.5.10 Slot Event Message

An event message from the CICAM on a change of slot status, this message shall be sent asynchronously whenever the slot status changes. No response shall be returned. The message shall only be transmitted when notifications are enabled. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_SLOT_EVENT`

ca_system_id: The identity of the CA system generating the event.

data_type(): The data type fields associated with this request are shown in Table M.61.

Table M.61: Slot Event Message Data Types

Data Type Identity	Description
`dtid_slot_event()`	The state of the slot.

M.5.11 Smart Card Event Message

An event message from the CICAM on a change of card status, this message shall be sent asynchronously whenever the card status changes. No response shall be returned. The message shall only be transmitted when notifications are enabled. The Semantics for the CAS_response_message() syntax are:

command_id: `CMD_SMARTCARD_EVENT`

ca_system_id: The identity of the CA system generating the event.

data_type(): The data type fields associated with this request are shown in Table M.62.

Table M.62: Slot Event Message Data Types

Data Type Identity	Description
`dtid_smartcard_event()`	The state of the smartcard.
`dtid_smartcard()`	The Smart Card associated with the event.

M.6 Data Type Id Components

The datatype_id structures are identified in the following sections:

M.6.1 Access Event

Status information about the access to the services from the CA system. The general form of the access status data shall be conveyed in the form show in Table M.63.

Table M.63: Access Event syntax

Syntax	No. of bits	Mnemonic
`dtid_access_event() {`		
`access_status`	8	uimsbf
`description`	*	string()
`object_id`	*	string()
`private_data`	*	string()
`}`		

Semantics for the dtid_access_event() event data type syntax:

access_status: The access state to the current material The values are shown in Table M.64.

Table M.64: Access Status Values

Value	Mnemonic	Description
`0x00`	n/a	Reserved for future use.
`0x01`	ACCESS_GENERIC_EVENT	An unknown or unspecified event.
`0x02`	ACCESS_DESCRAMBLING_BEGIN	The current service has started descrambling.
`0x03`	ACCESS_DESCRAMBLING_END	The descrambling process has been stopped for the current service.
`0x04`	ACCESS_FREE_WINDOW_BEGIN	The free window period for current PPV event has started.
`0x05`	ACCESS_FREE_WINDOW_END	The free window period for current PPV event has ended.
`0x06`	ACCESS_PURCHASE_PERIOD_BEGIN	The purchase period for current PPV event has started.
`0x07`	ACCESS_PURCHASE_PERIOD_END	The purchase period for current PPV event has ended.
`0x08`	ACCESS_GRANTED	The CA is entitled to descramble the current PPV event.
`0x09`	ACCESS_DENIED	The CA is not entitled to descramble the current PPV event.
`0x0a`	ACCESS_DENIED_FOR_PARENTAL_RATING	The CA is not entitled to descramble the current PPV event due to parental rating.
`0x0b`	ACCESS_CARD_NEEDED	A card is required.
`0x0c`	ACCESS_DENIED_FOR_SMART_CARD_ERROR	The CA is not entitled to descramble the current PPV event due to a smart card issue. The smart card status may be retrieved using other smartcard specific methods.
`0x0d`	ACCESS_CLEAR	The signal is not scrambled.
`0x0e`	ACCESS_FREE	The signal is scrambled in a free mode.
`0x0e-0x7f`	n/a	Reserved for future use.
`0x80-0xff`	n/a	User defined.

description: An optional text description of the event.

object_id: An optional CA object identity associated with this event.

private_data: Optional private data associated with the event.

M.6.2 Byte Data

The Byte Data includes an arbitrary string of data bytes. The datatype is formatted as shown in Table M.65.

Table M.65: Byte Data data type syntax

Syntax	No. of bits	Mnemonic

`dtid_byte_data() {`
`   byte_data`
`}`
	*	lstring()

Semantics for the dtid_byte_data() data type syntax:

byte_data: An arbitrary block of data.

M.6.3 CAS Information

The dtid_cas_information() conveys the CA System information. The general form shall be conveyed in the form shown in Table M.66 .

Table M.66: CA System Information data type syntax

Syntax	No. of bits	Mnemonic
`dtid_cas_information() {`		
`ca_system_id`	16	uimsbf
`name`	*	string()
`revision`	*	string()
`version`	*	string()
`}`		

Semantics for the dtid_cas_infomation() data type syntax:

ca_system_id: The DVB CA system identity as defined by ETSI TS 101 162 [32] or 0x0000 indicating that the record identifies the CICAM.

name: The name of the CA provider coded using the character sets and methods described in EN 300 468 [10].

revision: The revision of the CA kernel, in a CA system provider form, coded using the character sets and methods described in EN 300 468 [10].

version: The version of the CA kernel, in a CA system provider form, coded using the character sets and methods described in EN 300 468 [10].

M.6.4 CICAM Information

The dtid_cicam_information() conveys the CICAM information. The general form is show in Table M.67.

Table M.67: CICAM information data type syntax

Syntax	No. of bits	Mnemonic
`dtid_cicam_information() {`		
`slot_count`	4	uimsbf
`reserved`	4	bslbf
`name`	*	string()
`revision`	*	string()
`version`	*	string()
`serial_number`	*	string()
`}`		

Semantics for the dtid_cicam_infomation() data type syntax:

slot_count: The number of smart card slots supported by the CICAM.

reserved: Reserved for future use.

name: The name of the CICAM supplier coded using the character sets and methods described in EN 300 468 [10].

revision: The revision of the CICAM, in a CICAM determined form, coded using the character sets and methods described in EN 300 468 [10].

version: The version of the CICAM, in a CICAM form, coded using the character sets and methods described in EN 300 468 [10].

serial_number: The serial number of the CICAM, in a CICAM form, coded using the character sets and methods described in EN 300 468 [10].

M.6.5 Credit Status Event

Notification status about the wallet and credit from the CA system. The general form of the wallet and credit status data shall be conveyed in the form show in Table M.68.

Table M.68: Credit Status Event syntax

Syntax	No. of bits	Mnemonic
`dtid_credit_event() {`		
`credit_status`	8	uimsbf
`description`	*	string()
`object_id`	*	string()
`private_data`	*	string()
`}`		

Semantics for the dtid_credit_event() data type syntax:

credit_status: The status of the credit as defined in Table M.69:

Table M.69: Credit Status Values

Value	Mnemonic	Description
0x00	CREDIT_CHANGED	The credit on the card is changed.
0x01-0x7f	n/a	Reserved for future use.
0x80-0xff	n/a	User defined

description: An optional text description of the event.

object_id: An optional CA object identity associated with this event.

private_data: Optional private data associated with the event.

M.6.6 Error Status

The `dtid_error_status` data type conveys information about a failure of a request. The general form shall be conveyed in the form show in Table M.70.

Table M.70: Error Status field syntax

Syntax	No. of bits	Mnemonic
`dtid_error_status() {`		
`error_code`	8	uimsbf
`message`	*	string()
`}`		

Semantics for the dtid_error_status() block are:

error_code: An error code associated with the original request that failed, the error code shall be interpreted in the context of the original request. The error codes are shown in Table M.71.

Table M.71: Error code values

Value	Mnemonic	Description
0	OK	No error.
1	PIN_REQUIRED	A PIN code is required (or NULL PIN has been passed).
2	PIN_ERROR	The entered PIN code was incorrect.
3	CARD_BLOCKED	The smart card is blocked.
4	CARD_EXPIRED	The card has expired.
5	CREDIT_LACK	There is insufficient credit to purchase the PPV event.
6	CARD_REMOVED	The card was removed during the process.
7	CARD_ERROR	Generic communication error with the smart card.
8	PURCHASE_TIME_ENDED	The purchase period ended while proceeding with a purchase.
9	ALREADY_PURCHASED	It is not possible to buy the even because it has already been purchased.
10	CARD_MUTED	The card is muted.
11-21	n/a	Reserved for future use.
22	CARD_DAMAGED	No smart card is inserted.
23	UNSUPPORTED_FEATURE	Feature is not supported.
24	NO_OFFERS	No events are offered currently.
25-50	n/a	Reserved for future use.
51	SMS_DENIAL	SMS denied the recharge to success.
52	CONNECTION_ERROR	The recharge ended with a failure due to a connection problem.
53	INVALID_SCRATCH	Recharge event ended with a failure due to incorrect scratch card number.
54	MAXIMUM_CREDIT	Recharge event ended with a failure because the user reached the maximum credit.
55	PARAMETER_ERROR	Recharge event ended with a failure because parameters used in the transaction were incorrect.
56-99	n/a	Reserved for future use.
100	GENERIC_ERROR	Unspecified generic error.
101-124	n/a	Reserved for future use.
125	BUSY	The system is busy and cannot service the request.
126	SYSTEM_ERROR	The system has suffered a fatal error and cannot service the request.
127	BAD_COMMAND	An unrecognised command has been received.
128-255	n/a	User defined.

message: An optional string message associated with the error code.

