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- (71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (PUBL) [SE/SE]; S-164 83 Stockholm (SE).
- (72) Inventors: LINDQVIST, Fredrik; Karlavagnsgränd 24, S-175 66 Järfälla (SE). ERIKSSON, Erik; Landeryd, Skogsstugan, S-585 93 Linköping (SE). HESSLER, Martin; Kompanigatan 16, S-587 58 Linköping (SE). YILMAZ, Osman Nuri Can; Merivirta 9 A 11, FI-02320 Espoo (FI).
- (74) Agent: BOU FAICAL, Roger; Ericsson AB, Patent Unit Kista RAN1, S-164 80 Stockholm (SE).
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(54) Title: ADVANCED ERROR DETECTION CODING

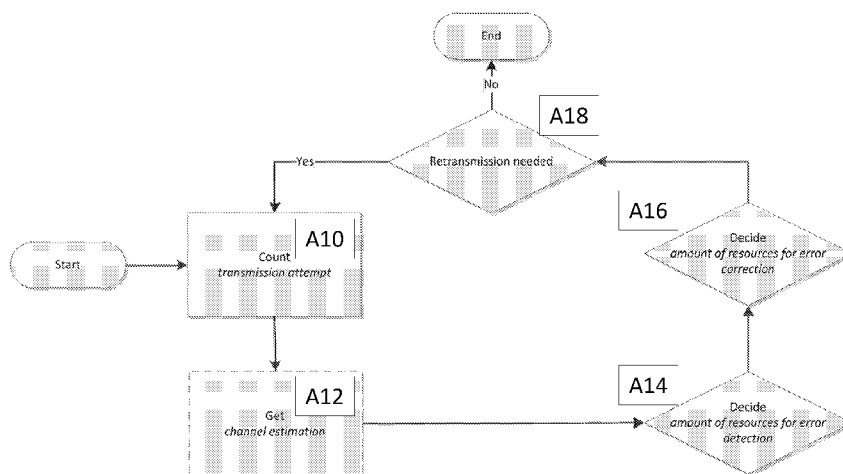


Figure 1

(57) Abstract: There is disclosed a method for operating a transmitting node (10, 100) for a wireless communication network, the transmitting node being adapted for transmitting data utilizing error detection coding, wherein the error detection coding has a coding length in bits, the method comprising adapting the coding length based on a retransmission status of the data. There are also disclosed a corresponding method for operating a receiving node and corresponding nodes and program products and storage media.

## Advanced error detection coding

### Technical Field

- 5 The present disclosure pertains to wireless communication networks and technology, in particular to the use of error detection coding.

### Background

- 10 In many wireless communication networks, data is transmitted in packets or transport blocks. Next to the data to be transmitted, each transport block may contain bits for error detection coding (EDC) and forward error correction (FEC, also called channel coding). Error detection coding enables determining whether data has been received (and/or decoded) correctly, whereas forward error correction may facilitate correcting  
15 incorrectly received (and/or decoded) data. The encoding (and decoding) for error detection and forward error correction may be separated from each other and may allow independent treatment of the data. The term error coding may generally refer to and/or encompass error detection coding and/or forward error correction coding. Coding may generally refer to encoding and/or decoding, wherein decoding may in particular be  
20 performed on a receiver side and/or encoding may be performed on a transmitter side.

- These codings may be used in a context with a HARQ-process (Hybrid Acknowledgement ReQuest), in which each transport block to be transmitted is assigned a HARQ-identifier. If a block is determined to be received (and/or decoded)  
25 correctly, the receiver (e.g., a terminal or user equipment) may reply with an acknowledgement signal (ACK) for the corresponding HARQ-identifier. If the block is determined not to be received (and/or decoded) correctly, the reply may signal non-acknowledgement (NACK). In this case, the transport block may be scheduled for resending using the same HARQ-identifier one or more times, until an ACK reply is  
30 received by the transmitting node.

Coding and decoding (both for error detection and FEC) both require like computational resources and occupy transmit resources like time and/or frequency resources when transmitting correspondingly encoded data or transport blocks. The thus produced  
5 overhead can be substantial.

## Summary

An object of the present disclosure is to provide solutions limiting the overhead, in  
10 particular regarding the use of computational and/or transmit resources, when dealing with data in the context of error coding.

There is disclosed a method for operating a transmitting node for a wireless communication network, the transmitting node being adapted for transmitting data  
15 utilizing error detection coding. The error detection coding has a coding length in bits. The method comprises performing adapting the coding length based on a retransmission status of the data.

Moreover, a transmitting node for a wireless communication network is described. The  
20 transmitting node is adapted for, and/or may comprise a transmitting module for, transmitting data utilizing error detection coding. It may be considered that the error detection coding has a coding length in bits. The transmitting node further is adapted for, and/or may comprise a coding length adapting module for, adapting the coding length based on a retransmission status of the data.

25 There is also disclosed a method for operating a receiving node for a wireless communication network, the receiving node being adapted for receiving error encoded data, the method comprising adapting of decoding the error encoded data based on a retransmission status of the data

30

Furthermore, a receiving node for a wireless communication network is described, the receiving node being adapted for, and/or comprising a receiving module for, receiving error encoded data, the receiving node further being adapted for, and/or comprising a decoding module for, adapting of decoding the error encoded data based on a  
5 retransmission status of the data.

There is also disclosed a program product comprising code executable by control circuitry, the code causing the control circuitry to perform and/or control any of the methods described herein when executed by the control circuitry, as well as a storage  
10 medium storing such a program product.

With the approaches and concepts disclosed herein, it is possible to adapt error coding to the dynamics of data transmission, allowing in particular reducing the overhead in cases in which data already has been transmitted and it may be assumed that the error  
15 probability is reduced due to the retransmission or expected to be low, e.g. in the case of MTC, in particular Critical-MTC.

#### Brief description of the drawings

20 The figures are intended to illustrate examples of the concepts introduced for the sake of illumination, not limitation.

Figure 1 shows a flowchart of a method for operating a transmitting node;

25 Figure 2 shows an example of a method for operating a transmitting node;

Figure 3 shows an example for a transmitting node;

Figure 4 shows an example of a method for operating a receiving node;

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Figure 5 shows an example for a receiving node;

Figure 6 shows an example for a transmitting node; and

5 Figure 7 shows an example of a receiving node.

#### Detailed description

10 In the context of this disclosure, the retransmission status of data may indicate whether a block of data, in particular a transport block, is intended and/or provided for (e.g., by a transmission node) and/or received in (e.g., by a receiving node) a first transmission or a subsequent re-transmission, in particular in a HARQ-process. The retransmission status may in particular indicate how often the transport block already has been transmitted (e.g., before the currently intended or scheduled or transmitted) and/or

15 which is the current number of retransmission. A retransmission status may pertain to a specific transport block (respectively the data therein) and/or a specific HARQ process and/or a correspondingly assigned HARQ identifier. A node, in particular a transmitting node or receiving node, may monitor (e.g., count), and/or be adapted for monitoring and/or comprise a monitoring module for monitoring, a retransmission status of a

20 transport block and/or a corresponding HARQ identifier (and, e.g. corresponding transmissions or transport blocks), e.g. by counting the number of transmission or retransmissions (e.g., the number of transmissions for the block or identifier, e.g. for a transmitting node, or the number of received blocks, in particular for the associated identifier, e.g. for a receiving node, and/or storing the blocks transmitted and/or

25 received, e.g. for a receiving node). A HARQ identifier may be reused after it has been determined that a transport block has been transmitted or received successfully, e.g. based on decoding of EDC and/or FEC. A different (re-)transmissions of data, the data may be in different transport blocks, e.g. due to different error detection coding and/or FEC coding.

