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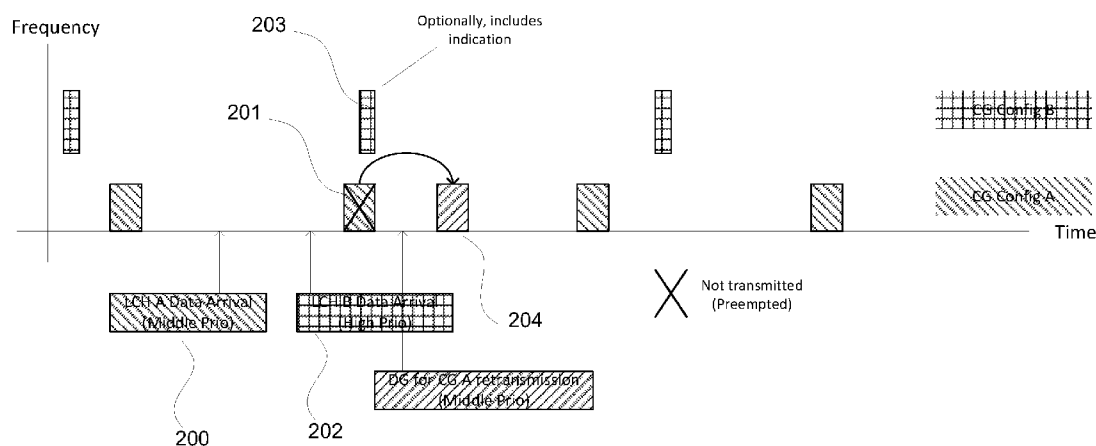


Figure 2

(57) **Abstract:** There is disclosed a method of data transmission in a cellular communications network, the method comprising the steps of at a UE receiving an LCH mapping restrictions configuration, which configuration configures the UE, based on a shared HARQ process ID for configured grant and dynamic grant resources, to apply implicit LCH mapping restrictions from the configured grant resources to the dynamic grant resources; attempting to transmit a transport block (TB) using configured grant resources, wherein the transmission attempt is pre-empted or cancelled; and utilising dynamic grant resources for retransmission of the transport block.



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Transmission Prioritisation

Technical Field

[1] The following disclosure relates to procedures for prioritisation of transmissions in a cellular system, and in particular to prioritisation of uplink transmissions following pre-emption or cancellation of a transmission.

Background

[2] Wireless communication systems, such as the third-generation (3G) of mobile telephone standards and technology are well known. Such 3G standards and technology have been developed by the Third Generation Partnership Project (3GPP). The 3rd generation of wireless communications has generally been developed to support macro-cell mobile phone communications. Communication systems and networks have developed towards a broadband and mobile system.

[3] In cellular wireless communication systems User Equipment (UE) is connected by a wireless link to a Radio Access Network (RAN). The RAN comprises a set of base stations which provide wireless links to the UEs located in cells covered by the base station, and an interface to a Core Network (CN) which provides overall network control. As will be appreciated the RAN and CN each conduct respective functions in relation to the overall network. For convenience the term cellular network will be used to refer to the combined RAN & CN, and it will be understood that the term is used to refer to the respective system for performing the disclosed function.

[4] The 3rd Generation Partnership Project has developed the so-called Long Term Evolution (LTE) system, namely, an Evolved Universal Mobile Telecommunication System Territorial Radio Access Network, (E-UTRAN), for a mobile access network where one or more macro-cells are supported by a base station known as an eNodeB or eNB (evolved NodeB). More recently, LTE is evolving further towards the so-called 5G or NR (new radio) systems where one or more cells are supported by a base station known as a gNB. NR is proposed to utilise an Orthogonal Frequency Division Multiplexed (OFDM) physical transmission format.

[5] The NR protocols are intended to offer options for operating in unlicensed radio bands, to be known as NR-U. When operating in an unlicensed radio band the gNB and UE must compete with other devices for physical medium/resource access. For example, Wi-Fi, NR-U, and LAA may utilise the same physical resources.

[6] A trend in wireless communications is towards the provision of lower latency and higher reliability services. For example, NR is intended to support Ultra-reliable and low-latency communications (URLLC) and massive Machine-Type Communications (mMTC) are intended to provide low latency and high reliability for small packet sizes (typically 32 bytes). A user-plane latency of 1ms has been proposed with a reliability of 99.99999%, and at the physical layer a packet loss rate of 10^{-5} or 10^{-6} has been proposed.

[7] mMTC services are intended to support a large number of devices over a long life-time with highly energy efficient communication channels, where transmission of data to and from each device occurs sporadically and infrequently. For example, a cell may be expected to support many thousands of devices.

[8] The disclosure below relates to various improvements to cellular wireless communications systems.

Summary

[9] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[10] In summary a method is provided to inherit LCH mapping restrictions from CG resources to DG resources. Those DG resources may be utilised to transmit a TB which was scheduled for transmission on the CG resources, but which was pre-empted or cancelled. The method includes the cellular network indicating an LCH mapping restrictions configuration to a UE utilising RRC signalling. The configuration may include an indication to apply implicit LCH mapping restrictions whereby a shared HARQ process ID for CG and DG resources indicates to apply the LCH mapping restrictions from the CG resource to the DG resources. The configuration may be also be such that a DCI message scheduling DG resources explicitly indicates to apply inheritance to those DG resources. There is therefore disclosed a method of indicating LCH mapping restriction inheritance, comprising transmitting an inheritance configuration to a UE, and subsequently transmitting a scheduling message (e.g. a DCI message) including an indication to apply LCH mapping restrictions from other resources to the indicated resources.

[11] There is also provided a method for application at a UE, comprising receiving an LCH mapping restriction inheritance configuration, attempting to transmit data on CG resources, but that transmission being pre-empted or cancelled by higher priority data, receiving a scheduling message scheduling DG resources for transmission of the pre-empted or cancelled data, applying LCH mapping restrictions from the CG resources to the DG resources, and transmitting the pre-empted or cancelled data in accordance with the LCH mapping restrictions. The scheduling message may include an explicit indication to apply LCH mapping restriction inheritance.

[12] The non-transitory computer readable medium may comprise at least one from a group consisting of: a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read Only Memory, a Programmable Read Only Memory, an Erasable Programmable Read Only Memory, EPROM, an Electrically Erasable Programmable Read Only Memory and a Flash memory.

Brief description of the drawings

[13] Further details, aspects and embodiments of the invention will be described, by way of example only, with reference to the drawings. Elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. Like reference numerals have been included in the respective drawings to ease understanding.

[14] Figure 1 shows selected elements of an exemplary cellular communications network; and

[15] Figures 2 to 11 show various examples of data transmission from a UE to a base station.

Detailed description of the preferred embodiments

[16] Those skilled in the art will recognise and appreciate that the specifics of the examples described are merely illustrative of some embodiments and that the teachings set forth herein are applicable in a variety of alternative settings.

[17] Figure 1 shows a schematic diagram of three base stations (for example, eNB or gNBs depending on the particular cellular standard and terminology) forming a cellular network. Typically, each of the base stations will be deployed by one cellular network operator to provide

geographic coverage for UEs in the area. The base stations form a Radio Area Network (RAN). Each base station provides wireless coverage for UEs in its area or cell. The base stations are interconnected via the X2 interface and are connected to the core network via the S1 interface. As will be appreciated only basic details are shown for the purposes of exemplifying the key features of a cellular network. The interface and component names mentioned in relation to Figure 1 are used for example only and different systems, operating to the same principles, may use different nomenclature.

[18] The base stations each comprise hardware and software to implement the RAN's functionality, including communications with the core network and other base stations, carriage of control and data signals between the core network and UEs, and maintaining wireless communications with UEs associated with each base station. The core network comprises hardware and software to implement the network functionality, such as overall network management and control, and routing of calls and data.

[19] Scheduled transmissions of data may be dropped if the transmission is pre-empted by a higher-priority transmission. It is then necessary to reschedule (or lose) the dropped transmission. The collision, and pre-emption, may occur between channels of the same UE, or between different UEs. Re-scheduling of traffic can be particularly important for Time Sensitive Communications (TSC) traffic or other data where latency is a significant concern, such as URLLC traffic.

[20] The lower layers of NR are split into several layers, including Radio Link Control (RLC), the Medium Access Control (MAC), and the physical layer. The MAC sublayer offers to the RLC sublayer logical channels, and the physical layer offers to the MAC sublayer transport channels, e.g. UL-SCH (in uplink). MAC PDUs transmitted on UL-SCH are referred to as transport blocks (TB).

[21] In NR Rel-15, the UE MAC entity shall have an uplink grant to transmit on the UL-SCH transport channel. The uplink grant provides PHY time/frequency resources for the corresponding PUSCH transmission. The uplink grant is either received dynamically on the PDCCH (dynamic grant, DG), in a Random Access Response, or configured semi-persistently by the RRC layer (configured grant, CG).

[22] The MAC entity uses several independent HARQ processes for TB transmission. The initial transmission on a HARQ process, which involves new TB building and submission to the corresponding HARQ process buffer, is referred to as new transmission. Following transmission of the same TB used for initial transmission on the same HARQ process is referred to as retransmission. When not otherwise specified, "transmission" may apply both to new transmission or retransmission cases.

[23] The CG system enables a base station to allocate periodic uplink resources on a pre-scheduled basis for the initial HARQ transmission opportunity. Each occurrence of the uplink resources may be termed a "Transmission Occasion" or "Transmission opportunity" (TO) of the relevant CG. Two types of configured uplink grants are generally defined.

[24] In Type 1 the RRC layer directly provides the configured uplink grant (including the periodicity). In Type 2, the RRC layer defines the periodicity of the configured uplink grant resources while PDCCH addressed to CS-RNTI can signal to activate the configured uplink grant or deactivate it; i.e. a PDCCH addressed to CS-RNTI indicates that the uplink grant can be implicitly reused according to the periodicity defined by RRC, until deactivated.

