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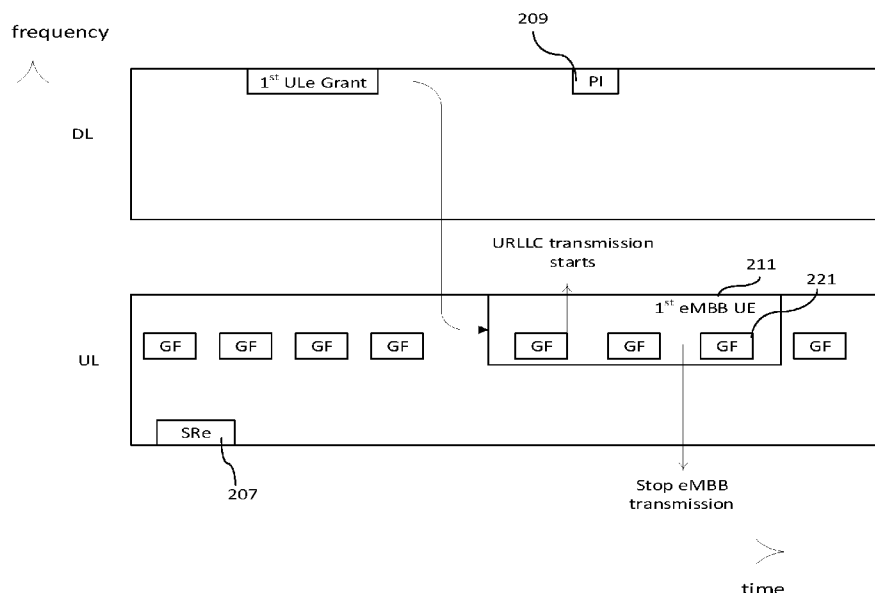


FIG. 4

(57) Abstract: A method for inter user equipment (UE) multiplexing. When a grant free (GF) region partially overlaps with radio resources allocated for a UE of non-latency critical communication service type, data transmission for a UE of latency critical communication service type is initiated in a portion of the GF region that are not overlapped with the radio resources allocated for the UE of non-latency critical communication service type according to control plane signaling.



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RADIO NODE DEVICE AND METHOD FOR INTER USER EQUIPMENT MULTIPLEXING

Technical Field

[0001] The present disclosure relates to the field of communication technology, and more particularly, to a radio node device and a method for inter user equipment multiplexing.

5 Background Art

[0002] New applications such as connected self-driving cars, automated industrial control, augmented and virtual reality have been increasingly attracting wireless standardization efforts. In that respect, 3rd Generation Partnership Project (3GPP) has defined three service paradigms for 5G, including enhanced mobile broadband (eMBB) for high data rate transmission, ultra-reliable low latency communication (URLLC) for devices requiring low latency and high link reliability, and massive machine-type communication (mMTC) to support a large number of low-power devices requiring long life-time and highly energy efficient communication. These services have diverse requirements on latency, reliability, massive connection density, energy efficiency and have resulted into introduction of many new techniques in the Rel-15 of 5G New Radio (NR).

[0003] For URLLC service requirements, the term reliability is defined in 3GPP TR 38.802 as: "Reliability can be evaluated by the success probability of transmitting X bytes within a certain delay, which is the time it takes to deliver a small data packet from the radio protocol layer 2/3 SDU ingress point to the radio protocol layer 2/3 SDU egress point of the radio interface, at a certain channel quality (e.g., coverage-edge)."

[0004] It is also noted in 3GPP TR 38.802 that spectral efficiency and energy consumption also should be considered in the endeavor to achieve a reliability target.

[0005] The reliability requirement for URLLC is specified in 3GPP TR 38.913: "A general URLLC reliability requirement for one transmission of a packet is 10^{-5} for 32 bytes with a user plane latency of 1ms."

[0006] NR supports multiplexing of the user equipment (UE) with different requirements such as the eMBB and URLLC UEs by two methods:

- Semi-static resource sharing: data from the UEs with different requirements and priorities are configured to transmit in exclusive bandwidth parts. At least one bandwidth part may be shared among all kinds of the UEs to increase the efficiency of radio resource utilization.

- Dynamic resource sharing: different services are configured to transmit in the same time and frequency resources. This method allows a better spectrum efficiency but might cause interferences among the UEs if they are scheduled to transmit in the same resource.

[0007] In an uplink, the eMBB UE sending a scheduling request (SR) can be allocated time and frequency resources in grant-based (GB) region by a gNB through an uplink grant (UL Grant). If an URLLC UE also has data to transmit and sends SR to the gNB, the gNB might have to schedule the URLLC UE to the resources that have been allocated to the eMBB UE due to the strict URLLC latency requirement. Accordingly, the gNB sends an uplink pre-emption indication (UL PI) to stop the eMBB transmission.

[0008] In another scenario, the URLLC UEs can be configured to transmit in grant-free (GF) regions using a random access protocol. These UEs can start to transmit data immediately without sending a SR to and waiting for UL Grant from the gNB to save transmission and processing time. However, resource utilization in the grant-free region may deteriorate when the data arrival rate for the URLLC UEs is low. To attain an efficient use of radio resources, the gNB can allocate radio resources in the grant-free region to the eMBB UEs. Because the gNB does not know in advance whether the URLLC UEs will transmit data in the next occasions or not, a collision between

the eMBB and URLLC UEs might happen. Under this circumstance, if one or more URLLC UEs become active on the GF regions, the gNB may try to identify and serve the URLLC UEs rapidly, and send a PI to stop the eMBB transmission upon URLLC transmission and retransmissions.

Technical Problem

- 5 [0009] A base station needs a mechanism to multiplex the latency critical and non-latency critical users. It is desirable to find a new strategy to inform and handle collisions, and coordinated data transmission/re-transmission.

Technical Solution

[0010] An object of the present disclosure is to propose a radio node device and a method for UE multiplexing.

- 10 [0011] In a first aspect of the present disclosure, a method for inter user equipment (UE) multiplexing is executable in a radio node device and include the following steps. When a grant free (GF) region partially overlaps with radio resources allocated for a UE of non-latency critical communication service type, data transmission for a UE of latency critical communication service type is initiated in a portion of the GF region that are not overlapped with the radio resources allocated for the UE of non-latency critical communication service type according to control plane signaling.

- 15 [0012] In a second aspect of the present disclosure, a method for inter user equipment (UE) multiplexing is executable in a radio node device and include the following steps. UEs of non-latency critical communication service type, which are scheduled to perform data transmission in a possible collision radio resource region, are determined. The determined UEs are triggered to increase monitoring periodicity for pre-emption indication (PI) monitoring in a mini-slot level.

- 20 [0013] In a second aspect of the present disclosure, an apparatus

[0014] In a third aspect of the present disclosure, a radio node device includes a transceiver and a processor connected with the transceiver. The processor is configured to execute the following steps. When a grant free (GF) region partially overlaps with radio resources allocated for a UE of non-latency critical communication service type, data transmission for a UE of latency critical communication service type is initiated in a portion of the GF region that are not overlapped with the radio resources allocated for the UE of non-latency critical communication service type according to control plane signaling.

- 25 [0015] In a fourth aspect of the present disclosure, a radio node device includes a transceiver and a processor connected with the transceiver. The processor is configured to execute the following steps. UEs of non-latency critical communication service type, which are scheduled to perform data transmission in a possible collision radio resource region, are determined. The determined UEs are triggered to increase monitoring periodicity for pre-emption indication (PI) monitoring in a mini-slot level.

[0016] The disclosed method may be implemented in a chip. The chip may include a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute the disclosed method.

- 35 [0017] The disclosed method may be programmed as computer executable instructions stored in non-transitory computer readable medium. The non-transitory computer readable medium, when loaded to a computer, directs a processor of the computer to execute the disclosed method.

[0018] 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.

[0019] The disclosed method may be programmed as computer program product, that causes a computer to execute the disclosed method.

5 [0020] The disclosed method may be programmed as computer program, that causes a computer to execute the disclosed method.

Advantageous Effects

10 [0021] When eMBB and URLLC transmissions need to be multiplexed in uplink (UL) transmission to increase spectrum efficiency, interference between these types of the UEs may degrade the performance of URLLC UEs and make the URLLC transmission unable to achieve the strict reliability and latency requirements. Hence, the invention proposes the strategies to avoid or reduce collision between the eMBB and URLLC UEs.

15 [0022] The eMBB UEs may be required to listen to pre-emption indication (PI) in mini-slot level each time they are scheduled, which may cause an unnecessary increase of power consumption. The invention proposes a method to select the UEs required to monitor PI in mini-slot level. Only these UEs may be triggered by a gNB to increase monitoring periodicity from slot level to mini-slot level. The gNB may add 1-bit flag in UL grant to activate monitoring periodicity in mini-slot level of the eMBB UEs. This is a mechanism to dynamically inform the eMBB UE to increase monitoring periodicity. Thus, eMBB UEs has mini-slot level DCI decoding capability is proposed, which is quite practical without excessive hardware burden.

20 [0023] A common DCI may inform the URLLC UE about the overlap in the GF region. The invention further defines the behaviour of the URLLC UEs after decoding the common DCI to avoid a collision with the eMBB transmission.

[0024] The invention has the following advantages:

- Dynamic indication from the base station to UEs to start monitoring and decoding PI.
- Reducing power consumption of eMBB UEs by specifying conditions to increase PI monitoring periodicity.
- Reducing collision of eMBB and URLLC transmission in the grant-free region.
- Protecting the retransmissions of URLLC UEs.

Description of Drawings

30 [0025] To more clearly illustrate the embodiments of the present disclosure or related art, the following figures will be described in the embodiments are briefly introduced. It is obvious that the drawings are merely some embodiments of the present disclosure, a person having ordinary skill in this field can obtain other figures according to these figures.

[0026] FIG. 1 is a block diagram of a base station (BS) and user equipment (UE) devices of different service types according to an embodiment of the present disclosure.

35 [0027] FIG. 2 is a schematic diagram showing radio resource allocation to eMBB and URLLC UEs in a grant based region according to an embodiment of the present disclosure.

[0028] FIG. 3 is a flowchart showing cancelation and pre-emption of eMBB transmission by URLLC UEs according to an embodiment of the present disclosure.

[0029] FIG. 4 is a schematic diagram showing cancelation and pre-emption of eMBB transmission by URLLC UEs according to an embodiment of the present disclosure.

[0030] FIG. 5 is a schematic diagram showing semi-static radio resource sharing.

[0031] FIG. 6 is a flowchart showing UE selection for PI monitoring occasion adjustment in semi-static radio resource sharing scenario according to an embodiment of the disclosed UE multiplexing method.

[0032] FIG. 7 is a flowchart showing UE selection based on some criteria according to an embodiment of the disclosed UE multiplexing method.

[0033] FIG. 8 is a flowchart showing selecting UEs allocated with GF resources for PI monitoring occasion adjustment scenario according to an embodiment of the disclosed UE multiplexing method.

[0034] FIG. 9 is a schematic diagram showing settings of different sub-carrier spacing (SCS).

[0035] FIG. 10 is a flowchart showing PI monitoring periodicity adjustment with respect to SCS according to an embodiment of the disclosed UE multiplexing method.

[0036] FIG. 11 is a flowchart showing configuration of control channel elements (CCEs) with respect to SCS according to an embodiment of the disclosed UE multiplexing method.

[0037] FIG. 12 is a schematic diagram showing downlink control information (DCI) warning URLLC UEs about presence of eMBB transmission in the grant-free regions.

[0038] FIG. 13 is a schematic diagram showing selecting a non-overlapped portion of a GF region for URLLC transmission according to an embodiment of the disclosed UE multiplexing method.

[0039] FIG. 14 is a flowchart showing selecting a non-overlapped portion of a GF region for URLLC transmission according to an embodiment of the disclosed UE multiplexing method.

[0040] FIG. 15 is a schematic diagram showing selecting a next GF region for URLLC transmission according to an embodiment of the disclosed UE multiplexing method.

[0041] FIG. 16 is a flowchart showing selecting a next GF region for URLLC transmission according to an embodiment of the disclosed UE multiplexing method.

