



(51) International Patent Classification:

H04L 1/18 (2006.01)

H04L 1/00 (2006.01)

H04L 1/08 (2006.01)

(21) International Application Number:

PCT/EP2017/054801

(22) International Filing Date:

01 March 2017 (01.03.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: NOKIA TECHNOLOGIES OY [FI/FI];

Karaportti 3, 02610 Espoo (FI).

(72) Inventors: VENKATASUBRAMANIAN, Venkatku-

mar; Strzegomska 202/713, 54-432 Wrocław (PL).

KHOSRAVIRAD, Saeed Reza; Podwale 2/89, 50043

Wrocław (PL). LUKOWA, Anna Maria; Raniewo 2B,

82-550 Prabuty (PL).

(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

(54) Title: DECODING

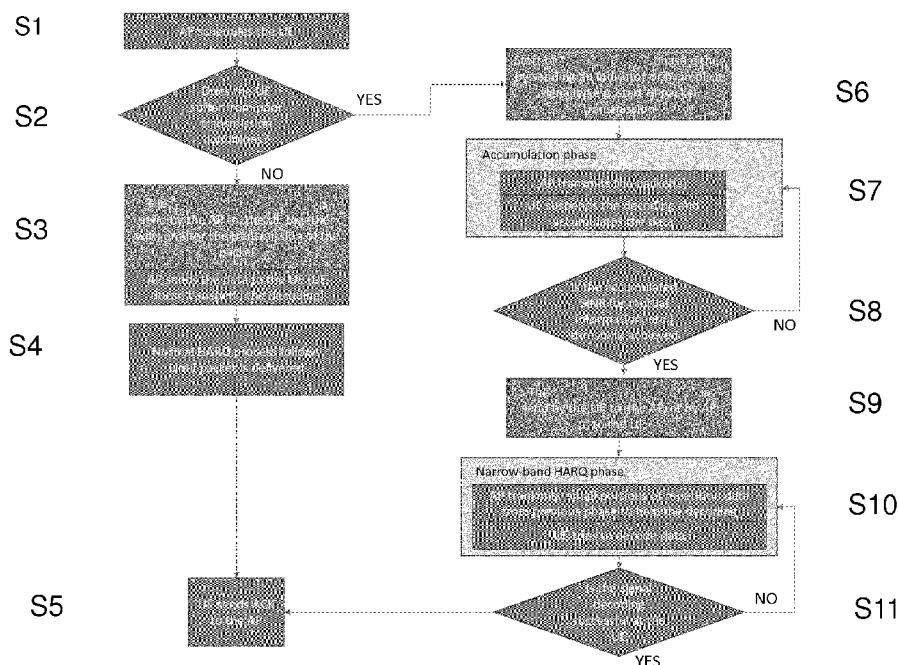


Figure 6

(57) **Abstract:** A method comprising: in response to a first cell condition in a wireless communication network, transmitting a first indication from an apparatus to a user equipment, the first indication configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is suspended; and in response to a second cell condition, communicating a second indication with the user equipment, the second indication configured to cause the user equipment and/or apparatus to operate according to a second mode in which decoding of the information is performed.

Published:

— *with international search report (Art. 21(3))*

DescriptionTitle**Decoding**

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Field

This disclosure relates to communications, and more particularly to decoding of communications in a wireless communication system. More particularly the present invention relates to scheduling of decoding in a wireless communication network.

10 Background

A communication system can be seen as a facility that enables communication between two or more devices such as user terminals, machine-like terminals, base stations and/or other nodes by providing communication channels for carrying information between the communicating devices. A communication system can be provided for example by means of a communication network and one or more compatible communication devices. The communication may comprise, for example, communication of data for carrying data for voice, electronic mail (email), text message, multimedia and/or content data communications and so on. Non-limiting examples of services provided include two-way or multi-way calls, data communication or multimedia services and access to a data network system, such as the Internet.

In a wireless system at least a part of communications occurs over wireless interfaces. Examples of wireless systems include public land mobile networks (PLMN), satellite based communication systems and different wireless local networks, for example wireless local area networks (WLAN). A local area wireless networking technology allowing devices to connect to a data network is known by the tradename WiFi (or Wi-Fi). WiFi is often used synonymously with WLAN. The wireless systems can be divided into cells, and are therefore often referred to as cellular systems. A base station provides at least one cell.

A user can access a communication system by means of an appropriate communication device or terminal capable of communicating with a base station. Hence nodes like base stations are often referred to as access points. A communication device of a user is often referred to as user equipment (UE). A communication device is provided with an appropriate signal receiving and transmitting apparatus for enabling communications, for example enabling communications with the base station and/or communications directly

with other user devices. The communication device can communicate on appropriate channels, e.g. listen to a channel on which a station, for example a base station of a cell, transmits.

A communication system and associated devices typically operate in accordance with a given standard or specification which sets out what the various entities associated with the system are permitted to do and how that should be achieved. Communication protocols and/or parameters which shall be used for the connection are also typically defined. Non-limiting examples of standardised radio access technologies include GSM (Global System for Mobile), EDGE (Enhanced Data for GSM Evolution) Radio Access Networks (GERAN), Universal Terrestrial Radio Access Networks (UTRAN) and evolved UTRAN (E-UTRAN). An example communication system architecture is the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. The LTE is standardized by the third Generation Partnership Project (3GPP). The LTE employs the Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access and a further development thereof which is sometimes referred to as LTE Advanced (LTE-A).

Since introduction of fourth generation (4G) services increasing interest has been paid to the next, or fifth generation (5G) standard. 5G may also be referred to as a New Radio (NR) network. Standardization of 5G or New Radio networks is an on-going study item.

5G systems are expected to support high data rates and diverse services using densification and concurrent usage of lower and higher frequency bands. Future UEs may be expected to support a huge amount of bandwidth in the scale of GHz, and make use of many frequency bands. For reliability as well as high throughput the variability of the radio channel can pose a challenge to the QoS. While in the lower bands interference and interference variability is an issue, in the higher frequency bands channel variations because of mobility and beam alignment has to be addressed. At the same time the energy consumption of UEs should also be minimised in the design of radio access networks.

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Statement of invention

In a first aspect there is provided a method comprising: in response to a first cell condition in a wireless communication network, transmitting a first indication from an apparatus to a user equipment, the first indication configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is

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suspended; and in response to a second cell condition, communicating a second indication with the user equipment, the second indication configured to cause the user equipment and/or apparatus to operate according to a second mode in which decoding of the information is performed.

5 According to some embodiments the user equipment operating in the first mode comprises the user equipment accumulating downlink information received from the apparatus, whilst decoding of the downlink information is suspended at the user equipment.

 According to some embodiments, the apparatus operating in the first mode comprises the apparatus accumulating uplink information received from the user
10 equipment, whilst decoding of the uplink information is suspended at the apparatus.

 According to some embodiments, the user equipment operating in the second mode comprises the user equipment decoding the downlink information accumulated at the user equipment.

 According to some embodiments, the user equipment operating in the second mode
15 comprises the user equipment entering a hybrid automatic repeat request state.

 According to some embodiments, the hybrid automatic repeat request state comprises communication of multiple redundancy versions of data communicated between the apparatus and user equipment when operating in the first mode.

 According to some embodiments, the multiple redundancy versions are transmitted
20 in a narrow-band mode.

 According to some embodiments, the multiple redundancy versions are transmitted in a wide-band mode.

 According to some embodiments, the multiple redundancy versions comprise multiple versions in time-frequency.

25 According to some embodiments, the first and second modes respectively comprise different control channel formats.

 According to some embodiments the first mode comprises an early transmission format, and the second mode comprises a grant format.

 According to some embodiments the second mode comprises a wideband mode.

30 According to some embodiments, the apparatus operating in the second mode comprises the apparatus decoding uplink information received at the apparatus.

According to some embodiments the first cell condition is determined by the apparatus or by the user equipment, and information of the first cell condition is transmitted to the other of the apparatus and the user equipment.

5 According to some embodiments the second cell condition is determined by the apparatus or by the user equipment, and transmitted to the other of the apparatus and user equipment.

According to some embodiments the first and second indications comprise alternative states of an indicator.

According to some embodiments the indicator comprises a 1-bit indicator.

10 According to some embodiments the first indication comprises a first value of the indicator, and the second indication comprises a second value of the indicator.

According to some embodiments the apparatus comprises a base station.

According to some embodiments the wireless communication network comprises a 5G new radio network.

15 According to some embodiments the second cell condition comprises favourable or improved transmission/reception conditions relative to the first cell condition.

In a second aspect there is provided a method comprising: in response to a first cell condition in a wireless communication network, receiving, from an apparatus, a first indication at a user equipment, the first indication configured to cause the user equipment
20 and/or apparatus to operate according to a first mode in which decoding of information is suspended; and in response to a second cell condition, communicating a second indication with the apparatus, the second indication configured to cause the user equipment and/or apparatus to operate according to a second mode.

25 According to some embodiments, the user equipment operating in the first mode comprises the user equipment accumulating downlink information received from the apparatus, whilst decoding of the downlink information is suspended at the user equipment.

According to some embodiments, the user equipment operating in the second mode comprises the user equipment decoding the downlink information accumulated at the user equipment.

30 According to some embodiments, the user equipment operating in the second mode comprises the user equipment entering a hybrid automatic repeat request state.

According to some embodiments, the hybrid automatic repeat request state comprises communication of multiple redundancy versions of data already communicated between the apparatus and user equipment when operating in the first mode.

According to some embodiments, the multiple redundancy versions are transmitted
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According to some embodiments, the multiple redundancy versions are transmitted in a wide-band mode.

According to some embodiments, the multiple redundancy versions comprise multiple versions in time-frequency.

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According to some embodiments the first mode comprises an early transmission format, and the second mode comprises a grant format.

According to some embodiments the second mode comprises a wideband mode.

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According to some embodiments the second cell condition is determined by the apparatus or by the user equipment, and transmitted to the other of the apparatus and user
20 equipment.

According to some embodiments the first and second indications comprise alternative states of an indicator.

According to some embodiments the indicator comprises a 1-bit indicator.

According to some embodiments the first indication comprises a first value of the
25 indicator, and the second indication comprises a second value of the indicator.

According to some embodiments the UE comprises a 5G enabled UE.

In a third aspect there is provided a computer program comprising program code means adapted to perform the steps of the first aspect when the program is run on a data processing apparatus.

In a fourth aspect there is provided a computer program comprising program code means adapted to perform the steps of the second aspect when the program is run on a data processing apparatus.

In a fifth aspect there is provided an apparatus comprising at least one processor,
5 and at least one memory including computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to: in response to a first cell condition in a wireless communication network, transmit a first indication to a user equipment, the first indication configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is
10 suspended; and in response to a second cell condition, communicate a second indication with the user equipment, the second indication configured to cause the user equipment and/or apparatus to operate according to a second mode in which decoding of the information is performed.

In a sixth aspect there is provided an apparatus comprising: means for, in response
15 to a first cell condition in a wireless communication network, transmitting a first indication to a user equipment, the first indication configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is suspended; and means for, in response to a second cell condition, communicating a second indication with the user equipment, the second indication configured to cause the user
20 equipment and/or apparatus to operate according to a second mode in which decoding of the information is performed.

