A General Packet Radio Service Proposed for GSM

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- Features and Applications Characteristics
- CELLPAC-V&D:
  A Voice-and-Data Packet-Access-Protocol
- Simulation of Packet Radio in GSM

RWTH

Abstract

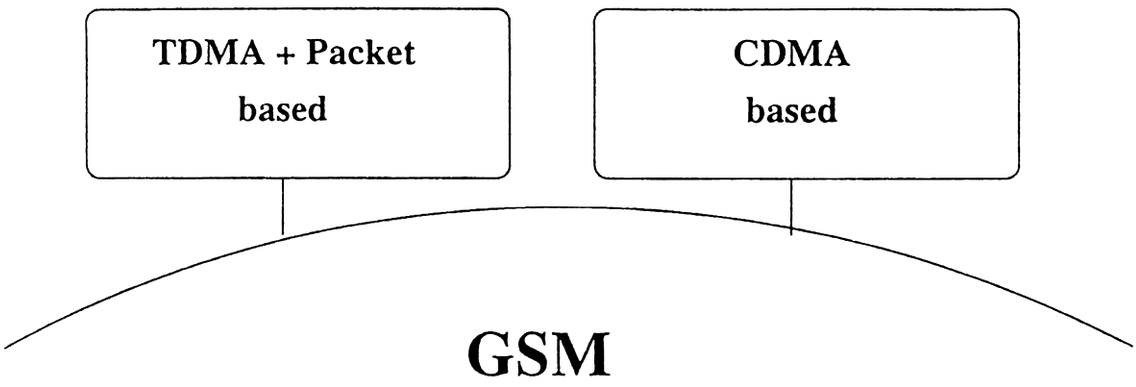
Cellular radio is in use in many European countries mainly to provide point-to-point telephone conversation and — today to a limited degree — data exchange between one mobile and another terminal at (in most cases) fixed location.

GSM only offers circuit switched services on the air interface. Future digital mobile radio systems based on TDMA (as in UMTS or TETRA) will use a packet access mechanism, which is known to give a better utilisation of the transmission medium in case of bursty traffic.

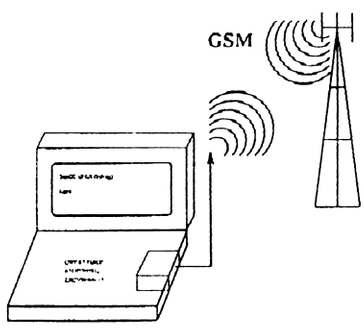
A packet access mechanism within GSM could provide several new services such as half duplex voice transmission as in trunked radio systems and medium bitrate data services. Medium variable bitrate data services are required in fields such as rail and road transport informatics.

A packet access protocol (CELLPAC V&D) adapted to the GSM TDMA structure is proposed. Simulation results for Packet Voice using voice sources switched by the GSM voice activity detection will be presented considering silence descriptors and handover support (SACCH). Radio wave propagation and the resulting bit errors are taken into account by modelling the channel according to a Rayleigh fading signal.

Beyond the GSM horizon:



Features of Packet Radio:



- gives a better utilisation of the transmission medium (transmission only when sources are active)
  → accommodation of more users than pure TDMA.
- permits the integration of
  - different low and medium bitrate services
  - variable or bursty bitrate services
  - multicast services

Packet Radio Services in GSM:

- Packet Data
  - packet radio for many X.25 DTEs via dedicated TCH
    e.g. for
    * personal data communication
    * advanced traffic control
    * dynamic route guidance
    * fleet management
- Packet Voice (approx. 90 ms delay)
  - trunked radio like voice service (half duplex)
  - telephony (duplex)
  - voice mail service

Characteristics & GSM Solution for Voice Telephony:

- talkspurts:

→ voice segments & SACCH data

- silence periods:

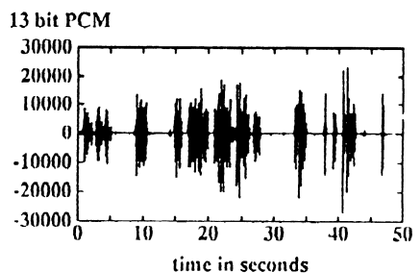
→ silence descriptors & SACCH data

- small delay (few ms)

→ about 60 to 100 ms

- voice activity: 40 .. 60%

→ discontinuous transmission: 47 .. 65% FR (54 .. 70% HR)

