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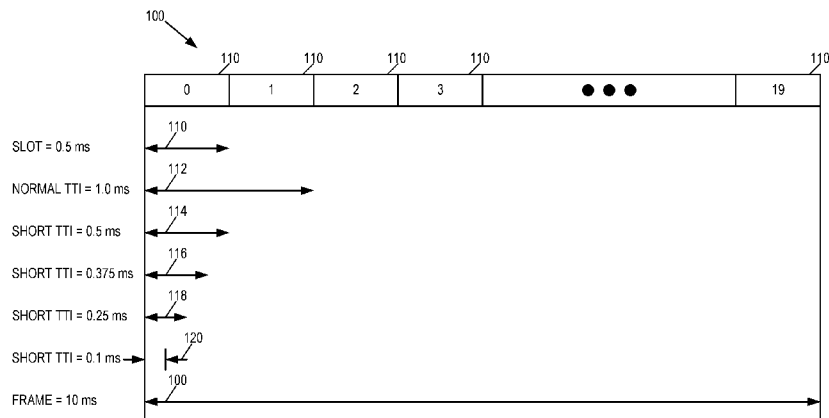


FIG.1

(57) Abstract: Briefly, in accordance with one or more embodiments, an apparatus of a user equipment (UE) comprises a radio-frequency (RF) transceiver to transmit a scheduling request message to an evolved Node B (eNB) indicating that the UE has data to be transmitted to the eNB, and to receive an uplink grant message from the eNB. One or more baseband processors determine if the data to be transmitted should use a normal TTI or a short TTI, and generate a message to include an indication whether the normal TTI or the short TTI will be used to transmit the data. The radio-frequency transceiver is to transmit the generated message to the eNB, and transmit the data to the eNB on a resource allocated by the uplink grant message using the normal TTI or the short TTI based on logical channel prioritization methods or according to the included indication if signaled.

COEXISTENCE OF LEGACY AND SHORT TRANSMISSION TIME INTERVAL FOR LATENCY REDUCTION

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CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of U.S. Application No. 62/233,154 filed Sep. 25, 2015. Said Application No. 62/233,154 is hereby incorporated herein by reference in its entirety.

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BACKGROUND

The Third Generation Partnership Project (3GPP) is studying on latency reduction techniques for 3GPP Long Term Evolution (LTE). One potential solution to reduce average Radio Access Network (RAN) latency and provide increased performance is Transmission Time Interval (TTI) reduction. For example TTI may be reduced from legacy duration of 1.0 milliseconds (ms) to 0.5 ms or even further. It is possible that TTI will be reduced for new Radio Access Technology (RAT) in the 3GPP LTE standards and beyond such as Fifth Generation (5G) standards. Therefore, it is foreseen that designing a system to allow the coexistence of short TTIs with legacy TTI is beneficial.

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DESCRIPTION OF THE DRAWING FIGURES

Claimed subject matter is particularly pointed out and distinctly claimed in the concluding portion of the specification. However, such subject matter may be understood by reference to the following detailed description when read with the accompanying drawings in which:

25 FIG. 1 is a diagram of a radio frame illustrating a normal or legacy transmission time interval (TTI), and one or more examples of a short TTI in accordance with one or more embodiments;

FIG. 2A is a diagram of an evolved universal terrestrial radio access network (EUTRAN) in accordance with one or more embodiments;

30 FIG. 2B is a diagram of a procedure for initial communication between a user equipment (UE) and an evolved Node B (eNB) on the EUTRAN of FIG. 2A to implement various techniques to differentiate between traffic using a normal TTI and traffic using a short TTI in accordance with one or more embodiments;

FIG. 3 is a diagram of a discontinuous reception (DRX) operation illustrating DRX operation for short TTI in accordance with one or more embodiments;

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FIG. 4 is a diagram of physical resource blocks (PRBs) adapted to the coexistence of short TTI PRBs with normal TTI PRBs in a frequency division multiplexing (FDM) manner in accordance with one or more embodiments;

FIG. 5 is a diagram of physical resource blocks (PRBs) adapted to the coexistence of short TTI PRBs with normal TTI PRBs in a time division multiplexing (TDM) manner in accordance with one or more embodiments;

FIG. 6 is a diagram of physical resource blocks (PRBs) adapted to the coexistence of short TTI PRBs with normal TTI PRBs in both a frequency division multiplexing (FDM) manner and in a time division multiplexing (TDM) manner in accordance with one or more embodiments;

FIG. 7 is a block diagram of an information handling system capable of transmission with reduced latency in accordance with one or more embodiments;

FIG. 8 is an isometric view of an information handling system of FIG. 7 that optionally may include a touch screen in accordance with one or more embodiments; and

FIG. 9 is a diagram of example components of a wireless device in accordance with one or more embodiments.

It will be appreciated that for simplicity and/or clarity of illustration, elements illustrated in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further, if considered appropriate, reference numerals have been repeated among the figures to indicate corresponding and/or analogous elements.

DETAILED DESCRIPTION

In the following detailed description, numerous specific details are set forth to provide a thorough understanding of claimed subject matter. However, it will be understood by those skilled in the art that claimed subject matter may be practiced without these specific details. In other instances, well-known methods, procedures, components and/or circuits have not been described in detail.

In the following description and/or claims, the terms coupled and/or connected, along with their derivatives, may be used. In particular embodiments, connected may be used to indicate that two or more elements are in direct physical and/or electrical contact with each other. Coupled may mean that two or more elements are in direct physical and/or electrical contact. However, coupled may also mean that two or more elements may not be in direct contact with each other, but yet may still cooperate and/or interact with each other. For example, "coupled" may mean that two or more elements do not contact each other but are indirectly joined together via another element or intermediate elements. Finally, the terms "on," "overlying," and "over"

may be used in the following description and claims. "On," "overlying," and "over" may be used to indicate that two or more elements are in direct physical contact with each other. However, "over" may also mean that two or more elements are not in direct contact with each other. For example, "over" may mean that one element is above another element but not contact each other and may have another element or elements in between the two elements. Furthermore, the term "and/or" may mean "and", it may mean "or", it may mean "exclusive-or", it may mean "one", it may mean "some, but not all", it may mean "neither", and/or it may mean "both", although the scope of claimed subject matter is not limited in this respect. In the following description and/or claims, the terms "comprise" and "include," along with their derivatives, may be used and are intended as synonyms for each other.

Referring now to FIG. 1, a diagram of a radio frame illustrating a normal or legacy transmission time interval (TTI), and one or more examples of a short TTI in accordance with one or more embodiments will be discussed. As shown in FIG. 1, a radio frame 100 comprises twenty slots 110, for example slot 0, slot 1, slot 2, slot 3, up to slot 19. A slot 110 may have a duration of 0.5 milliseconds (ms), and a normal transmission time interval (TTI) 112 may have a duration of two slots, or 1.0 ms. A normal TTI 112 may be utilized to accommodate devices operating in compliance with a currently existing or legacy standard such as a Third Generation Partnership Project (3GPP) standard such as a Long Term Evolution (LTE) standard, an LTE advanced (LTE-A) standard, and/or a Fifth Generation (5G) standard and beyond. In accordance with one or more embodiments as discussed in further detail herein, a short TTI 114 may be utilized wherein the short TTI 114 may have a duration of 0.5 ms in order to reduce the latency of operation of traffic between network elements (such as eNB and UE) in a radio access network. In accordance with one or more alternative embodiments, various other short TTIs may be utilized having even short durations, for example short TTI 116 having a duration of 0.375 ms, short TTI 118 having a duration of 0.25 ms, or short TTI 120 having a duration of 0.1 ms. Other examples of a short TTI may include a short TTI of 0.2857 ms in duration which corresponds to four orthogonal frequency-division multiplexing (OFDM) symbols with a normal cyclic prefix, a short TTI of 0.1429 ms corresponding to two OFDM symbols, or a short TTI of 0.0714 ms in duration corresponding to one OFDM symbol, and the scope of the claimed subject matter is not limited in this respect. Radio frame 100 may have a duration of 10 ms. In general, short TTI 114 will be utilized for purposes of example and discussion, which may encompass the various other durations of a short TTI, and the scope of the claimed subject matter is not limited in this respect. A radio access network capable of utilizing both a normal TTI and a short TTI coexisting on the network is shown in and described with respect to FIG. 2A, below.

Referring now to FIG. 2A, a diagram of an evolved universal terrestrial radio access network (EUTRAN) in accordance with one or more embodiments will be discussed. As shown in FIG. 2A, EUTRAN 200 may comprise one or more network nodes or elements such as one or more user equipment (UE) 210 devices to communicate with one or more evolved Node B (eNB) 212 devices. It should be noted that the eNB 212 devices may also include one or more relay devices, one or more home eNBs, one or more microcells, one or more picocells, one or more remote radio head (RRH) devices (not shown), and so on, and the scope of the claimed subject matter is not limited in this respect. In the present discussion, eNB 212 may be utilized as a representative network node or network element of EUTRAN 200 for purposes of example. The multiple eNBs 212 may be coupled to one another via an X2 interface. EUTRAN 200 may couple to an evolved packet core (EPC) 202 that may one or more mobility management entity (MME)/Serving Gateway (S-GW) 214 devices coupled to the one or more eNBs 210 via an S1 interface. As discussed in further detail below,

Referring now to FIG. 2B, a diagram of a procedure for initial communication between a user equipment (UE) and an evolved Node B (eNB) on the ETURAN of FIG. 2A to implement various techniques to differentiate between traffic using a normal TTI and traffic using a short TTI in accordance with one or more embodiments will be discussed. As shown in FIG. 2B, procedure 204 may be performed between one or more of user equipment (UE) 210 and one or more of evolved Node B (eNB) 212 comprising the network elements of EUTRAN 200. It should be noted that although FIG. 2A shows eNB 212 for purposes of discussion, various other nodes on the network side of EUTRAN 200 likewise may implement the procedure shown in FIG. 2B, and eNB 212 may represent and/or be substituted by any or all the nodes on the network side of EUTRAN 200, and the scope of the claimed subject matter is not limited in this respect. The one or more network elements of EUTRAN 200 may be capable of differentiating between low latency traffic wherein a short TTI 114 may be utilized, and normal traffic wherein a normal TTI 112 may be utilized. In such an arrangement, UE 210 may have both kinds of traffic present or active at a time, including applications that require or otherwise may benefit from low-latency operation such as voice over internet protocol (VoIP) applications, and normal or legacy traffic or operations where low-latency is not required or not critical such as web browsing traffic. In some instances, some types of normal traffic may not support low-latency operations, whereas other types of traffic may be able to operate with either a normal TTI 112 or low-latency, short TTI 114. As a result, the network elements of EUTRAN 200 may be able to differentiate between providing a normal TTI 112 to some traffic on EUTRAN 200, while also providing a short TTI 114 to other traffic on ETURAN 200. The following examples illustrate

example embodiments for providing coexistence and differentiation of normal and low-latency traffic.

In one or more embodiments, UE 210 may handle differentiation between normal traffic and low-latency traffic. As shown in FIG. 2, if UE 210 has traffic or data to transmit to eNB 212, or to any other node on the network side of EUTRAN 200, UE 210 may transmit a scheduling request (SR) message 214 to eNB 212 for example in a physical uplink control channel (PUCCH). Alternatively, UE 210 may transmit SR message 214 to eNB 212 in a physical uplink shared channel (PUSCH). In response to SR message 214, eNB 212 may transmit an uplink (UL) grant message 216 in a physical downlink control channel (PDCCH). UE 210 may transmit a buffer status report (BSR) message 218 to eNB 212 in a PUSCH, and then may transmit the traffic in a data transmission 220 to eNB 212 in a PUSCH. Where UE 210 handles traffic latency differentiation, when traffic is generated at UE 210, UE 210 may identify any low-latency applications and/or low-latency traffic and differentiate such traffic from normal traffic, for example using categorization or identifiers such as Quality of Service (QoS) class, traffic type, and so on. UE 210 then may prioritize the low-latency traffic accordingly when preparing for UL data transmission 220. In some embodiments, the buffer status report (BSR) message 218 may be enhanced or modified to indicate the arrival or availability of low-latency or normal traffic at the buffer of UE 210 for UL transmission to eNB 212. Alternatively, a specific logical channel group (LCG) may be used for all data bearers corresponding to the low-latency traffic to inform the eNB 212 of the low-latency buffer status using existing BSR mechanisms. Further alternatively, a new logical channel identifier (LCID) and/or logical channel group (LCG) may be defined as part of a media access control (MAC) header of a MAC protocol data unit (PDU) to inform the eNB 212 of the low-latency buffer status using existing BSR mechanisms. Thus, UE 210 may utilize BSR message 218 to indicate to eNB 212 and/or EUTRAN 200 the differentiation between normal latency and low-latency traffic to be transmitted to eNB 212 in data transmission 220, or otherwise between traffic using a normal TTI 112 and traffic using a short TTI 114.

