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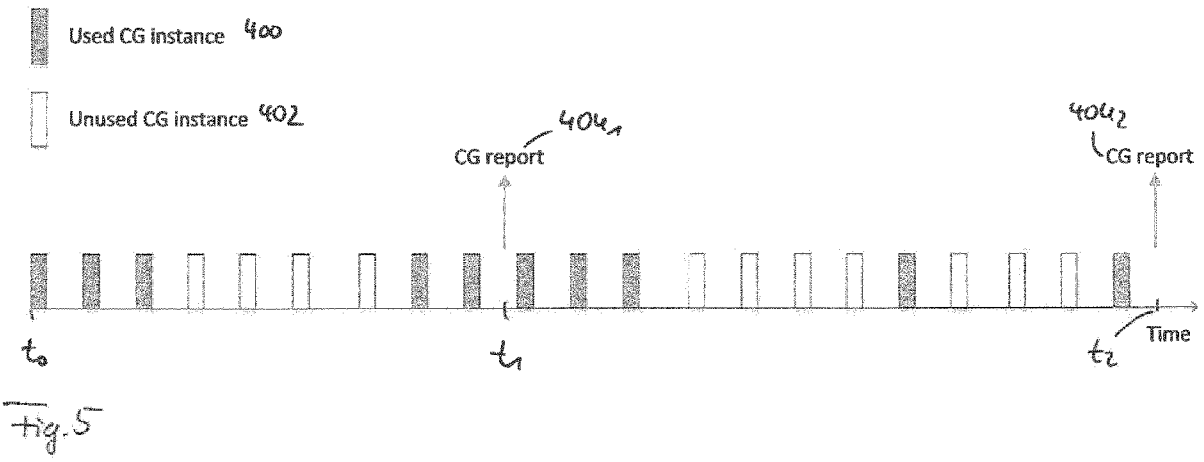

Fig. 5

(57) Abstract: An apparatus for a communication with a receiver in a wireless communication system is described. The apparatus transmits one or more configured grant, CG, messages to at least one receiver using one or more CG transmissions, and transmits feedback related to the one or more CG transmissions to the receiver. Another apparatus for a communication with a transmitter in a wireless communication system, which receives one or more configured grant, CG, messages from at least one transmitter using one or more CG transmissions, and receives feedback related to the one or more CG transmissions from the transmitter.

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MONITORING PERFORMANCE OF CONFIGURED-GRANT TRANSMISSIONS IN A WIRELESS COMMUNICATION SYSTEM

Description

The present invention relates to the field of mobile communication systems or networks, more specifically to approaches for monitoring the performance of configured-grant, CG, transmissions in mobile communication systems or networks.

Fig. 1 is a schematic representation of an example of a terrestrial wireless network 100 including, as is shown in Fig. 1(a), a core network 102 and one or more radio access networks RAN_1, RAN_2, ...RAN_N. Fig. 1(b) is a schematic representation of an example of a radio access network RAN_n that may include one or more base stations gNB_1 to gNB_5, each serving a specific area surrounding the base station schematically represented by respective cells 106_1 to 106_5. The base stations are provided to serve users within a cell. The term base station, BS, refers to a gNB in 5G networks, an eNB in UMTS/LTE/LTE-A/ LTE-A Pro, or just a BS in other mobile communication standards. A user may be a stationary device or a mobile device. The wireless communication system may also be accessed by mobile or stationary IoT devices which connect to a base station or to a user. The mobile devices or the IoT devices may include physical devices, ground based vehicles, such as robots or cars, aerial vehicles, such as manned or unmanned aerial vehicles (UAVs), the latter also referred to as drones, buildings and other items or devices having embedded therein electronics, software, sensors, actuators, or the like as well as network connectivity that enables these devices to collect and exchange data across an existing network infrastructure. Fig. 1(b) shows an exemplary view of five cells, however, the RAN_n may include more or less such cells, and RAN_n may also include only one base station. Fig. 1(b) shows two users UE_1 and UE_2, also referred to as user equipment, UE, that are in cell 106_2 and that are served by base station gNB_2. Another user UE_3 is shown in cell 106_4 which is served by base station gNB_4. The arrows 108_1, 108_2 and 108_3 schematically represent uplink/downlink connections for transmitting data from a user UE_1, UE_2 and UE_3 to the base stations gNB_2, gNB_4 or for transmitting data from the base stations gNB_2, gNB_4 to the users UE_1, UE_2, UE_3. Further, Fig. 1(b) shows two IoT devices 110_1 and 110_2 in cell 106_4, which may be stationary or mobile devices. The IoT device 110_1 accesses the wireless communication system via the base station gNB_4 to receive and transmit data as schematically represented by arrow 112_1. The IoT device 110_2 accesses the wireless

communication system via the user UE_3 as is schematically represented by arrow 112_2. The respective base station gNB_1 to gNB_5 may be connected to the core network 102, e.g. via the S1 interface, via respective backhaul links 114_1 to 114_5, which are schematically represented in Fig. 1(b) by the arrows pointing to "core". The core network 102 may be connected to one or more external networks. Further, some or all of the respective base station gNB_1 to gNB_5 may connected, e.g. via the S1 or X2 interface or the XN interface in NR, with each other via respective backhaul links 116_1 to 116_5, which are schematically represented in Fig. 1(b) by the arrows pointing to "gNBs".

For data transmission a physical resource grid may be used. The physical resource grid may comprise a set of resource elements to which various physical channels and physical signals are mapped. For example, the physical channels may include the physical downlink, uplink and sidelink shared channels (PDSCH, PUSCH, PSSCH) carrying user specific data, also referred to as downlink, uplink and sidelink payload data, the physical broadcast channel (PBCH) carrying for example a master information block (MIB) and a system information block (SIB), the physical downlink, uplink and sidelink control channels (PDCCH, PUCCH, PSSCH) carrying for example the downlink control information (DCI), the uplink control information (UCI) and the sidelink control information (SCI). For the uplink, the physical channels may further include the physical random access channel (PRACH or RACH) used by UEs for accessing the network once a UE synchronized and obtained the MIB and SIB. The physical signals may comprise reference signals or symbols (RS), synchronization signals and the like. The resource grid may comprise a frame or radio frame having a certain duration in the time domain and having a given bandwidth in the frequency domain. The frame may have a certain number of subframes of a predefined length, e.g. 1ms. Each subframe may include one or more slots of 12 or 14 OFDM symbols depending on the cyclic prefix (CP) length. A frame may also consist of a smaller number of OFDM symbols, e.g. when utilizing shortened transmission time intervals (sTTI) or a mini-slot/non-slot-based frame structure comprising just a few OFDM symbols.

The wireless communication system may be any single-tone or multicarrier system using frequency-division multiplexing, like the orthogonal frequency-division multiplexing (OFDM) system, the orthogonal frequency-division multiple access (OFDMA) system, or any other IFFT-based signal with or without CP, e.g. DFT-s-OFDM. Other waveforms, like non-orthogonal waveforms for multiple access, e.g. filter-bank multicarrier (FBMC), generalized frequency division multiplexing (GFDM) or universal filtered multi carrier (UFMC), may be

used. The wireless communication system may operate, e.g., in accordance with the LTE-Advanced pro standard or the 5G or NR, New Radio, standard.

The wireless network or communication system depicted in Fig. 1 may by a heterogeneous network having distinct overlaid networks, e.g., a network of macro cells with each macro cell including a macro base station, like base station gNB_1 to gNB_5, and a network of small cell base stations (not shown in Fig. 1), like femto or pico base stations.

In addition to the above described terrestrial wireless network also non-terrestrial wireless communication networks exist including spaceborne transceivers, like satellites, and/or airborne transceivers, like unmanned aircraft systems. The non-terrestrial wireless communication network or system may operate in a similar way as the terrestrial system described above with reference to Fig. 1, for example in accordance with the LTE-Advanced Pro standard or the 5G or NR, new radio, standard.

In mobile communication networks, for example in a network like that described above with reference to Fig. 1, like an LTE or 5G/NR network, there may be UEs that communicate directly with each other over one or more sidelink (SL) channels, e.g., using the PC5 interface. UEs that communicate directly with each other over the sidelink may include vehicles communicating directly with other vehicles (V2V communication), vehicles communicating with other entities of the wireless communication network (V2X communication), for example roadside entities, like traffic lights, traffic signs, or pedestrians. Other UEs may not be vehicular related UEs and may comprise any of the above-mentioned devices. Such devices may also communicate directly with each other (D2D communication) using the SL channels.

When considering two UEs directly communicating with each other over the sidelink, both UEs may be served by the same base station so that the base station may provide sidelink resource allocation configuration or assistance for the UEs. For example, both UEs may be within the coverage area of a base station, like one of the base stations depicted in Fig. 1. This is referred to as an "in-coverage" scenario. Another scenario is referred to as an "out-of-coverage" scenario. It is noted that "out-of-coverage" does not mean that the two UEs are not within one of the cells depicted in Fig. 1, rather, it means that these UEs

- may not be connected to a base station, for example, they are not in an RRC connected state, so that the UEs do not receive from the base station any sidelink resource allocation configuration or assistance, and/or

- may be connected to the base station, but, for one or more reasons, the base station may not provide sidelink resource allocation configuration or assistance for the UEs, and/or
- may be connected to the base station that may not support NR V2X services, e.g. GSM, UMTS, LTE base stations.

When considering two UEs directly communicating with each other over the sidelink, e.g. using the PC5 interface, one of the UEs may also be connected with a BS, and may relay information from the BS to the other UE via the sidelink interface. The relaying may be performed in the same frequency band (in-band-relay) or another frequency band (out-of-band relay) may be used. In the first case, communication on the Uu and on the sidelink may be decoupled using different time slots as in time division duplex, TDD, systems.

In a wireless communication system, e.g., the one described above with reference to Fig. 1, configured grant, CG, transmissions may be implemented as described, e.g., in reference [1], which allow a low latency communication by authorizing a user equipment, UE, to transmit a message without a scheduling grant for this message. Fig. 2 schematically illustrates the concept of CG transmissions in a mobile communication network, for example a NR or 5G network. Fig. 2 illustrates schematically a single cell, for example, a cell as depicted above in Fig. 1, including the base station gNB as well as two mobile devices UE1, UE2, for example vehicles or the like. The base station gNB allocates time-frequency resources on which a CG transmission is to be performed. Fig. 2 illustrates the time-frequency resources 200 that are provided or allocated by the gNB for CG transmissions, for example, with a certain periodicity. The configured grant resources 200 may be randomly utilized by the user as UE1, UE2 when they have data to transmit. By assigning the configured grant resources, the system or network eliminates the packet transmission delay for a scheduling request procedure and increases the utilization ratio of the allocated radio resources. In the example of Fig. 2, the user UE1 has data 202_1 to be transmitted. The data 202_1 may be available or generated at a time t1, and at a time t_2 the data 202_1 may be transmitted by the user UE1 using the configured grant resources without the need for a scheduling request procedure. Further data 202_2 may be available at time t3, and the data may be transmitted using the configured grant resources at time t4. At the other user, UE2, data 202_3 may be available at a time t5 which is then transmitted using the CG resources at time t6. The time-frequency resources, also referred to as the CG resources or the CG resource pool, on which the CG transmission is transmitted may be preconfigured, for example via radio resource control, RRC, signaling alone, also referred to as a CG type 1,

or via RRC signaling and downlink L1/L2 signaling, also referred to as CG type 2 (see references [1] and [2]). CG transmissions as explained above with reference to Fig. 2 may be used for low latency applications, for example for an ultra-reliable low-latency communication, URLLC, for vehicle-to-everything, V2X, scenarios or applications or device-to-device, D2D, scenarios or applications.

It is noted that the information in the above section only for enhancing the understanding of the background of the invention and therefore it may contain information that does not form prior art that is already known to a person skilled in the art.

Starting from a prior art as described above, there may be a need for improvements in the wireless communication among entities of a wireless communication system using configured grant, CG, transmissions.

Embodiments of the present invention are now described in further detail with reference to the accompanying drawings:

Fig. 1 shows a schematic representation of an example of a wireless communication system;

Fig. 2 schematically illustrates the concept of CG transmissions in a mobile communication network;

Fig. 3 illustrates examples indicating misdetections/false alarms versus SNR when detecting at a gNB signals from a first user under the assumption that two users transmit over the same CG resources;

Fig. 4 is a schematic representation of a wireless communication system including a transmitter, like a base station, and one or more receivers, like user devices, UEs;

Fig. 5 illustrates an embodiment for providing a counter-triggered UE report;

Fig. 6 illustrates an embodiment of using periodic/timer-based UE reports;

Fig. 7 illustrates an embodiment of a gNB-triggered UE report for S prior CG instances so that the feedback or report provides activity information for the S CG instances before or prior to the gNB request;

Fig. 8 illustrates an embodiment of using a gNB-triggered UE report for S future CG instances so that the activity information is provided for the S CG instances following the gNB request;

Fig. 9 illustrates the use of sequence-numbered messages in accordance with embodiments; and

Fig. 10 illustrates an example of a computer system on which units or modules as well as the steps of the methods described in accordance with the inventive approach may execute.

Embodiments of the present invention are now described in more detail with reference to the accompanying drawings in which the same or similar elements have the same reference signs assigned.

As described above, in wireless communication systems or networks, like those described with reference to Fig. 1 and to Fig. 2, the respective entities may communicate using CG transmissions. For every connected UE with enabled CG capability, a NR base station, gNB, is aware of the time-frequency resources or positions which are configured for the CG transmissions of the UE. More specifically, the gNB is aware of the time-frequency resources for the CG transmissions and that may be used by one or more of the UEs being in coverage with the gNB. The UEs may randomly use the CG time-frequency resources for a transmission to the gNB so that there may also be situations in which a collision occurs, namely when two or more UEs use the same resources at a certain time for the CG transmission.

The gNB determines for a certain CG transmission instance whether that CG instance carries a message from the UE or not. The certain CG transmission instance may be a certain number of time-frequency resources allocated for the CG transmissions, like the CG resources 200 indicated in Fig. 2. As is also shown in Fig. 2, not each of the CG resources

may be used by the UEs for the CG transmission. In other words, in case a UE does not have a message to be transmitted on a CG transmission resource, for example a message delivered from upper layers, the UE does not transmit on these resources (see reference [1]). Therefore, the gNB needs to determine whether a CG instance is a used instance, i.e., an instance carrying a message from the UE, or whether the CG instance is a unused instance not carrying a message from the UE.

In accordance with a first approach, referred to herein as an Always Decode approach, for determining whether a CG instance carries a message from the UE or not, the gNB attempts to decode every CG instance. In case there is no transmission on the CG resources at this instance, the gNB determines a decode failure. This approach may involve a high amount of decode operations which are computationally expensive. A second approach, referred to herein as Detect and Decode approach, for determining whether a CG instance carries a message from the UE or not, the gNB employs a detector so as to determine for every CG instance whether the CG instance contains a signal from the UE. In case the detector decides that a signal from the UE is present, decoding is attempted by the gNB. For example, a decoder may exploit the demodulation reference signals, DMRSs, as provided by the UE in the transmission in its decision making (see reference [3]).

The reception of CG transmissions from the UE at the gNB may be associated with a message error rate, MER, a false alarm rate, and a misdetection rate. These rates may be defined as follows:

- Message error rate, MER: In case the information bits transmitted by a UE in a CG instance are not received correctly at the gNB, a message error occurs. The ratio of a number of message errors to a number of used CG instances, i.e., the number of CG instances carrying a message from a UE, is defined as the MER.
- False alarm rate: The false alarm rate is a property of the detector used at the gNB for detecting signals from the UE. A false alarm event occurs when a UE does not transmit on a CG instance, i.e., there is no signal from the UE, but the detector at the gNB decides that there was a transmission by the UE. The false alarm rate may be defined as the ratio of a number of false alarm events to a number of unused CG instances, i.e., CG instances not carrying a message from the UE.
- Misdetection rate: This is a property of the detector at the gNB. A misdetection event occurs when a UE transmits on a CG instance, i.e., there is a signal from the UE, but the detector at the gNB decides that there was no transmission by the UE. The

misdetection rate may be defined as the ratio of a number of misdetection events to a number of used CG instances.

In the Always Decode approach, the gNB may not determine whether a decode failure is caused by an unused CG instance or by a disturbed transmission, for example a disturbed transmission due to noise and/or interference, in a used CG instance. As a consequence, the gNB may not estimate the MER of the CG transmissions. Without an estimation of the MER, the gNB may not be confident that the CG transmissions deliver the expected performance. Moreover, such a situation prevents the gNB from applying corrective actions, for example, adapting a threshold used in the detector in the detect and decode approach or the like.

When considering the detect and decode approach, the MER may be influenced by the misdetection rate of the detector and the block error rate, BLER of the transmission scheme. A misdetection may occur when the detector fails to detect a desired signal, e.g., due to a low SINR. The BLER target may be less than 10^{-4} for URLLC or V2X scenarios. The misdetection rate may be chosen to be significantly lower than the BLER, more specifically in such a way that the MER is approximately equal to the BLER. The desired misdetection rate may be selected by fixing the false alarm rate of the detector at the gNB. Typical values of the desired false alarm rate may have a range of 10^{-2} to 10^{-3}. For a detection algorithm, the detection threshold may be calculated assuming a certain model, for example assuming a certain coherence bandwidth, a certain number of users and a certain number of frequency errors and the like. In case there is a mismatch between the assumed signal model and the reality, the achieved false alarm or misdetection rates deviate from the target value.

This may be significant in situations with a high signal-to-noise ratio, SNR, and a low signal-to-interference ratio, SIR, as it may occur when multiple UEs transmit over the same CG resources.

Thus, for CG transmissions the situation is different from conventional uplink data transmissions using scheduling requests. In uplink data transmissions, a data transmission is initiated by a scheduling request and maintained by the buffer status reports. The gNB allocates the UE uplink resources where to transmit the data. Therefore, there is no situation in which the gNB attempts to decode when there is actually no signal transmitted as then also no uplink resources are scheduled for the UE. Consequently, the gNB may directly

detect a decode success or a decode failure, and the decoding status may be used in HARQ so as to further improve the reliability of the transmission. Compared to conventional uplink data transmissions, CG transmissions are different and are mainly intended to deliver short messages with the low latency. The latency is reduced by leaving out the scheduling request and the scheduling grant. The UE is allowed to immediately transmit on the preconfigured CG resources when a message is ready and since the latency requirement is an issue, retransmission mechanisms, like HARQ, may not be employed. Instead, a preconfigured number of repetitions may be sent without any feedback.

At the gNB a decoder may be employed implementing a certain detection algorithm for detecting signals from a receiver over a wireless communication channel. The detection algorithm may be based on a certain model. However, deviations from a detector operating point may occur, for example due to parameter estimation errors or a mismatch of the model used for selecting the detector operation point. Such deviations are discussed, for example, in reference [6]. For a given model, a designer may attempt to provide a constant false alarm rate detector which is immune to parameter estimation errors, however, this requires to choose a model, which, usually, is selected so as to be sufficiently accurate in the expected deployment scenarios so that any deviation in the false alarm rate due to modeling errors is negligible. In typical detection algorithms, false alarm rate deviations tend to increase at higher SNRs where the modeling error has a significant influence on the statistics of the detection metric.

When considering CG transmissions, a detection algorithm for detecting signals from a receiver over a wireless communication channel may be based on a certain model. The model is based on certain error rates, however, such error rates may experience deviations. A polynomial modeling of channel variations in the frequency direction can be considered as a suitable model in constructing a detector. A designer may also adopt a different type of modeling instead of the polynomial model. However, the issue of modeling error is expected in all cases and therefore, for the following the issues are discussed with respect to the polynomial model. The amount of deviation from reality may depend on the degree polynomial modeling of channel variations used. The deviation may be low in case a high degree polynomial modeling of channel variations is applied, and may be high in case a low degree of polynomial modeling of channel variations is applied.