M.6.7 History

A History item represents a previous purchase of a pay event, be it a subscription or PPV event. The general form of the history request shall be conveyed in the form show in Table M.72.

Table M.72: History field syntax

Syntax	No. of bits	Mnemonic
`dtid_history() {`		
`type`	8	uimsbf
`id`	*	string()
`nid`	32	uimsbf
`cancelled`	1	bslbf
`status`	7	uimsbf
`history_date`	*	time()
`private_data`	*	lstring()
`if (type == HISTORY_TYPE_PPV) {`		
`ppv_product_id`	*	string()
`ppv_order_date`	*	time()
`ppv_item_status`	8	uimsbf
`}`		
`else if (type == HISTORY_TYPE_RECHARGE) {`		
`recharge_value`	*	money()
`recharge_source`	8	
`recharge_transaction_id`	*	string()
`}`		
`else if (type == HISTORY_TYPE_MESSAGE) {`		
`message_subject`	*	string()
`message_body`	*	lstring()
`message_priority`	8	uimsbf
`message_date`	*	time()
`}`		
`else {`		
`properties`	*	properties()
`}`		
`}`		

Semantics for the dtid_history() data type syntax:

type: The type of history, as defined in Table M.73.

Table M.73: History Type Values

Value	Mnemonic	Description
0x00	HISTORY_TYPE_RESERVED	Reserved for future use.
0x01	HISTORY_TYPE_PPV	Pay per view item.
0x02	HISTORY_TYPE_RECHARGE	Recharge item.
0x03	HISTORY_TYPE_MESSAGE	A message from the broadcaster.
0x04-0x7f	n/a	Reserved for future use.
0x80-0xff	n/a	User defined.

id: The CA system string identity assigned to the history item, this field is opaque and private to the CA system. This is a variable length text string.

nid: The CA system numeric identity assigned to the history item that uniquely identifies it.

cancelled: The purchase cancel state, zero "0" indicates that the order has not been cancelled, "1" indicates that the order has been cancelled.

status: The status of the history item, defined as Table M.74:

Table M.74: History Status Values

Value	Mnemonic	Description
0x00	HISTORY_STATUS_RESERVED	Reserved for future use.
0x01	HISTORY_STATUS_UNREAD	The history item is un-read.
0x02	HISTORY_STATUS_READ	The history item has been read.
0x03	HISTORY_STATUS_DISPOSED	The history item has been disposed.
0x04-0x3e	n/a	Reserved for future use.
0x3f	HISTORY_STATUS_DELETE	Delete the history item.
0x40-0x7f	n/a	User defined.

history_date: The date when the item was added to the history list. This may be undefined if the CA system does not associate a date with the history.

private_data: Private data associated with the purchase.

ppv_product_id: The CA system assigned product identity that was purchased. This is a variable length string.

ppv_order_date: The date when the order was made.

ppv_item_status: The current status of the history item, as defined in Table M.75.

Table M.75: History Event Item Status Values

Value	Mnemonic	Description
0x00	ITEM_STATUS_ EVENT_SEEN	The event has already been seen.
0x01	ITEM_STATUS_ EVENT_UPCOMING	The event has been purchased and it is upcoming.
0x02	ITEM_STATUS_EVENT_LOST	The event has been purchased and not viewed. The event has been lost and credit deducted.
0x03	ITEM_STATUS_ EVENT_REFUNDED	The event has been refunded by broadcaster.
0x04-0x7f	n/a	Reserved for future use.
0x80-0xff	n/a	User defined.

recharge_value: The value recharged for this history item.

recharge_source: The source of the re-charge, defined as Table M.76:

Table M.76: Recharge Source Values

Value	Mnemonic	Description
0x00	RECHARGE_SOURCE_RESERVED	Reserved for future use.
0x01	RECHARGE_PROMOTIONAL	The recharge has been performed by the broadcaster for free for promotional purpose.
0x02	RECHARGE_DEBIT_CANCELLATION	The recharge has been performed by the broadcaster to cancel a debit.
0x03	RECHARGE_REQUESTED	The recharge has arrived after a request performed by the user (both via OTA and via RC).
0x04-0x7f	n/a	Reserved for future use.
0x80-0xff	n/a	User defined.

recharge_transaction_id: A unique identifier of the recharge transaction.

message_subject: Optional string with the subject of the message, this shall be empty if there is no subject.

message_body: The message text.

message_priority: The priority of the message, defined as Table M.77.

Table M.77: Message Priority Values

Value	Mnemonic	Description
`0x00`	PRIORITY_LOW	A low priority message.
`0x01`	PRIORITY_NORMAL	A normal priority message.
`0x02`	PRIORITY_HIGH	A high priority message.
`0x03-0x7f`	n/a	Reserved for future use.
`0x80-0xff`	n/a	User defined.

message_date: The date when the message was originally stored.

M.6.8 History Event

Notification status about a change in the purchase history status or arrival of a new message from the CA system. The general form of the history status data shall be conveyed in the form show in Table M.78.

Table M.78: History Event syntax

Syntax	No. of bits	Mnemonic
`dtid_history_event() {`		
`history_status`	8	uimsbf
`description`	*	string()
`object_id`	*	string()
`private_data`	*	string()
`}`		

Semantics for the dtid_history_event() data type syntax:

history_status: The status of the history as defined in Table M.79.

Table M.79: History Change Status Values

Value	Mnemonic	Description
`0x00`	PURCHASE_HISTORY_CHANGE	The purchase list stored on the card has been changed.
`0x01`	RECHARGE_HISTORY_CHANGED	The recharge list stored on the card has been changed.
`0x02`	MESSAGE_HISTORY_CHANGED	The message list stored on the card has been changed.
`0x03-0x0f`	n/a	Reserved for future use.
`0x10`	NEW_MESSAGE	A new message has arrived.
`0x01-0x7f`	n/a	Reserved for future use.
`0x80-0xff`	n/a	User defined.

description: A text description of the event.

object_id: The CA object string identity associated with this event.

private_data: Private data associated with the event.

M.6.9 History Request

A History Request requests the history information from the CA system. The general form of the purchase request shall be conveyed in the form show in Table M.80.

Table M.80: History Request field syntax

Syntax	No. of bits	Mnemonic
`dtid_history_request() {`		
`   reserved`	4	bslbf
`   request_type`	4	uimsbf
`   if (request_type == ID_HISTORY) {`		
`      history_id`	*	string()
`   else if (request_type == NID_HISTORY) {`		
`      history_nid`	32	uimsbf
`   }`		
`   private_data`	*	string()
`}`		

Semantics for the dtid_history_request() data type syntax:

request_type: The type of history requested as defined in Table M.81.

Table M.81: History Request Type Values

Value	Mnemonic	Description
0x0	ALL_HISTORY	All of the history information.
0x1	PPV_HISTORY	The history of PPV events
0x2	RECHARGE_HISTORY	The history of recharge events.
0x3	MESSAGE_HISTORY	The history of messages.
0x4	ID_HISTORY	The history item with specified CA system assigned string identity.
0x5	NID_HISTORY	The history item with specified CA system assigned numeric identity.
0x6-0xf	n/a	Reserved for future use.

history_id: The CA system string identity assigned to the history item, this field is opaque and private to the CA system. This is a variable length text string. Note that a history item is generally expected to use a CA numeric identity rather than a CA string identity.

history_nid: The CA system numeric identity to the history item, this field is opaque and private to the CA system.

private_data: Optional private data associated with the request.

M.6.10 Numeric Index

The numeric index identifies a numerically defined item in the CASystem. The datatype is formatted as shown in Table M.82.

Table M.82: Numeric Index data type syntax

Syntax	No. of bits	Mnemonic
`dtid_numeric_index() {`		
`   numeric_index`	32	uimsbf
`}`		

Semantics for the dtid_numeric_index() data type syntax:

identity: A numeric value interpreted in the context of the message type.

M.6.11 Object Identity

The Object identifies the CASystem returned object identification. The datatype is formatted as shown in Table M.83.

Table M.83: Object Identity data type syntax

Syntax	No. of bits	Mnemonic
`dtid_object_identity() {`		
`identity`	*	lstring()
`}`		

Semantics for the dtid_object_identity() data type syntax:

identity: The identification string obtained from a CA object interpreted in the context of the message type.

M.6.12 Parental Level

The Parental Level conveys information about the current parental control level. The datatype is formatted as shown in Table M.84.