[25] In NR, skipping of CG UL resources is anticipated to be enabled by default (and can be configured for DG). In accordance with this the MAC entity will not generate a MAC PDU for the HARQ entity if the following conditions are satisfied:

- the MAC entity is configured with *skipUplinkTxDynamic* and the grant indicated to the HARQ entity was addressed to a C-RNTI, or the grant indicated to the HARQ entity is a configured uplink grant; and
- there is no aperiodic CSI requested for this PUSCH transmission as specified in TS 38.212; and
- the MAC PDU includes zero MAC SDUs; and
- the MAC PDU includes only the periodic BSR and there is no data available for any LCG, or the MAC PDU includes only the padding BSR.

[26] If these conditions are met the UL grant TO is “skipped” (no transmission is performed).

[27] CG may be used for sporadic low latency traffic. In such cases, a short periodicity is used, and most of TOs of the CG may not be used (skipped). When CG is used for TSC traffic, periodicity can span from very short to arbitrary long depending on the traffic pattern. However, it is expected that all (or most) TOs are used since TSC traffic is not sporadic.

[28] In NR, an “assume ACK” scheme is used for CG, in which upon sending a new transmission, the UE will assume that a transmission is ACKed (at HARQ level) upon expiry of a timer (configured grant timer) if it has not received a retransmission request by the base station before expiry. That is, positive ACK messages are not sent. This requires that the base station must very efficiently detect transmissions, since a missed detection will not lead to a retransmission request and the UE will consider that the TB was successfully received which can lead to packet loss (if e.g. RLC UM is used).

[29] It is expected that multiple CGs will be supported, principally in order to be able to map TSC traffic to CGs.

[30] The MAC sublayer provides data transfer services on logical channels (LCHs). To accommodate different kinds of data transfer services, multiple types of LCHs are defined, each supporting transfer of a particular type of information. For user traffic, Dedicated Traffic Channel LCHs are used. The MAC performs multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels. The multiplexing is performed within the Logical channel prioritization (LCP) function, based on LCH parameters such as LCH priority.

[31] LCH mapping restrictions can be defined on a per LCH basis, restraining the possible mapping of a LCHs to transmission resources (for instance, on CG Type 1 grant only). It is anticipated that multiple CGs are supported, and that the LCH mapping restriction is extended to enable for instance mapping of any LCH to any CG.

[32] An UL grant conflict (or collision) occurs when different PUSCH transmissions would overlap in time and/or in time/frequency. Generally, a UE might not have the capability within a single HARQ entity to transmit PUSCH transmissions overlapping in time even if they do not overlap, i.e. UL grant collision occurs when corresponding PUSCH transmission would overlap in time, at least within the same carrier. However, a UE may have a capability to transmit time overlapping PUSCH transmissions as long as they are not overlapping in frequency (for instance, a UE may support UL CA and the capability to transmit 2 PUSCHs at the same time on two different carriers). In such case, UL grant collision occurs when corresponding PUSCH transmissions overlap in time/frequency.

[33] As can be seen, UL grant conflict / collision is also a matter of UE capability, and the following disclosure is not restricted to a particular kind of conflict. An UL grant conflict / collision may be generally defined as a situation when the UE does not have the capability to transmit simultaneously the PUSCH transmissions corresponding to the UL grants (while it could have transmitted those PUSCH separately).

[34] In general, a DG is sent following an earlier BSR (Buffer Status Report) from the UE, hence data transmission is expected, and a CG may be used for sporadic traffic (for latency reduction purpose), in which case most of the time there is no data to transmit and the transmission may be skipped. In such case, an UL grant conflict may occur only when there is effectively data available for transmission on the corresponding UL grant.

[35] It is anticipated that for IIoT in case of conflict, UL grants should be prioritized based on the highest priority of data that can be transmitted in the grant.

[36] For handling UL grant conflict, there are 2 main methods which can be utilised to address the conflict:

- MAC prioritizes/selects the grant – for example, configured grants (CG) conflicting with a dynamic grant (DG) are ignored i.e. not processed by MAC. Unless otherwise specified, we will use the term “cancelled” transmission/TB/PDU to refer to this case where the potential new data transmission on the CG TO (which would have taken place assuming data to be transmitted on the corresponding CG TO) did not occur because e.g. the corresponding UL CG TO was just ignored by MAC. That is to say, in case of cancelled transmission, there is no built TB in HARQ buffer corresponding to that transmission.
- MAC does not perform such prioritization/selection – for example, MAC has handled a first DG (e.g. prepared and submitted the TB for transmission) and then receives a later DG conflicting with the first one. The general understanding is that the NW sends the 2nd DG with full knowledge that it should pre-empt (have priority) over the first one. Hence, MAC handles the 2nd DG and PHY handles conflicting transmissions. Unless otherwise specified, we will use the term “pre-empted” or “dropped” transmission/TB/PDU to refer to this case where the data transmission on the CG TO did not occur whereas a TB was actually built by MAC, stored in a HARQ buffer but not transmitted e.g. because PHY prioritized a later DG transmission conflicting with this CG TO transmission.

[37] Time Sensitive Communication (TSC), or equivalently Time Sensitive Networking (TSN), traffic is typically periodic, deterministic (bounded latency), as well as scheduled, i.e. with a known transmission time (and possibly known jitter) relative to a time reference. TSN scheduled traffic enhancements are detailed in 802.1Qbv specification.

[38] If in case of conflict, UL grants should be prioritized based on the highest priority of data that can be transmitted in the grant, an issue may occur if the lower priority data is from a CG. It is possible that a new transmission on a CG is pre-empted or cancelled, for instance by a higher priority CG transmission (it was agreed that CG/CG conflict is possible), or by a DG (which could be for instance for a retransmission of higher priority data). Generally, CG are used for UM data (either periodic or sporadic low latency).

[39] TSC traffic is deterministic (bounded latency) and periodic, and targets very high reliability. Pre-emption of CG resources used to carry TSC traffic would lead to packet loss which is not acceptable for this kind of traffic. Though focused on TSC traffic, the embodiments and methods described are also applicable to any traffic using CG and for which QoS would require to dynamically schedule a new transmission or retransmission when a CG transmission is pre-empted or cancelled. This is the case for URLLC traffic.

[40] A method of addressing pre-emption of a CG resource is to utilise the next CG resource. However, this is not acceptable for TSC traffic as the latency would be too large.

[41] Figure 2 shows an example more appropriate for TSC traffic. In this example there are two sets of CG resources – CG config B and CG config A. LCH A is mapped to CG config A, and LCH B to CG config B. LCH B has a higher priority than LCH A.

[42] Generally, it is understood that the important events here are the time instants when MAC/PHY processing is started and cannot be potentially cancelled by UE implementation. It is sometimes considered for description simplification that the MAC/PHY processing is started and cannot be cancelled as soon as data is received for a given UL grant (e.g. a following CG TO), but the UE may e.g. based on implementation or standardization delay such processing so that the transmission can be cancelled (equivalently the UL grant can be ignored).

[43] At 200 data arrives on LCH A and can be scheduled for TO 201 on CG config A. However, at 202, after the data for TO 201 is sent to the PHY layer, data arrives on LCH B (with a higher priority) and is thus scheduled for TO 203 on CG config B, but this conflicts with TO 201. The LCH B data thus pre-empts LCH A data and is transmitted in TO 203. The cellular network (once aware of the pre-emption) schedules DG resources 204 (for example using CS-RNTI) for transmission of the LCH A data.

[44] Figure 3 shows the opposite example to Figure 2 in which higher priority data arrives at 300 prior to lower priority data which arrives at 301 after the higher priority data has been sent to PHY. The MAC layer can build a TB to carry the lower priority data and send it to PHY, even though it knows it won't be transmitted. Once the network is aware the data has not been sent it can again schedule DG resources 302 which are used to transmit the LCH A data.

[45] A drawback of Figures 2 and 3 however is that the MAC layer has to form TBs for all data, even though they may not be transmitted, rather than allowing the MAC layer to perform prioritisation.

[46] To exemplify the disclosure an example scenario with 2 LCHs is used. LCH A corresponds to middle priority traffic (for example TSC), and LCH B corresponds to high priority traffic (for example URLLC or TSN). LCH A is mapped to CG A and LCH B is either mapped to a CG B, and/or may utilise DG resources (DG B, for which LCH restrictions allow LCH B mapping).

[47] Figure 4 shows an example scenario which will be used for explanation. At event 400 LCH A (middle priority) traffic arrives for transmission on CG A. MAC starts processing the data (LCP, build TB A, deliver to PHY) for transmission on the next CG TO 401. At event 402 the MAC layer receives a request for transmission of LCH B data on an Uplink Grant B (ULG B). The ULG B may be CG B (the request is when new data arrives on LCH B), or an uplink grant message for DG B (the request is reception of a DG B). It might be for instance a DG for retransmission of an earlier CG B transmission.

[48] Events 400 & 402 refer to the point in time at which MAC/PHY processing is started and cannot be cancelled by UE implementation (i.e. Event 400 would be the time when such processing starts, independently of when the data for LCH A was received before).

[49] In the example of Figure 4, where event 400 (lower/middle priority) occurs before event 402 (higher/high priority), the TB-B pre-empts TB-A and TB-B is transmitted on CG B resources at 404. TB-A can then be transmitted on subsequent DG resources according to a CS-RNTI indication.