Fig. 3 illustrates examples indicating misdetections/false alarms versus SNR when detecting at a gNB signals from a first user under the assumption that two users transmit

over the same CG resources. Fig. 3 illustrates misdetection and false alarm curves obtained by the simulations assuming different degrees of polynomial modeling of channel variations. The subcarrier spacing is 30 kHz and the signal is transmitted over a contiguous set of 12 resource blocks. The first OFDM symbol of the transmission contains the DMRS symbols which are present in every alternate subcarrier. The model splits the signal bandwidth into multiple sections and a polynomial fit is assumed for the channel variations across the frequency direction in each section. The curves 1a, 1b illustrate the misdetection and false alarm curves for a polynomial modeling with a 0th order (Nd=0) polynomial fit and 6 sections. The curves 2a, 2b illustrate the misdetection and false alarm curves for a polynomial modeling with a 1st order (Nd=1) polynomial fit and 6 sections. The curves 3a, 3b illustrate the misdetection and false alarm curves for a polynomial modeling with a 2nd order (Nd=2) polynomial fit and 6 sections. The curves 4a, 4b illustrate the misdetection and false alarm curves for a polynomial modeling with a 3rd order (Nd=3) polynomial fit and 6 sections. The curves 5a, 5b illustrate the misdetection and false alarm curves for a polynomial modeling with a 4th order (Nd=4) polynomial fit and 6 sections. The curves 6a, 6b illustrate the misdetection and false alarm curves for a polynomial modeling with a 5th order (Nd=5) polynomial fit and 3 sections.

Fig. 3(a) illustrates the waveforms have by a simulation assuming a delay spread of 300 ns, a signal bandwidth, 12 RBs, split into sections of 6 or 3 sections, two users, a SIR of 0 dB and different degrees Nd of polynomial modeling channel variations in frequency in a section. The respective waveforms indicate the modeling errors, i.e., the deviations from the preferred ranges for the false alarm rate, which is set to 10^{-3}, in the simulation. The respective curves illustrated in Fig. 3(a) show that the misdetection targets are achieved as all curves 1a to 6a associated with the misdetection rate fall steeply at a SNR greater than 0 dB so as to be clearly in the range of the desired target which is at or below 10^{-4}. On the other hand, one can see that the false alarm curves 1b to 6b are within the desired range of 10^{-2} to 10^{-3} for a SNR up to about 5 dB. However, for higher SNRs the respective false alarm targets deviate from the desired target. For example, at SNRs above 15 dB almost all false alarm curves 1b to 6b are above the desired target range of 10^{-2} to 10^{-3}. At the lower SNR values the modeling error is small and the noise is more significant, while at higher SNR values the noise is less significant and the modeling error becomes more prominent. Thus, in Fig. 3(a) while the misdetection target may be met, the false alarm rate attains a high value, i.e., the number of false alarm events increases.

Fig. 3(b) illustrates similar results for a simulation assuming basically the same parameters as in Fig. 3(a) except that the delay spread is selected to be 100 ns so that the channel assumed for the simulation in Fig. 3(b) is considered to vary less than the channel used for the simulation in Fig. 3(a). Again, it can be seen that the misdetection targets for the different models 1 to 6 associated with respective misdetection curves 1a to 6a are at or below the desired target of 10^{-4} for SNRs greater than 0 dB while, in a similar way as in Fig. 3(a), the false alarm curves 1b to 6b are within the target rage 10^{-2} to 10^{-3} for a larger SNR range and, actually, in the depicted example only for models 1 and 2 the false alarm rate increases above the desired range for SNRs greater than 20 dB.

Fig. 3(c) and Fig. 3(d) illustrate further simulations using the same parameters as described above with reference to Fig. 3(a) and Fig. 3(b), respectively, however, the DMRS sequences used by the gNB for detecting signals from a user are orthogonal for the two users. In such situations, it can be seen from Fig. 3(c) and Fig. 3(d) that the false alarm curves 1b to 6b are all at or below the target range of 10^{-2} to 10^{-3}, however, the misdetection curves 1a to 6a may reach the desired target value of 10^{-4} of below only at SNRs above 5 dB. The main observation is that the false alarm rate has deviates significantly from the targeted value of 10^{-3} in the simulation.

The above-summarized simulation scenarios show that the gNB may not be in a position to determine whether a decode failure is caused by a false alarm or by a failure to decode a signal transmitted by the UE in a CG instance, i.e., the reliability of the CG transmissions may not be assessed by the gNB so that, like in the above-described Always Decode approach, the gNB is not in a position to make corrective actions so as to ensure that both the misdetection rate and the false alarm rate is within the desired target range.

The present invention provides improvements or enhancements in the wireless communication among entities of a wireless communication system using CG transmissions. Embodiments of the present invention provide approaches for addressing or recognizing deviations of respective error rates at certain SNRs so as to allow for countermeasures for ensuring a reliable transmission of CG messages. Further embodiments provide mechanisms allowing a receiver of CG transmissions to learn about deviations in the false alarm rate and/or the message error rates from a desired range so as to allow the receiver to apply corrective actions.

Embodiments of the present invention are advantageous as they allow the gNB (for the uplink) or the UE (for the downlink) or the receiving UE (for a sidelink) to monitor the reliability of the CG transmissions received. Embodiments of the present invention are further advantageous as they allow the gNB (for the uplink), the UE (for the downlink) or the receiving UE (for the sidelink) to identify catastrophic situations, for example, in case the false alarm rate is very high the network may assume that one or more entities or devices are not operating properly or are defect. Yet further advantages of the embodiments of the present invention are that the gNB (for the uplink), the UE (for the downlink) or the receiving UE (for the sidelink) may reduce the false alarm rates if they are too high thereby reducing the number of unnecessary decoding operations. Embodiments provide the above improvements especially for situations in which more than one entity is allowed to transmit on the same CG resources.

Embodiments of the present invention may be implemented in a wireless communication system as depicted in Fig. 1 including base stations and users, like mobile terminals or IoT devices. Fig. 4 is a schematic representation of a wireless communication system including a base station 300, and one or more UEs 302_1 to 302_n. The base station 300 and the UEs 302 may communicate via one or more wireless communication links or channels 304a, 304b, 304c, like a radio link. The base station 300 may include one or more antennas ANT_T or an antenna array having a plurality of antenna elements, a signal processor 300a and a transceiver 300b, coupled with each other. The UEs 302 include one or more antennas ANT_R or an antenna array having a plurality of antennas, a signal processor $302a_1$, $302a_n$, and a transceiver $302b_1$, $302b_n$ coupled with each other. The base station 300 and the UEs 302 may communicate via respective first wireless communication links 304a and 304b, like a radio link using the Uu interface, while the UEs 302 may communicate with each other via a second wireless communication link 304c, like a radio link using the PC5 interface. When the UEs are not served by the base station, are not be connected to a base station, for example, they are not in an RRC connected state, or, more generally, when no SL resource allocation configuration or assistance is provided by a base station, the UEs may communicate with each other over the sidelink. The system, the one or more UEs 302 and the base stations 300 may operate in accordance with the inventive teachings described herein.

ENTITY PERFORMING THE CG TRANSMISSION

The present invention provides (see for example claim 1) an apparatus for a communication with a receiver in a wireless communication system, wherein the apparatus is to

transmit one or more configured grant, CG, messages to at least one receiver using one or more CG transmissions, and

transmit feedback related to the one or more CG transmissions to the receiver.

In accordance with embodiments (see for example claim 2), the feedback related to the one or more CG transmissions includes one or more of:

- information associated with at least a number of CG transmissions performed by the apparatus during a certain time or period,
- an activity pattern report, the activity pattern report indicating a number of CG transmissions and a usage status of each CG instance in a certain period, the usage status indicating the actual resources on which the CG transmissions occurred.

In accordance with embodiments (see for example claim 3), the apparatus is to transmit a feedback message each time a predefined number (N) of CG transmissions has been transmitted, wherein the apparatus may transmit the feedback message in a control channel or in a data channel between the apparatus and the receiver, like the PDCCH, the PDSCH, the PUCCH, the PUSCH, the PSCCH or the PSSCH.

In accordance with embodiments (see for example claim 4), for transmitting the feedback related to the CG transmissions to the receiver, the apparatus is to add a flag, e.g., a one-bit flag, to a header of a predefined number (Q) of CG transmissions, and to

- set the flag to a first value in all but the last of the CG transmissions, and set the flag to a second value in the last CG transmission so as to indicate to the receiver that the predefined number (Q) of CG messages have been transmitted since the last time a CG message was transmitted with the flag set to the second value, or
- change a value of the flag each time the predefined number (Q) of CG transmissions has been transmitted so as to indicate that the predefined number (Q) of CG messages have been transmitted since a last change of the value of the flag.

In accordance with embodiments (see for example claim 5), the apparatus is to encode the flag as a modification of a subset of cyclic redundancy check, CRC, bits.

In accordance with embodiments (see for example claim 6), the apparatus is to transmit a feedback message in every predefined number (T) of CG transmission instances, wherein

the feedback message contains a number of CG instances carrying a CG message from the apparatus in the predefined number (T) of CG transmission instances.

In accordance with embodiments (see for example claim 7), the apparatus is to send, responsive to a request from the receiver,

- a report containing a number of CG instances carrying a CG message from the apparatus in a predefined number (S) of past CG transmission instances, or
- a report containing a number of CG instances carrying a CG message from the apparatus in a predefined number (S) of future CG transmission instances.

In accordance with embodiments (see for example claim 8), the apparatus is to transmit the feedback message in a control channel or in a data channel between the apparatus and the receiver, like the PDCCH, the PDSCH, the PUCCH, the PUSCH, the PSCCH or the PSSCH.

In accordance with embodiments (see for example claim 9), the one or more CG messages are numbered so that a CG message has associated therewith a certain sequence number, and wherein the apparatus is to transmit to the receiver a CG message together with its associated sequence number.

In accordance with embodiments (see for example claim 10) the apparatus is to

- add to a CG message a sequence number represented by a predefined number (M) of bits, or
- encode the sequence number into the CG message, e g., as a modification of a subset of cyclic redundancy check, CRC, bits.

In accordance with embodiments (see for example claim 11), the apparatus is to transmit an activity pattern report providing the CG activity information over a predefined number (R) of transmitted CG transmissions.

In accordance with embodiments (see for example claim 12), the apparatus is to transmit the activity pattern report

- responsive to a request from the receiver, or
- responsive to a timer reaching a certain value, or
- responsive to a counter reaching a certain value, the counter indicating a number of CG instances carrying a CG message from the apparatus.

In accordance with embodiments (see for example claim 13), the report comprises a message including the predefined number (R) of bits, wherein each bit position uniquely identifies a CG instance in the predefined number (R) of past CG transmissions, and a value of a bit indicates whether the corresponding CG instance was carrying a CG message from the apparatus or not.

In accordance with embodiments (see for example claim 14), the apparatus is to receive from the receiver an acknowledgement of the reception of the feedback message.

In accordance with embodiments (see for example claim 15) , the apparatus is to

- receive a plurality of different CG configurations defining different sets of CG resources in the time-frequency plane, like different subframes; available for CG transmissions, like RRC messages, Layer1/Layer2 messages or a broadcast message, and
- transmit a distinct feedback for each of the CG configurations, or a combined feedback for the plurality of the CG configurations.

In accordance with embodiments (see for example claim 16),

- in case of a combined feedback and configurations causing the apparatus to transmit after every N CG transmissions a feedback message, the apparatus is to provide individual counters for each CG configuration and send the feedback when a sum of the individual counters equals a positive integer multiple of N, or
- in case of a combined feedback and configurations causing the apparatus to set a flag in Q CG transmissions, the apparatus is to provide individual counters for each CG configuration and set the flag when the sum of the individual counters equals a positive integer multiple of Q, or
- in case of a combined feedback and configurations causing the apparatus to transmit a feedback message containing a number of CG instances carrying a CG message from the apparatus in the last T, last S or next S CG transmissions, the apparatus is to provide individual counters for each CG configuration and include into the feedback a value equal to the sum of the counters,
- in case of a combined feedback and configurations causing the apparatus to add to a CG message a M-bit number indicating the sequence number, the apparatus is to provide a single counter for M for calculating the sequence numbers of CG messages of the different CG configurations, the counter being incremented whenever a CG message is transmitted in any of the CG configurations, or

- in case of a combined feedback and configurations causing the apparatus to transmit to the receiver an activity pattern report providing the CG activity information over the latest R CG transmissions, the apparatus is to assemble activity flags of different CG configurations in chronological order to form the activity pattern reports.

In accordance with embodiments (see for example claim 17),

- each CG instance carrying a CG message from the apparatus includes a unique message, or
- a plurality (k) of CG instances carrying a CG message from the apparatus include an initial CG message and one or more repetitions of the initial CG message, the repetitions including a copy of the initial CG message or a predefined redundancy version of the initial CG message, and
- wherein the apparatus is to
- treat every CG instance carrying a CG message from the apparatus as a distinct message, and increment a counter associated with the predefined number (N, Q, T, S, M R) for each CG transmission by the apparatus, or
- treat CG instances carrying an initial CG message or one or more repetitions of the initial CG message as the same message, increment a counter associated with the predefined number (N, Q, T, S, M, R) for the CG transmission of the initial CG message by the apparatus and maintain the counter unchanged for CG transmissions performed by the apparatus that are repetitions of the initial CG message.

In accordance with embodiments (see for example claim 18), responsive to receiving from the receiver a number of dynamic scheduling grants for retransmissions, which do not correspond to an initial transmitted message, or a number of negative acknowledgements, which do not correspond to a transmitted message, that exceeds a first threshold, the apparatus is to conclude that the receiver is facing a number of false alarm events that exceeds a second threshold.

In accordance with embodiments (see for example claim 19), responsive to concluding that the receiver is facing a number of false alarm events that exceeds the second threshold , the apparatus, in case of receiving dynamic scheduling grants for retransmissions, is to use the scheduling grant to transmit a special message that allows the receiver to determine the CG instances at which the receiver suffered false alarms or to estimate the number of false alarm events at the receiver.

In accordance with embodiments (see for example claim 20), responsive to receiving form the receiver a number of dynamic scheduling grants for retransmissions, which do not correspond to an initial transmitted message, that exceeds a first threshold, the apparatus is to use the scheduling grant to transmit a special message that allows the receiver to determine the CG instances at which the receiver suffered false alarms or to estimate the number of false alarm events at the receiver.

In accordance with embodiments (see for example claim 21), the special message includes

- a packet including header bits set in a predefined way so as to allow the receiver to identify the special message, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, or
- a special physical layer signal.

In accordance with embodiments (see for example claim 22), the special message includes

- a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission, and
- an indication that the special message includes the new transmission and not a retransmission.

In accordance with embodiments (see for example claim 23), the indication includes:

- a special header indicating, e.g., by certain bits values, that the special message includes the new transmission and not a retransmission, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the special message includes the new transmission and not a retransmission, or
- a special physical layer signal to indicate that the special message includes the new transmission and not a retransmission.

In accordance with embodiments (see for example claim 24), responsive to receiving form the receiver a number of dynamic scheduling grants for retransmissions, which do not correspond to an initial transmitted message, that exceeds a first threshold, the apparatus is to

- treat the scheduling grant as a request for a receiver triggered report or an activity pattern report, and

- transmit a special message using the scheduling grant, the special message including the receiver triggered report or the activity pattern report.

In accordance with embodiments (see for example claim 25), the special message includes

- a packet including header bits set in a predefined way so as to allow the receiver to identify the special message as the receiver triggered report or the activity pattern report, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs.

In accordance with embodiments (see for example claim 26), the special message includes

- a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission, the new transmission multiplexed with the receiver triggered report or the activity pattern report, and
- an indication that the special message includes the multiplexed new transmission.

In accordance with embodiments (see for example claim 27), the indication includes:

- a special header indicating, e.g., by certain bits values, that the special message includes the multiplexed new transmission, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the special message includes the multiplexed new transmission, or
- a special physical layer signal to indicate that the special message includes the multiplexed new transmission.

In accordance with embodiments (see for example claim 28), the apparatus is to send the special message in case the number of dynamic scheduling grants for retransmissions, which do not have a corresponding transmitted message, that occur in a time window exceeds a certain value or threshold.

In accordance with embodiments (see for example claim 29), responsive to receiving form the receiver a number of NACKs, which do not correspond to a transmitted message, that exceeds a first threshold, the apparatus is to

- send a scheduling request to the receiver, and use the corresponding scheduling grant to transmit to the receiver a special message indicating that the number of

NACKs, which do not correspond to a transmitted message, have exceeded the first threshold, or

- transmit to the receiver on a CG instance a special message indicating that the number of NACKs, which do not correspond to a transmitted message, have exceeded the first threshold.

In accordance with embodiments (see for example claim 30), the special message includes a receiver triggered report or an activity pattern report, and

- a packet including header bits set in a predefined way so as to allow the receiver to identify the message as the receiver triggered report or the activity pattern report, or
- a CRC of the message which is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs.

In accordance with embodiments (see for example claim 31), the special message includes a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission, and

- a special header indicating, e.g., by certain bits values, that the message includes the new transmission and not a retransmission, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the message includes the new transmission and not a retransmission.

In accordance with embodiments (see for example claim 32), the special message includes a receiver triggered report or an activity pattern report multiplexed with a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission, and

- a special header indicating, e.g., by certain bits values, that the message includes the multiplexed new transmission, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the message includes the multiplexed new transmission.

In accordance with embodiments (see for example claim 33), the apparatus is to send the message in case the number of NACKs, which do not have a corresponding transmitted message, that occur in a time window exceeds a certain value or threshold.

ENTITY RECEIVING THE CG TRANSMISSION

The present invention provides (see for example claim 34) an apparatus for a communication with a transmitter in a wireless communication system, wherein the apparatus is to

receive one or more configured grant, CG, messages from at least one transmitter using one or more CG transmissions, and

receive feedback related to the one or more CG transmissions from the transmitter.

In accordance with embodiments (see for example claim 35), the feedback related to the one or more CG transmissions includes one or more of:

- information associated with at least a number of CG transmissions performed by the apparatus during a certain time or period,
- an activity pattern report, the activity pattern report indicating a number of CG transmissions and a usage status of each CG instance in a certain period, the usage status indicating the actual resources on which the CG transmissions occurred.

In accordance with embodiments (see for example claim 36), responsive to the feedback related to the CG transmissions, the apparatus is to evaluate the reliability of the reception of the CG transmissions, and wherein, dependent on the reliability of the reception of the CG transmissions, the apparatus may adapt one or more parameters associated with the detection of the CG messages or may reconfigure the CG resources at least for the transmitter.

In accordance with embodiments (see for example claim 37), responsive to the feedback related to the CG transmissions, the apparatus is to calculate one or more achieved error rates associated with the CG transmissions, and to adapt one or more parameters associated with the detection of the CG messages received from the transmitter using the calculated error rates.

In accordance with embodiments (see for example claim 38), the one or more error rates include one or more of:

- a message error rate, MER, defined as a ratio of a number of message errors to a number of CG instances carrying a CG message from the transmitter, wherein a message error occurs when information bits associated with the usage of a CG instance by the transmitter are not received correctly at the apparatus,

- a false alarm rate defined as the ratio of a number of false alarm events to a number of CG instances not carrying a CG message from the transmitter, wherein a false alarm event occurs when the transmitter does not transmit on a CG instance, while the apparatus decides that the transmitter performed a transmission,
- a misdetection rate defined as a ratio of a number of misdetection events to a number of CG instances carrying a CG message from the transmitter, wherein a misdetection event occurs when the transmitter transmits on a CG instance, while the apparatus decides that the transmitter performed no transmission.

In accordance with embodiments (see for example claim 39), the apparatus is to

- receive, in a control channel or in a data channel between the apparatus and the transmitter, like the PDCCH, the PDSCH, the PUCCH, the PUSCH, the PSCCH or the PSSCH, a feedback message each time a predefined number (N) of CG transmissions has been transmitted, and
- determine, based on the knowledge of the predefined number (N), a number of successful or non-successful receptions of CG messages.