Table M.84: Parental Level data type syntax

Syntax	No. of bits	Mnemonic
`dtid_parental_level() {`		
`parental_level`	*	parental_level()
`}`		

Semantics for the dtid_parental_level() data type syntax:

parental_level: The parental level.

M.6.13 PIN Code

The Pin Code conveys the pin-code required to perform some operation. Information is formatted as shown in Table M.85.

Table M.85: PIN code data type syntax

Syntax	No. of bits	Mnemonic
`dtid_pin_code() {`		
`pin_code`	*	pin_code()
`}`		

Semantics for the dtid_pin_code() data type syntax:

new_parental_level: The requested parental level.

pin_code: The PIN code required to modify the parental level setting , enable a data update or unblock an event etc.

M.6.14 PIN Request Event

Notification status from the CA system requesting that the PIN code should be entered. The general form of the pin entry notification shall be conveyed in the form show in Table M.86.

Table M.86: PIN Request Event syntax

Syntax	No. of bits	Mnemonic
`dtid_pin_event() {`		
`pin_type`	8	uimsbf
`description`	*	string()
`object_id`	*	string()
`private_data`	*	string()
`}`		

Semantics for the dtid_pin_event() data type syntax:

pin_type: The type of PIN code required, the types are the same as those defined in dtid_pin_information() for the **type** field defined in Table M.87.

description: A text description of the event.

object_id: The CA object identity associated with this event.

private_data: Private data associated with the event.

M.6.15 PIN Information

The PIN conveys information associated with the Personal Identification Number associated with the CA system or SmartCard. The PIN Information conveys information formatted as shown in Table M.87.

Table M.87: PIN information data type syntax

Syntax	No. of bits	Mnemonic
`dtid_pin_information() {`		
`   id`	*	string()
`   type`	6	uimsbf
`   is_required`	2	bslbf
`   is_validated`	1	bslbf
`   reserved`	3	bslbf
`   retries_remaining`	4	uimsbf
`   pin_code`	*	pin_code()
`}`		

Semantics for the dtid_pin_infomation() data type syntax:

id: The CA system identity assigned to the smart card, this field is opaque and private to the CA system and uniquely identifies the pin. This is a variable length text string.

type: The type of PIN code. The values are shown in Table M.88.

Table M.88: Pin Type Values

Value	Description
0x00	Reserved.
0x01	Parental control PIN that protects parental control modes.
0x02	SmartCard PIN that protects the CA system functions of the smart card.
0x03	History PIN that protects history data.
0x04-0x0f	Reserved for future use.
0x10-0x1f	User defined.

is_required: A 2-bit field that designates whether PIN code use is required, the top bit is effectively a lock and determines if the access may be changed, the lower bit is the state of the PIN requirement, as defined in Table M.89.

Table M.89: Pin Required Values

Value	Description
0x0	The PIN code is not required.
0x1	The PIN code is required.
0x2	The PIN code is not required and cannot be enabled.
0x3	The PIN code is required and cannot be disabled.

is_validated: This single bit indicates if the current PIN has been validated since the last reset. "1" indicates that the PIN has been validated, otherwise "0".

retries_remaining: The number of tries of the PIN before the PIN is blocked from further use. A value of 0xf indicates that there is no blocking in effect, a value of 0x0 indicates that the PIN is currently blocked and there are no more re-tries outstanding.

M.6.16 Product

The product identifies information about a specified product. The datatype is formatted as shown in Table M.30

The product details a pay item. The general form of any product shall be conveyed in the form as show in Table M.90.

Table M.90: Product data type syntax

Syntax	No. of bits	Mnemonic
`dtid_product() {`		
`  product_type`	8	uimsbf
`  id`	*	string()
`  name`	*	string()
`  description`	*	string()
`  xdescription`	*	lstring()
`  pw_start_time`	*	time()
`  pw_end_time`	*	time()
`  preview`	*	duration()
`  cost`	*	money()
`  num_contained_products`	8	uimsbf
`  for (i=0; i<num_products; i++) {`		
`    contained_product_id`	*	string()
`  }`		
`  if (product_type == PPT) {`		
`    ppt_locator`	*	locator()
`    ppt_rating`	8	uimsbf
`    ppt_slice_price`	*	money()
`    ppt_slice_duration`	*	duration()
`  }`		
`  else if (product_type == PPE) {`		
`    ppv_locator`	*	locator()
`    ppv_rating`	8	uimsbf
`    ppv_start_time`	*	time()
`    ppv_end_time`	*	time()
`    ppv_num_packages`	8	uimsbf
`    for (i=0; i<ppv_num_packages; i++) {`		
`      ppv_package`	*	string()
`    }`		
`  }`		
`  else if (product_type == SUB) {`		
`    sub_start_time`	*	time()
`    sub_end_time`	*	time()
`    sub_num_services`	16	uimsbf
`    for (i=0; i<sub_num_services; i++) {`		
`      sub_service`	*	locator()
`    }`		
`  }`		
`  private_data`	*	lstring()
`}`		

Semantics for the dtid_product() data type syntax:

product_type: The type of product. The product types are defined in Table M.91.

Table M.91: Product Type Values

Value	Description
`0x00`	Reserved.
`0x01`	Generic Product.
`0x02`	Pay per Time (PPT) Event.
`0x03`	Pay per Event (PPE) Event.
`0x04`	Pay per View (PPV) Package.
`0x05`	Subscription (SUB) Package.
`0x06-0x7f`	Reserved for future use.
`0x80-0xff`	User defined.

id: The CA system identity assigned to the product, this field is opaque and private to the CA system. This is a variable length text string.

name: The name of the product item. This is a variable length text string.

description: A brief description of the product which may be up to 255 characters.

xdescription: An extended description of the product which may exceed 255 characters in length.

pw_start_time: The purchase window start time and date of the product item specified in UTC. If the pw_start_time is not applicable to the product then the field may have a undefined value.

pw_end_time: The purchase window end time and date of the product item specified in UTC. If the pw_end_time is not applicable to the product then the field may have an undefined value.

preview: The preview time associated with the product. If there is no preview period available then this field shall be undefined.

cost: The cost of the product, if the product is free then the cost shall be assigned the value 0. If there is no cost assigned then the field value shall be the undefined value.

num_contained_products: The number of products contained within this product.

contained_product_id: The contained product identity. These are the identities of products that are contained within this product.

ppt_locator: The pay per time locator of the event of type `locator()`.

ppt_rating: The pay per time rating of the event. This 8-bit field is coded as the rating field of the `parental_rating_descriptor` as defined by EN 300 468 [10]. The value of "0" means that the rating of zero is undefined.

ppt_slice_price: The pay per time price for a single slice of time of type money().

ppt_slice_duration: The pay per time duration for a single slice of time of type duration().

ppv_locator: The pay per view locator of the event of type locator().

ppv_rating: The pay per view rating of the event. This 8-bit field is coded as the rating field of the `parental_rating_descriptor` as defined by EN 300 468 [10]. The value of "0" means that the rating of zero is undefined.

ppv_start_time: The pay per view purchase window start time.

ppv_end_time: The pay per view purchase window end time.

ppv_num_packages: The number of packages associated with this pay per view event.

ppv_package: A package associated with the pay per view event. Each package is an CA system identity string which references a product.

sub_start_time: The starting date of the subscription service.

sub_end_time: The ending date of the subscription service.

sub_num_service: The number of services that comprise the subscription package.

sub_service: A locator that describes the service reference.

private_data: A string of bytes which may be used for private data.

M.6.17 Product Event

Notification status about the product from the CA system. The general form of the product status data shall be conveyed in the form show in Table M.92.

Table M.92: Product Event syntax

Syntax	No. of bits	Mnemonic
`dtid_product_event() {`		
`   product_status`	8	uimsbf
`   description`	*	string()
`   object_id`	*	string()
`   private_data`	*	string()
`}`		

Semantics for the dtid_product_event() data type syntax:

product_status: The status of the current product as defined in Table M.93.

Table M.93: Product Status Values

Value	Mnemonic	Description
0x00	EVENT_END	The current PPV event reached the end.
0x01	EVENT_STOPPED	The current PPV event has been stopped by the user (e.g. by the remote control).
0x02	EVENT_BEGIN	A new PPV event has just started.
0x03	PRODUCTS_OFFERS_LIST_CHANGE	The offered products' list has changed.
0x04-0x7f	n/a	Reserved for future use.
0x80-0xff	n/a	User defined.

description: An optional text description of the event.

object_id: An optional CA object identity associated with this event.

private_data: Optional private data associated with the event.

