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(71) Applicant: **NOKIA SOLUTIONS AND NETWORKS OY** [FI/FI]; Karaportti 3, FI-02610 Espoo (FI).

(72) Inventors: **FREDERIKSEN, Frank**; Hornbækvej 4, DK-9270 Klarup (DK). **KOLDING, Troels Emil**; Sneppevej 21, DK-9270 Klarup (DK).

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(54) Title: SCHEDULING DATA TRANSMISSIONS FOR ERROR RECOVERY PROCESSES ON AIR INTERFACE

(57) Abstract: There is provided adjusting the number error recovery processes for the data transmissions between UE and radio access node. Data transmissions for error recovery processes are scheduled on an air interface between user equipment and a radio access node. A message including information indicating a new number of error recovery processes for the data transmissions between the user equipment and the radio access node is caused to be sent. The new number of error recovery processes indicated by the message are applied to data transmissions on the air interface.

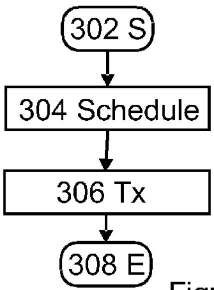

Figure 3

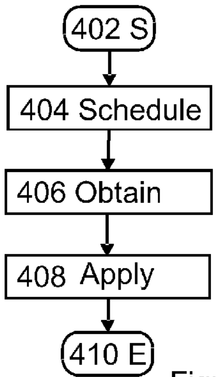

Figure 4

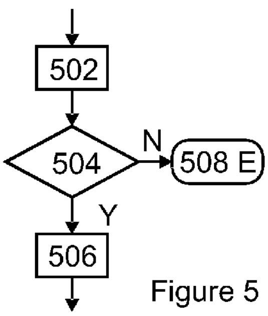

Figure 5

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SCHEDULING DATA TRANSMISSIONS FOR ERROR RECOVERY PROCESSES ON AIR INTERFACE

FIELD

The invention relates to scheduling data transmissions for error recovery processes on an air interface, and particularly to data transmissions between user equipment (UE) and a radio access node.

BACKGROUND

Wireless communication systems typically have error recovery mechanisms in order to handle transmission errors over the wireless transmission channel. Examples of conventional mechanisms for error recovery and detection are: (a) forward error correction through channel coding for correcting single bit errors and (b) Hybrid automatic repeat request (H-ARQ), reusing already transmitted energy when doing the retransmission for failed packets. In Long Term Evolution (LTE) communications system defined by the 3rd Generation Partnership Project (3GPP), the HARQ mechanism is typically implemented to include a number of parallel stop-and-wait (SAW) HARQ channels to ensure continuous transmission on the air interface. LTE support Frequency Division Duplex and Time Division Duplex communications on the air-interface. For FDD 8 HARQ SAW processes are defined for each link direction. For LTE Time Division Duplex (TDD), different TDD configurations have different numbers of HARQ SAW processes.

In an LTE SAW HARQ process, once a packet from a eNB (evolved NodeB) has been transmitted to the UE on Physical Downlink Shared Channel (PDSCH), the UE will decode the packet and provide feedback to the eNB on Physical Uplink Control Channel (PUCCH). In case of a negative acknowledgement (NACK) message being received at the eNB, the eNB will normally send a retranmission and the UE will combine the retransmission with the original transmission and run decoding again. After the decoding is successful the UE will send a positive acknowledgement (ACK) message to the eNB. After receiving an ACK message, the eNB will send a new packet for that HARQ process in case there is data available for the given UE, and provided that the UE is selected for scheduling at this time instant. In a traditional implementation, the minimum delay between the end of a packet and the start of a retransmission is 7ms, which is 7 tranmission time intervals

(TTIs), when one TTI is 1 ms sub-frame. The ACK/NACK tranmission follows four TTIs after the transmission TTI of the packet. Thus, processing time for the packet at the UE is approximately 3ms and processing time for the ACK/NACK and preparation for the tranmission of a new packet or a retranismission is approximately 3ms. If these budgeted processing times are exceeded, there are no more HARQ processes available for scheduling, and transmission gaps will be experienced towards the UE in question. On the other hand, the budgeted processing times do not adapt if the UE or the eNB are capable of faster processing of the packets, which would allow transmissions earlier than the budgeted processing times. In the case that the eNB implements very fast processing of the ACK/NACK message, it is possible for the eNB to decide to use fewer HARQ processes, leaving some HARQ processes unused at the UE side. However, this is normally not the case.

BRIEF DESCRIPTION

According to an aspect, there is provided the subject matter of the independent claims. Embodiments are defined in the dependent claims.

One or more examples of implementations are set forth in more detail in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

Some embodiments allow adjusting the number error recovery processes for the data transmissions between UE and radio access node.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 presents an example of a communications network according to an embodiment;

Figure 2a illustrates an implementation of a radio access node having remote radio heads according to an embodiment;

Figure 2b illustrates an implementation of a radio access node having remote radio heads, local data processing units and a central data processing unit according to an embodiment;

Figures 3 and 4 illustrate methods for adjusting the number of HARQ processes according to embodiments;

Figure 5 illustrates a method for conditionally adjusting the number of HARQ processes according to an embodiment;

Figure 6 illustrates communications for adjusting the number of HARQ processes according to an embodiment; and

Figure 7 illustrates a block diagram for an apparatus according to an embodiment.