In accordance with embodiments (see for example claim 40),

- a header of a predefined number (Q) of CG transmissions includes a flag, e.g., a one-bit flag, being set to a first value in all but the last of the CG transmissions, and being set to a second value in the last CG transmission, and the apparatus is to determine, based on the knowledge of the predefined number (Q), a number of successful or non-successful receptions of CG messages, or
- a header of a predefined number (Q) of CG transmissions includes a flag, e.g., a one-bit flag, a value of the flag changing each time the predefined number (Q) of CG transmissions has been transmitted, and the apparatus is to determine, based on the knowledge of the predefined number (Q), a number of successful or non-successful receptions of CG messages.

In accordance with embodiments (see for example claim 41), the apparatus is to decode the flag, the flag being encoded as a modification of a subset of cyclic redundancy check, CRC, bits.

In accordance with embodiments (see for example claim 42), the apparatus is to

- receive a feedback message every predefined number (T) of CG transmission instances and the feedback message contains a number of CG instances carrying a

CG message from the transmitter in the predefined number (T) of CG transmission instances, and

- determine, based on the knowledge of the predefined number (T), a number of successful or non-successful receptions of CG messages

In accordance with embodiments (see for example claim 43), the apparatus is to

- receive, responsive to a request to the transmitter, a report containing a number of CG instances carrying a CG message from the transmitter in a predefined number (S) of past CG transmission instances, or
- a report containing a number of CG instances carrying a CG message from the transmitter in a predefined number (S) of future CG transmission instances,
- determine, based on the knowledge of the predefined number (S), a number of successful or non-successful receptions of CG messages.

In accordance with embodiments (see for example claim 44), the apparatus is to receive the feedback message in a control channel or in a data channel between the apparatus and the receiver, like the PDCCH, the PDSCH, the PUCCH, the PUSCH, the PSCCH or the PSSCH.

In accordance with embodiments (see for example claim 45), the one or more CG messages are numbered so that a CG message has associated therewith a certain sequence number, and wherein the apparatus is to receive from the transmitter a CG message together with its associated sequence number, and to determine, based on the knowledge of the sequence numbers, a number of successful or non-successful receptions of CG messages.

In accordance with embodiments (see for example claim 46), the apparatus is to

- retrieve from a CG message a sequence number represented by a predefined number (M) of bits, or
- decode the sequence number, the sequence number being encoded into the CG message, e.g., as a modification of a subset of cyclic redundancy check, CRC, bits.

In accordance with embodiments (see for example claim 47), the apparatus is to receive an activity pattern report providing the CG activity information over a predefined number (R) of transmitted CG transmission instances, and to determine, based on the knowledge of the predefined number (R), a number of successful or non-successful receptions of CG messages, a number of false alarm events, a number of misdetection events.

In accordance with embodiments (see for example claim 48), the apparatus is to request the activity pattern report from the transmitter.

In accordance with embodiments (see for example claim 49), the apparatus is to acknowledge to the transmitter the reception of the feedback message.

In accordance with embodiments (see for example claim 50), the apparatus is to

- send a plurality of different CG configurations defining different sets of CG resources in the time-frequency plane, like different subframes; available for CG transmissions, like RRC messages, Layer1/Layer2 messages or a broadcast message, and
- receive a distinct feedback for each of the CG configurations, or a combined feedback for the plurality of the CG configurations.

In accordance with embodiments (see for example claim 51), the apparatus is to adjust a detector, responsive to receiving from the transmitter a message indicating that a number of decode failures signaled for CG instances on which the transmitter has transmitted exceeds a threshold.

In accordance with embodiments (see for example claim 52), to adjust the detector, the apparatus is to

- identify that a false alarm operating point of the detector deviated from a desired value, and/or
- adjust a detector threshold, e.g., change the threshold over a certain period of time so the threshold reaches or approaches a value that results in the desired false alarm probability.

GENERAL

In accordance with embodiments (see for example claim 53), the predefined number (N, Q, T, S, M R) is fixed or is configured by signaling, e.g., via a specific RRC signaling, like a ConfiguredGrantConfig message, via a Layer1/Layer2 signaling, like a PDCCH, PSCCH, or via a broadcast.

In accordance with embodiments (see for example claim 54), transmitting of the feedback message is enabled responsive to receiving a parameter associated with the predefined

number (N, Q, T, S, M R) in a configuration message, like an RRC message, a Layer1/Layer2 message or a broadcast message.

In accordance with embodiments (see for example claim 55), transmitting of the feedback message is disabled, in case the configuration message does not include a value for the parameter or includes a certain value for the parameter.

In accordance with embodiments (see for example claim 56), a parameter associated with the predefined number (N, Q, T, S, M, R) is communicated using a configuration message, like an RRC message, a Layer1/Layer2 message or a broadcast message, and wherein transmitting of the feedback message is enabled responsive to a flag in the configuration message.

In accordance with embodiments (see for example claim 57), the configuration message includes one or more of:

- a configuration causing a feedback message to be transmitted after every N CG transmissions,
- a configuration causing a flag, e.g., a one-bit flag, to be added to a header of the CG transmissions or to be encoded in a subset of the CRC bits, and to be
  - set to a first value in Q-1 CG transmissions, and to a second value in the Qth CG transmission, or
  - changed after every Q CG transmissions so as to indicate that Q CG messages have been transmitted since a last change of the value of the flag,
- a configuration causing a transmission of a feedback message every T CG transmission instances, wherein the feedback message contains a number of CG instances carrying a CG message in the last T CG transmission instances,
- a configuration causing to send, responsive to a request,
  - a report containing a number of CG instances carrying a CG message in last S CG transmission instances, or
  - a report containing a number of CG instances carrying a CG message in next S CG transmission instances,
- a configuration causing a CG message to be to transmitted together with its associated sequence number,
- a configuration causing an activity pattern report to be transmitted, the activity pattern report providing the CG activity information over the latest R CG transmissions.

In accordance with embodiments (see for example claim 58), a CG transmission uses a CG instance, the CG instance comprising one or more defined resources, like configured time-frequency resources or positions, for the CG transmissions.

In accordance with embodiments (see for example claim 59), the time-frequency resources for the CG transmissions are preconfigured, e.g., via Radio Resource Control, RRC, signaling, or via RRC signaling and L1/L2 signaling.

In accordance with embodiments (see for example claim 60), the apparatus comprises a UE and the receiver comprises a gNB, or the apparatus comprises a gNB and the receiver comprises a UE, or the apparatus comprises a first UE and the receiver comprises a second UE, the first and second UEs to communicate over a sidelink.

In accordance with embodiments (see for example claim 61), the apparatus comprises

a user device, UE, the UE comprising one or more of a mobile terminal, or stationary terminal, or cellular IoT-UE, or vehicular UE, or vehicular group leader (GL) UE, an IoT or narrowband IoT, NB-IoT, device, or a ground based vehicle, or an aerial vehicle, or a drone, or a moving base station, or road side unit, or a building, or any other item or device provided with network connectivity enabling the item/device to communicate using the wireless communication network, e.g., a sensor or actuator, or

a base station or gNB, the base station comprising one or more of a macro cell base station, or a small cell base station, or a central unit of a base station, or a distributed unit of a base station, or a road side unit, or a UE, or a group leader (GL), or a relay, or a remote radio head, or an AMF, or an SMF, or a core network entity, or mobile edge computing entity, or a network slice as in the NR or 5G core context, or any transmission/reception point, TRP, enabling an item or a device to communicate using the wireless communication network, the item or device being provided with network connectivity to communicate using the wireless communication network.

SYSTEM

The present invention provides (see for example claim 62), a wireless communication system, comprising a plurality of the inventive apparatus.

METHODS

The present invention provides (see for example claim 63) a method for a communication with a receiver in a wireless communication system, the method comprising:

transmitting one or more configured grant, CG, messages to at least one receiver using one or more CG transmissions, and

transmitting feedback related to the one or more CG transmissions to the receiver.

The present invention provides (see for example claim 64) a method for a communication with a transmitter in a wireless communication system, the method comprising:

receiving one or more configured grant, CG, messages from at least one transmitter using one or more CG transmissions, and

receiving feedback related to the one or more CG transmissions from the transmitter.

COMPUTER PROGRAM PRODUCT

The present invention provides a computer program product comprising instructions which, when the program is executed by a computer, causes the computer to carry out one or more methods in accordance with the present invention.

Embodiments of the present invention are now described with reference to a wireless communication system, like the one described above in Fig. 1 and Fig. 2. In the subsequent description it is assumed that a UE is provided that uses, for uplink transmission to the gNB, especially for low latency applications, CG transmissions, in other words, for the uplink, the UE is the entity performing the CG transmissions, while the base station or gNB is the entity receiving the CG transmissions. However, the present invention is not limited to such embodiments, rather, the embodiments described hereinbelow may be equally applied for CG transmissions in the downlink, i.e., for transmission from the gNB to a UE or to a plurality of UEs. In other words, in the downlink scenario, the gNB is the entity performing the CG transmission while the one or more UEs are the entities receiving the CG transmissions and estimate the reliability thereof so as to allow for a reliable receipt of the messages from the gNB.

It is further noted that the inventive approach is not limited to uplink or downlink transmissions, rather, the inventive approach as described in the subsequent embodiments may equally be applied for sidelink communications, i.e., for CG transmissions over a sidelink. In accordance with such embodiments, a UE may transmit directly to another UE over a sidelink. In such embodiments, the entity transmitting the CG transmission is a first UE, also referred to as the transmitting UE of the sidelink, and the entity receiving the CG transmission is a second UE, also referred to as a receiving UE of the sidelink which may evaluate the reliability of the CG transmission over the sidelink in a way as described below so as to take countermeasures, if needed.

In accordance with embodiments of the present invention, a report is introduced that is provided by the UE so as to allow the gNB to calculate the achieved error rates to a certain degree of accuracy. More specifically, in accordance with embodiments, the UE may report a history of CG transmissions, for example periodically or upon a request from the gNB. For example, the history may include a number of CG transmissions in the last x milliseconds, or each CG message may be associated with a consecutive number so as to allow the gNB to determine the actual numbers of CG messages received, for example, by a using a n-bit sequence number in each CG message. These embodiments and further embodiments are described in more detail below.

Responsive to the UE report, the gNB may monitor the health of the CG transmissions so as to know, for example, the false alarm rate or other error rates so that the gNB may adjust, for example, parameters of a detection algorithm, in case of a deviation of the respective rates from predefined target values. In accordance with embodiments, when the deviations are too high, the gNB may also consider the currently used resources for the CG transmission to be not suited anymore and may reconfigure one or more of the UEs to use other, collision-free resources. In other words, in accordance with the present invention, the gNB may use the information obtained from the UE so as to gain confidence that the CG transmissions meet certain reliability requirements, and in case this is no longer given, the UE may adapt for example the false alarm operating point of a detection algorithm towards a desired target value. This, in accordance with the present invention, is enabled by providing an explicit or implicit feedback related to CG transmissions by the UE.

In the following, several embodiments for providing the feedback from the UE to the gNB are described in more detail.

In accordance with embodiments, the feedback related to the one or more CG transmissions may include information associated with at least a number of CG transmissions performed by the apparatus during a certain time or period, or an activity pattern report, which indicates a number of CG transmissions and a usage status of each CG instance in a certain period. Other than the mere information about the number of CG transmissions, the usage status may also indicate the actual resources on which the CG transmissions occurred. Responsive to the feedback, the gNB may evaluate the reliability of the reception of the CG transmissions and, dependent on the reliability, the gNB may adapt one or more parameters associated with the detection of the CG messages or may reconfigure the CG resources to be used by a UE for transmitting the CG messages. For example, responsive to the feedback, the gNB may calculate the message error rate, the false alarm rate or the misdetection rate so as to adapt the detection parameters associated with detecting the CG messages accordingly so as to bring the error rates towards the target values discussed above.

Counter-Triggered UE Report

In accordance with embodiments, the feedback may be a counter-triggered UE report. The UE may transmit a message in the uplink control channel or the uplink data channel every N CG transmissions. Fig. 5 illustrates an embodiment for providing a counter-triggered UE report where N is selected to be 5. Fig. 5 illustrates the used CG instances 400 and the unused CG instances 402, i.e., those instances 400 in which the UE transmits a CG message and those instances 402 in which no CG transmission is performed by the UE, for example, because there is no data to be transmitted. As is indicated in Fig. 5, during the depicted time interval, initially there are three used CG instances, where respective transmissions of messages from the UE towards the gNB occur, followed by four unused CG instances, where no transmissions of messages from the UE towards the gNB occur. Another two used CG instances follow. Since N is selected to be 5, following the fifth used CG instance the UE creates a CG report 404_1 at a time t1 and transmits the report to the gNB. Responsive to the report 404_1, the gNB may estimate or calculate the reliability of the transmissions so as to adapt, if necessary, any parameters in the detection mechanism for detecting messages transmitted from the UE to the gNB during the used CG instances.

Fig. 5 further illustrates, following the time t1, three used CG instances followed by four unused CG instances. Then another used CG instance occurs followed by three unused CG instances. Then a fifth used CG instance 400_5 occurs. At a time t2 following the fifth

used CG instance a further CG report 404_2 is created or generated at the UE and transmitted to the gNB.

As may be seen from Fig. 5, the intervals between the CG reports 404_1 and 404_2 are not the same, rather they depend on the number of unused CG instances so that the time period from t0 to t1 is shorter than the time period from t1 to t2.

In accordance with embodiments, N has a large value, for example, N = 100, 500, 1000, so as to avoid, on the one hand, a signaling overhead associated with transmitting the CG report to the gNB, and, on the other hand, unnecessary action at the gNB in case of a low target for the alarm rate.

The value of N may be a fixed value or may be a value configured, for example, by the gNB. The configuration may be done via a UE specific RRC signaling, for example using a ConfiguredGrantConfig message as described in reference [2]. In accordance with other embodiments, a Layer1/Layer2 signaling may be used, for example via the PDCCH. Also a broadcast information available for all UEs within the coverage of the gNB may be used for transmitting or configuring the value N at the UE.

Enabling the transmission of UE reports may be signaled in various ways, for example by including into a configuration message the parameter N, like into the above-mentioned RRC message, Layer1/Layer2 message or broadcast message. The transmission of the CG feedback may be enabled in case the configuration message includes one or more values for the parameter N. On the other hand, the CG feedback may be disabled in case the configuration message does not include a N value or in case a certain, predefined value is used thereby indicating that no CG feedback reporting is needed or required by the network. In accordance with other embodiments, the configuration message may include an additional flag, besides the value N, so as to indicate, dependent on the status of the flag, whether reporting the CG feedback is desired or not.

A message forwarding the CG feedback includes an identification as a CG report, for example by providing a specific field or the like in the header of the message, and reception of the message may be acknowledged by the gNB to the UE so as to ensure reliability of the transmission of the report information or feedback information.

Counter-Triggered Flag

In accordance with other embodiments, a counter-triggered flag may be used for reporting the feedback from the UE to the gNB. The UE may add a one-bit flag to the header of the respective CG transmissions.

In accordance with an embodiment, in most transmissions, the flag has first value, like 0, and after every Q CG transmissions, i.e., after Q transmissions have been made at the UE, the flag may set to a second value, like 1, to indicate that Q CG message have been transmitted since the last value equal one flag.

In accordance with another embodiment, a differential signaling may be employed meaning that the flag stays at the first value, like 0, for Q transmissions, then changes for Q transmissions to the second value, like 1, and then changes back for Q transmission to the first value and so on.

When considering, for example, high SNRs, the misdetection rate and the BLER are expected to be low and to meet the target values, despite any deviations in the model used for determining the detection algorithm. Therefore, the flag is correctly received at the gNB with a high probability. This allows addressing the above discussed issue regarding high false alarm rates at the high SNRs which, on the basis of the reliably received flags may be measured by the gNB.

The value of Q may be a fixed value or may be a value configured, for example, by the gNB. The configuration may be done via a UE specific RRC signaling, for example using a ConfiguredGrantConfig message as described in reference [2]. In accordance with other embodiments, a Layer1/Layer2 signaling may be used, for example via the PDCCH. Also a broadcast information available for all UEs within the coverage of the gNB may be used for transmitting or configuring the value Q at the UE.

Enabling the transmission of UE reports may be signaled in various ways, for example by including into a configuration message the parameter Q, like into the above-mentioned RRC message, Layer1/Layer2 message or broadcast message. The transmission of the CG feedback may be enabled in case the configuration message includes one or more values for the parameter Q. On the other hand, the CG feedback may be disabled in case the configuration message does not include a Q value or in case a certain, predefined value is used thereby indicating that no CG feedback reporting is needed or required by the network. In accordance with other embodiments, the configuration message may include an

additional flag, besides the value Q, so as to indicate, dependent on the status of the flag, whether reporting the CG feedback is desired or not.

A message forwarding the CG feedback includes an identification as a CG report, for example by providing a specific field or the like in the header of the message, and reception of the message may be acknowledged by the gNB to the UE so as to ensure reliability of the transmission of the report information or feedback information.

Periodic/Timer-Based UE Report

In accordance with yet other embodiments, the UE feedback may include a periodic or timer-based report. The UE may transmit a message in the uplink control channel or in the uplink data channel after every T CG transmission instances.

Fig. 6 illustrates an embodiment of using periodic/timer-based UE reports assuming T to be 5. Fig. 6 illustrates CG instances over a certain time period and, like Fig. 5, illustrates the used CG instances 400 and the unused CG instances 402. When T is set to be 5, following every fifth CG instance, the UE will create and transmit a CG report. In the embodiment depicted in Fig. 6, at a time t1 and assuming T to 5, the CG report generated and transmitted at the time t1 from the UE to the gNB indicates a value of three CG messages, i.e., the three used CG instances carrying a message between t0 and t1. Fig. 6 illustrates a second CG report 404_2 as well as a third and fourth CG report 404_3, 404_4 created and transmitted at times t2, t3 and t4, respectively. Each value indicates the number of used CG instances or CG instances carrying a message in the last T = 5 CG instances so that CG report 404_2 has a value of three, CG report 404_3 has a value of two and CG report 404_4 has a value of one.

In other words, the feedback message reports the number of used CG instances in the last T CG transmission instances.

The value of T may be a fixed value or may be a value configured, for example, by the gNB. The configuration may be done via a UE specific RRC signaling, for example using a ConfiguredGrantConfig message as described in reference [2]. In accordance with other embodiments, a Layer1/Layer2 signaling may be used, for example via the PDCCH. Also a broadcast information available for all UEs within the coverage of the gNB may be used for transmitting or configuring the value T at the UE.

Enabling the transmission of UE reports may be signaled in various ways, for example by including into a configuration message the parameter T, like into the above-mentioned RRC message, Layer1/Layer2 message or broadcast message. The transmission of the CG feedback may be enabled in case the configuration message includes one or more values for the parameter T. On the other hand, the CG feedback may be disabled in case the configuration message does not include a T value or in case a certain, predefined value is used thereby indicating that no CG feedback reporting is needed or required by the network. In accordance with other embodiments, the configuration message may include an additional flag, besides the value T, so as to indicate, dependent on the status of the flag, whether reporting the CG feedback is desired or not.

A message forwarding the CG feedback includes an identification as a CG report, for example by providing a specific field or the like in the header of the message, and reception of the message may be acknowledged by the gNB to the UE so as to ensure reliability of the transmission of the report information or feedback information.

gNB-Triggered UE Report

In accordance with further embodiments, the feedback may be triggered by a request of the gNB received at the UE. For example, the gNB may send a message to the UE to report a summary of CG transmissions, for example a summary of the last S CG transmissions.