M.6.18 Product Info

Status information about the product received from the CA system. The general form of the product info shall be conveyed in the form show in Table M.94.

Table M.94: Product Info field syntax

Syntax	No. of bits	Mnemonic
`dtid_product_info() {`		
`   purchase_status`	4	bslbf
`   is_current_service`	1	bslbf
`   reserved`	3	bslbf
`   access_state`	8	uimsbf
`   product_id`	*	string()
`   private_data`	*	lstring()
`}`		

Semantics for the dtid_product_info() data type syntax:

purchase_status: The purchase status of the product as defined in Table M.95.

Table M.95: Purchase Status Values

Value	Mnemonic	Description
`0x0`	PURCHASE_STATUS_ PURCHASABLE	The product may be purchased.
`0x1`	PURCHASE_STATUS_ NOT_PURCHASABLE	The product may not be purchased for CAS reasons (i.e. no access rights on air)
`0x2`	PURCHASE_STATUS_ PURCHASED	The product has already been purchased and specific rights are on the smart card.
`0x3`	PURCHASE_STATUS_ LOW_CREDIT	The inserted smart card has insufficient credit to buy an associated event.
`0x4`	PURCHASE_STATUS_ NO_CREDIT	The inserted smart card has no credit. If the event has zero cost this cannot be stated as a purchase status.
`0x5`	PURCHASE_STATUS_ SMART_CARD_ISSUE	The inserted smart card has some condition that caused the event not to be purchasable. The reason may be retrieved using the dedicated get status method of the Smart Card.
`0x6-0xf`	n/a	Reserved for future use.

access_status: The access state of the current programme. The values are shown in Table M.64.

is_current_service: A 1-bit flag that indicates whether this is the service on air to which the receiver is tuned. The bit field is `"1"` if this service is current and `"0"` when it is not the current service.

product_id: The CA system assigned product identity that was purchased. This is a variable length string.

private_data: Optional private data associated with the purchase status.

M.6.19 Product Request

A Product Request requests product information from the CA system. The general form of the product request shall be conveyed in the form show in Table M.96.

Table M.96: Product Request field syntax

Syntax	No. of bits	Mnemonic
`dtid_product_request() {`		
`   reserved`	3	bslbf
`   request_qualifier`	2	uimsbf
`   type`	3	uimsbf
`   if (request_qualifier == PRODUCT_ID) {`		
`      product_id`	*	string()
`   } else if (request_qualifier == PRODUCT_LOCATOR) {`		
`      locator`	*	locator()
`   }`		
`   private_data`	*	lstring()
`}`		

Semantics for the dtid_product_request() data type syntax:

request_qualifier: The qualification of the information requested as defined in Table M.97.

Table M.97: Product Request Qualifier Values

Value	Mnemonic	Description
`0x0`	PRODUCT_NONE	No qualification is specified.
`0x1`	PRODUCT_ID	The product(s) with given *product_id* are required.
`0x2`	PRODUCT_LOCATOR	The product(s) with the given *locator* are required.
`0x3`	n/a	Reserved for future use.

type: The type of product request as defined in Table M.98. When the *request_qualifier* is a identity then the type shall be `ALL_PRODUCT`.

Table M.98: Product Request Type Values

Value	Mnemonic	Description
`0x0`	ALL_PRODUCT	All products are required.
`0x1`	CURRENT_PRODUCT	The current event product(s) are required
`0x2`	NEXT_PRODUCT	The next event product(s) are required.
`0x3`	OFFERED_PRODUCT	The offered product(s) are required.
`0x4-0x7`	n/a	Reserved for future use.

product_id: The CA system identity assigned to the product, this field is opaque and private to the CA system. This is a variable length text string.

locator: The DVB locator of the service to query.

private_data: The private data associated with the purchase.

M.6.20 Purchase

A Purchase represents a purchase of a pay event, be it a subscription or PPV event. The general form of the purchase request shall be conveyed in the form show in Table M.99.

Table M.99: Purchase field syntax

Syntax	No. of bits	Mnemonic
`dtid_purchase() {`		
`id`	*	string()
`product_id`	*	string()
`cancelled`	1	bslbf
`reserved`	7	bslbf
`private_data`	*	lstring()
`}`		

Semantics for the dtid_purchase() data type syntax:

id: The CA system identity assigned to the purchase, this field is opaque and private to the CA system. This is a variable length text string. When a purchase request is made then this field may be the empty string until assigned by the CA system.

product_id: The CA system assigned product identity that was purchased. This is a variable length string.

cancelled: The purchase has been cancelled.

private_data: The private data associated with the purchase.

M.6.21 Recharge

A Recharge requests a recharge of credit from the CA system. The general form of the recharge message shall be conveyed in the form show in Table M.100.

Table M.100: Recharge field syntax

Syntax	No. of bits	Mnemonic
dtid_recharge() {		
reserved	4	bslbf
request_type	4	uimsbf
phone	*	string()
user	*	string()
password	*	string()
ip_address	*	string()
port	*	string()
if (request_type == CREDIT_CARD_MODE) {		
surname	*	string()
name	*	string()
card_number	*	string()
start_date	16	bslbf
expiry_date	16	bslbf
value	*	money()
}		
recharge_value	*	money()
transaction	*	lstring()
private_data	*	lstring()
}		

Semantics for the dtid_recharge () data type syntax:

request_type: The type of history requested as defined in Table M.101.

Table M.101: Request Type Values

Value	Mnemonic	Description
0x0	n/a	Reserved
0x1	CREDIT_CARD_MODE	Recharge request using a credit card
0x2	SCRATCH_CARD_MODE	Recharge request using a scratch card
0x3-0xf	n/a	Reserved for future use.

phone: The phone number to be called.

user: The name of the user for login.

password: The password supplied by the user for login.

ip_address: The IP address of the server, specified as a decimal character string with a period character delimiting the address ranges.

port: The port number of the server, specified as a decimal character string.

surname: The credit card surname.

name: The credit card forename(s) or initials.

card_number: The credit card number, specified as a decimal character string with no spaces.

start_date: The start date of the credit card expressed as a MJD value, refer to the time() field definition.

expiry_date: The expiry date of the credit card expressed as a MJD value, refer to the time() field definition.

value: The recharge value requested.

recharge_value: The amount of monies recharged, this field shall be undefined when forming part of a request.

transaction: Additional transaction information which may be optionally populated with information.

private_data: Additional private data.

M.6.22 Recharge Event

Notification status about a recharge from the CA system. The general form of the recharge event data shall be conveyed in the form show in Table M.102.

Table M.102: Recharge Event syntax

Syntax	No. of bits	Mnemonic
`dtid_recharge_event() {`		
`recharge_status`	8	uimsbf
`description`	*	string()
`object_id`	*	string()
`value`	*	money()
`private_data`	*	string()
`}`		

Semantics for the dtid_recharge_event() data type syntax:

recharge_status: The recharge status, the values are defined in Table M.76.

description: An optional text description of the event.

value: The value of the recharge event.

object_id: An optional CA object identity associated with this event.

private_data: Optional private data associated with the event.

M.6.23 Service Id

The Service Id includes a locator that identifies the service. The datatype is formatted as shown in Table M.103.

Table M.103: Service Identity data type syntax

Syntax	No. of bits	Mnemonic
`dtid_service_id() {`		
`service_locator`	*	locator()
`}`		

Semantics for the dtid_service_id() data type syntax:

service_locator: A locator that identifies the service.

M.6.24 Slot

The Slot identifies the state of a smart card slot in the system. The datatype is formatted as shown in Table M.104.

Table M.104: Slot data type syntax

Syntax	No. of bits	Mnemonic
`dtid_slot() {`		
`slot_id`	8	uimsbf
`slot_status`	8	uimsbf
`}`		

Semantics for the dtid_slot() data type syntax:

slot_id: The identity number of the slot commencing from 0.

slot_status: The status of a smart card slot. The values are shown in Table M.105.

Table M.105: Slot Status Values

Value	Mnemonic	Description
0x00	SLOT_STATUS_RESERVED	Reserved for future use.
0x01	SLOT_STATUS_CARD_IN	A card is present in the slot.
0x02	SLOT_STATUS_CARD_OUT	A card is not present in the slot.
0x03	SLOT_STATUS_CARD_ERROR	a smart card is inserted into the reader but wrong ATR is received (e.g. because of a damaged card).
0x04	SLOT_STATUS_CARD_MUTED	A smart card is inserted into the reader but no ATR is retrieved because no electrical communication is established with the smart card (e.g. card upside-down).
0x05	SLOT_STATUS_ ACCESS_DENIED	Access to the card currently inserted in the slot is denied; this normally means that the card does not correspond to the current active service and CAS.
0x06	SLOT_STATUS_ VERIFYING	A smart card is in the slot and is being verified.
0x07	SLOT_STATUS_UNKNOWN	Status is unknown, the status of the slot has not been retrieved yet.
0x08-0x7f	n/a	Reserved for future use.
0x80-0xff	n/a	User defined.