DETAILED DESCRIPTION

Figure 1 presents an example of a communications network 100 according to an embodiment. The communications network may comprise a radio access network formed by one or more radio access nodes 102, 104. The radio access nodes, for example evolved NodeBs (eNBs) or base stations, may be capable of providing access to the network for one or more UE 106. In the following the terms eNB and a radio access node are used interchangeably. The radio access nodes and UE are connected wirelessly on an air interface for communications of data and/or signaling. The air interface may include uplink/or downlink communications on one or more communications channels. An uplink communications refers to a direction of the transmission from the UE to the eNB, and the downlink communications refers to a direction of the transmission from the eNB to the UE.

The radio access nodes may have coverage areas, where wireless communications between the UE and the radio access nodes is possible. The coverage areas may be defined by a range of the wireless radio communications. The UE may be movable within and between the coverage areas of the radio access nodes. Accordingly the communications network may be referred to as a mobile communications network.

Each radio access node may have one or more cells, for example ranging from 1 to 50 cells or more, that have resources for communications with the UE on the air interface. The cells may have separate or overlapping or partly overlapping coverage areas. Each cell may be identified by a cell identifier for identifying the cell to the UE.

A resource may be a resource block that may be allocated for communication on an air interface between UE and a radio access node. The resource block may be formed by a combination of one or more subcarriers and a time interval. The subcarriers may be allocated to UE and a radio access node in groups of subcarriers, for example in groups of 12 subcarriers. The subcarriers may have center frequencies with 15 kHz spacing. Accordingly a group of 12 subcarriers may form a resource block of width 180 kHz. It should be appreciated that the above details of subcarriers is given as a non-limiting example and other configurations of the subcarriers may be used depending on implementation of the air interface of the communications network. Also, it should be appreciated that the principles covered here are independent of the radio access technology in the sense that the principles are applicable to any system that uses error recovery protocols for example based on hybrid automatic repeat request (HARQ) with stop-and-wait (SAW) channels.

The subcarriers in a resource block may be according to a digital multicarrier modulation method, for example Orthogonal Frequency Division Multiplexing (OFDM) without limiting thereto. In time domain, the resource block length may be defined by the symbol duration of the multicarrier modulation that is used. In an example using OFDM, an OFDM symbol may have a useful length of 0.0667 ms, a slot is constructed of 7 OFDM symbols each having a cyclic prefix, thereby spanning a time duration of 0.5 ms. Furthermore, a single resource block may be 0.5 ms in time and 180kHz in frequency. The total bandwidth of the resource block may vary depending on the groups of subcarriers in the resource block. For example 12 subcarriers may be the minimum and the maximum number of subcarriers may be defined by the available system bandwidth, for example 20 MHz. Also a higher duration than the duration of a single OFDM symbol, for example a duration of two or more OFDM symbols, may be used for the resources block. The time duration of the resource block may be defined in Transmission Time Intervals (TTIs) in synchronous communications on the air interface such that 1 TTI = n x OFDM symbol, where n= 1, 2, 3, 4…or any integer value. In LTE, 1 TTI = 14 OFDM symbols for normal cyclic prefix configuration and 12 OFDM symbols for extended cyclic prefix operation, thus n = 14 or n = 12 for LTE networks and LTE-Advanced networks.

A radio access node may include one or more schedulers 101, 103 for scheduling data transmissions on an air interface between the UE and the radio access node. The radio access node may have one, two, or more cells via which the UE may connect to the radio access node. Each cell may have its own scheduler.

The radio access node and UE employ an error recovery mechanism, for example HARQ, to data transmissions on the air interface. Although

HARQ is used as an example of an error recovery mechanism, it should be appreciated that also other mechanisms may be used in the present description. The error recovery mechanism may be employed in uplink data transmissions and/or downlink data transmissions. The scheduler of the radio access node may schedule the data transmissions on the air interface by the number of parallel HARQ mechanisms for the data transmissions. A HARQ mechanism that is operational may be referred to as a HARQ process. A HARQ process may have associated memory resources and a specific identifier that may identify data transmissions and the memory resources of the HARQ process. The HARQ process may be operational as a hardware implementation, software implementation or a combination of hardware and software. Preferably the UE and the radio access node have a number of operational HARQ processes such that more than one data transmissions may be carried out in parallel.

A Core Network (CN) 108 may be connected to the radio access nodes. The CN may comprise a control entity 112 and a gateway entity 112 for routing user traffic, managing subscription profiles of UE and managing service connectivity. Examples of the control entity and the gateway entity in the CN may comprise a Serving Gateway (SGW) and Mobility Management Entity (MME). The CN may further comprise an Operation and Management system (O&M -system) 110. The O&M –system provides management of the entities of the communications network, for example. A packet data gateway (PGW) 114 may be provided for communications between the communications network and external network.