Fig. 7 illustrates an embodiment of a gNB-triggered UE report for S = 5 prior CG instances so that the feedback or report provides activity information for the S CG instances before or prior to the gNB request. In Fig. 7, in a similar way as in Fig. 5, used and unused CG instances 400, 402 are illustrated over a certain period. In the embodiment depicted in Fig. 7, initially there are three consecutive used CG instances, followed by four unused CG instances which, in turn, are followed by five used CG instances. At a time t1, the UE receives a gNB request 406_1 requesting from the UE to report a summary of the last S = 5 CG transmissions. The last S =5 transmissions are indicated at 408_1 and there are two used CG instances, i.e., two CG messages were transmitted by the UE to the gNB. The UE creates a respective CG report including a value of 2, indicating that in the requested time period two CG messages were uploaded and the CG report 404_1 is reported to the gNB at the time t2. As is further illustrated in Fig. 7, at a later time t3 another gNB request 406_2 is received at the UE, and the last S = 5 CG transmissions are indicated at 408_2. During the last five CG instances, one used CG instance occurred so that the UE creates a CG report

404_2 indicating a value of 1 meaning that one CG message has been transmitted, and the CG report is forwarded to the gNB at a time t4.

In accordance with another embodiment of the gNB-triggered UE report, the gNB may send a message to the UE to report a summary, however, in accordance with this embodiment, the gNB requests a summary of the next S or the future S CG transmissions.

Fig. 8 illustrates an embodiment of using a gNB-triggered UE report for S = 5 future CG instances so that the activity information is provided for the S = 5 CG instances following the gNB request. Fig. 8 illustrates the used and unused CG instances 400, 402 over a time window. At a time t1, the UE receives the gNB request 406_1 requesting the activity information for the next S = 5 CG instances as indicated at 408_1. After the next S = 5 CG instances, the UE creates the CG report 404_1 indicating a value of 4 meaning that following the receipt of the gNB request 406_1 there were four used CG instances. The CG report 404_1 is transmitted to the gNB at a time t2 following the fifth CG instance since the time t1. Fig. 8 further illustrates that at a time t3, a further gNB request 406_2 is received requesting, again for S = 5 CG instances, as indicated at 408_2, the activity report. Following the occurrence of the five CG instances, the UE creates the CG report 404_2 now indicating a value of 2, i.e., there were used CG instances in the last five CG instances from the receipt of the gNB request 406_2 at the time t3. At the time t4, the gNB report 404_2 is transmitted from the UE to the gNB.

In accordance with embodiments, the gNB reports 404_1, 404_2 may be transmitted by the UE to the gNB through the uplink control channel, like the PUCCH, or though the uplink data channel, like the PUSCH.

The value of S may be a fixed value or may be a value configured, for example, by the gNB. The configuration may be done via a UE specific RRC signaling, for example using a ConfiguredGrantConfig message as described in reference [2]. In accordance with other embodiments, a Layer1/Layer2 signaling may be used, for example via the PDCCH. Also a broadcast information available for all UEs within the coverage of the gNB may be used for transmitting or configuring the value S at the UE.

Enabling the transmission of UE reports may be signaled in various ways, for example by including into a configuration message the parameter S, like into the above-mentioned RRC message, Layer1/Layer2 message or broadcast message. The transmission of the CG

feedback may be enabled in case the configuration message includes one or more values for the parameter S. On the other hand, the CG feedback may be disabled in case the configuration message does not include a S value or in case a certain, predefined value is used thereby indicating that no CG feedback reporting is needed or required by the network. In accordance with other embodiments, the configuration message may include an additional flag, besides the value S, so as to indicate, dependent on the status of the flag, whether reporting the CG feedback is desired or not.

A message forwarding the CG feedback includes an identification as a CG report, for example by providing a specific field or the like in the header of the message, and reception of the message may be acknowledged by the gNB to the UE so as to ensure reliability of the transmission of the report information or feedback information.

Sequence-Numbered Messages

In accordance with yet further embodiments, sequence-numbered messages may be employed.

In accordance with embodiments, the UE may attach a M-bit number as a part of the CG message indicating the actual number of the CG transmission. The value of the M-bit number may indicate a sequence number in the range of (0, ..., 2^{M-1}) that may be represented using the M-bits. Fig. 9 illustrates the use of sequence-numbered messages in accordance with embodiments, with the value of M set to be 3, i.e., three bits are used for indicating an actual number of the CG transmission. Fig. 9 illustrates the used and unused CG instances 400, 402 and that each used CG instance has associated a sequence number x which, in the depicted embodiment, has a value between 0 and 7 because a three-bit number is used. In other words, each of the CG messages that is transmitted at the used CG instances to the gNB has associated a specific sequence number, like 0, 1, ..., 7. More specifically, over the illustrated time period, initially three CG messages having the sequence numbers 0, 1, 2 are transmitted at the shown used CG instances, and the following four instances are not used, i.e., do not carry a CG message. Then, five CG messages are transmitted in the following five consecutive CG instances, namely messages 3, 4, 5, 6 and 7.

When considering, for example, high SNRs, the misdetection rate and the BLER are expected to be low and to meet the target values, despite any deviations in the model used for determining the detection algorithm. Therefore, the sequence number is correctly

received at the gNB with a high probability. This allows addressing the above discussed issue regarding high false alarm rates at the high SRNs which, on the basis of the reliably received sequence numbers may be measured by the gNB.

The value of M may be a fixed value or may be a value configured, for example, by the gNB. The configuration may be done via a UE specific RRC signaling, for example using a ConfiguredGrantConfig message as described in reference [2]. In accordance with other embodiments, a Layer1/Layer2 signaling may be used, for example via the PDCCH. Also a broadcast information available for all UEs within the coverage of the gNB may be used for transmitting or configuring the value M at the UE.

Enabling the transmission of UE reports may be signaled in various ways, for example by including into a configuration message the parameter M, like into the above-mentioned RRC message, Layer1/Layer2 message or broadcast message. The transmission of the CG feedback may be enabled in case the configuration message includes one or more values for the parameter M. On the other hand, the CG feedback may be disabled in case the configuration message does not include a M value or in case a certain, predefined value is used thereby indicating that no CG feedback reporting is needed or required by the network. In accordance with other embodiments, the configuration message may include an additional flag, besides the value M, so as to indicate, dependent on the status of the flag, whether reporting the CG feedback is desired or not.

In accordance with other embodiments of the sequence-numbered messages, rather than using the above-described M-bit number as part of the CG message, the sequence number may be encoded into the CG message, for example, it may be implicitly encoded as a modification of a subset of the cyclic redundancy check, CRC, bits which is a function of the sequence number. The encoding may be performed using scrambling, XOR-ing or the like.

UE Activity Pattern Report

In accordance with yet another embodiment, the UE may provide a UE activity pattern report. The UE activity pattern report may provide a full activity information over the latest R CG transmission instances. The creation and the transmission of the activity pattern report may be triggered by a respective request issued by the gNB, or by a timer, or by a counter indicating a number of used CG instances, i.e., a counter counting the number of actual CG transmissions. The report may include a R-bit message in which a bit position uniquely identifies a CG instance in the latest R CG transmission instances, and the value

of the bit indicates whether the corresponding CG instance was used or not, i.e., whether at a certain instance a CG message was transmitted by the UE or not.

In accordance with embodiments, values of R may be high, for example R = 100, 500, 1000, ... and the report may be sent over the uplink data channel or the uplink control channel including an identification indicating that it is the activity pattern report to be used for evaluating the reliability of the CG transmissions at the gNB. In other words, the R-bit information may be considered as a transport block generated at the physical layer.

The value of R may be a fixed value or may be a value configured, for example, by the gNB. The configuration may be done via a UE specific RRC signaling, for example using a ConfiguredGrantConfig message as described in reference [2]. In accordance with other embodiments, a Layer1/Layer2 signaling may be used, for example via the PDCCH. Also a broadcast information available for all UEs within the coverage of the gNB may be used for transmitting or configuring the value R at the UE.

Enabling the transmission of UE reports may be signaled in various ways, for example by including into a configuration message the parameter R, like into the above-mentioned RRC message, Layer1/Layer2 message or broadcast message. The transmission of the CG feedback may be enabled in case the configuration message includes one or more values for the parameter R. On the other hand, the CG feedback may be disabled in case the configuration message does not include a R value or in case a certain, predefined value is used thereby indicating that no CG feedback reporting is needed or required by the network. In accordance with other embodiments, the configuration message may include an additional flag, besides the value R, so as to indicate, dependent on the status of the flag, whether reporting the CG feedback is desired or not.

Modification for k Repetitions

The above embodiments concerning the counter-triggered UE report, the counter-triggered flag, the periodic/timer-based UE report, the gNB-triggered UE report, the sequence-numbered messages and the UE activity pattern report assumed that that each of the used CG instances carries a unique message, like a transport block. However, in accordance with embodiments, the CG transmission may include one or more repetitions, for example, a certain message, also referred to as an initial CG message, may be repeated k times. Each repetition of the initial message may be a certain redundancy version of the initial message, like a copy of the message or a message including the same bits or more or less

bits of the codeword corresponding to the message. The above-described embodiments may implement the repetition of the CG messages as follows:

1. With regard to the reporting, the setting of the flags and the generation of the sequence numbers, the UE may treat every used CG instance as being distinct, whether it is a repetition or not, and the respective counter values and/or sequence numbers may be incremented for each use of the CG instance by the UE, i.e., for each transmission of CG message during a CG instance.
2. With regard to the reporting, the setting of the flags and the generation of the sequence numbers, the UE may only consider the unique messages, i.e., the counter values and/or sequence numbers remain the same in case a CG message is a repetition of an initial CG message by the UE.

Modification for Multiple CG Configurations

In accordance with further embodiments, multiple CG configurations may be used for a UE. Each CG configuration may define a specific set of resources, like subframes, in the time-frequency plane for the CG instances. For example, when considering a scenario using two CG configuration, the first CG configuration may allocate resources for the CG transmission every 5th subframe so that CG transmissions may occur in the 5th subframe, the 10th subframe, the 15th subframe and so on. The second first CG configuration may also allocate resources for the CG transmission every 5th subframe but starting at a different subframe, like the 2nd subframe, so that CG transmissions may occur in the 2nd subframe, the 7th subframe, the 12th subframe and so on. In other words, having multiple configurations allows interlacing the CG instances of different configurations in the time direction, which may further reduce the latency.

For example, when considering the above scenario of two configurations and the above described embodiments using a counter, like the counter-triggered UE report embodiment, the counter-triggered flag embodiment, the periodic/timer-based UE report embodiment, and the gNB-triggered UE report embodiment, the UE may transmit CG messages on the resources, like subframes, as defined by the two configurations. For example, the UE may transmit a CG message in subframes 1 and 5 of the first CG configuration so that the counter associated with the first CG configuration is 2, and a CG message in subframe 2 of the second CG configuration so that the counter associated with the second CG configuration is 1.

When considering the above scenario of two configurations and the above described embodiments using sequence-numbered messages, the UE may transmit CG messages on the resources, like subframes, as defined by the two configurations. For example, the UE may transmit a CG message in subframes 1 and 5 of the first CG configuration so that the sequence-numbers associated with the first CG configuration are 1 and 2, and a CG message in subframe 2 of the second CG configuration so that the sequence-number associated with the second CG configuration is 1.

In accordance with embodiments, the UE may provide a distinct feedback for each of the different configurations. When providing the distinct feedback, the UE may keep distinct reports/flags/sequence numbers, as described in the above embodiments for different configurations, using the parameters N, Q, T, S, M or R as specified for the respective CG configurations by the gNB (e.g., via RRC signaling or via broadcast information). This also allows the gNB to decide which CG configurations is to be selected for the feedback, e.g., by not including any values for the parameters for those configurations no desired. In the above described examples using two configurations and the counters, the distinct feedback reports for the first CG configuration a value of a first counter to be 2, and reports for the second CG configuration a value of a second counter to be 1. Likewise, in the above described examples using two configurations and the sequence numbers, the distinct feedback reports for the first CG configuration a first sequence of numbers {1, 2}, and reports for the second CG configuration a first sequence of numbers {1}.

In accordance with other embodiments, the UE may provide a combined feedback corresponding to the respective CG configurations. In the above described examples using two configurations and the counters, the combined feedback reports for the first and second CG configurations a value of a common counter to be 3. Likewise, in the above described examples using two configurations and the sequence numbers, the distinct feedback reports for the first and second CG configurations a combined sequence of numbers {1, 2, 3}. When considering the above described embodiments, the UE may combine the counters/activity information corresponding to individual CG configurations as follows:

- In case of the counter-triggered UE report embodiment, individual counters for each CG configuration may be provided, and the report may be sent when a sum of the individual counters equals to a positive integer multiple of N. The counter may be incremented in a way as described in the above-mentioned embodiment concerning the use of k repetitions of the message.

- In case of the counter-triggered flag embodiment, individual counters for each CG configuration may be provided, and the flag may be set when the sum of the individual counters equals a positive integer number of Q. The counter may be incremented in a way as described in the above-mentioned embodiment concerning the use of k repetitions of the message.
- In case of the periodic/time-based UE report embodiment or the gNB-triggered UE report embodiment, individual counters for each CG configuration may be provided, and the report includes a value equal to the sum of the counters (counting T or S). The counter may be incremented in a way as described in the above-mentioned embodiment concerning the use of k repetitions of the message.
- In case of the sequence numbered embodiment, a single counter may be used to calculate the sequence numbers of messages of different CG configurations. The counter is incremented whenever a message is transmitted in any of the CG configurations. The counter may be incremented in a way as described in the above-mentioned embodiment concerning the use of k repetitions of the message.
- In case of the UE activity pattern report embodiment, the one-bit activity flag of different CG configurations may be assembled in chronological order so as to form the UE activity pattern report.

In accordance with further embodiments, the UE or, more generally, the CG transmitter may react to situations in which the gNB or, more generally, the CG receiver, erroneously requests a retransmission from the UE. For example, the UE may experience a feedback for a retransmission from the gNB that is not associated with any transmission by the UE but that is due to a false alarm at the gNB. For example, the UE may receive scheduling grants for retransmission, which do not correspond to an initial transmitted message, or negative acknowledgements, NACKs, which do not correspond to a transmitted message, that may arise from a false alarm at the gNB.

In accordance with an embodiment, the UE reacts to scheduling grants for retransmission arising from a false alarm at the gNB. A false alarm may occur at the gNB during the detection of a CG transmission, and the gNB may assume a decode failure and send a scheduling grant to the UE so that the message, assumed to be failed, may be retransmitted to the gNB. In other words, the retransmission is designed to occur in a grant-based mode. This approach is basically known in the art, and it is for the gNB to decide to whether to use this approach or not. In case the gNB employs this approach, e.g., in high false alarm situations, the UE will receive frequent dynamic grants for retransmission for which the UE

has no corresponding message or initial messages. These unwanted dynamic grants may increase the control overhead and degrade the control channel capacity. The present embodiment addresses this issue.

In accordance with embodiments, when the UE receives from the gNB dynamic scheduling grants for retransmissions, which do not correspond to an initial transmitted message, also referred to as unwanted scheduling grants, and when the number of such unwanted scheduling grants exceeds a first threshold, the UE concludes that the gNB is facing a number of false alarm events that exceeds a second threshold. The UE may use the scheduling grant to transmit a special message that allows the gNB to determine the CG instances at which the gNB suffered false alarms or allows the gNB to estimate the number of false alarm events at the gNB.

In accordance with other embodiments, when the UE receives from the gNB dynamic scheduling grants for retransmissions, which do not correspond to an initial transmitted message, also referred to as unwanted scheduling grants, and when the number of such unwanted scheduling grants exceeds a first threshold, the UE uses the scheduling grant to transmit a special message that allows the receiver to determine the CG instances at which the receiver suffered false alarms or to estimate the number of false alarm events at the receiver. In other words, upon reception of unwanted scheduling grants, the UE may indirectly conclude that the gNB is facing high false alarm events

The UE may respond to unwanted scheduling grants in one or more of the following ways:

- The UE may use the scheduling grant to transmit a special message that informs the gNB that the UE has not transmitted in the CG instances which the gNB interpreted as a decode failure. The special message may be a packet whose header bits are set in a way that the gNB can identify as the special message. In another variant, instead of using special header bits values, the CRC of the message may be masked by a sequence that is different from the sequence that is used normally in grant-based transmissions, e.g., using different RNTIs). In yet another variant, the special message may be a special physical layer signal.
- The UE may treat the unwanted scheduling grant as a request for the gNB triggered UE report and transmit the report corresponding to the gNB triggered UE report using the scheduling grant. In another variant, the UE transmits the activity pattern report using the scheduling grant. The header bits of the message may be set in a way that allows the gNB to identify the message as the UE report or the activity pattern report.

In another variant, instead of using special header bits values, the CRC of the message may be masked by a sequence that is different from the sequence that is used normally in grant-based transmissions (e.g. using different RNTIs).

- The UE may use the unwanted scheduling grant to transmit a special message that includes a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission from the UE to the gNB. The special message may include an indication that the special message includes the new transmission and not a retransmission. For example, the special message may include a special header indicating, e.g., by certain bits values, that the special message includes the new transmission and not a retransmission. In another variant, instead of using special header bits values, a CRC of the message may be masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the special message includes the new transmission and not a retransmission. In yet another variant, the special message may include a physical layer signal to indicate that the special message includes the new transmission and not a retransmission.
- The UE may treat the unwanted scheduling grant as a request for the gNB triggered UE report and transmit the report corresponding to the gNB triggered UE report using the scheduling grant together with a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission from the UE to the gNB. The new transmission is multiplexed with the triggered UE report or the activity pattern report. The message includes an indication that the special message includes the multiplexed new transmission. The message may have a special header indicating, e.g., by certain bits values, that the special message includes the multiplexed new transmission. In another variant, instead of using special header bits values, a CRC of the message may be masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the special message includes the multiplexed new transmission. In yet another variant, the special message may include a physical layer signal to indicate that the special message includes the multiplexed new transmission.

In accordance with yet another embodiment, the UE reacts to negative acknowledgements arising from a false alarm at the gNB. When a false alarm occurs at the gNB during the detection of a CG transmission, the gNB may assume a decode failure and send a negative acknowledgement, NACK, to the UE so that the message, assumed to be failed, may be retransmitted to the gNB. When the gNB employs this approach, e.g., in high false alarm

situations, the UE may receive frequent NACKs for retransmission for which the UE has no corresponding messages. These unwanted NACKs increase the control overhead as well as degrade the control channel capacity. The present embodiment addresses this issue.

In accordance with embodiments, when the UE receives from the gNB NACKs, which do not correspond to a transmitted message, referred to as unwanted NACKs, and when the number of unwanted NACKs exceeds a first threshold, the UE concludes that the gNB is facing a number of false alarm events that exceeds a second threshold.

In accordance with other embodiments, when the UE receives from the gNB NACKs, which do not correspond to a transmitted message, and when the number of unwanted NACKs grants exceeds a first threshold, the UE may indirectly conclude that the gNB is facing high false alarm events.

The UE may respond to unwanted NACKs in one or more of the following ways:

- The UE may send a scheduling request to the gNB after the number of unwanted NACKs, which do not have a corresponding transmitted message, exceeds a certain value. Then, the UE may use the corresponding scheduling grant to transmit the gNB triggered UE report or the activity pattern report, or a special message/signal that indicates the number of NACKs that do not correspond to a transmitted message have exceeded a certain number. The header bits of the message may be set in a way that allows the gNB to identify the message as the UE report or the activity pattern report or the special message. In another variant, instead of using special header bits values, the CRC of the message may be masked by a sequence that is different from the sequence that is used normally in grant-based transmissions (e.g. using different RNTIs).
- The UE may send a scheduling request to the gNB after the number of unwanted NACKs, which do not have a corresponding transmitted message, exceeds a certain value. Then, the UE may use the corresponding scheduling grant to transmit the gNB a special message including a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission. The message may include a special header indicating, e.g., by certain bits values, that the message includes the new transmission and not a retransmission. In another variant, instead of using special header bits values, the CRC of the message may be masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different

RNTIs, to indicate that the message includes the new transmission and not a retransmission.