M.6.25 Slot Event

Notification status about a card event from the CA system. The general form of the slot event data shall be conveyed in the form show in Table M.106.

Table M.106: Slot Event syntax

Syntax	No. of bits	Mnemonic
`dtid_slot_event() {`		
`slot_status`	8	uimsbf
`slot_id`	8	uimsbf
`description`	*	string()
`object_id`	*	string()
`private_data`	*	string()
`}`		

Semantics for the dtid_slot_event() data type syntax:

slot_status: The slot status, the values are defined in Table M.105.

slot_id: The identity number of the slot commencing from 0.

description: An optional text description of the event.

value: The value of the recharge event.

object_id: An optional CA object identity associated with this event.

private_data: Optional private data associated with the event.

M.6.26 SmartCard

The SmartCard conveys information associated with the smart card slot in the system. The datatype is formatted as shown in Table M.107.

Table M.107: Smart Card data type syntax

Syntax	No. of bits	Mnemonic
`dtid_smartcard() {`		
`   id`	*	string()
`   status`	8	uimsbf
`   slot_id`	8	uimsbf
`   expiry_date`	*	time()
`   id_number`	*	string()
`   version`	*	string()
`   provider_name`	*	string()
`   service_provider_name`	*	string()
`   user_data`	*	string()
`   num_pin_codes`	8	uimsbf
`   for (i=0; i<num_pin_codes; i++) {`		
`      pin_id`	*	string()
`   }`		
`   num_wallets`	8	uimsbf
`   for (i=0; i<num_wallets; i++) {`		
`      wallet_id`	*	string()
`   }`		
`   current_wallet`	*	string()
`   additional_info`	*	properties()
`   private_data`	*	string()
`}`		

Semantics for the dtid_smartcard() data type syntax:

id: The CA system identity assigned to the smart card, this field is opaque and private to the CA system and uniquely identifies the smart card. This is a variable length text string.

status: This 8-bit value denotes the current status of the smart card. The values are shown in Table M.108.

Table M.108: SmartCard Status Values

Value	Mnemonic	Description
0x00	SCS_VALID	Notifies that the smart card is valid. This value may also be returned when a smart card check is performed.
0x01	SCS_INVALID	Notifies that the smart cart is not valid. When in this state, the smart card cannot perform any further operation. This value may also be returned when a smart card check is performed.
0x02	SCS_EXPIRED	Notifies that the smart card is expired. When in this state, the smart card cannot perform any further operation. This value may also be returned when a smart card check is performed.
0x03	SCS_BLACKLISTED	Notifies that the smart card is blacklisted. When in this state, the smart card cannot perform any further operation. This value may also be returned when a smart card check is performed.
0x04	SCS_SUSPENDED	Notifies that the smart card is suspended. When in this state, the smart card cannot perform any further operation. This value may also be returned when a smart card check is performed.
0x05	SCS_NEVER_PAIRED	Notifies that the smart card has never been paired with box. When in this state, the smart card cannot perform any further operation. This value may also be returned when a smart card check is performed.
0x06	SCS_NOT_PAIRED	Notifies that the smart card is not actually paired with the box. When in this state, the smart card cannot perform any further operation. This value may also be returned when a smart card check is performed.
0x07	SCS_NOT_CERTIFIED	Notifies that the smart card is not certified. When in this state, the smart card cannot perform any further operation. This value may also be returned when a smart card check is performed.
0x08	SCS_MEMORY_FULL	Notifies that the smart card has filled up memory. This value may also be returned when a smart card check is performed.
0x09	SCS_GENERIC_CARD_ERROR	Notifies that there is an unknown error with the smart card. When in this state, the smart card cannot perform any further operation. This value may also be returned when a smart card check is performed.

Value	Mnemonic	Description
0x0a	SCS_PIN_CHANGED	Notifies that the pin of the smart card is changed (i.e. to have notification on reset by SMS).
0x0b-0x7f	n/a	Reserved for future use.
0x80-0xff	n/a	User defined.

slot_id: The identity of the slot in which the card is placed.

expiry_date: The date of expiry of the card, if there is no expiry date then this field may be the undefined value.

id_number: The smart card identification number for the card. This is a variable length string.

version: The version number of the smart card, returned as a CA system specific formatted string.

provider_name: The name of the smart card provider (normally the same as the CA provider name).

service_provider_name: The name of the service provider who delivered the card.

user_data: The user data field stored on the card. The format of the data is CA system specific.

num_pin_codes: This is an 8-bit number of Personal Identification Numbers (PIN) available on the card.

pin_id: The CA system identity of the PIN code.

num_wallets: This 8-bit field indicates the number of wallets available on the SmartCard. This may be zero if there are no wallets.

wallet_id: The CA system identity of the wallets stored on the smart card.

current_wallet_id: The CA system identity of the wallet that is current. This may be a zero length string if there is no current wallet.

additional_info: Additional information available on the smart card, this may include addition version numbers and identification information.

private_data: Optional private data associated with the object.

M.6.27 SmartCard Event

Notification status about a smart card event from the CA system. The general form of the slot event data shall be conveyed in the form show in Table M.109.

Table M.109: Smartcard Event syntax

Syntax	No. of bits	Mnemonic
`dtid_smartcard_event() {`		
`   smartcard_status`	8	uimsbf
`   description`	*	string()
`   object_id`	*	string()
`   private_data`	*	string()
`}`		

Semantics for the dtid_smartcard_event() data type syntax:

smartcard_status: The smart card status, the values are defined in Table M.108.

description: An optional text description of the event.

object_id: An optional CA object identity associated with this event.

private_data: Optional private data associated with the event.

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M.6.28 SmartCard Request

A SmartCard Request requests information about the smart card from the CA system. The general form of the smart card request shall be conveyed in the form show in Table M.110.

Table M.110: Smart Card Request field syntax

Syntax	No. of bits	Mnemonic
`dtid_smartcard_request() {`		
`   reserved`	6	bslbf
`   request_qualifier`	2	uimsbf
`   if (request_qualifier == SMARTCARD_ID) {`		
`      smartcard_id`	*	string()
`   } else if (request_qualifier == SMARTCARD_SLOT) {`		
`      slot_id`	8	uimsbf
`   }`		
`   private_data`	*	string()
`}`		

Semantics for the dtid_smartcard_request() data type syntax:

request_qualifier: The qualification of the information requested as defined in Table M.111.

Table M.111: Request Qualifier Values

Value	Mnemonic	Description
0x0	SMARTCARD_ALL	All smart card information.
0x1	SMARTCARD_ID	The smart card identified by the given CA identifier.
0x2	SMARTCARD_SLOT	The smart card located in the given slot identity.
0x3	n/a	Reserved for future use.

smartcard_id: The identity of the smart card assigned by the CA system.

slot_id: The identity of the slot containing a smart card starting from index 0.

private_data: Optional private data associated with the request.

M.6.29 User Data

The User Data includes an arbitrary string of data bytes. The datatype is formatted as shown in Table M.112.

Table M.112: User Data type syntax

Syntax	No. of bits	Mnemonic
`dtid_user_data() {`		
`   byte_data`	*	lstring()
`}`		

Semantics for the dtid_user_data() data type syntax:

byte_data: An arbitrary block of data.

M.6.30 Wallet

Wallet represents an account containing details of monies registered with the system (typically the SmartCard). The general form of the wallet shall be conveyed in the form show in Table M.113.

Table M.113: Wallet field syntax

Syntax	No. of bits	Mnemonic
`dtid_wallet() {`		
`product_type`	8	uimsbf
`id`	*	string()
`name`	*	string()
`balance`	*	money()
`expiry_date`	*	time()
`transaction_count`	16	uimsbf
`transaction_remain`	8	uimsbf
`}`		

Semantics for the dtid_wallet() data type syntax:

id: The CA system identity assigned to the wallet, this field is opaque and private to the CA system. This is a variable length text string.

name: The name associated with this wallet. This is a variable length string.

balance: The balance of monies in the wallet.

expiry_date: The expiry date of the wallet, where there is no expiry date then the data value shall be set to the *undefined* value.

transaction_count: The number of transactions that have been made against this wallet. A value of `0xffff` indicates that the transaction count is unknown.

transaction_remain: An estimate of the number of remaining transactions that can be purchased. A value of `0xff` indicates that no estimate is available.