According to some embodiments, the user equipment operating in the first mode comprises the user equipment accumulating downlink information received from the apparatus, whilst decoding of the downlink information is suspended at the user equipment.

25 According to some embodiments, the apparatus operating in the first mode comprises the apparatus accumulating uplink information received from the user equipment, whilst decoding of the uplink information is suspended at the apparatus.

According to some embodiments, the user equipment operating in the second mode comprises the user equipment decoding the downlink information accumulated at the user
30 equipment.

According to some embodiments, the user equipment operating in the second mode comprises the user equipment entering a hybrid automatic repeat request state.

According to some embodiments, the hybrid automatic repeat request state comprises communication of multiple redundancy versions of data communicated between the apparatus and user equipment when operating in the first mode.

5 According to some embodiments, the multiple redundancy versions are transmitted in a narrow-band mode.

According to some embodiments, the multiple redundancy versions are transmitted in a wide-band mode.

According to some embodiments, the multiple redundancy versions comprise multiple versions in time-frequency.

10 According to some embodiments, the first and second modes respectively comprise different control channel formats.

According to some embodiments the first mode comprises an early transmission format, and the second mode comprises a grant format.

15 According to some embodiments the second mode comprises a wideband mode.

According to some embodiments, the apparatus operating in the second mode comprises the apparatus decoding uplink information received at the apparatus.

20 According to some embodiments the first cell condition is determined by the apparatus or by the user equipment, and information of the first cell condition is transmitted to the other of the apparatus and the user equipment.

According to some embodiments the second cell condition is determined by the apparatus or by the user equipment, and transmitted to the other of the apparatus and user equipment.

25 According to some embodiments the first and second indications comprise alternative states of an indicator.

According to some embodiments the indicator comprises a 1-bit indicator.

According to some embodiments the first indication comprises a first value of the indicator, and the second indication comprises a second value of the indicator.

According to some embodiments, the apparatus comprises a base station.

30 According to some embodiments the wireless communication network comprises a 5G new radio network.

In a seventh aspect there is provided an apparatus comprising at least one processor, and at least one memory including computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to: in response to a first cell condition in a wireless communication network, receive from a second apparatus a first indication, the first indication configured to cause the apparatus and/or second apparatus to operate according to a first mode in which decoding of information is suspended; and in response to a second cell condition, communicating a second indication with the second apparatus, the second indication configured to cause the apparatus and/or second apparatus to operate according to a second mode.

In an eighth aspect there is provided an apparatus comprising: in response to a first cell condition in a wireless communication network, means for receiving from a second apparatus a first indication, the first indication configured to cause the apparatus and/or second apparatus to operate according to a first mode in which decoding of information is suspended; and, in response to a second cell condition, means for communicating a second indication with the second apparatus, the second indication configured to cause the apparatus and/or second apparatus to operate according to a second mode.

According to some embodiments, the apparatus operating in the first mode comprises the apparatus accumulating downlink information received from the second apparatus, whilst decoding of the downlink information is suspended at the apparatus.

According to some embodiments, the apparatus operating in the second mode comprises the apparatus decoding the downlink information accumulated at the apparatus.

According to some embodiments, the apparatus operating in the second mode comprises the apparatus entering a hybrid automatic repeat request state.

According to some embodiments, the hybrid automatic repeat request state comprises communication of multiple redundancy versions of data already communicated between the apparatus and the second apparatus when operating in the first mode.

According to some embodiments, the multiple redundancy versions are transmitted in a narrow-band mode.

According to some embodiments, the multiple redundancy versions are transmitted in a wide-band mode.

According to some embodiments, the multiple redundancy versions comprise multiple versions in time-frequency.

According to some embodiments, the first and second modes respectively comprise different control channel formats.

5 According to some embodiments the first mode comprises an early transmission format, and the second mode comprises a grant format.

According to some embodiments the second mode comprises a wideband mode.

According to some embodiments the first cell condition is determined by the apparatus or by the user equipment, and information of the first cell condition is transmitted
10 to the other of the apparatus and the user equipment.

According to some embodiments the second cell condition is determined by the apparatus or by the user equipment, and transmitted to the other of the apparatus and user equipment.

According to some embodiments the first and second indications comprise
15 alternative states of an indicator.

According to some embodiments the indicator comprises a 1-bit indicator.

According to some embodiments the first indication comprises a first value of the indicator, and the second indication comprises a second value of the indicator.

According to some embodiments, the apparatus comprises a 5G enabled UE.

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Brief description of Figures

The invention will now be described in further detail, by way of example only, with reference to the following examples and accompanying drawings, in which:

25 Figure 1 shows a schematic example of a wireless communication system where the invention may be implemented;

Figure 2 shows an example of a communication device;

Figure 3 shows an example of a control apparatus;

Figure 4 schematically shows the phases of a scheduling process according to an
30 embodiment;

Figure 5 schematically shows the phases of a scheduling process according to an embodiment;

Figure 6 is a flowchart showing steps of a method according to an embodiment;

Figure 7 is a flowchart showing steps of a method according to an embodiment;

5 Figure 8 is a flowchart showing steps of a method according to an embodiment;

Figure 9 is a flowchart showing steps of a method according to an embodiment;

Figure 10 is a flowchart showing steps of a method according to an embodiment.

Detailed description

Before explaining in detail the examples, certain general principles of a wireless
10 communication system and mobile communication devices are briefly explained with
reference to Figures 1 to 2 to assist in understanding the technology underlying the
described examples.

In a wireless communication system 100, such as that shown in Figure 1, a wireless
communication devices, for example, user equipment (UE) or MTC devices 102, 104, 105
15 are provided wireless access via at least one base station or similar wireless transmitting
and/or receiving wireless infrastructure node or point. Such a node can be, for example, a
base station or an eNodeB (eNB), or in a 5G system a Next Generation NodeB (gNB), or
other wireless infrastructure node. These nodes will be generally referred to as base
stations. Base stations are typically controlled by at least one appropriate controller
20 apparatus, so as to enable operation thereof and management of mobile communication
devices in communication with the base stations. The controller apparatus may be located
in a radio access network (e.g. wireless communication system 100) or in a core network
(CN) (not shown) and may be implemented as one central apparatus or its functionality may
be distributed over several apparatus. The controller apparatus may be part of the base
25 station and/or provided by a separate entity such as a Radio Network Controller. In Figure
1 control apparatus 108 and 109 are shown to control the respective macro level base
stations 106 and 107. In some systems, the control apparatus may additionally or
alternatively be provided in a radio network controller. Other examples of radio access
system comprise those provided by base stations of systems that are based on technologies
30 such as 5G or new radio, wireless local area network (WLAN) and/or WiMax (Worldwide
Interoperability for Microwave Access). A base station can provide coverage for an entire
cell or similar radio service area.

In Figure 1 base stations 106 and 107 are shown as connected to a wider communications network 113 via gateway 112. A further gateway function may be provided to connect to another network.

The smaller base stations 116, 118 and 120 may also be connected to the network 113, for example by a separate gateway function and/or via the controllers of the macro level stations. The base stations 116, 118 and 120 may be pico or femto level base stations or the like. In the example, stations 116 and 118 are connected via a gateway 111 whilst station 120 connects via the controller apparatus 108. In some embodiments, the smaller stations may not be provided.

A possible wireless communication device will now be described in more detail with reference to Figure 2 showing a schematic, partially sectioned view of a communication device 200. Such a communication device is often referred to as user equipment (UE) or terminal. An appropriate mobile communication device may be provided by any device capable of sending and receiving radio signals. Non-limiting examples comprise a mobile station (MS) or mobile device such as a mobile phone or what is known as a 'smart phone', a computer provided with a wireless interface card or other wireless interface facility (e.g., USB dongle), personal data assistant (PDA) or a tablet provided with wireless communication capabilities, or any combinations of these or the like. A mobile communication device may provide, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and so on. Users may thus be offered and provided numerous services via their communication devices. Non-limiting examples of these services comprise two-way or multi-way calls, data communication or multimedia services or simply an access to a data communications network system, such as the Internet. Users may also be provided broadcast or multicast data. Non-limiting examples of the content comprise downloads, television and radio programs, videos, advertisements, various alerts and other information.

A wireless communication device may be for example a mobile device, that is, a device not fixed to a particular location, or it may be a stationary device. The wireless device may need human interaction for communication, or may not need human interaction for communication. In the present teachings the terms UE or "user equipment" are used to refer to any type of wireless communication device.

The wireless device 200 may receive signals over an air or radio interface 207 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 2 transceiver apparatus is designated schematically by block 206. The transceiver apparatus 206 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the wireless device.

A wireless device is typically provided with at least one data processing entity 201, at least one memory 202 and other possible components 203 for use in software and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 204. The user may control the operation of the wireless device by means of a suitable user interface such as key pad 205, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 208, a speaker and a microphone can be also provided. Furthermore, a wireless communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto. The communication devices 102, 104, 105 may access the communication system based on various access techniques.

Figure 3 shows an example of a control apparatus for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a RAN node, e.g. a base station, gNB, a central unit of a cloud architecture or a node of a core network such as an MME or S-GW, a scheduling entity such as a spectrum management entity, or a server or host. The control apparatus may be integrated with or external to a node or module of a core network or RAN. In some embodiments, base stations comprise a separate control apparatus unit or module. In other embodiments, the control apparatus can be another network element such as a radio network controller or a spectrum controller. In some embodiments, each base station may have such a control apparatus as well as a control apparatus being provided in a radio network controller. The control apparatus 300 can be arranged to provide control on communications in the service area of the system. The control apparatus 300 comprises at least one memory 301, at least one data processing unit 302, 303 and an input/output interface 304. Via the interface the control apparatus can be coupled to a receiver and a transmitter of the base station. The receiver and/or the transmitter may be implemented as a radio front end or a remote radio head. For example the control apparatus 300 or processor 201 can be configured to execute an appropriate software code to provide the control functions.

Instances of high interference within the communication system may result in a high decoding failure of transmissions. This may in turn lead to high amount of uplink re-transmissions via hybrid automatic repeat request (HARQ). In cases when the interfering cell has a high amount of downlink transmissions, this may result in an unacceptable quality of service to the cell. The cell(s) due to suffer unacceptable quality of service may be referred to as "victim" cell(s).

The HARQ technique is used for retransmission of failed initial transmissions, along with storing the received packet for combining all the received portions of the same packet by a negative-acknowledgment (NACK) message. In HARQ, the receiving node simply informs the transmitter about the decoding failure of the packet, and stores the received information for a more efficient future combining with the received retransmissions. In traditional systems, the transmitter will transmit extra redundancy of the same packet over the data channel after receiving a NACK from the receiver entity. In any subsequent transmission attempt (so-called retransmission), the receiver will evaluate the received data while considering the earlier information. This way, the receiver combines the old and new data to increase the decoding success chances. On the other hand, for latency purposes, certain applications (latency critical MTC (machine type communications)) may be designed to work without using HARQ. The absence of HARQ for these applications thus make network assistance even more important in order to guarantee the required quality-of-service (QoS).