In one or more embodiments, eNB 212 may differentiate between normal latency and low-latency traffic. According to a current LTE specification, eNB 212 provides grants with UL resources in UL grant message 216 to UE 210 without explicitly specifying what this grant can or cannot be used for. Logical channel prioritization normally is handled by UE 210 in current standards wherein UE 210 alone makes the decision on which traffic to send using the UL grant from among the traffic available at the UL buffer. For example, hybrid automatic repeat request (HARQ) retransmissions generally will be prioritized over new transmissions. In one embodiment, if short TTI 114 is utilized for low-latency applications coexisting with normal TTI

112, eNB 212 may provide specific short TTI 114 UL grants in UL grant message 216 for low-latency applications, and specific normal TTI 112 UL grants in UL grant message 216 for normal traffic. In one or more alternative embodiments, eNB 212 may indicate in the UL grant message 216 whether the present grant is for normal traffic or low-latency traffic, for example using a low-latency indication flag in UL grant message 216 to indicate that a short TTI 114 should be utilized. Such a solution also may be applicable to transmission using normal TTI 112 wherein a flag in UL grant message 216 may indicate that a normal TTI 112 should be utilized. It should be noted that although the description above describes uplink grant differentiation specific to low-latency traffic or normal latency traffic, such differentiation likewise may apply to other types and/or characteristics of the traffic, and not necessarily only to latency, and the scope of the claimed subject matter is not limited in this respect.

Referring now to FIG. 3, a diagram of a discontinuous reception (DRX) operation illustrating DRX operation for short TTI in accordance with one or more embodiments will be discussed. As shown in FIG. 3, graph 300 illustrates the operation of UE 210 for discontinuous reception (DRX), wherein the state of UE 210 (UE STATE) is indicated by vertical axis 310, and time (TIME) 312 is indicated by horizontal axis 312. During a DRX cycle 314, UE 210 may be on for a first duration 316, and may have an opportunity for DRX for a second duration 318. While UE 210 is on in duration 316, UE 210 monitors the physical downlink control channel (PDCCH) to look for any incoming messages or traffic directed to UE 210, and determines if UE 210 may enter a sleep state during duration 318, for example if there is no traffic intended for UE 210 during DRX cycle 314. In a current version of the 3GPP specification, some DRX timers for controlling the DRX cycle 314 are defined in terms of PDCCH-subframes, for example onDurationTimer, drx-InactivityTimer, and drx-RetransmissionTimer, and other DRX timers are defined in terms of 1.0 ms subframes, for example shortDRX-Cycle, longDRX-Cycle, and drxStartOffset. UE 210 checks for a possible state transition for each subframe as described in 3GPP Technical Specification (TS) 36.321 V12.2.1 (2014-06), Section 5.7. It is noted that TS 36.321 V12.2.1 (2014-06), Section 5.7 is discussed herein for purposes of example, and other sections, portions, versions or technical specifications likewise may be applicable, and the scope of the claimed subject matter is not limited in this respect. If current subframe numbering is preserved by introducing a short-subframe index for short TTIs 114, then in accordance with the specification, the DRX state transitions will occur at the 1.0 ms subframe boundaries even for short TTI 114 operations. This means that in some cases, UE 210 will not go to sleep for several short TTIs 114 even though UE 210 has been inactive for the duration of the inactivity timer. In one or more embodiment, such a situation may be addressed as follows by defining DRX operations for short TTI 114.

In one embodiment, the procedure of 3GPP Technical Specification (TS) 36.321 V12.2.1 (2014-06), Section 5.7 may be modified by requiring the procedure to be performed by the media access control (MAC) entity for each short TTI 114 or short subframe, if so configured. . It is noted that TS 36.321 V12.2.1 (2014-06), Section 5.7 is discussed herein for purposes of example, and other sections, portions, versions or technical specifications likewise may be applicable or modified similarly, and the scope of the claimed subject matter is not limited in this respect. The procedure of Section 5.7 is as follows.

5.7 Discontinuous Reception (DRX)

The UE may be configured by RRC with a DRX functionality that controls the UE's PDCCH monitoring activity for the UE's C-RNTI, TPC-PUCCH-RNTI, TPC-PUSCH-RNTI, Semi-Persistent Scheduling C-RNTI (if configured) and eIMTA-RNTI (if configured). When in RRC_CONNECTED, if DRX is configured, the UE is allowed to monitor the PDCCH discontinuously using the DRX operation specified in this subclause; otherwise the UE monitors the PDCCH continuously. When using DRX operation, the UE shall also monitor PDCCH according to requirements found in other subclauses of this specification. RRC controls DRX operation by configuring the timers *onDurationTimer*, *drx-InactivityTimer*, *drx-RetransmissionTimer* (one per DL HARQ process except for the broadcast process), the *longDRX-Cycle*, the value of the *drxStartOffset* and optionally the *drxShortCycleTimer* and *shortDRX-Cycle*. A HARQ RTT timer per DL HARQ process (except for the broadcast process) is also defined (see subclause 7.7).

When a DRX cycle is configured, the Active Time includes the time while:

- *onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimer* or *mac-ContentionResolutionTimer* (as described in subclause 5.1.5) is running; or
- a Scheduling Request is sent on PUCCH and is pending (as described in subclause 5.4.4); or
- an uplink grant for a pending HARQ retransmission can occur and there is data in the corresponding HARQ buffer; or
- a PDCCH indicating a new transmission addressed to the C-RNTI of the UE has not been received after successful reception of a Random Access Response for the preamble not selected by the UE (as described in subclause 5.1.4).

When DRX is configured, the UE shall for each subframe:

- if a HARQ RTT Timer expires in this subframe and the data of the corresponding HARQ process was not successfully decoded:

- start the *drx-RetransmissionTimer* for the corresponding HARQ process.
- if a DRX Command MAC control element or a Long DRX Command MAC control element is received:
 - stop *onDurationTimer*;
 - 5 - stop *drx-InactivityTimer*.
- if *drx-InactivityTimer* expires or a DRX Command MAC control element is received in this subframe:
 - if the Short DRX cycle is configured:
 - start or restart *drxShortCycleTimer*;
 - 10 - use the Short DRX Cycle.
 - else:
 - use the Long DRX cycle.
 - if *drxShortCycleTimer* expires in this subframe:
 - use the Long DRX cycle.
 - 15 - if a Long DRX Command MAC control element is received:
 - stop *drxShortCycleTimer*;
 - use the Long DRX cycle.
 - If the Short DRX Cycle is used and $[(SFN * 10) + \text{subframe number}] \bmod (shortDRX-Cycle) = (drxStartOffset) \bmod (shortDRX-Cycle)$; or
 - 20 - if the Long DRX Cycle is used and $[(SFN * 10) + \text{subframe number}] \bmod (longDRX-Cycle) = drxStartOffset$:
 - start *onDurationTimer*.
 - during the Active Time, for a PDCCH-subframe, if the subframe is not required for uplink transmission for half-duplex FDD UE operation and if the subframe is not part of a
 - 25 configured measurement gap; or
 - during the Active Time, for a subframe other than a PDCCH-subframe and for a UE capable of simultaneous reception and transmission in the aggregated cells, if the subframe is a downlink subframe indicated by a valid eIMTA L1 signalling for at least one serving cell not configured with *schedulingCellId* [8] and if the subframe is not part of a
 - 30 configured measurement gap; or
 - during the Active Time, for a subframe other than a PDCCH-subframe and for a UE not capable of simultaneous reception and transmission in the aggregated cells, if the subframe is a downlink subframe indicated by a valid eIMTA L1 signalling for the PCell and if the subframe is not part of a configured measurement gap:
 - 35 - monitor the PDCCH;

- if the PDCCH indicates a DL transmission or if a DL assignment has been configured for this subframe:
 - start the HARQ RTT Timer for the corresponding HARQ process;
 - stop the *drx-RetransmissionTimer* for the corresponding HARQ process.
- 5 - if the PDCCH indicates a new transmission (DL or UL):
 - start or restart *drx-InactivityTimer*.
- in current subframe n, if the UE would not be in Active Time considering grants/assignments/DRX Command MAC control elements received and Scheduling Request sent until and including subframe n-5 when evaluating all DRX Active Time conditions as specified in this subclause, type-0-triggered SRS [2] shall not be reported.
- 10 - if CQI masking (*cqi-Mask*) is setup by upper layers:
 - in current subframe n, if *onDurationTimer* would not be running considering grants/assignments/DRX Command MAC control elements received until and including subframe n-5 when evaluating all DRX Active Time conditions as specified in this subclause, CQI/PMI/RI/PTI on PUCCH shall not be reported.
 - 15 - else:
 - in current subframe n, if the UE would not be in Active Time considering grants/assignments/DRX Command MAC control elements received and Scheduling Request sent until and including subframe n-5 when evaluating all DRX Active Time conditions as specified in this subclause, CQI/PMI/RI/PTI on PUCCH shall not be reported.
 - 20 - in current subframe n, if the UE would not be in Active Time considering grants/assignments/DRX Command MAC control elements received and Scheduling Request sent until and including subframe n-5 when evaluating all DRX Active Time conditions as specified in this subclause, CQI/PMI/RI/PTI on PUCCH shall not be reported.

Regardless of whether the UE is monitoring PDCCH or not, the UE receives and transmits HARQ feedback and transmits type-1-triggered SRS [2] when such is expected.

NOTE: The same active time applies to all activated serving cell(s).

- 25 NOTE: In case of downlink spatial multiplexing, if a TB is received while the HARQ RTT Timer is running and the previous transmission of the same TB was received at least N subframes before the current subframe (where N corresponds to the HARQ RTT Timer), the UE should process it and restart the HARQ RTT Timer.

- 30 In such a modification of the procedure of Section 5.7 of TS, 36.321 V12.2.1 (2014-06), the checks for timer expiry for HARQ RTT timer expiry, DRX inactivity timer expiry, short cycle timer expiry, long cycle timer expiry, and so on are checked for each short TTI 114.

- 35 In one or more embodiments, normal TTI 112 and short TTI 114 may coexist, and the network elements of EUTRAN 200 may multiplex or otherwise switch between the use of a normal TTI 112 and a short TTI 114. The functionality of short TTI 114 may be available in

both the uplink (UL) and in the downlink (DL) to realize the gains from TTI reduction. In such embodiments, the data channels physical downlink shared channel (PDSCH) and physical uplink shared channel (PUSCH) both may support short TTI 114.

From the point of view of UE 210 it may not be required to receive both normal TTI 112 and short TTI 114 simultaneously in a single normal or legacy subframe period. As a result, a particular UE 210 may multiplex normal TTI 112 and short TTI 114 in a Time Division Multiplexing (TDM) manner across different normal or legacy subframes. As discussed herein above, not all traffic may require or otherwise get low-latency treatment. A UE 210 having both types of traffic may switch between short TTIs 114 and normal TTIs 112 in a TDM fashion.

For a particular UE 210 supporting both short TTIs 114 and normal TTIs 112, UE 210 may have the capability to fallback from short TTI 114 to normal TTI 112, for example when the short TTI 114 capacity is full, and to switch back to short TTI 114, for example when short TTI 114 capacity is available, even for low-latency specific traffic. Such a capability may support switching a certain resource block (RB) or group of RBs. An example embodiment of such capability may be as follows.

In one or more embodiments, UE 210 is allowed to switch between the short TTI 114 and normal TTI 112 based on the traffic characteristics UE 210 is supporting including during the ongoing traffic session. In one example, UE 210 operates using short TTI 114 during the transmission control protocol (TCP) slow-start period of a low-latency application, and to reduce L1/L2 overhead for example, UE 210 may switch to normal TTI 112 when substantial TCP congestion window size (CWND) has been achieved. The switching may be triggered by UE 210 or by EUTRAN 200 and/or eNB 212.

In general, the switching between the different TTI duration operations may be dynamic or semi-static. Information about the UE capabilities may be indicated by UE 210 to the network depending on the type of switching supported by the UE. In a dynamic switching embodiment, UE 210 may switch on a more dynamic and/or more frequent basis, for example as frequently as on the order of per subframe. In such an arrangement, UE 210 may monitor the physical downlink control channel (PDCCH) on both the normal TTIs and on the short TTIs 114 and then may utilize the corresponding physical downlink shared channel PDSCH and/or physical uplink shared channel (PUSCH) normal TTI 112 or short TTI 114 based on the scheduling information. To support synchronous HARQ retransmissions in the uplink (UL), the normal TTIs 112 and the short TTIs 114 may be multiplexed based on HARQ round trip time (RTT) of short TTI 114 such that synchronous retransmissions may be possible in a short TTI 114.