M.6.31 Wallet Identity

The Wallet Identity identifies the name of a wallet. The data type is formatted as shown in Table M.114.

Table M.114: Wallet Identity data type syntax

Syntax	No. of bits	Mnemonic
`dtid_wallet_id() {`		
`wallet_id`	*	string()
`}`		

Semantics for the dtid_wallet_id() data type syntax:

wallet_id: The CA System id for the wallet.

M.7 MHP API Mapping

Table M.115 provides a list of the MHP API and the CI Plus commands that satisfy them.

Table M.115: MHP API Message Mapping

Class	Method	Message Mapping

CAManagerFactory	SessionOpener()
	SessionCloser()
	openSession()
	closeSession()
	AccessDeniedException
		M.2.1 Session Establishment
		APDU open_session_request()
		APDU open_session_response()
		APDU close_session_request()
		APDU close_session_response()
		APDU SAS_connect_rqst()
		APDU SAS_connect_cnf()

CAManager	getCAProvider()
	getCARevision()
	getCAVersion()
	getSlots()
		CMD_CAPABILITIES_REQUEST

CAManager	getCurrentProducts()
	getNextProducts()
		CMD_PRODUCT_GET_REQUEST

CAManager	getParentalControlLevel()	CMD _PARENTAL_LEVEL_GET _REQUEST
CAManager	setParentalControlLevel()	CMD_ PARENTAL_LEVEL_ SET_REQUEST
CAManager	getPins()	CMD_PIN_GET_REQUEST

Pin	setRequired()
	reset()
	change()
		CMD_PIN_SET_REQUEST

Pin	check()	CMD_PIN_CHECK_REQUEST

Pin	isRequired()
	getRetriesRemaining()
	isValidated()
		See CAManager::getPins()

Slot	getStatus()	CMD_SLOT_GET_REQUEST
Slot	getSmartCard()	CMD_SMARTCARD_GET_REQUEST
SmartCard	getATR()	CMD_ATR_GET_REQUEST

SmartCard	getExpiryDate()
	getMoreInfo()
	getNumber()
	getPins()
	getProvider()
	getServiceProviderName()
	getStatus()
	getUsedWallet()
	getUserData()
	getVersion()
	getWallets()
		CMD_SMARTCARD_GET_REQUEST

SmartCard	setUserData()
	setUsedWallet()
		CMD_SMARTCARD_SET_REQUEST

CAAcessEvent	CAAdapter()
	getType()
		CMD_ACCESS_EVENT

CAProductEvent	CAProductEvent	CMD_PRODUCT_EVENT
CreditsEvent		CMD_CREDIT_EVENT
NewMessageEvent		CMD_MESSAGE_EVENT
HistoryUpdateEvent		CMD_PURCHASE_HISTORY_EVENT
PinRequestEvent		CMD_PIN_REQUEST_EVENT
RechargeEvent		CMD_RECHARGE_EVENT
SlotEvent		CMD_SLOT_EVENT
SmartCardEvent		CMD_SMARTCARD_EVENT

ppv.Product	getId()
	getPrivateData()
	getType()
	getName()
	getDescription()
	getExtendedDescription()
	etPurchaseWindowStartTime()
	getPurchaseWindowEndTime()
	getContainedProducts()
	getPrice()
	isFree()
	getPreviewTime()
		CMD__PRODUCT_GET_REQUEST

PPVEvent	getRating()
	getLocator()
	getPackages()
		CMD__PRODUCT_GET_REQUEST

Class	Method	Message Mapping

	getStartTime()
	getEndTime()
	isFree()
	getType()	

PPTEvent	getSlicePrice()
	getSliceDuration()
	getType()
		CMD__PRODUCT_GET_REQUEST

PPVPackage	isFree()
	getType()
		CMD__PRODUCT_GET_REQUEST

Subscription	getSubscriptionStart()
	getSubscriptionEnd()
	getServices()
	isFree()
	getType()
		CMD__PRODUCT_GET_REQUEST

request	BuyRequest()	CMD_PURCHASE_SET_REQUEST
request.CARequest	cancel()	CMD_PURCHASE_CANCEL_REQUEST
request.CARequest	setPrivateData()	CMD_PURCHASE_SET_REQUEST

request.CARequest	isCancelled()
	getPrivateDate()
		CMD_PURCHASE_SET_REQUEST

HistoryRequest	getHistoryLength()
	getItem()
	getItems()
	getPrivateData()
	isCancelled()
		CMD_HISTORY_GET_REQUEST

HistoryRequest	setItems()
	setPrivateData()
	cancel()
		CMD_HISTORY_SET_REQUEST

BuyResponseEvent	buyResponseEvent()	CMD_PURCHASE_SET_RESPONSE

FailureResponseEvent	FailureResponseEvent()
	getErrorCode()
		CMD_*_RESPONSE

HistoryResponseEvent	HistoryResponseEvent()
	getHistory()
		CMD_HISTORY_GET_RESPONSE

HistoryUpdateRequest	HistoryUpdateRequest()
	getHistory()
		CMD_HISTORY_SET_REQUEST

HistoryUpdateResponseEv	HistoryUpdateResponseEvent()	CMD_HISTORY_SET_RESPONSE

ProductInfoRequest	ProductInfoRequest()
	getProduct()
		CMD_PRODUCT_INFO_GET_REQUEST
		CMD_PRODUCT_INFO_GET_RESPONSE

RcRechargeRequest	RcRechargeRequest()
	getRcParameter()
		CMD_RECHARGE_REQUEST

RcRechargeResponse	RcRechargeResponse()
	getRechargeValue()
	getWallet
		CMD_RECHARGE_RESPONSE

R.OfferedProducts	RetrieveOfferedProductsRequest()	CMP_PRODUCT_GET_REQUEST

OfferedProductsResponse	OfferedProductsResponseEvent()
	getProducts()
		CMP_PRODUCT_GET_RESPONSE

Annex N (normative): CICAM Broadcast Profile

This Annex describes the pseudo broadcast profile that is created with the Operator Profile resource that shall be supported by a CI Plus Host and optionally supported by a CICAM. It is a mandatory for a CI Plus Host to support the Operator Profile resource and to support the broadcast profile requirements set down in this Annex.

N.1 Service Information (Normative)

This section describes the Service Information (SI) that shall be minimally specified and interpreted by the Host.

N.1.1 CI Plus Private Descriptors

The private descriptors recognised by a CI Plus Host device are summarised in Table N.1. All CI Plus private descriptors shall only be interpreted in the context of the CI Plus private data specifier value.

Table N.1: CI Plus private descriptors

Descriptor	Tag	Description
`ci_protection_descriptor`	`0xce`	CI Plus Host shunning control.
`ciplus_content_label_descriptor`	`0xcb`	Content descriptor text label applicable for the network.
`ciplus_service_descriptor`	`0xcc`	Service name and type.

N.1.2 CICAM NIT

A single quasi-static CICAM NIT$_{actual}$ shall be common to all multiplexes of the network. It shall detail the transmission parameters of the multiplexes within the network and may be constructed by the CICAM using service operator specific information. The CICAM NIT defined in this specification shall be in compliance with ISO/IEC 13818-1 [13] and ETSI EN 300 468 [10]. A new version of the CICAM NIT shall be passed to the Host in one of the following circumstances:

- A new multiplex is added or removed to/from the network.
- When the transmission parameters are changed.
- When the service line up changes.
- When attributes of the network are changed (including text labels).

The NIT version number may not change without changes to the payload i.e. a CICAM constructing the NIT$_{actual}$ from various broadcast tables shall not update the NIT in response to a broadcast table version change if the change does not result in any NIT payload change. The NIT version number shall always be updated following any change to the NIT payload by incrementing the version_number field.

The CICAM NIT is a complete self contained definition of the operator profile service line up. The Host shall construct the channel list from information entirely obtained from the CICAM NIT, there is no requirement for the Host to scan or monitor any part of the broadcast SI in order to construct or maintain the profiled channel list.

The use of descriptors within the NIT shall be strictly according to Table N.2, other descriptors may be skipped if not known to the Host. The scope of all private descriptors shall be honoured by the Host.