In LTE, two different HARQ timing implementations are available: the asynchronous HARQ, where the retransmission time can vary and is used in DL HARQ; and the synchronous HARQ where the retransmission in one HARQ stop-and-wait (SAW) process is only at predetermined time instances (of e.g. 8 ms or 8xTTI (transmission time interval) duration in case of FDD (frequency division duplex) deployment) and is used in UL HARQ.

For the 5G new radio (NR), a general flexible timing consensus is expected which will result in configurable timing between initial transmission and the corresponding ACK/NACK as well as configurable timing between a transmission and the following retransmission (asynchronous operation). The flexible HARQ timing will in practice make room for potential energy efficient enhancements to the reception/decoding/feedback loop, as will be shown and described in the embodiments below.

One disadvantage of the existing HARQ feedback methods is that they can place a significant burden on the control radio resources because of the ACK/NACK overhead. This issue can lead to significant wastage of radio resources, for example when the ACK/NACK is sent repeatedly when the channel conditions are poor or when high interference is experienced. Furthermore, repeated decoding attempts by a receiver can lead to wastage of precious energy resources. Two such situations are highlighted below

- A high interference variability in a flexible TDD (time division duplex) scenario, e.g. a failed uplink because the interference becomes difficult to estimate because of interference flashlight effect. With the existing mechanisms, repeated ACK/NACKs (potentially enriched) will then be sent on the downlink control channel in response to uplink decoding failure. This will further lead to repeated uplink transmission

attempts, which results in wastage of energy resources at the UE as well as consuming precious computational resources at the base station.

- A dynamic blockage scenario at higher frequency bands where poor channel conditions due to lack of LOS (level of service) or because of beam misalignment may persists for a short time period. In such situations, repeated decoding attempts by the UE along with ACK/NACK indications after each transmission leads to significant wastage of UE energy as well as radio resources.

The embodiments described below propose enhancements to the early feedback which can address the shortcomings.

As described above, in case of dense cell deployment the interference can be a serious problem limiting system performance. The victim cell can suffer from poor transmission conditions, especially for cell edge users. It can apply to both uplink and downlink reception. This may lead to an increase in the rate of failed signal decoding in a victim node resulting in retransmission rate increase. The victim receiver will try to decode received downlink data, while poor received signal quality will lead to decoding failure. The unsuccessful decoding attempts leads to the waste of processing resources of a victim receiver. Transmission conditions, signal quality, interference level etc may be considered a cell condition. For example poor transmission conditions may be considered poor cell conditions. On the other hand good transmission conditions may be considered a good, favourable or improved cell condition. The present invention proposes techniques for saving the data processing resources at the victim receiver and enabling efficient data reception in an interfering scenario.

It is proposed to use signalling to indicate when a node or entity e.g. a UE, or access point (AP) such as a gNB, is to begin decoding received transmissions. In some embodiments a new decoding indicator is provided, which can indicate to a node to hold and start decoding the received signal to ensure increased probability of successful decoding of the received signal. For example, in case of poor transmission quality (e.g. a first cell condition), the UE can suspend the start of the signal decoding until it accumulates a sufficient amount of the data. That is the UE and/or AP may operate according to a first mode in which decoding of information is suspended. The AP can inform the UE whether it should start decoding the received signal from that time instance onwards, or suspend it and accumulate the data. In some embodiments, this can be signaled by a "decoding indicator". In some embodiments the decoding indicator is a 1-bit indicator. When the bit is 0 (e.g. a first indication), the decoding in a victim receiver is suspended, and the receiver accumulates the data for future decoding. When the bit is 1 (e.g. a second indication), the

receiver starts the decoding of received (and accumulated) data. The decoding phase may be considered the AP and/or UE operating according to a second mode.

The process may therefore be considered a multi-stage transmission process. The idea of the multi-stage transmission process makes use of an “early”, or first, data transmission period and a decoding start indicator. The above two phases (early transmission and transmission of decoding start indicator) occur before the traditional HARQ mechanisms used based on the decoder status.

The early data transmission period may therefore have the following characteristics:

- The early data transmission period is used for accumulation of data. This can be based on a pre-configured MCS (modulation and coding scheme). Thus even though the early data transmission period is scheduled by the base station as part of the transmission period, the transmission parameters may be defined specifically for this period (e.g. the MCS, Tx power, time duration, bandwidth). That is the transmission parameters in the early data transmission period may be pre-defined.
- The scheduling for the early data transmission period can be semi-persistently scheduled, e.g. a certain resource block for a certain (e.g. relatively long) period. At least some (and in some examples many) transport blocks can thus be sent over the early transmission period under the same HARQ process id (without using ACK/NACK feedback or HARQ during the early transmission period). This implicitly allows for time interleaving and interlacing a certain transport block in different time intervals to exploit time diversity in the channel.

The early data transmission period is followed by a decoding start indicator, which has the following characteristics:

- This indicator may be triggered by the receiver (e.g. UE) or by the base station.
- The base station may proactively transmit the decoding start indicator to the downlink UE receiver. By using network coordination, the base station may predict a time interval when the interference is reduced to the receiver. The decoding start indicator can thus be used to inform the UE when the interference is relatively low (for example has reached a threshold level) and the link becomes more reliable
- Similarly the base station can predict and inform the UE of a time when beam alignment can be expected. The decoding start indicator can thus provide information of a time when the base station establishes beam alignment to the UE.
- In the case of uplink transmission, the base station receiver can indicate the decoding start time (i.e. decoding at the base station) based on the computational resources available at the base station.

- The decoding start indicator can also be initiated by the receiver (e.g. UE) based on latency targets for the application, energy and memory resources apart from channel conditions.

It may be considered that the first and second modes respectively comprise different control channel formats. For example the first mode (accumulation) may follow an early transmission channel format, whereas the second mode (decoding) follows a specific grant channel format.

Following the early transmission and decoding start indicator phases, the transmission enters a target transmission period where the data transmission is made, or prepared, for reliable decoding of the full data.

The usage of the target transmission period can be switched dynamically based on the service requirements of latency and reliability as follows.

High redundancy mode

For services requiring low latency and high reliability, the full available bandwidth is used for the target transmission period. That is this may be considered a wideband case for low latency traffic. The data sent in the early transmission period is repeated using a very low code rate. For example 100 information bits sent in the early transmission phase are mapped to 800 coded bits to be sent in the target transmission subframes. This results in reliability-waterfilling, wherein the target transmission period is used opportunistically with low code rate for ultra-high reliability with ultra-low error rates. For example, this mechanism can be used for V2X (vehicle to everything) services where the target transmission period is aligned with the time period during which the vehicle is in coverage. Because of the latency constraints, the data transmission may then end with the target transmission period.

After the time interleaved transmission in the early transmission period, selected transport blocks are sent with high redundancy (low code rates) using the frequency domain on the target subframes. A fixed number of transport blocks from the early transmission phase are blindly repeated with a low code rate to assist in fast decoding of the data. The receiver can also send a multi-bit feedback along with "decoding start" informing the transport block(s) which will be decoded first. Thus redundancy information across multiple transport blocks under the same HARQ process id are frequency multiplexed.

Narrow-band HARQ mode

For services where latency is not important but a high reliability is sought, the target transmission period can be configured with the so-called narrow-band HARQ periods, where the data is sent in small incremental amounts to assist the decoder. The usage of narrow-band increments is beneficial for radio resources as well as for energy savings. Thus in the case of narrow-band HARQ the retransmissions may happen over a longer time until

an ACK is received. In this case for example at one time instant only 10 HARQ bits may be sent for the same 100 information bits, leading to a longer decoding latency.

Two embodiments will now be explained in more detail to further explain the invention:
(i) low-cost/low-energy UE type; (ii) low latency traffic.

5 (i) Low-cost/low-energy UE type

As previously discussed, the mechanism allows (or causes) the receiver node (e.g. UE in downlink, base station in uplink) to postpone the decoding process of received signals until it accumulates a sufficient amount of data to increase the probability of successful decoding. In other words, decoding only begins when the chances are high enough for
10 successful decoding. Therefore the receiver node can save up energy by reducing the rate of unsuccessful decoding. The receiver node can in practice determine a likelihood of a successful decoding in different manners including: monitoring the SINR level of the received signal prior to decoding; and/or measuring the accumulated mutual information of the soft bits at the input of the decoding module.

15 For the purpose of the above mentioned mechanisms the following signalling messages may be used:

“Decoding indicator”. The decoding indicator determines, or defines, the start of the decoding process at a victim receiver. The decoding indicator may be represented by a single bit taking a value of 0 or 1. That is the receiver uses information in the decoding
20 indicator to determine when decoding may begin. In some embodiments the decoding indicator causes the receiver to begin decoding at a certain time. This signal may be transmitted during an ongoing packet transmission (or multiple packets). The decoding indicator can be transmitted either by the transmitting or the receiving nodes. In some embodiments the receiving node has the most accurate information regarding the
25 computational resources. Therefore it may be the receiving node which generates and/or transmits the decoding indicator. Alternatively or additionally the base station may by default inform the UE of the most opportune time for decoding.

In some embodiments the receiving node generates the decoding indicator based on an estimated likelihood of successful decoding. The receiver node then informs the
30 transmitter node of the beginning of decoding. That is the receiver node can inform the transmitter node of when the decoding actually begins.

In a different embodiment, the transmitting node may send the decoding indicator. The determination of whether and/or when to send the decoding indicator may be based on a determination of the channel condition or traffic load in its buffer, and as such trigger the
35 decoding process to begin at the receiving node. The determination of channel conditions

and/or traffic load may be carried out at the receiving node, or at the transmitting node, or indeed at any other network node.

As mentioned above the decoding indicator may be a 1-bit indicator having two states, a first state and a second state.

5 In an example `decoding_indicator=0` can be treated as a first state. This state may be considered a “decoding hold indicator” which puts on hold the start of decoding at the victim receiver. After sending the indicator the transmitter sends the data which is to be stored or accumulated at the victim receiver in the accumulation phase. This indicator can be sent, for example, from the AP to the UE together with the scheduling decision. In some examples
10 the decoding hold indicator can also be assumed implicit. For example, by starting transmission of a packet, decoding will be put on hold until the decoding start indicator is received or determined.

Decoding_indicator=1 can be treated as a second state of the decoding indicator. This may be considered a “decoding start indicator” which indicates whether and/or when the
15 victim receiver shall start decoding the received data from that time instance. Once decoding has begun, the transmitter may switch to or enter a Narrow-band HARQ phase. The “start decoding” decision may be based on one or more of: accumulated SINR; UE state; UE mobility; buffer status of a victim receiver. The ordinary HARQ feedback mechanisms such as ACK/NACK and/or enriched feedback can alternatively or additionally
20 be used after receiving the “decoding start indicator”.