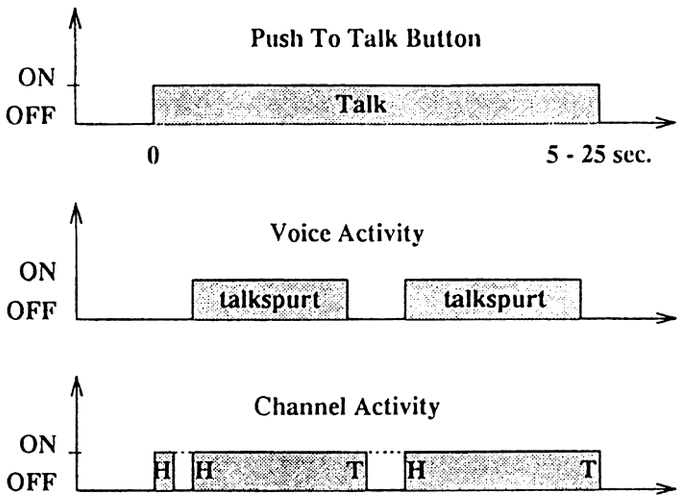


Proposal:

voice activity detection (VAD)
currently used for discontinuous transmission
→ can be used for packet voice

Characteristics of Trunked Radio like Voice Conversation:

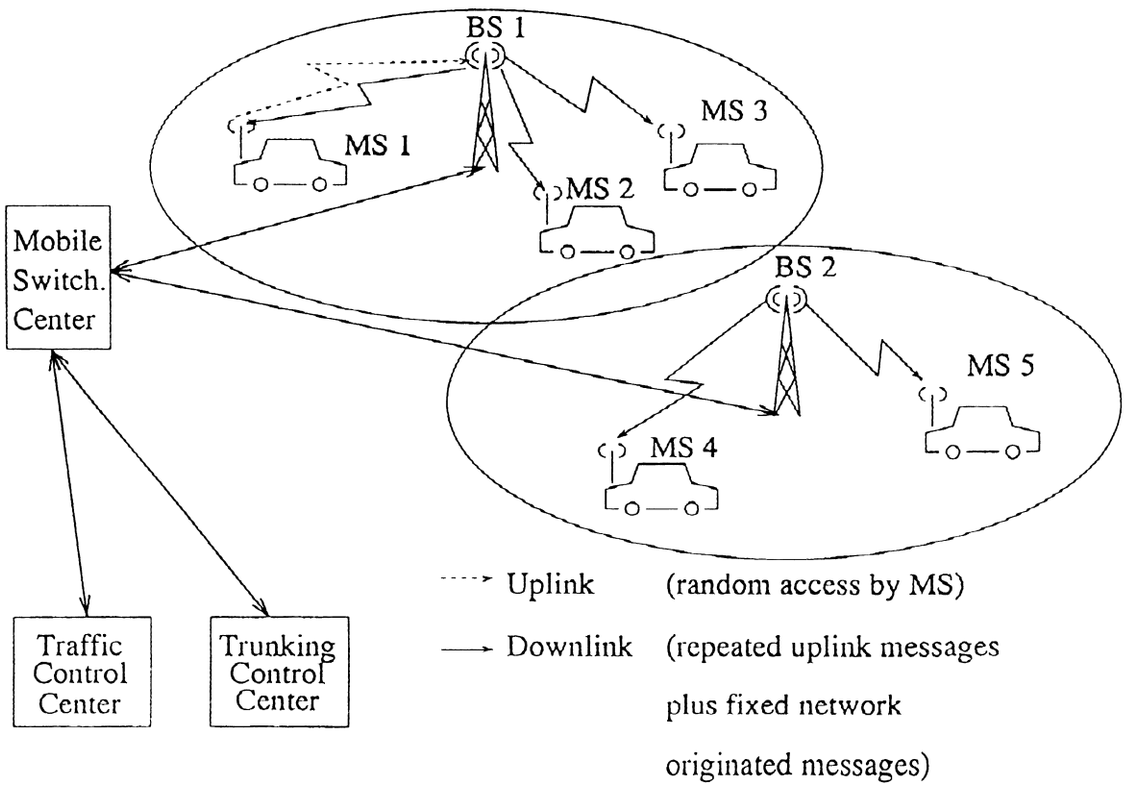
- 4 – 20 times per hour and MS
- halfduplex speech
- voice activity < 100 %