Table N.2: CICAM NIT descriptors

NIT Descriptor	Tag Value	Loop	Actual	Other	Notes
`*_delivery_system_descriptor`	*	2nd	Mb/Mr	N/A	The delivery system descriptors supported by the Host network interfaces shall be supported. Delivery system descriptors not supported by the Host shall be ignored.
`ciplus_content_label_descriptor`	0xcb	1st	Ob/Or	N/A	Shall be preceded by a CI Plus private data specifier.
`ciplus_service_descriptor`	0xcc	2nd	Mb/Mr	N/A	Shall be preceded by a CI Plus private data specifier.
`linkage_descriptor`	0x4a	1st	Ob/Mr	N/A	The Host shall interpret and enact linkage_type 0x02 EPG service.
`linkage_descriptor`	0x4a	1st	Ob/Or	N/A	DVB-SSU information with linkage_type 0x09 and 0x0A.
`network_name_descriptor`	0x40	1st	Ob/Or	N/A	The profile_name of the operator_info() APDU shall be used in preference to any network name appearing in the NIT.
`private_data_specifier_descriptor`	0x5f	1st/2nd	Ob/Mr	N/A	The CI Plus private data specifier value shall be recognised by all Hosts and shall precede any CI Plus private descriptors.
`image_icon_descriptor`	0x7f/0x00	1st	Ob/Or	N/A	An in-line image icon of the service operator which may be optionally used by the Host in any network selection, channel banner and EPG.
Notes: **Mb** – Mandatory to broadcast; **Ob** – Optional to broadcast; **Mr** – Mandatory to receive; **Or** – Optional to receive; **N/A** – not applicable.					

The CICAM shall propagate DVB-SSU linkage information in the CICAM NIT with the appropriate DVB-SSU signalling using the linkage_descriptor with linkage_type's 0x09 and 0x0A. This may require that the CICAM construct the correct signalling from a broadcast NIT or BAT.

N.1.2.1 system_delivery_descriptor

The system_delivery_descriptor, defined by ETSI EN 300 468 [10], appropriate to the network shall be included in the 2nd loop of the CICAM NIT and shall fully describe the location of the multiplex.

N.1.2.2 linkage_descriptor

The linkage_descriptor with tag `0x4a`, defined by ETSI EN 300 468 [10], may optionally be present in the 1st loop of the NIT with linkage_type `0x02` (EPG Service). The linkage shall indicate the presence of any Electronic Programme Guide (EPG) barker service and shall be interpreted by the Host when the EPG is invoked.

Other linkage descriptors may be present in the CICAM NIT. The CICAM is required to propagate all DVB-SSU descriptors to the Host.

N.1.2.3 ciplus_service_descriptor

The CI Plus service descriptor provides the names of the service provider and the service in text form together with the service_type and logical channel information. The descriptor shall be used in the 2nd loop of the NIT, one descriptor shall be present for each service to be included in the logical channel list. The descriptor shall only be interpreted in the context of a CI Plus private data specifier.

The Host shall include all services in the logical channel list that are specified by this descriptor, irrespective of whether the Host is able to display the service_type. The CICAM shall profile the services based on the service_type declaration of the Host and the operational constraints defined by the Service Operator (which may require that unsupported service types are included in the Host logical channel list).

Data in this descriptor shall be treated as quasi-static and shall be used to define services in the Host service list or channel list. A service may be assigned more than one logical channel number i.e. the same service may be specified to appear multiple times in a channel list with a different logical channel number assignment, different visibility status and different name.

The CICAM shall ensure that all selectable services are assigned a unique logical channel number, this requires the CICAM to select a numbered service ordering in the case where a logical channel numbering is not assigned by the network. This may be based on an alphabetical sort of the channels etc. to determine the ordering and hence numbering. There is no requirement for the Host to allocate a logical channel number for any services which are incorrectly labelled and conflicting services shall be discarded.

Table N.3: ciplus_service_descriptor syntax

Syntax	No. of bits	Mnemonic
`ciplus_service_descriptor(){`		
`descriptor_tag`	8	uimsbf
`descriptor_length`	8	uimsbf
`service_id`	16	uimsbf
`service_type`	8	uimsbf
`visible_service_flag`	1	bslbf
`selectable_service_flag`	1	bslbf
`logical_channel_number`	14	uimsbf
`service_provider_name_length`	8	uimsbf
`for (i=0; i<N; i++) {`		
`char`	8	uimsbf
`}`		
`service_name_length`	8	uimsbf
`for (i=0; i<N; i++) {`		
`char`	8	uimsbf
`}`		
`}`		

Where the fields are defined as follows:

descriptor_tag: This 8-bit field shall be assigned the value `0xcc` and shall only be interpreted in the context of a CI Plus private data specifier descriptor.

service_id: This is a 16-bit field which identifies the service from any other service in the transport stream. The service_id is the same as the program_number in the corresponding program_map_table.

service_type: This is an 8-bit field specifying the type of the service. It shall be coded in accordance to the service_type field of the service_descriptor defined in ETSI EN 300 468 [10].

visible_service_flag: This 1-bit field when set to "1" indicates that the service is normally visible via the Host service or channel list and EPG etc. When set to "0" this indicates that the receiver is not expected to offer the service to the user in normal navigation modes but the receiver shall provide a mechanism to access these services by direct entry of the logical channel number, depending on the setting of the selectable_service_flag field.

selectable_service_flag: This 1-bit field is only interpreted when the visible_service_flag field is set to "0". When set to "1" indicates that the hidden service is selectable by direct entry of the logical channel number, when set to "0" then the hidden service is not directly selectable by the user (but may be selectable by LCN from an application environment).

logical_channel_number: This 14-bit field indicates the logical channel number to be assigned to the service, however only 4-digit channel numbers from 0 to 9999 are allowed. The value of all-ones (0x3fff) indicates that the service is not available for selection and shall be hidden but retained in the Host channel list. The same service may be allocated more than one logical channel number and shall appear at multiple locations in the service list. Logical channel numbers shall be unique throughout the network i.e. the logical channel number shall be used once only (with the exception of all-ones).

The Host behaviour with logical channel numbers > 9999 is unspecified and may be discarded. Where services are assigned the same logical channel number then the Host shall retain one service and discard any others.

service_provider_name_length: This 8-bit field specifies the number of bytes that follow the service_provider_name_length field for describing characters of the name of the service provider.

char: This is an 8-bit field. A string of char fields specify the name of the service provider or service. Text information is coded using the character sets and methods described in ETSI EN 300 468 [10], Annex A in conjunction with the operator_info() APDU.

service_name_length: This 8-bit field specifies the number of bytes that follow the service_name_length field for describing characters of the name of the service.

N.1.2.4 ciplus_content_label_descriptor

The CI Plus content label descriptor is used in the 1st descriptor loop of the NIT and provides a new text label for the ETSI EN 300 468 [10] content_descriptor (`0x54`) content_byte field. The descriptor allows the default text labels associated with the genre of the programme event to be modified in the context of the network. Multiple instances of the descriptor are permitted in the loop and may appear in any content_byte order. Multiple instances of the same text label for an identical range may exist with a different language assignment. The text labels bind a content_byte value range with a text string.

When processing the content_descriptor then the content_byte is compared with the active range of the content label descriptor, if the content_byte matches the range then the text label is used. Where multiple labels match the content_byte then the content label with the smallest matching content range shall be selected in preference to any other label that has a larger matching content range. If none of the labels of the CICAM NIT match a content_byte value then the default assigned DVB content_descriptor text labels are used. i.e. a specific label is assigned a narrow range of content_byte values whilst a generic genre category has a wider range of content_byte values.

Informative: The Host processing is equivalent to effectively re-ordering the text labels for evaluation with narrow range labels appearing before any other labels with a wider range and the content label is searched from top to bottom of the list until a match is found. e.g.

```
0x67-0x67 Dance music     // Create a new label
0x65-0x65 Opera           // Over-ride existing label
0x60-0x6f Music           // Over-ride the generic category name must
                          // appear after the specific labels in same range
```

Table N.4: ciplus_content_label_descriptor syntax

Syntax	No. of bits	Mnemonic
`ciplus_content_label_descriptor(){`		
`descriptor_tag`	8	uimsbf
`descriptor_length`	8	uimsbf
`content_byte_min`	8	uimsbf
`content_byte_max`	8	uimsbf
`ISO_639_language_code`	24	bslbf
`for (i=0; i<N; i++) {`		
`label_char`	8	uimsbf
`}`		
`}`		

Where the fields are defined as follows:

descriptor_tag: This 8-bit field shall be assigned the value `0xcb` and shall only be interpreted in the context of a CI Plus private data specified descriptor.

content_byte_min/max: These 8-bit fields identify the maximum and minimum range of the content_descriptor content_byte field value which should be matched if this label should be used for the content_byte. The values are inclusive values and are compared as follows:

```
if ((content_byte >= content_byte_min) && (content_byte <= content_byte_max))
then
   // Use this content label.
endif
```

ISO_639_language_code: This 24-bit field identifies the language code of the content label.

label_char: This is a 8-bit field, a string of "char" fields specifies the text label of the content_byte. Text information is coded using the character sets and methods defined in ETSI EN 300 468[10], Annex A.