Figure 4 schematically shows the phases of the process at 400. The accumulation phase is shown at 402. The narrowband HARQ phase is shown at 404. Each phase comprises one or more resource blocks. The early transmission accumulation phase is started with decoding hold indicator 406, followed by a series of transport blocks (TBs). The
25 TBs are shown generally at 407. The decoding start indicator 408 is transmitted at the end of the accumulation phase 408, and precedes the narrowband HARQ phase 404. As shown phase 404 comprises the transmission/reception of redundancy versions (RVs) of data already communicated (e.g. TBs 1 to 4) in the accumulation phase 402. That is the hybrid automatic repeat request state may comprise communication of multiple redundancy
30 versions of data communicated between the apparatus and user equipment when operating in the first mode (i.e. accumulation mode). The multiple redundancy versions may comprise multiple versions in time-frequency domain. At the end of the narrowband HARQ phase the receiver can indicate to the transmitter that it has successfully decoded the information, by means of ACK 410. The phases are discussed in more detail below.

35 The accumulation phase is triggered by the “decoding hold indicator”. In a case that during the accumulation phase the receiver experiences severe interference from neighboring cells, the received data with very low SINR may not be sufficient for successful

decoding. However, in the conventional approach, the decoder may still try to decode the data and the need for retransmission (NACK) would be sent to the transmitter. This may lead to waste of processing resources at the receiver (i.e. power consumption due to decoding), as well as to the signaling overhead (ACK/NACK signaling after each decoding failure). On the other hand, in the present embodiments the “decoding hold indicator” is used to initiate the accumulation phase. During this phase the transmitter sends additional redundancy bits of the same data packet to the receiver during the successive timeslots. The receiver puts the decoding on hold and accumulates the received data. The accumulation phase is ended by the start of the decoding process. As explained above, this can be triggered by the decoding start indicator.

The Narrow-band HARQ phase is triggered by “decoding start indicator”. Whether and/or when to send the decoding start indicator can be determined by one or more of: accumulated SINR level; receiver memory and hardware constraints; UE mobility; UE state; scheduling decisions of neighbouring cell, etc. During this phase the receiver starts the process of decoding, while the transmitter switches to the narrow-band HARQ phase (narrowband small size extra redundancy for the same packet). During the narrow-band HARQ phase, the transmitter sends portions, which may be small portions, of redundancy from the accumulation phase. A purpose of the narrow-band HARQ retransmission is to provide the receiver with extra information in a simplified and consistent narrowband transmission manner. This may increase the chances of decoding success. Unlike regular HARQ retransmission, the receiver doesn’t need to acknowledge reception of the narrow-band HARQ retransmission portions. Rather, in embodiments it is up to the receiving node to perform reception on the narrow-band HARQ portions and take them into account in the decoding process. The transmitting node chooses to schedule a receiving node by narrow-band HARQ transmissions when the necessary resources are available. The receiving node acknowledges (ACK/NACK) the packet at the specified regular HARQ feedback opportunity. For example, in a case where the transmitting node sends a decoding start indicator in a rush because of a full buffer of high priority data at the transmitter, it can accommodate the decoding process in return by consistent and small size “narrow-band HARQ” retransmission.

This embodiment (Low-cost/low-energy UE type) of the invention as explained above can be used for any traffic type, although it may be found most beneficial in case of mMTC/IoT (massive machine type communications/internet of things) type of traffic. Particularly in a case of a large number of UEs with critical battery life, it is to the benefit of the UE to limit the number of signaling, feedback transmission, reception and any battery-draining activity to a strictly necessary amount. With the decoding-start indication signaling

proposed above, an mMTC UE can listen to repetition of a DL transmission until it accumulates enough data for a successful decoding without the need to perform feedback during the reception time. The start of the relatively energy-consuming decoding process can then be postponed to when the chance or possibility of successful decoding is high enough. The possibility of successful decoding can be determined either at the UE to stop the reception. Alternatively the possibility of successful decoding can be determined at the eNB, which sends the indication and triggers the decoding. The decoding start indication can be sent by the eNB to announce an end to the repetition of a given packet, while saving the UE from consuming energy for feedback.

10 (ii) Low latency traffic

In this embodiment, the decoding start indicator can be used to send a high number of parity bits to the receiver to assist in decoding with low latency decoding. This may for example be to support low latency services in MBB mobile broadband or other machine type communications. Such a configuration may be beneficial for low latency services as explained below.

In the accumulation phase the accumulation can be used for encoding of data for channel coding with low latency. For example, in some embodiments, only the systematic bits of the data are sent in the accumulation phase. This can enable fast transmission of data using only a minimal latency at the baseband for modulating the information bits. The data can then be repeated over a semi-persistent period. During the accumulation period, the receiver can perform equalization and detection of data. By using time diversity in the transmission a certain amount of reliability is already achieved in detection of the information bits. The accumulation phase can for example last for a certain number of slots. For many low latency use cases a short to medium transport block of about 100-600 bits can be envisioned, with a low to medium throughput requirement (e.g. factory automation with 10 ms deadline, or low latency MBB traffic). The following points are noted:

- The accumulation phase may use a smaller (RF) bandwidth from an individual UE perspective and make use of time diversity by repetition for accumulation of data.
- A part of time repetition may carry coded bits in addition to the information bits, i.e. while the first set of transmission of data can be only information bits, the later set of repetition(s) in time can already carry some parity bits for the information.
- The accumulation phase of one or more UEs can be FDMed (frequency division multiplexed), while the accumulation phase of one UE can also be FDMed with target phase of another UE.

- As in the low-cost/low-energy UE embodiment, the accumulation phase can be used as an early transmission period, while the user plane processing such as encoding, beam training is in progress.

The decoding start indicator may be triggered by a time deadline. For example the
 5 decoding start indicator may be triggered when the data has to be reliably decoded by the receiver before a stringent time deadline e.g. after few slots of accumulation phase. The indicator could in general comprise a multi-bit feedback conveying the TB indexes (or in a different embodiment CB (coded block) indexes inside a large TB) that are about to be decoded. This may allow the eNB to supply the UE with a high redundancy subframe for (at
 10 least) those TBs (or CBs). The following points are noted:

- The decoding start indicator can be received or sent by the individual UE again in a lower RF bandwidth.
- Multi-bit feedback can be added to the decoding start indicator conveying whether and how much coded data is needed in high redundancy slots.
- After the decoding start indicator the UE can immediately start decoding. This may
 15 be based on the parity bits already available during the accumulation phase.

High redundancy target slots may be used. In these time slots (which can be mini-slots or slots) after the decoding start indicator, the network provides a high amount of parity bits for the transport blocks that were previously transmitted, so that the receiver can decode
 20 the data with high reliability. For example the transport block can be represented using high redundancy, e.g. 100 bits mapped to 1000 bits and transmitted in the high redundancy subframe. The transport blocks transmitted in high redundancy subframes may be based on multi-bit feedback from the UE or based on first in first out (FIFO) pipeline. The following points are noted:

- The high redundancy slots may use a wide RF bandwidth to receive a large number of coded bits for the transport blocks that were sent in the accumulation phase.
- The decoder may already perform detection (and potentially some decoding) of information bits while the high redundancy bits are being sent.

Figure 5 schematically shows the phases of the process for this embodiment (low
 30 latency traffic) at 500. The early transmission accumulation phase is shown generally at 502. This phase is initiated by transmission/receipt of the decoding hold indicator 506. Following the communication of the decoding hold indicator 506 transport blocks (TBs) are transmitted to the receiver (where they are accumulated). These transport blocks are shown generally at 507. The accumulation phase is ended by decoding start indicator 508,
 35 which triggers decoding of the accumulated transport blocks. As discussed above the decoding start indicator may be triggered by a time deadline. High redundancy slots are

then used for the decoding. A first high redundancy slot is shown at 504 which codes TB1 and TB2. High redundancy slot 510 codes bits TB3 and TB4. Once the high redundancy slot 504 has been decoded an ACK is sent to the transmitter, as shown at 512. A further ACK (not shown) may also be sent following the coding of high redundancy slot 510. The term high redundancy slot may also be referred to as a target subframe.

Some implementation examples will now be considered. First, a situation of downlink transmission to a victim cell is considered.

In the downlink situation, the AP (e.g. base station) schedules downlink transmission to a UE. In case of poor transmission quality, the UE can suspend the start of the signal decoding until it accumulates a sufficient amount of the data. The AP can inform the UE whether it should start decoding the received signal from that time instance onwards or suspend it and accumulate the data. In general, and as described above this can be signaled by one-bit “decoding_indicator” as shown in Table1.

Decoding_indicator value	Mode
0	“ Decoding hold indicator ” The decoding in a victim receiver is suspended. Receiver accumulates the data for future decoding.
1	“ Decoding start indicator ” The receiver starts the decoding of received (and accumulated) data

Table 1

It may therefore be considered that the indicator comprises a first state or first indication (i.e. decoding hold indicator or “0”), and a second state or second indication (i.e. decoding start indicator or “1”). Using the “decoding hold indicator” the AP initiates the accumulation phase at the victim receiver. Starting from that time instance, the AP sends accumulation data to the UE. The receiver accumulates the data from subsequent transmission slots, and suspends decoding until the end of the accumulation phase.

In one embodiment, the end of the accumulation phase can be determined and signaled with a “decoding start indicator”. In an embodiment the decoding start indicator can be generated by the UE. The UE can make the decision based on one or more of the following constraints:

- Accumulated SINR – the victim UE accumulates the data during the accumulation phase. Once the accumulated SINR reaches a given threshold (e.g. the probability

of successful decoding is sufficient), the UE informs the AP that it will start decoding the received data from that time instance. The AP then switches to a narrow-band HARQ phase and sends small portions of repetition data until it receives an ACK from the UE.

- 5 • UE buffer status – due to hardware and memory constraints, the amount of data accumulated by the UE may be limited by its buffer size. In one embodiment the UE can signal the decoding start (and end of accumulation phase) whenever it is incapable of storing more data. Furthermore, in some embodiments the “decoding start indicator” can be used together with enriched feedback. The UE can indicate the probability of successful decoding of accumulated data, and feed that message to the AP. In turn, the transmitting AP can adjust the retransmission parameters for the narrow-band HARQ phase accordingly.

In another embodiment the end of accumulation phase (i.e. decoding start indicator) can be determined by the AP (e.g. base station), based on one or more of the following:

- 15 • Interference level – the victim cell AP can react to the neighboring cells' scheduling decisions. It can send the “decoding start indicator” whenever its dominant interferer(s) stop transmission or switch to uplink. From that point, the interference level is reduced and the victim UE can start to decode the data.
- Cell load – the AP can signal the end of the accumulation phase to the AP whenever there are other high-priority users that need to be served within that cell. Thus, the serving AP switches to narrow-band HARQ serving the victim AP, and uses the rest of the resources to serve other users.

Figure 6 is a flowchart showing steps of such an embodiment, where an AP such as a base station is scheduling a UE for downlink transmission.

25 As shown at step S1 the AP schedules the UE.

At step S2 a determination is made as to whether the UE is suffering from poor transmission conditions.

If the answer is “no” then the method proceeds to step S3, where the “decoding start indicator” is sent by the AP to the UE, together with or after the transmission of the packet(s).

30 In such a case the UE does not need to suspend the decoding.

At step S4 a normal HARQ process is followed until the packets are delivered.

Then, at step S5 the UE sends an ACK to the AP.