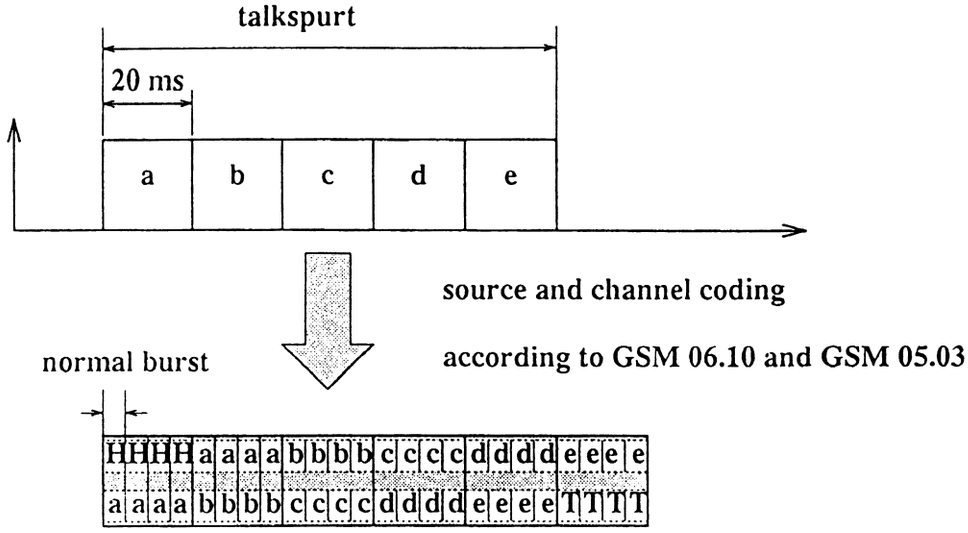
Observarions:

- no silence descriptors and no SACCH necessary
- delay requirements: total delay < 500 ms

Packet Radio Scenario:



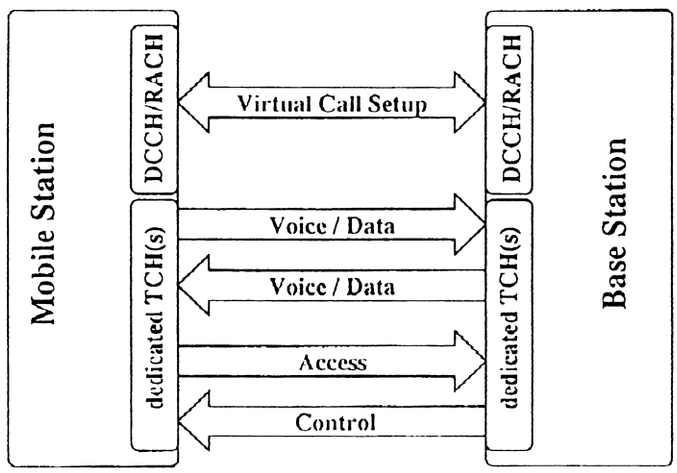
Example: Full Rate Voice Coding



H: message header (originator, service-id., etc.)

T: trailer

Logical Channels:



Packet Control Channel (Downlink):

- acknowledgements to successfully received access bursts
- indication of starting downlink transmissions

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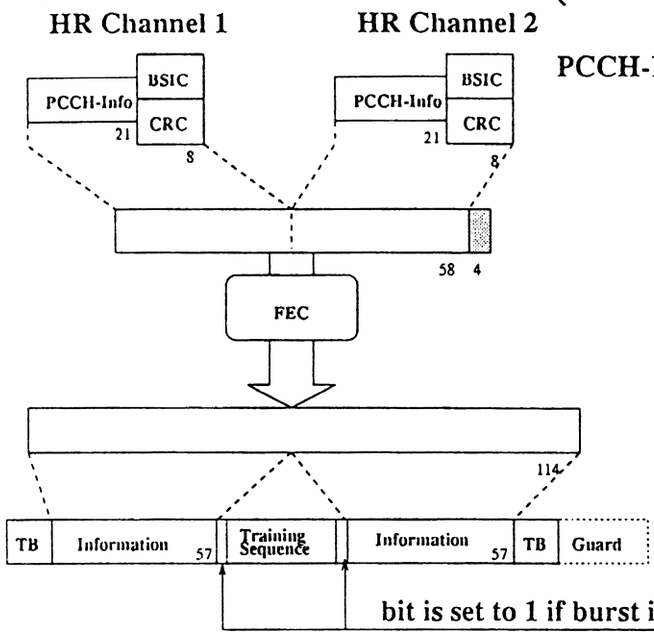