[0042] FIG. 17 is a block diagram of a system for wireless communication according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0043] Embodiments of the present disclosure are described in detail with the technical matters, structural features, achieved objects, and effects with reference to the accompanying drawings as follows. Specifically, the terminologies in the embodiments of the present disclosure are merely for describing the purpose of the certain embodiment, but not to limit the disclosure.

[0044] This invention relates to latency critical communication service type and non-latency critical communication service type transmission multiplexing in uplink (UL) transmission to increase spectrum efficiency. The non-latency critical communication service type may include enhanced mobile broadband (eMBB) service type and machine type communication (MTC), and the latency critical communication service type may include ultra-reliable low-latency communication (URLLC) service type. MTC may include mMTC service type. An interference between different types of the user equipment (UE) devices may degrade performance of latency critical communication service type UEs and makes the URLLC transmission unable to achieve the stringent requirements

of reliability and latency. The invention proposes strategies to avoid or reduce collision between the eMBB and URLLC UEs.

[0045] The disclosure provides a method to handle dynamic multiplexing of URLLC and eMBB users, which includes issuing an indication from a base station, such as a gNB, to the eMBB UEs about the potential multiplexing and pre-emption. Upon receiving this indication, the eMBB UEs are expected to receive and decode sub-slot level pre-emption indication (PI) which might be sent by the base station. As a result, power efficient eMBB UEs may be obtained.

[0046] To realizing effective pre-emption, the eMBB UEs may listen to pre-emption indication on sub-slot granularity, which may become a significant burden on the capacity of eMBB UEs. The invention provides a method of selecting the judicious limits on periodicity of sub-slot level downlink control information (DCI) decoding to solve the trade-off between sub-slot decoding performance and energy efficiency. This design ameliorate unnecessary burden on the eMBB UEs of decoding pre-emption indication while still enabling effective multiplexing and successful pre-emption when needed.

[0047] This disclosure also proposes a transmission method to reduce collision of eMBB and URLLC transmission in the grant-free region. Even in case a collision is inevitable, this method helps to protect the retransmissions of URLLC data.

[0048] With reference to FIG. 1, a UE 10a, a UE 10b, a base station 200a, and a network entity device 300 executes a UE multiplexing method according to an embodiment of the present disclosure. Connections between devices and device components are shown as lines and arrows in the FIG. 1. The UE 10a may include a processor 11a, a memory 12a, and a transceiver 13a. The UE 10b may include a processor 11b, a memory 12b, and a transceiver 13b. The base station 200a may include a processor 201a, a memory 202a, and a transceiver 203a. The network entity device 300 may include a processor 301, a memory 302, and a transceiver 303. Each of the processors 11a, 11b, 201a, and 301 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of radio interface protocol may be implemented in the processors 11a, 11b, 201a, and 301. Each of the memory 12a, 12b, 202a, and 302 operatively stores a variety of program and information to operate a connected processor. Each of the transceiver 13a, 13b, 203a, and 303 is operatively coupled with a connected processor, transmits and/or receives a radio signal. The base station 200a may be an eNB, a gNB, or one of other radio nodes.

[0049] Each of the processor 11a, 11b, 201a, and 301 may include a general purpose central processing unit (CPU), an application-specific integrated circuits (ASICs), other chipsets, logic circuits and/or data processing devices. Each of the memory 12a, 12b, 202a, and 302 may include a read-only memory (ROM), a random access memory (RAM), a flash memory, a memory card, a storage medium and/or other storage devices. Each of the transceiver 13a, 13b, 203a, and 303 may include baseband circuitry and radio frequency (RF) circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules, procedures, functions, entities and so on, that perform the functions described herein. The modules can be stored in a memory and executed by the processors. The memory can be implemented within a processor or external to the processor, in which those can be communicatively coupled to the processor via various means are known in the art.

[0050] The network entity device 300 may be a node in a CN. CN may include LTE CN or 5GC which may include user plane function (UPF), session management function (SMF), mobility management function (AMF),

unified data management (UDM), policy control function (PCF), control plane (CP)/user plane (UP) separation (CUPS), authentication server (AUSF), network slice selection function (NSSF), and the network exposure function (NEF).

[0051] In some embodiments, the processor 201 in the BS 200a is configured to send UL pre-emption indication (PI) for eMBB UEs. According to 3GPP technical document (Tdoc), PI has been proposed to enable multiplexing between eMBB and URLLC UEs in different scenarios. An embodiment of multiplexing eMBB and URLLC in grant-based (GB) transmission is detailed in the following:

[0052] The BS 200a serves a plurality of latency-critical UEs, such as URLLC UEs, and a plurality of non-latency-critical UEs, such as eMBB UEs. For example, the UE 10b serves as one of eMBB UEs, and the UE 10a serves as one of URLLC UEs. When the eMBB UE 10b has data to transmit, the processor 11b sends a scheduling request (SR) to the BS 200a and receives an UL grant from the BS 200a with radio resource allocation. After radio resources are allocated to the eMBB UEs, an URLLC UE, such as the UE 10a, also has data to transmit and requests radio resources from the gNB as shown in FIG. 2. SRe represents a scheduling request from an eMBB UE, and SRu represents a scheduling request from an URLLC UE. An ULe grant represents an UL grant for an eMBB UE while an ULu grant represents an UL grant for an URLLC UE.

[0053] Due to latency requirement of URLLC service type, the BS 200a may have to allocate radio resources scheduled to the eMBB UEs to the URLLC UE. The BS 200a sends PI to the eMBB UE to cancel or stop temporarily the eMBB transmission to avoid an interference among the UEs with different requirements. For example, a first eMBB UE transmits a first SRe to the BS 200a, and a second eMBB UE transmits a second SRe to the BS 200a. The BS 200a transmits a first ULe grant to the first eMBB UE in response to the first SRe. The first ULe grant allocates radio resources 211 to the first eMBB UE. The BS 200a transmits a second ULe grant to the second eMBB UE in response to the second SRe. The second ULe grant allocates radio resources 212 to the second eMBB UE. When the UE 10a has data to transmit, the processor 11a transmits a SRu 210 to the BS 200a to request radio resources from the BS 200a. The BS 200a may issue an ULu grant 208 to allocate to the URLLC UE 10a radio resources 213 in the eMBB resource region 212 which is previously scheduled to the second eMBB UE and PI 209 to stop the transmission of the second eMBB UE.

[0054] The uplink radio resources may include grant-free (GF) regions where the URLLC UEs transmit data without explicit SR. To attain a better radio resource utilization, the BS 200a can schedule the eMBB UEs to transmit in a GF region dedicated to the URLLC UE because the arriving rate of URLLC data might be low. When the BS 200a allocates radio resources for the eMBB UEs on both grant-based (GB) and grant-free (GF) region, grant-free URLLC transmission may collide with eMBB transmission because the BS 200a cannot identify URLLC transmission in advance via an SR.

[0055] With reference to FIGs. 3 and 4, for example, a first eMBB UE, such as UE 10b, transmits a first SRe 207 to the BS 200a (311). The BS 200a transmits a first ULe grant to the first eMBB UE in response to the first SRe (312). The first ULe grant allocates radio resources 211 to the first eMBB UE. If the URLLC UE transmits (313) data in the configured grant (CG) regions or so called GF regions that are overlapped with radio resources for an eMBB UE, such as the UE 10b, the BS 200a detects demodulation reference signal (DMRS) sequences from the URLLC UE and determines (314) that the URLLC data transmission of the URLLC UE is carried out over the GF regions scheduled to the eMBB UE. The BS 200a sends PI 209 (315) to the eMBB UE 10b to cancel or stop (316) immediately eMBB data transmissions. As a consequence, the URLLC UE has the collision-free GF region 221 for

URLLC data transmission to achieve the latency and reliability requirements after the eMBB transmission is stopped.

[0056] URLLC transmission is mini-slot level transmission. Thereby, PI may also be transmitted in mini-slot level to the eMBB UEs to stop the eMBB transmission on time and satisfy the latency requirements. This design requires that the eMBB UEs monitor PI in mini-slot level. However, the eMBB UEs transmit data and monitor DCI in slot level. If DCI is used as PI, the eMBB UEs are required to increase monitoring periodicity. Monitoring capability of the eMBB UEs should be also enhanced with a growth of monitoring occasions. The invention provides a method to select the eMBB UEs and trigger an increase of monitoring periodicity.

[0057] Selection of the eMBB UEs that are required to monitor PI is detailed in the following. In an embodiment of the invention, multiplexing between eMBB and URLLC transmission is performed in semi-static radio resource sharing.

[0058] In semi-static radio resource sharing, regions are exclusively allocated to eMBB or URLLC transmissions. Because URLLC traffic might be sparse, the eMBB UEs are able to be configured to transmit in one part of URLLC band, called a shared/co-existence region. With reference to FIG. 5, for example, the BS 200a allocates radio resource region 231 for URLLC transmission, region 232 for shared/co-existence of URLLC and eMBB, and region 233 for eMBB transmission. When the eMBB UEs are allocated transmission radio resource in the eMBB only band, such as region 233, no collision with the URLLC UEs will occur. Thereby, the BS 200a does not need to activate these UEs to increase monitoring periodicity to listen to PI.

[0059] If the eMBB UEs are configured to transmit in the shared region, such as region 232, the BS 200a may have chance to stop eMBB transmission to prioritize URLLC transmission. These eMBB UEs are required to listen to PI in mini-slot level so that one or more of the eMBB UEs can stop eMBB transmission in mini-slot level delay in response to the PI. Accordingly, the invention provides the following proposals:

[0060] Proposal 1: Only the eMBB UEs scheduled to transmit in the shared region of semi-static are triggered by a base station to increase monitoring periodicity and listen to PI in mini-slot level.

[0061] For example, one of the eMBB UEs, such as UE 10b, may initially monitor PI in slot level. With reference to FIG. 6, for example, the BS 200a determines UEs of non-latency critical communication service type, which are scheduled to perform data transmission in a possible collision radio resource region (block 321), and triggers the determined UEs including the UE 10b to increase monitoring periodicity for PI monitoring in a mini-slot level. The possible collision radio resource region may include a semi-static shared region.

[0062] An embodiment of Multiplexing between eMBB GB and URLLC GB transmission is detailed in the following.

[0063] When the BS 200a sends PI to one of the eMBB UEs to stop the scheduled transmission and avoid an interference with the URLLC UE, not all the eMBB UEs are the candidates for cancellation of transmission. One example is shown in FIG. 2, the BS 200a selects the second eMBB UE allocated with region 212 to become a candidate for a potential transmission cancellation. The second eMBB UE has a smaller packet than the first eMBB UE, so that the BS 200a can spend less radio resources for an eMBB packet retransmission for the second eMBB UE after the transmission cancellation. Additionally, the first eMBB UE with a larger packet size has more chance to have collision with a URLLC UE. The first eMBB UE may have to stop transmission or puncture data many times if selected as the candidate for transmission cancellation, and the probability of packet decoding error may be high.

[0064] Accordingly, the BS 200a selects the second eMBB UE to listen to PI. That is, the second eMBB UE has been selected by the BS 200a for a potential transmission cancellation for URLLC transmission. Thus, only the selected second eMBB UE has to increase its monitoring periodicity for PI monitoring in mini-slot level. The BS 200a triggers the second eMBB UE to increase monitoring periodicity upon selecting the second eMBB UE as one of the candidates for transmission cancellation. Accordingly, the invention provides the following proposals:

[0065] Proposal 2: Only the eMBB UEs that are selected as candidates for potential cancellation by a base station are triggered to increase monitoring periodicity.

[0066] An option of the candidate selection is to select the UE candidates based on the UE capability. Some eMBB UEs are able to listen to DCI in mini-slot, and thus are not selected for transmission cancellation since not being able to stop transmission within mini-slot level delay to satisfy URLLC latency requirement.

[0067] The positions of the eMBB UEs may be also taken into account in the candidate selection. The eMBB UEs at the edge of a cell are not selected for potential cancellation because these UEs use higher power and lower MCS for the initial transmission. Much more power and radio resources are needed for eMBB retransmission than those UEs being close to the BS 200a.

[0068] Channel condition that the BS 200a knows from SRs may be also a criterion to select UE candidate for cancellation. Accordingly, the invention provides the following proposals:

[0069] Proposal 3: The eMBB UEs are selected as candidates for transmission cancellation based on selection criteria following the priority: UE capability, UE position to the BS, data size, and channel condition.