If on the other hand the answer at step S2 to is “yes” then the method proceeds to step S6 where a “decoding hold” phase is begun, causing the UE to pause the coding of any downlink data. The decoding hold information may either be sent as an explicit indicator or
35 by implicit signalling, for example at the start of packet transmission.

The accumulation phase begins at step S7. In the accumulation phase the AP transmits the packets to the UE, which suspends the decoding and accumulated data.

As shown at step S8 a determination is made as to whether a certain threshold (e.g. SNIR) is achieved. If the answer is "no" then the method loops back to step S7.

5 If on the other hand the answer is "yes" then the method proceeds to step S9 where the "decoding start indicator" is generated. The decoding start indicator may be sent by the UE to the AP, or by the AP to the UE.

At step S10 the narrow band HARQ phase is entered. This may occur after or in parallel with the decoding. In the narrow band HARQ phase the AP transmits small portions of repetition data from the previous phase to help the decoder, and the UE tries to decode the data.
10

At step S11 a determination is made as to whether the signal decoding is successful at the UE. If the answer is "no" then the method loops back to step S10. If on the other hand the answer at step S11 is "yes", then the method proceeds to step S5, where the UE sends an ACK message to the AP.
15

As discussed, the proposed concept can also apply to scheduling uplink traffic, for example in uplink transmission in a victim cell in flexible TDD, when interference comes from a neighboring cell transmitting in downlink. In case of uplink transmission, the AP receiver can send the decoding start indicator on a UE-specific basis. Thus the indicator indicates for which UEs the decoding is put on hold. The UE can send the same data over multiple non-continuous subframes before the reception of the decoding start indicator. The UE transmitter can then switch to narrow-band repetition mode on a narrowband channel (narrow-band HARQ) once the decoding start indicator is received. The UE can concatenate data over multiple continuous sub-frames once the decoding start indicator is received, to reduce uplink latency.
20
25

Figure 7 is a flowchart showing such an example where the AP is scheduling a UE for uplink transmission.

As shown at step S1 the AP schedules one or more UEs for uplink.

At step S2 it is determined whether the scheduled UE suffers from poor transmission conditions in the uplink.
30

If the answer is "no" then the process proceeds to step S3 where data transmission from the UE to the AP can continue as normal. Then a normal HARQ process is followed until the data packet(s) is delivered.

The method then proceeds to step S4 where the AP sends an ACK to the UE.

35 If, on the other hand, the answer at step S2 is "yes" then the method proceeds to step S5 where the "decoding hold" information is sent by the AP to the UE to inform the UE of

the accumulation phase. This information may be implicitly signalled e.g. from the start of the packet transmission.

The process then proceeds to step S6, which is the accumulation phase. At this stage the UE transmits the data to the AP, and the AP suspends the decoding and accumulates the data received at the AP.

A determination is then made at step S7 as to whether a threshold SINR is achieved. If the answer is "no" then the method loops back to step S6.

If on the other hand the answer is "yes" then the "decoding start indicator" is sent by the AP to the UE. This may request the UE to either stop transmitting data, or to switch to the narrow band HARQ phase.

The method then proceeds to step S9, which is the narrow band HARQ phase. At this phase the UE transmits small portions of repetition data from the previous phase, and the AP tries to decode the data.

The method then proceeds to step S10 where it is determined whether the signal decoding is successful at the AP. If the answer is "no" then the method loops back to step S9. If on the other hand the answer is "yes", then the method proceeds to step S4, where the AP sends an ACK to the UE.

The procedures in the UL may therefore be considered as follows, according to some embodiments:

- In the case of uplink, the decoding start indicator is triggered by the base station based on the status of uplink receiver
- The receiver status, e.g. whether the base station receiver expects accumulation phase or the decoding phase, will be provided on a UE specific basis.
- The base station takes into account UEs transmission buffer capabilities for scheduling the accumulation phase and the decoding phase. For example, UEs with insufficient transmit buffering capability can be preferably scheduled given an earlier decoding start indicator for target transmission (decoding phase).
- A UE may therefore use a DTx (discontinuous transmission) in between the accumulation phase and the target transmission phase, where incremental narrow band HARQ is sent. Moreover because the HARQ is narrowband, a UE may use only a sub-set of the bandwidth in the target transmission phase while coming out of the DTx.
- For the DTx period in between the accumulation phase and the target transmission phase, the UE may enter into an "RRC connected inactive state" for a fast transition to the connected state.

- The base station can use the DTx period to perform decoding, and inform the UE of the transport blocks for which narrow band HARQ is needed once the UE comes out of DTx.

Figure 8 is a flowchart showing a method implementing the high redundancy mode
5 embodiment. This is an exemplary embodiment comprising trigger conditions.

At step S1 the AP schedules UEs with low latency traffic.

At step S2 a determination is made of whether there are many UEs to be supported on the radio interface e.g. whether there are too many to be supported adequately.

If the answer is "no" then the method proceeds to step S3, where channel coding is
10 applied and modulated data is transmitted.

If on the other hand the answer at step S2 is "yes", then the UEs' user plane data is buffered as shown at step S4.

The method then proceeds to the accumulation phase (early transmission) at step S5. At this step the transmitter completely suspends channel encoding and modulates the small
15 information blocks. The buffered information bits are transmitted without encoding.

The method then proceeds to step S6 where it is determined whether the SINR threshold is achieved.

If the answer is "yes" then the method proceeds to step S7, and the transmission of the uncoded bits is not repeated.

If the answer at step S6 is "no", then the method proceeds to step S8, where
20 transmission of the uncoded bits with time frequency diversity is repeated.

Following either step S7 or step S8 the method then proceeds to step S9 where it is determined whether the latency threshold is achieved.

If the answer is "yes" then the UE or AP triggers the decoding indicator (along with multi-
25 bit feedback).

The method then proceeds to step S11 where channel coding is applied across the accumulated (and selected) transport blocks with a low code rate.

The method then proceeds to step S12, where transmission takes place on a high
30 redundancy subframe.

Some benefits may include:

- Performance of fast transmission of information with low latency, without a delay for channel encoding time.
- Performance of fast detection of data using channel equalization, and possible
35 repetition without using computational resources for packet decoding.

- Performance of robust channel encoding, where encoding can be carried out in parallel with the fast transmission of the information bits.
- Reduction of the ACK/NACK periodicity by transmitting the ACK/NACK only after the so-called high redundancy subframes, where a robust channel coder is used.

5 Therefore reduced computational effort for encoding and decoding, as well as fewer ACK/NACK bits, may be realized.

Figure 9 is a flowchart of a method viewed from the perspective of an apparatus, such as an access point or a base station e.g. such as an eNB or gNB.

10 At step S1 the apparatus transmits a first indication to a user equipment. This is in response to a first cell condition, such as interference for example. The first indication is configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is suspended.

15 At step S2 a second indication is communicated between the apparatus and user equipment. This may comprise the apparatus sending the second indication to the user equipment, or vice versa. This is in response to a second cell condition, such as an improved interference condition compared to the first cell condition. The second indication is configured to cause the user equipment and/or apparatus to operate according to a second mode in which decoding of the information is performed.

Figure 10 is a flowchart of a method viewed from the perspective of a user equipment.

20 At step S1 the user equipment receives a first indication. This is in response to a first cell condition, such as interference for example. The first indication is configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is suspended.

25 At step S2 a second indication is communicated between the user equipment and apparatus. This may comprise the user equipment sending the second indication to the apparatus, or vice versa. This is in response to a second cell condition, such as an improved interference condition compared to the first cell condition. The second indication is configured to cause the user equipment and/or apparatus to operate according to a second mode in which decoding of the information is performed.

30 In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects of the invention may be implemented in hardware, while other aspects may be implemented in firmware or

software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or
5 methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

The embodiments of this invention may be implemented by computer software executable by a data processor of the mobile device, such as in the processor entity, or by
10 hardware, or by a combination of software and hardware. Computer software or program, also called program product, including software routines, applets and/or macros, may be stored in any apparatus-readable data storage medium and they comprise program instructions to perform particular tasks. A computer program product may comprise one or more computer-executable components which, when the program is run, are configured to
15 carry out embodiments. The one or more computer-executable components may be at least one software code or portions of it.

Further in this regard it should be noted that any blocks of the logic flow as in the Figures may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. The software
20 may be stored on such physical media as memory chips, or memory blocks implemented within the processor, magnetic media such as hard disk or floppy disks, and optical media such as for example DVD and the data variants thereof, CD. The physical media is a non-transitory media.

The memory may be of any type suitable to the local technical environment and may
25 be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The data processors may be of any type suitable to the local technical environment, and may comprise one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors
30 (DSPs), application specific integrated circuits (ASIC), FPGA, gate level circuits and processors based on multi core processor architecture, as non-limiting examples.

Embodiments of the inventions may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a
35 logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

The foregoing description has provided by way of non-limiting examples a full and informative description of the exemplary embodiment of this invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention as defined in the appended claims. Indeed there is a further embodiment comprising a combination of one or more embodiments with any of the other embodiments previously discussed.

Claims

1. A method comprising:

5 in response to a first cell condition in a wireless communication network, transmitting a first indication from an apparatus to a user equipment, the first indication configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is suspended; and

10 in response to a second cell condition, communicating a second indication with the user equipment, the second indication configured to cause the user equipment and/or apparatus to operate according to a second mode in which decoding of the information is performed.

2. A method as set forth in claim 1, wherein the user equipment operating in the first mode comprises the user equipment accumulating downlink information received from the apparatus, whilst decoding of the downlink information is suspended at the user equipment.

3. A method as set forth in claim 1 or claim 2, wherein the apparatus operating in the first mode comprises the apparatus accumulating uplink information received from the user equipment, whilst decoding of the uplink information is suspended at the apparatus.

20

4. A method as set forth in claim 2, wherein the user equipment operating in the second mode comprises the user equipment decoding the downlink information accumulated at the user equipment.

25 5. A method as set forth in any preceding claim, wherein the user equipment operating in the second mode comprises the user equipment entering a hybrid automatic repeat request state.

30 6. A method as set forth in claim 5, wherein the hybrid automatic repeat request state comprises communication of multiple redundancy versions of data communicated between the apparatus and user equipment when operating in the first mode.

7. A method as set forth in claim 6, wherein the multiple redundancy versions are transmitted in a narrow-band mode.
- 5 8. A method as set forth in claim 6, wherein the multiple redundancy versions are transmitted in a wide-band mode.
9. A method as set forth in claim 7 or claim 8, wherein the multiple redundancy versions comprise multiple versions in time-frequency.
- 10 10. A method as set forth in any preceding claim, wherein the first and second modes respectively comprise different control channel formats.
11. A method as set forth in any preceding claim, wherein the apparatus operating in
15 the second mode comprises the apparatus decoding uplink information received at the apparatus.
12. A method comprising:
- in response to a first cell condition in a wireless communication network, receiving,
20 from an apparatus, a first indication at a user equipment, the first indication configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is suspended; and
- in response to a second cell condition, communicating a second indication with the
apparatus, the second indication configured to cause the user equipment and/or apparatus
25 to operate according to a second mode.
13. A method as set forth in claim 12, wherein the user equipment operating in the first mode comprises the user equipment accumulating downlink information received from the apparatus, whilst decoding of the downlink information is suspended at the user equipment.