[50] Figure 5 shows an example in which event 400 (lower/middle priority) occurs after event 403 (higher/high priority). In this example the MAC layer has begun processing the high priority

data from event 403 when the lower priority data arrives at event 400. The MAC layer may therefore transmit a TB A for the lower priority data to the physical layer, knowing it will not be transmitted (pre-empted/dropped transmission), or perform prioritisation and ignore the TO on CG A which conflicts with the ULG B (cancelled transmission). In the figure, we assume the MAC layer performs UL grant prioritization/selection, e.g. by ignoring the CG A transmission opportunity conflicting with the ULG B. This is preferable as this avoids useless processing at the UE.

[51] The cellular network can request new transmission resources for LCH A (for example a new DG A as shown at 500 in Figure 5), but this may have drawbacks.

[52] A new transmission using a DG A would not use the same LCH restrictions as the ones configured for CG A. To support IIoT use cases efficiently (in particular TSC traffic patterns), multiple CGs are supported (it is expected that up to 16 can be configured, corresponding to the maximum HARQ process number). It is expected that it will be possible to map any LCH(s) to any CG(s) configuration.

[53] In the example above, LCH A is mapped on CG A such that only LCH A can be transmitted on CG A as per LCH mapping restrictions. If a DG A is used, such mapping restrictions would not be used, and other traffic could be considered a higher priority for transmission in TB A (LCH A and B may be only a few of the on-going traffic flows, and not the ones with the highest priority). This would again pre-empt transmission of the LCH A data, as LCH A data would not be included or only partially included in the transmission. An oversized UL grant could avoid further pre-emption by making sufficient resources available for all data, but this is not an efficient use of resources and would impact the processing delay at the UE. The UE should only be required to perform UL processing for TB A (LCH A) data – not for all other possible data buffered for transmission.

[54] This issue may be addressed by DG A, used for a new transmission of TB A, inheriting the LCH mapping restrictions of the corresponding CG A. When a DG A for the new transmission with LCH mapping restriction inheritance from CG A is received by the UE, the UE would apply the LCH mapping restrictions of the corresponding CG. That is, there is an inheritance of mapping restrictions from CG resources to DG resources. The TB for LCH A can thus be built exactly as if a TO of CG A was to be used for the transmission. This avoids the cellular network needing to provide oversized UL grants and avoids additional UE processing requirements.

[55] Set out below are options for implementing LCH mapping restriction inheritance.

[56] The Downlink Control Information (DCI) PHY message providing the new DG grant may include an explicit indication of the LCH mapping restrictions to be used for the indicated DG resources. For example, an LCH mapping index used by the MAC layer may be included. The indication may include a CG index, assuming CG configurations can be configured in the MAC layer with LCH restrictions. Including an explicit indication of inheritance provides flexibility (as configuration can be on a per-DG basis) but adds overhead to the DCI message. The use of a new DCI format including the inheritance field could be configured by the RRC layer. The presence of the inheritance field could indicate LCH mapping restriction inheritance.

[57] A given CG configuration may be associated to one or several HARQ processes. The HARQ process number in the DG transmission can thus be utilised to infer the CG configuration of the original resources intended for transmission of the TB. The UE can thus determine LCH mapping restrictions which were applicable for the CG resources and thus apply them to the new DG transmission resources. This enables an implicit indication of LCH mapping restriction inheritance without the need to add overhead in DCI. Use of such implicit inheritance can be indicated in RRC or MAC configuration. To improve flexibility implicit inheritance may be

configured on a per-CG basis rather than for all CGs. Implicit indication avoids additional signalling overhead in DCI but may be less flexible as inheritance cannot be defined on a per-DG basis.

[58] Generally, the HARQ processes of a CG may be reused for dynamic transmission (e.g. eMBB) when there is no CG traffic (for instance between 2 TOs). However, such re-use may not imply inheritance of the LCH mapping restrictions since different traffic is being carried. A system therefore may be required such that inheritance from CG to DG is not automatic in all cases.

[59] The inheritance of LCH mapping restrictions may also be dependent on TB size. For example, the restrictions may only be inherited if the DG TB size is the same as the CG TB size. This does not require any additional signalling and would only lead to incorrect inheritance in the situation where the DG T is for a different channel, but coincidentally has the same size. The cellular network scheduler could easily avoid such situation with very limited loss of scheduling flexibility.

[60] When implicit inheritance is configured, one bit may be added to the DCI message to indicate whether the LCH mapping restriction should be inherited for the particular grant. This provides increased flexibility but adds 1 bit of overhead to the DCI.

[61] LCH mapping restriction inheritance may be applied only when the DG falls within a certain time window corresponding to the CG or HARQ process. For example, in case of a single HARQ process for the CG, a time window starting from the CG TO and with a given length could be defined, such as only DG falling within such time window would be subject to LCH mapping restriction inheritance. DG outside the time window would not. The time windows can be defined as set out below for deciding whether a new transmission or retransmission is required.

[62] Similarly, LCH mapping restriction inheritance may also be applied only when the DG falls within a configured frequency range, e.g. a certain BWP or uplink carrier.

[63] The LCH mapping inheritance processes described herein may also be applied in the context of inter-UE prioritisation. In certain situations, the cellular network may cancel a CG transmission (for example using a "cancellation indication" due to a collision with another UE; note that even though cancellation wording is used, the NW may not know whether a TB was built or not i.e. the transmission may be actually pre-empted or cancelled) and schedule DG resources with LCH mapping inheritance to replace the cancelled CG resources. A common message could be used to indicate both the cancellation, and replacement resources. For example, a DCI may be transmitted to schedule the DG resources which includes an indication cancelling the CG resources and to apply the same LCH mapping restrictions to the DG resources. The common message may implicitly cancel the CG resources by including the HARQ process number which indicates the next TO of the CG to be cancelled.

[64] Resources scheduled to replace CG resources (which were cancelled, or pre-empted) may be selected in any appropriate manner by the cellular network. For example, the resources may be on the same or different frequencies and at any appropriate location in time. Figure 6a shows an example in which pre-empted CG resources 600 are replaced with DG resources 601 at the same frequency position, but later in time. Figure 6b shows an example in which pre-empted CG resources 602 are replaced by DG resources 603 at the same time, but at a different frequency which avoids the conflicting resources.

[65] When scheduling DG resources to replace the CG resources, it must be decided whether this is a new transmission or retransmission, and how that is indicated to the UE. When addressing a DG to a UE, the DCI can be scrambled by different RNTIs previously configured for the UE. The CS-RNTI is currently only used for retransmission of CG (as well as

activation/release in case of Type 2). The CS-RNTI currently cannot be used to trigger a new transmission.

[66] Generally, the C-RNTI (equivalently MCS-C-RNTI) currently can be used for new transmission. The C-RNTI will trigger a new transmission if the corresponding HARQ process was previously used either for a CG or a CS-RNTI based retransmission (or if it is empty), i.e. in that case the NDI is ignored. The C-RNTI can be used for a retransmission in case the process was previously used for a new transmission triggered by C-RNTI with the same NDI.

[67] Using a C-RNTI based DG on the CG HARQ process will always trigger a new transmission (except when used for retransmission following the initial transmission of the DG). Using a CS-RNTI based DG on the CG HARQ process will always trigger a retransmission. However, the cellular network might not know whether to trigger a new transmission or a retransmission. In the intra-UE prioritization case (i.e. a CG transmission is pre-empted or cancelled by another transmission (LCH) of the same UE), an indication in the pre-empting TB B can be used so that the NW is aware of a potential pre-emption or cancellation of transmission, but this may be complex to implement. This approach would not be suitable in the inter-UE case where a UE's CG resources are pre-empted or cancelled due to a transmission from a different UE.

[68] It may be preferable to use the same approach for situations where a retransmission is needed since transmission was pre-empted (Lower priority event occurs before higher priority event – Figure 4) and where a new transmission is needed since initial transmission was cancelled (Higher priority event occurs before lower priority event – Figure 5).

[69] The handling of C-RNTI scrambled DCI messages can be modified as set out below to provide the required behaviours. For purposes of explanation, the case of scheduled TSC traffic, which is periodic and deterministic (bounded latency) can be considered. Generally, such traffic will consist of 1 data packet every TSC period, which needs to be transmitted within a latency bound typically equal to the periodicity. The transmission is performed using CG resources. A concept of a periodic time window is defined. The start of such time windows can occur with a periodicity equal to the CG periodicity (which may correspond to the TSC periodicity). The time windows can be aligned with the CG (i.e. starts with each TO of the CG) or may be aligned different if appropriate.

[70] The duration of the time windows can be equal to the TSC or CG periodicity or be a multiple of such periodicity. The duration may be defined implicitly based on the periodicity or may be configured by RRC signalling. The duration can reuse the configured grant timer duration, which may be attractive as the configured grant timer duration may correspond to when retransmission can be scheduled. Alternatively, the time window may be derived from the HARQ process equation for the corresponding CG. For instance, a DG would use the HARQ Process ID associated to a CG which it is replacing. The HARQ process equation for the CG defines time windows for DG using one HARQ Process ID associated to a CG.

$$\text{HARQ Process ID} = [\text{floor}(\text{CURRENT_symbol}/\text{periodicity})] \bmod n_{\text{rofHARQ-Processes}}$$

[71] The following formula could be used so that the windows start along with the CG TO:

$$\text{HARQ Process ID} = [\text{floor}((\text{CURRENT_symbol} - \text{CG_TimeOffset})/\text{periodicity})] \bmod n_{\text{rofHARQ-Processes}}$$

[72] Within each time window, a CG TO occurs for which the UE is expected to build/transmit a TB. Whenever the CG TO in a window is cancelled or pre-empted by a DG addressed to a HARQ process allocated to a CG, a new transmission or retransmission is triggered depending

on whether the TB for the corresponding time window (i.e. the time window which includes the CG TO which is pre-empted by the DG) was already built (and is buffered in the HARQ process) or not. If the TB for the corresponding time window is already built (and buffered in the HARQ process buffer) a retransmission is triggered, or if the TB for the corresponding time window is not already built a new transmission is triggered (i.e. generate a TB).

