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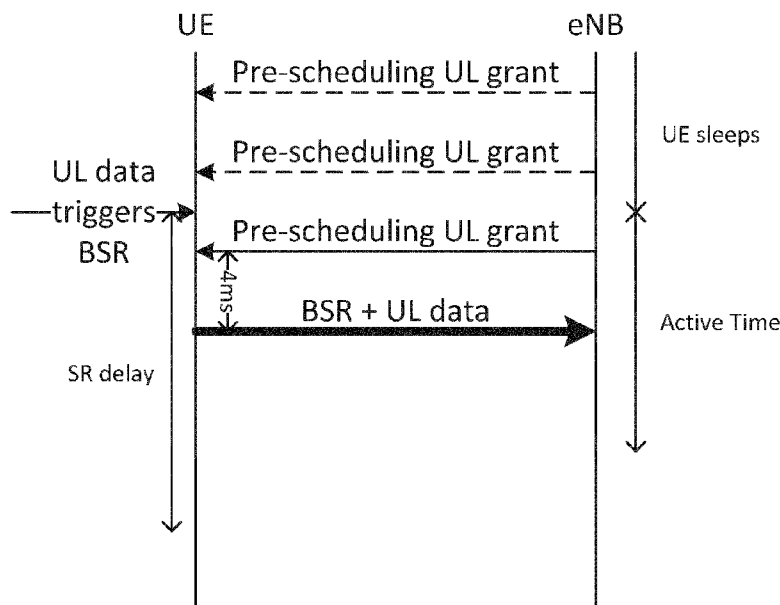


Fig. 8

(57) **Abstract:** There are provided measures for latency enhancement in discontinuous reception scenarios. Such measures exemplarily comprise obtaining a discontinuous reception related configuration setting, detecting information indicative of a filling state of a data buffer, and deciding, based on said discontinuous reception related configuration setting, to activate monitoring of a control channel for scheduled resources, if said information indicative of said filling state of said data buffer indicates that said data buffer is not empty.

5

Title

Latency enhancement in discontinuous reception scenarios

10 Field

The present invention relates to latency enhancement in discontinuous reception scenarios. More specifically, the present invention exemplarily relates to measures (including methods, apparatuses and computer program products) for realizing latency
15 enhancement in discontinuous reception scenarios.

Background

The present specification generally relates to latency reductions. In networks according
20 to 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) standards or standards of its predecessor Long Term Evolution Advanced (LTE-A), there is a demand for fast uplink access for active mobile devices like terminals, e.g. user equipment (UE) and for mobile devices (e.g. UEs) that have been inactive a longer time, but are kept in RRC Connected state (RRC: radio resource control). For such fast
25 uplink access, user plane latency for a scheduled uplink (UL) transmission is to be reduced.

A principle named pre-scheduling or blind scheduling is known for reducing latency. Here, pre-scheduling grants do not differ from "normal" scheduling grants. Whether
30 some scheduling is called "pre-scheduling" or "blind scheduling" simply emphasizes the fact that network side has decided to schedule the UE blindly without knowing whether UE has data or not. Namely, according to this principle, the network schedules UE just in case even if there was no scheduling request (SR) from the UE's side. In so doing the UL latency is reduced. Namely, in case UE has data for UL transmission, an
35 UL grant is already available, and the delay from the known SR procedure, according to which the UE having data for UL transmission has to first request scheduling and

wait for scheduling grant, is avoided. In particular, according to the pre-scheduling principle the inactive UE is given UL grants via a physical downlink control channel PDCCH just in case (provided that there are free PDCCH resources and UL resources), and ideally UE transmits only if it has something to transmit and has a pre-scheduled resource. According to the current standard, if UE receives an UL grant, UE is supposed to use the UL grant and transmit in the UL. If the UE has no data, it sends a buffer status report (BSR) indicating an empty buffer and padding bits to fill the allocated resource.

10 A principle for saving energy consumption by the UE is known as discontinuous reception (DRX), meaning that if configured by RRC, UE is allowed to monitor PDCCH in a discontinuous manner. This procedure is targeted especially for RRC_CONNECTED mode, but could be used as well in RRC_IDLE (following the paging cycles). For LTE the connected mode DRX is specified in 3GPP TS 36.321
15 V12.6.0 (2015-06).

Currently, UE goes to Active Time after sending an SR.