In one example, the 3GPP Release 12 Specifications may be used to implement the communications network illustrated in Figure 1. An overall description of the E-UTRA may be referred to in 3GPP TS 36.300 V12.4.0 (2014-12), which may be referred to for purposes of implementing the communications network and/or an entity such as UE and eNBs, and/or a function such as data transmission performed by the entity.

Figure 2a illustrates an implementation of a radio access node having remote radio heads according to an embodiment. The remote radio heads include radio transceivers that are remote to the rest of the radio access node, for example data processing unit operating on baseband frequencies. The remote radio heads support coverage extensions and/or Multiple Input Multiple Output (MIMO) operation of the radio access node. The radio access node may include one or more remote radio heads 202a, 204a, 206a that are operatively connected to a central data processing unit 208. The central data processing unit may be capable of operating as a scheduler of data transmissions on an air interface between UE and the radio access node. The scheduler may operate on baseband frequencies, whereas the remote radio heads convert data transmissions between the baseband and radio frequencies. The scheduler may schedule one or more data blocks for transmission over the air interface. The data blocks may comprise user data and/or signalling. The scheduled data blocks may be transferred from the scheduler to the remote radio heads over a transport connection for transmission on the air interface by the remote radio head. Similarly, the remote radio heads may receive one or more data blocks. The received data blocks may be transferred to the scheduler via the transport connection.

Figure 2b illustrates an implementation of a radio access node having remote radio heads 202b, 204b, 206b, local data processing units 203, 205, 207 and a central data processing unit 210 according to an embodiment. The remote radio heads include radio transceivers that are remote to the rest of the radio access node, for example data processing unit operating on baseband frequencies. The local data processing units may be at the remote radio heads and remote form the central data processing unit.

The local data processing units and the central data processing unit may be capable of operating as schedulers of data transmissions on an air interface between UE and the radio access node. A scheduler may operate on baseband frequencies, whereas the remote radio heads convert data transmissions between the baseband and radio frequencies. The schedulers may schedule one or more data blocks for transmission over the air interface. Data blocks scheduled by the central data processing unit may be transferred from the central data processing unit to the remote radio heads over transport connections for transmission on the air interface by the remote radio heads. The data blocks may comprise user data and/or signalling.

At the remote radio heads the local data processing units may receive the data blocks from the central data processing unit and change the scheduling of the data blocks. Accordingly, a scheduling decision of the data block made by the central data processing unit may be overridden by the local data processing unit at the remote radio head. The central data processing unit provides that data processing resources of the scheduler are used efficiently since the central scheduler serves more than one radio access node, and will also allow for coordination of radio resource utilization between the different transmission points being controlled by the same central data processing unit.

On the other hand the use of local schedulers provide the possibility to have faster response to local needs without consideration of neighbouring nodes, for example radio access nodes, in the system. Preferably the local data processing units, preferably all of the local data processing units, should have data processing capabilities according to the worst case load scenario in each cell, which might cause overprovisioning of resources when considering the entire network layout.

However, the central data processing unit allows that the data processing capabilities of the local data processing units may be dimensioned to meet a lower load than the load in the worst case load scenario, since the excess load in the local data processing units may be unloaded to the central data processing unit. Accordingly, the central data processing unit provides that the overprovisioning of resources may be avoided in the entire network layout.

Referring to both Figures 2a and 2b, in an embodiment, the schedulers 208, 210 may be connected to remote radio heads of more than one radio access node. Accordingly, the schedulers may serve one or more radio access nodes.

Figures 3 and 4 illustrate methods for adjusting the number of HARQ processes according to embodiments. The methods may be performed by an apparatus in the communications network illustrated in Figure 1.

Figure 3 illustrates a method for adjusting the number of HARQ processes in managing air interface resources in a communications network. The method may be performed by an apparatus, for example a data processing unit, a radio access node such as an eNB or a module of the radio access node, or any other network node, that is responsible for the management of air interface resources. It should be appreciated that the transmissions from the eNB may be received by UE served by the eNB.

The method may start 302, when at least one radio access node of the communications network is operational for connecting UE on an air interface and the UE and the radio access node have been configured with a current number of HARQ processes for data transmissions. The current number of HARQ processes may be a default number or a previously adjusted number of HARQ processes.

Data transmissions are scheduled 304 for HARQ processes on an air interface between UE and the radio access node. The scheduling may comprise determining at least one air interface resource for the data transmission. An air interface resource may comprise a resource block for example. The air interface resource may define a data transmission to UE at a specific time instant, for example in a specific TTI. A control message may be transmitted for indicating the data transmission and the scheduled air interface resource in uplink and/or downlink. The control message may include an identifier, for example Cell Radio Network Temporary Identifier (C-RNTI), of the UE and an identifier of the HARQ process. The identifier of the UE may identify the UE within a specific radio access node. The control message may be for example a Physical Downlink Control Channel (PDCCH).