In a semi-static switching embodiment, switching may be supported at a frequency of on the order of multiple radio frames 100. One or more UEs 210 may be signaled by EUTRAN 200 and/or eNB 212 at the time of switching. Afterwards, UE 210 only needs to monitor the corresponding PDCCH. The signaling to indicate a switch may be radio resource control (RRC) based or other in-band signaling for example using media access control (MAC) control elements (CEs). In some embodiments, HARQ retransmissions for one type of TTI may continue even after switching to another type of TTI. In some embodiments, the HARQ retransmissions may not be allowed after switching to a different type of TTI is performed. In other embodiments, for example in the case of synchronous UL HARQ, UE 210 may switch back to short TTI 114 for such retransmission based on the HARQ RTT corresponding to short TTI 114.

Referring now to FIG. 4, a diagram of physical resource blocks (PRBs) adapted to the coexistence of short TTI PRBs with normal TTI PRBs in a frequency division multiplexing (FDM) manner in accordance with one or more embodiments will be discussed. From the point of view of eNB 212 and/or EUTRAN 200 point of view, multiple options may be utilized to multiplex short TTI 114 and legacy or normal TTI 112. In the embodiment shown in FIG. 4, diagram 400 shows physical resource blocks with frequency represented by vertical axis 410 and time represented by horizontal axis 412. Certain PRBs 416 may be dedicated for use for short TTI 114 service coexisting with legacy or normal TTI 112 service in other PRBs 414 in an FDM manner. Short TTI 114 PRBs 416 may be used in a first frequency range, and normal TTI 112 PRBs 414 may be used in a second frequency range.

Referring now to FIG. 5, a diagram of physical resource blocks (PRBs) adapted to the coexistence of short TTI PRBs with normal TTI PRBs in a time division multiplexing (TDM) manner in accordance with one or more embodiments will be discussed. In the embodiment shown in FIG. 5, diagram 500 shows physical resource blocks with frequency represented by vertical axis 510 and time represented by horizontal axis 510. Certain legacy or normal subframes 516 may allow support of short TTIs 114 coexisting with legacy or normal TTI 112 service in other legacy or normal subframes 514 in a TDM manner. Subframes 514 may utilize normal TTIs 112, and subframes 516 may utilize short TTIs 114.

Referring now to FIG. 6, a diagram of physical resource blocks (PRBs) adapted to the coexistence of short TTI PRBs with normal TTI PRBs in both a frequency division multiplexing (FDM) manner and in a time division multiplexing (TDM) manner in accordance with one or more embodiments will be discussed. In the embodiment shown in FIG. 6, diagram 600 shows physical resource blocks with frequency represented by vertical axis 610 and time represented by horizontal axis 612. Certain legacy or normal subframes dynamically may be assigned from

certain PRBs for short TTI 114 service coexisting with legacy or normal TTI 112 service in other PRBs and/or legacy or normal subframes in a dynamic hybrid FDM and TDM manner. Normal TTIs 112 may be used in PRBs 614 for some frequency bands or for all frequency bands in a given subframe, and short TTIs 114 may be in PRBs 616 for some frequency bands or for all frequency bands in other subframes.

In one or more embodiments relating to HARQ timing and RTT, the HARQ timing for the channels supporting short TTI 114 may depend on processing delay for UE 210 and for eNB 212 as well as the design of the HARQ acknowledgment/negative acknowledgment (ACK/NACK) mechanism. It is expected that for a short TTI 114, the transport block size may be smaller and therefore the processing times at eNB 212 and UE 210 may be reduced, for example compared to the 3.0 ms processing times in the current 3GPP LTE specification. As a result, the HARQ timing may be modified wherein different number of HARQ processes may be supported depending on the TTI and node processing delay at UE 210 and/or at eNB 212.

As an example, the number of HARQ processes in a frequency division duplexing mode that are capable of being supported may be based on the TTI and node processing delay at UE 210 and/or at eNB 212 as shown in Table 1, below.

Node processing delay (ms)	1ms TTI		0.5ms TTI		2 OFDM symbol TTI with extended CP	
	HARQ RTT (ms)	Max num of UL HARQ processes	HARQ RTT (ms)	Max num of UL HARQ processes	HARQ RTT (ms)	Max num of UL HARQ processes
3ms	8	8	7	14	6.33	38
2ms	6	6	5	10	4.33	26
1.5ms	5	5	4	8	3.33	20
1ms	4	4	3	6	2.33	14
0.5ms	3	4	2	4	1.33	8

Table 1 - Number of possible HARQ processes in FDD mode

It should be noted that in Table 1 for column directed 2 OFDM symbols with extended CP using current LTE numerology, short TTI duration is 1/6 ms or 0.167 ms. Furthermore, for a node processing delay of 0.5 ms, even though the processing delay is smaller than one TTI, UE 210 and/or eNB 212 needs to wait until the next TTI for transmissions, resulting in a maximum of 4 HARQ processes. Cells indicating a value of 8 maximum number of UL HARQ processes correspond to node processing times exactly scaled by the same factor as TTI reduction, thus resulting in 8 HARQ processes, which is equal to 8 HARQ processes in the current 3GPP LTE specification.

Referring now to FIG. 7, a block diagram of an information handling system capable of transmission with reduced latency in accordance with one or more embodiments will be discussed. Information handling system 700 of FIG. 7 may tangibly embody any one or more of the network elements described herein, above, including for example the elements of EUTRAN 200 such as UE 210 and/or eNB 212, with greater or fewer components depending on the hardware specifications of the particular device. In one embodiment, information handling system 700 may tangibly embody an apparatus of a user equipment (UE), comprising a radio-frequency transceiver to transmit a scheduling request message to an evolved Node B (eNB) in a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB, and receive an uplink grant message from the eNB on a physical downlink control channel (PDCCH), and further comprising one or more baseband processors to determine if the data to be transmitted should use a normal TTI or a short TTI, and generate a message to include an indication whether the normal TTI or the short TTI will be used to transmit the data, wherein the radio-frequency transceiver is to transmit the generated message to the eNB, and transmit the data to the eNB on a physical uplink shared channel (PUSCH) on a resource allocated by the uplink grant message using the normal TTI or the short TTI according to the indication. In another embodiment, information handling system 700 may tangibly embody an apparatus of an evolved Node B (eNB), comprising a radio-frequency transceiver to receive a scheduling request message from a user equipment (UE) on a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB, and further comprising one or more baseband processors to generate uplink grant message to include an indication whether a resource allocation in the uplink grant message is for data to be transmitted as normal latency or low-latency data, wherein the radio-frequency transceiver is to transmit the uplink grant message to the UE on a physical downlink control channel (PDCCH), and receive the data to the UE on a physical uplink shared channel (PUSCH) using a normal transmission time interval (TTI) or a short TTI according to the indication. Although information handling system 700 represents one example of several types of computing platforms, information handling system 700 may include more or fewer elements and/or different arrangements of elements than shown in FIG. 7, and the scope of the claimed subject matter is not limited in these respects.

In one or more embodiments, information handling system 700 may include one or more application processors 710 and one or more baseband processors 712. Application processor 710 may be utilized as a general-purpose processor to run applications and the various subsystems for information handling system 700. Application processor 710 may include a single core or alternatively may include multiple processing cores. One or more of the cores may comprise a digital signal processor or digital signal processing (DSP) core. Furthermore, application

processor 710 may include a graphics processor or coprocessor disposed on the same chip, or alternatively a graphics processor coupled to application processor 710 may comprise a separate, discrete graphics chip. Application processor 710 may include on board memory such as cache memory, and further may be coupled to external memory devices such as synchronous dynamic random access memory (SDRAM) 714 for storing and/or executing applications during operation, and NAND flash 716 for storing applications and/or data even when information handling system 700 is powered off. In one or more embodiments, instructions to operate or configure the information handling system 700 and/or any of its components or subsystems to operate in a manner as described herein may be stored on an article of manufacture comprising a non-transitory storage medium. In one or more embodiments, the storage medium may comprise any of the memory devices shown in and described herein, although the scope of the claimed subject matter is not limited in this respect. Baseband processor 712 may control the broadband radio functions for information handling system 700. Baseband processor 712 may store code for controlling such broadband radio functions in a NOR flash 718. Baseband processor 712 controls a wireless wide area network (WWAN) transceiver 720 which is used for modulating and/or demodulating broadband network signals, for example for communicating via a 3GPP LTE or LTE-Advanced network or the like.

In general, WWAN transceiver 720 may operate according to any one or more of the following radio communication technologies and/or standards including but not limited to: a Global System for Mobile Communications (GSM) radio communication technology, a General Packet Radio Service (GPRS) radio communication technology, an Enhanced Data Rates for GSM Evolution (EDGE) radio communication technology, and/or a Third Generation Partnership Project (3GPP) radio communication technology, for example Universal Mobile Telecommunications System (UMTS), Freedom of Multimedia Access (FOMA), 3GPP Long Term Evolution (LTE), 3GPP Long Term Evolution Advanced (LTE Advanced), Code division multiple access 2000 (CDMA2000), Cellular Digital Packet Data (CDPD), Mobitex, Third Generation (3G), Circuit Switched Data (CSD), High-Speed Circuit-Switched Data (HSCSD), Universal Mobile Telecommunications System (Third Generation) (UMTS (3G)), Wideband Code Division Multiple Access (Universal Mobile Telecommunications System) (W-CDMA (UMTS)), High Speed Packet Access (HSPA), High-Speed Downlink Packet Access (HSDPA), High-Speed Uplink Packet Access (HSUPA), High Speed Packet Access Plus (HSPA+), Universal Mobile Telecommunications System-Time-Division Duplex (UMTS-TDD), Time Division-Code Division Multiple Access (TD-CDMA), Time Division-Synchronous Code Division Multiple Access (TD-CDMA), 3rd Generation Partnership Project Release 8 (Pre-4th Generation) (3GPP Rel. 8 (Pre-4G)), 3GPP Rel. 9 (3rd Generation Partnership Project Release

9), 3GPP Rel. 10 (3rd Generation Partnership Project Release 10) , 3GPP Rel. 11 (3rd Generation Partnership Project Release 11), 3GPP Rel. 12 (3rd Generation Partnership Project Release 12), 3GPP Rel. 13 (3rd Generation Partnership Project Release 12), 3GPP Rel. 14 (3rd Generation Partnership Project Release 12), 3GPP LTE Extra, LTE Licensed-Assisted Access (LAA), UMTS Terrestrial Radio Access (UTRA), Evolved UMTS Terrestrial Radio Access (E-UTRA), Long Term Evolution Advanced (4th Generation) (LTE Advanced (4G)), cdmaOne (2G), Code division multiple access 2000 (Third generation) (CDMA2000 (3G)), Evolution-Data Optimized or Evolution-Data Only (EV-DO), Advanced Mobile Phone System (1st Generation) (AMPS (1G)), Total Access Communication System/Extended Total Access Communication System (TACS/ETACS), Digital AMPS (2nd Generation) (D-AMPS (2G)), Push-to-talk (PTT), Mobile Telephone System (MTS), Improved Mobile Telephone System (IMTS), Advanced Mobile Telephone System (AMTS), OLT (Norwegian for Offentlig Landmobil Telefoni, Public Land Mobile Telephony), MTD (Swedish abbreviation for Mobiltelefonisystem D, or Mobile telephony system D), Public Automated Land Mobile (Autotel/PALM), ARP (Finnish for Autoradiopuhelin, “car radio phone”), NMT (Nordic Mobile Telephony), High capacity version of NTT (Nippon Telegraph and Telephone) (Hicap), Cellular Digital Packet Data (CDPD), Mobitex, DataTAC, Integrated Digital Enhanced Network (iDEN), Personal Digital Cellular (PDC), Circuit Switched Data (CSD), Personal Handy-phone System (PHS), Wideband Integrated Digital Enhanced Network (WiDEN), iBurst, Unlicensed Mobile Access (UMA), also referred to as also referred to as 3GPP Generic Access Network, or GAN standard), Zigbee, Bluetooth®, Wireless Gigabit Alliance (WiGig) standard, millimeter wave (mmWave) standards in general for wireless systems operating at 10-90 GHz and above such as WiGig, IEEE 802.11ad, IEEE 802.11ay, and so on, and/or general telemetry transceivers, and in general any type of RF circuit or RFI sensitive circuit. It should be noted that such standards may evolve over time, and/or new standards may be promulgated, and the scope of the claimed subject matter is not limited in this respect.