30

Data (which may also be called communication data) may generally comprise or be user data and/or control data and/or allocation data. Control data may pertain to controlling a node, e.g. a receiving node, and/or may comprise control signaling, e.g. Allocation data may pertain to scheduling resources, e.g. for a receiving node. Control  
5 data and/or allocation data may pertain to a configuration (or configurations) for a node to be configured, e.g. a terminal or UE.

Data may be transmitted or received in packets, e.g. transport blocks. A transport block of data (called transport block for short) may comprise data, in particular bits of data, to  
10 be transmitted, e.g. user data and/or control data and/or allocation data, for example a certain amount of bits and/or having a data bit length (the amount may be adaptable, e.g. according to data transmissions conditions and/or amount of total data to be transmitted). In addition, a transport block may comprise coding for error detection, in particular bits for error detection, which may be called error detection bits or EDC bits,  
15 and coding for forward error correction, in particular bits for forward error correction, which may be called (forward) error correction or FEC bits.

Error encoded data may comprise or be data on which error encoding has been performed, in particular EDC and/or FEC. Error encoded data may be transmitted in the  
20 form of a transport block, to which a HARQ identifier may be assigned; for retransmissions the transport block assigned the same HARQ identifier may be different due to differences in error coding used, but contain the same data. Data encoded for EDC may be called EDC encoded data, data encoded for FEC may be called FEC encoded data. Data in a transport block may be encoded both for EDC and FEC. FEC  
25 may be performed after EDC and/or including bits of error detection coding.

The coding (for error correction) and/or the error detection bits may be provided by performing error detection coding, in particular encoding, the size of the coding may represent or correspond to the number of error detection bits and may be referred to as  
30 coding length or error detection coding length. Error detection coding, in particular

encoding, may be performed by a transmitting node and/or an EDC encoding module of the transmitting node. A coding may be represented by one or more codes and/or algorithm to be performed when coding. A coding for decoding may be complementary to a corresponding coding for encoding (and vice versa).

5

Analogously, the correction coding and/or the error correction bits may be provided by performing (forward) error correction coding, in particular encoding, the size of the coding may represent or correspond to the number of error correction bits and may be referred to as correction coding length or error correction coding length. Forward error correction coding, in particular encoding, may be performed by a transmitting node and/or an FEC encoding module of the transmitting node.

10

Encoding for error detection may comprise determining and/or calculating one or more EDC bits, in particular a predetermined number of EDC bits (corresponding to the coding length) and/or according to a chosen algorithm. In particular, encoding for error detection may comprise utilizing a CRC (Cyclic Redundancy Check) algorithm.

15

Encoding for forward error correction may comprise determining and/or calculating one or more FEC bits, in particular a predetermined number of FEC bits (corresponding to the correction coding length) and/or according to a chosen algorithm. In particular, encoding for forward error correction may comprise utilizing an error correcting algorithm or code, e.g. a convolutional code and/or a Hamming code and/or Reed-Solomon code and/or a Reed-Muller code and/or a turbo code, or any other suitable FEC code.

20

Decoding (for error detection coded data and analogously for FEC encoded data) may comprise utilizing a coding for decoding error encoded data, wherein the coding in particular may have a coding length. The coding may be configured, e.g. by a transmission node, and/or be pre-determined. Decoding error detection coding may comprise determining whether (or not) an error occurred when transmitting and/or

30

5 decoding the data. Decoding error detection decoding and/or such determining may comprise determining a probability that one or more errors occurred (and/or a probability, that no error occurred), based on the error detection coding. This decoding may comprise comparing the probability (and/or corresponding parameter/s or a set of parameters) with a threshold (or corresponding threshold value).

10 The threshold or value may be configured or pre-defined. It may be considered that the threshold or value is adapted or adaptable based on the retransmission status and/or transmission conditions. If the probability that an error occurred is below the threshold, it may be determined that no error occurred. Determining a probability may comprise calculating and/or estimating the probability and/or a parameter or set of parameters indicative and/or representing the probability. Decoding a FEC coding may comprise soft-combining of previously received error encoded data (in particular of the same transport block and/or the same HARQ process or identifier). If a coding length (and/or correction coding length) has been changed, decoding for FEC or soft-combining may generally comprise re-calculating some values for FEC, e.g., as the FEC may be performed including and/or on error detection coding bits.

20 A wireless communication network may comprise one or more radio nodes adapted for wireless and/or radio communication. One or more of the nodes may form a Radio Access Network (RAN), e.g. according to one or more specific Radio Access Technologies (RAT), e.g. LTE (Long-Term Evolution, a telecommunication standard describing a RAT) and/or LTE-based. At least one radio node like a base station may be connected or connectable to node providing higher-level functionality and/or a core network.

25 A radio node in the context of this disclosure may in particular a transmitting node and/or a receiving node (or vice versa). A transmitting node may in particular be a base station. It may be considered that a receiving node is a terminal or user equipment (UE).  
30 A base station may generally be adapted for radio and/or wireless communication with



one or more terminals or UEs and/or to control communication to and/or with the terminals or UEs, e.g. by configuring and/or scheduling them. Scheduling may comprise determining and/or assigning time-frequency resources for and/or to communication, in particular for transmission and/or reception, e.g. for Uplink (UL) and/or Downlink (DL) communication. Scheduling may comprise sending corresponding signals or information, e.g. control data or allocation data.

Configuring a node, in particular a receiving node and/or terminal or UE, may comprise sending control data indicating a configuration (which may be allocation data) to the node to be configured. A configuration may describe a setting and/or operational mode for the configured node, which may be adapted to configure itself for such configuration, e.g. based on the corresponding data. A configuration may for example pertain to scheduled resources for the configured node and/or setting for transmission and/or reception or corresponding circuitry like control and/or radio circuitry and/or pertain to coding of data, in particular the decoding of data, e.g. one or more transport blocks of data received and/or to be received and/or intended for the node. A base station generally may be an eNodeB (eNB).

There is disclosed a method for operating a transmitting node for a wireless communication network, the transmitting node being adapted for transmitting data utilizing error detection coding. The error detection coding has a coding length in bits. The method comprises adapting the coding length based on a retransmission status of the data. The method may comprise transmitting the data or error encoded data at least once before adapting the coding length.

Moreover, a transmitting node for a wireless communication network is described. The transmitting node is adapted for, and/or may comprise a transmitting module for, transmitting data utilizing error detection coding. It may be considered that the error detection coding has a coding length in bits. The transmitting node further is adapted

for, and/or may comprise a coding length adapting module for, adapting the coding length based on a retransmission status of the data.

5 Adapting the coding length may be performed after transmitting the data at least once and/or for a retransmission of the data, e.g. within the same HARQ process and/or for the same HARQ process identifier. The transmitting node or the coding length adapting module may be adapted accordingly.

10 There is also disclosed a method for operating a receiving node for a wireless communication network, the receiving node being adapted for receiving error encoded data, the method comprising adapting of decoding the error encoded data based on a retransmission status of the data. The method may comprise receiving the data or error encoded data at least once before adapting the decoding.

15 Furthermore, a receiving node for a wireless communication network is described, the receiving node being adapted for, and/or comprising a receiving module for, receiving error encoded data, the receiving node further being adapted for, and/or comprising a decoding module for, adapting of decoding the error encoded data based on a retransmission status of the data.

20 Adapting the decoding may be performed after receiving (and decoding) the data at least once and/or for a retransmission of the data, e.g. within the same HARQ process and/or for the same HARQ process identifier. The receiving node or the decoding module may be adapted accordingly.

25 Adapting the coding length and/or adapting the decoding may generally comprise changing (e.g., reducing) the coding length and/or the decoding or decoding method as compared to an earlier or the (directly) preceding transmission of data.

There is also disclosed a program product comprising code executable by control circuitry, the code causing the control circuitry to perform and/or control any of the methods described herein when executed by the control circuitry, as well as a storage medium storing such a program product.