[0070] The basic idea here is that the base station can apply some selection rules on the transmissions to regulate types and priority of preemptable eMBB UEs in case urgent URLLC transmission needs to be scheduled. One simple example as discussed is that a UE which is scheduled to a large transport block (TB) is not pre-empted compared to a UE which has a smaller TB in the candidate selection for transmission pre-emption.

[0071] With reference to FIG. 7, the BS 200a selects the UEs of the eMBB service type as candidates for transmission cancellation based on at least one or more of UE capability, a UE position, a data size, and a channel condition associated with the UEs of the eMBB service type (block 331), and triggers the eMBB UEs that are selected as the candidates to increase monitoring periodicity (block 341).

[0072] An embodiment of multiplexing between eMBB GB and URLLC GF transmission is detailed in the following.

[0073] If radio resources allocated for eMBB data transmission overlaps with the GF regions, the BS 200a triggers the eMBB UEs transmitting the data to increase monitoring periodicity for PI monitoring in mini-slot level to cater an unexpected arrival of URLLC data. The eMBB UEs are demanded to stop eMBB transmission in the GF region by the BS 200a if an URLLC UE also transmits in the scheduled GF region. The cancellation of eMBB transmission releases radio resources for URLLC transmission in the next GF region. Accordingly, the invention provides the following proposals:

[0074] Proposal 4: The eMBB UEs allocated with radio resources in GF regions are triggered by a base station to increase monitoring periodicity.

[0075] With reference to FIG. 8, the BS 200a determines the UEs of the eMBB service type allocated with radio resources in a grant free (GF) region (block 341), and triggers determined the UEs of the eMBB service type allocated with radio resources in a GF region to increase monitoring periodicity (block 342). The possible collision radio resource region may include a GF region.

[0076] An embodiment of increasing monitoring periodicity is detailed in the following.

[0077] If the eMBB UEs are configured to constantly monitor PI in mini-slot level after being scheduled, power consumption would rise significantly. Therefore, only the eMBB UEs specified in Proposal 1, Proposal 2, Proposal 4 are triggered to increase monitoring periodicity. Activation to increase monitoring periodicity is issued by the BS 200 using 1-bit flag in the UL grant to notify the eMBB UEs and to trigger the monitoring in mini-slot level. The bit used as a flag can be a padding bit or the first bit in the field of frequency domain radio resource assignment (FDRA). Accordingly, the invention provides the following proposals:

[0078] Proposal 5: 1-bit flag is used in the UL grant for specific eMBB UEs to notify and trigger the eMBB UEs to increase monitoring periodicity. This bit can be a padding bit or the first bit in the field of frequency domain resource assignment (FDRA).

[0079] Limit of monitoring periodicity for eMBB UEs is explained in the following.

[0080] An increase of monitoring periodicity can be realized without significantly modifying UE design. With reference to FIG. 9, in 5G NR, a UE supports different sub-carrier spacing (SCS) including: 15 kHz, 30 kHz, 60 kHz, and 120 kHz.

[0081] In a time frame of 1 ms, the maximum number of slots are 8 slots each with SCS 120 kHz in frequency domain and 0.125 ms in time domain. The UEs monitoring DCI in slot level have 8 monitoring occasions. This means that the UEs are capable of supporting 8 monitoring occasions in current design. It is proposed that the number of monitoring occasions at the eMBB UEs are still kept at the same 8 occasions in 1 ms even if the value of SCS decreases after the eMBB UEs receive 1-bit flag in UL grant. The proposed setting allows the eMBB UEs to monitor PI in mini-slot level when a low SCS is used. For example, SCS 60 kHz may be associated with only 4 monitoring occasions in 1 ms. According to an embodiment of the invention, the number of occasions are doubled to 8 with the same SCS 60 kHz. As a result, the UEs monitor DCI in sub-slot level with each interval of 0.125 ms. The effects of this proposal further manifest for low SCS 15 kHz and 30 kHz. Accordingly, the invention provides the following proposals:

[0082] Proposal 6: An eMBB UE indicated to decode pre-emption indication in sub-slot level can be configured to DCI monitoring periodicity up to its highest capability sub-carrier spacing slot timing.

[0083] With reference to FIG. 10, the BS 200a may determine UEs of the eMBB service type being indicated to decode sub-slot level PI (block 351), and configures the determined eMBB UEs to increase DCI monitoring capability to a highest monitoring periodicity corresponding to the highest capability sub-carrier spacing (SCS) slot timing, such as 8 monitoring occasions (block 352). The monitoring capability comprises at least one of a number of monitoring occasions, a number of PDCCH candidates, and a number of control channel elements (CCEs) in an interval. As an example, if a UE is capable of operating at 120 KHz SCS with 0.125ms time domain configuration, and is currently operating at 15 KHz SCS, the UE can be configured to monitor and decode pre-emption indication DCI at up to $120/15 = 8$ distinct monitoring occasions within a slot.

[0084] Monitoring capability also has to be enhanced if monitoring occasions increase, especially for SCS 15 kHz. In a normal case, a UE has 44 physical downlink control channel (PDCCH) candidates and 56 non-overlapped control channel elements (CCEs) in a 1ms slot with SCS 15 kHz. When the number of monitoring occasions increases to 8 in 1ms slot, the UEs only have around 5 PDCCH candidates and 7 CCEs for each monitoring occasion. If an aggregation level (AL) 8 is required for PI so as to guarantee the reliability, 7 CCEs are not enough for that PI. Due to the very high reliability requirement of URLLC transmission, the reliability of PI to stop the eMBB

transmission is also high and approximate to the 10^{-5} reliability requirement of URLLC. The invention proposes that the maximum number of CCEs for an eMBB UE should be kept the same at 64 CCEs for all SCS to ensure PI transmission bound to AL 8. Similar to the proposal of the value of monitoring occasions, the maximum number of CCEs are only applied after the eMBB UEs receive an indication of 1 bit-flag in UL grant. Accordingly, the invention provides the following proposals:

[0085] Proposal 7: The maximum number of CCEs for an eMBB UE should be kept the same at 64 CCEs for all SCS after the eMBB UE receives an indication of 1 bit-flag in UL grant to monitor PI in mini-slot level.

[0086] With reference to FIG. 11, the BS 200a determines a SCS configuration for one of the UEs of the eMBB service type (block 361), and keeps the maximum number of CCEs for the one of eMBB UEs the same at 64 CCEs for all SCS after the eMBB UE receives an indication of 1 bit-flag in UL grant to monitor PI in mini-slot level (block 362)

[0087] The number of monitoring occasions that an URLLC UE are able to increase can be defined by different criteria than SCS as in Proposal 6. In an embodiment of the invention, based on the processing time of DCI, the eMBB UE can define the maximum number of monitoring occasions to monitor and blindly decode DCI.

[0088] Proposal 8: The maximum number of monitoring occasion can be defined by other features rather than SCS, including processing time of DCI in each occasion.

[0089] Embodiments of adjusting period of monitoring occasion are given in the following.

[0090] URLLC transmission is carried out in mini-slot level with periods of 2, 4 and 7 symbols for normal prefix or 2, 4, 6 symbols for extended prefix. The eMBB UEs are required to monitor PI in the same period of URLLC transmission so that eMBB UEs can identify the overlapping situation indicated by the BS 200a and stop eMBB transmission in the required delay. This means that monitoring occasions increase from 1 per slot to 7, 4 and 2 per slot corresponding to periods of 2, 4 and 7 symbols of URLLC transmission for normal prefix or 7, 4 and 3 per slot corresponding to periods of 2, 4 and 6 symbols of URLLC transmission for extended prefix.

[0091] The requirement of monitoring periodicity can be lower than the URLLC transmission configuration if the traffic is not much sensitive to latency. The PI processing time at the eMBB UE may be much faster than processing time of UL grant at the URLLC UE that is also allocated with a GB region. This is possibly true because the eMBB UE only needs to proceed PI and stops transmission while the URLLC UE must consume much time in decoding UL grant and preparing data for the uplink transmission.

[0092] An embodiment of UL overlap avoidance indication for URLLC UEs is detailed in the following.

[0093] When the BS 200a allocates radio resources for the eMBB UEs on both grant-based (GB) and grant-free (GF) region, grant-free URLLC transmission may collide with eMBB transmission because the BS 200a does not know URLLC transmission in advance through SR. As shown in FIG. 12, the BS 200a may send a signal, such as DCI 214, to the URLLC UEs at the same time with the first and second UL grants for the eMBB UEs to warn the URLLC UEs about presence of eMBB transmission in the grant-free regions 222, 223, 224, 242, 243, and 244. For example, the warning signal states that the grant-free regions 222, 223, and 224 overlap with the region 211 for a first eMBB UE, and the grant-free regions 242, 243, and 244 overlap with the region 212 for a second eMBB UE.

[0094] The disclosure proposes operations of an URLLC UE after the URLLC UE receives a signal warning about overlapping with non-URLLC transmission in the GF region to avoid a collision with the non-URLLC transmission, such as eMBB transmission.

[0095] Upon decoding the warning signal from the BS 200a, the URLLC UEs can identify which GF regions have been taken by the eMBB UEs. The URLLC UEs may select one of the following methods depending on latency and available radio resources to avoid or reduce the collision with eMBB transmission.

[0096] In a first case, as shown in FIG. 13, if eMBB transmission in region 212 only overlaps a part of a GF region 225, a URLLC UE, such as UE10a move to the available radio resource 226 of the same GF region 225 if the radio resource 226 is enough for URLLC data. In Release 15 of 3GPP, the GF users are configured with radio resource size, transport block size and MCS among other GF parameters. This means that normally as soon as part of the radio resource becomes unavailable, UEs of the GF users cannot transmit the configured transport block size with the configured MCS. To address this problem, the embodiment of the invention allows the URLLC UE to select a suitable MCS for the configured transport block size. Thus, URLLC UE can be able to adjust transmitted data to fit the remaining non-overlapping radio resources 226 in the GF region 225. As the BS 200a has indicated the overlapping region 227 to the URLLC UE, the URLLC UE performs calculation to find and select a suitable MCS to perform URLLC transmission with the configured transport block size in this partially overlapping GF radio resource 226.

[0097] Proposal 9: When the eMBB radio resources partially overlap with a GF region, an URLLC UE transmits data in a portion of the GF region that are not overlapped using a suitable MCS indicated by the BS through a DCI signal.

[0098] With reference to FIG. 14, the BS 200a determines a grant free (GF) region, such as 225, partially overlaps with radio resources, such as 212, allocated for a UE, such as UE10b, of non-latency critical communication service type (block 371), and initiates data transmission for a UE, such as UE10a, of latency critical communication service type in a portion, such as 226, of the GF region that are not overlapped with the radio resources allocated for the UE of non-latency critical communication service type according to control plane signaling (block 372).

[0099] The non-latency critical communication service type may include eMBB service type and MTC service type, and the latency critical communication service type may include URLLC service type. The control plane signaling may include an indication in a downlink control information (DCI) signal or in a radio resource control (RRC) signal. For example, the indication by the DCI signal may include a modulation and coding scheme (MCS) indicated by the DCI signal.

[00100] In a second case, with reference to FIGs. 15 and 16, the BS 200a determines (block 381) the eMBB transmission in region 212 overlaps an entire GF region which includes GF regions 222, 223, and 224. The URLLC UE obtains information about the GF regions 225 and 226 in the next occasion that have not been allocated to the eMBB UEs by decoding the warning signal from the BS 200a (block 382). The URLLC UE senses latency budget and decides (block 383) whether latency budget has enough time to wait for the next available GF region, such as 225. If latency budget is enough, for example, latency budget is greater than a range from the region 224 to the region 225, the URLLC UEs wait for a non-overlapping GF region 225 to avoid interference with the eMBB transmission. That is, the URLLC UE postpones data transmission for the UE of the URLLC service type until a next non-overlapping GF region, such as 225, if the latency budget associated with the URLLC service type is sufficient for the postponing of the data transmission (block 384). The URLLC UE performs data transmission for the UE of the URLLC service type in the next non-overlapping GF region (block 385). The BS 200a facilitates eMBB cancellation and pre-emption by URLLC transmission in the regions 222-224, if the latency budget associated with

the URLLC service type is insufficient for the postponing of the data transmission (block 384). Accordingly, the invention provide the following proposal:

[00101] Proposal 10: When the eMBB radio resources fully overlap with the GF region, the URLLC UE waits for the next non-overlapping GF region if latency budget is sufficient.