A message including information indicating a new number of HARQ processes for the data transmissions between the UE and the radio access node is caused 306 to be transmitted over the air interface. The information indicating a new number of HARQ processes may be transmitted as an effort to improve efficiency of the scheduling of data transmissions. The efficiency of the scheduling may be determined for example in terms of throughput, delay and/or jitter of the transmitted data or of the transport network that the data travels through. The new number of HARQ processes may indicate the number of HARQ processes per cell or per user equipment. The new number of HARQ processes may be determined on the basis of UE capabilities and/or channel quality information, for example. The message may be signalling on an air interface of the UE. Examples of the message include a system information message, a Radio Resource Control (RRC) message, a Medium Access Control (MAC) message, or a link layer control message.

It should be appreciated that the message including information indicating a new number of HARQ processes may be transmitted in connection with scheduling of the data transmissions. Accordingly, it may be even preferable to transmit the message including information indicating a new number of HARQ processes prior to scheduling of the data transmission so as to ensure that the receiver of the message, e.g. UE, may have a sufficient number of HARQ processes of processing the data transmissions.

The method may end 308 after the message has been transmitted and the receiver, e.g. UE, has been provided with information for allocating resources for processing the data transmission using HARQ.

Figure 4 illustrates a method for adjusting the number of HARQ processes under management of air interface resources in a communications network. The method may be performed by an apparatus, for example UE or module of UE, that is capable of communicating on the air interface resources that are managed by another apparatus, for example a radio access node. It should be appreciated that the transmissions from the UE may be received by a radio access node such as an eNB serving the UE.

The method may start 402, when at least one radio access node of the communications network is operational for connecting the UE on an air interface and as the UE and the radio access node have been configured with a current number of HARQ processes for data transmissions. The current number of HARQ processes may be a default number or a previously adjusted number of HARQ processes.

Data transmissions are scheduled 404 for HARQ processes on an air interface between UE and the radio access node. The scheduling may comprise determining at least one air interface resource for the data transmission. The air interface resource may comprise a resource block for example. The air interface resource may define a data transmission to UE at a specific time instant, for example in a specific TTI. A control message may be received, e.g. at the UE, for indicating a data transmission and a scheduled air interface resource in uplink and/or downlink direction. The control message may include an identifier, for example Cell Radio Network Temporary Identifier (C-RNTI), of the UE and an identifier of the HARQ process. The identifier of the UE may identify the UE within a specific radio access node. The control message may be for example a Physical Downlink Control Channel (PDCCH).

A message including information indicating a new number of HARQ processes for the data transmissions between the UE and the radio access node may be obtained 406. The information indicating a new number of HARQ processes may be obtained as an effort to improve efficiency of the scheduling of data transmissions. The efficiency of the scheduling may be determined for example in terms of throughput, delay and/or jitter of the transmitted data which may be experienced in the transport network from the scheduler to the transmitting node. The new number of HARQ processes may indicate the number of HARQ processes per cell or per user equipment.

The message may be signalling on an air interface of the UE. Examples of the message include a system information message, a Radio Resource Control (RRC) message, a Medium Access Control (MAC) message or a link layer control message.

It should be appreciated that the message including information indicating a new number of HARQ processes may be transmitted in connection with scheduling of the data transmissions. Accordingly, it may be even preferable to transmit the message including information indicating a new number of HARQ processes prior to scheduling of the data transmission so as to ensure that the receiver of the message, e.g. UE, may have a sufficient number of HARQ processes of processing the data transmissions.

The new number of HARQ processes may be applied 408 to data transmissions on the air interface. The new number of HARQ processes may be used to configuring a memory for HARQ processes. The configuration of the memory may define memory blocks associated with a specific HARQ, for example. The HARQ and corresponding memory may be identified by a HARQ identifier. The memory configuration is preferably maintained unchanged during the time the UE is served by the eNB, since re-configuration of the memory during the connection could lead to loss of data.

In an embodiment a HARQ process for a data transmission in a transmission time interval may be identified as a function of a time varying property of an element in synchronous communications on the air interface and an identifier in a control message for scheduling the data transmission and said control message associated to the element. The element may be a specific time slot or TTI that may form or be a part of a radio frame on an air interface between UE and eNB. In one example the control message is a control message for indicating a data transmission on the air interface in uplink and/or downlink. The control message may include an identifier, for example Cell Radio Network Temporary Identifier (C-RNTI), of the UE and an identifier of the HARQ process. The identifier of the UE may identify the UE within a specific radio access node. The control message may be for example a Physical Downlink Control Channel (PDCCH).Accordingly, the identifier of the HARQ process in the control message may be replaced by separate identifier that may correspond to the identifier of the HARQ process in a deterministic manner as defined by the time varying property of an element, e.g. specific slot or TTI, in synchronous communications.

Accordingly, each HARQ process may have a HARQ identifier that may be maintained at the UE and eNB. The signaling message for scheduling data transmission transmitted on the air interface between the UE and eNB may include another identifier and the HARQ identifier at the UE and eNB may be derived from the identifier carried in the signaling message on the basis of the time varying property of an element, e.g. a slot or TTI. In this way the value range of the identifiers in the signaling message carried on the air interface may be limited, while the number of HARQ processes may exceed the value range of the value range of the identifiers in the signaling message.