The WWAN transceiver 720 couples to one or more power amps 742 respectively coupled to one or more antennas 424 for sending and receiving radio-frequency signals via the WWAN broadband network. The baseband processor 712 also may control a wireless local area network (WLAN) transceiver 726 coupled to one or more suitable antennas 728 and which may be capable of communicating via a Wi-Fi, Bluetooth®, and/or an amplitude modulation (AM) or frequency modulation (FM) radio standard including an IEEE 802.11 a/b/g/n standard or the like. It should be noted that these are merely example implementations for application processor 710 and baseband processor 712, and the scope of the claimed subject matter is not limited in these respects. For example, any one or more of SDRAM 414, NAND flash 716 and/or NOR flash

718 may comprise other types of memory technology such as magnetic memory, chalcogenide memory, phase change memory, or ovonic memory, and the scope of the claimed subject matter is not limited in this respect.

In one or more embodiments, application processor 710 may drive a display 730 for displaying various information or data, and may further receive touch input from a user via a touch screen 732 for example via a finger or a stylus. An ambient light sensor 434 may be utilized to detect an amount of ambient light in which information handling system 700 is operating, for example to control a brightness or contrast value for display 730 as a function of the intensity of ambient light detected by ambient light sensor 734. One or more cameras 736 may be utilized to capture images that are processed by application processor 710 and/or at least temporarily stored in NAND flash 716. Furthermore, application processor may couple to a gyroscope 738, accelerometer 740, magnetometer 742, audio coder/decoder (CODEC) 744, and/or global positioning system (GPS) controller 746 coupled to an appropriate GPS antenna 748, for detection of various environmental properties including location, movement, and/or orientation of information handling system 700. Alternatively, controller 746 may comprise a Global Navigation Satellite System (GNSS) controller. Audio CODEC 744 may be coupled to one or more audio ports 750 to provide microphone input and speaker outputs either via internal devices and/or via external devices coupled to information handling system via the audio ports 750, for example via a headphone and microphone jack. In addition, application processor 710 may couple to one or more input/output (I/O) transceivers 752 to couple to one or more I/O ports 754 such as a universal serial bus (USB) port, a high-definition multimedia interface (HDMI) port, a serial port, and so on. Furthermore, one or more of the I/O transceivers 752 may couple to one or more memory slots 756 for optional removable memory such as secure digital (SD) card or a subscriber identity module (SIM) card, although the scope of the claimed subject matter is not limited in these respects.

Referring now to FIG. 8, an isometric view of an information handling system of FIG. 7 that optionally may include a touch screen in accordance with one or more embodiments will be discussed. FIG. 8 shows an example implementation of information handling system 700 of FIG. 7 tangibly embodied as a cellular telephone, smartphone, or tablet type device or the like.

The information handling system 700 may comprise a housing 810 having a display 730 which may include a touch screen 732 for receiving tactile input control and commands via a finger 816 of a user and/or a via stylus 818 to control one or more application processors 710. The housing 810 may house one or more components of information handling system 700, for example one or more application processors 710, one or more of SDRAM 714, NAND flash 716, NOR flash 718, baseband processor 712, and/or WWAN transceiver 720. The information handling system

700 further may optionally include a physical actuator area 820 which may comprise a keyboard or buttons for controlling information handling system via one or more buttons or switches. The information handling system 700 may also include a memory port or slot 756 for receiving non-volatile memory such as flash memory, for example in the form of a secure digital (SD) card or a subscriber identity module (SIM) card. Optionally, the information handling system 700 may further include one or more speakers and/or microphones 824 and a connection port 754 for connecting the information handling system 700 to another electronic device, dock, display, battery charger, and so on. In addition, information handling system 700 may include a headphone or speaker jack 828 and one or more cameras 736 on one or more sides of the housing 810. It should be noted that the information handling system 700 of FIG. 8 may include more or fewer elements than shown, in various arrangements, and the scope of the claimed subject matter is not limited in this respect.

As used herein, the terms "circuit" or "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 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 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, circuitry may include logic, at least partially operable in hardware. Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software.

Referring now to FIG. 9, example components of a wireless device such User Equipment (UE) device 900 in accordance with one or more embodiments will be discussed. User equipment (UE) 900 may correspond, for example, to UE 210 of EUTRAN 200, or alternatively to eNB 212 EUTRAN 200, although the scope of the claimed subject matter is not limited in this respect. In some embodiments, UE device 900 may include application circuitry 902, baseband circuitry 904, Radio Frequency (RF) circuitry 906, front-end module (FEM) circuitry 908 and one or more antennas 910, coupled together at least as shown.

Application circuitry 902 may include one or more application processors. For example, application circuitry 902 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The one or more processors may include any combination of general-purpose processors and dedicated processors, for example graphics processors, application processors, and so on. The processors may be coupled with and/or may include memory and/or storage and may be configured to execute instructions stored in the memory and/or storage to enable various applications and/or operating systems to run on the system.

Baseband circuitry 904 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. Baseband circuitry 904 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of RF circuitry 906 and to generate baseband signals for a transmit signal path of the RF circuitry 906. Baseband processing circuitry 904 may interface with the application circuitry 902 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 906. For example, in some embodiments, the baseband circuitry 904 may include a second generation (2G) baseband processor 904a, third generation (3G) baseband processor 904b, fourth generation (4G) baseband processor 904c, and/or one or more other baseband processors 904d for other existing generations, generations in development or to be developed in the future, for example fifth generation (5G), sixth generation (6G), and so on. Baseband circuitry 904, for example one or more of baseband processors 904a through 904d, may handle various radio control functions that enable communication with one or more radio networks via RF circuitry 906. The radio control functions may include, but are not limited to, signal modulation and/or demodulation, encoding and/or decoding, radio frequency shifting, and so on. In some embodiments, modulation and/or demodulation circuitry of baseband circuitry 904 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping and/or demapping functionality. In some embodiments, encoding and/or decoding circuitry of baseband circuitry 904 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder and/or decoder functionality. Embodiments of modulation and/or demodulation and encoder and/or decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

In some embodiments, baseband circuitry 904 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. Processor 904e of the baseband circuitry 904 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers.

In some embodiments, the baseband circuitry may include one or more audio digital signal processors (DSP) 904f. The one or more audio DSPs 904f may include elements for compression and/or decompression and/or echo cancellation and may include other suitable processing elements in other embodiments. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of baseband

circuitry 904 and application circuitry 902 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, baseband circuitry 904 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, baseband circuitry 904 may support communication with an 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 baseband circuitry 904 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 906 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, RF circuitry 906 may include switches, filters, amplifiers, and so on, to facilitate the communication with the wireless network. RF circuitry 906 may include a receive signal path which may include circuitry to down-convert RF signals received from FEM circuitry 908 and provide baseband signals to baseband circuitry 904. RF circuitry 906 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 1004 and provide RF output signals to FEM circuitry 1008 for transmission.

In some embodiments, RF circuitry 906 may include a receive signal path and a transmit signal path. The receive signal path of RF circuitry 906 may include mixer circuitry 906a, amplifier circuitry 906b and filter circuitry 906c. The transmit signal path of RF circuitry 906 may include filter circuitry 906c and mixer circuitry 906a. RF circuitry 906 may also include synthesizer circuitry 906d for synthesizing a frequency for use by the mixer circuitry 906a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 906a of the receive signal path may be configured to down-convert RF signals received from FEM circuitry 908 based on the synthesized frequency provided by synthesizer circuitry 906d. Amplifier circuitry 906b may be configured to amplify the down-converted signals and the filter circuitry 906c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to baseband circuitry 904 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 906a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, mixer circuitry 906a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by synthesizer

circuitry 906d to generate RF output signals for FEM circuitry 908. The baseband signals may be provided by the baseband circuitry 904 and may be filtered by filter circuitry 906c. Filter circuitry 906c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

5 In some embodiments, mixer circuitry 906a of the receive signal path and the mixer circuitry 906a of the transmit signal path may include two or more mixers and may be arranged for quadrature down conversion and/or up conversion respectively. In some embodiments, mixer circuitry 906a of the receive signal path and the mixer circuitry 906a of the transmit signal path may include two or more mixers and may be arranged for image rejection, for example
10 Hartley image rejection. In some embodiments, mixer circuitry 906a of the receive signal path and the mixer circuitry 906a may be arranged for direct down conversion and/or direct up conversion, respectively. In some embodiments, mixer circuitry 906a of the receive signal path and mixer circuitry 906a of the transmit signal path may be configured for super-heterodyne operation.

15 In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, RF circuitry 1006 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry, and baseband
20 circuitry 904 may include a digital baseband interface to communicate with RF circuitry 906. In some dual-mode embodiments, separate radio integrated circuit (IC) circuitry may be provided for processing signals for one or more spectra, although the scope of the embodiments is not limited in this respect.

In some embodiments, synthesizer circuitry 906d may be a fractional-N synthesizer or a
25 fractional $N/N+1$ synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 906d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

Synthesizer circuitry 906d may be configured to synthesize an output frequency for use by
30 mixer circuitry 906a of RF circuitry 1006 based on a frequency input and a divider control input. In some embodiments, synthesizer circuitry 906d may be a fractional $N/N+1$ synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either baseband circuitry 904 or applications processor 902 depending on the desired output frequency.

In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by applications processor 902.

Synthesizer circuitry 906d of RF circuitry 1006 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+1, for example based on a carry out, to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into Nd equal packets of phase, where Nd is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 906d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency, for example twice the carrier frequency, four times the carrier frequency, and so on, and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a local oscillator (LO) frequency (fLO). In some embodiments, RF circuitry 1006 may include an in-phase and quadrature (IQ) and/or polar converter.

FEM circuitry 908 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 910, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 906 for further processing. FEM circuitry 908 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by RF circuitry 906 for transmission by one or more of the one or more antennas 910.

In some embodiments, FEM circuitry 908 may include a transmit/receive (TX/RX) switch to switch between transmit mode and receive mode operation. FEM circuitry 908 may include a receive signal path and a transmit signal path. The receive signal path of FEM circuitry 908 may include a low-noise amplifier (LNA) to amplify received RF signals and to provide the amplified received RF signals as an output, for example to RF circuitry 906. The transmit signal path of FEM circuitry 908 may include a power amplifier (PA) to amplify input RF signals, for example provided by RF circuitry 906, and one or more filters to generate RF signals for subsequent transmission, for example by one or more of antennas 910. In some embodiments, UE device 900 may include additional elements such as, for example, memory and/or storage, display,

camera, sensor, and/or input/output (I/O) interface, although the scope of the claimed subject matter is not limited in this respect.

The following are example implementations of the subject matter described herein. It should be noted that any of the examples and the variations thereof described herein may be used in any permutation or combination of any other one or more examples or variations, although the scope of the claimed subject matter is not limited in these respects. In example one, an apparatus of a user equipment (UE), comprises a radio-frequency transceiver to transmit a scheduling request message to an evolved Node B (eNB) in a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB, and receive an uplink grant message from the eNB on a physical downlink control channel (PDCCH), and one or more baseband processors to determine if the data to be transmitted should use a normal TTI or a short TTI, and generate a buffer status report (BSR) message to include an indication whether the normal TTI or the short TTI will be used to transmit the data, wherein the radio-frequency transceiver is to transmit the BSR message to the eNB, and transmit the data to the eNB on a physical uplink shared channel (PUSCH) on a resource allocated by the uplink grant message using the normal TTI or the short TTI according to the indication. In example two, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein the normal TTI is used for normal latency data, and the short TTI is used for low-latency data. In example three, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein the BSR message is transmitted to the eNB on the PUSCH. In example four, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein data radio bearers using the short TTI are assigned to a same logical channel group (LCG) of the BSR to indicate a difference between data using the normal TTI and data using the short TTI. In example five, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein the generated message comprises a media access control (MAC) protocol data unit (PDU), and the indication comprises a logical channel identifier in a header of the PDU that is transmitted to the eNB on the PUCCH. In example six, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein the data is transmitted to the eNB on one or more physical resource blocks (PRBs) on the PUSCH, wherein normal latency data is transmitted on a first group of PRBs and low-latency data is transmitted on a second group of PRBs in a frequency division multiplexing (FDM) manner, in a time division multiplexing (TDM) manner, or a combination of an FDM and a TDM manner. In example seven, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein the one or more baseband processors are to determine if the data to be

transmitted is normal latency or low-latency data based at least in part on traffic categorization, Quality of Service (QoS) requirements, delay constraints, or low-latency capacity, or a combination thereof. In example eight, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein the decoded uplink grant message indicates if normal latency or low-latency data may be transmitted on a resource allocated on the uplink grant. In example nine, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein normal latency data is multiplexed with low-latency data transmitted on the PUSCH based at least in part on a hybrid automatic repeat request (HARQ) round trip time (RTT). In example ten, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein the one or more baseband processors are to apply discontinuous reception (DRX) checks on one or more short TTIs within a subframe. In example eleven, the subject matter of example one or any of the examples described herein further may comprise an apparatus, wherein the radio-frequency transceiver is to transmit the data using a short TTI during a first phase, transmit the data using a normal TTI during a second phase, and optionally transmit the data using the short TTI during a third phase. In example twelve, the subject matter of example one or any of the examples described herein further may comprise an apparatus, where the first phase is a TCP slow-start period, the second phase is a result of a congestion window size (CWND) being achieved, and the third phase is a congestion avoidance phase.