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Transmitting utilizing error detection coding may comprise performing encoding for error detection before transmitting. A transmitting node may be adapted for, and/or comprise an EDC encoding module for, such encoding. Alternatively, transmitting utilizing error detection coding may comprise receiving EDC encoded data and transmitting (e.g.,  
10 relaying) it. It may be considered that transmitting has a target, which may be a receiving node and/or a relaying node, which for example may relay data transmitted to a final or intermediate (relaying) target, wherein a final target may e.g. be a receiving node. Transmitting data may in particular be in the context of Critical-MTC and/or with a defined and/or required BLER of  $10^{-4}$  or below, in particular  $10^{-5}$  or below or  $10^{-6}$  or  
15 below, and/or between  $10^{-6}$  and  $10^{-9}$  or below. Transmitting may include re-transmitting data, in particular in the context of a HARQ-process and/or based on a NACK indication received, e.g. from a receiving node.

Adapting the coding length based on a retransmission status of the data may comprise  
20 encoding for error detection with a coding having a different length and/or using a different coding algorithm (in particular, having a different coding length) for encoding than coding used in an earlier transmission of the (same) data or transport block.

The coding or algorithm used for encoding (and/or the coding length) may be selected  
25 from a pre-defined or configured set of codings or algorithms or coding lengths, which may e.g. be stored in a memory of the transmission node.

The error detection coding may generally comprise or be CRC coding.

It may be considered that adapting the coding length comprises reducing the coding length for retransmission of the data, for example by selecting a corresponding coding and/or coding length. The coding length may be reduced sequentially and/or more than once for a sequence of retransmissions and/or according to a pre-defined or configured  
5 scheme. By reducing the coding length, both the computational power and the total amount of bits to be transmitted (in the transport block) may be reduced. In a variant, reducing the coding length may comprise increasing a correction coding length (of FEC), e.g. to keep the sum of bits represented by coding length and correction coding length constant (e.g., in comparison of an earlier transmission of the data, in particular  
10 earlier within the same HARQ process), or to lower the sum below a sum of the bits of a corresponding earlier transmission. The earlier transmission may be the directly preceding transmission.

Generally, adapting the coding length, e.g. for encoding or decoding, may be performed  
15 for a retransmitting the data or retransmitted data, respectively. In particular, such adapting may pertain to data intended for retransmission or transmitted at least once before, e.g. within the same HARQ process and/or for the same identifier.

Adapting the coding length may be based on transmission conditions, in particular  
20 channel conditions.

Transmission conditions may generally be determined based on and/or comprise a SIR/SINR and/or interference and/or transmitting power and/or received power and/or corresponding measurements and/or report/s, e.g. transmission feedback, and/or one or  
25 more transmission condition reports, from at least one receiving node, which e.g. may indicate transmission conditions like SIR/SINR and/or received power and/or CSI measurement reports. The transmission node may receive, and/or be adapted for receiving, and/or comprise a report or feedback receiving module for receiving, transmission feedback and/or one or more transmission condition reports, e.g. from one  
30 or more receiving nodes. Thus, the overhead involved with error coding may be

responsive to transmission conditions and generally be lowered for good transmission conditions. It may be considered that transmission conditions comprise information pertaining to the data or type of data, e.g. Quality of Service level associated to the data, and/or whether the data is control data or user data. Transmission conditions may  
5    pertain and/or be determined for a previous transmission of the encoded data, in particular the directly preceding transmission.

The method for operating a transmission node may comprise performing forward error correction coding on the data, in particular after error detection coding, the forward error  
10    correction coding having a correction coding length in bits. The coding performed may be encoding. The encoding may be performed before transmitting the (error encoded) data.

Alternatively or additionally, the method may comprise adapting a correction coding  
15    length for forward error correction coding of the data based on the retransmission status of the data and/or transmission conditions, in particular channel conditions.

The transmitting node may further be adapted for, and/or comprise a FEC module for, performing forward error correction coding on the data, in particular after error detection  
20    coding, the forward error correction coding having a correction coding length in bits. The coding performed may be encoding. The encoding may be performed before transmitting the (error encoded) data.

Alternatively or additionally, the transmitting node may be adapted for adapting a  
25    correction coding length for forward error correction coding of the data based on the retransmission status of the data.

Generally, adapting of decoding the error encoded data may further be based on transmission conditions, in particular channel conditions.

30

Adapting of decoding the error encoded data may comprise adapting a threshold value for error detection. Adapting a threshold value may in particular comprise increasing the probability that it is determined that no error occurred (e.g. when decoding), which may lower the overhead needed for decoding. Alternatively or additionally, adapting of  
5 decoding the error encoded data may comprise adapting a number of hypotheses for codewords tested for correctness with the error detection coding based on the retransmission status, e.g. increasing the number of hypotheses with increasing number of (re-) transmissions.

10 Alternatively or additionally, adapting of decoding the error encoded data may comprise adapting a coding length for decoding of error detection coding the data is encoded with. It may be considered that adapting the coding length comprises reducing the coding length, e.g. for retransmission of the data (e.g., as received by the receiving node), for example by selecting a corresponding coding and/or coding length. The  
15 coding length may be reduced sequentially and/or more than once for a sequence of retransmissions and/or according to a pre-defined or configured scheme. By reducing the coding length, both the computational power and the total amount of bits to be transmitted (in the transport block) may be reduced. In a variant, reducing the coding length may comprise increasing a correction coding length (of FEC), e.g. to keep the  
20 sum of bits represented by coding length and correction coding length constant (e.g., in comparison of an earlier transmission of the data, in particular earlier within the same HARQ process), or to lower the sum below a sum of the bits of a corresponding earlier transmission. The earlier transmission may be the directly preceding transmission:

25 Adapting of decoding the error encoded data may comprise adapting a correction coding length for decoding of forward error correction coding the data is encoded with.

The transmitting node may receive, and/or be adapted for receiving, and/or comprise a reception module for receiving, a transmission feedback, e.g. from a receiving node.

30

Transmission feedback may generally comprise an ACK or NACK, in particular pertaining to a specific retransmission process and/or HARQ process and/or transport block, which may be represented by a corresponding identifier, e.g. a HARQ process identifier. Transmitting data may comprise retransmitting data based on transmission  
5 feedback, in particular based on a NACK received. It may be considered that transmission feedback comprises one or more transmission condition reports.

The receiving node may transmit, and/or be adapted for transmitting, and/or comprise a feedback transmitting module for transmitting, transmission feedback to a transmitting  
10 node, from which the error encoded data may be received. The transmission feedback may be determined based on decoding error coding, in particular decoding error detection coding and/or FEC.

It may be considered that the transmitting node configures, and/or is adapted for  
15 configuring, and/or comprises a configuring module for configuring, a receiving node with a coding for EDC and/or a coding for FEC and/or a coding length and/or correction coding length and/or a scheme for adapting the coding and/or coding length and/or FEC coding and/or correction coding length and/or for adapting its decoding to correspond to the adapted error coding utilized for transmitting the data, in particular for error detection  
20 coding and/or FEC coding. Alternatively or additionally, such configuring may comprise configuring the receiving node with one or more threshold values to be used for error decoding, in particular error detection decoding. Such configuring may comprise transmitting a corresponding indication of which EDC coding and/or coding length and/or FEC coding and/or correction coding length and/or scheme and/or threshold  
25 value/s to be used for decoding. Decoding error encoded data may be based on such a configuration, which may be received from the network, in particular a transmitting node.