Preferably the obtained 406 new number of HARQ processes is different than a current number of HARQ processes. In this way the efficiency of the scheduling of data transmissions may be positively affected, when the new number of HARQ processes is applied 408.

The method may end 410 after the number of HARQ processes have been applied to the data transmissions on the basis of the obtained 406 information.

Figure 5 illustrates a method for conditionally adjusting the number of HARQ processes according to an embodiment. The method may be performed by a network node, UE or eNB, in connection with scheduling 502 of data transmissions for HARQ processes on an air interface between UE and the radio access node. The scheduling may be performed as described in the methods of Figures 3 and 4, for example.

In an embodiment a condition may be included in a message including information indicating a new number of HARQ processes for the data transmissions between the UE and the radio access node. This message may be the message in steps 306 and 406 in Figures 3 and 4 for example. The number of HARQ processes may be indicated for a specific link direction, for example uplink or downlink. The message may include the number of HARQ processes for both uplink and/or downlink direction. It should be appreciated the HARQ process identifier may be determined in each link direction in its own way.

A condition for adjusting the number of HARQ processes may be evaluated 504. The condition may be a value or a corresponding indicator for throughput, delay, jitter and/or TTI. The conditions for throughput, delay and/or jitter may serve determining an inefficient scheduling, e.g. transmission gaps due to lack of available HARQ processes, or underutilization of the available HARQ processes on the air interface. That is, for cases, where there are some

HARQ processes that are never used for scheduling. The TTI may serve for defining a specific starting TTI, from which onwards, the new number of HARQ processes is applied.

When 504 the condition is met, the number of HARQ processes may be adjusted 506 to correct inefficient scheduling of data transmissions and/or to define a starting time for the adjustment of the number of HARQ processes. The adjusting may be performed as described in steps 306, 406 and 408 for example.

In an embodiment a throughput, delay and/or jitter of a communication link for determining a need to adjust the number of HARQ processes may be measured for evaluating 506 a condition for adjusting the number of HARQ processes. The communication link may be a communication link between two entities that communicate over an air interface. In one example the entities may be UE and a radio access node such as an eNB. In another example the entities may be two eNBs communicating to each other. In yet another example the entities may be an eNB and a central data processing unit doing scheduling for multiple transmission points, for example remote radio heads. On the other hand the communication link may be considered between protocol entities, for example protocol entities of protocols used on the air interface between the UE and eNB. Examples of the protocols on the air interface between UE and eNB include MAC protocol, RRC protocol, Packet Data Convergence Protocol, Radio Link Control protocol and physical layer protocols. The results of the measurements may be compared 504 with the values or indicators of for the condition for adjusting the number of HARQ processes.

On the other hand, when 504 the condition is not met, the number of HARQ processes may not be adjusted and the current number of HARQ processes may be maintained, and the method may end 508.

Figure 6 illustrates communications for adjusting the number of HARQ processes according to an embodiment. The communications may be performed by network nodes or modules of network nodes of a communications network. Examples of the network nodes comprise a central data processing unit, UE and eNB in a communications network for example the communications network illustrated in Figure 1.

A need to adjust the number of HARQ processes may be determined 602 in the eNB. The need may be determined on the basis of measurements as described above in connection with Figure 5 step 504. On the other hand the need may arise from a new configuration to be applied in the eNB, in which case measurements may not be needed. The configuration may be defined by an O&M-system by an operator of the communications network.

A message 604 including information indicating a new number of HARQ processes for the data transmissions between the UE and the radio access node may be transmitted over the air interface from the eNB to the UE.

In an embodiment, the message 604 may be signalling on an air interface of the UE. The message may be a system information message, a Radio Resource Control (RRC) message, a Medium Access Control (MAC) message or a link layer control message. Examples of the system information message may comprise a Master Information Block (MIB) that may be transmitted on Physical Broadcast Channel (PBCH) and System Information Block (SIB) that may be transmitted on Physical Downlink Shared Channel (PDSCH). RRC messages may be used by RRC protocol for controlling the radio resource usage. RRC protocol may manage UE's signalling data connections, for example. Examples of link layer control messages comprise MAC PDUs generated by a MAC protocol entity. The information indicating a new number of HARQ processes may be included in a new or existing element in a MAC PDU.

Figure 7 illustrates a block diagram for an apparatus 700 according to an embodiment. The apparatus may be a UE, eNB or a data processing unit such as a central data processing unit or a local data processing unit. The apparatus may comprise a memory (M) 708 and processor (P) 702 that are electrically connected. The electrical connection between the processor and the memory may be implemented by an electrical conductor, for example a data transfer bus or conductive material. The processor may read instructions stored in the memory, execute the instructions and cause performing an embodiment.

In an embodiment, the apparatus may include a memory configuration including memory for a number of HARQ process for uplink data transmissions and a number of number of HARQ process for downlink data transmissions. The uplink and downlink HARQ processes may be configured with memory according to the number of HARQ processes communicated in the message as described in steps 306 and 406 in Figures 3 and 4.