[00102] FIG. 17 is a block diagram of an example system 700 for wireless communication according to an embodiment of the present disclosure. Embodiments described herein may be implemented into the system using any suitably configured hardware and/or software. FIG. 17 illustrates the system 700 including a radio frequency (RF) circuitry 710, a baseband circuitry 720, an application circuitry 730, a memory/storage 740, a sensor 770, and an input/output (I/O) interface 780, coupled with each other at least as illustrated.

[00103] The application circuitry 730 may include a circuitry, such as, but not limited to, one or more single-core or multi-core processors. The processors may include any combinations of general-purpose processors and dedicated processors, such as graphics processors and application processors. The processors may be coupled with the memory/storage and configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems running on the system.

[00104] The baseband circuitry 720 may include a circuitry, such as, but not limited to, one or more single-core or multi-core processors. The processors may include a baseband processor. The baseband circuitry may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry. The radio control functions may include, but are not limited to, signal modulation, encoding, decoding, radio frequency shifting, etc. In some embodiments, the baseband circuitry may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry may support communication with an NR, LTE, evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry. In various embodiments, the baseband circuitry 720 may include circuitry to operate with signals that are not strictly considered as being in a baseband frequency. For example, in some embodiments, baseband circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

[00105] The RF circuitry 710 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. In various embodiments, the RF circuitry 710 may include circuitry to operate with signals that are not strictly considered as being in a radio frequency. For example, in some embodiments, RF circuitry may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

[00106] In various embodiments, the transmitter circuitry, control circuitry, or receiver circuitry discussed above with respect to the user equipment, eNB, or gNB may be embodied in whole or in part in one or more of the RF circuitries, the baseband circuitry, and/or the application circuitry. As used herein, "circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or a memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the electronic device circuitry may be implemented in, or functions associated with the circuitry

may be implemented by, one or more software or firmware modules. In some embodiments, some or all of the constituent components of the baseband circuitry, the application circuitry, and/or the memory/storage may be implemented together on a system on a chip (SOC).

[00107] The memory/storage 740 may be used to load and store data and/or instructions, for example, for system.

5 The memory/storage for one embodiment may include any combination of suitable volatile memory, such as dynamic random access memory (DRAM)), and/or non-volatile memory, such as flash memory. In various embodiments, the I/O interface 780 may include one or more user interfaces designed to enable user interaction with the system and/or peripheral component interfaces designed to enable peripheral component interaction with the system. User interfaces may include, but are not limited to a physical keyboard or keypad, a touchpad, a speaker, a
10 microphone, etc. Peripheral component interfaces may include, but are not limited to, a non-volatile memory port, a universal serial bus (USB) port, an audio jack, and a power supply interface.

[00108] In various embodiments, the sensor 770 may include one or more sensing devices to determine environmental conditions and/or location information related to the system. In some embodiments, the sensors may include, but are not limited to, a gyro sensor, an accelerometer, a proximity sensor, an ambient light sensor, and a
15 positioning unit. The positioning unit may also be part of, or interact with, the baseband circuitry and/or RF circuitry to communicate with components of a positioning network, e.g., a global positioning system (GPS) satellite. In various embodiments, the system 700 may be a mobile computing device such as, but not limited to, a laptop computing device, a tablet computing device, a netbook, an ultrabook, a smartphone, etc. In various embodiments, system may have more or less components, and/or different architectures. Where appropriate, methods described
20 herein may be implemented as a computer program. The computer program may be stored on a storage medium, such as a non-transitory storage medium.

[00109] The embodiment of the present disclosure is a combination of techniques/processes that can be adopted in 3GPP specification to create an end product.

[00110] A person having ordinary skill in the art understands that each of the units, algorithm, and steps described
25 and disclosed in the embodiments of the present disclosure are realized using electronic hardware or combinations of software for computers and electronic hardware. Whether the functions run in hardware or software depends on the condition of application and design requirement for a technical plan. A person having ordinary skill in the art can use different ways to realize the function for each specific application while such realizations should not go beyond the scope of the present disclosure. It is understood by a person having ordinary skill in the art that he/she can refer
30 to the working processes of the system, device, and unit in the above-mentioned embodiment since the working processes of the above-mentioned system, device, and unit are basically the same. For easy description and simplicity, these working processes will not be detailed.

[00111] It is understood that the disclosed system, device, and method in the embodiments of the present disclosure can be realized with other ways. The above-mentioned embodiments are exemplary only. The division of
35 the units is merely based on logical functions while other divisions exist in realization. It is possible that a plurality of units or components are combined or integrated in another system. It is also possible that some characteristics are omitted or skipped. On the other hand, the displayed or discussed mutual coupling, direct coupling, or communicative coupling operate through some ports, devices, or units whether indirectly or communicatively by ways of electrical, mechanical, or other kinds of forms.

[00112] The units as separating components for explanation are or are not physically separated. The units are or are not physical units, that is, located in one place or distributed on a plurality of network units. Some or all of the units are used according to the purposes of the embodiments. Moreover, each of the functional units in each of the embodiments can be integrated in one processing unit, physically independent, or integrated in one processing unit with two or more than two units.

[00113] If the software function unit is realized and used and sold as a product, it can be stored in a readable storage medium in a computer. Based on this understanding, the technical plan proposed by the present disclosure can be essentially or partially realized as the form of a software product. Or, one part of the technical plan beneficial to the conventional technology can be realized as the form of a software product. The software product in the computer is stored in a storage medium, including a plurality of commands for a computational device (such as a personal computer, a server, or a network device) to run all or some of the steps disclosed by the embodiments of the present disclosure. The storage medium includes a USB disk, a mobile hard disk, a read-only memory (ROM), a random access memory (RAM), a floppy disk, or other kinds of media capable of storing program codes.

[00114] To sum up, the invention provides a method to dynamically trigger the eMBB UE selected to increase monitoring periodicity. In an embodiment, 1-bit flag is used in the UL grant of the selected eMBB UEs to dynamically trigger the increase of monitoring periodicity. This bit can be a padding bit or the first bit in the field of frequency domain resource assignment.

[00115] When eMBB UEs are indicated to monitor pre-emption indication in sub-slot level, the number of monitoring occasions in an interval are kept the same as the maximum capability of UE DCI decoder in the same interval for the largest sub-carrier spacing, such as 120 kHz.

[00116] After the eMBB UEs being indicated by 1-bit flag to monitor PI in mini-slot level, the maximum number of CCEs in a slot for all SCS settings is configured so as to ensure that a PI with high AL can be transmitted at any transmission occasion in mini-slot level.

[00117] While the present disclosure has been described in connection with what is considered the most practical and preferred embodiments, it is understood that the present disclosure is not limited to the disclosed embodiments but is intended to cover various arrangements made without departing from the scope of the broadest interpretation of the appended claims.

Claims

1. A method for inter user equipment (UE) multiplexing executable in a radio node device, comprising:
when a grant free (GF) region partially overlaps with radio resources allocated for a UE of non-latency critical communication service type, initiating data transmission for a UE of latency critical communication service type in a portion of the GF region that are not overlapped with the radio resources allocated for the UE of non-latency critical communication service type according to control plane signaling.
2. The method of claim 1, wherein the non-latency critical communication service type comprises enhanced mobile broadband (eMBB) service type, and the latency critical communication service type comprises ultra-reliable low-latency communication (URLLC) service type.
3. The method of claim 1, wherein the control plane signaling comprises an indication by a downlink control information (DCI) signal.
4. The method of claim 3, wherein the indication by the DCI signal comprises a modulation and coding scheme (MCS) indicated by the DCI signal.
5. The method of claim 2, wherein the radio resources allocated for non-latency critical communication service type are eMBB radio resources, the method further comprises:
when the GF region fully overlaps with the eMBB radio resources, postponing data transmission for the UE of the URLLC service type until a next non-overlapping GF region if a latency budget associated with the URLLC service type is sufficient for the postponing of the data transmission.
6. A method for inter user equipment (UE) multiplexing executable in a radio node device, comprising:
determining UEs of non-latency critical communication service type, which are scheduled to perform data transmission in a possible collision radio resource region; and
triggering the determined UEs to increase monitoring periodicity for pre-emption indication (PI) monitoring in a mini-slot level.
7. The method of claim 6, wherein the PI monitoring is for monitoring PI associated with latency critical communication service type, the non-latency critical communication service type comprises enhanced mobile broadband (eMBB) service type, and the latency critical communication service type comprises ultra-reliable low-latency communication (URLLC) service type.
8. The method of claim 7, further comprising:
selecting the UEs of the eMBB service type as candidates for potential transmission cancellation and pre-emption by transmission associated with a UE of the URLLC service type; and
triggering the eMBB UEs that are selected as the candidates to increase PI monitoring periodicity.
9. The method of claim 8, further comprising:
selecting the UEs of the eMBB service type as candidates based on UE capability, a UE position, a data size, and a channel condition associated with the UEs of the eMBB service type.
10. The method of claim 8 or 9, wherein the possible collision radio resource region comprises a grant free (GF) region.
11. The method of claim 8 or 9, wherein the possible collision radio resource region comprises a semi-static shared region.
12. The method of claim 8, further comprising:

triggering the UEs of the eMBB service type to increase PI monitoring periodicity using 1-bit flag in an uplink (UL) grant.

13. The method of claim 12, wherein the 1-bit flag is a padding bit.

14. The method of claim 12, wherein the 1-bit flag is a first bit in a field of frequency domain resource assignment (FDRA).

15. The method of claim 12, wherein one of the UEs of the eMBB service type, when being indicated to decode sub-slot level pre-emption indication (PI), is configured to increase DCI monitoring capability to a highest capability corresponding to a highest sub-carrier spacing (SCS) slot timing, and the monitoring capability comprises at least one of a number of monitoring occasions, a number of PDCCH candidates, and a number of control channel elements (CCEs) in an interval.

16. The method of claim 12, wherein a maximum number of control channel elements (CCEs) is kept the same at 64 CCEs for all SCS options after one of UEs of the eMBB service type being indicated by the 1 bit-flag in the UL grant to monitor PI in a mini-slot level.

17. The method of claim 12, further comprising determining a maximum number of monitoring occasions associated with one of the UEs of the eMBB service type based on a DCI processing time associated with the one of the UEs of the eMBB service type.

18. A radio node device comprising:

a transceiver; and

a processor connected with the transceiver and configured to execute the following steps comprising:

when a grant free (GF) region partially overlaps with radio resources allocated for a UE of non-latency critical communication service type, initiating data transmission for a UE of latency critical communication service type in a portion of the GF region that are not overlapped with the radio resources allocated for the UE of non-latency critical communication service type according to control plane signaling.

19. The device of claim 18, wherein the non-latency critical communication service type comprises enhanced mobile broadband (eMBB) service type, and the latency critical communication service type comprises ultra-reliable low-latency communication (URLLC) service type.

20. The device of claim 18, wherein the control plane signaling comprises an indication by a downlink control information (DCI) signal.

21. The device of claim 20, wherein the indication by the DCI signal comprises a modulation and coding scheme (MCS) indicated by the DCI signal.

22. The device of claim 19, wherein the radio resources allocated for non-latency critical communication service type are eMBB radio resources, the processor further executes the following step:

when the GF region fully overlaps with the eMBB radio resources, postponing data transmission for the UE of the URLLC service type until a next non-overlapping GF region if a latency budget associated with the URLLC service type is sufficient for the postponing of the data transmission.

23. A radio node device comprising:

a transceiver; and

a processor connected with the transceiver and configured to execute the following steps comprising:

determining UEs of non-latency critical communication service type, which are scheduled to perform data

transmission in a possible collision radio resource region; and

triggering the determined UEs to increase monitoring periodicity for pre-emption indication (PI) monitoring in a mini-slot level.

24. The device of claim23, wherein the PI monitoring is for monitoring PI associated with latency critical communication service type, the non-latency critical communication service type comprises enhanced mobile broadband (eMBB) service type, and the latency critical communication service type comprises ultra-reliable low-latency communication (URLLC) service type.