Hence, the problem arises that in case pre-scheduling is used together with DRX, then
20 the UE is not monitoring (is not required to monitor) PDCCH when the UE is not in Active Time. Hence, UE is not receiving UL grant (pre-scheduled UL grant) before it has sent SR. Namely, UE enters Active Time only after sending SR until it receives an UL grant. When UL data is received (i.e. is available at the UE), a buffer status report (BSR) is triggered, which is to be transmitted. If the UE does not have an UL grant for
25 sending the BSR, then the UE triggers a (transmission of a) SR. Depending on the SR periodicity, there may be a long delay before SR is actually sent using the periodic SR resource.

Figure 7 shows a schematic diagram of possible signaling sequences if UE utilizes
30 DRX while the network (e.g. an evolved NodeB, eNB) uses pre-scheduling.

Namely, as is derivable from Figure 7, in case UE sleeps (i.e. is not in Active Time), the UE does not monitor PDCCH where UL grants are transmitted/received, and hence, the UE does not realize the pre-scheduling UL grants. In Figure 7, the pre-scheduling
35 UL grants which are not received/realized are indicated by the dashed arrows. Active

Time starts only when UE sends due to available UL data an SR. After the SR is sent, the UE receives the pre-scheduling UL grant and can in turn send the BSR and data.

5 Hence, there is a need to provide for latency enhancement in discontinuous reception scenarios.

Summary

10 Various exemplary embodiments of the present invention aim at addressing at least part of the above issues and/or problems and drawbacks.

Various aspects of exemplary embodiments of the present invention are set out in the appended claims.

15 According to an exemplary aspect of the present invention, there is provided a method for a communication endpoint of a mobile communications network, said communication endpoint utilizing discontinuous reception of a control channel carrying information on scheduled resources, the method comprising obtaining a discontinuous reception related configuration setting, detecting information indicative of a filling state
20 of a data buffer, and deciding, based on said discontinuous reception related configuration setting, to activate monitoring of said control channel for said scheduled resources, if said information indicative of said filling state of said data buffer indicates that said data buffer is not empty.

25 According to an exemplary aspect of the present invention, there is provided a method for a network node of a mobile communications network allowing discontinuous reception of a control channel carrying information on scheduled resources, the method comprising deciding whether pre-scheduling of resources is intended, and delivering, based on a result of said deciding, a discontinuous reception related configuration
30 setting.

According to an exemplary aspect of the present invention, there is provided an apparatus for a mobile communications network, said apparatus utilizing discontinuous reception of a control channel carrying information on scheduled resources, the
35 apparatus comprising an obtaining circuitry configured to obtain a discontinuous

reception related configuration setting, a detecting circuitry configured to detect information indicative of a filling state of a data buffer, and a deciding circuitry configured to decide, based on said discontinuous reception related configuration setting, to activate monitoring of said control channel for said scheduled resources, if
5 said information indicative of said filling state of said data buffer indicates that said data buffer is not empty.

According to an exemplary aspect of the present invention, there is provided an apparatus for a mobile communications network allowing discontinuous reception of a
10 control channel carrying information on scheduled resources, the apparatus comprising a deciding circuitry configured to decide whether pre-scheduling of resources is intended, and a delivering circuitry configured to deliver, based on a result of said deciding circuitry, a discontinuous reception related configuration setting.

15 According to an exemplary aspect of the present invention, there is provided an apparatus for a mobile communications network, said apparatus utilizing discontinuous reception of a control channel carrying information on scheduled resources, the apparatus comprising at least one processor, at least one memory including computer program code, and at least one interface configured for communication with at least
20 another apparatus, the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform obtaining a discontinuous reception related configuration setting, detecting information indicative of a filling state of a data buffer, and deciding, based on said discontinuous reception related configuration setting, to activate monitoring of said control channel for said
25 scheduled resources, if said information indicative of said filling state of said data buffer indicates that said data buffer is not empty.

39. An apparatus for a mobile communications network allowing discontinuous reception of a control channel carrying information on scheduled resources, the
30 apparatus comprising at least one processor, at least one memory including computer program code, and at least one interface configured for communication with at least another apparatus, the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform deciding whether pre-scheduling of resources is intended, and delivering, based on a result of
35 said deciding, a discontinuous reception related configuration setting.