Referring to Figure 7, in an embodiment, the at least one memory 708 and the instructions are configured to, with the at least one processor 702, cause the apparatus at least to perform scheduling data transmissions for HARQ processes on an air interface between UE and a radio access node, and causing to send a message including information indicating a new number of HARQ processes for the data transmissions between the UE and the radio access node. The apparatus may include an interface unit (IFU) 710 that may be electrically connected to the processor. The electrical connection between the processor and the IFU may be implemented similar to the connection between the M and the processor. The IFU may be capable of transmission and/or reception of data and signalling. The data and signalling may be communicated using an applicable channel and protocol. Examples of the channels include a data communications bus and an air interface. Examples of the protocols include data bus protocols and protocols on an air interface between UE and eNB such as MAC protocol, RRC protocol, Packet Data Convergence Protocol, Radio Link Control protocol and physical layer protocols.

The IFU 710 may be an internal unit to the apparatus. The apparatus may include a radio signal transmission and/or reception unit that may be operatively connected to the radio signal transmission and/or reception unit to cause a message including information indicating a new number of HARQ processes to be sent.

On the other hand the IFU may be a radio signal transmission and/or reception unit, whereby the processor may control the IFU to send a message including information indicating a new number of HARQ processes.

Referring to Figure 7, in an embodiment, the at least one memory 708 and the instructions are configured to, with the at least one processor 702, cause the apparatus at least to perform scheduling data transmissions for HARQ processes on an air interface between UE and a radio access node, obtaining a message including information indicating a new number of HARQ processes for the data transmissions between the UE and the radio access node, applying the new number of HARQ processes to data transmissions on the air interface. The apparatus may include an interface unit (IFU) 710 that may be electrically connected to the processor. The electrical connection between the processor and the IFU may be implemented similar to the connection between the M and the processor. The IFU may be capable of transmission and/or reception of data and signalling. The data and signalling may be communicated using an applicable channel and protocol. Examples of the channels include a data communications bus and an air interface. Examples of the protocols include data bus protocols and protocols on an air interface between UE and eNB such as MAC protocol, RRC protocol, Packet Data Convergence Protocol, Radio Link Control protocol and physical layer protocols.

The IFU 710 may be an internal unit to the apparatus. The apparatus may include a radio signal transmission and/or reception unit that may be operatively connected to the radio signal transmission and/or reception unit to cause a message including information indicating a new number of HARQ processes to be sent. The IFU may be capable of transmission and/or reception of data and messages.

On the other hand the IFU may be a radio signal transmission and/or reception unit, whereby the processor may control the IFU to receive a message including information indicating a new number of HARQ processes.

According to an embodiment, an apparatus such as a network node, eNB or UE, or a part of the apparatus, for example a data processing unit or a module, may comprise processing means configured to carry out any of the embodiments of Figures 2a, 2b, 3, 4, 5 and 6. The processing means may be formed by the at least one processor 702 and the memory 708. The processing means may be a computer or a part of a computer.

In an embodiment there is provided a computer program comprising computer program code for execution on a computer to cause a method according to an embodiment, when said product is run on a computer. The computer program may be embodied on a computer –readable storage medium.

In an embodiment there is provided a computer program product for a computer, comprising a computer program according to an embodiment.

An embodiment concerns a computer program embodied on a computer –readable storage medium, the computer program comprising program to execute a process comprising a method according an embodiment.

Embodiments as described may also be carried out in the form of a computer process defined by a computer program. The computer program may be in source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, which may be any entity or device capable of carrying the program. For example, the computer program may be stored on a computer –readable storage medium. The computer –readable storage medium may be a computer program distribution medium readable by a computer or a processor. The computer –readable storage medium may be, for example but not limited to, a record medium, computer memory, read-only memory, electrical carrier signal, telecommunications signal, and software distribution package, for example.

The various embodiments may be applied to communications networks and communications systems, where data may be transmitted between devices such as UE or a terminal and the network infrastructure such as a radio access node or a data processing unit. The techniques described herein may be implemented by various means so that an apparatus implementing one or more functions of data processing unit, eNB or UE described with an embodiment comprises not only prior art means, but also means for implementing the one or more functions of a corresponding apparatus described with an embodiment and it may comprise separate means for each separate function, or means may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. A hardware implementation may be through one or more circuits, for example Application Specific Circuits (ASICs). For a firmware or software, implementation can be through modules (e.g., procedures, functions, and so on) that perform the functions described herein. The software codes may be stored in any suitable, processor/computer-readable data storage medium(s) or memory unit(s) or article(s) of manufacture and executed by one or more processors/computers. The data storage medium or the memory unit may be implemented within the processor/computer or external to the processor/computer, in which case it can be communicatively coupled to the processor/computer via various means as is known in the art.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. A method comprising:

scheduling data transmissions for error recovery processes on an air interface between user equipment and a radio access node; and

causing to send a message including information indicating a new number of error recovery processes for the data transmissions between the user equipment and the radio access node.