N.1.3 SDT

Within a profiled environment (profile_type=1) then all of the static service name and type information is obtained from the CICAM NIT rather than the broadcast SDT, the service_descriptor() of the broadcast SDT shall be ignored.

The SDT_{actual} is used by the Host Shunning mechanism, in addition SDT_{actual} may be used for run-time service running state information. The SDT_{other} tables shall only be trusted when the operator_info() APDU sdt_other_trusted field is set to "1".

The minimal interpretation of descriptors within the SDT handled by a CI Plus Host with a CICAM NIT shall be according to Table N.5.

Table N.5: Minimally interpreted CI Plus SDT descriptors

SDT Descriptor	Tag Value	Actual	Other	Quasi-static	Notes
`ci_protection_descriptor`	`0xce`	Ob/Mr	Ob/Or	yes	Shall be preceded by a private data specifier. Quasi-static for 7 days.
`private_data_specifier_descriptor`	`0x5f`	Ob/Mr	Ob/Or	no	Precedes the ci_protection_descriptor.
Notes: **Mb** – Mandatory to broadcast; **Ob** – Optional to broadcast; **Mr** – Mandatory to receive; **Or** – Optional to receive; **N/A** – not applicable.					

The running_state in the SDT may be interpreted by the Host if the operator_info() APDU field sdt_running_status_trusted is set to "1" and the Host may optionally indicate to the user that the service is not available when the service is not running.

N.1.4 EIT

The $\mathrm{EIT}_{p/f}$ and EIT_{sch} may be present for each service providing information on the present, following and schedule events. The Host shall be able to robustly handle the SDT::EIT_present_following_flag and SDT::EIT_schedule_flag being miss-signalled. The availability of EIT information available to the Host may be determined from the operator_info() APDU eit_present_following_usage and eit_schedule_usage fields.

Where a linkage_descriptor containing linkage_type `0x02` is present in the first loop of the CICAM NIT then the Host shall acquire the EIT_{sch} information from the barker channel by tuning to the multiplex defined in the linkage_descriptor when required in any Electronic Programme Guide (EPG).

The running_state of the EIT may be interpreted by the Host if the operator_info() APDU eit_running_status_usage field is set to "1" and the Host may optionally indicate to the user that the service is not available when the service is signalled as not running or paused.

N.1.4.1 EIT delivery

The Electronic Programme Guide (EPG) of a CI Plus Host is derived from the EIT_{sch} information broadcast on the network, the network operation may be qualified with the ciplus operator_info() APDU EIT schedule hint information. The EIT_{sch} may be protected in the broadcast network by scrambling the EIT table sections. $\mathrm{EIT}_{p/f}$ is not allowed to be scrambled.

Where EIT_{sch} tables are scrambled on a barker channel then the guidelines of ETSI TR 101 211 shall be followed and the service may use a PMT with service_id of `0xffff`. The PMT shall contain an elementary stream of type private sections with one or more CA_descriptors to identify the associated CAS. The Host shall pass the EIT service in the ca_pmt() when descrambling is required. The location of the barker channel shall be identified with a linkage_descriptor of linkage_type 0x02 and a tuning operation is required for the Host to move to the EPG service. The network should contain a service describing the EPG service (which may be hidden).

Where the EIT_{sch} tables are scrambled and cross carried on the multiplexes of the network then the descrambling shall operate as follows:

- The CICAM may optionally automatically descramble the EIT_{sch} tables for a CI Plus Authenticated Host, this requires no additional signalling in the PMT.
- The PMT shall include a Elementary Stream of stream_type 0x05 containing ISO/IEC 13818-1 private sections for elementary _PID=0x0012. The elementary_stream loop shall contain one or more CA_descriptors to identify the associated CA streams and the Host shall pass this elementary stream to the CICAM in a ca_pmt() request with any other elementary stream components that require descrambling.

N.2 Profile Behaviour

This section describes the behaviour of a profiled CICAM network (profile_type = 1)

N.2.1 Logical Channel List Organisation

The logical channel list for a profiled CICAM is organised as a separate channel list (sandbox) of channel numbers identified by the profile_name of the operator_info() APDU. The logical channel list shall be strictly restricted to the services specified by the service operator using the ciplus_service_descriptor() in the CICAM NIT 2nd loop. Additional services may not be added to the profile specific channel list. The Host receiver may construct other channel lists (i.e. favourites) which are under user control.

N.2.2 Logical Channel Numbering

Services delivered with the CICAM NIT shall be labelled and numbered according to the ciplus_service_descriptor. The CICAM shall ensure that a logical channel number is allocated only once to a service i.e. logical channel numbers are unique. A service may be assigned multiple logical channel numbers and the assigned service shall appear multiple times in the logical channel list with a different logical channel number.

Hidden selectable services shall not appear in the channel list but may be selected by direct entry of the logical channel number and shall be presented.

Hidden non-selectable services shall not appear in the channel list and may only be selected by an application environment (where supported by the Host).

In networks without any logical channel assignment then the CICAM shall determine the channel ordering i.e. network order, alphabetic etc. and assign logical channel numbers. Special services which are not explicitly assigned a logical channel assignment shall use a logical channel assignment value of all-ones (0x3fff) used to hide a service e.g. a special software download service. Any special hidden services for S/W download and alike may be included in the logical channel list so that their multiplex is accessible to the CICAM via the Host Control tune() with a DVB triplet.

Services assigned a logical channel number by the service operator, via the CICAM NIT, may not be re-numbered by the user in the context of the service operator logical channel list.

The CICAM shall manage the logical channel number assignment through the CICAM NIT and shall take into account the service_type's supported by the Host (i.e. SD or HD) and regional services based on the receiver location. The methods used by the CICAM to determine the regional location and regional service line up is outside the scope of this specification and is operator specific.

N.2.3 Service Types

Services shall be added to the channel list according to the rules of the ciplus_service_descriptor; all services explicitly required in the channel list shall be declared by this descriptor. The service shall be included irrespective of whether the Host is able to decode that service type, the CICAM is notified of the service types known to the Host and is able to tailor the service list according to this Host information and the requirements of the service operator.

The CICAM shall ensure that the service list is constructed based on the service operator rules and takes into consideration the capabilities of the supported Host service_type's.

A Host encountering a unknown service type shall remain robust and shall provide an indication to the user that the service is not supported i.e. "This service is not supported please contact your Service Operator for more information".

N.2.4 Network Updates

Changes in the network occurring in the CICAM NIT shall be handled by the Host within 24 hours of the change notification whilst the Host is operating in the profile channel list. The Host may automatically update the channel list or minimally inform the user that there has been a change in the network, providing a manual mechanism to update the Host.

N.2.5 Text Strings

The CICAM shall monitor the host_language APDU to determine the Host language, a change in the Host language may require the CICAM to update the CICAM NIT with new text strings that match the Host preferred language.

History

Document history		
Version	**Date**	**Description**
1.3.1	22-Sept-2011	Registered Service Mode clarification [5.4.2] Clarification of Operator Profile including profile type 0 usage [14.7.2], Host initiated cancel [14.7.5.9], operator_status [14.7.5.3] and operator_info [14.7.5.7] Clarifications to PIN [5.11,11.3.2] and license handling [5.10] Security improvements to Host Control v2 [14.6.2.1] Clarification of the SAS Resource [11.4.2] Clarification to CICAM upgrade progress reporting [14.3.5.4] Miscellaneous typographic corrections
1.3	14-Jan-2011	prng_seed per manufacturer [5.3] URI version 2 [5.7.5.2] Digital Only Token [5.7.5.3] Content license [5.10] Parental Control [5.11] Recording and Storage [5.12] Host Authentication [Table 6.3, step 13, item d] Certificates, Service operator ID [9.3.6] Host shunning, SDT absent [10.4] Version 2 of CC resource [11.3] SAS APDU clarifications [11.4, Annex M.2.1] MHEG profile extensions [12.8] Low Speed Communications v3 [14.1] IP connection by name [14.2.1.2] Application MMI clarifications [14.4] Application MMI File Caching [14.5] Host Control v2 [14.6] Operator Profile [14.7, Annex N] APDU clarifications [Annex E] CIS Feature Identification [G.3.1] Removal of PVR Resource [v1.2, 15]
1.2	16-Apr-2009	Addition of module CI Plus compatibility identifier (Annex G.3) Qualify all SHA algorithms as FIPS 180-3[3] and adhere to SHS validation list[11] Corrections to the resource summary (Annex L) Miscellaneous typographic corrections.
1.1	28-Nov-2008	New release.
1.0	23-May-2008	Publication.
0.80	18-Dec-2007	Public Review.