25. The device of claim24, wherein the processor further executes the following steps comprising:

selecting the UEs of the eMBB service type as candidates for potential transmission cancellation and pre-emption by transmission associated with a UE of the URLLC service type; and

triggering the eMBB UEs that are selected as the candidates to increase PI monitoring periodicity.

26. The device of claim25, wherein the processor further executes the following step:

selecting the UEs of the eMBB service type as candidates based on UE capability, a UE position, a data size, and a channel condition associated with the UEs of the eMBB service type.

27. The device of claim25 or 26, wherein the possible collision radio resource region comprises a grant free (GF) region.

28. The device of claim 25 or26, wherein the possible collision radio resource region comprises a semi-static shared region.

29. The device of claim25, wherein the processor further executes the following step:

triggering the UEs of the eMBB service type to increase PI monitoring periodicity using 1-bit flag in an uplink (UL) grant.

30. The device of claim29, wherein the 1-bit flag is a padding bit.

31. The device of claim 29, wherein the 1-bit flag is a first bit in a field of frequency domain resource assignment (FDRA).

32. The device of claim 29, wherein one of the UEs of the eMBB service type, when being indicated to decode sub-slot level pre-emption indication (PI), is configured to increase DCI monitoring capability to a highest capability corresponding to a highest sub-carrier spacing (SCS) slot timing, and the monitoring capability comprises at least one of a number of monitoring occasions, a number of PDCCH candidates, and a number of control channel elements (CCEs) in an interval.

33. The device of claim 29, wherein a maximum number of control channel elements (CCEs)is kept the same at 64 CCEs for all SCS options after one of UEs of the eMBB service type being indicated by the 1 bit-flag in the UL grant to monitor PI in a mini-slot level.

34. The device of claim 29, further comprising determining a maximum number of monitoring occasions associated with one of the UEs of the eMBB service type based on a DCI processing time associated with the one of the UEs of the eMBB service type.

35. A chip, comprising:

a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute any of the method of claims 1 to 5.

36. A chip, comprising:
a processor, configured to call and run a computer program stored in a memory, to cause a device in which the chip is installed to execute any of the method of claims 6 to 17.
37. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute any of the method of claims 1 to 5.
38. A computer readable storage medium, in which a computer program is stored, wherein the computer program causes a computer to execute any of the method of claims 6 to 17.
39. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute any of the method of claims 1 to 5.
40. A computer program product, comprising a computer program, wherein the computer program causes a computer to execute any of the method of claims 6 to 17.
41. A computer program, wherein the computer program causes a computer to execute any of the method of claims 1 to 5.
42. A computer program, wherein the computer program causes a computer to execute any of the method of claims 6 to 17.