2. A method according to claim 1, comprising:

measuring at least one of a throughput, delay and jitter of a communication link for determining a need to adjust the number of error recovery processes.

3. A method according to claim 2, comprising:

determining a need to adjust the number of error recovery processes, when results of at least one of the measurements indicate inefficient scheduling of data transmissions on the air interface.

4. A method comprising:

scheduling data transmissions for error recovery processes on an air interface between user equipment and a radio access node;

obtaining a message including information indicating a new number of error recovery processes for the data transmissions between the user equipment and the radio access node;

applying the new number of error recovery processes to data transmissions on the air interface.

5. A method according to any one of claims 1 to 4, wherein the new number of error recovery processes indicates the number of error recovery processes per cell or per user equipment.

6. A method according of any one of the preceding claims, wherein the message includes information indicating a condition for applying the new number of error recovery processes.

7. A method according to claim 6, wherein the condition is a transmission time interval in synchronous communications on the air interface.

8. A method according to any one of the preceding claims, wherein the message is signaling, for example a system information message, Radio Resource Control message or a Medium Access Control message.

9. A method according to any one of the preceding claims, wherein an error recovery process for data transmission in a transmission time interval is identified as a function of a time varying property of an element in synchronous communications and an identifier in a control message for scheduling a data transmission and said control message associated to the element.

10. An apparatus comprising at least one processor, and

at least one memory for storing instructions to be executed by the processor, wherein

the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to cause a method according to any one of claims 1 to 3 and 5 to 9.

11. An apparatus according to claim 10, wherein the apparatus is a radio access node, a data processing unit or a module of a radio access node.

12. An apparatus according to claim 11, wherein the radio access node comprises one or more remote radio heads operatively connected to a central data processing unit.

13. An apparatus comprising at least one processor, and

at least one memory for storing instructions to be executed by the processor, wherein

the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to cause a method according to any one of claims 4 to 9.

14. An apparatus according to claim 13, wherein the apparatus is user equipment or a module of user equipment.

15. A communications network comprising an apparatus according to claim 10 operatively connected to a plurality of remote radio heads for scheduling data transmissions between the remote radio heads and user equipment.

16. A communications network according to claim 15, wherein the communications network comprises a local scheduler and a central scheduler for scheduling data transmissions in error recovery processes on an air interface between user equipment and a radio access node, wherein scheduling decisions of the local scheduler override the scheduling decisions of the remote scheduler.

17. A computer program comprising computer program code for execution on a computer to cause a method according to any one of claims 1 to 9, when said computer program code is run on a computer.