The concepts and ideas discussed herein are particularly applicable to 5G radio  
30 concepts or Machine-Type-Communication (MTC). For example, one main object of a

5G radio concept is to support highly reliable and low delay machine-type communication (MTC), so-called Critical-MTC. The Critical-MTC concept should address the design trade-offs regarding e.g., end-to-end latency, transmission reliability, system capacity and deployment, and provide solutions for how to design a wireless network for different industrial application use case. The Critical MTC system should allow for the coexistence between different classes of applications: with low latency sporadic data (e.g., alert message) and with real-time periodic data (or simply best-effort data). An alert message (e.g., alarm) is one important type of messages that needs support for critical MTC application. The ultra-high reliability of Critical MTC dictates that even the worst case scenarios need to be supported. This differs from traditional mobile broadband (e.g. LTE) where a BLER of 0.1 is common, in comparison to  $10^{-6} - 10^{-9}$  that are discussed for Critical MTC applications. The mechanism used in today's 3G/4G MBB systems for detecting block errors is by means of including n error detection coding like a cyclic redundancy check (CRC), i.e. a check-sum, to the block of data bits (within the transport block) received at the physical layer from higher layers (e.g. MAC and RLC). CRCs are widely used for detecting random errors in data communication and storage media. Examples of common CRCs are:

- CRC-16-CDMA2000 is used in 3G mobile networks;
- CRC-CCITT is used in Bluetooth;
- CRC-32 is used in Ethernet, HDLC protocols;
- CRC-40-GSM is used in GSM control channel.

where CRC-n denotes a CRC with the generator polynomial of degree n. A CRC with the generator polynomial of degree n detects all burst errors of length n or less. The CRC encoding and decoding can be efficiently implemented using a Linear Feedback Shift Register (LFSR).

After the error detection code, in particular CRC, has been added, channel coding is included to allow for forward error correction (FEC), which may include adding



redundancy bits. Commonly used FEC codes are turbo codes and convolutional codes. While the FEC enables correcting certain bit errors, the CRC only allows the receiver to detect, typically with high probability, whether the block contains any bit errors. If at least one bit error is detected within the block at the CRC decoding, a non-acknowledge (NACK) is sent to the transmitter to inform that the block should be re-transmitted. This mechanism is referred to as hybrid-ARQ (HARQ) where multiple parallel HARQ processes can be employed. At each re-transmission, the same CRC is commonly included to the data, even though the redundancy bits (used in FEC) may differ dependent on the redundancy versions used by the HARQ (e.g. chase combining or incremental redundancy). This has the advantage that the transmitter does not need to re-calculate the CRC. By soft combining all (erroneously) received blocks within the same HARQ process, the effective BLER is successively decreased for each re-transmission at the cost of increased delay and computational complexity. However, for a fading radio channel this re-transmissions mechanism offered by the HARQ-CRC scheme has proved successful for MBB systems employed today.

Current standards for e.g. 3G (HSPA, UMTS) and 4G (LTE) systems are designed primarily for packet-based (block-based) mobile broadband (MBB) communication. This means that the system requirements are quite different from the herein considered system of MTC communication with low delay and ultra-high reliability (i.e. MTC critical). For example, the block-error rate (BLER) of 3G/4G MBB is typically designed for roughly 0.1 whereas for MTC Critical applications the system needs to operate with much lower BLER, for instance  $10^{-9}$ . This implies that the probability of a block error, i.e. the likelihood of a transmission time interval (TTI) becoming erroneously detected, can be in the order of 1 out of 1 billion. That is, a very rare event indeed. Hence, if these systems utilize an error detection mechanism, for example, by utilizing a re-transmission mechanism based on the HARQ-CRC scheme, the control overhead will in practice only be of effective use at very rare events. In many MTC applications the situation is made more severe by the fact that the number of information bits is much smaller than in typical data transmissions like web-surfing, ftp-download and video-streaming. Hence,

the CRC overhead should be kept to a minimum in order for the system to be (spectrum) efficient. However, by decreasing the CRC overhead the strength of the CRC also decreases, which means that the probability of a missed block-error increases. The latter is undesirable since it can result in that the block will (likely) be detected as erroneous first at a higher layer, which also typically employs CRC, and hence causes a re-transmission at higher layers, leading to additional system delays.

A concept described herein comprises adapting the amount of resources for error detection based upon the error probability of the transmission. For example, by varying the length of the CRC to the HARQ re-transmission scheme in order to keep the control overhead to a minimum while at the same time not decrease the probability of missed detection of an erroneous block. This should be seen in the light of that a MTC-critical package could be fairly short, implying that the CRC would constitute a non-negligible overhead.

Some proposed solutions include a reduction of the coding length for error detection coding (e.g., a CRC length) at least one or even each re-transmission in order to lower the control overhead. At set of embodiments described below are envisioned.

In the first three embodiments, the proposed solution reduces the control overhead by employing adapted amount of error detection, for example, by adapting the CRC length. In the last embodiment, the reduced CRC overhead is used to strengthen the FEC (i.e. increased FEC overhead), which potentially lowers the number of re-transmissions and thereby decreases the (re-)transmission delay. The latter may be of particular importance for Critical-MTC applications.

In one embodiment, the successive reduction of the CRC coding length is determined by a standardized scheme known to both the transmitter and the receiver, e.g. a pre-defined scheme. For instance, a 24-bit CRC (having a corresponding coding length of

24 bit) may be used at first transmission attempt, while a 16-bit CRC is used thereafter, and possibly an 8-bit CRC is used for a third or last re-transmission attempt.

With the proposed solution, an erroneously detected code word is signaled by the receiver as a NACK to the transmitter to allow re-transmissions. The transmitter will

5 then first reduce the CRC length according to a standardized procedure known by both transmitter and receiver. More specifically, the CRC length is determined by the re-transmission count. The new CRC is calculated for the original transport block used at the first transmission attempt, received from the MAC layer. After the CRC inclusion, channel coding is performed where the number of transmitted redundancy  
10 bits (FEC) may correspond to the redundancy version employed and the re-transmission number in the HARQ process. Given the shorter packet size (due to lower CRC length), the re-transmission mechanism can be made fast. Hence the channel variations (channel conditions or transmission conditions) between successive transmissions are typically negligible and the channel may be considered  
15 as (approximately) stationary. The receiver can therefore utilize coherent combining in order to increase the SINR prior to FEC decoding. This increases the likelihood of correct decoding which is thus traded against the reduced CRC length.

It should be noted that soft-combining as in LTE may not be straightforwardly applicable, since when the CRC changes between re-transmissions, the FEC bits may  
20 have to be re-calculated.

In another embodiment, adapting and/or an adaptation-formula of or for the CRC may be based on a transmission conditions, e.g. set of reliability measurements such as SINR and previous transmission attempts, etc., to allow e.g. the instantaneous  
25 transmission or channel conditions to impact the CRC length.

This embodiment differs from the above embodiment in how the number of CRC bits (representing the coding length) for a re-transmission attempt is obtained. More specifically, adapting the coding length, namely the CRC bits, is performed based on or  
30 according to transmission or channel conditions, e.g. based on SINR measurements. As

the measurements take place at the receiver side (or a receiving node), measurement results or an indication thereof may be signaled as part of the NACK feedback and/or as transmission feedback. For systems requiring very few number of feedback bits, it is proposed to quantize the measurement results and only feedback an index to a look-up  
5 table where the transmitter retrieves the CRC length. As in the above embodiment, the receiver or receiving node may typically employ coherent combining (soft-combining) to take advantage of accumulated energy with re-transmissions.

In another embodiment, a scheme may be employed that gradually reduces both FEC  
10 bits and CRC bits, for instance based on a change in the transmission or channel conditions.