In example thirteen, an apparatus of an evolved Node B (eNB) comprises a radio-frequency transceiver to receive a scheduling request message from a user equipment (UE) on a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB, and one or more baseband processors to generate uplink grant message to include an indication whether a resource allocation in the uplink grant message is for data to be transmitted as normal latency or low-latency data, wherein the radio-frequency transceiver is to transmit the uplink grant message to the UE on a physical downlink control channel (PDCCH), and receive the data to the UE on a physical uplink shared channel (PUSCH) using a normal transmission time interval (TTI) or a short TTI according to the indication. In example fourteen, the subject matter of example thirteen or any of the examples described herein may comprise an apparatus, wherein the indication comprises a low-latency indication flag. In example fifteen, the subject matter of example thirteen or any of the examples described herein may comprise an apparatus, wherein a first uplink grant message is generated for normal latency traffic, and a second uplink grant message is generated for low-latency traffic. In example sixteen, the subject matter of example thirteen or any of the examples described herein may comprise an apparatus, wherein the radio-frequency transceiver it to transmit the uplink grant message to one or more additional

UEs as a group grant for contention based access, and wherein an allocated resource of the uplink grant message may be shared among the UE and the one or more additional UEs based at least in part on traffic patterns, or UE priority, or a combination thereof. In example seventeen, the subject matter of example thirteen or any of the examples described herein may comprise an apparatus, wherein the normal TTI is used for normal or legacy data, and the short TTI is used for low-latency data. In example eighteen, the subject matter of example thirteen or any of the examples described herein may comprise an apparatus, wherein the data is received from the UE or from one or more additional UEs, or a combination thereof, on one or more physical resource blocks (PRBs) on the PUSCH, wherein normal latency data is received on a first group of PRBs and low-latency data is received on a second group of PRBs in a frequency division multiplexing (FDM) manner, in a time division multiplexing (TDM) manner, or a combination of an FDM and a TDM manner. In example nineteen, the subject matter of example thirteen or any of the examples described herein may comprise an apparatus, wherein normal latency data received from the UE is multiplexed with low-latency data received from the UE based at least in part on a hybrid automatic repeat request (HARQ) round trip time (RTT). In example twenty, the subject matter of example thirteen or any of the examples described herein may comprise an apparatus, wherein the radio-frequency transceiver is to receive the data using a short TTI during a first phase, receive the data using a normal TTI during a second phase, and receive the data using the short TTI during a third phase. In example twenty-one, the subject matter of example thirteen or any of the examples described herein may comprise an apparatus, where the first phase is a TCP slow-start period, the second phase is a result of a congestion window size (CWND) being achieved, and the third phase is a congestion avoidance phase.

In example twenty-two, one or more computer-readable media may have instructions stored thereon that, if executed by a user equipment (UE), result in causing a scheduling request message to be transmitted to an evolved Node B (eNB) on a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB, processing an uplink grant message from the eNB on a physical downlink control channel (PDCCH), determining if the data to be transmitted should use a normal TTI or a short TTI, generating a buffer status report (BSR) message to include an indication whether the normal TTI or the short TTI will be used to transmit the data, causing the BSR message to be transmitted to the eNB, and causing the data to be transmitted to the eNB on a physical uplink shared channel (PUSCH) on a resource allocated by the uplink grant message using the normal TTI or the short TTI according to the indication. In example twenty-three, the subject matter of example twenty-two or any of the examples described herein may comprise one or more computer-readable media, wherein the data is transmitted to the eNB on one or more physical resource blocks (PRBs) on the PUSCH,

and wherein normal latency data is transmitted on a first group of PRBs and low-latency data is transmitted on a second group of PRBs in a frequency division multiplexing (FDM) manner, in a time division multiplexing (TDM) manner, or a combination of an FDM and a TDM manner. In example twenty-four, the subject matter of example twenty-two or any of the examples described
5 herein may comprise one or more computer-readable media, wherein normal latency data is multiplexed with low-latency data transmitted on the PUSCH based at least in part on a hybrid automatic repeat request (HARQ) round trip time (RTT).

In example twenty-five, one or more computer-readable media may have instructions stored thereon that, if executed by an evolved Node B (eNB) result in processing a scheduling
10 request message received from a user equipment (UE) on a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB, generating an uplink grant message to include an indication whether a resource allocation in the uplink grant message is for data to be transmitted as normal latency or low-latency data, causing the uplink grant message to be transmitted to the UE on a physical downlink control channel (PDCCH), and
15 processing the data received from the UE on a physical uplink shared channel (PUSCH) using a normal transmission time interval (TTI) or a short TTI according to the indication. In example twenty-six, the subject matter of example twenty-five or any of the examples described herein may comprise one or more computer-readable media, wherein the instructions, if executed, further result in causing the uplink grant message to be transmitted to one or more additional
20 UEs as a group grant for contention based access, wherein an allocated resource of the uplink grant message may be shared among the UE and the one or more additional UEs based at least in part on traffic patterns, or UE priority, or a combination thereof.

In example twenty-seven, an apparatus comprises means for transmitting a scheduling request message to an evolved Node B (eNB) on a physical uplink control channel (PUCCH)
25 indicating that the UE has data to be transmitted to the eNB, means for processing an uplink grant message received from the eNB on a physical downlink control channel (PDCCH), means for determining if the data to be transmitted should use a normal TTI or a short TTI, means for generating buffer status report (BSR) a message to include an indication whether the normal TTI or the short TTI will be used to transmit the data, means for transmitting the BSR message to the
30 eNB, and means for transmitting the data to the eNB on a physical uplink shared channel (PUSCH) on a resource allocated by the uplink grant message using the normal TTI or the short TTI according to the indication. In example twenty-eight, the subject matter of example twenty-seven or any of the examples described herein may comprise an apparatus, wherein the data is transmitted to the eNB on one or more physical resource blocks (PRBs) on the PUSCH, and
35 wherein normal latency data is transmitted on a first group of PRBs and low-latency data is

transmitted on a second group of PRBs in a frequency division multiplexing (FDM) manner, in a time division multiplexing (TDM) manner, or a combination of an FDM and a TDM manner. In example twenty-nine, the subject matter of example twenty-two or any of the examples described herein may comprise an apparatus, wherein normal latency data is multiplexed with low-latency data transmitted on the PUSCH based at least in part on a hybrid automatic repeat request (HARQ) round trip time (RTT).

In example thirty, an apparatus comprises means for receiving a scheduling request message from a user equipment (UE) on a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB, means for generating an uplink grant message to include an indication whether a resource allocation in the uplink grant message is for data to be transmitted as normal latency or low-latency data, means for transmitting the uplink grant message to the UE on a physical downlink control channel (PDCCH), and means for receiving the data from the UE on a physical uplink shared channel (PUSCH) using a normal transmission time interval (TTI) or a short TTI according to the indication. In example thirty-one, the subject matter of example thirty or any of the examples described herein may comprise an apparatus, further comprising means for transmitting the uplink grant message to one or more additional UEs as a group grant for contention based access, wherein an allocated resource of the uplink grant message may be shared among the UE and the one or more additional UEs based at least in part on traffic patterns, or UE priority, or a combination thereof. In example thirty-three, machine-readable storage may include machine-readable instructions, when executed, to realize an apparatus as claimed in any preceding example.

Although the claimed subject matter has been described with a certain degree of particularity, it should be recognized that elements thereof may be altered by persons skilled in the art without departing from the spirit and/or scope of claimed subject matter. It is believed that the subject matter pertaining to the coexistence of legacy and short transmission time interval for latency reduction and many of its attendant utilities will be understood by the forgoing description, and it will be apparent that various changes may be made in the form, construction and/or arrangement of the components thereof without departing from the scope and/or spirit of the claimed subject matter or without sacrificing all of its material advantages, the form herein before described being merely an explanatory embodiment thereof, and/or further without providing substantial change thereto. It is the intention of the claims to encompass and/or include such changes.

CLAIMS

What is claimed is:

- 5 1. An apparatus of a user equipment (UE), comprising:
a radio-frequency transceiver to transmit a scheduling request message to an evolved Node B (eNB) in a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB, and receive an uplink grant message from the eNB on a physical downlink control channel (PDCCH); and
- 10 one or more baseband processors to determine if the data to be transmitted should use a normal TTI or a short TTI, and generate a buffer status report (BSR) message, optionally including an indication whether the normal TTI or the short TTI will be used to transmit the data;
wherein the radio-frequency transceiver is to transmit the BSR message to the eNB, and transmit the data to the eNB on a physical uplink shared channel (PUSCH) on a resource
- 15 allocated by the uplink grant message using the normal TTI or the short TTI, optionally according to the indication if indicated.
2. The apparatus as claimed in claim 1, wherein the normal TTI is used for normal latency data, and the short TTI is used for low-latency data.
- 20 3. The apparatus as claimed in any of claims 1-2, wherein the buffer status report (BSR) message is transmitted to the eNB on the PUSCH.
4. The apparatus as claimed in any of claims 1-3, wherein data radio bearers using or
- 25 intending to use the short TTI are assigned to a same logical channel group (LCG) to indicate a difference in buffer status between data traffic using the normal TTI and data traffic using the short TTI.
5. The apparatus as claimed in and of claims claim 1-4, wherein the generated message
- 30 comprises a media access control (MAC) protocol data unit (PDU), and the indication comprises a logical channel identifier in a header of the PDU that is transmitted to the eNB on the PUCCH.
6. The apparatus as claimed in any of claims 1-5, wherein the data is transmitted to the eNB on one or more physical resource blocks (PRBs) on the PUSCH, wherein normal latency
- 35 data is transmitted on a first group of PRBs and low-latency data is transmitted on a second

group of PRBs in a frequency division multiplexing (FDM) manner, in a time division multiplexing (TDM) manner, or a combination of an FDM and a TDM manner.

7. The apparatus as claimed in any of claims 1-6, wherein the one or more baseband processors are to determine if the data to be transmitted is normal latency or low-latency data based at least in part on traffic categorization, Quality of Service (QoS) requirements, delay constraints, or low-latency capacity, or a combination thereof.

8. The apparatus as claimed in any of claims 1-7, wherein the decoded uplink grant message indicates if normal latency or low-latency data may be transmitted on a resource allocated on the uplink grant.

9. The apparatus as claimed in any of claims 1-8, wherein normal latency data is multiplexed with low-latency data transmitted on the PUSCH based at least in part on a hybrid automatic repeat request (HARQ) round trip time (RTT).

10. The apparatus as claimed in any of claims 1-9, wherein the one or more baseband processors are to apply discontinuous reception (DRX) checks on one or more short TTIs within a subframe.

11. The apparatus as claimed in any of claims 1-10, wherein the radio-frequency transceiver is to transmit the data using a short TTI during a first phase, transmit the data using a normal TTI during a second phase, and optionally transmit the data using the short TTI during a third phase.

12. The apparatus as claimed in claim 11, where the first phase is a TCP slow-start period, the second phase is a result of a congestion window size (CWND) being achieved, and the third phase is a congestion avoidance phase.

13. An apparatus of an evolved Node B (eNB), comprising
a radio-frequency transceiver to receive a scheduling request message from a user equipment (UE) on a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB; and

one or more baseband processors to generate uplink grant message, optionally including an indication whether a resource allocation in the uplink grant message is for data to be transmitted as normal latency or low-latency data;

wherein the radio-frequency transceiver is to transmit the uplink grant message to the UE on a physical downlink control channel (PDCCH), and receive the data to the UE on a physical uplink shared channel (PUSCH) using a normal transmission time interval (TTI) or a short TTI, optionally according to the indication if indicated.

14. The apparatus as claimed in claim 13, wherein the indication comprises a low-latency indication flag.

15. The apparatus as claimed in any of claims 13-14, wherein a first uplink grant message is generated for normal latency traffic, and a second uplink grant message is generated for low-latency traffic.