[73] Example implementations of the above techniques are described below, with reference to the noted figures, in which one HARQ process is used for the CG. The modified DG behaviour is referred to as EDG (enhanced DG) for convenience of description only. As is clear from the following examples, the same DG (EDG) is used for both new transmissions and retransmissions, and accordingly the cellular network does not need to be aware of whether the UE has already built the TB or not when transmitting the scheduling message.

[74] Figure 7 shows an example in which the EDG is used to override a CG using resources at the same time. A CG might be overridden by a DG, when overlapping resources are scheduled by the NW (for instance, at the same time instant). The overridden CG is ignored, and the DG is used for a new transmission. Such behaviour is generally the baseline for CG/DG scheduling, as it enables NW scheduling flexibility between UEs, and could be kept with the modified EDG behaviour.

[75] The EDG may provide several additional functionalities as described below.

[76] Figure 8 shows an example in which CG resources are replaced by DG resources later in the same time window, but at the same frequency as the CG resources. CG overriding within the same time window provides the cellular network with additional scheduling flexibility as it can override a CG while not having to schedule a DG on the same resources. Instead, the NW could just schedule the DG in the corresponding time window. This is especially effective for TSC traffic since the cellular network knows the traffic requirements and can hence decide on an appropriate position for the retransmission. For example, the cellular network may be aware of how much the transmission can be delayed while still meeting the quality of service requirements.

[77] As set out above the principles of the EDG can be used to trigger a retransmission. In this disclosure the term “retransmission” is used from the perspective of the UE HARQ entity. A TB was already built due to an earlier UL grant, but may not have been actually transmitted by the Physical layer (in case of pre-emption). Hence, the EDG triggers a retransmission from HARQ entity point of view, even though this could be the first actual transmission of the TB.

[78] As shown in Figures 9 & 10 a lower priority transmission, which is pre-empted by a higher priority transmission, can be re-transmitted in the same time window as indicated by the EDG.

[79] An advantage of EDG may be that the same DG is used for both new transmission cases and retransmission cases – the NW does not have to know whether a TB was already built or not. This is decided based on timing of the EDG and whether TB was built or not for the corresponding time window.

[80] As noted above, the time windows may be offset to the CG resource periods. Setting the time window earlier than the CG period may enable the cellular network to schedule a DG in advance compared to the forthcoming CG if there is enough time between data arrival at the UE and the CG TO.

[81] The same principles can also be applied if there are multiple HARQ processes allocated to the CG. However, if multiple HARQ processes are allocated to the CG, the window can also use the period between 2 TOs of the same HARQ process, as the HARQ process number in the DG enables to identify a single TO within such an extended window. In such case the windows

may be overlapping, which may reduce DG scheduling restrictions, while keeping the same principle to identify the CG TO and corresponding TB.

[82] The principles described above for C-RNTI can also be applied to the use of CS-RNTI.

[83] This EDG should be configurable, as it is expected to be used only for specific traffic such as TSC traffic. For instance, it could be configured by RRC on a CG basis, on an LCH basis or on a HARQ process basis.

[84] The EDG (modified DG behaviour) could be advantageously combined with LCH mapping restriction inheritance, as both enables enhanced handling of rescheduling of cancelled CG TO. For instance, the configuration and conditions proposed for LCH mapping restriction inheritance could apply as well to EDG behaviour.

[85] Although not shown in detail any of the devices or apparatus that form part of the network may include at least a processor, a storage unit and a communications interface, wherein the processor unit, storage unit, and communications interface are configured to perform the method of any aspect of the present invention. Further options and choices are described below.

[86] The signal processing functionality of the embodiments of the invention especially the gNB and the UE may be achieved using computing systems or architectures known to those who are skilled in the relevant art. Computing systems such as, a desktop, laptop or notebook computer, hand-held computing device (PDA, cell phone, palmtop, etc.), mainframe, server, client, or any other type of special or general purpose computing device as may be desirable or appropriate for a given application or environment can be used. The computing system can include one or more processors which can be implemented using a general or special-purpose processing engine such as, for example, a microprocessor, microcontroller or other control module.

[87] The computing system can also include a main memory, such as random access memory (RAM) or other dynamic memory, for storing information and instructions to be executed by a processor. Such a main memory also may be used for storing temporary variables or other intermediate information during execution of instructions to be executed by the processor. The computing system may likewise include a read only memory (ROM) or other static storage device for storing static information and instructions for a processor.

[88] The computing system may also include an information storage system which may include, for example, a media drive and a removable storage interface. The media drive may include a drive or other mechanism to support fixed or removable storage media, such as a hard disk drive, a floppy disk drive, a magnetic tape drive, an optical disk drive, a compact disc (CD) or digital video drive (DVD) read or write drive (R or RW), or other removable or fixed media drive. Storage media may include, for example, a hard disk, floppy disk, magnetic tape, optical disk, CD or DVD, or other fixed or removable medium that is read by and written to by media drive. The storage media may include a computer-readable storage medium having particular computer software or data stored therein.

[89] In alternative embodiments, an information storage system may include other similar components for allowing computer programs or other instructions or data to be loaded into the computing system. Such components may include, for example, a removable storage unit and an interface, such as a program cartridge and cartridge interface, a removable memory (for example, a flash memory or other removable memory module) and memory slot, and other removable storage units and interfaces that allow software and data to be transferred from the removable storage unit to computing system.

[90] The computing system can also include a communications interface. Such a communications interface can be used to allow software and data to be transferred between a

computing system and external devices. Examples of communications interfaces can include a modem, a network interface (such as an Ethernet or other NIC card), a communications port (such as for example, a universal serial bus (USB) port), a PCMCIA slot and card, etc. Software and data transferred via a communications interface are in the form of signals which can be electronic, electromagnetic, and optical or other signals capable of being received by a communications interface medium.

[91] In this document, the terms 'computer program product', 'computer-readable medium' and the like may be used generally to refer to tangible media such as, for example, a memory, storage device, or storage unit. These and other forms of computer-readable media may store one or more instructions for use by the processor comprising the computer system to cause the processor to perform specified operations. Such instructions, generally referred to as 'computer program code' (which may be grouped in the form of computer programs or other groupings), when executed, enable the computing system to perform functions of embodiments of the present invention. Note that the code may directly cause a processor to perform specified operations, be compiled to do so, and/or be combined with other software, hardware, and/or firmware elements (e.g., libraries for performing standard functions) to do so.

[92] The non-transitory computer readable medium may comprise at least one from a group consisting of: a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read Only Memory, a Programmable Read Only Memory, an Erasable Programmable Read Only Memory, EPROM, an Electrically Erasable Programmable Read Only Memory and a Flash memory. In an embodiment where the elements are implemented using software, the software may be stored in a computer-readable medium and loaded into computing system using, for example, removable storage drive. A control module (in this example, software instructions or executable computer program code), when executed by the processor in the computer system, causes a processor to perform the functions of the invention as described herein.

[93] Furthermore, the inventive concept can be applied to any circuit for performing signal processing functionality within a network element. It is further envisaged that, for example, a semiconductor manufacturer may employ the inventive concept in a design of a stand-alone device, such as a microcontroller of a digital signal processor (DSP), or application-specific integrated circuit (ASIC) and/or any other sub-system element.

[94] It will be appreciated that, for clarity purposes, the above description has described embodiments of the invention with reference to a single processing logic. However, the inventive concept may equally be implemented by way of a plurality of different functional units and processors to provide the signal processing functionality. Thus, references to specific functional units are only to be seen as references to suitable means for providing the described functionality, rather than indicative of a strict logical or physical structure or organisation.

[95] Aspects of the invention may be implemented in any suitable form including hardware, software, firmware or any combination of these. The invention may optionally be implemented, at least partly, as computer software running on one or more data processors and/or digital signal processors or configurable module components such as FPGA devices.

[96] Thus, the elements and components of an embodiment of the invention may be physically, functionally and logically implemented in any suitable way. Indeed, the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. Although the present invention has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the accompanying claims. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognise

that various features of the described embodiments may be combined in accordance with the invention. In the claims, the term 'comprising' does not exclude the presence of other elements or steps.

[97] Furthermore, although individually listed, a plurality of means, elements or method steps may be implemented by, for example, a single unit or processor. Additionally, although individual features may be included in different claims, these may possibly be advantageously combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. Also, the inclusion of a feature in one category of claims does not imply a limitation to this category, but rather indicates that the feature is equally applicable to other claim categories, as appropriate.

[98] Furthermore, the order of features in the claims does not imply any specific order in which the features must be performed and in particular the order of individual steps in a method claim does not imply that the steps must be performed in this order. Rather, the steps may be performed in any suitable order. In addition, singular references do not exclude a plurality. Thus, references to 'a', 'an', 'first', 'second', etc. do not preclude a plurality.

[99] Although the present invention has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the accompanying claims. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognise that various features of the described embodiments may be combined in accordance with the invention. In the claims, the term 'comprising' or "including" does not exclude the presence of other elements.

Claims

1. A method of data transmission in a cellular communications network, the method comprising the steps of
 - at a UE receiving an LCH mapping restrictions configuration, which configuration configures the UE, based on a shared HARQ process ID for configured grant and dynamic grant resources, to apply implicit LCH mapping restrictions from the configured grant resources to the dynamic grant resources;
 - attempting to transmit a transport block (TB) using configured grant resources, wherein the transmission attempt is pre-empted or cancelled; and
 - utilising dynamic grant resources for retransmission of the transport block.