Figure 1 shows an example flowchart of a method for operating a transmitting node. When transmitting error encoded data, in an action A10 the number of the  
15 transmission attempt of the (same) data or within the same HARQ process may be counted to determine the retransmission status. In an optional action A12, a channel estimate as representative of transmission conditions may be obtained or gotten, e.g. via a transmission feedback. In action S14, based on the channel estimate (or, more generally, based on transmission conditions), if action S12 has been performed, and  
20 the retransmission status, the resources for error detection coding, in particular the coding length, may be determined. The resources (correction coding length) for FEC may be determined in A16. After transmitting the data utilizing error detection coding and FEC coding according to the determinations in A14 and A16, in action A18 it may be determined whether another retransmission is needed, e.g. based on transmission  
25 feedback. If so, it may be continued with action A10 with an increased count of transmissions. If not, the transmission of this data may be ended, and e.g. a new HARQ process may be started with new data.

Thus, as shown in the flow-chart in Figure 1, in addition to ACK/NACK response (as  
30 part of a transmission feedback) and the retransmission count, channel estimation

e.g., based on the instantaneous channel knowledge or the channel knowledge from the previous attempt may be used when deciding for the number of error correcting redundancy bits (i.e. number of FEC bits) and/or the number of bits for EDC.

Depending on the channel condition, redundancy bits can be increased, reduced or  
5 kept the same whereas error detecting CRC bits are likely to be reduced in every retransmission attempt, depending on the scheme used for coding length adapting.

In a another embodiment, the scheme for determining the number of reduced CRC bits comprises determining the number of increased FEC bits possible to employ without  
10 increasing the control overhead with respect to the first transmission attempt. For example, a reduction in CRC coding length may be used to strengthen (increase the correction coding length) the FEC. Although the latter does not decrease the control overhead, it will potentially lead to fewer re-transmissions compared to fixed-length CRC/FEC, and hence result in lower re-transmission delays.

15

In another embodiment, the overhead reduction may be on the receiver side, e.g. for the receiving node. In some implementations this may be known on the transmitter side, in some the transmitting node is unaware. In this embodiment, error detection coding may be adapted based on the retransmission status such that the threshold for accepting or  
20 determining a decoding as correct is adapted. For example, a standard decoder may calculate the confidence, i.e. the estimated probability that the most likely code word is the correct code word, as an example of determining a probability of correct decoding. This confidence probability may be denoted  $G_j$  for attempt  $j$ . In this embodiment, a decoding attempt will be seen as successful if  $G_j > T_j$  for some threshold or threshold  
25 value  $T_j$  such that a *required* error-detection error probability  $D_j$  is fulfilled. The requirement may be dictated by a standard or application of the receiving node. The choice of  $T_j$  to fulfill this criteria may depend on details in the decoder, channel-estimator etc, which are not further described herein, which may be configured by the network or a transmitting node. The overhead in this embodiment is related to the  
30 probability that, given that the decoding is correct, the decoding result is not accepted if

$G_j \leq T_j$ , i.e. the overhead is lowered if we can make the threshold smaller. To lower the overhead, the threshold or corresponding value may be adapted for retransmissions such that thresholds  $T_1 \geq T_2 \geq \dots \geq T_{k-1}$  are determined or utilized for error detection decoding, which achieves  $D_1 \leq D_2 \leq \dots \leq D_{k-1}$ . The indices here indicate the number of transmission (representing the retransmission status) of the error encoded data. For this approach, error detection (de)coding may be based on a known or assumed coding length, which may e.g. pre-defined (and/or stored in a memory of the receiving module) and/or received from the network, in particular a transmitting node. This approach does not require changes on the transmitter side per se, however, it may be combined with adapting the coding length and/or with the transmitting node configuring, and/or being adapted for configuring and/or comprising a configuring module for configuring, a receiving module with a coding length and/or one or more threshold values used for error detection coding.

A further embodiment for reducing overhead reduction on the receiver side is presented. Again, in some implementations this may be known on the transmitter side, in some the transmitting node is unaware.

Assuming an error detection coding or scheme therefor or for the coding length adaption, e.g. a fixed coding length  $S$ , for a code-word  $C$ , the overhead may be reduced on the receiver side as follows. The receiving node (or a decoder or decoder module of the receiving node) may decode, or be adapted for decoding, based on guessing a most likely codeword, and/or may provide or determine multiple hypotheses for codewords. The codewords may be checked using the error detection coding, e.g. fixed-length CRC. Using this technique, the "efficient" CRC length may be reduced. For example, for a 24 bit CRC and a number of guesses of  $8 = 2^3$ , the "efficient" CRC length may be reduced to 21 bits. The number of hypotheses may be limited, for example, due to complexity and that the error behavior could become complex with many hypothesis in some scenarios. This approach is possible to implement with very minor updates to the decoding implementation of a, for example, Turbo-decoder.

To exemplify, suppose  $D_1$  ( defined as above) is to be very low, for example, less than  $10^{-9}$  if  $P_1 = 10\%$  then for the CRC  $P$ , at least 30 bits for the CRC  $S$  have to be used. Assume further that  $P_j = 10^{-j}$ , then  $D_j \approx 10^{-(10-j)}$ . This implies that the efficient number of bits needed is **30, 27, 24, ... 4** and hence we would allow (at most) 1, 8, 64, ...,  $2^{26}$  hypothesis in the decoding attempts (note that the last numbers are for completeness only and it is unlikely that  $2^{26}$  are being provided and tested. This approach may also be combined with adapting the coding length.

10 Error detection probability adaptation

An error-detection probability adaptation used to scale the error detection overhead is described, which illustrates the technical principle that is behind the performance gains achieved. The principle is that if the error probability for FEC decoding is  $P_j$  in decoding attempt  $j$ , and the error-detection (CRC) error probability is  $D_j$  given that a wrong FEC decoding has occurred, then the packet error rate for some maximum number of  $k$  transmission attempts should fulfill

$$\sum_{j=1}^{k-1} P_j D_j + P_k < \text{Error rate}$$

That is, the probability that decode after all  $k$  transmissions will fail is  $P_k$ , but if detecting the decoding error fails in some previous step this will also result in an error.

20 Hence,  $P_1 \geq P_2 \geq \dots \geq P_k$ , which implies that for a resource efficient solution, the error detection error probabilities should be  $D_1 \leq D_2 \leq \dots \leq D_{k-1}$ . For example, if  $k=10$  and error rate  $10^{-9}$  is desired, one possible solution is to use  $P_j D_j \approx P_k \approx 10^{-10}$ . To further clarify the notation, there may be considered two examples. In the first example, suppose that  $P_k$  is **1** which implies that  $D_j = 0$ . For the second example, suppose  $P_1$  is **0**, then  $D_j$  are undefined but we can redefine  $D_j$  as **0** in this case (or actually any number in  $[0,1]$ ).

Thus, based on e.g. SINR measurements at re-transmission attempt  $k-1$ ,  $P_{k-1}$  can be estimated. By further assuming stationary channel conditions,  $P_k = P_{k-1}$ , thus  $D_k$  may be solved for via the above equation, for a desirable or give Error rate. The CRC

length (coding length (indicated by  $D_k$ ) can be transferred to the transmitting node as part of the NACK message.

Figure 2 schematically shows a method for operating a transmitting node for or in a wireless communication network. The transmitting node may be adapted for transmitting data utilizing error detection coding, wherein the error detection coding has a coding length in bits. The method may comprise an action TA10 of adapting the coding length based on a retransmission status of the data, e.g. as described above. An optional action TA8 may include at least a first transmission before action TA10.

Figure 3 shows an example for a transmitting node 100, which may be a radio node or network node, in particular a base station or eNodeB. The transmitting node 100 may comprise an optional transmitting module TN8 for performing action TA8 and an coding length adapting module TN10 for performing action TA10.

Figure 4 schematically shows a method for operating a receiving node for or in a wireless communication network. The receiving node may be adapted for receiving error encoded data. The method may comprise an action RA10 of adapting the decoding based on a retransmission status of the data, e.g. as described above. An optional action RA8 may include receiving the data at least twice before action TA10 and/or performing a decoding of at least a first transmission of the data at least once before action RA10.