14. A method as set forth in claim 13, wherein the user equipment operating in the second mode comprises the user equipment decoding the downlink information accumulated at the user equipment.
- 5 15. A method as set forth in any of claims 12 to 14, wherein the user equipment operating in the second mode comprises the user equipment entering a hybrid automatic repeat request state.
- 10 16. A method as set forth in claim 15, wherein the hybrid automatic repeat request state comprises communication of multiple redundancy versions of data already communicated between the apparatus and user equipment when operating in the first mode.
17. A method as set forth in claim 16, wherein the multiple redundancy versions are transmitted in a narrow-band mode.
- 15 18. A method as set forth in claim 16, wherein the multiple redundancy versions are transmitted in a wide-band mode.
- 20 19. A method as set forth in claim 17 or claim 18, wherein the multiple redundancy versions comprise multiple versions in time-frequency.
20. A method as set forth in any of claims 12 to 19, wherein the first and second modes respectively comprise different control channel formats.
- 25 21. A computer program comprising program code means adapted to perform the steps of any of claims 1 to 11 when the program is run on a data processing apparatus.
22. A computer program comprising program code means adapted to perform the steps of any of claims 12 to 20 when the program is run on a data processing apparatus.

23. An apparatus comprising at least one processor, and at least one memory including computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to:

in response to a first cell condition in a wireless communication network, transmit a
5 first indication to a user equipment, the first indication configured to cause the user equipment and/or apparatus to operate according to a first mode in which decoding of information is suspended; and

in response to a second cell condition, communicate a second indication with the user equipment, the second indication configured to cause the user equipment and/or
10 apparatus to operate according to a second mode in which decoding of the information is performed.

24. An apparatus as set forth in claim 23, wherein the apparatus operating in the first mode comprises the apparatus accumulating uplink information received from the user
15 equipment, whilst decoding of the uplink information is suspended at the apparatus.

25. An apparatus as set forth in claim 23 or claim 24, wherein the apparatus operating in the second mode comprises the apparatus decoding uplink information received at the apparatus.

20

26. An apparatus as set forth in any of claims 23 to 25, wherein the apparatus comprises a base station.

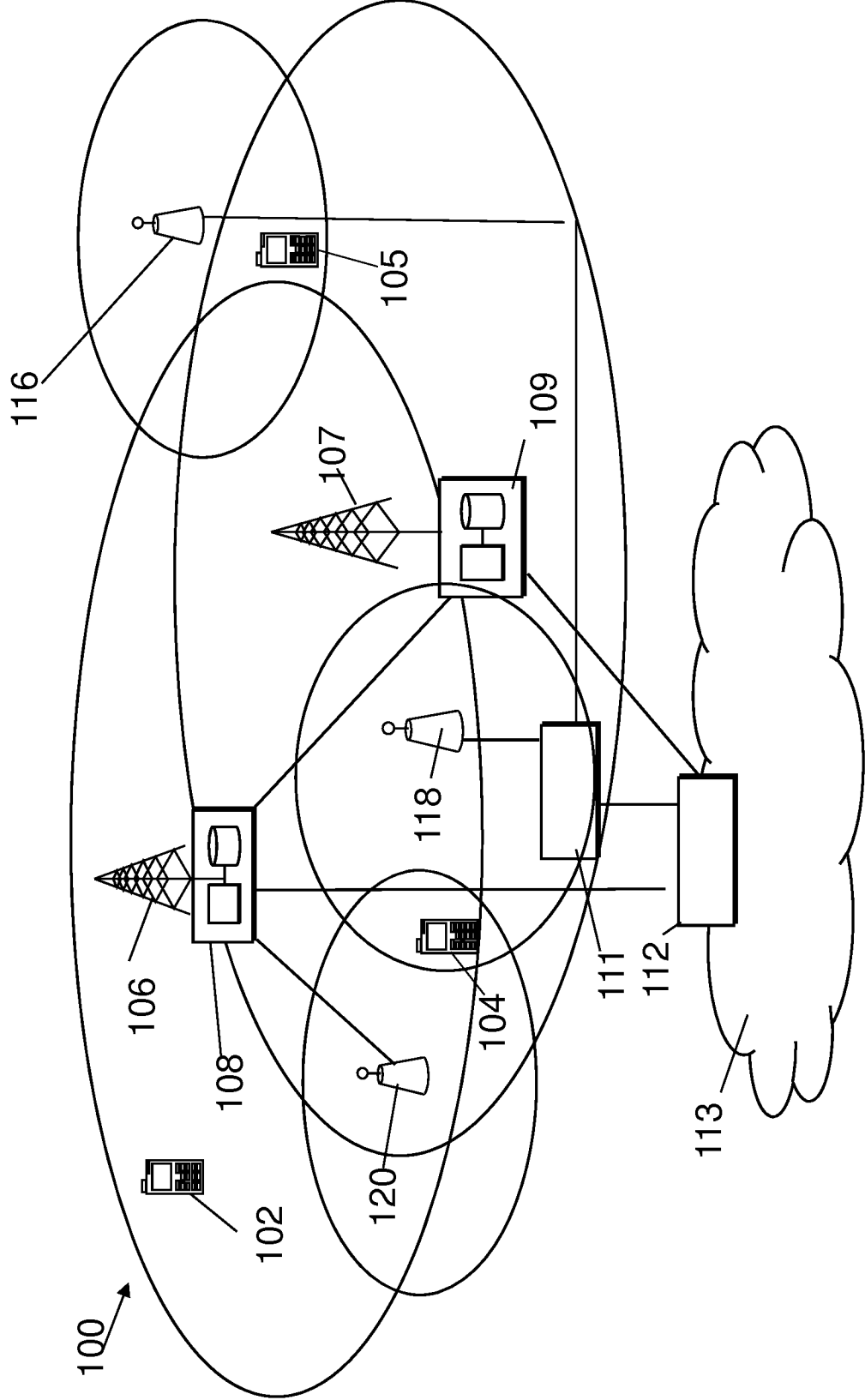
27. An apparatus comprising at least one processor, and at least one memory including computer program code, wherein the at least one memory and the computer program code are configured, with the at least one processor, to:

in response to a first cell condition in a wireless communication network, receive from a second apparatus a first indication, the first indication configured to cause the apparatus and/or second apparatus to operate according to a first mode in which decoding
30 of information is suspended; and

in response to a second cell condition, communicating a second indication with the second apparatus, the second indication configured to cause the apparatus and/or second apparatus to operate according to a second mode.

- 5 28. An apparatus as set forth in claim 27, wherein the apparatus operating in the first mode comprises the apparatus accumulating downlink information received from the second apparatus, whilst decoding of the downlink information is suspended at the apparatus.
- 10 29. An apparatus as set forth in claim 27 or claim 28, wherein the apparatus operating in the second mode comprises the apparatus decoding the downlink information accumulated at the apparatus.
- 15 30. An apparatus as set forth in any of claims 27 to 29, wherein the apparatus comprises a 5G enabled UE.