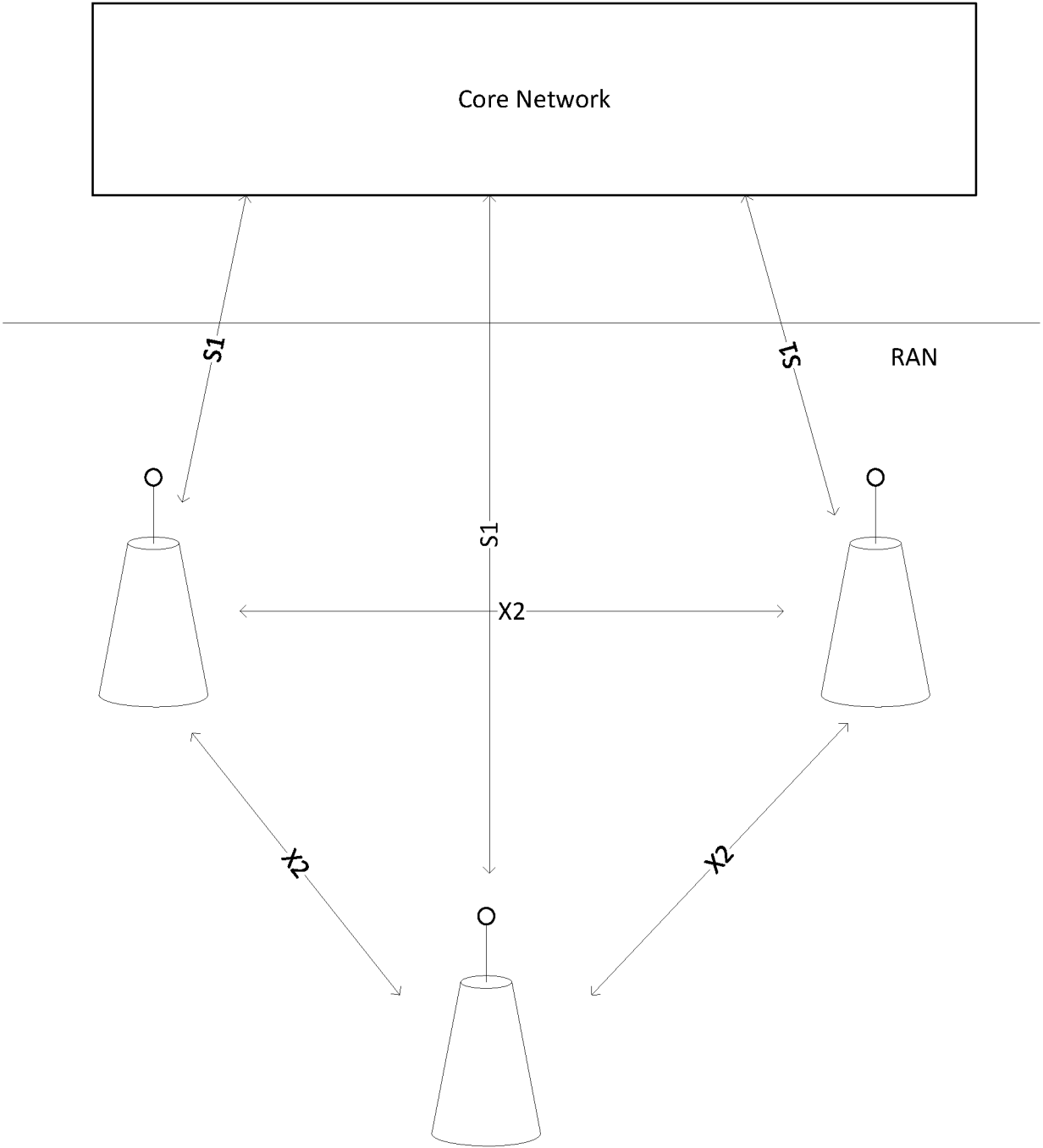


Figure 1

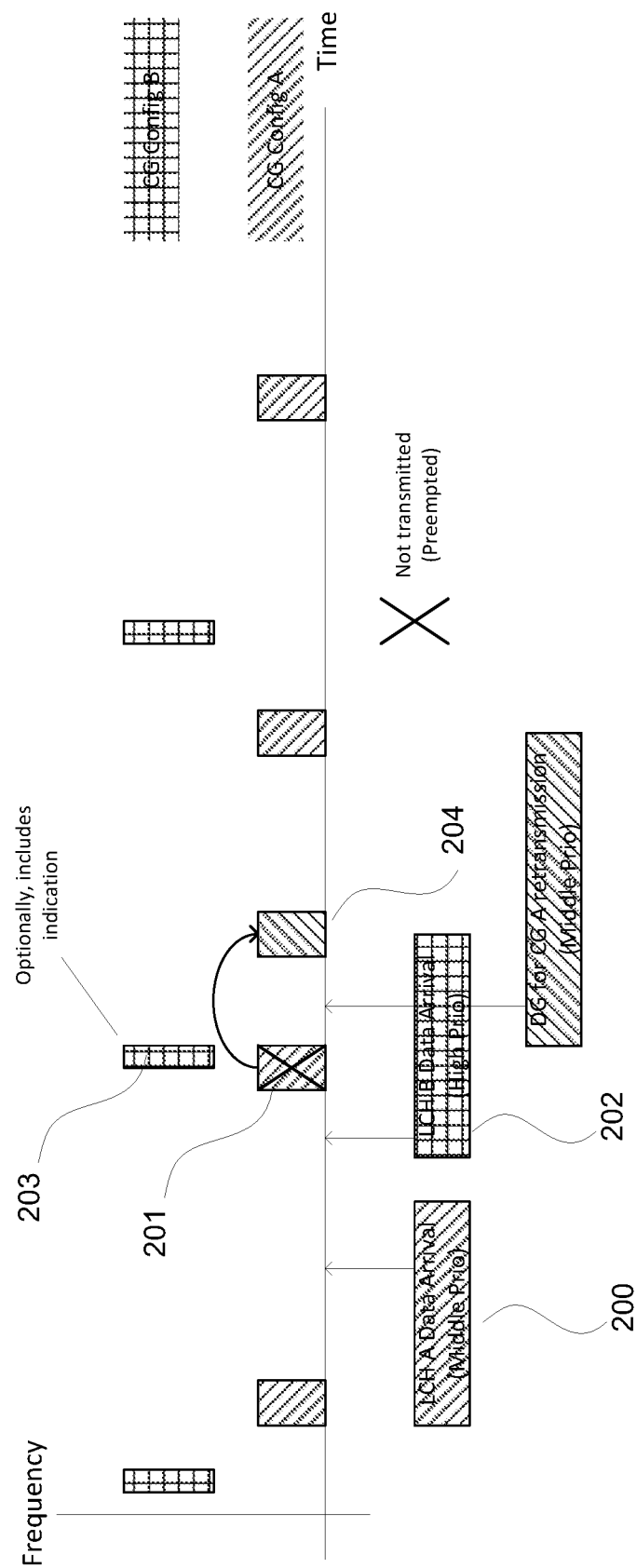


Figure 2

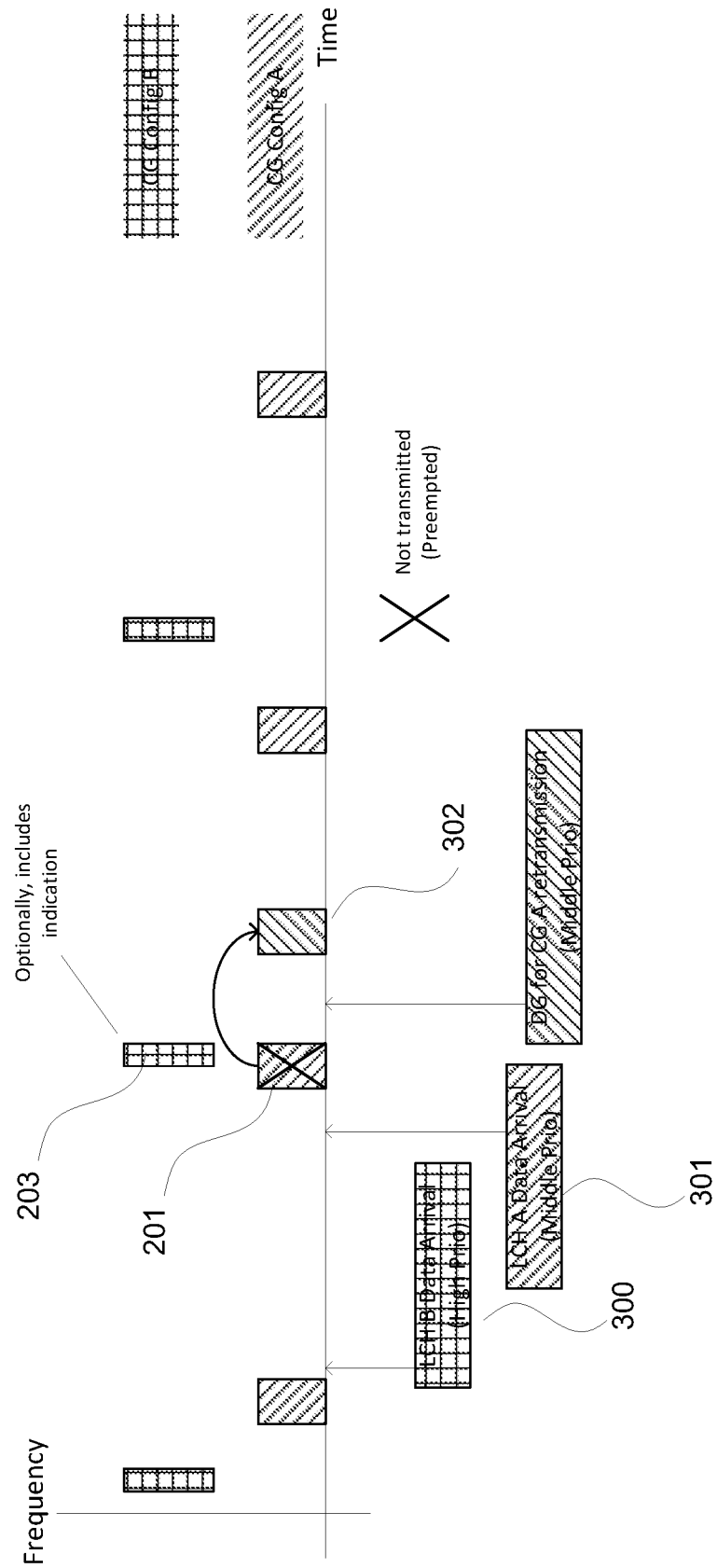


Figure 3

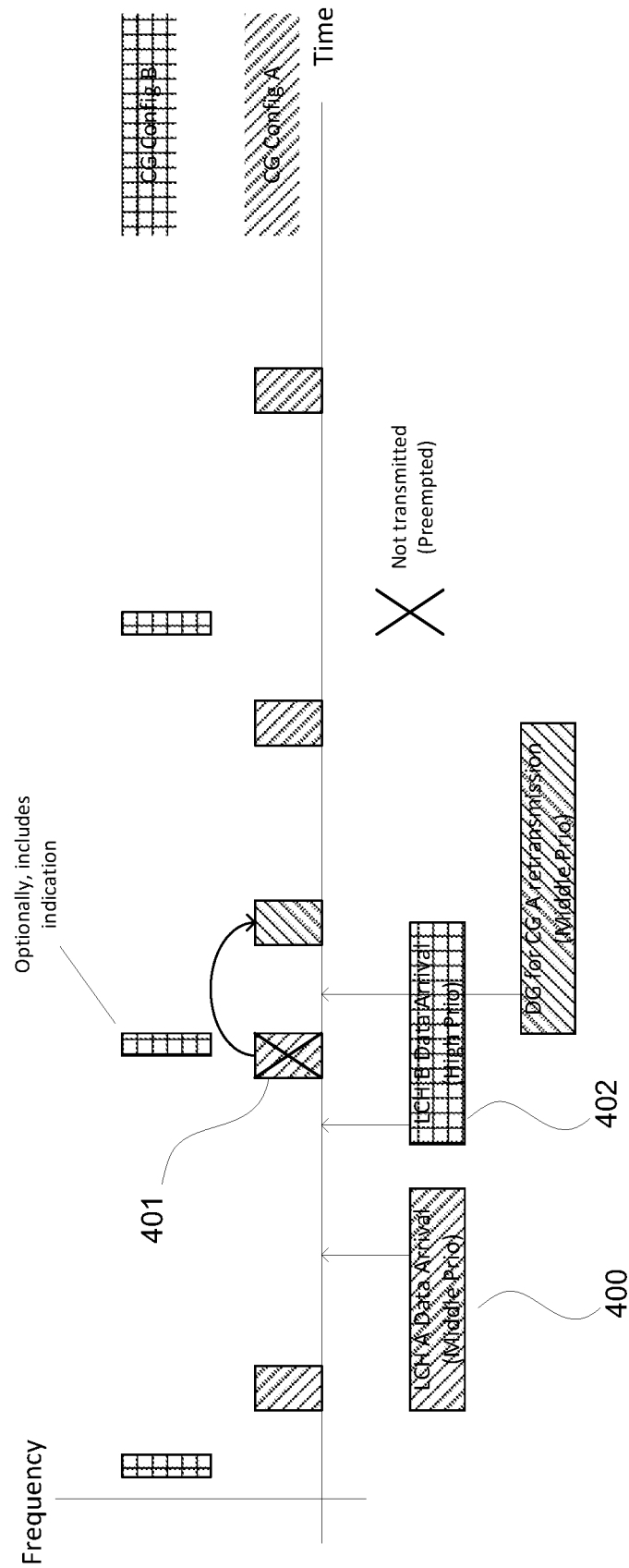


Figure 4

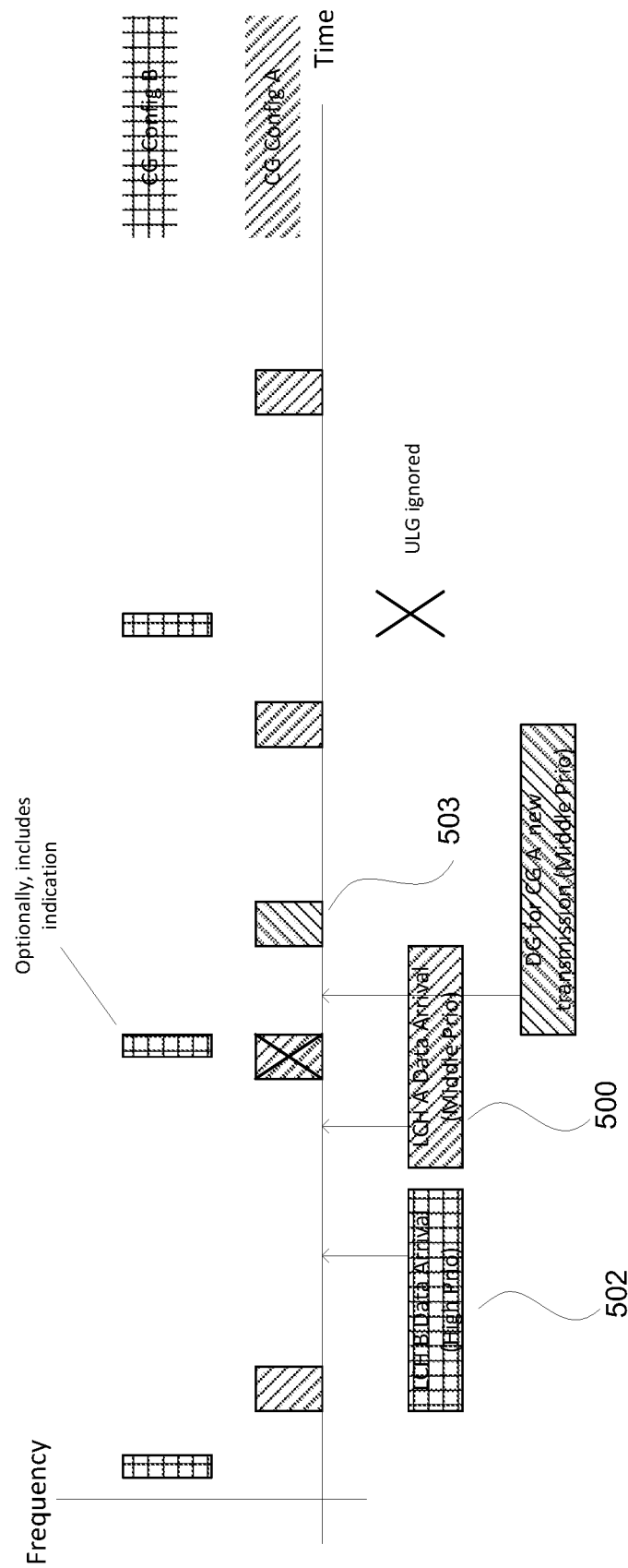


Figure 5

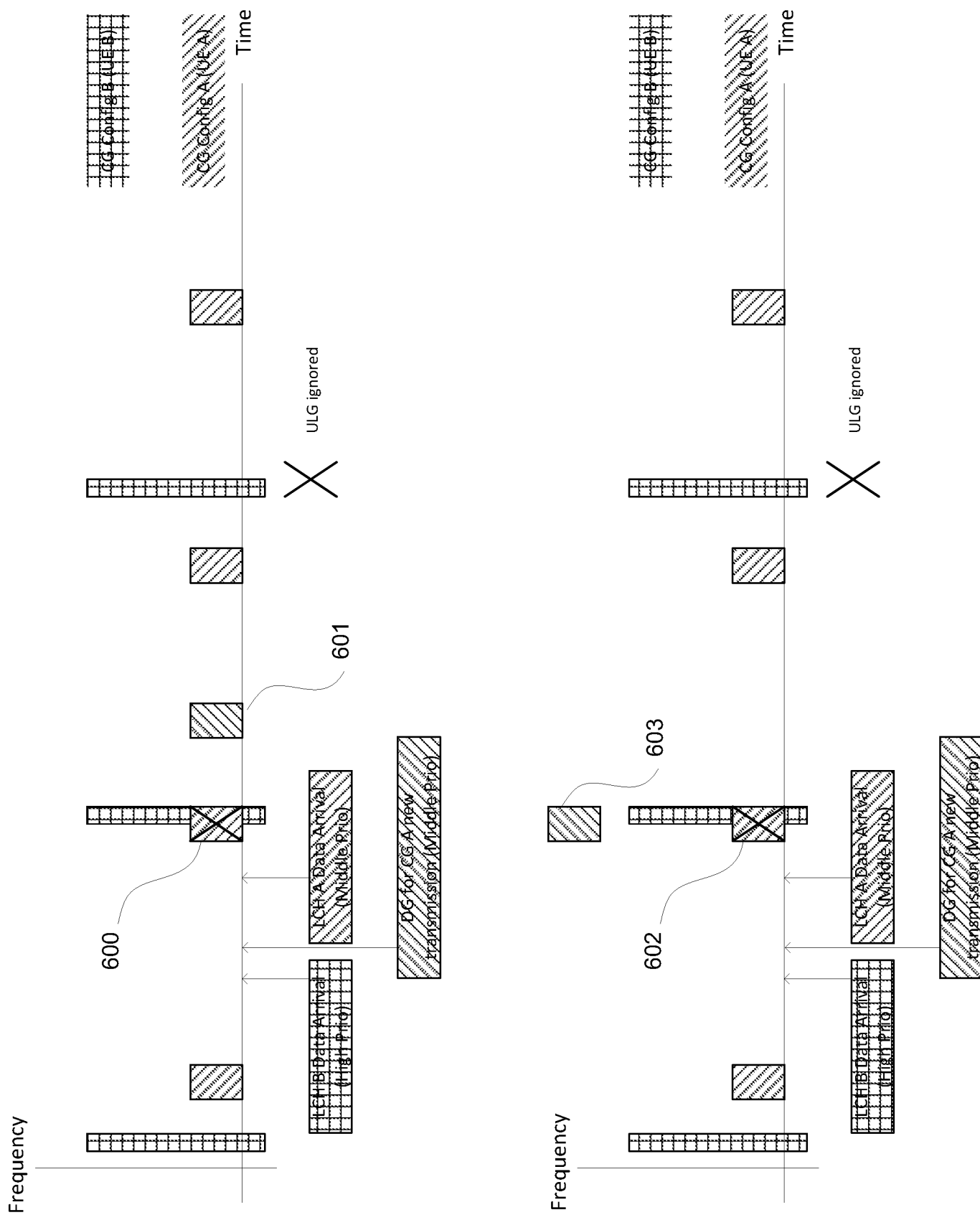


Figure 6

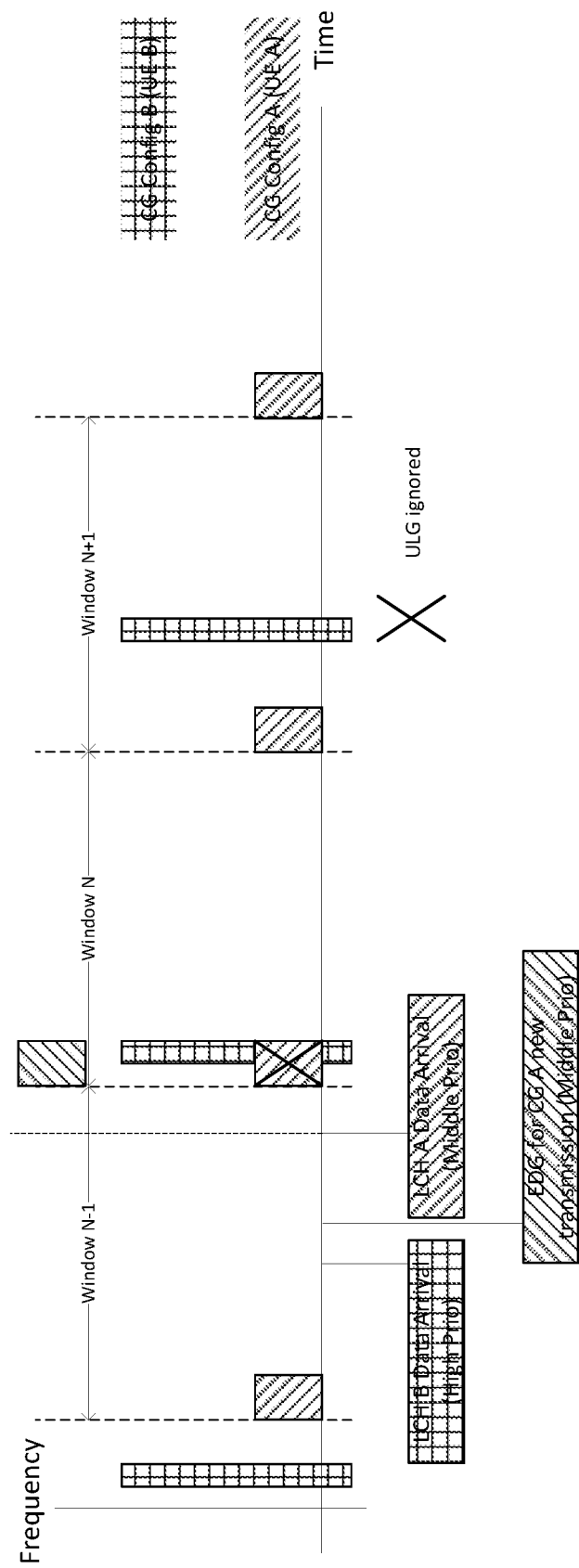


Figure 7

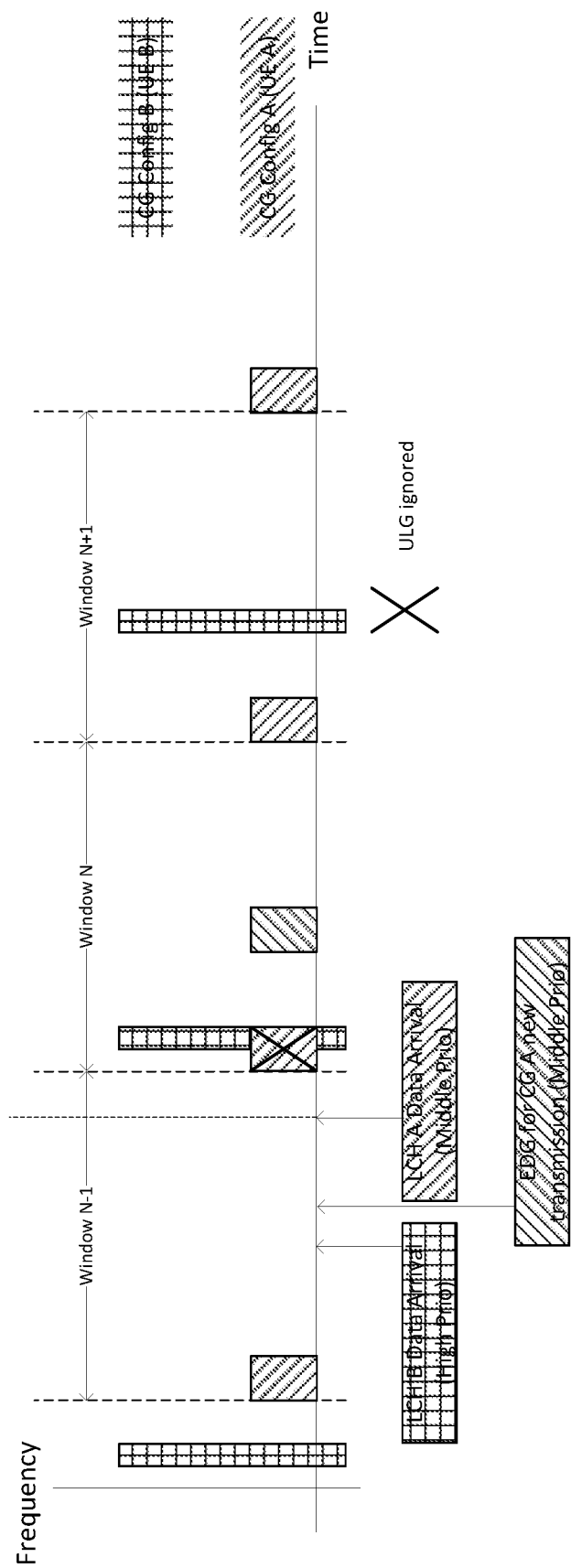


Figure 8

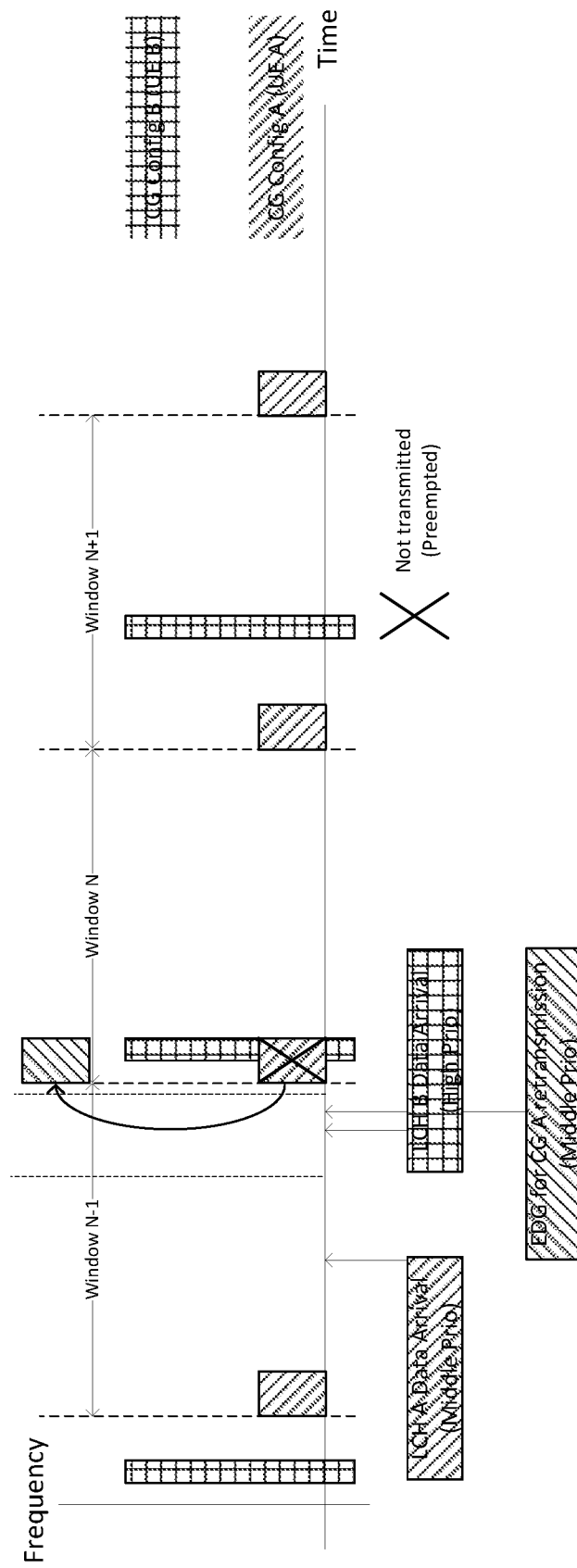


Figure 9

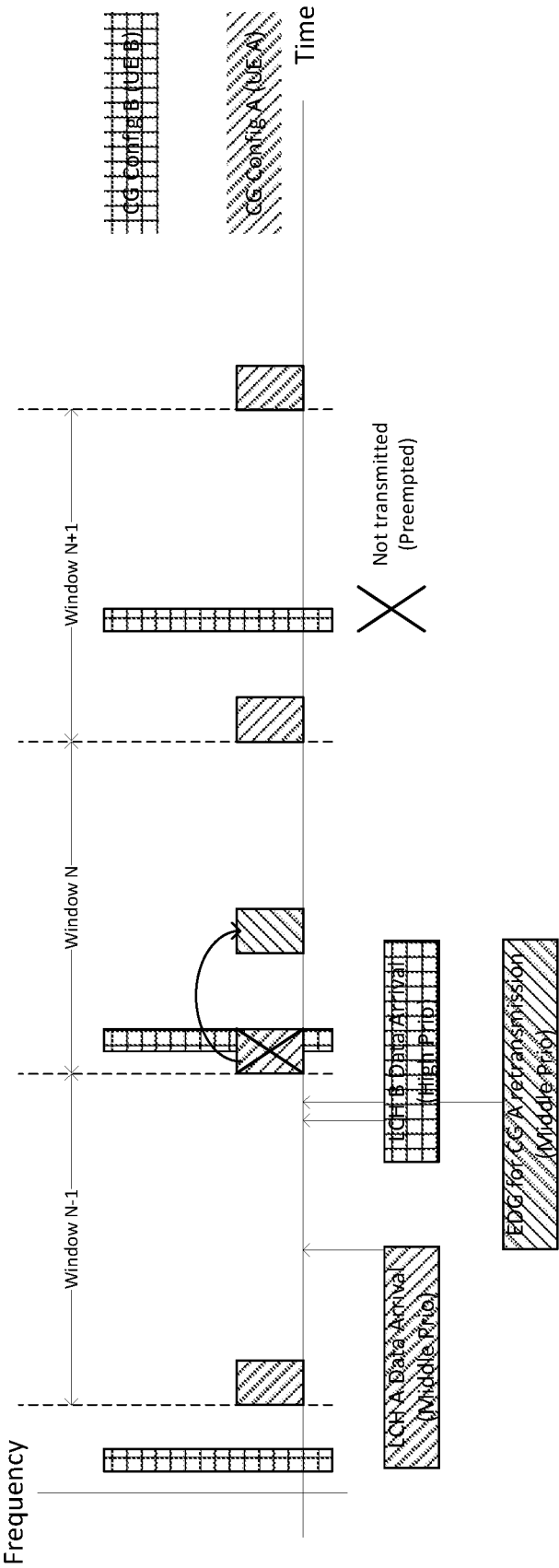


Figure 10

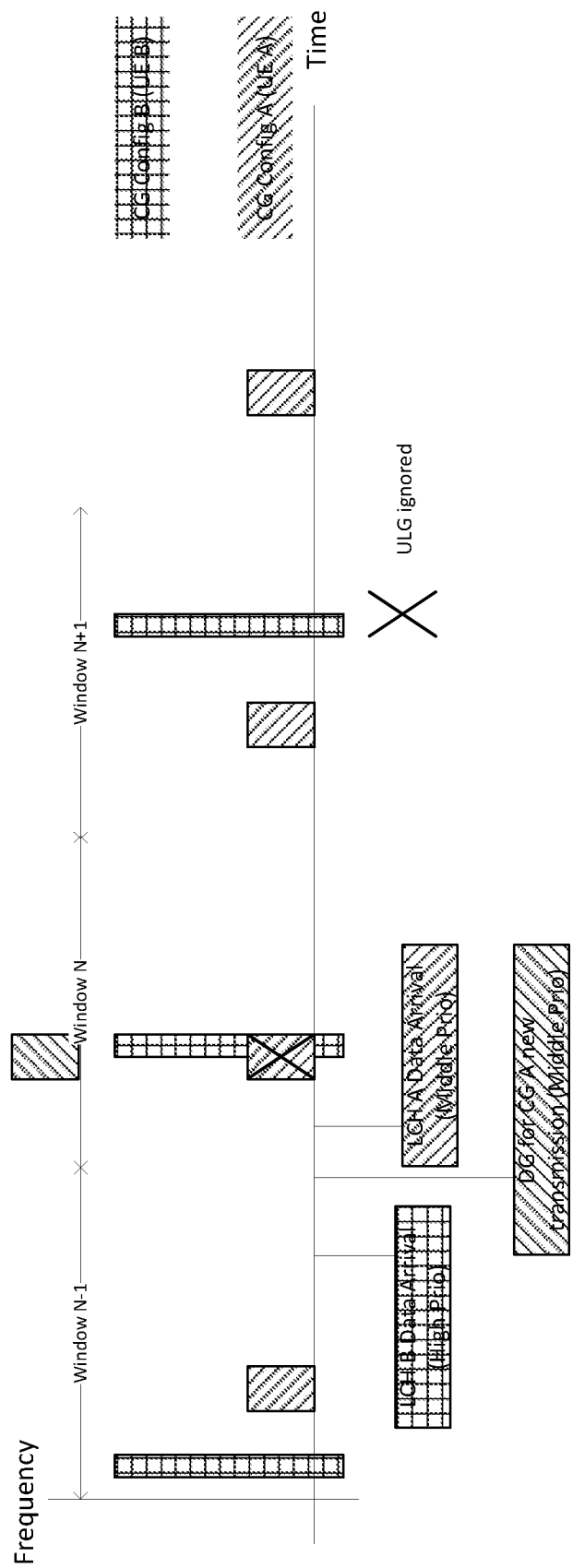


Figure 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2020/054215

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/12(2009.01)i

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)

H04W; H04L; H04Q

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)