Figure 5 schematically shows an example for a receiving node 10, which may be a radio node, in particular a terminal or UE. The receiving node 10 may comprise an optional receiving module RN8 for performing action RA8 and an adapting module RN10 for performing action RA10.

Figure 6 schematically shows a transmitting node 100, which may in particular be a network node or base station or eNodeB. Transmitting node 100 comprises control



circuitry 120, which may comprise a controller connected to a memory. A receiving module and/or transmitting module and/or control or processing module and/or scheduling module and/or modulation and/or configuring module, may be implemented in and/or executable by the control circuitry 120. The control circuitry is (operatively) connected or connectable to control radio circuitry 122 of the network node 100, which provides receiver and transmitter and/or transceiver functionality. An antenna circuitry 124 may be connected or connectable to radio circuitry 122 for signal reception or transmittance and/or amplification. The transmitting node 100 may be adapted to carry out any of the methods for operating a transmitting node disclosed herein; in particular, it may comprise corresponding circuitry, e.g. control circuitry. Modules of a transmitting node as described herein may be implemented in software and/or hardware and/or firmware in corresponding circuitry.

Figure 7 shows an example of a receiving node 10, which may be implemented as a user equipment or terminal. Receiving node 10 comprises control circuitry 20 and also comprises radio circuitry 22 providing receiving and transmitting or transceiving functionality, the radio circuitry 22 being (operatively) connected or connectable to the control circuitry 20. An antenna circuitry 24 may be (operatively) connected or connectable to the radio circuitry 22, e.g. to collect or send and/or amplify signals. Radio circuitry 22 and the control circuitry 20 controlling it (and, e.g. the antenna circuitry) are configured for cellular communication with a network or a network node, in particular a transmitting node, e.g. node 100. The radio node 10 may be adapted to carry out any of the methods for operating a receiving node disclosed herein; in particular, it may comprise corresponding circuitry, e.g. control circuitry. Modules or functionality of a receiving node as described herein may be implemented in software and/or hardware and/or firmware in corresponding circuitry.

Generally, control circuitry may comprise integrated circuitry for processing and/or control, e.g. one or more processors and/or processor cores and/or FPGAs (Field Programmable Gate Array) and/or ASICs (Application Specific Integrated Circuitry).

Control circuitry may comprise and/or be connected to and/or be adapted for accessing (e.g. writing to and/or reading from) memory, which may comprise any kind of volatile and/or non-volatile memory, e.g. cache and/or buffer memory and/or RAM (Random Access Memory) and/or ROM (Read-Only Memory) and/or optical memory and/or  
5 EPROM (Erasable Programmable Read-Only Memory). Such memory may be adapted to store code executable by control circuitry and/or other data, e.g. data pertaining to communication, e.g. configuration/s and/or address data of nodes, etc. Control circuitry may be adapted to control any of the methods described herein and/or to cause such methods to be performed, e.g. by the radio node. Corresponding instructions may be  
10 stored in the memory, which may be readable and/or readably connected to the control circuitry.

Radio circuitry may comprise receiving circuitry (e.g. one or more receivers) and/or transmitting circuitry (e.g. one or more transmitters). Alternatively or additionally, radio  
15 circuitry may comprise transceiving circuitry for transmitting and receiving (e.g. one or more transceivers). It may be considered that radio circuitry comprises a sensing arrangement for performing LBT/CCA. Antenna circuitry may comprise one or more antennas or antenna elements, which may be arranged in an antenna array.

20 Configuring a radio node, in particular a user equipment, may refer to the radio node being adapted or caused or set to operate according to the configuration. Configuring may be done by another device, e.g. a network node (for example, a radio node of the network like a base station or eNodeB) or network, in which case it may comprise transmitting configuration data to the radio node to be configured. Such configuration  
25 data may represent the configuration to be configured and/or comprise one or more instruction pertaining to a configuration, e.g. regarding a freeze interval and/or a transmission start interval. A radio node may configure itself, e.g. based on configuration data received from a network or network node.

Generally, configuring may include determining configuration data representing the configuration and providing it (e.g., via transmitting) to one or more other nodes (parallel and/or sequentially), which may transmit it further to the radio node (or another node, which may be repeated until it reaches the wireless device). Alternatively or additionally, configuring a radio node, e.g. by a network node or other device, may include receiving configuration data and/or data pertaining to configuration data, e.g. from another node like a network node, which may be a higher-level node of the network, and/or transmitting received configuration data to the radio node. Accordingly, determining a configuration and transmitting the configuration data to the radio node may be performed by different network nodes or entities, which may be able to communicate via a suitable interface, e.g. an X2 interface in the case of LTE.

A storage medium may generally be computer-readable and/or accessible and/or readable by control circuitry (e.g., after connecting it to a suitable device or interface), and may comprise e.g. an optical disc and/or magnetic memory and/or a volatile or non-volatile memory and/or flash memory and/or RAM and/or ROM and/or EPROM and/or EEPROM and/or buffer memory and/or cache memory and/or a database and/or an electrical or optical signal.

Generally, a transmitting node and receiving node may be defined by their respective functionality as described herein. It may be considered that one physical device combines both functionalities and thus is configured to be both a transmitting node and receiving node, based on its respective interaction with at least one other radio node.

In this description, for purposes of explanation and not limitation, specific details are set forth (such as particular network functions, processes and signaling steps) in order to provide a thorough understanding of the technique presented herein. It will be apparent to one skilled in the art that the present concepts and aspects may be practiced in other embodiments and variants that depart from these specific details.

30

For example, the concepts and variants are partially described in the context of Long Term Evolution (LTE) or LTE-Advanced (LTE-A) mobile or wireless communications technologies; however, this does not rule out the use of the present concepts and aspects in connection with additional or alternative mobile communication technologies such as the Global System for Mobile Communications (GSM). While the following 5 embodiments will partially be described with respect to certain Technical Specifications (TSs) of the Third Generation Partnership Project (3GPP), it will be appreciated that the present concepts and aspects could also be realized in connection with different Performance Management (PM) specifications.

10

Moreover, those skilled in the art will appreciate that the services, functions and steps explained herein may be implemented using software functioning in conjunction with a programmed microprocessor, or using an Application Specific Integrated Circuit (ASIC), a Digital Signal Processor (DSP), a Field Programmable Gate Array (FPGA) or general 15 purpose computer. It will also be appreciated that while the embodiments described herein are elucidated in the context of methods and devices, the concepts and aspects presented herein may also be embodied in a program product as well as in a system comprising control circuitry, e.g. a computer processor and a memory coupled to the processor, wherein the memory is encoded with one or more programs or program 20 products that execute the services, functions and steps disclosed herein.

25

It is believed that the advantages of the aspects and variants presented herein will be fully understood from the foregoing description, and it will be apparent that various changes may be made in the form, constructions and arrangement of the exemplary 25 aspects thereof without departing from the scope of the concepts and aspects described herein or without sacrificing all of its advantageous effects. Because the aspects presented herein can be varied in many ways, it will be recognized that any scope of protection should be defined by the scope of the claims that follow without being limited by the description.