According to an exemplary aspect of the present invention, there is provided a computer program product comprising computer-executable computer program code which, when the program is run on a computer (e.g. a computer of an apparatus
5 according to any one of the aforementioned apparatus-related exemplary aspects of the present invention), is configured to cause the computer to carry out the method according to any one of the aforementioned method-related exemplary aspects of the present invention.

10 Such computer program product may comprise (or be embodied) a (tangible) computer-readable (storage) medium or the like on which the computer-executable computer program code is stored, and/or the program may be directly loadable into an internal memory of the computer or a processor thereof.

15 Any one of the above aspects enables an efficient latency reduction without increasing UE power consumption to thereby solve at least part of the problems and drawbacks identified in relation to the prior art.

By way of exemplary embodiments of the present invention, there is provided latency
20 enhancement in discontinuous reception scenarios. More specifically, by way of exemplary embodiments of the present invention, there are provided measures and mechanisms for realizing latency enhancement in discontinuous reception scenarios.

Thus, improvement is achieved by methods, apparatuses and computer program
25 products enabling/realizing latency enhancement in discontinuous reception scenarios.

Brief description of the drawings

In the following, the present invention will be described in greater detail by way of non-
30 limiting examples with reference to the accompanying drawings, in which

Figure 1 is a block diagram illustrating an apparatus according to exemplary embodiments of the present invention,

Figure 2 is a block diagram illustrating an apparatus according to exemplary embodiments of the present invention,

5 Figure 3 is a block diagram illustrating an apparatus according to exemplary embodiments of the present invention,

Figure 4 is a block diagram illustrating an apparatus according to exemplary embodiments of the present invention,

10 Figure 5 is a schematic diagram of a procedure according to exemplary embodiments of the present invention,

Figure 6 is a schematic diagram of a procedure according to exemplary embodiments of the present invention,

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Figure 7 shows a schematic diagram of possible signaling sequences if UE utilizes DRX while the network (e.g. an evolved NodeB) uses pre-scheduling according to known principles,

20 Figure 8 shows a schematic diagram of signaling sequences according to exemplary embodiments of the present invention,

Figure 9 shows a schematic diagram of signaling sequences according to exemplary embodiments of the present invention, and

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Figure 10 is a block diagram alternatively illustrating apparatuses according to exemplary embodiments of the present invention.

Detailed description of drawings and embodiments of the present invention

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The present invention is described herein with reference to particular non-limiting examples and to what are presently considered to be conceivable embodiments of the present invention. A person skilled in the art will appreciate that the invention is by no means limited to these examples, and may be more broadly applied.

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It is to be noted that the following description of the present invention and its embodiments mainly refers to specifications being used as non-limiting examples for certain exemplary network configurations and deployments. Namely, the present invention and its embodiments are mainly described in relation to 3GPP specifications being used as non-limiting examples for certain exemplary network configurations and deployments. In particular, pre-scheduling (blind scheduling) related techniques and DRX related techniques are used as a non-limiting example for the applicability of thus described exemplary embodiments. As such, the description of exemplary embodiments given herein specifically refers to terminology which is directly related thereto. Such terminology is only used in the context of the presented non-limiting examples, and does naturally not limit the invention in any way. Rather, any other communication or communication related system deployment, etc. may also be utilized as long as compliant with the features described herein.

Hereinafter, various embodiments and implementations of the present invention and its aspects or embodiments are described using several variants and/or alternatives. It is generally noted that, according to certain needs and constraints, all of the described variants and/or alternatives may be provided alone or in any conceivable combination (also including combinations of individual features of the various variants and/or alternatives).

According to exemplary embodiments of the present invention, in general terms, there are provided measures and mechanisms for (enabling/realizing) latency enhancement in discontinuous reception scenarios.

In general terms, according to exemplary embodiments of the present invention, Active Time is redefined such that UE goes to Active Time (and thus starts monitoring PDCCH) already when BSR is triggered, i.e., when UL data to be transmitted is available at the UE.

Consequently, pre-scheduling can be used more efficiently since UE would receive UL grant even already before sending SR.