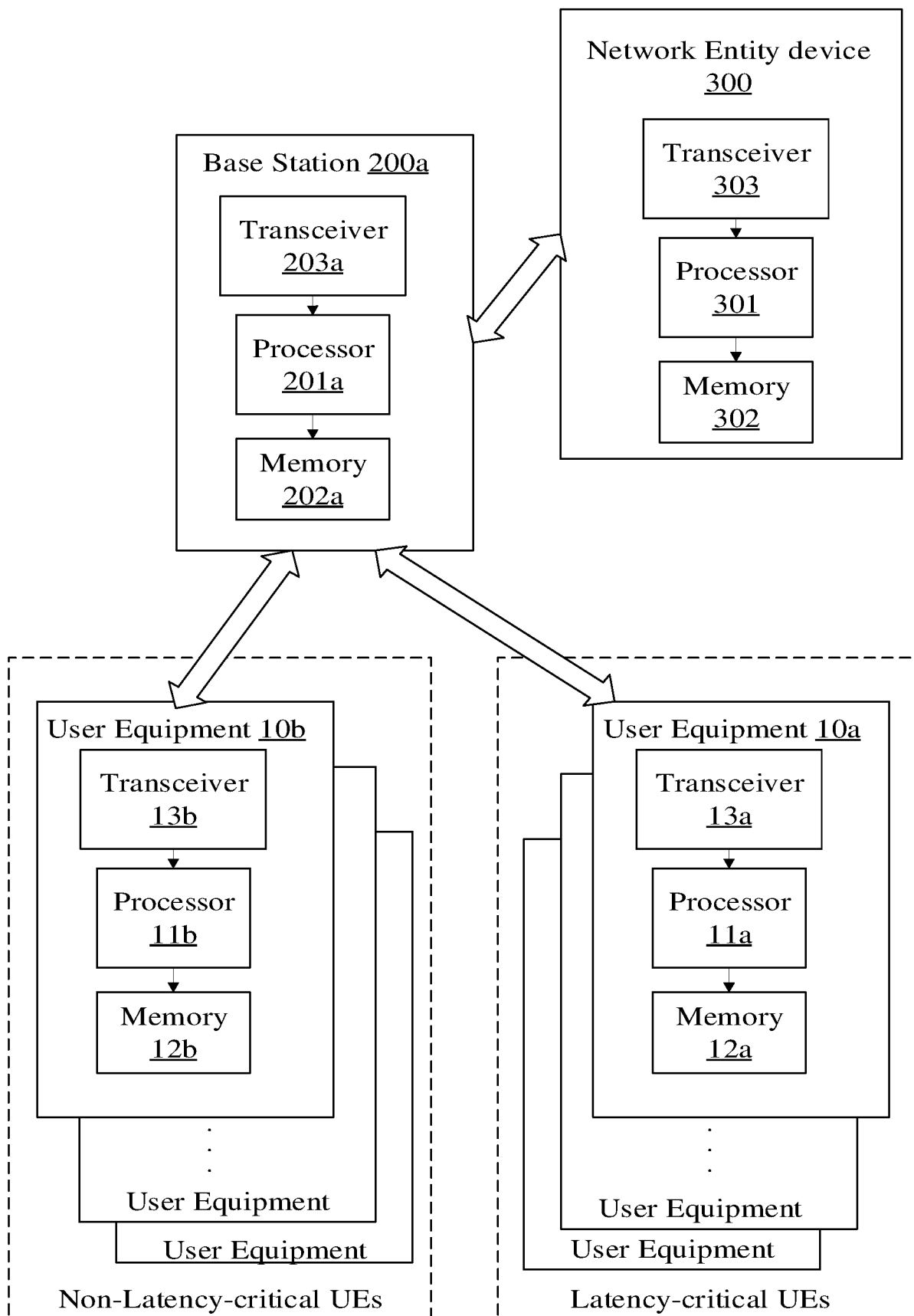


FIG. 1

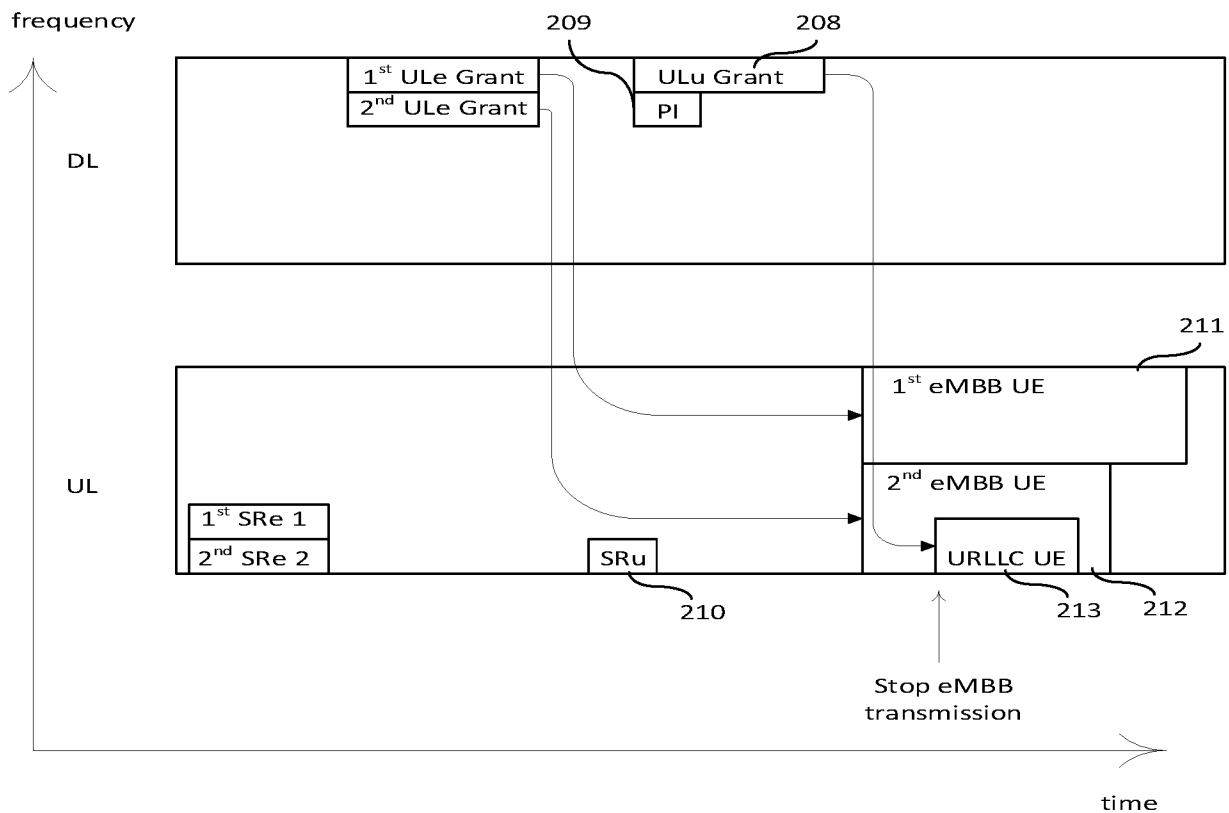


FIG. 2

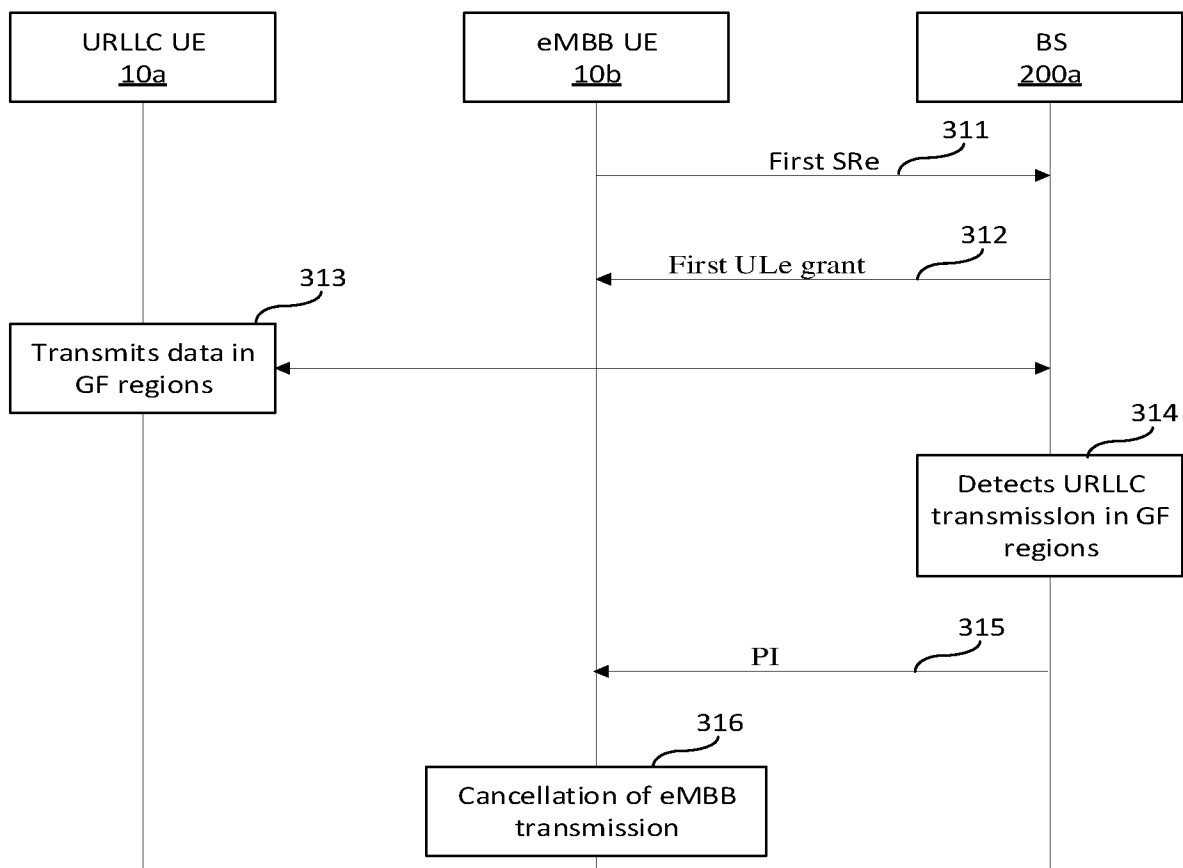


FIG. 3

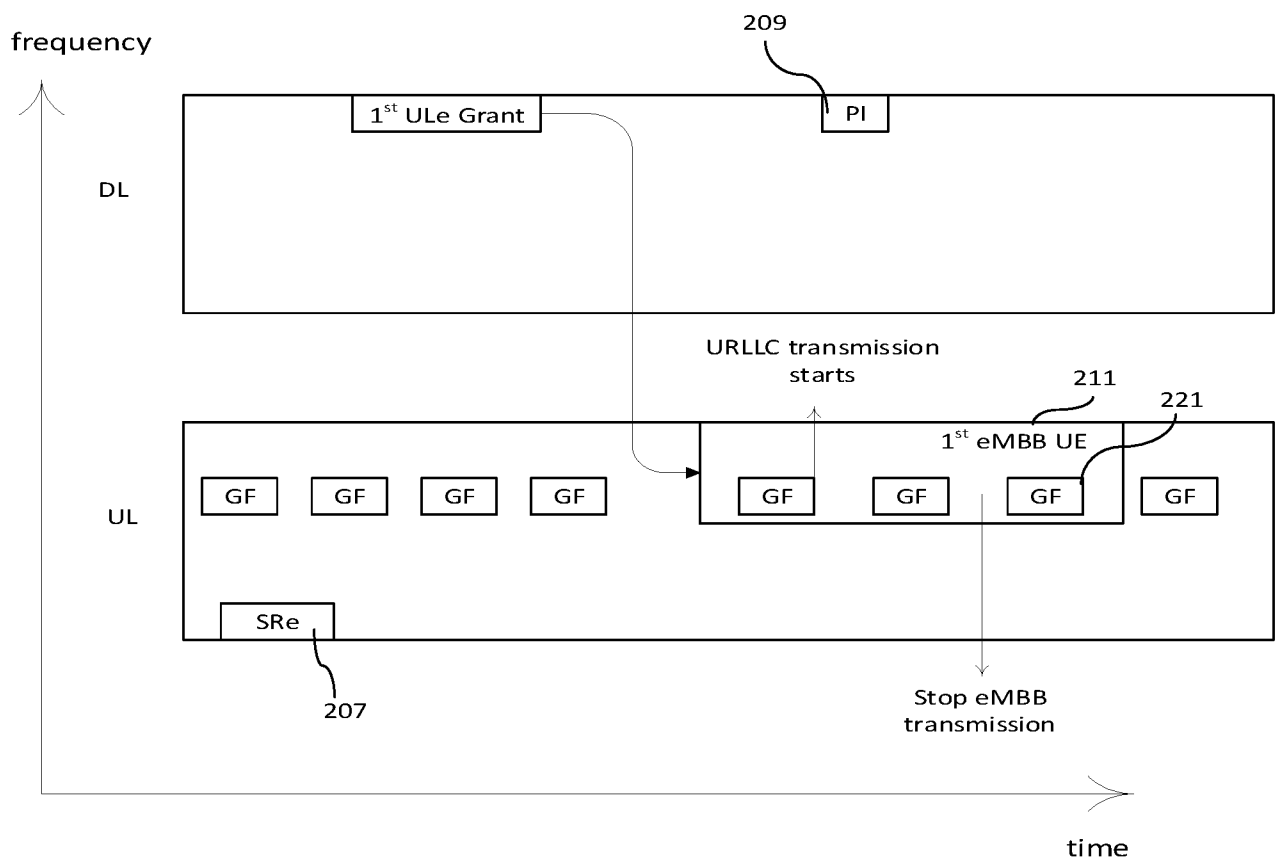


FIG. 4

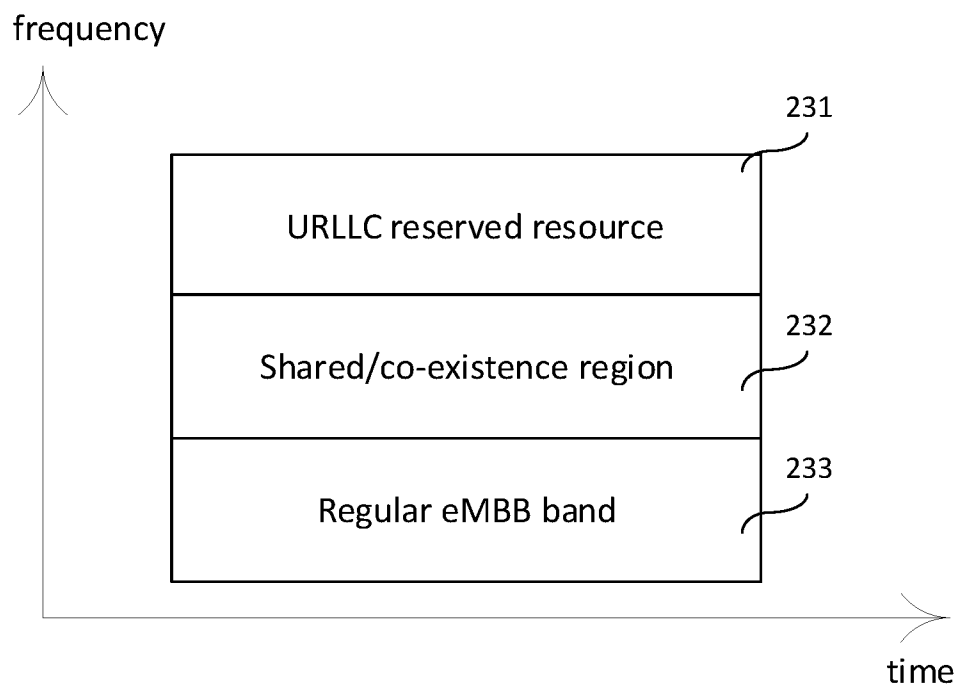


FIG. 5

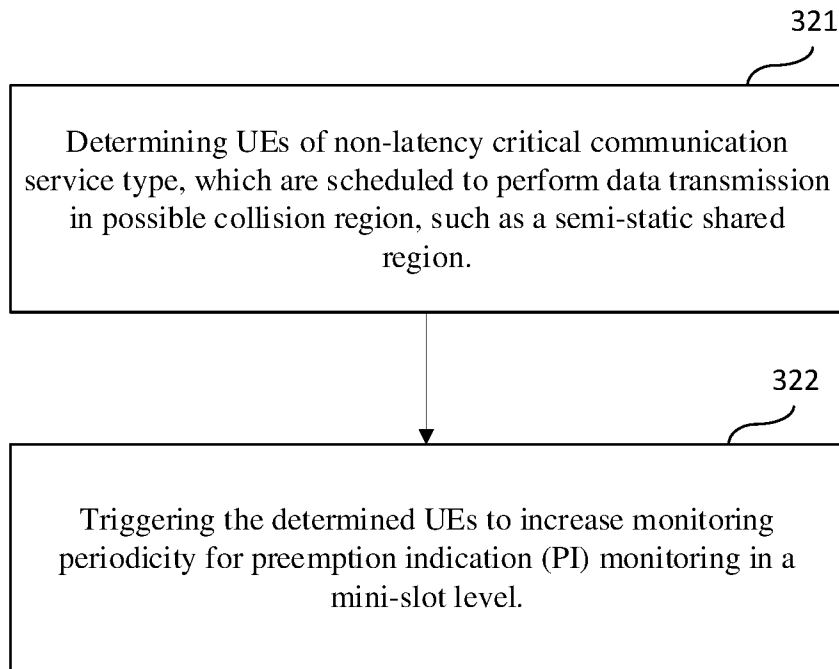


FIG. 6

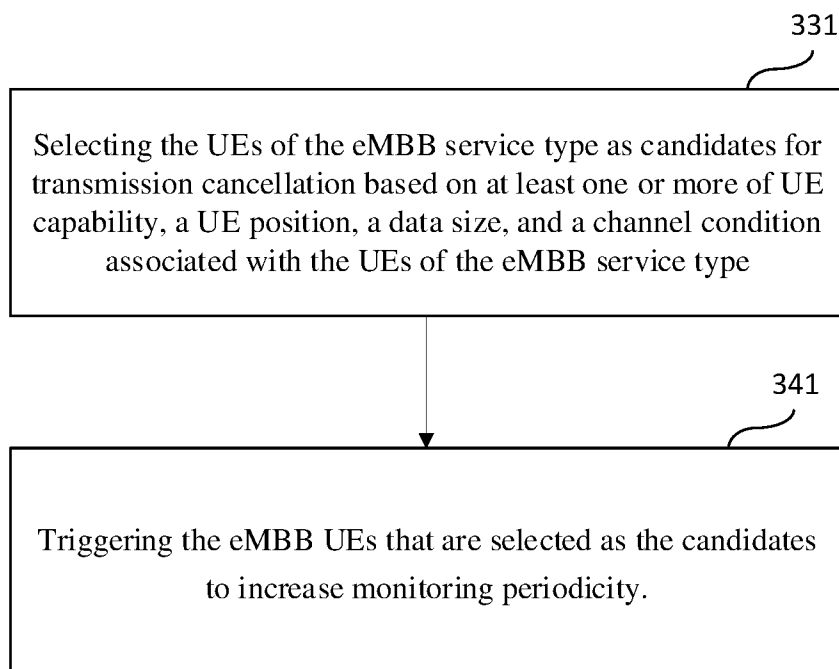


FIG. 7

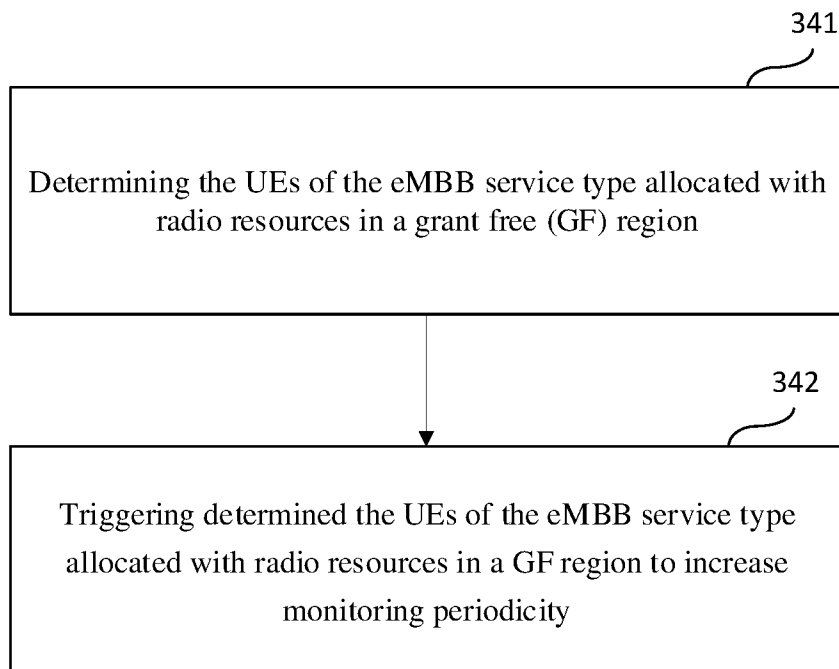


FIG. 8

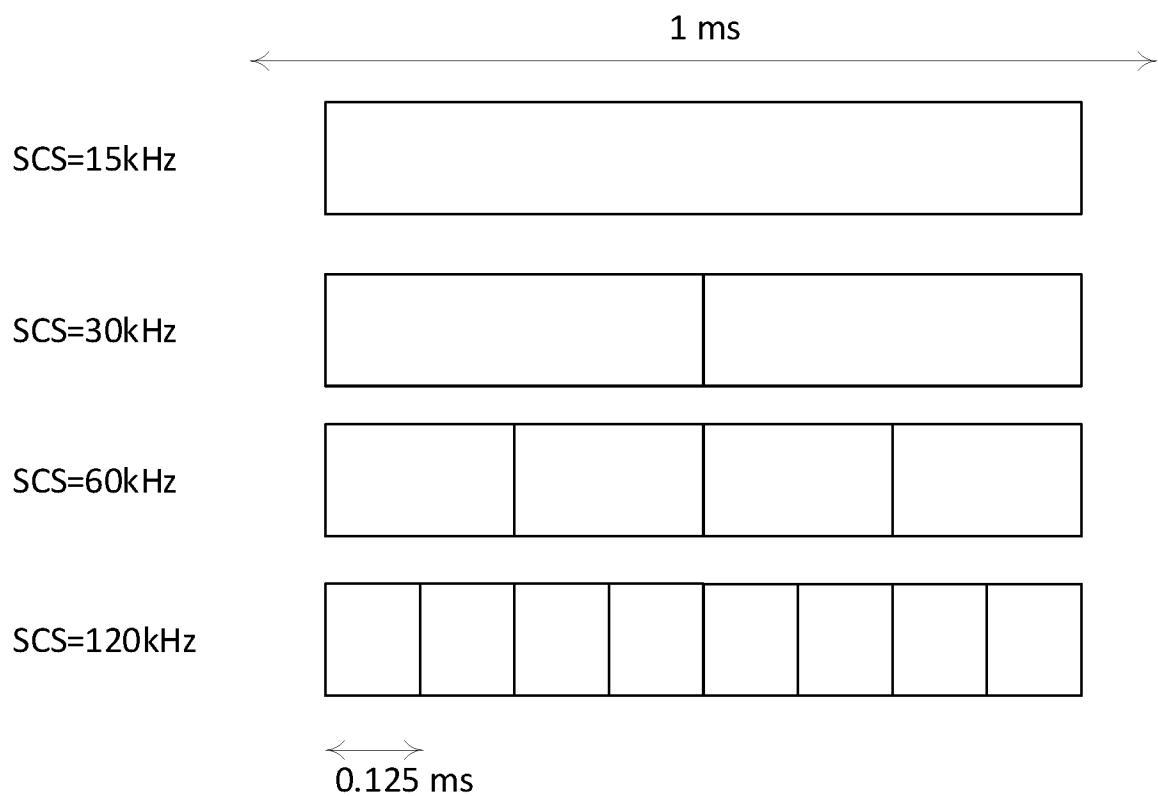


FIG. 9

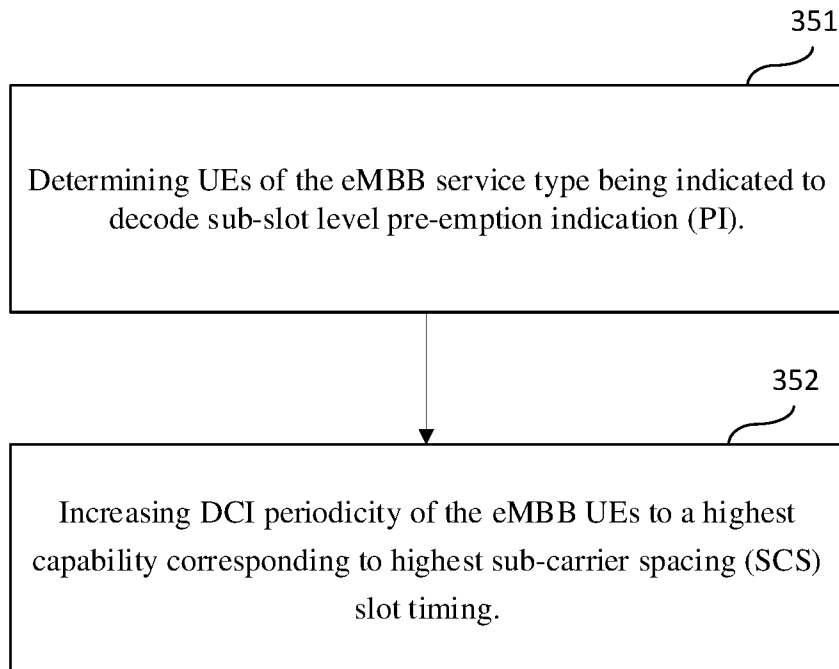


FIG. 10

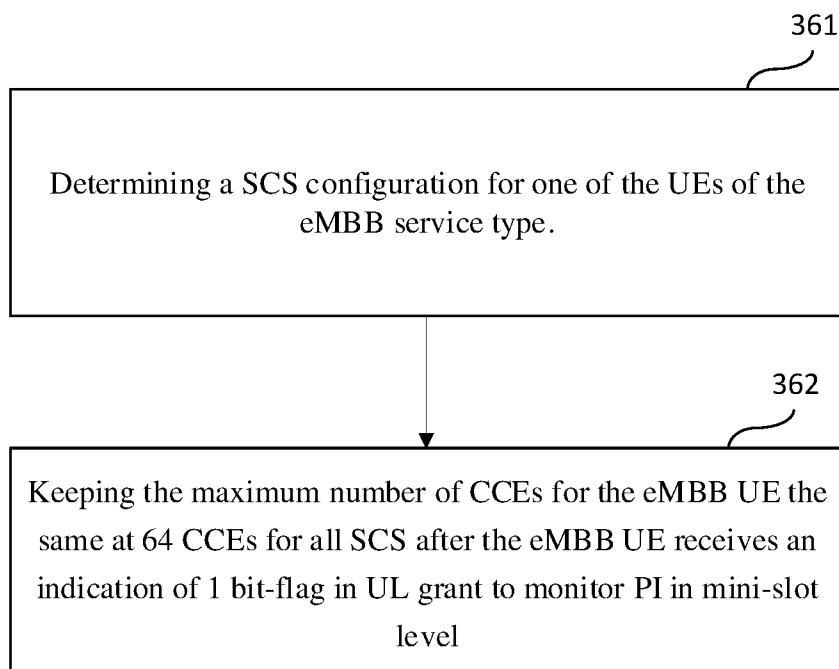


FIG. 11

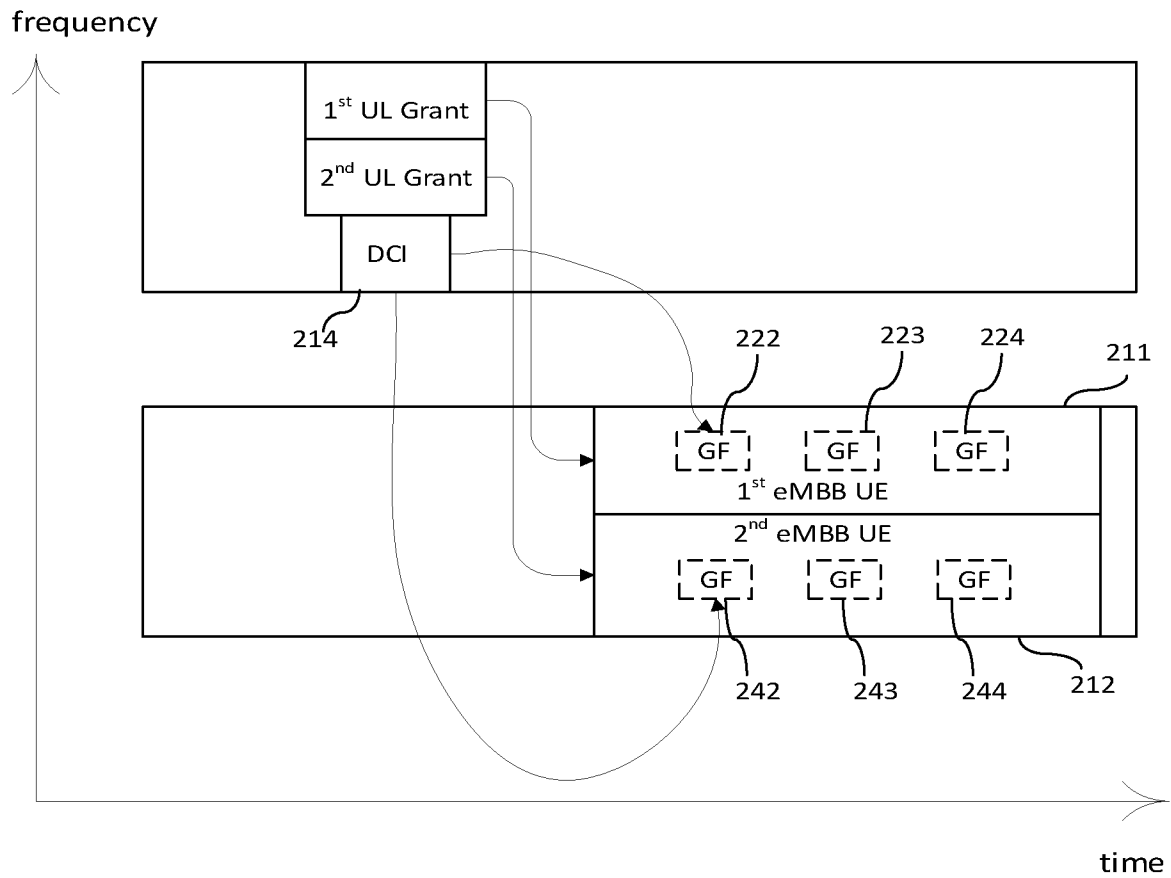


FIG. 12

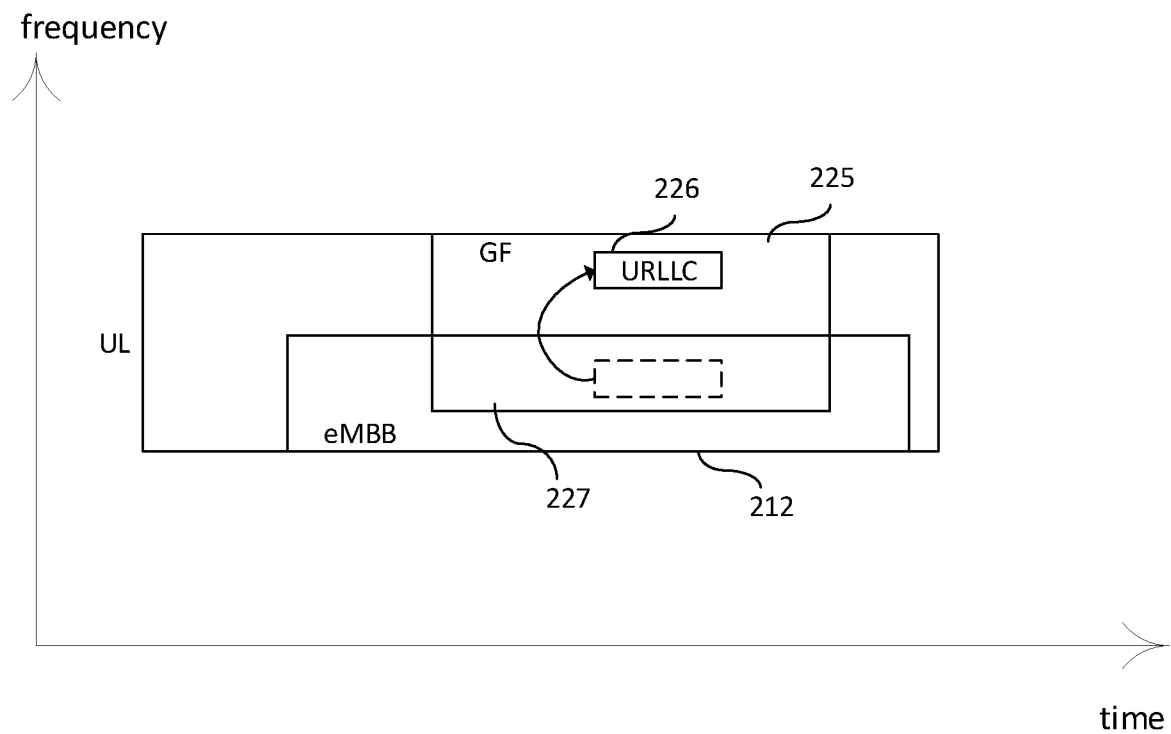


FIG. 13

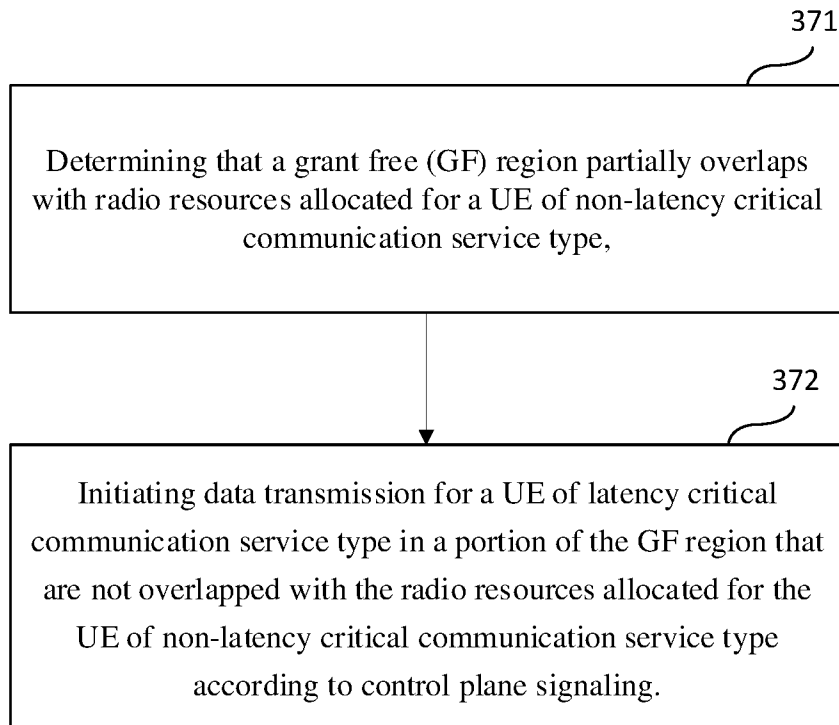


FIG. 14

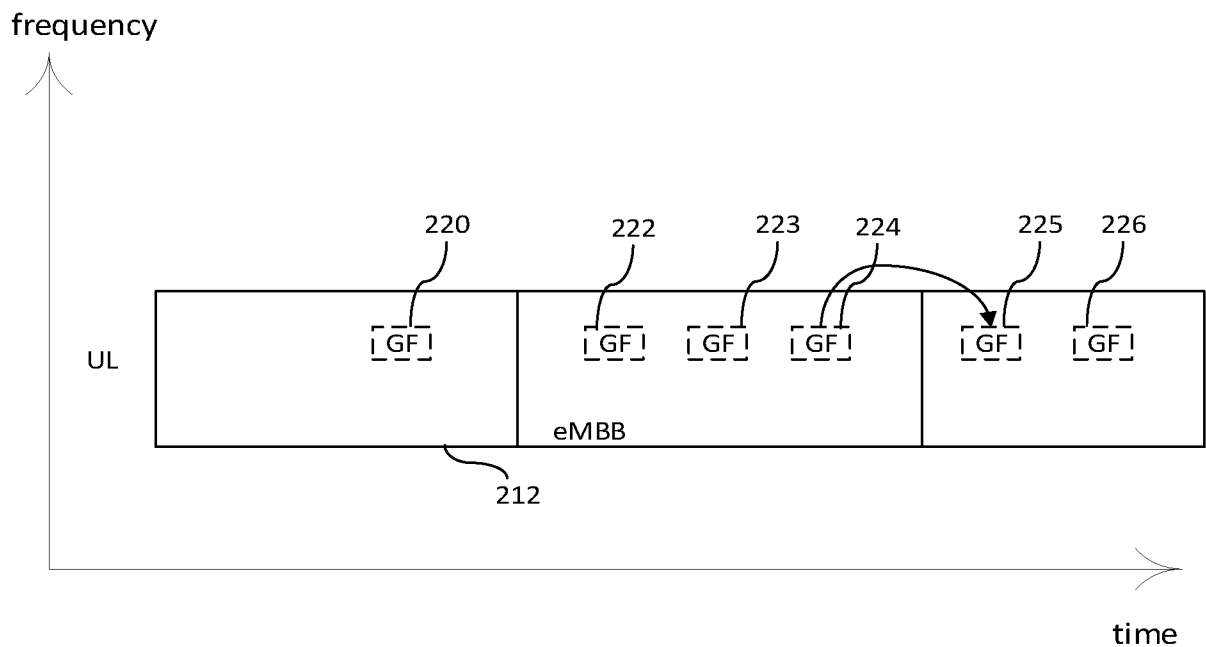


FIG. 15

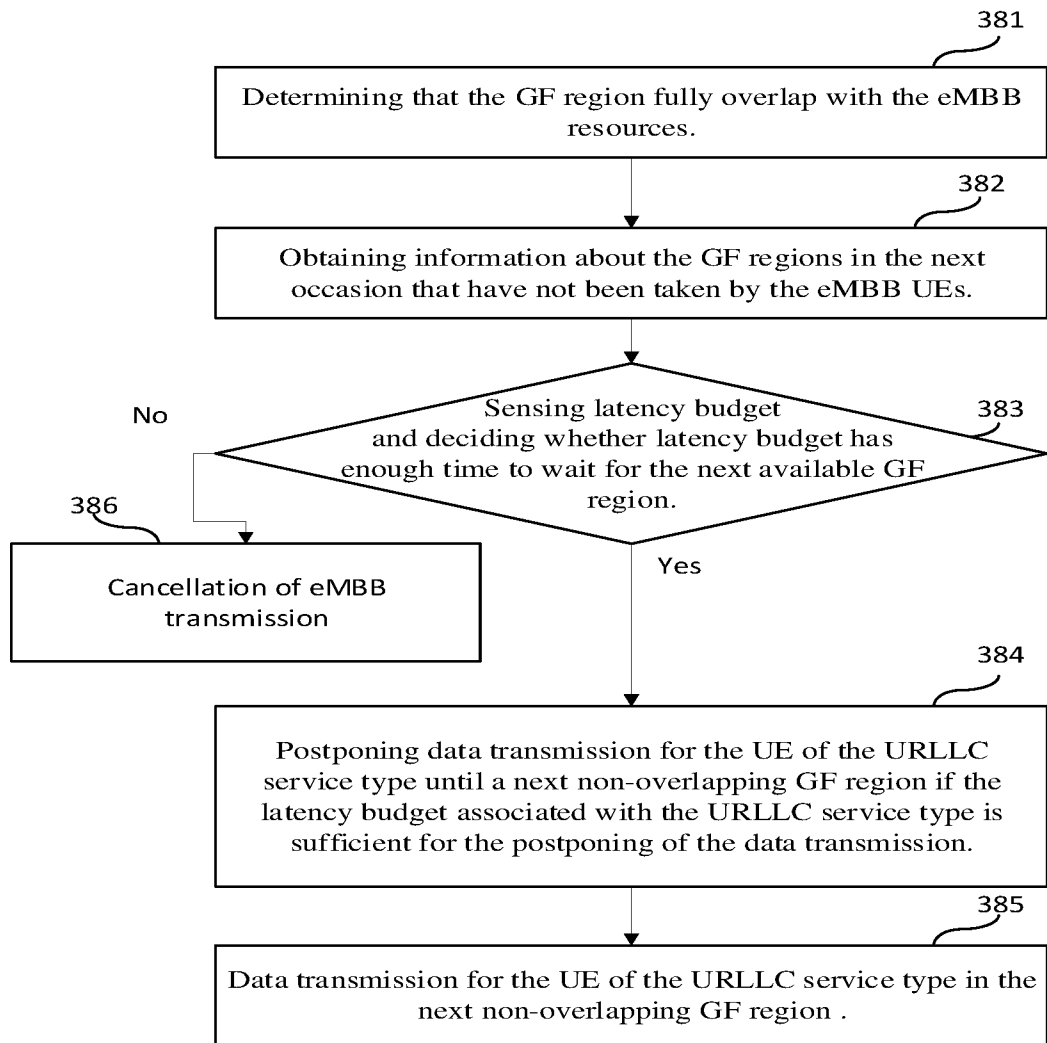


FIG. 16

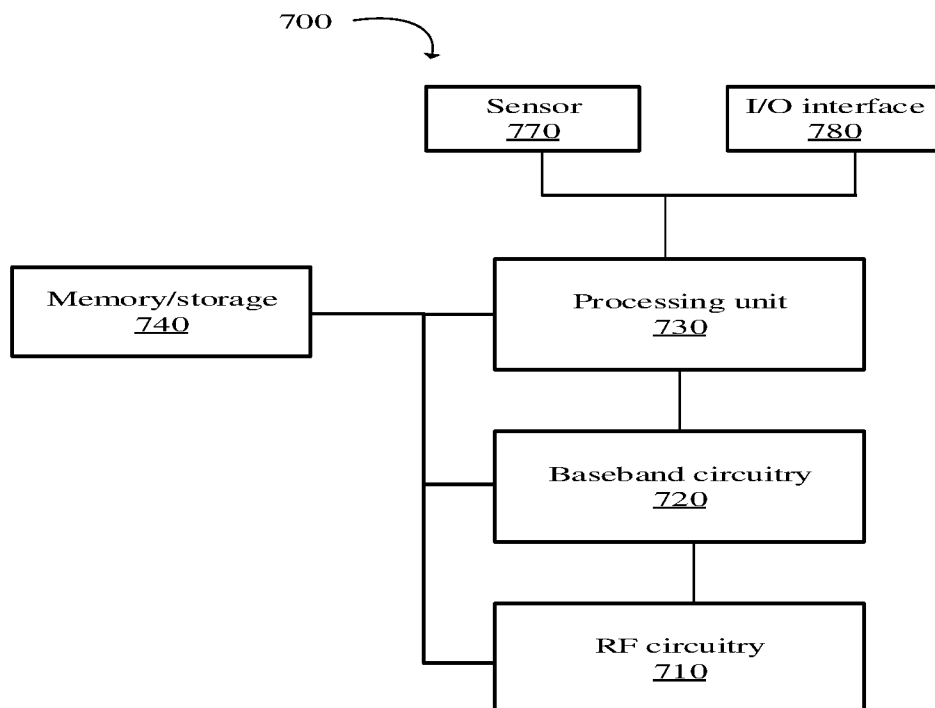