30

Some abbreviations:

3GPP 3rd Generation Partnership Project

Ack/Nack Acknowledgment/Non-Acknowledgement, also A/N

AP Access point

BER/BLER Bit Error Rate, BLock Error Rate;

BS Base Station

CA Carrier Aggregation

CCA Clear Channel Assessment

CIS Transmission Confirmation Signal

CoMP Coordinated Multiple Point Transmission and Reception

CQI Channel Quality Information

CRS Cell-specific Reference Signal

CSI Channel State Information

CSI-RS CSI reference signal

D2D Device-to-device

DCI Downlink Control Information

DL Downlink

Downlink; generally referring to transmission of data to a node/into a direction further away from network core (physically and/or logically); in particular from a base station or eNodeB terminal; more generally, may refer to transmissions received by a terminal or node (e.g. in a D2D environment); often uses specified spectrum/bandwidth different from UL (e.g. LTE)

DMRS Demodulation Reference Signals

DRS Discovery Reference Signal

eNB evolved NodeB; a form of base station, also called eNodeB

EPDCCH Enhanced Physical DL Control CHannel

E-UTRA/N Evolved UMTS Terrestrial Radio Access/Network, an example of a RAT

FDD	Frequency Division Duplexing
HARQ	Hybrid Automatic Repeat reQuest
ID	Identity
L1	Layer 1
L2	Layer 2
LA	Licensed Assisted
LA	Licensed Assisted Access
LBT	Listen-before-talk
LTE	Long Term Evolution, a telecommunications standard
MAC	Medium Access Control
MBSFN	Multiple Broadcast Single Frequency Network
MCS	Modulation and Coding Scheme
MDT	Minimisation of Drive Test
NW	Network
O&M	Operational and Maintenance
OFDM	Orthogonal Frequency Division Multiplexing
OSS	Operational Support Systems
PC	Power Control
PCFICH	Physical Control Format Indicator Channel
PDCCH	Physical Downlink Control Channel
PDCCH	Physical DL Control CHannel
PH	Power Headroom
PHR	Power Headroom Report
PMI	Precoding Matrix Indicator
PRB	Physical Resource Block
PSS	Primary Synchronization Signal
PUCCH	Physical Uplink Control Channel

PUSCH	Physical Uplink Shared CHannel
RA	Random Access
RACH	Random Access CHannel
RAT	Radio Access Technology
RB	Resource Block
RE	Resource Element
RI	Rank Indicator
RRC	Radio Resource Control
RRH	Remote radio head
RRM	Radio Resource Management
RRU	Remote radio unit
RSRP	Reference signal received power
RSRQ	Reference signal received quality
RSSI	Received signal strength indicator
RX	reception/receiver, reception-related
SA	Scheduling Assignment
SCell	Secondary Cell
SFN	Single Frequency Network
SINR/SNR	Signal-to-Noise-and-Interference Ratio; Signal-to-Noise Ratio
SON	Self Organizing Network
SR	Scheduling Request
SRS	Sounding Reference Signal
SSS	Secondary Synchronization Signal
TDD	Time Division Duplexing
TPC	Transmit Power Control
TTI	Transmission-Time Interval
TX	transmission/transmitter, transmission-related
UE	User Equipment

UL Uplink; generally referring to transmission of data to a node/into a direction closer to a network core (physically and/or logically); in particular from a D2D enabled node or UE to a base station or eNodeB; in the context of D2D, it may refer to the spectrum/bandwidth utilized for transmitting in D2D, which may be the same used for UL communication to a eNB in cellular communication; in some D2D variants, transmission by all devices involved in D2D communication may in some variants generally be in UL spectrum/bandwidth/carrier/frequency; generally, UL may refer to transmission by a terminal (e.g. to a network or network node or another terminal, for example in a D2D context).

These and other abbreviations may be used according to LTE standard definitions



## Claims

1. Method for operating a transmitting node (10, 100) for a wireless communication network, the transmitting node being adapted for transmitting data utilizing error  
5 detection coding, wherein the error detection coding has a coding length in bits, the method comprising adapting the coding length based on a retransmission status of the data.
2. Method according to claim 1, wherein the error detection coding comprises or is CRC  
10 coding.
3. Method according to one of the preceding claims, wherein adapting the coding length comprises reducing the coding length for retransmission of the data.
- 15 4. Method according to one of the preceding claims, wherein adapting the coding length is based on transmission conditions, in particular channel conditions.
5. Method according to one of the preceding claims, comprising performing forward  
20 error correction coding on the data, in particular after error detection coding, the forward error correction coding having a correction coding length in bits.
6. Method according to one of the preceding claims, comprising adapting a correction  
coding length for forward error correction coding of the data based on the  
25 retransmission status of the data and/or transmission conditions, in particular channel conditions.
7. Transmitting node (10, 100) for a wireless communication network, the transmitting  
node (10, 100) being adapted for transmitting data utilizing error detection coding,  
wherein the error detection coding has a coding length in bits, the transmitting node (10,

100) being further adapted for adapting the coding length based on a retransmission status of the data.

5 8. Transmitting node according to claim 7, wherein the error detection coding comprises or is CRC coding.

9. Transmitting node according to one of claims 7 to 8, wherein adapting the coding length comprises reducing the coding length for retransmission of the data.

10 10. Transmitting node according to one of claims 7 to 9, wherein adapting the coding length is based on transmission conditions, in particular channel conditions.

11. Transmitting node according to one of claims 7 to 10, the transmitting node (10, 100) further being adapted for performing forward error correction coding on the data, in particular after error detection coding, the forward error correction coding having a correction coding length in bits.  
15

12. Transmitting node according to one of claims 7 to 11, the transmitting node (10, 100) being adapted for adapting a correction coding length for forward error correction coding of the data based on the retransmission status of the data.  
20

13. Method for operating a receiving node (10, 100) for a wireless communication network, the receiving node (10, 100) being adapted for receiving error encoded data, the method comprising adapting of decoding the error encoded data based on a retransmission status of the data.  
25

14. Method according to claim 13, wherein adapting of decoding the error encoded data is further based on transmission conditions, in particular channel conditions.

15. Method according to one of claims 13 to 14, wherein adapting of decoding the error encoded data comprises adapting a threshold value for error detection.

5 16. Method according to one of claims 13 to 15, wherein adapting of decoding the error encoded data comprises adapting a coding length for decoding of error detection coding the data is encoded with.

10 17. Method according to one of claims 13 to 16, wherein adapting of decoding the error encoded data comprises adapting a correction coding length for decoding of forward error correction coding the data is encoded with.

15 18. Receiving node (10, 100) for a wireless communication network, the receiving node (10, 100) being adapted for receiving error encoded data, the receiving node (10, 100) further being adapted for adapting of decoding the error encoded data based on a retransmission status of the data.

20 19. Receiving node according to claim 18, wherein adapting of decoding the error encoded data is further based on transmission conditions, in particular channel conditions.

20. Receiving node according to one of claims 18 to 19, wherein adapting of decoding the error encoded data comprises adapting a threshold value for error detection.

25 21. Receiving node according to one of claims 18 to 20, wherein adapting of decoding the error encoded data comprises adapting a coding length for decoding of error detection coding the data is encoded with.

30 22. Receiving node according to one of claims 18 to 21, wherein adapting of decoding the error encoded data comprises adapting a correction coding length for decoding of forward error correction coding the data is encoded with.

23. Program product comprising code executable by control circuitry, the code causing the control circuitry to perform and/or control the method of one of claims 1 to 7 or 13 to 17 when executed by the control circuitry.