16. The apparatus as claimed in any of claims 13-15, wherein the radio-frequency transceiver it to transmit the uplink grant message to one or more additional UEs as a group grant for contention based access, and wherein an allocated resource of the uplink grant message may be shared among the UE and the one or more additional UEs based at least in part on traffic patterns, or UE priority, or a combination thereof.

17. The apparatus as claimed in any of claims 13-16, wherein the normal TTI is used for normal or legacy data, and the short TTI is used for low-latency data.

18. The apparatus as claimed in any of claims 13-17, wherein the data is received from the UE or from one or more additional UEs, or a combination thereof, on one or more physical resource blocks (PRBs) on the PUSCH, wherein normal latency data is received on a first group of PRBs and low-latency data is received on a second group of PRBs in a frequency division multiplexing (FDM) manner, in a time division multiplexing (TDM) manner, or a combination of an FDM and a TDM manner.

19. The apparatus as claimed in any of claims 13-18, wherein normal latency data received from the UE is multiplexed with low-latency data received from the UE based at least in part on a hybrid automatic repeat request (HARQ) round trip time (RTT).

20. The apparatus as claimed in any of claim 13-19, wherein the radio-frequency transceiver is to receive the data using a short TTI during a first phase, receive the data using a normal TTI during a second phase, and receive the data using the short TTI during a third phase.

5 21. The apparatus as claimed in any of claims 13-20, where the first phase is a TCP slow-start period, the second phase is a result of a congestion window size (CWND) being achieved, and the third phase is a congestion avoidance phase.

10 22. One or more computer-readable media having instructions stored thereon that, if executed by a user equipment (UE), result in:

causing a scheduling request message to be transmitted to an evolved Node B (eNB) on a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB;

15 processing an uplink grant message from the eNB on a physical downlink control channel (PDCCH);

determining if the data to be transmitted should use a normal TTI or a short TTI;

generating a buffer status report (BSR) message to include an indication whether the normal TTI or the short TTI will be used to transmit the data;

causing the BSR message to be transmitted to the eNB; and

20 causing the data to be transmitted to the eNB on a physical uplink shared channel (PUSCH) on a resource allocated by the uplink grant message using the normal TTI or the short TTI, optionally according to the indication if indicated.

25 23. The one or more computer-readable media as claimed in claim 22, wherein the data is transmitted to the eNB on one or more physical resource blocks (PRBs) on the PUSCH, and wherein normal latency data is transmitted on a first group of PRBs and low-latency data is transmitted on a second group of PRBs in a frequency division multiplexing (FDM) manner, in a time division multiplexing (TDM) manner, or a combination of an FDM and a TDM manner.

30 24. The one or more computer-readable media as claimed in any of claims 22-23, wherein normal latency data is multiplexed with low-latency data transmitted on the PUSCH based at least in part on a hybrid automatic repeat request (HARQ) round trip time (RTT).

35 25. One or more computer-readable media having instructions stored thereon that, if executed by an evolved Node B (eNB) result in:

processing a scheduling request message received from a user equipment (UE) on a physical uplink control channel (PUCCH) indicating that the UE has data to be transmitted to the eNB;

generating an uplink grant message to include an indication whether a resource allocation in the uplink grant message is for data to be transmitted as normal latency or low-latency data;

causing the uplink grant message to be transmitted to the UE on a physical downlink control channel (PDCCH); and

processing the data received from the UE on a physical uplink shared channel (PUSCH) using a normal transmission time interval (TTI) or a short TTI, optionally according to the indication if indicated.

26. The one or more computer-readable media as claimed in claim 24, wherein the instructions, if executed, further result in causing the uplink grant message to be transmitted to one or more additional UEs as a group grant for contention based access, wherein an allocated resource of the uplink grant message may be shared among the UE and the one or more additional UEs based at least in part on traffic patterns, or UE priority, or a combination thereof.