CNPAT, CNKI, EPODOC, WPI, 3GPP: LCH?, logic channel?, mapping, restrict+, configured grant?, CG?, dynamic grant?, DG?, pre-empt+, preempt+, cancell+, overlap+, conflict+, collid+, collision, overrid+, retransmi+, re-transmi+, HARQ, process, ID, inherit+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	SEQUANS COMMUNICATIONS. "Enhanced rescheduling for dropped CG" <i>3GPP TSG-RAN WG2 Meeting #108 R2-1916233</i> , 18 November 2019 (2019-11-18), sections 1-2.1, figures 1-2	1
PX	SEQUANS COMMUNICATIONS. "Enhanced rescheduling for dropped CG" <i>3GPP TSG-RAN WG2 Meeting #107bis R2-1913625</i> , 18 October 2019 (2019-10-18), sections 1-2.2, figures 1-2	1
X	SEQUANS COMMUNICATIONS. "Handling of collisions with a CG" <i>3GPP TSG-RAN WG2 Meeting #105bis R2-1904762</i> , 12 April 2019 (2019-04-12), sections 1-2.2, figures 1-3	1
A	NOKIA et al. "Prioritization between dynamic grant and configured grant" <i>3GPP TSG-RAN WG2 NR Ad hoc 1801 R2-1800586</i> , 16 January 2018 (2018-01-16), the whole document	1
A	SONY. "UL Intra-UE prioritization and multiplexing of Data and Data" <i>3GPP TSG-RAN WG2 Meeting #105bis R2-1904202</i> , 12 April 2019 (2019-04-12), the whole document	1