PCCH-Info: [1] Uplink State Indication Bit
[8] MS-Random Number
[6] MS-Timing Advance
[5] MS-Power Level
[1] Paging Bit

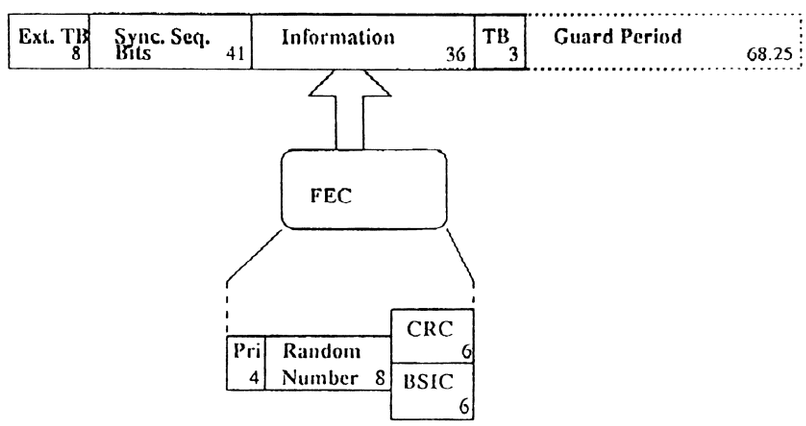
[21] for one HR Channel

Packet Control Channel Burst (Normal Burst)

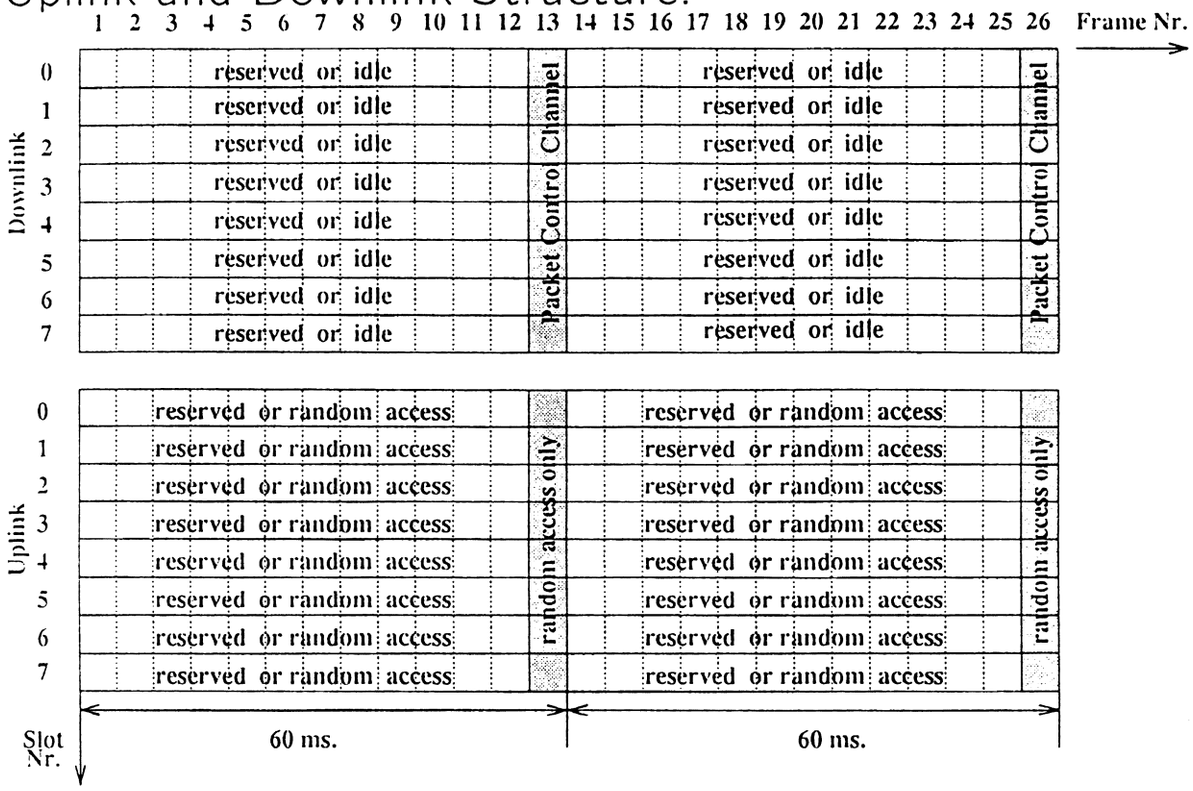
bit is set to 1 if burst is not transmitted on the provided slot