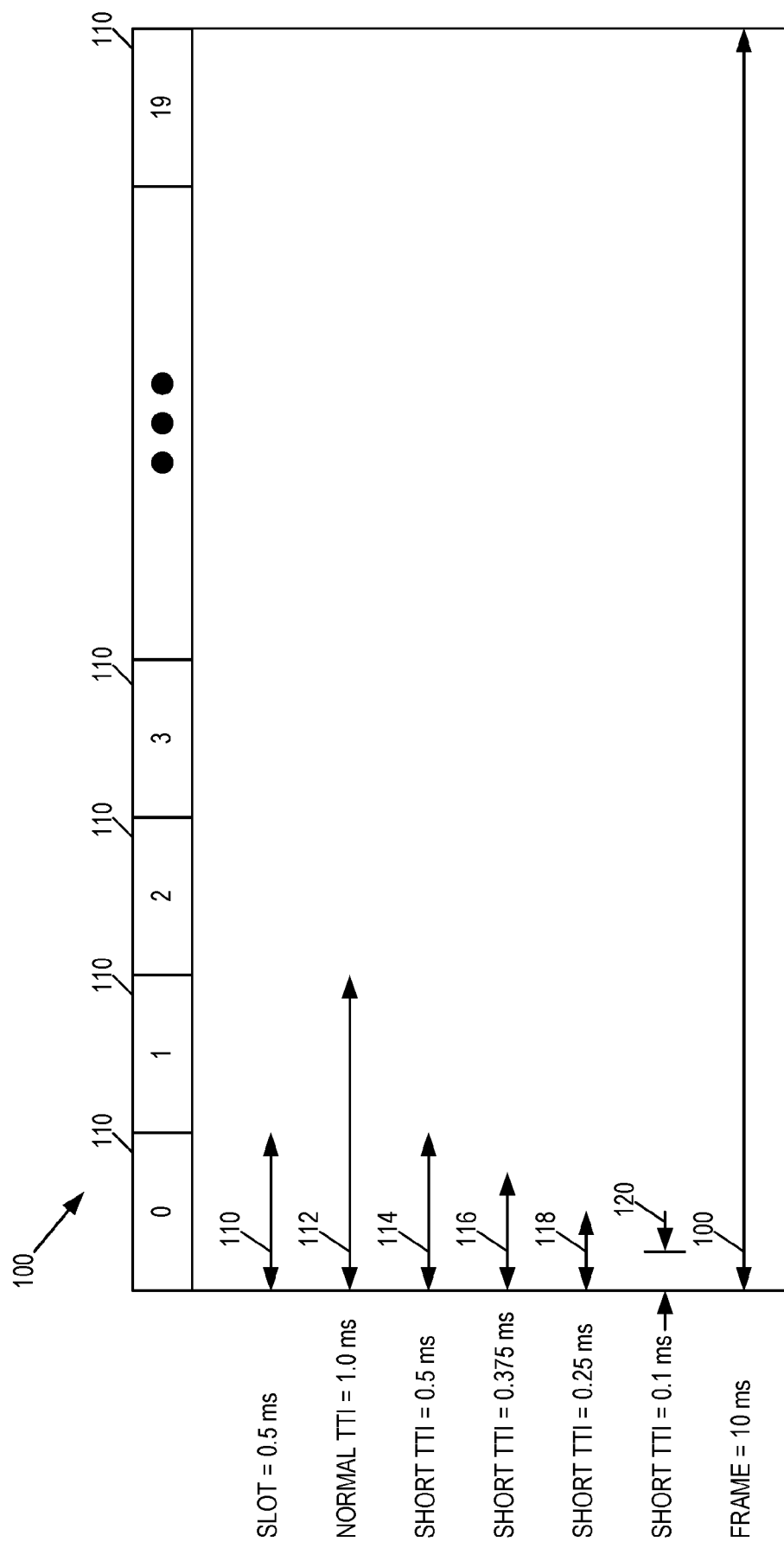


FIG.1

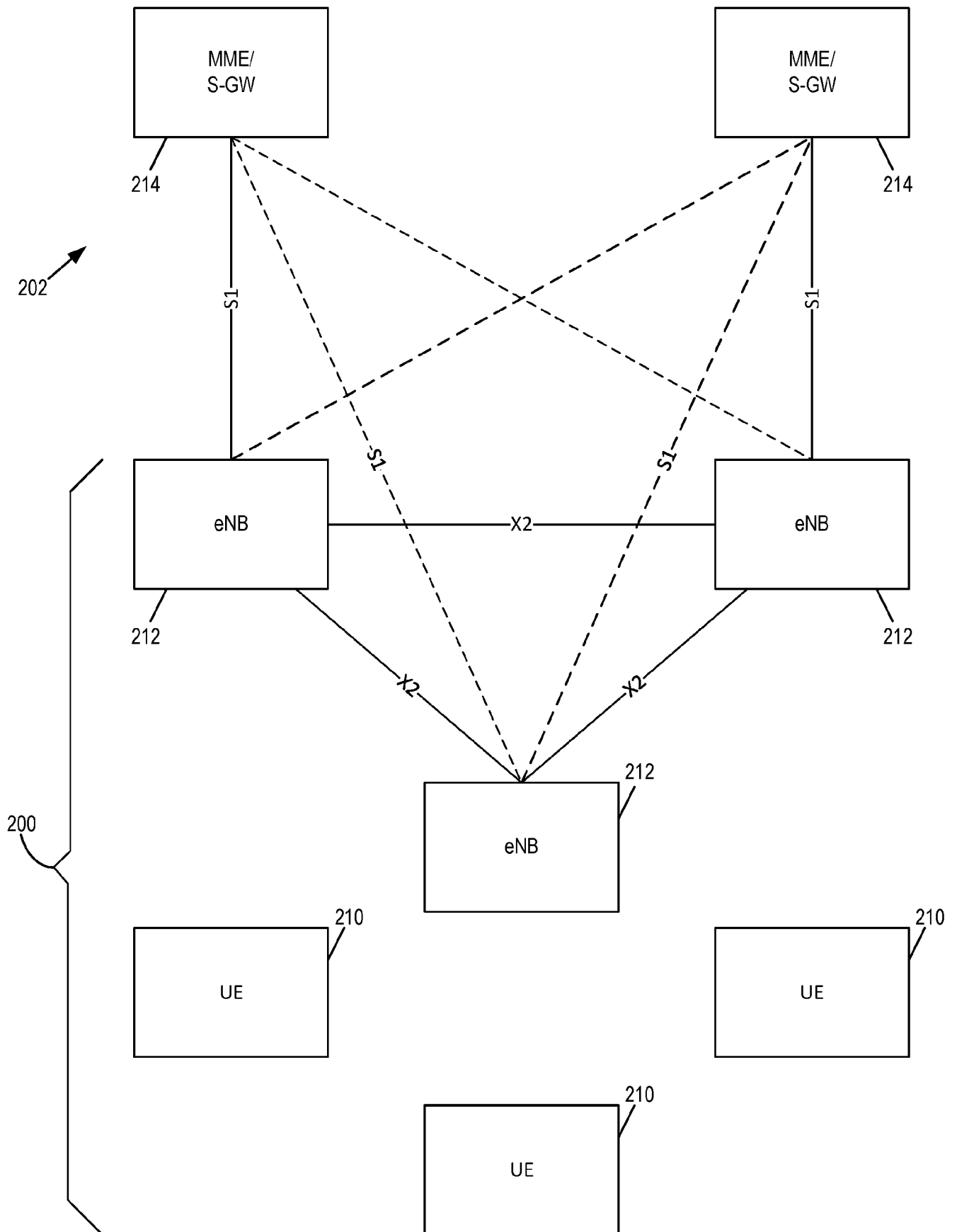


FIG. 2A

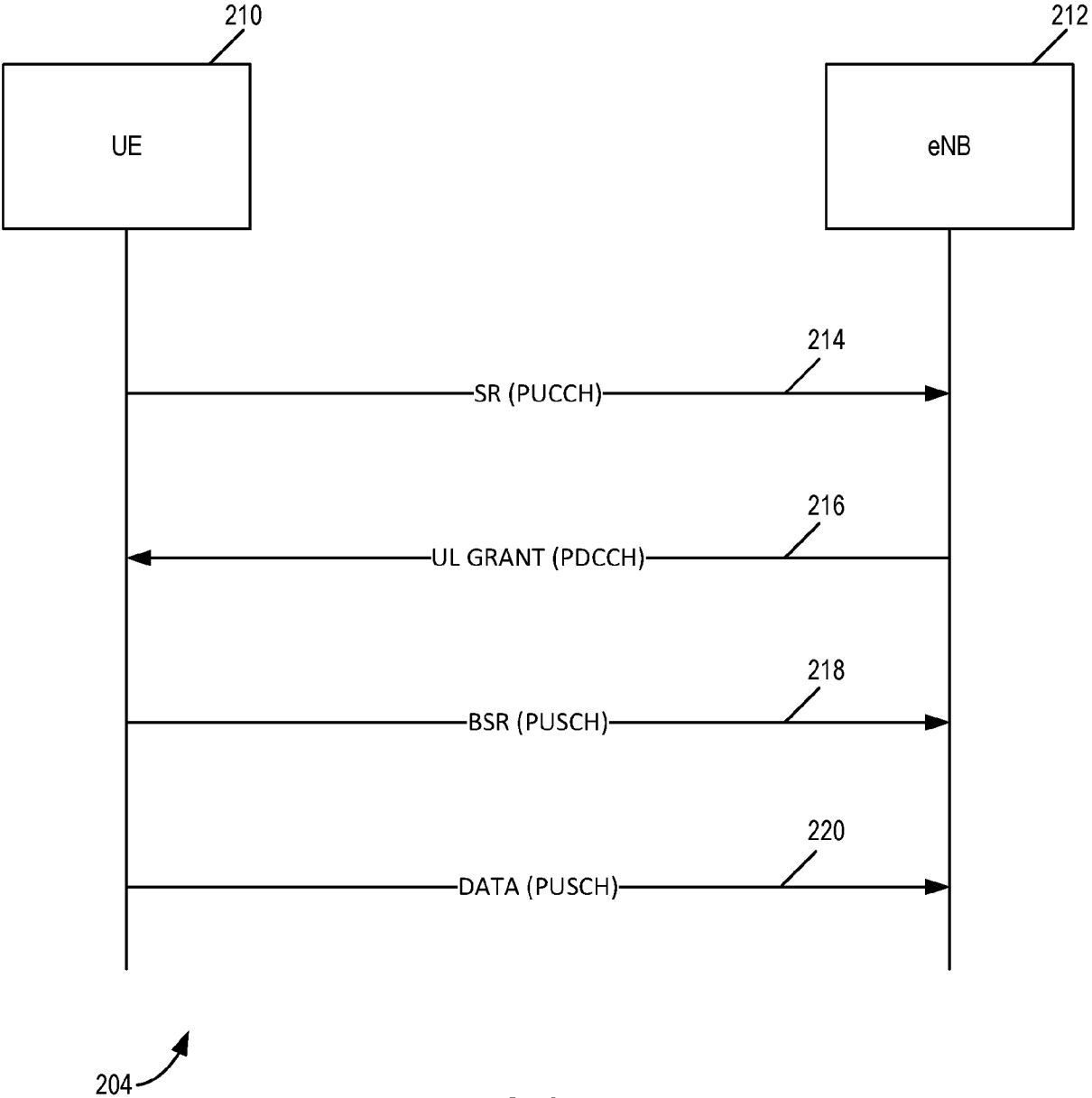


FIG. 2B

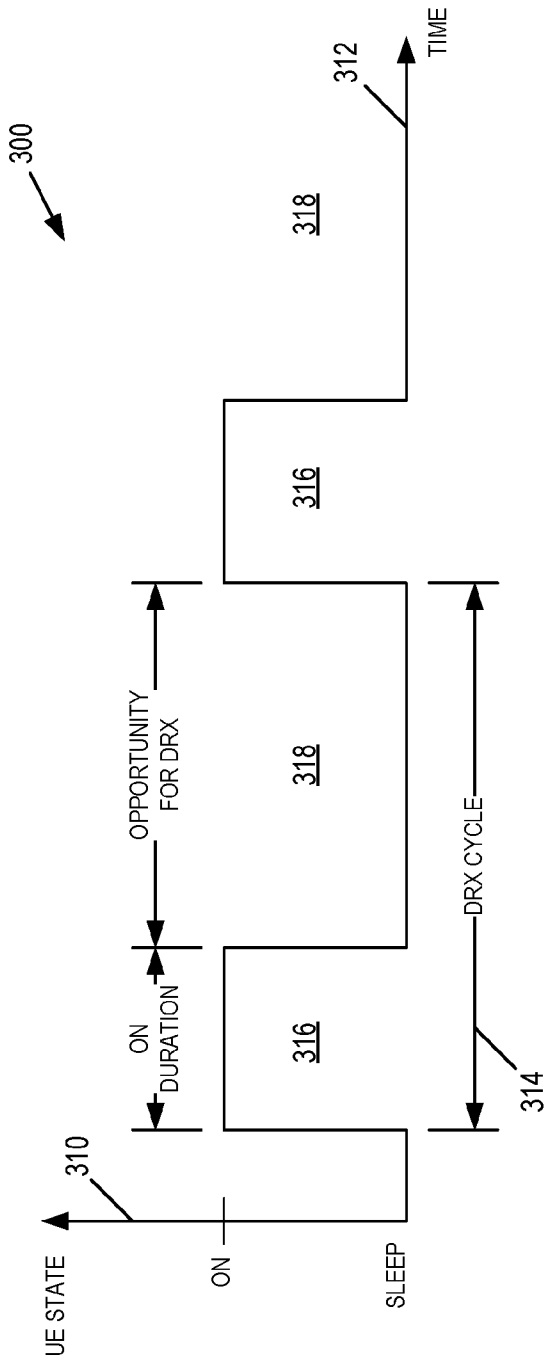


FIG. 3

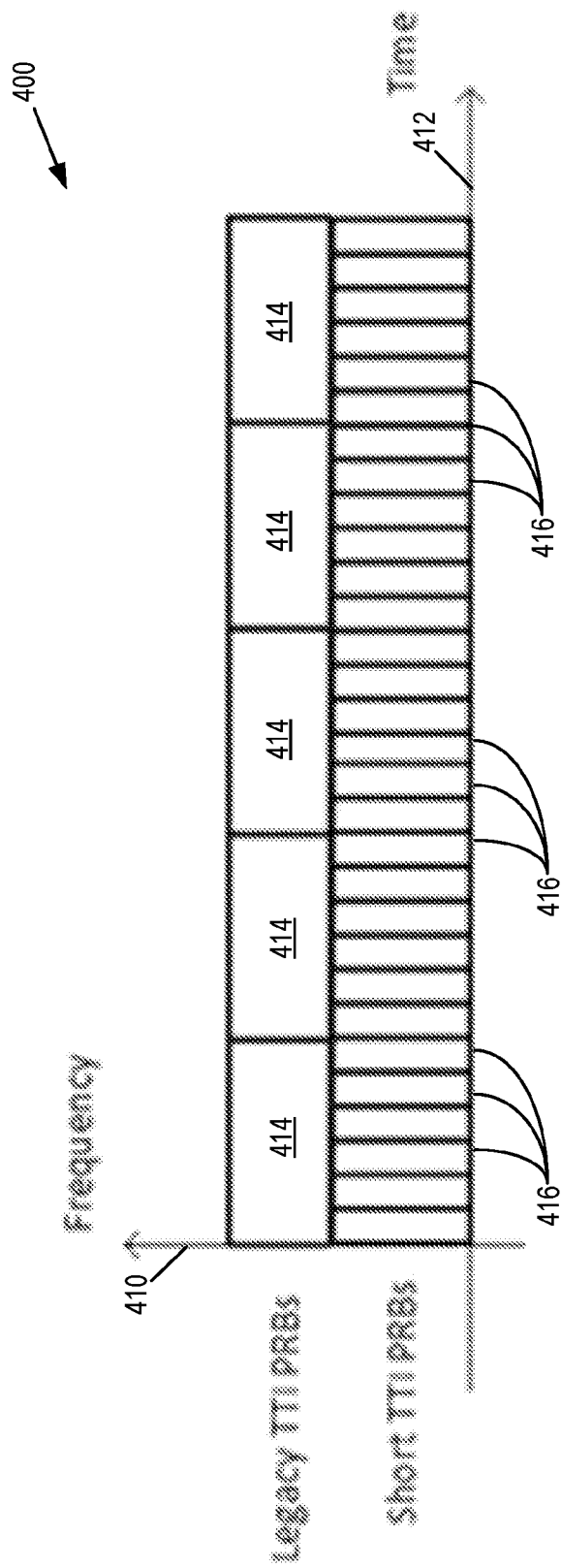


FIG. 4

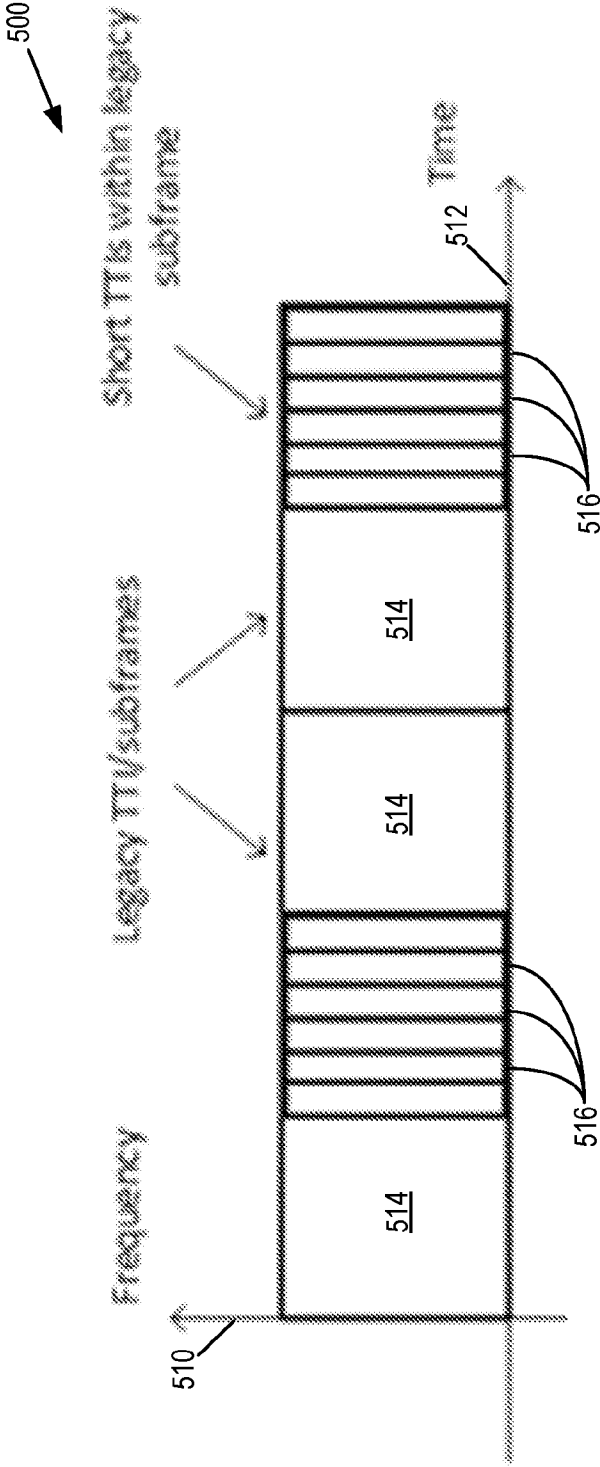


FIG. 5

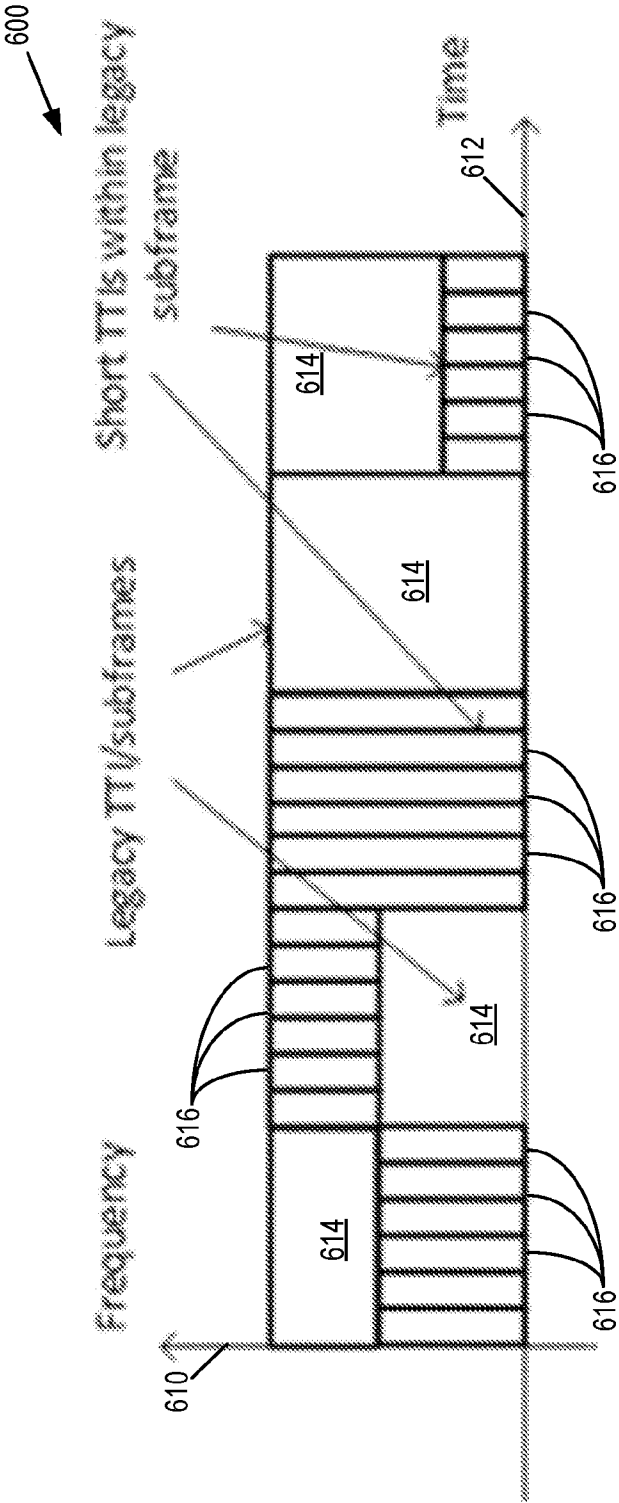


FIG. 6

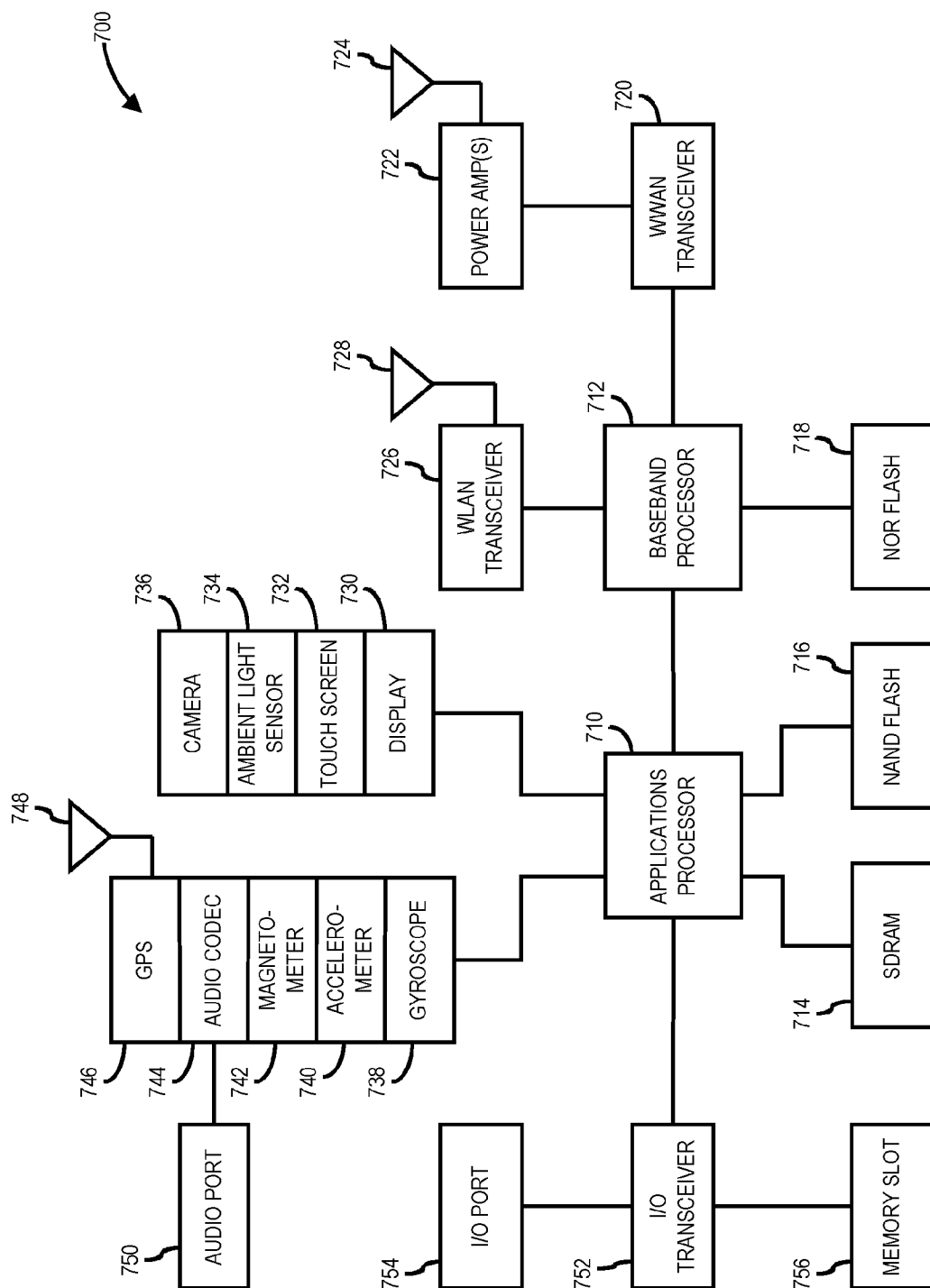


FIG. 7

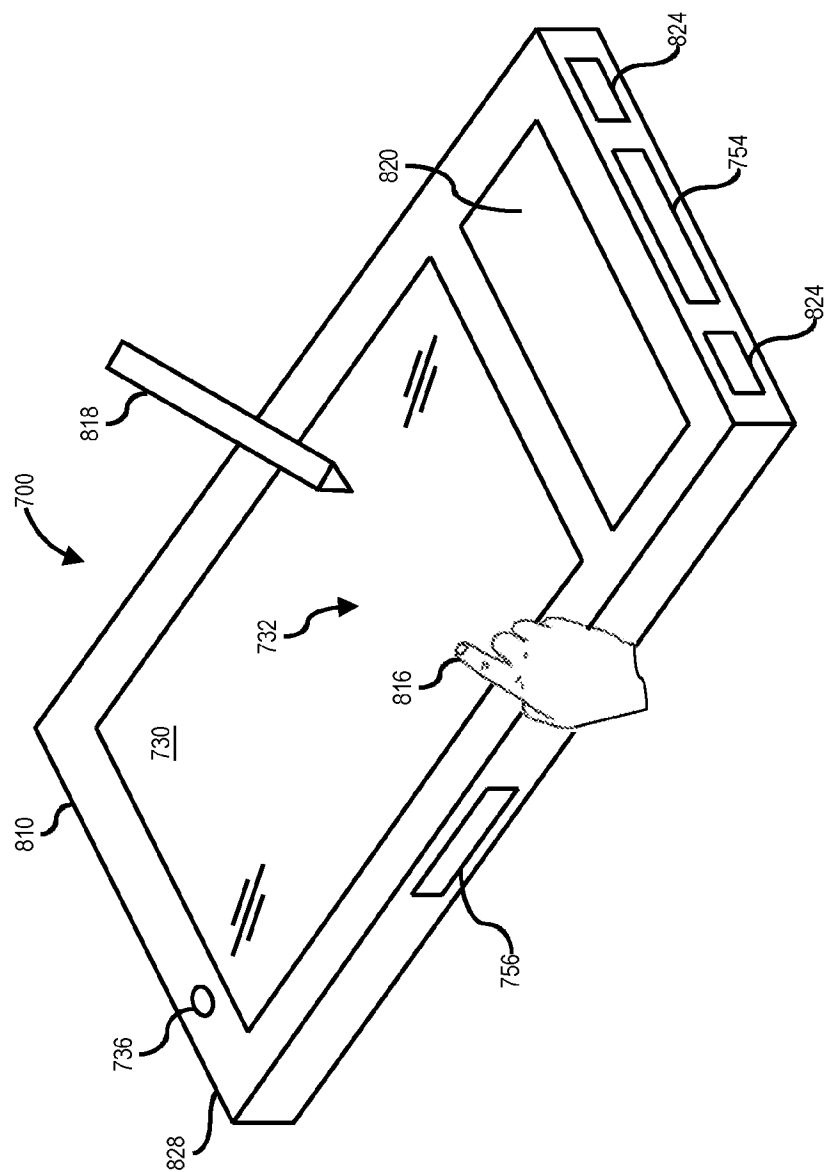


FIG. 8

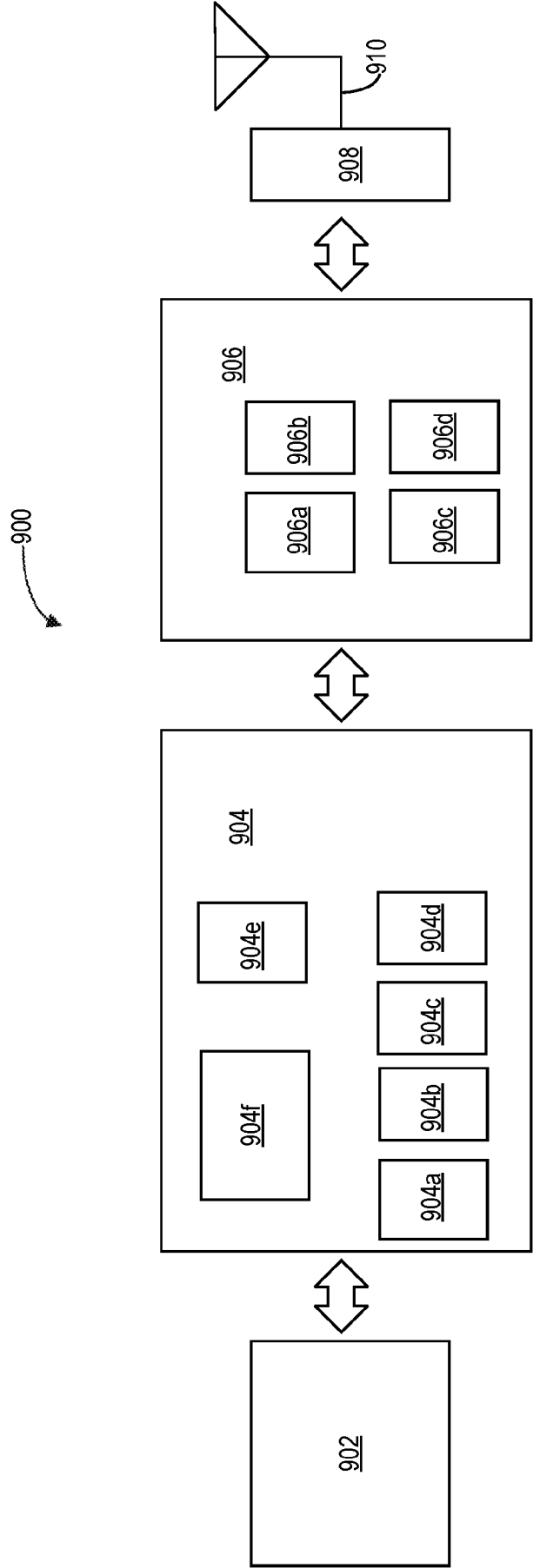


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/053209

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W72/12

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Study on latency reduction techniques for LTE (Release 13)", 3GPP DRAFT; R2-153910 36.881 TR FOR STUDY ON LATENCY REDUCTION TECHNIQUES FOR LTE V0.2.1 CLEAN REV, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06 15 September 2015 (2015-09-15), XP051042304, Retrieved from the Internet: URL: http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_91/Docs/[retrieved on 2015-09-15] -/-	1,3,13, 22,25



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"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

28 November 2016

Date of mailing of the international search report

05/12/2016

Name and mailing address of the ISA/

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Authorized officer

Schut, Gerhard

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/053209

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	----- EP 2 665 219 A1 (QUALCOMM INC [US]) 20 November 2013 (2013-11-20) paragraphs [0031], [0037] - [0041], [0048] - [0049] -----	1,13-22, 25,26
A	----- US 2014/071954 A1 (AU KELVIN KAR KIN [CA] ET AL) 13 March 2014 (2014-03-13) paragraphs [0024] - [0029] -----	1-26
A	----- ERICSSON: "Areas for latency reduction", 3GPP DRAFT; R2-153489 AREAS FOR LATENCY REDUCTION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Beijing, P.R. China; 20150824 - 20150828 23 August 2015 (2015-08-23), XP051004201, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN2/Docs/ [retrieved on 2015-08-23] the whole document -----	1-26

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/053209

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			CL	2006002230	A1	24-03-2008			
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			CN	102523083	A	27-06-2012			
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