5

24. Storage medium storing a program product according to claim 23.

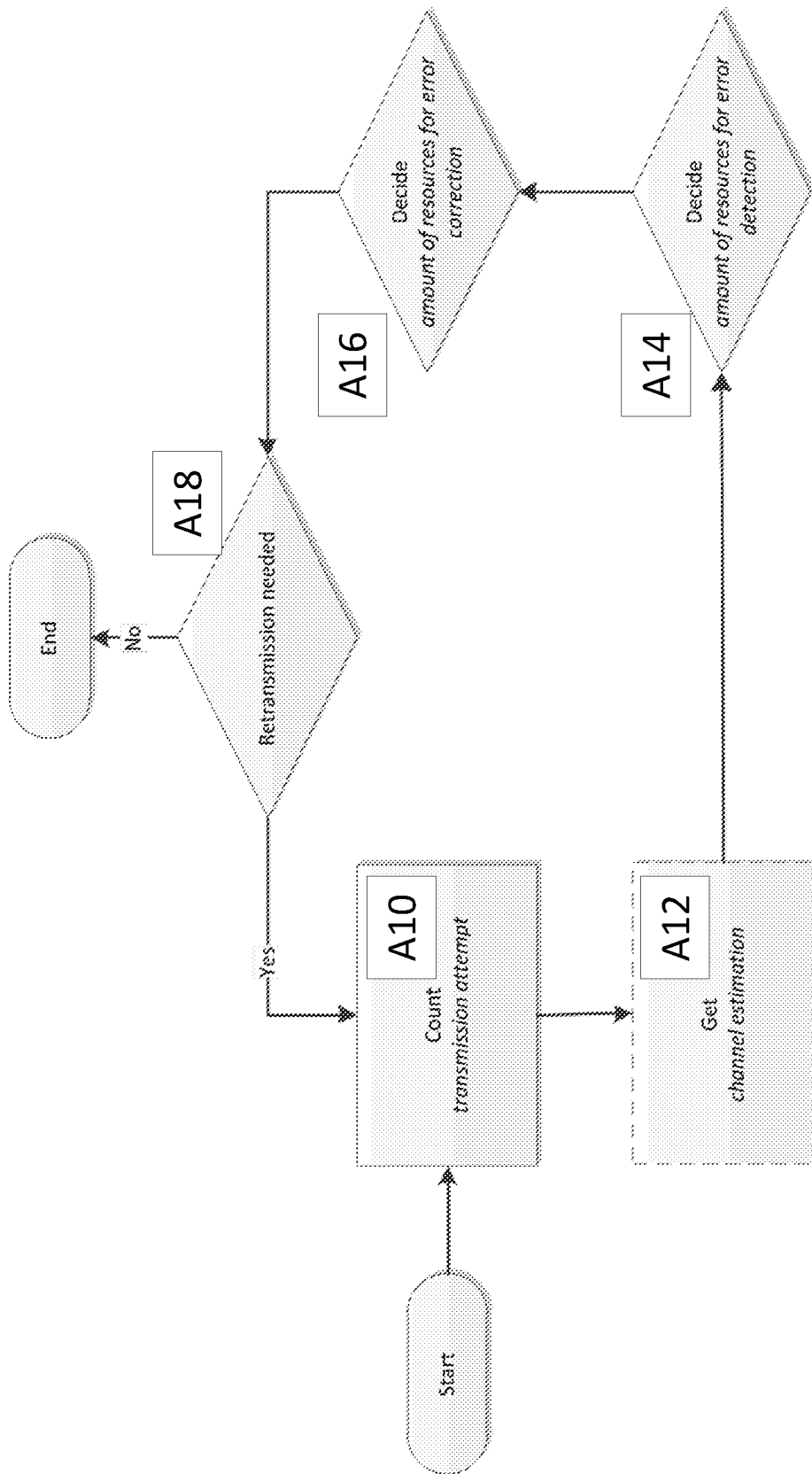


Figure 1

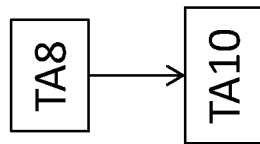


Figure 2

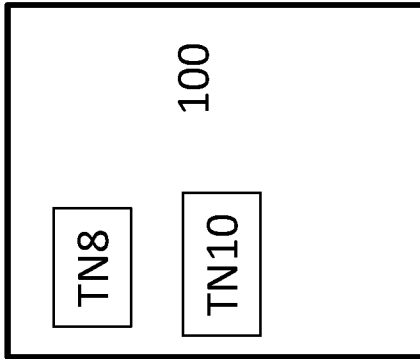


Figure 3

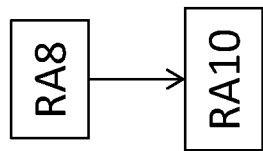


Figure 4

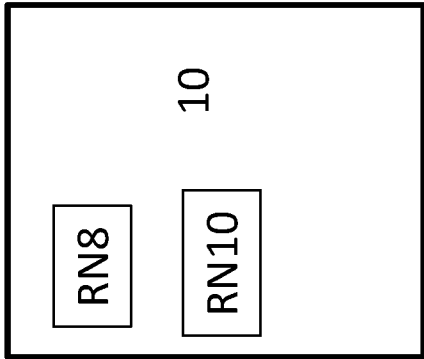


Figure 5

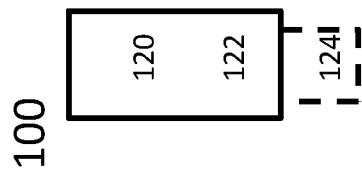


Figure 6

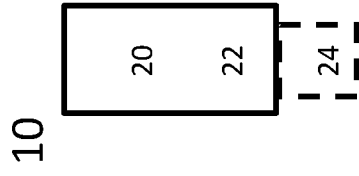


Figure 7



INTERNATIONAL SEARCH REPORT

International application No  
PCT/SE2015/050406

A. CLASSIFICATION OF SUBJECT MATTER  
INV. H04L1/00  
ADD.  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED  
Minimum documentation searched (classification system followed by classification symbols)  
H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 931 072 A2 (FUJITSU LTD [JP]) 11 June 2008 (2008-06-11)	1,2,4-8, 10-12, 23,24
A	abstract figures 1,7 paragraphs [0007], [0008], [0039] - [0042], [0054] - [0058]	3,9
A	EP 2 129 140 A1 (NTT DOCOMO INC [JP]) 2 December 2009 (2009-12-02) abstract figure 11B paragraphs [0428], [0429]	1,6,7,12
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Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search  25 January 2016	Date of mailing of the international search report  03/02/2016
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Xu, Yuhuan
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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/SE2015/050406

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 180 625 A2 (FUJITSU LTD [JP]) 28 April 2010 (2010-04-28)	13, 15-18, 20-22
A	abstract figure 31 paragraphs [0156] - [0158] -----	14,19
X	WO 2013/142039 A1 (QUALCOMM INC [US]) 26 September 2013 (2013-09-26)	13-15, 18-20
A	abstract figures 3-7 paragraphs [0038] - [0054] -----	16,17, 21,22
A	US 2011/078531 A1 (UMEDA MASATAKA [JP] ET AL) 31 March 2011 (2011-03-31)	13,15, 18,20
	abstract figure 9 paragraphs [0089] - [0094] -----	

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/SE2015/050406

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
  
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
  
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-12, 23, 24

Adaptation of error detection coding length

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2. claims: 13-22

Adaptation of decoding method

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/SE2015/050406
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1931072	A2	11-06-2008	EP 1931072 A2 11-06-2008
			JP 4930024 B2 09-05-2012
			JP 2008147960 A 26-06-2008
			US 2008141105 A1 12-06-2008
-----			
EP 2129140	A1	02-12-2009	AU 2008222128 A1 12-09-2008
			BR PI0807876 A2 16-06-2015
			CN 101669382 A 10-03-2010
			EP 2129140 A1 02-12-2009
			JP 5100745 B2 19-12-2012
			KR 20090118075 A 17-11-2009
			RU 2009135449 A 10-04-2011
			US 2010111008 A1 06-05-2010
			WO 2008108227 A1 12-09-2008
-----			
EP 2180625	A2	28-04-2010	EP 2180625 A2 28-04-2010
			JP 5187132 B2 24-04-2013
			JP 2010103638 A 06-05-2010
			US 2010098045 A1 22-04-2010
-----			
WO 2013142039	A1	26-09-2013	US 2013251013 A1 26-09-2013
			WO 2013142039 A1 26-09-2013
-----			
US 2011078531	A1	31-03-2011	JP 2011077822 A 14-04-2011
			US 2011078531 A1 31-03-2011
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