- The UE, instead of sending a scheduling request to the gNB, may transmit on a CG instance the gNB triggered UE report or the activity pattern report multiplexed with a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission. The message may include a special header indicating, e.g., by certain bits values, that the message includes the multiplexed new transmission. In another variant, instead of using special header bits values, the CRC of the message may be masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the message includes the multiplexed new transmission.
- The UE, instead of sending a scheduling request to the gNB, may transmit the gNB triggered UE report or the activity pattern report, or a special message/signal, on a CG instance. The header bits of the message may be set in a way that allows the gNB to identify the message as the UE report or the activity pattern report or the special message. In another variant, instead of using special header bits values, the CRC of the message may be masked by a sequence that is different from the sequence that is used normally in grant-based transmissions (e.g. using different RNTIs).

The CRC is a collection of bits attached to a message/packet, i.e., a group of information bits, that allows detecting if the packet is in error. So maybe we should say "a packet whose CRC is masked...". Likewise in other places. If present wording has the same meaning, then we can keep it as it is.

To save power, the UE may send the message or report only when the unwanted scheduling grants are frequent. For example, the UE may send a message or report to the gNB after the number of unwanted scheduling grants or unwanted NACKs, which do not have a corresponding transmitted message, that occur in a time window exceeds a certain value

The gNB or, more generally, the CG receiver, may use these messages/reports to identify that a false alarm operating point of the detector deviated from the desired value. Furthermore, the gNB may use the messages/reports to adjust a threshold of a detector such that over a certain period of time the threshold reaches or approaches the value that results in the desired false alarm probability.

GENERAL

With regard to the above-described embodiments of the various aspects of the present invention, it is noted that they have been described in an environment in which a communication is between a transmitter, like a gNB or a UE, and a receiver, like a UE and a gNB. However, the invention is not limited to such a communication, rather, the above-described principles may equally be applied for a device-to-device communication, like a D2D, V2V, V2X communication. In such scenarios, the communication is over a sidelink between the respective devices. The transmitter is a first UE and the receiver is a second UE communicating using the sidelink resources.

Embodiments of the present invention have been described in detail above, and the respective embodiments and aspects may be implemented individually or two or more of the embodiments or aspects may be implemented in combination.

Embodiments of the present invention have been described in detail above with reference to a uplink communication using, e.g., the Uu interface. However, the present invention is not limited to the use of the Uu interface. Any other interface allowing for a communication among a gNB and a UE (UL or DL) of for a direct communication among one or more UEs may be employed.

In accordance with embodiments, the wireless communication system may include a terrestrial network, or a non-terrestrial network, or networks or segments of networks using as a receiver an airborne vehicle or a spaceborne vehicle, or a combination thereof.

In accordance with embodiments, a receiver may comprise one or more of a mobile or stationary terminal, an IoT device, a ground-based vehicle, an aerial vehicle, a drone, a building, or any other item or device provided with network connectivity enabling the item/device to communicate using the wireless communication system, like a sensor or actuator. In accordance with embodiments, a transmitter may comprise one or more of a macro cell base station, or a small cell base station, or a spaceborne vehicle, like a satellite or a space, or an airborne vehicle, like a unmanned aircraft system (UAS), e.g., a tethered UAS, a lighter than air UAS (LTA), a heavier than air UAS (HTA) and a high altitude UAS platforms (HAPs), or any transmission/reception point (TRP) enabling an item or a device provided with network connectivity to communicate using the wireless communication system.

Although some aspects of the described concept have been described in the context of an apparatus, it is clear that these aspects also represent a description of the corresponding method, where a block or a device corresponds to a method step or a feature of a method step. Analogously, aspects described in the context of a method step also represent a description of a corresponding block or item or feature of a corresponding apparatus.

Various elements and features of the present invention may be implemented in hardware using analog and/or digital circuits, in software, through the execution of instructions by one or more general purpose or special-purpose processors, or as a combination of hardware and software. For example, embodiments of the present invention may be implemented in the environment of a computer system or another processing system. Fig. 10 illustrates an example of a computer system 500. The units or modules as well as the steps of the methods performed by these units may execute on one or more computer systems 500. The computer system 500 includes one or more processors 502, like a special purpose or a general-purpose digital signal processor. The processor 502 is connected to a communication infrastructure 504, like a bus or a network. The computer system 500 includes a main memory 506, e.g., a random-access memory (RAM), and a secondary memory 508, e.g., a hard disk drive and/or a removable storage drive. The secondary memory 508 may allow computer programs or other instructions to be loaded into the computer system 500. The computer system 500 may further include a communications interface 510 to allow software and data to be transferred between computer system 500 and external devices. The communication may be in the from electronic, electromagnetic, optical, or other signals capable of being handled by a communications interface. The communication may use a wire or a cable, fiber optics, a phone line, a cellular phone link, an RF link and other communications channels 512.

The terms "computer program medium" and "computer readable medium" are used to generally refer to tangible storage media such as removable storage units or a hard disk installed in a hard disk drive. These computer program products are means for providing software to the computer system 500. The computer programs, also referred to as computer control logic, are stored in main memory 506 and/or secondary memory 508. Computer programs may also be received via the communications interface 510. The computer program, when executed, enables the computer system 500 to implement the present invention. In particular, the computer program, when executed, enables processor 502 to implement the processes of the present invention, such as any of the methods described herein. Accordingly, such a computer program may represent a controller of the computer

system 500. Where the disclosure is implemented using software, the software may be stored in a computer program product and loaded into computer system 500 using a removable storage drive, an interface, like communications interface 510.

The implementation in hardware or in software may be performed using a digital storage medium, for example cloud storage, a floppy disk, a DVD, a Blue-Ray, a CD, a ROM, a PROM, an EPROM, an EEPROM or a FLASH memory, having electronically readable control signals stored thereon, which cooperate (or are capable of cooperating) with a programmable computer system such that the respective method is performed. Therefore, the digital storage medium may be computer readable.

Some embodiments according to the invention comprise a data carrier having electronically readable control signals, which are capable of cooperating with a programmable computer system, such that one of the methods described herein is performed.

Generally, embodiments of the present invention may be implemented as a computer program product with a program code, the program code being operative for performing one of the methods when the computer program product runs on a computer. The program code may for example be stored on a machine readable carrier.

Other embodiments comprise the computer program for performing one of the methods described herein, stored on a machine readable carrier. In other words, an embodiment of the inventive method is, therefore, a computer program having a program code for performing one of the methods described herein, when the computer program runs on a computer.

A further embodiment of the inventive methods is, therefore, a data carrier (or a digital storage medium, or a computer-readable medium) comprising, recorded thereon, the computer program for performing one of the methods described herein. A further embodiment of the inventive method is, therefore, a data stream or a sequence of signals representing the computer program for performing one of the methods described herein. The data stream or the sequence of signals may for example be configured to be transferred via a data communication connection, for example via the Internet. A further embodiment comprises a processing means, for example a computer, or a programmable logic device, configured to or adapted to perform one of the methods described herein. A further

embodiment comprises a computer having installed thereon the computer program for performing one of the methods described herein.

In some embodiments, a programmable logic device (for example a field programmable gate array) may be used to perform some or all of the functionalities of the methods described herein. In some embodiments, a field programmable gate array may cooperate with a microprocessor in order to perform one of the methods described herein. Generally, the methods are preferably performed by any hardware apparatus.

The above described embodiments are merely illustrative for the principles of the present invention. It is understood that modifications and variations of the arrangements and the details described herein are apparent to others skilled in the art. It is the intent, therefore, to be limited only by the scope of the impending patent claims and not by the specific details presented by way of description and explanation of the embodiments herein.

Abbreviations

Abbreviation	Meaning
CG	Configured grant
URLLC	Ultra-reliable low-latency communication
V2X	Vehicle-to-everything
gNB	5G base-station
UE	User equipment
SCI	Sidelink control information
UCI	Uplink control information
DCI	Downlink control information
PRB	Physical resource block
RA	Resource allocation
DMRS	Demodulation reference signal
MER	Message error rate
BLER	Block error rate
SNR	Signal-to-noise ratio
SIR	Signal-to-interference ratio
ACK	Acknowledgement
NACK	Negative acknowledgement
CRC	Cyclic redundancy check
PDCCH	Physical downlink control channel
PSCCH	Physical sidelink shared channel

References

[1] 3GPP TS38.214, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Physical layer procedures for data (Release 15); V15.2.0

[2] 3GPP TS38.331, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Radio resource control (Release 15); V15.4.0

[3] 3GPP TS38.211, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Physical channels and modulation (Release 15); V15.1.0

[4] 3GPP TS38.213, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; Physical layer procedures for control (Release 15); V15.2.0

[5] RP-190339, Status report to TSG "Study on physical layer enhancements for NR ultra-reliable and low latency case (URLLC)", 3GPP TSG RAN meeting #83, Shenzhen, China, March 2019

[6] R. Tandra and A. Sahai, "SNR Walls for Signal Detection," in IEEE Journal of Selected Topics in Signal Processing, vol. 2, no. 1, pp. 4-17, Feb. 2008.

CLAIMS

1. An apparatus for a communication with a receiver in a wireless communication system, wherein

the apparatus is to

transmit one or more configured grant, CG, messages to at least one receiver using one or more CG transmissions, and

transmit feedback related to the one or more CG transmissions to the receiver.

2. The apparatus of claim 1, wherein the feedback related to the one or more CG transmissions includes one or more of:
   - information associated with at least a number of CG transmissions performed by the apparatus during a certain time or period,
   - an activity pattern report, the activity pattern report indicating a number of CG transmissions and a usage status of each CG instance in a certain period, the usage status indicating the actual resources on which the CG transmissions occurred.

3. The apparatus of any one claim 1 or 2, wherein the apparatus is to transmit a feedback message each time a predefined number (N) of CG transmissions has been transmitted, wherein the apparatus may transmit the feedback message in a control channel or in a data channel between the apparatus and the receiver, like the PDCCH, the PDSCH, the PUCCH, the PUSCH, the PSCCH or the PSSCH.

4. The apparatus of any one of the preceding claims, wherein, for transmitting the feedback related to the CG transmissions to the receiver, the apparatus is to add a flag, e.g., a one-bit flag, to a header of a predefined number (Q) of CG transmissions, and to
   - set the flag to a first value in all but the last of the CG transmissions, and set the flag to a second value in the last CG transmission so as to indicate to the receiver that the predefined number (Q) of CG messages have been transmitted since the last time a CG message was transmitted with the flag set to the second value, **or**

- change a value of the flag each time the predefined number (Q) of CG transmissions has been transmitted so as to indicate that the predefined number (Q) of CG messages have been transmitted since a last change of the value of the flag.

5. The apparatus of claim 4, wherein the apparatus is to encode the flag as a modification of a subset of cyclic redundancy check, CRC, bits.

6. The apparatus of any one of the preceding claims, wherein the apparatus is to transmit a feedback message in every predefined number (T) of CG transmission instances, wherein the feedback message contains a number of CG instances carrying a CG message from the apparatus in the predefined number (T) of CG transmission instances.

7. The apparatus of any one of the preceding claims, wherein the apparatus is to send, responsive to a request from the receiver,

- a report containing a number of CG instances carrying a CG message from the apparatus in a predefined number (S) of past CG transmission instances, or
- a report containing a number of CG instances carrying a CG message from the apparatus in a predefined number (S) of future CG transmission instances.

8. The apparatus of claim 7, wherein the apparatus is to transmit the feedback message in a control channel or in a data channel between the apparatus and the receiver, like the PDCCH, the PDSCH, the PUCCH, the PUSCH, the PSCCH or the PSSCH.

9. The apparatus of any one of the preceding claims, wherein the one or more CG messages are numbered so that a CG message has associated therewith a certain sequence number, and wherein the apparatus is to transmit to the receiver a CG message together with its associated sequence number.

10. The apparatus of claim 9, wherein the apparatus is to

- add to a CG message a sequence number represented by a predefined number (M) of bits, or
- encode the sequence number into the CG message, e.g., as a modification of a subset of cyclic redundancy check, CRC, bits.

11. The apparatus of any one of the preceding claims, wherein the apparatus is to transmit an activity pattern report providing the CG activity information over a predefined number (R) of transmitted CG transmissions.

12. The apparatus of claim 11, wherein the apparatus is to transmit the activity pattern report
- responsive to a request from the receiver, or
- responsive to a timer reaching a certain value, or
- responsive to a counter reaching a certain value, the counter indicating a number of CG instances carrying a CG message from the apparatus.

13. The apparatus of claim 11 or 12, wherein the report comprises a message including the predefined number (R) of bits, wherein each bit position uniquely identifies a CG instance in the predefined number (R) of past CG transmissions, and a value of a bit indicates whether the corresponding CG instance was carrying a CG message from the apparatus or not.

14. The apparatus of any one of the preceding claims, wherein the apparatus is to receive from the receiver an acknowledgement of the reception of the feedback message.

15. The apparatus of any one of the preceding claims, wherein the apparatus is to
- receive a plurality of different CG configurations defining different sets of CG resources in the time-frequency plane, like different subframes; available for CG transmissions, like RRC messages, Layer1/Layer2 messages or a broadcast message, and
- transmit a distinct feedback for each of the CG configurations, or a combined feedback for the plurality of the CG configurations.

16. The apparatus of claim 15, wherein
- in case of a combined feedback and configurations causing the apparatus to transmit after every N CG transmissions a feedback message, the apparatus is to provide individual counters for each CG configuration and send the feedback when a sum of the individual counters equals a positive integer multiple of N, or
- in case of a combined feedback and configurations causing the apparatus to set a flag in Q CG transmissions, the apparatus is to provide individual counters for

each CG configuration and set the flag when the sum of the individual counters equals a positive integer multiple of Q, or

- in case of a combined feedback and configurations causing the apparatus to transmit a feedback message containing a number of CG instances carrying a CG message from the apparatus in the last T, last S or next S CG transmissions, the apparatus is to provide individual counters for each CG configuration and include into the feedback a value equal to the sum of the counters,
- in case of a combined feedback and configurations causing the apparatus to add to a CG message a M-bit number indicating the sequence number, the apparatus is to provide a single counter for M for calculating the sequence numbers of CG messages of the different CG configurations, the counter being incremented whenever a CG message is transmitted in any of the CG configurations, or
- in case of a combined feedback and configurations causing the apparatus to transmit to the receiver an activity pattern report providing the CG activity information over the latest R CG transmissions, the apparatus is to assemble activity flags of different CG configurations in chronological order to form the activity pattern reports.

17. The apparatus of any one of the preceding claims, wherein

- each CG instance carrying a CG message from the apparatus includes a unique message, or
- a plurality (k) of CG instances carrying a CG message from the apparatus include an initial CG message and one or more repetitions of the initial CG message, the repetitions including a copy of the initial CG message or a predefined redundancy version of the initial CG message, and

wherein the apparatus is to

- treat every CG instance carrying a CG message from the apparatus as a distinct message, and increment a counter associated with the predefined number (N, Q, T, S, M R) for each CG transmission by the apparatus, or
- treat CG instances carrying an initial CG message or one or more repetitions of the initial CG message as the same message, increment a counter associated with the predefined number (N, Q, T, S, M, R) for the CG transmission of the initial CG message by the apparatus and maintain the counter unchanged for CG transmissions performed by the apparatus that are repetitions of the initial CG message.

18. The apparatus of any one of the preceding claims, wherein, responsive to receiving from the receiver a number of dynamic scheduling grants for retransmissions, which do not correspond to an initial transmitted message, or a number of negative acknowledgements, which do not correspond to a transmitted message, that exceeds a first threshold, the apparatus is to conclude that the receiver is facing a number of false alarm events that exceeds a second threshold.

19. The apparatus of claim 18, wherein, responsive to concluding that the receiver is facing a number of false alarm events that exceeds the second threshold , the apparatus, in case of receiving dynamic scheduling grants for retransmissions, is to use the scheduling grant to transmit a special message that allows the receiver to determine the CG instances at which the receiver suffered false alarms or to estimate the number of false alarm events at the receiver.

20. The apparatus of any one of claims 1 to 17, wherein, responsive to receiving form the receiver a number of dynamic scheduling grants for retransmissions, which do not correspond to an initial transmitted message, that exceeds a first threshold, the apparatus is to use the scheduling grant to transmit a special message that allows the receiver to determine the CG instances at which the receiver suffered false alarms or to estimate the number of false alarm events at the receiver.

21. The apparatus of claim 20, wherein the special message includes
- a packet including header bits set in a predefined way so as to allow the receiver to identify the special message, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, or
- a special physical layer signal.

22. The apparatus of claim 20, wherein the special message includes
- a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission, and
- an indication that the special message includes the new transmission and not a retransmission.

23. The apparatus of claim 22, wherein the indication includes:
    - a special header indicating, e.g., by certain bits values, that the special message includes the new transmission and not a retransmission, or
    - a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the special message includes the new transmission and not a retransmission, or
    - a special physical layer signal to indicate that the special message includes the new transmission and not a retransmission.

24. The apparatus of any one of claims 1 to 17, wherein, responsive to receiving form the receiver a number of dynamic scheduling grants for retransmissions, which do not correspond to an initial transmitted message, that exceeds a first threshold, the apparatus is to
    - treat the scheduling grant as a request for a receiver triggered report or an activity pattern report, and
    - transmit a special message using the scheduling grant, the special message including the receiver triggered report or the activity pattern report.

25. The apparatus of claim 24, wherein the special message includes
    - a packet including header bits set in a predefined way so as to allow the receiver to identify the special message as the receiver triggered report or the activity pattern report, or
    - a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs.

26. The apparatus of claim 25, wherein the special message includes
    - a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission, the new transmission multiplexed with the receiver triggered report or the activity pattern report, and
    - an indication that the special message includes the multiplexed new transmission.

27. The apparatus of claim 26, wherein the indication includes:

- a special header indicating, e.g., by certain bits values, that the special message includes the multiplexed new transmission, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the special message includes the multiplexed new transmission, or
- a special physical layer signal to indicate that the special message includes the multiplexed new transmission.

28. The apparatus of any one of claims 19 to 27, wherein the apparatus is to send the special message in case the number of dynamic scheduling grants for retransmissions, which do not have a corresponding transmitted message, that occur in a time window exceeds a certain value or threshold.

29. The apparatus of any one of claims 1 to 17, wherein, responsive to receiving form the receiver a number of NACKs, which do not correspond to a transmitted message, that exceeds a first threshold, the apparatus is to

- send a scheduling request to the receiver, and use the corresponding scheduling grant to transmit to the receiver a special message indicating that the number of NACKs, which do not correspond to a transmitted message, have exceeded the first threshold, or
- transmit to the receiver on a CG instance a special message indicating that the number of NACKs, which do not correspond to a transmitted message, have exceeded the first threshold.

30. The apparatus of any one of claims 29, wherein the special message includes a receiver triggered report or an activity pattern report, and

- a packet including header bits set in a predefined way so as to allow the receiver to identify the message as the receiver triggered report or the activity pattern report, or
- a CRC of the message which is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs.

31. The apparatus of any one of claims 29, wherein the special message includes a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission, and

- a special header indicating, e.g., by certain bits values, that the message includes the new transmission and not a retransmission, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the message includes the new transmission and not a retransmission.

32. The apparatus of any one of claims 29, wherein the special message includes a receiver triggered report or an activity pattern report multiplexed with a new transmission, e.g., new bits or new data or a new codeword, awaiting transmission, and

- a special header indicating, e.g., by certain bits values, that the message includes the multiplexed new transmission, or
- a packet whose CRC is masked by a predefined sequence different from a sequence used normally in grant-based transmissions, e.g. using different RNTIs, to indicate that the message includes the multiplexed new transmission.