Figure 1



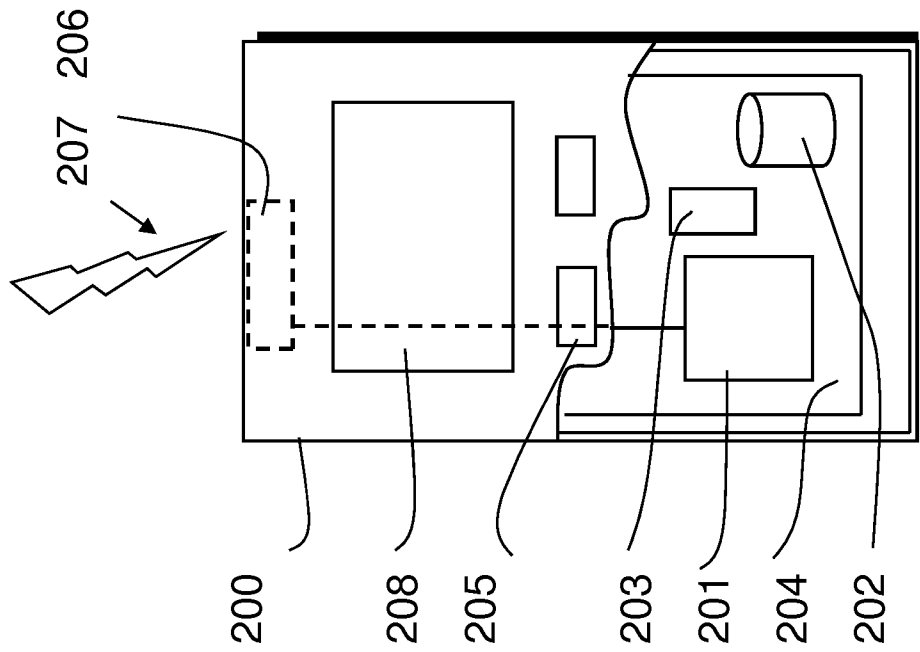


Figure 2

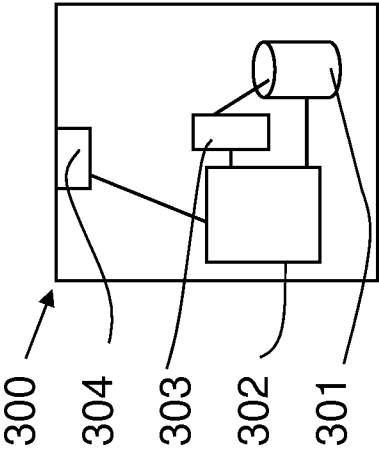


Figure 3

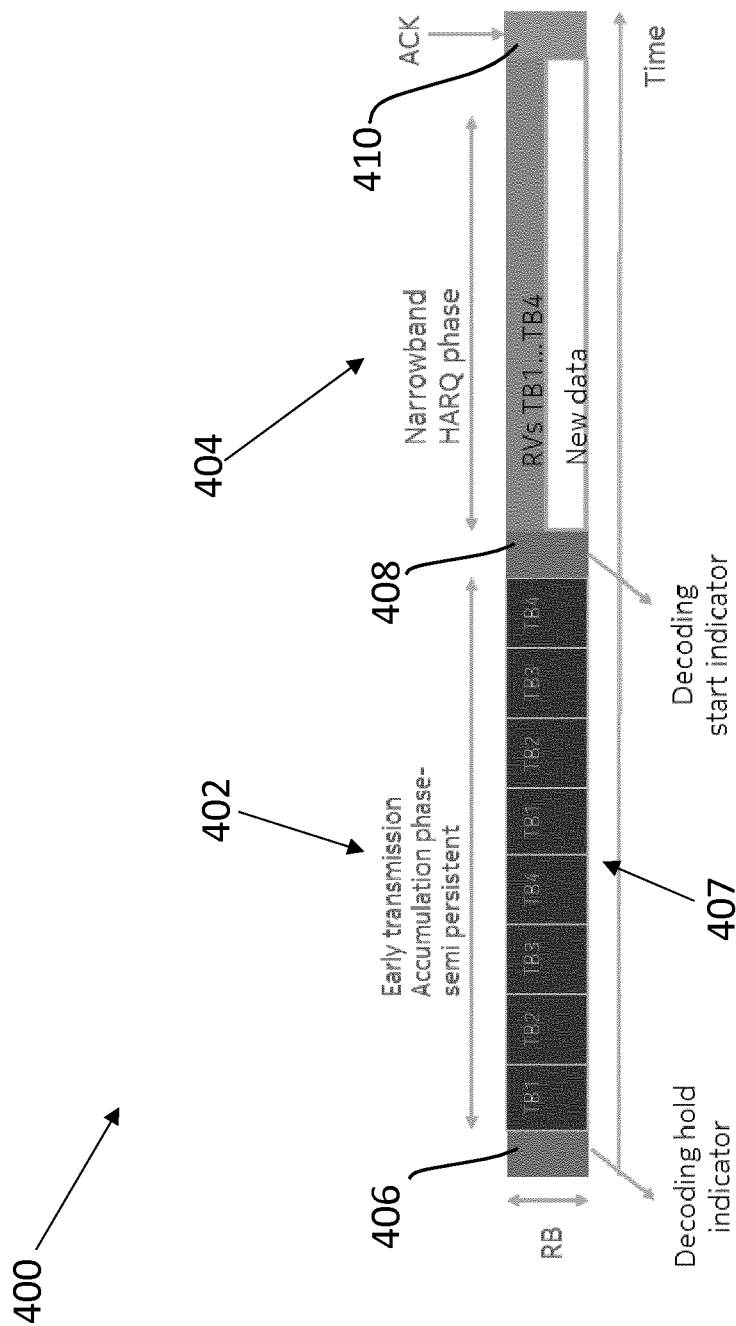


Figure 4

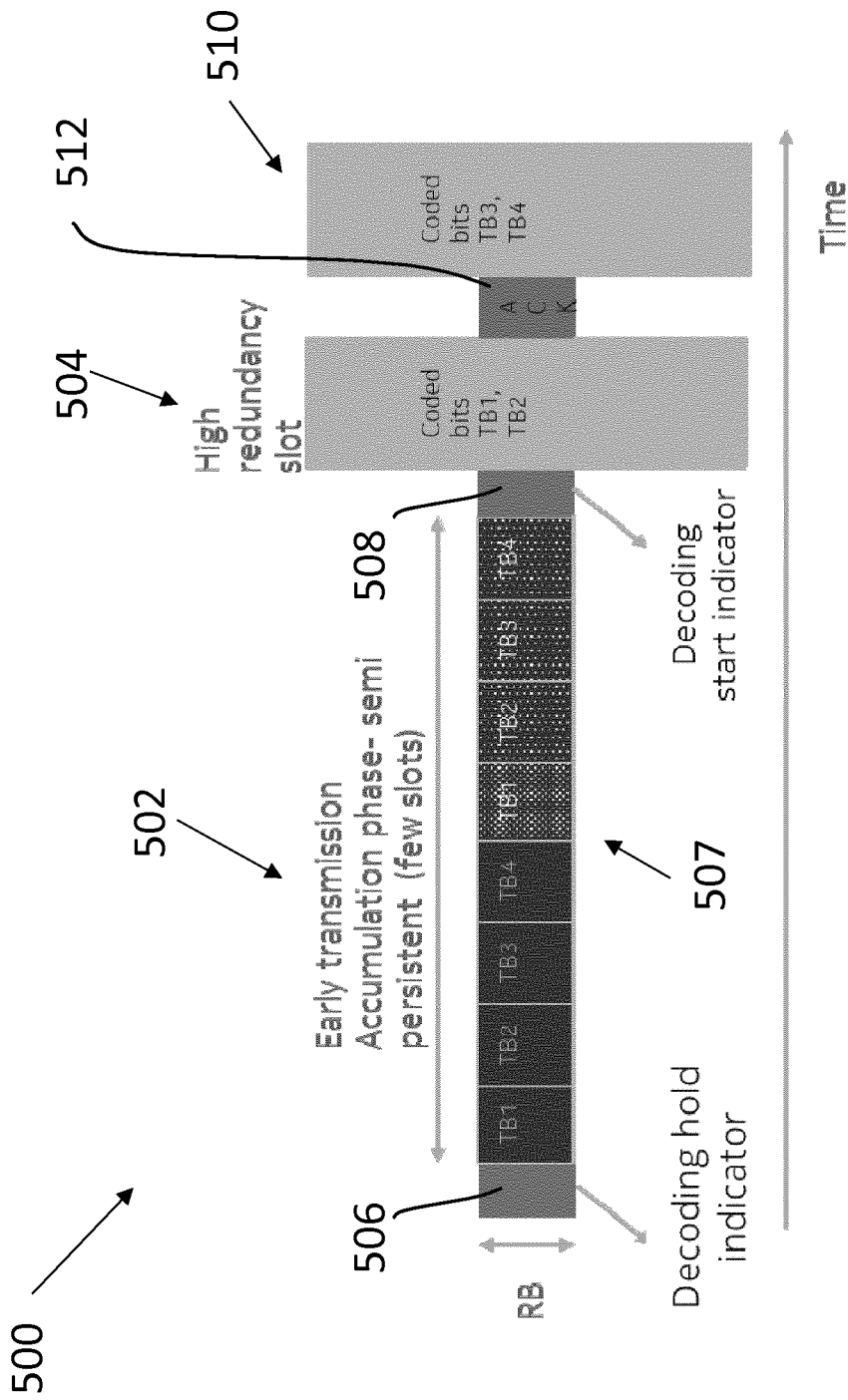


Figure 5

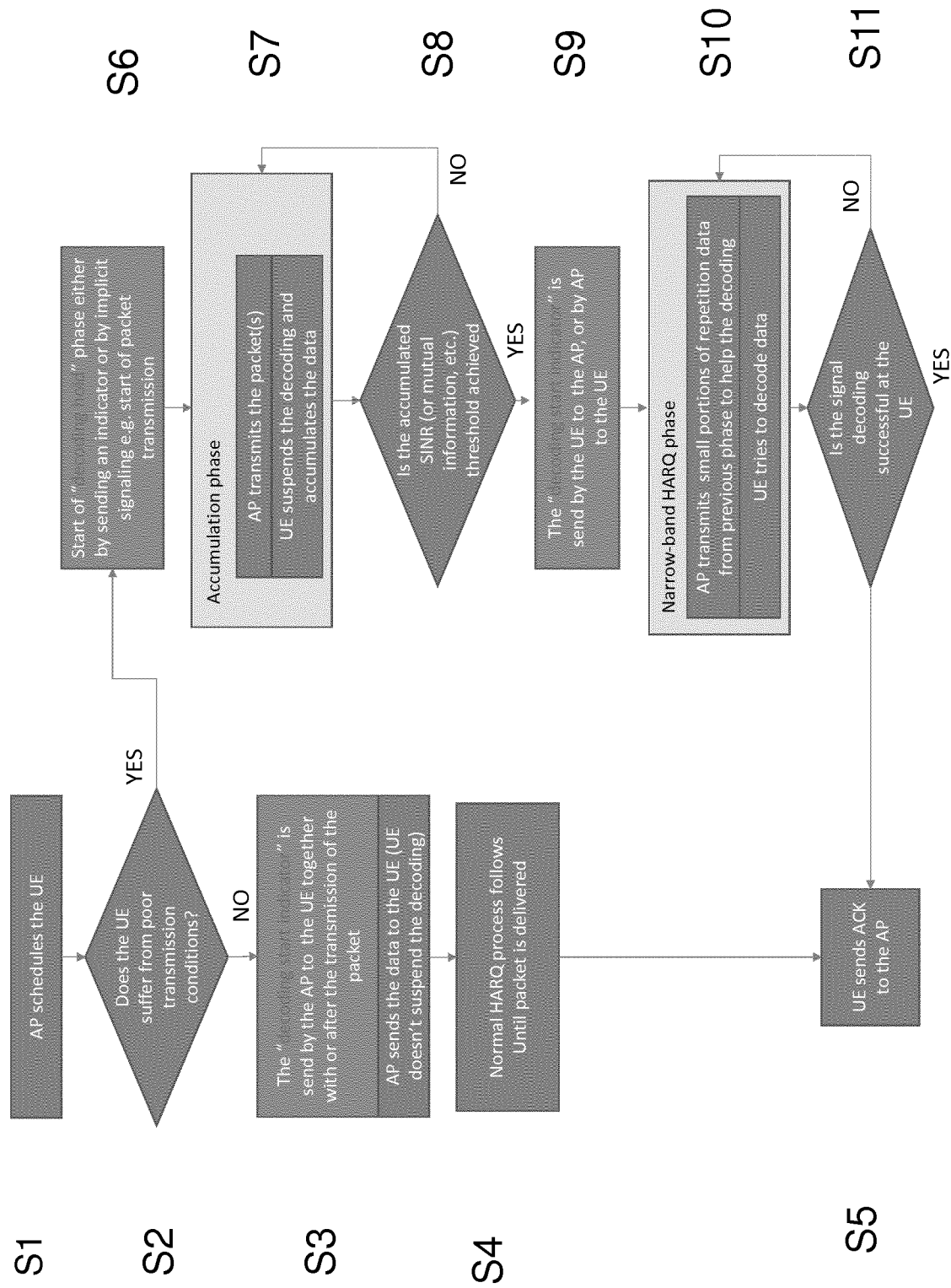


Figure 6

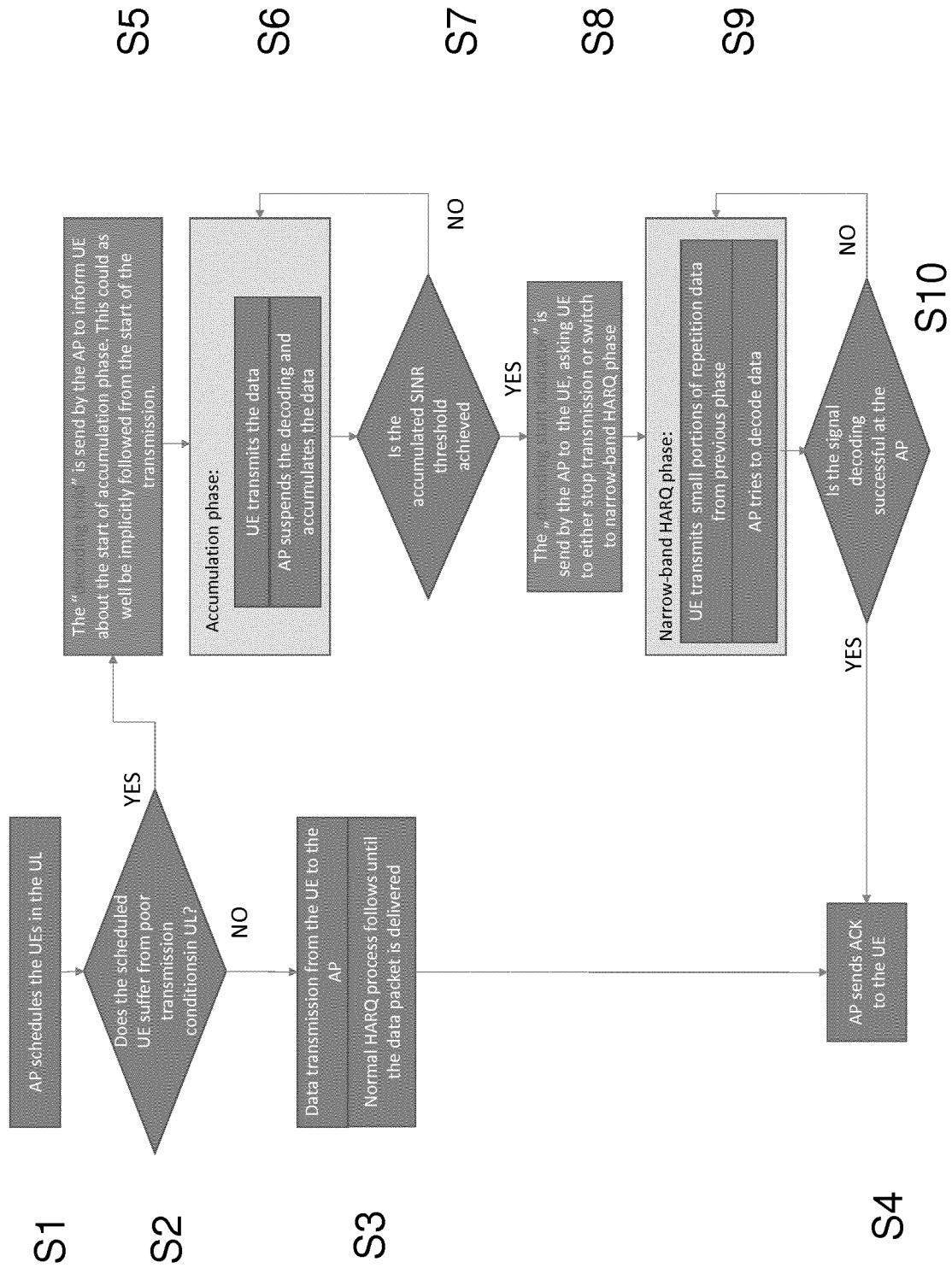


Figure 7

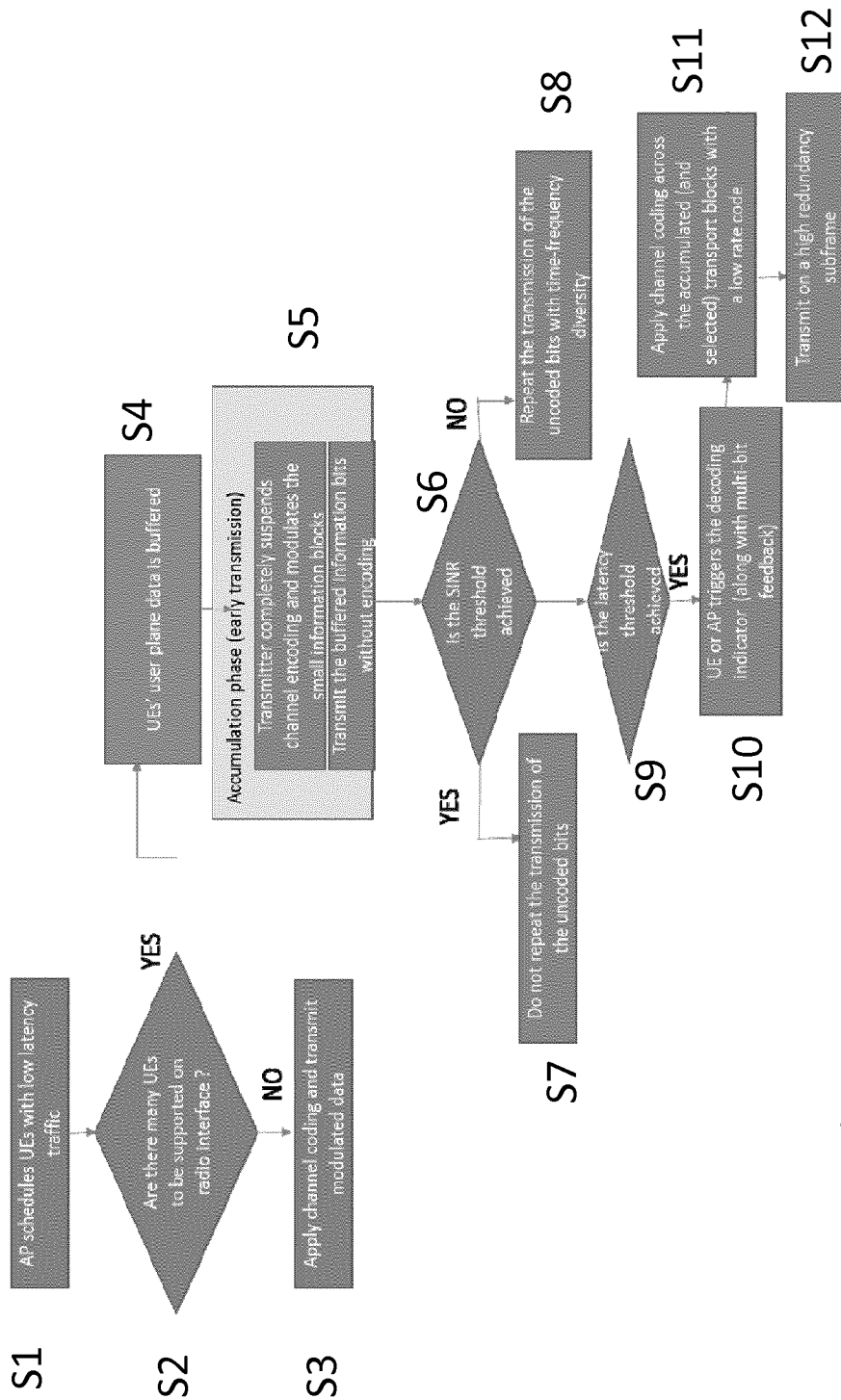


Figure 8

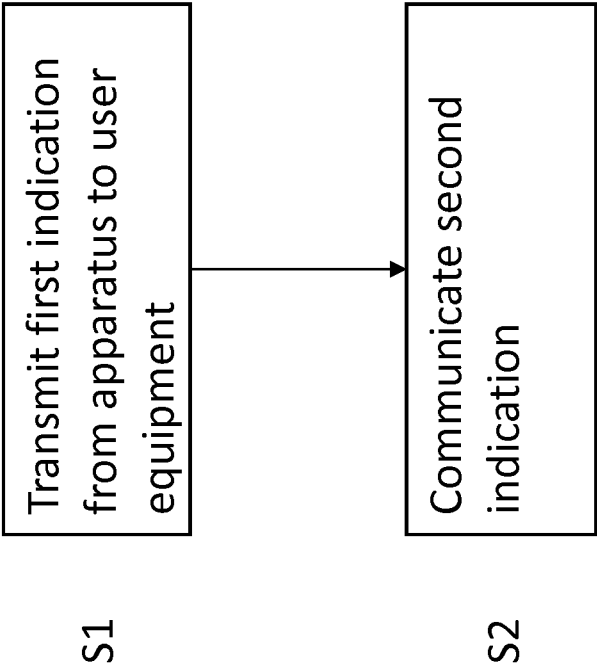


Figure 9

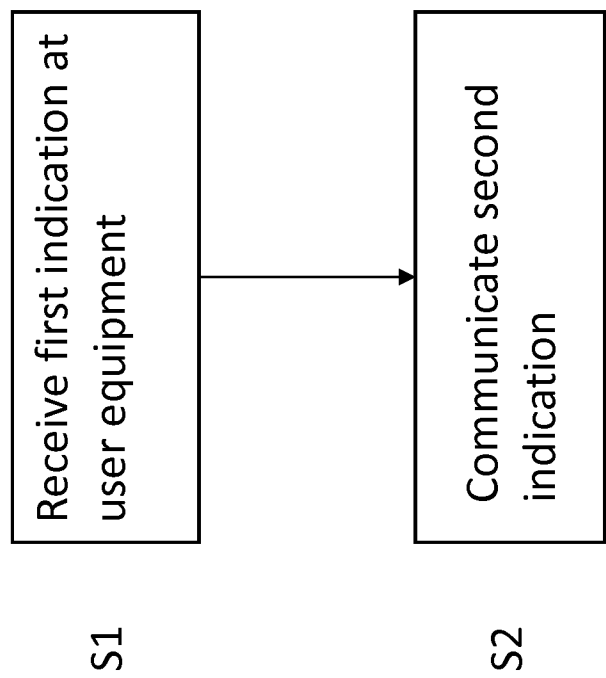


Figure 10

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/054801

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04L1/18 H04L1/08 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 1 926 243 A2 (MATSUSHITA ELECTRIC IND CO LTD [JP]) 28 May 2008 (2008-05-28)	1-5, 11-15, 21-30
Y	paragraph [0041] - paragraph [0051] figures 1,4, 5, 6, 7 paragraph [0005]	6-10, 16-20
X	----- US 2012/254703 A1 (RUBIN AMIR [IL]) 4 October 2012 (2012-10-04) paragraph [0014] - paragraph [0019] paragraph [0041] - paragraph [0049] figure 5	1,12, 21-23,27
X	----- EP 2 224 632 A1 (RESEARCH IN MOTION LTD [CA]) 1 September 2010 (2010-09-01) paragraph [0009] figure 4 ----- -/-	1,12, 21-23,27



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

13 November 2017

Date of mailing of the international search report

23/11/2017

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

Nölle, Markus