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/071100

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/04(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, H04B

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)

WPI, EPODOC, CNKI, CNPAT, 3GPP: grant, free, overlap, collide, collision, GF, URLLC, eMBB, partial+, PI, pre-emption, indication, mini-slot, minislots

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HUAWEI et al. "Discussion on UL multiplexing of URLLC and eMBB" <i>R1-1800057, 3GPP TSG RAN WG1 Ad Hoc Meeting</i> , 26 January 2018 (2018-01-26), section 3.2	1-5, 18-22, 35, 37, 39, 41
X	HUAWEI et al. "UL multiplexing between URLLC and eMBB" <i>R1-1803659, 3GPP TSG RAN WG1 Meeting #92bis</i> , 20 April 2018 (2018-04-20), section 2.1	6-17, 23-34, 36, 38, 40, 42
A	CN 108738135 A (HUAWEI TECHNOLOGIES CO. LTD.) 02 November 2018 (2018-11-02) the whole document	1-42
A	WO 2018143738 A1 (LG ELECTRONICS INC.) 09 August 2018 (2018-08-09) the whole document	1-42

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"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

27 March 2020

Date of mailing of the international search report

09 April 2020

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Facsimile No. (86-10)62019451

Telephone No. 53961602

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/071100

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	108738135	A	02 November 2018	WO	2018188561	A1	18 October 2018
				US	2020045694	A1	06 February 2020
				EP	3606234	A1	05 February 2020
WO	2018143738	A1	09 August 2018	CN	110192422	A	30 August 2019
				US	2020045722	A1	06 February 2020
				EP	3582563	A1	18 December 2019