33. The apparatus of any one of claims 29 to 32, wherein the apparatus is to send the message in case the number of NACKs, which do not have a corresponding transmitted message, that occur in a time window exceeds a certain value or threshold.

34. An apparatus for a communication with a transmitter in a wireless communication system, wherein

the apparatus is to

receive one or more configured grant, CG, messages from at least one transmitter using one or more CG transmissions, and

receive feedback related to the one or more CG transmissions from the transmitter.

35. The apparatus of claim 34, wherein the feedback related to the one or more CG transmissions includes one or more of:
    - information associated with at least a number of CG transmissions performed by the apparatus during a certain time or period,
    - an activity pattern report, the activity pattern report indicating a number of CG transmissions and a usage status of each CG instance in a certain period, the usage status indicating the actual resources on which the CG transmissions occurred.

36. The apparatus of claim 34 or 35, wherein, responsive to the feedback related to the CG transmissions, the apparatus is to evaluate the reliability of the reception of the CG transmissions, and wherein, dependent on the reliability of the reception of the CG transmissions, the apparatus may adapt one or more parameters associated with the detection of the CG messages or may reconfigure the CG resources at least for the transmitter.

37. The apparatus of any one of claims 34 to 36, wherein, responsive to the feedback related to the CG transmissions, the apparatus is to calculate one or more achieved error rates associated with the CG transmissions, and to adapt one or more parameters associated with the detection of the CG messages received from the transmitter using the calculated error rates.

38. The apparatus of claim 37, wherein the one or more error rates include one or more of:
    - a message error rate, MER, defined as a ratio of a number of message errors to a number of CG instances carrying a CG message from the transmitter, wherein a message error occurs when information bits associated with the usage of a CG instance by the transmitter are not received correctly at the apparatus,
    - a false alarm rate defined as the ratio of a number of false alarm events to a number of CG instances not carrying a CG message from the transmitter, wherein a false alarm event occurs when the transmitter does not transmit on a CG instance, while the apparatus decides that the transmitter performed a transmission,
    - a misdetection rate defined as a ratio of a number of misdetection events to a number of CG instances carrying a CG message from the transmitter, wherein

a misdetection event occurs when the transmitter transmits on a CG instance, while the apparatus decides that the transmitter performed no transmission.

39. The apparatus of any one of claims 34 to 38, wherein the apparatus is to

- receive, in a control channel or in a data channel between the apparatus and the transmitter, like the PDCCH, the PDSCH, the PUCCH, the PUSCH, the PSCCH or the PSSCH, a feedback message each time a predefined number (N) of CG transmissions has been transmitted, and
- determine, based on the knowledge of the predefined number (N), a number of successful or non-successful receptions of CG messages.

40. The apparatus of any one of claims 34 to 39, wherein

- a header of a predefined number (Q) of CG transmissions includes a flag, e.g., a one-bit flag, being set to a first value in all but the last of the CG transmissions, and being set to a second value in the last CG transmission, and the apparatus is to determine, based on the knowledge of the predefined number (Q), a number of successful or non-successful receptions of CG messages, or
- a header of a predefined number (Q) of CG transmissions includes a flag, e.g., a one-bit flag, a value of the flag changing each time the predefined number (Q) of CG transmissions has been transmitted, and the apparatus is to determine, based on the knowledge of the predefined number (Q), a number of successful or non-successful receptions of CG messages.

41. The apparatus of claim 40, wherein the apparatus is to decode the flag, the flag being encoded as a modification of a subset of cyclic redundancy check, CRC, bits.

42. The apparatus of any one of claims 34 to 41, wherein the apparatus is to

- receive a feedback message every predefined number (T) of CG transmission instances and the feedback message contains a number of CG instances carrying a CG message from the transmitter in the predefined number (T) of CG transmission instances, and
- determine, based on the knowledge of the predefined number (T), a number of successful or non-successful receptions of CG messages

43. The apparatus of any one of claims 34 to 42, wherein the apparatus is to

- receive, responsive to a request to the transmitter,

- a report containing a number of CG instances carrying a CG message from the transmitter in a predefined number (S) of past CG transmission instances, or
- a report containing a number of CG instances carrying a CG message from the transmitter in a predefined number (S) of future CG transmission instances,

- determine, based on the knowledge of the predefined number (S), a number of successful or non-successful receptions of CG messages.

44. The apparatus of claim 43, wherein the apparatus is to receive the feedback message in a control channel or in a data channel between the apparatus and the receiver, like the PDCCH, the PDSCH, the PUCCH, the PUSCH, the PSCCH or the PSSCH.

45. The apparatus of any one of claims 34 to 44, wherein the one or more CG messages are numbered so that a CG message has associated therewith a certain sequence number, and wherein the apparatus is to receive from the transmitter a CG message together with its associated sequence number, and to determine, based on the knowledge of the sequence numbers, a number of successful or non-successful receptions of CG messages.

46. The apparatus of claim 45, wherein the apparatus is to

- retrieve from a CG message a sequence number represented by a predefined number (M) of bits, or
- decode the sequence number, the sequence number being encoded into the CG message, e.g., as a modification of a subset of cyclic redundancy check, CRC, bits.

47. The apparatus of any one of claims 34 to 46, wherein the apparatus is to receive an activity pattern report providing the CG activity information over a predefined number (R) of transmitted CG transmission instances, and to determine, based on the knowledge of the predefined number (R), a number of successful or non-successful receptions of CG messages, a number of false alarm events, a number of misdetection events.

48. The apparatus of claim 47, wherein the apparatus is to request the activity pattern report from the transmitter.

49. The apparatus of any one of claims 34 to 48, wherein the apparatus is to acknowledge to the transmitter the reception of the feedback message.

50. The apparatus of any one of claims 34 to 49, wherein the apparatus is to
- send a plurality of different CG configurations defining different sets of CG resources in the time-frequency plane, like different subframes; available for CG transmissions, like RRC messages, Layer1/Layer2 messages or a broadcast message, and
- receive a distinct feedback for each of the CG configurations, or a combined feedback for the plurality of the CG configurations.

51. The apparatus of any one of claims 34 to 50, wherein the apparatus is to adjust a detector, responsive to receiving from the transmitter a message indicating that a number of decode failures signaled for CG instances on which the transmitter has transmitted exceeds a threshold.

52. The apparatus of claim 51, wherein, to adjust the detector, the apparatus is to
- identify that a false alarm operating point of the detector deviated from a desired value, and/or
- adjust a detector threshold, e.g., change the threshold over a certain period of time so the threshold reaches or approaches a value that results in the desired false alarm probability.

53. The apparatus of any one of the preceding claims, wherein the predefined number (N, Q, T, S, M R) is fixed or is configured by signaling, e.g., via a specific RRC signaling, like a ConfiguredGrantConfig message, via a Layer1/Layer2 signaling, like a PDCCH, PSCCH, or via a broadcast.

54. The apparatus of any one of the preceding claims, wherein transmitting of the feedback message is enabled responsive to receiving a parameter associated with the predefined number (N, Q, T, S, M R) in a configuration message, like an RRC message, a Layer1/Layer2 message or a broadcast message.

55. The apparatus of claim 54, wherein transmitting of the feedback message is disabled, in case the configuration message does not include a value for the parameter or includes a certain value for the parameter.

56. The apparatus of any one of the claims 1 to 53, wherein a parameter associated with the predefined number (N, Q, T, S, M, R) is communicated using a configuration message, like an RRC message, a Layer1/Layer2 message or a broadcast message, and wherein transmitting of the feedback message is enabled responsive to a flag in the configuration message.

57. The apparatus of any one of the claims 53 to 56, wherein the configuration message includes one or more of:

- a configuration causing a feedback message to be transmitted after every N CG transmissions,
- a configuration causing a flag, e.g., a one-bit flag, to be added to a header of the CG transmissions or to be encoded in a subset of the CRC bits, and to be
  - set to a first value in Q-1 CG transmissions, and to a second value in the Qth CG transmission, or
  - changed after every Q CG transmissions so as to indicate that Q CG messages have been transmitted since a last change of the value of the flag,
- a configuration causing a transmission of a feedback message every T CG transmission instances, wherein the feedback message contains a number of CG instances carrying a CG message in the last T CG transmission instances,
- a configuration causing to send, responsive to a request,
  - a report containing a number of CG instances carrying a CG message in last S CG transmission instances, or
  - a report containing a number of CG instances carrying a CG message in next S CG transmission instances,
- a configuration causing a CG message to be to transmitted together with its associated sequence number,
- a configuration causing an activity pattern report to be transmitted, the activity pattern report providing the CG activity information over the latest R CG transmissions.

58. The apparatus of any one of the preceding claims, wherein a CG transmission uses a CG instance, the CG instance comprising one or more defined resources, like configured time-frequency resources or positions, for the CG transmissions.

59. The apparatus of claim 58, wherein the time-frequency resources for the CG transmissions are preconfigured, e.g., via Radio Resource Control, RRC, signaling, or via RRC signaling and L1/L2 signaling.

60. The apparatus of any one of the preceding claims, wherein

the apparatus comprises a UE and the receiver comprises a gNB, or

the apparatus comprises a gNB and the receiver comprises a UE, or

the apparatus comprises a first UE and the receiver comprises a second UE, the first and second UEs to communicate over a sidelink

61. The apparatus of any one of the preceding claims, wherein the apparatus comprises

a user device, UE, the UE comprising one or more of a mobile terminal, or stationary terminal, or cellular IoT-UE, or vehicular UE, or vehicular group leader (GL) UE, an IoT or narrowband IoT, NB-IoT, device, or a ground based vehicle, or an aerial vehicle, or a drone, or a moving base station, or road side unit, or a building, or any other item or device provided with network connectivity enabling the item/device to communicate using the wireless communication network, e.g., a sensor or actuator, or

a base station or gNB, the base station comprising one or more of a macro cell base station, or a small cell base station, or a central unit of a base station, or a distributed unit of a base station, or a road side unit, or a UE, or a group leader (GL), or a relay, or a remote radio head, or an AMF, or an SMF, or a core network entity, or mobile edge computing entity, or a network slice as in the NR or 5G core context, or any transmission/reception point, TRP, enabling an item or a device to communicate using the wireless communication network, the item or device being provided with network connectivity to communicate using the wireless communication network.

62. A wireless communication system, comprising a plurality of apparatus of any one of the preceding claims.

63. A method for a communication with a receiver in a wireless communication system, the method comprising:

transmitting one or more configured grant, CG, messages to at least one receiver using one or more CG transmissions, and

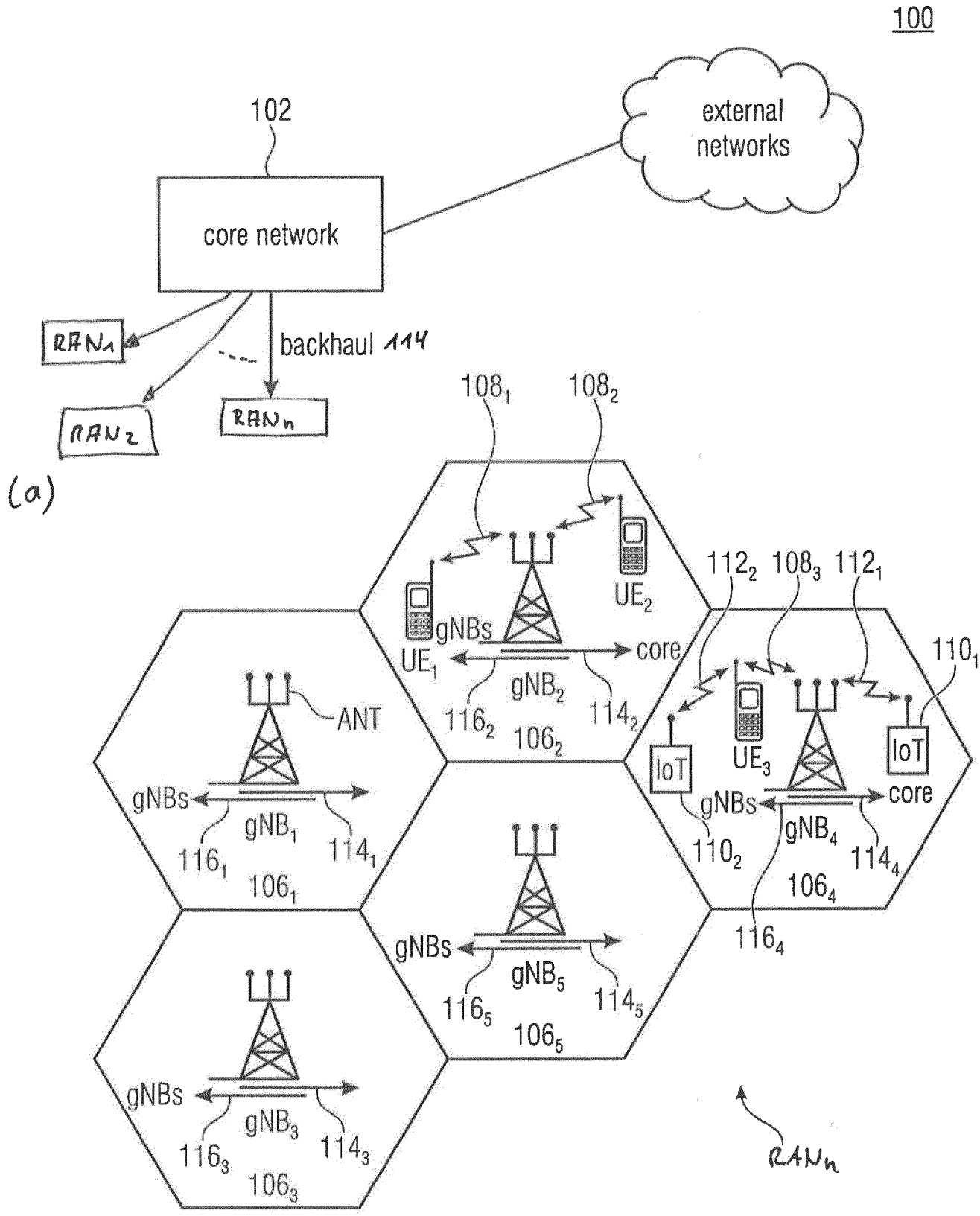
transmitting feedback related to the one or more CG transmissions to the receiver.

64. A method for a communication with a transmitter in a wireless communication system, the method comprising:

receiving one or more configured grant, CG, messages from at least one transmitter using one or more CG transmissions, and

receiving feedback related to the one or more CG transmissions from the transmitter.

65. A non-transitory computer program product comprising a computer readable medium storing instructions which, when executed on a computer, perform the method of any one of claims 63 to 64.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112_2
108_3
112_1
110_1
UE_1
UE_2
UE_3
gNBs
core
gNB_2
116_2
114_2
106_2
ANT
gNB_1
116_1
114_1
106_1
IoT
110_2
gNB_4
114_4
106_4
116_4
gNB_5
116_5
114_5
106_5
gNB_3
116_3
114_3
106_3
RANn
(b)

Fig. 1

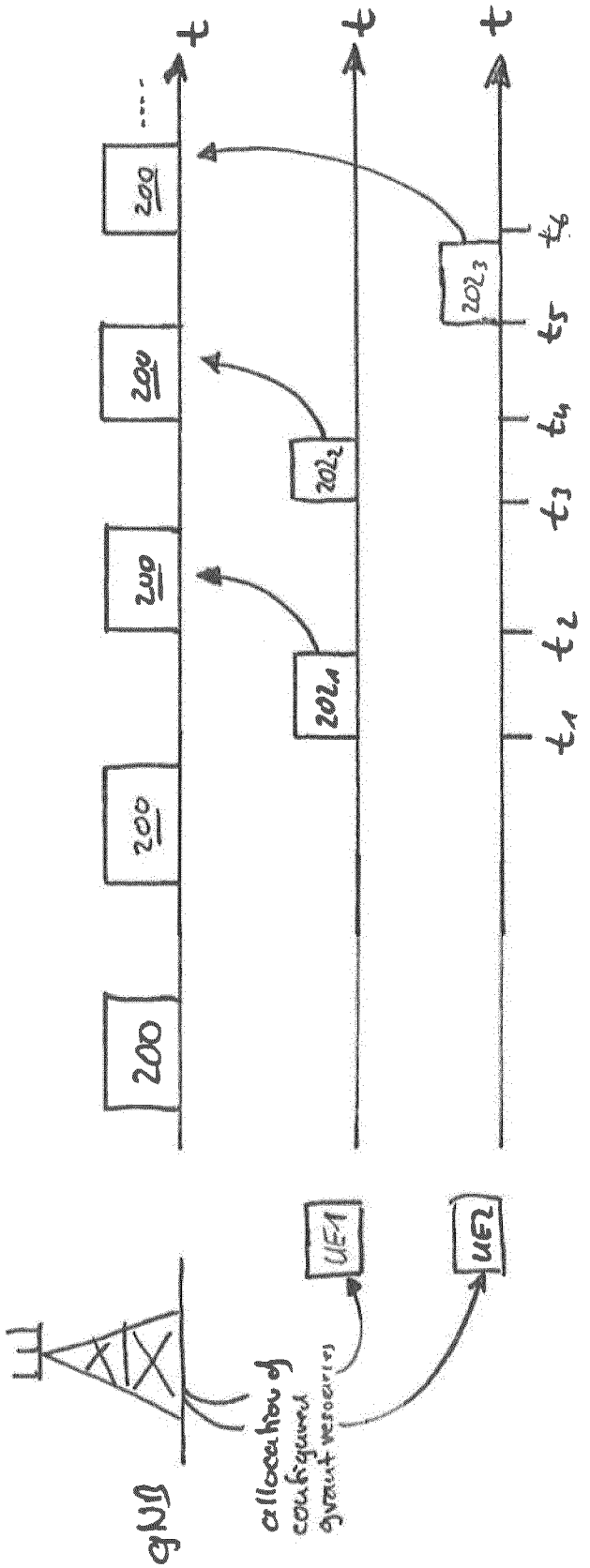
gNB
allocation of configured grant resource(s)
UE1
UE2
200
200
200
200
....
202_1
202_2
202_3
t
t_1
t_2
t_3
t_4
t_5
t_6