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/054801

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ERICSSON: "System information for low complexity and extended coverage", 3GPP DRAFT; R2-1701562 - SYSINFO FOR LOW COMPLEXITY AND EXT COVERAGE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; F , vol. RAN WG2, no. Athens, Greece; 20170213 - 20170217 12 February 2017 (2017-02-12), XP051212179, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2017-02-12] section 1, 2 figure 1 -----	6-9, 16-19
Y	"3 Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding (Release 14)", 3GPP STANDARD; 3GPP TS 36.212, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. V14.1.1, 4 January 2017 (2017-01-04), pages 1-149, XP051230357, [retrieved on 2017-01-04] Section 5.3.3.1 -----	10,20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/054801

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
EP 1926243	A2	28-05-2008	CN	101188482 A		28-05-2008
			EP	1926243 A2		28-05-2008
			JP	2008131601 A		05-06-2008
			US	2008125049 A1		29-05-2008

US 2012254703	A1	04-10-2012	CN	103597769 A		19-02-2014
			EP	2692138 A2		05-02-2014
			US	2012254703 A1		04-10-2012
			WO	2012134678 A2		04-10-2012

EP 2224632	A1	01-09-2010	AT	542321 T		15-02-2012
			CA	2694938 A1		27-08-2010
			CA	2694940 A1		27-08-2010
			EP	2224632 A1		01-09-2010
			EP	2224634 A2		01-09-2010
			EP	2416515 A2		08-02-2012