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

29 July 2020

Date of mailing of the international search report

10 August 2020

Name and mailing address of the ISA/CN

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Facsimile No. (86-10)62019451

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LIU, Hanyan

Telephone No. 86-010-53961659

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2020/054215

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SAMSUNG. "Prioritization of SR Transmission for URLLC" 3GPP TSG-RAN WG2 Meeting #105bis R2-194922, 12 April 2019 (2019-04-12), the whole document	1
A	CA 3022159 A1 (COMCAST CABLE COMMUNICATIONS, LLC) 26 April 2019 (2019-04-26) the whole document	1
A	US 2011305210 A1 (WU, Chih-Hsiang) 15 December 2011 (2011-12-15) the whole document	1
A	US 2018049193 A1 (TELEFONAKTIEBOLAGET LM ERICSSON PUBL) 15 February 2018 (2018-02-15) the whole document	1

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/IB2020/054215

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CA	3022159	A1	26 April 2019	US	2019132862	A1	02 May 2019
				US	2019132824	A1	02 May 2019
				CA	3022244	A1	27 April 2019
				CA	3024549	A1	16 May 2019
				EP	3478019	A1	01 May 2019
				US	2019289513	A1	19 September 2019
US	2011305210	A1	15 December 2011	CN	103561473	B	18 January 2017
				EP	2395802	A2	14 December 2011
				CN	103561473	A	05 February 2014
				EP	2395802	B8	16 October 2013
				EP	2395802	A3	22 February 2012
				TW	201204145	A	16 January 2012
				CN	102281645	A	14 December 2011
				US	8743804	B2	03 June 2014
				EP	2395802	B1	11 September 2013
				TW	I437901	B	11 May 2014
US	2018049193	A1	15 February 2018	EP	3510818	A1	17 July 2019
				WO	2018029382	A1	15 February 2018
				EP	3498019	A1	19 June 2019
				US	2019223195	A1	18 July 2019
				AR	109335	A1	21 November 2018
				WO	2018028478	A1	15 February 2018
				EP	3498019	A4	01 January 2020