Fig. 2

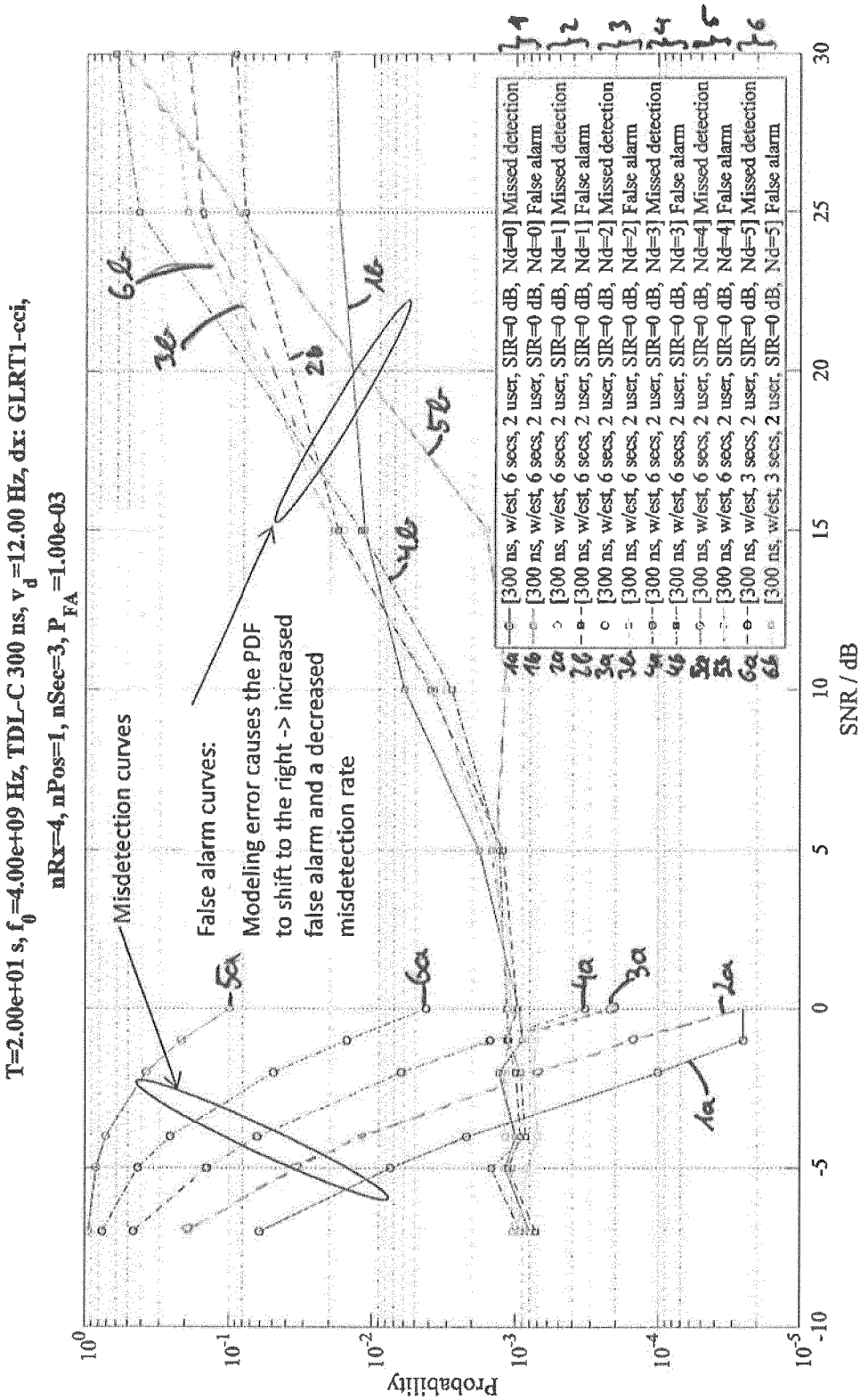
T=2.00e+01 s, f0=4.00e+09 Hz, TDL-C 300 ns, vd=12.00 Hz, dx: GLRT1-cci,
nRx=4, nPos=1, nSec=3, PFA=1.00e-03
Misdetection curves
False alarm curves:
Modeling error causes the PDF to shift to the right -> increased false alarm and a decreased misdetection rate
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=0] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=0] False alarm
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=1] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=1] False alarm
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=2] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=2] False alarm
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=3] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=3] False alarm
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=4] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=4] False alarm
[300 ns, w/est, 3 secs, 2 user, SIR=0 dB, Nd=5] Missed detection
[300 ns, w/est, 3 secs, 2 user, SIR=0 dB, Nd=5] False alarm
Probability
SNR / dB

Fig. 3(a)

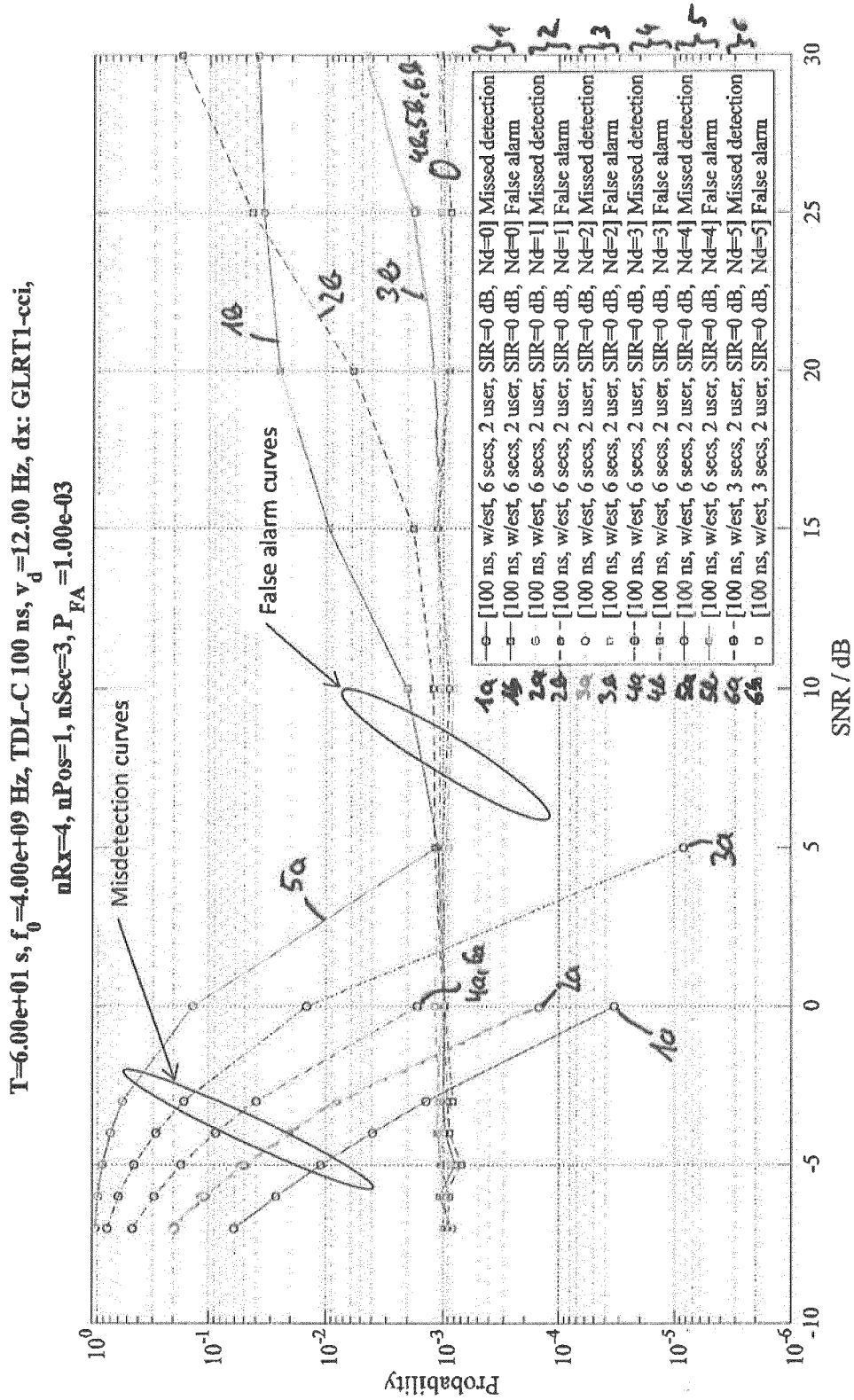
T=6.00e+01 s, f0=4.00e+09 Hz, TDL-C 100 ns, vd=12.00 Hz, dx: GLRT1-cci,
nRx=4, nPos=1, nSec=3, PFA=1.00e-03
Misdetection curves
False alarm curves
Probability
SNR / dB
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=0] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=0] False alarm
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=1] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=1] False alarm
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=2] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=2] False alarm
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=3] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=3] False alarm
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=4] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=4] False alarm
[100 ns, w/est, 3 secs, 2 user, SIR=0 dB, Nd=5] Missed detection
[100 ns, w/est, 3 secs, 2 user, SIR=0 dB, Nd=5] False alarm

Fig. 3(a)

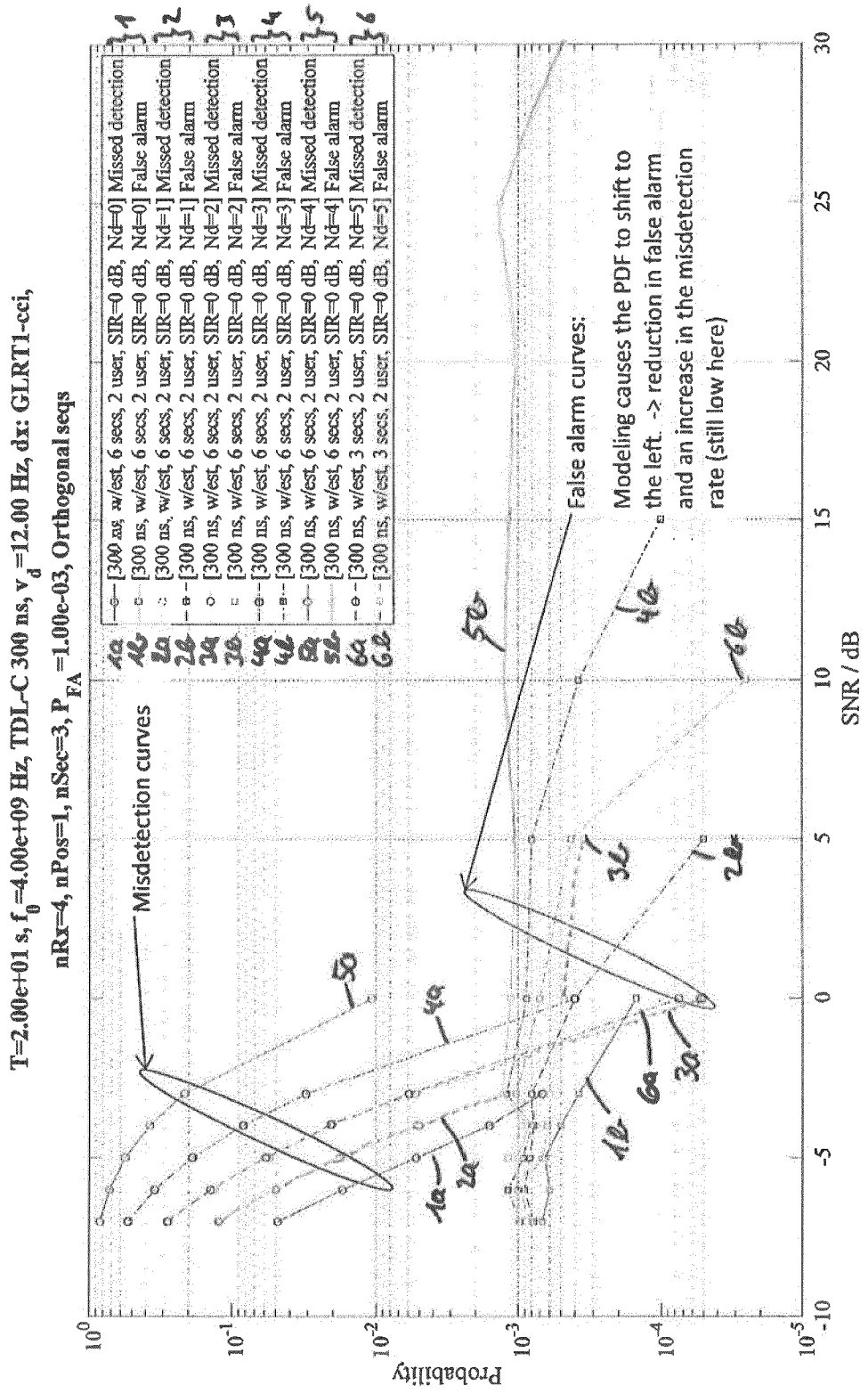
T=2.00e+01 s, f0=4.00e+09 Hz, TDL-C 300 ns, vd=12.00 Hz, dx: GLRT1-cci,
nRx=4, nPos=1, nSec=3, PFA=1.00e-03, Orthogonal seqs
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=0] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=0] False alarm
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=1] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=1] False alarm
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=2] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=2] False alarm
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=3] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=3] False alarm
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=4] Missed detection
[300 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=4] False alarm
[300 ns, w/est, 3 secs, 2 user, SIR=0 dB, Nd=5] Missed detection
[300 ns, w/est, 3 secs, 2 user, SIR=0 dB, Nd=5] False alarm
Misdetection curves
False alarm curves:
Modeling causes the PDF to shift to the left. -> reduction in false alarm and an increase in the misdetection rate (still low here)
Probability
SNR / dB

Fig. 3 (c)

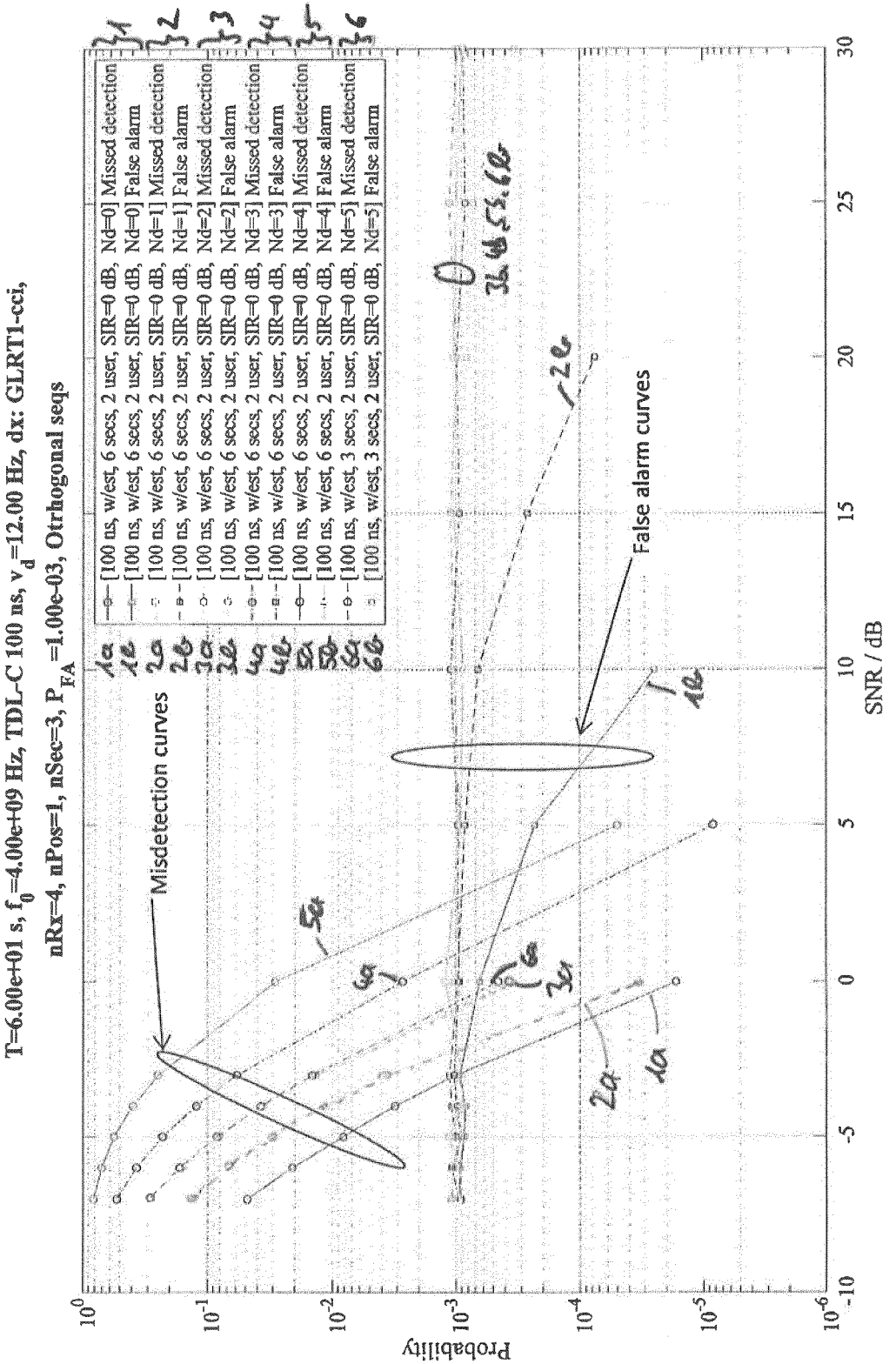
T=6.00e+01 s, f0=4.00e+09 Hz, TDL-C 100 ns, vd=12.00 Hz, dx: GLRT1-cci,
nRx=4, nPos=1, nSec=3, PFA=1.00e-03, Otrhogonal seqs
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=0] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=0] False alarm
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=1] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=1] False alarm
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=2] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=2] False alarm
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=3] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=3] False alarm
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=4] Missed detection
[100 ns, w/est, 6 secs, 2 user, SIR=0 dB, Nd=4] False alarm
[100 ns, w/est, 3 secs, 2 user, SIR=0 dB, Nd=5] Missed detection
[100 ns, w/est, 3 secs, 2 user, SIR=0 dB, Nd=5] False alarm
Misdetection curves
False alarm curves
Probability
SNR / dB

Fig. 3 (a)

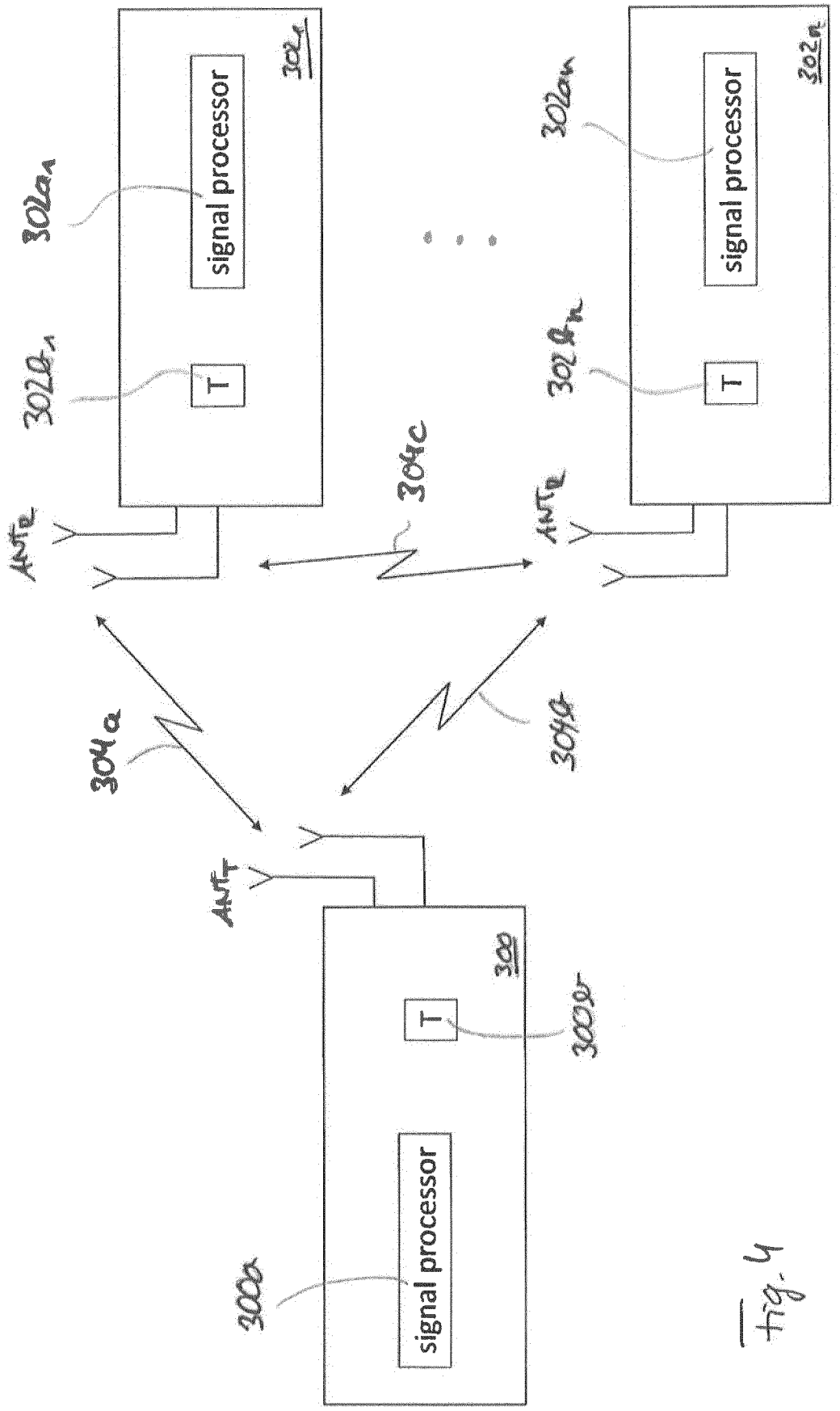
signal processor
T
signal processor
T
signal processor
T
300
300a
300b
302a1
302b1
302an
302bn
302n
304a
304b
304c
ANT1
ANT2
ANT3