Uplink Structure:

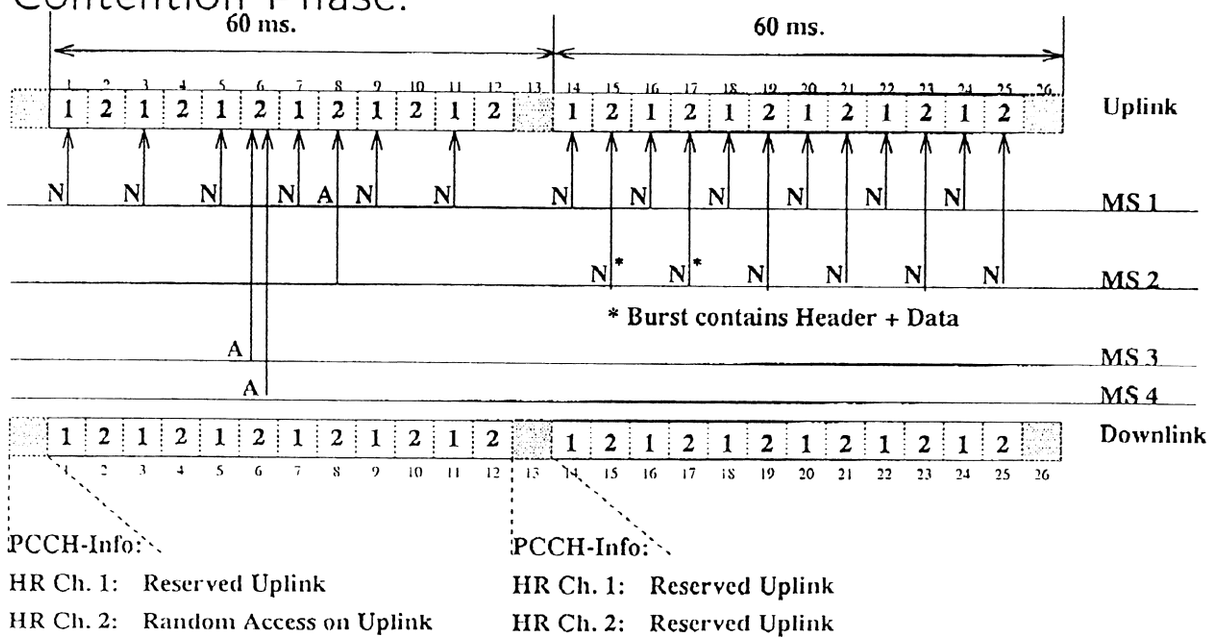
- Uplink Normal Burst: (in reserved state)
  Packets containing data from a single MS.
- Uplink Access Burst: (in random access state)
  Access bursts containing
  a random number (8 bit) and a priority (4 bit)



Uplink and Downlink Structure:



Contention Phase:



PCCH-Info:
HR Ch. 1: Reserved Uplink
HR Ch. 2: Random Access on Uplink

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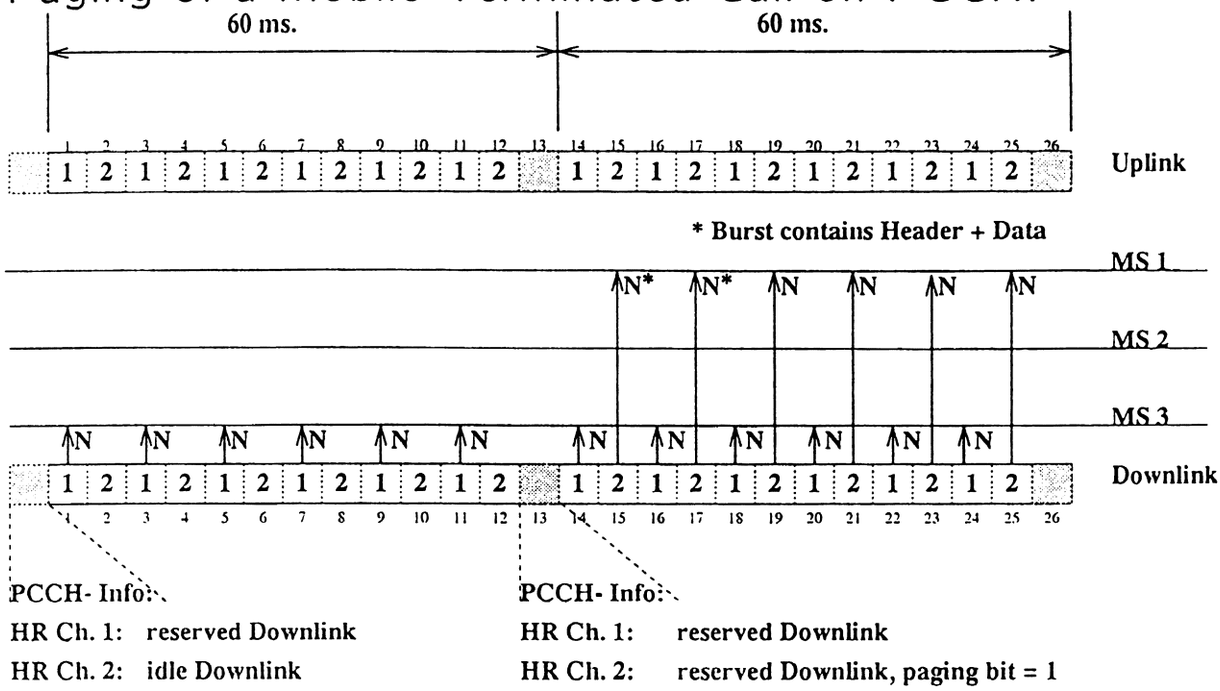
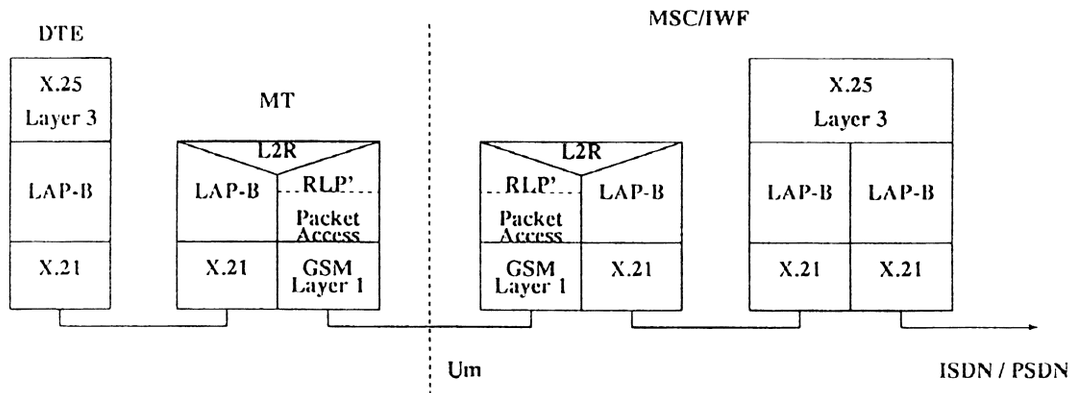
PCCH information can also be carried on idle HR downlink TCH

Paging of a Mobile Terminated Call on PCCH:



Protocol Stacks for a Packet Data Service in GSM:



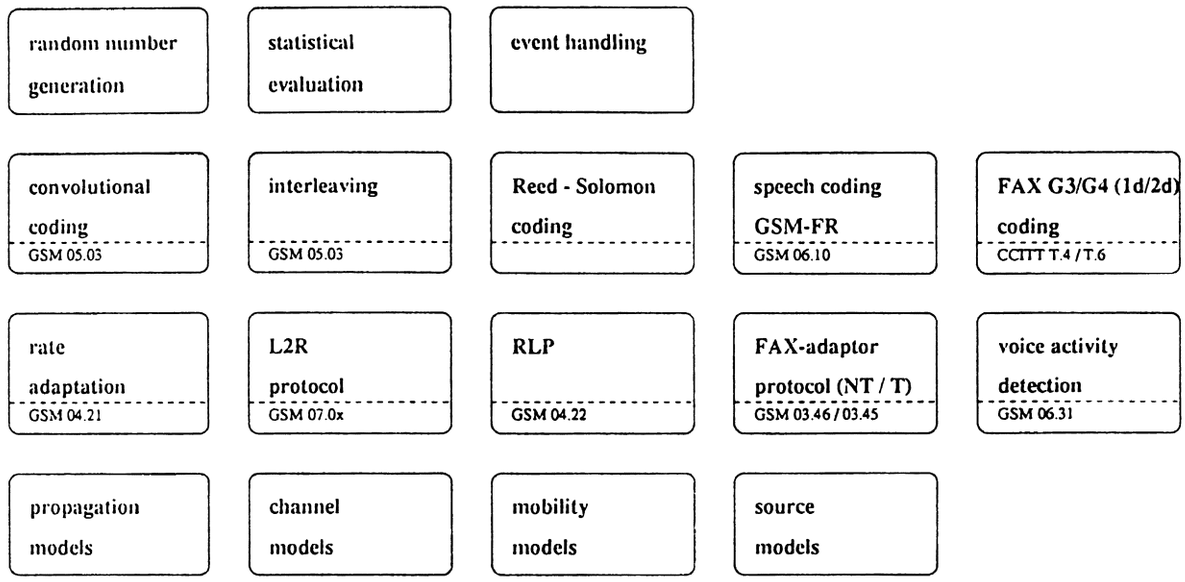
Layer 3 virtual circuits service /
connectionless datagram service (fast select)

RLP' modified Radio Link Protocol
(e.g. a Type-II Hybrid ARQ/FEC protocol)

Packet Access CELLPAC-DO or CELLPAC-V&D

Protocol Stacks for packet voice (f.f.s)

Simulator Structure (Modules)



Evaluated Protocols

- GSM Voice Transmission
- RLP and FAX Adapter Protocols
- LAPDm and Radio Resource Management

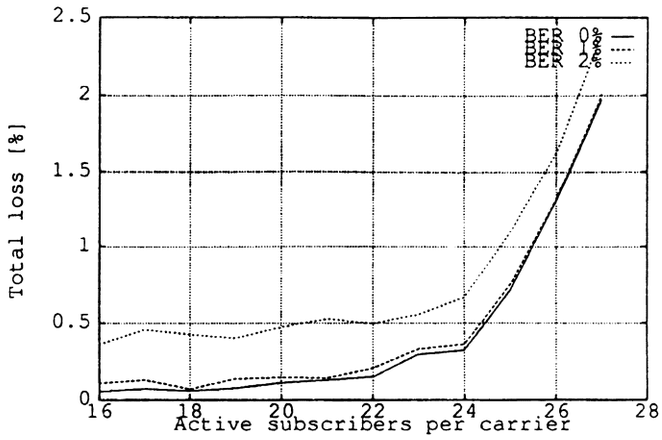
Packet Radio Protocols suitable for GSM:

- CELLPAC-DO → one dedicated TCH
- CELLPAC-V&D → for multiple dedicated TCHs

Packet Voice GSM

Assumptions:

- voice activity: 40%
- silence descriptors (transmitted relative to the end of a talkspurt)
- SACCH on separate channel
- Rayleigh Fading Channel with BER = [0..2%]
- 16 Half Rate TCH



Packet Loss

Trunked Radio Applications (First Simulation Results)

Assumptions:

- no silence descriptors
- no interference/fading
- infinite queue
- mean access delay < 500 ms
- voice activity: 100%
- station activity: A [mErl]
- call interarrival time: neg. exp. distributed

Number of Channels (HR-TCH)	Number of Mobile Stations (HR coding)	
	A=50 mErl	A=10 mErl
2	10	50
4	35	190
8	105	520
16	240	1300

- call duration: Erlang distributed mean value $= 10s$, variance $= 10s^2$

CELLPAC-V&D:

Pros:

- integration of packet voice and packet data services without changing the GSM burst and channel structure
- adaptivity to packet load (number of assigned channels)
- full and half rate speech coding allowed simultanuously
- discontinuous reception possible, controlled by paging bit

Cons:

- additional transmission delay of approx. 90 ms
- packet dedicated TCHs need use the same frequency (up to 8 FR-TCH or 16 HR-TCH)

Current Work

- Simulation of CELLPAC-V&D in mobile outdoor/indoor environment at 900/1800 MHz under different traffic assumptions and interference scenarios
- Improvments on the Radio Link Protocol based on hybrid ARQ Type-II techniques

Future Work

- Development of adaptive channel assignment methods dependent on packet traffic
- Optimization of access control and logical link control protocols in mixed voice and data applications