18. A computer program product for a computer, comprising a computer program according to claim 17.

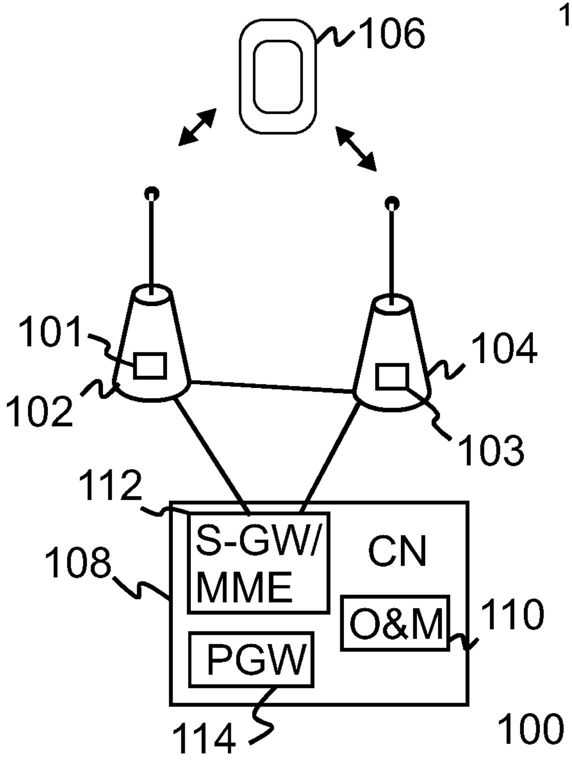

Figure 1

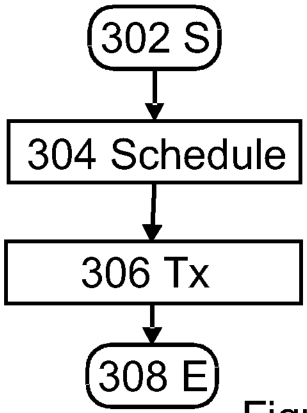

Figure 3

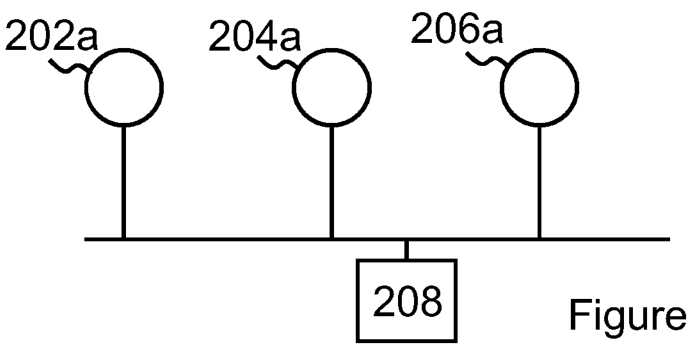

Figure 2a

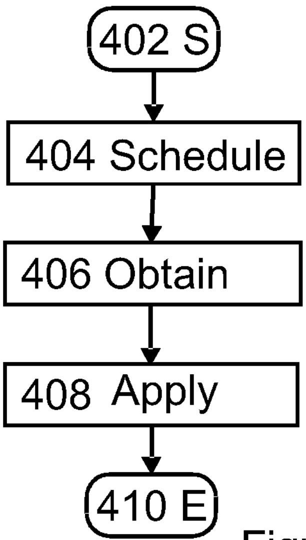

Figure 4

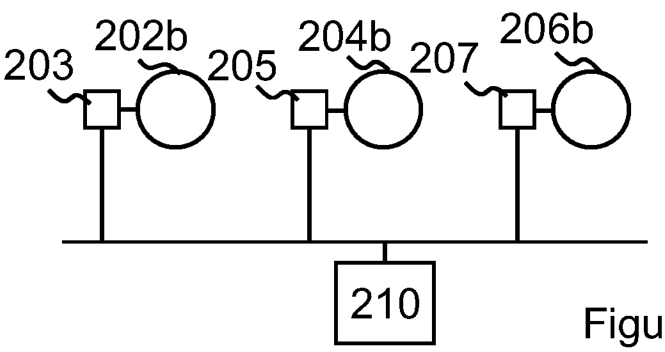

Figure 2b

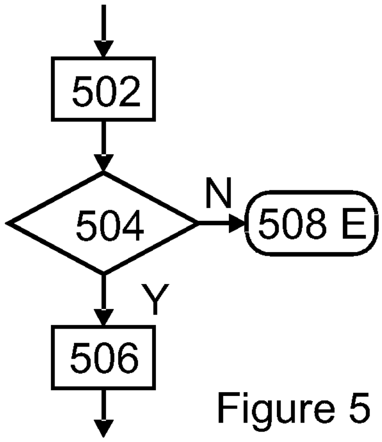

Figure 5

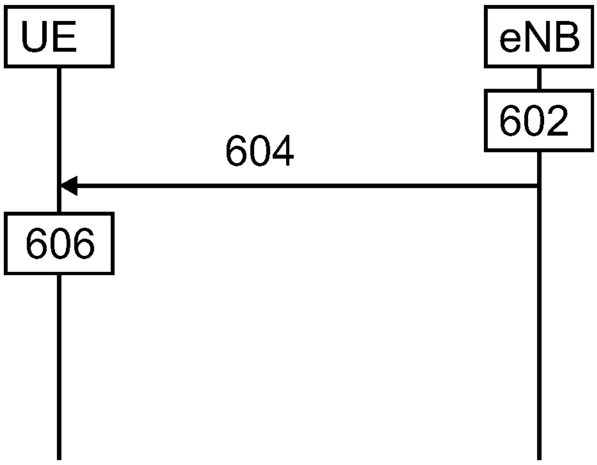

Figure 6

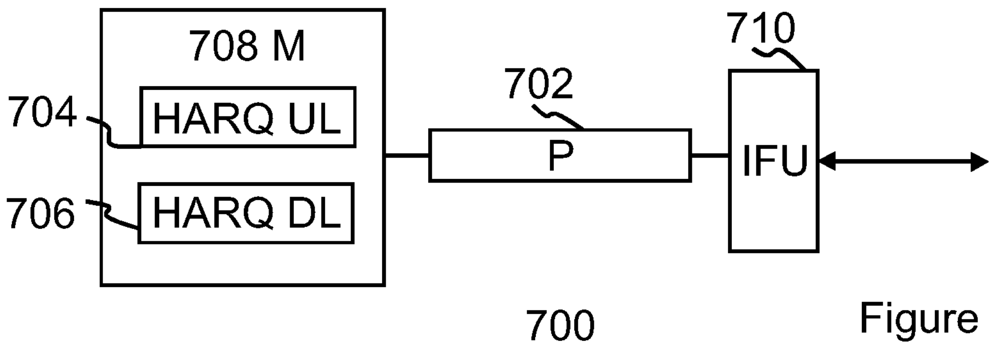

Figure 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/059262

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L1/18
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 1 389 847 A1 (MATSUSHITA ELECTRIC IND CO LTD [JP]) 18 February 2004 (2004-02-18) figure 1 paragraphs [0018], [0019], [0050] - [0058] -----	1-18
X	US 2009/323564 A1 (CHIU CHUN-YUAN [TW]) 31 December 2009 (2009-12-31) figures 7,8 paragraphs [0048] - [0058] -----	1-7, 9-15,17, 18

☐ 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

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"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	Date of mailing of the international search report
8 January 2016	18/01/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Marjanovic, Djordje

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/059262

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