Fig. 4

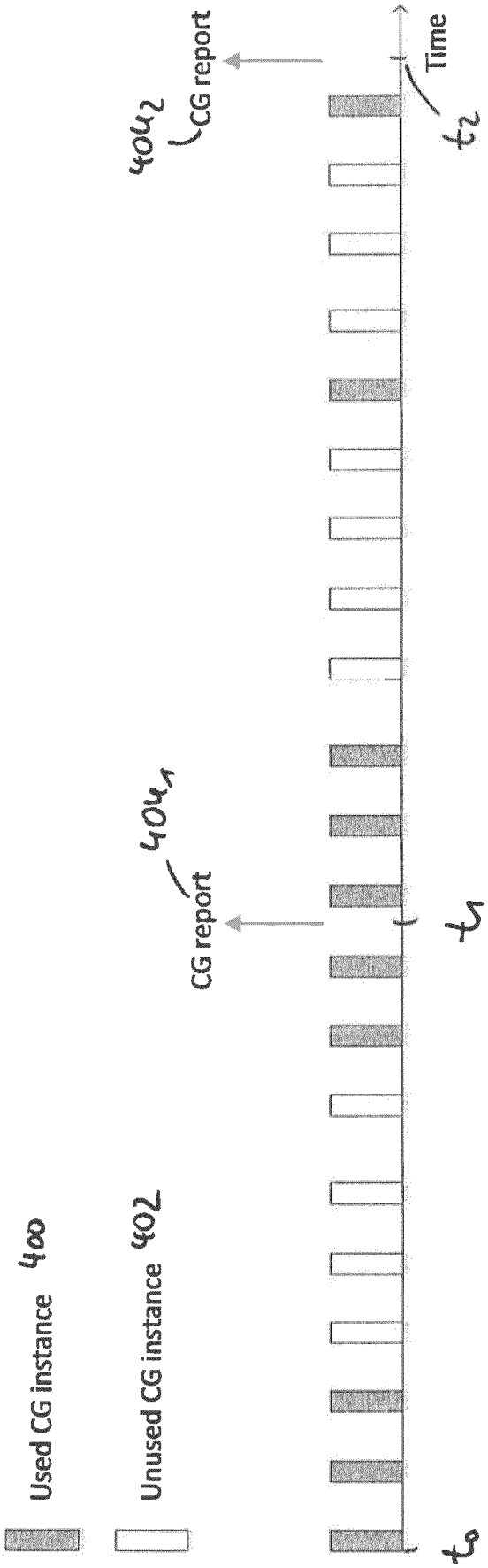
Used CG instance 400
Unused CG instance 402
CG report 404₁
CG report 404₂
Time
t1
t2

Fig. 5

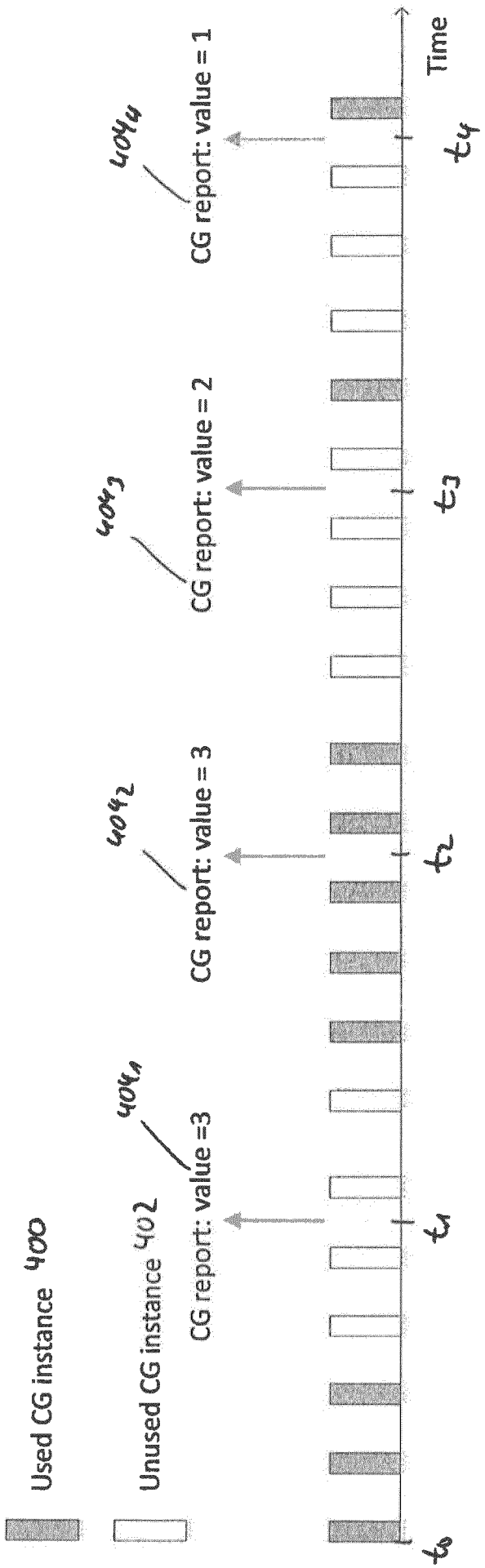
Used CG instance 400
Unused CG instance 402
CG report: value =3
CG report: value = 3
CG report: value = 2
CG report: value = 1
404₁
404₂
404₃
404₄
t1
t2
t3
t4
t5
Time

Fig. 6

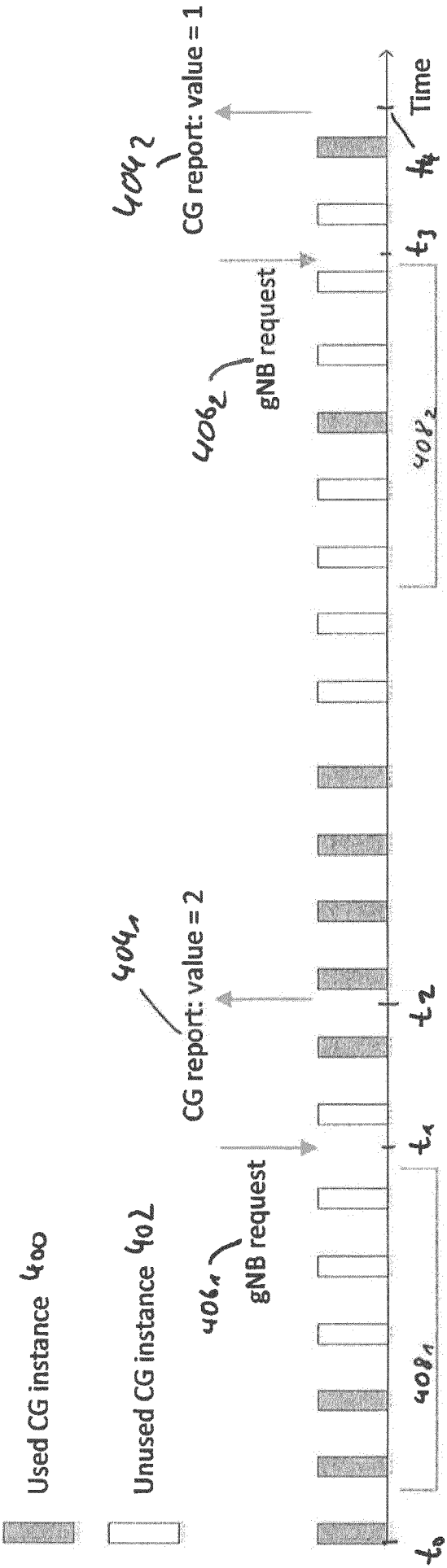
Used CG instance 400
Unused CG instance 402
406₁
gNB request
CG report: value = 2
404₁
406₂
gNB request
CG report: value = 1
404₂
Time
t0
t1
t2
t3
t4
408₁
408₂

Fig. 7

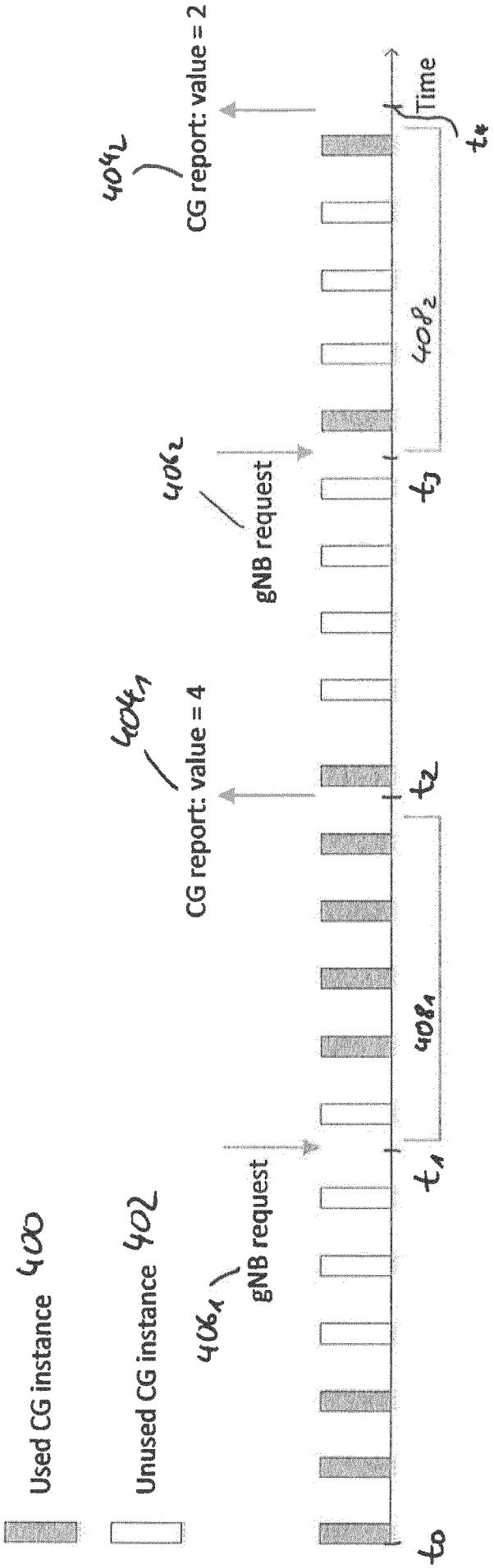
Used CG instance 400
Unused CG instance 402
406₁
gNB request
CG report: value = 4
404₁
406₂
gNB request
CG report: value = 2
404₂
Time
t0
t1
t2
t3
t*
408₁
408₂

Fig. 8

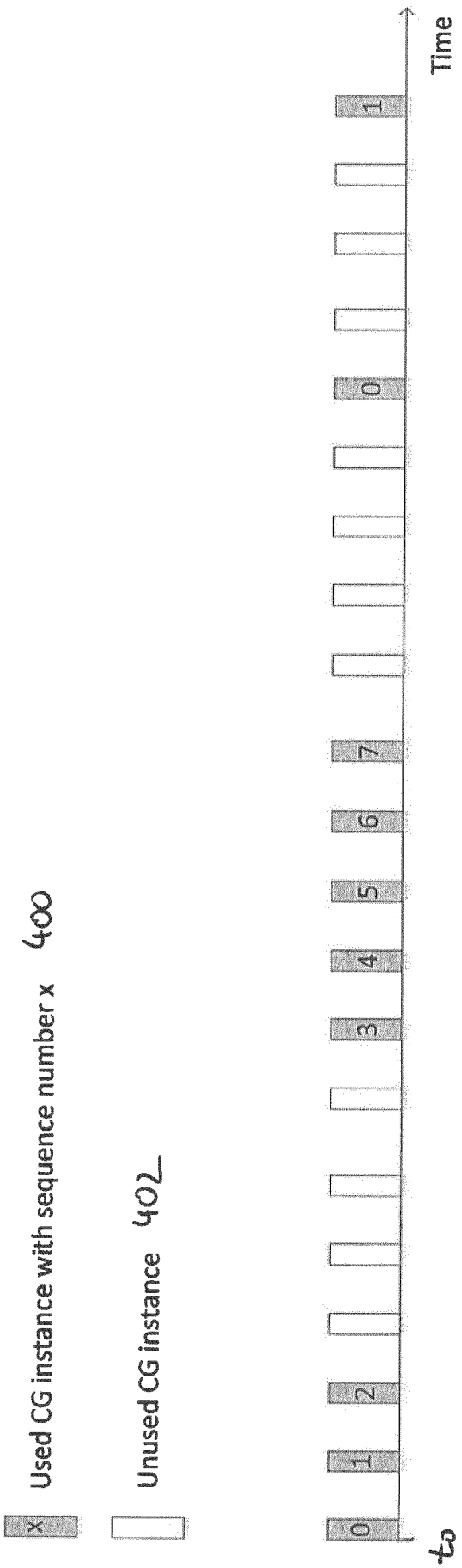
Used CG instance with sequence number x
400
Unused CG instance
402
Time
0
1
2
3
4
5
6
7
0
1
t0

Fig. 9

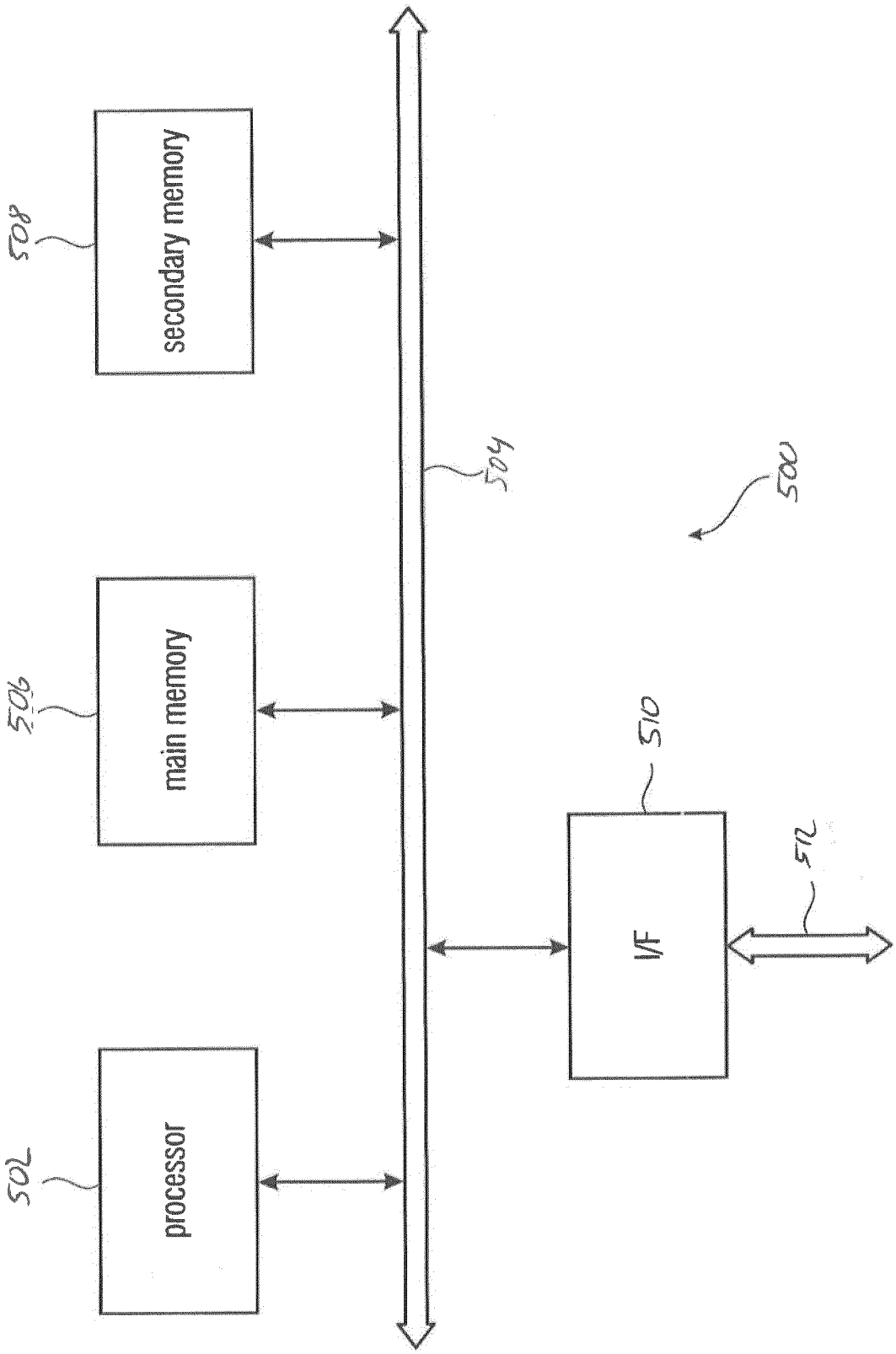
secondary memory
main memory
processor
I/F
502
504
506
508
510
512
500

Fig. 10

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
FH191006PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP2019/077653	11 October 2019 (11-10-2019)	27 May 2019 (27-05-2019)
Applicant		
FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER...		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language,** the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (See Box No. II)

3. ☒ **Unity of invention is lacking** (see Box No III)

4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant
   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 5
      ☐ as suggested by the applicant
      ☒ as selected by this Authority, because the applicant failed to suggest a figure
      ☐ as selected by this Authority, because this figure better characterizes the invention
   b. ☐ none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2019/077653

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-17, 34, 35, 39-50, 58-65

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/077653

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L1/00 H04L1/16 H04L5/00 H04W74/00 H04W74/08
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 H04W

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2018/201959 A1 (HUAWEI TECH CO LTD [CN]) 8 November 2018 (2018-11-08) the whole document -& EP 3 598 682 A1 (HUAWEI TECH CO LTD [CN]) 22 January 2020 (2020-01-22) column 13, paragraph 92 - column 29, paragraph 148; figures 1-10 -----	1-17,34, 35, 39-50, 58-65
X	US 2018/367255 A1 (JEON HYOUNGSUK [US] ET AL) 20 December 2018 (2018-12-20) page 11, paragraph 200 - paragraph 202; figures 17a, 17b page 16, paragraph 241 - page 17, paragraph 250; figures 24,25 -----	1-17,34, 35, 39-50, 58-65

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 February 2020	24/06/2020

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	Courville, Nicolas

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/077653

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2018201959 A1	08-11-2018	CN 108809541 A	13-11-2018
		EP 3598682 A1	22-01-2020
		US 2020067655 A1	27-02-2020
		WO 2018201959 A1	08-11-2018
EP 3598682 A1	22-01-2020	CN 108809541 A	13-11-2018
		EP 3598682 A1	22-01-2020
		US 2020067655 A1	27-02-2020
		WO 2018201959 A1	08-11-2018
US 2018367255 A1	20-12-2018	NONE	

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

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

1. claims: 1-17, 34, 35, 39-50, 58-65

   Transmitting feedback in case of configured grant transmission in order to reduce miss-detections

   ---

2. claims: 18-33

   A number of NACKs or of dynamic scheduling grants indicates a critical false alarm situation and a special message is transmitted to enable the receiver to determine a number of false alarms

   ---

3. claims: 36-38, 51, 52

   Adjusting the threshold of the detector according to the feedback: if the receiver notices too many miss-detections, counter-measures must be applied to avoid/reduce miss-detections

   ---

4. claims: 53-57

   Signalling parameters related to the number of configured grants and associated feedback to enable the transmission of feedback.