According to exemplary embodiments of the present invention, the proposed new behavior may be made configurable, i.e., when eNB intends to use pre-scheduling for a

given UE, then eNB configures the UE (via RRC signaling) to enter Active Time already when BSR is triggered. Alternatively, medium access control (MAC) control element (CE) may be used to indicate to the UE that Active Time should be started already when BSR is triggered (and network plans to use pre-scheduling). A benefit making
5 this proposed new behavior configurable, i.e., of introducing this signaling (RRC or MAC) is that UE does not unnecessarily monitor PDCCH during DRX unless it knows that the eNB is using pre-scheduling.

Figure 1 is a block diagram illustrating an apparatus according to exemplary
10 embodiments of the present invention. The apparatus may be a terminal 10 such as a user equipment for a mobile communications network, said apparatus utilizing discontinuous reception of a control channel carrying information on scheduled resources. The apparatus comprises an obtaining circuitry 11, a detecting circuitry 12, and a deciding circuitry 13. The obtaining circuitry 11 obtains a discontinuous reception
15 related configuration setting. The detecting circuitry 12 detects information indicative of a filling state of a data buffer. The deciding circuitry 13 decides, based on said discontinuous reception related configuration setting, to activate monitoring of said control channel for said scheduled resources, if said information indicative of said filling state of said data buffer indicates that said data buffer is not empty.

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According to exemplary embodiments of the present invention, the obtaining may be implemented using e.g., RRC signaling and/or using e.g., MAC signaling.

Figure 2 is a block diagram illustrating an apparatus according to exemplary
25 embodiments of the present invention. In particular, Figure 2 illustrates a variation of the apparatus shown in Figure 1. The apparatus according to Figure 2 may (marked with dashed lines) thus further comprise a receiving circuitry 21, an acquiring circuitry 22, an entering circuitry 23, and/or an identifying circuitry 24.

30 In an embodiment at least some of the functionalities of the apparatus shown in Figure 1 (or Figure 2) may be shared between two physically separate devices forming one operational entity. Therefore, the apparatus may be seen to depict the operational entity comprising one or more physically separate devices for executing at least some of the described processes.

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Figure 5 is a schematic diagram of a procedure according to exemplary embodiments of the present invention. The apparatus according to Figure 1 (and Figure 2) may perform the method of Figure 5 but is not limited to this method. The method of Figure 5 may be performed by the apparatus of Figure 1 (or Figure 2) but is not limited to being performed by this apparatus.

As shown in Figure 5, a procedure (for a communication endpoint of a mobile communications network, said communication endpoint utilizing discontinuous reception of a control channel carrying information on scheduled resources) according to exemplary embodiments of the present invention comprises an operation of obtaining (S51) a discontinuous reception related configuration setting, an operation of detecting (S52) information indicative of a filling state of a data buffer, and an operation of deciding (S53), based on said discontinuous reception related configuration setting, to activate monitoring of said control channel for said scheduled resources, if said information indicative of said filling state of said data buffer indicates that said data buffer is not empty.

The "discontinuous reception related configuration setting" means that the principle according to the present invention ("Active Time (immediately) after BSR trigger", "Active Time after UL data arrival") is activated/set, i.e., that the "specific behavior" is ON. Since this setting takes effect when the terminal is in DRX mode, this setting is a discontinuous reception related configuration setting. Further, according to exemplary embodiments of the present invention, the network intends to activate this "specific behavior" in case the network plans to schedule blindly (i.e. blind scheduling, pre-scheduling, the network plans to schedule without a scheduling request, etc.), this setting is indicative of that the network plans to schedule blindly, i.e., that the network intends pre-scheduling of resources.

Furthermore, according to exemplary embodiments of the present invention the "discontinuous reception related configuration setting" may be a configuration option/item as is as well as a state of the configuration option. That is, a setting may be the option/item "Active Time upon filled buffer/triggered BSR" or "Active Time upon filled buffer/triggered BSR possible" and may further be the state "Active Time upon filled buffer/triggered BSR ON" or "Active Time upon filled buffer/triggered BSR OFF".

According to a variation of the procedure shown in Figure 5, exemplary details of the obtaining operation (S51) are given, which are inherently independent from each other as such.

- 5 Such exemplary obtaining operation (S51) according to exemplary embodiments of the present invention may comprise an operation of receiving a radio resource control message indicative of said discontinuous reception related configuration setting.

10 According to a further variation of the procedure shown in Figure 5, exemplary details of the obtaining operation (S51) are given, which are inherently independent from each other as such.

Such exemplary obtaining operation (S51) according to exemplary embodiments of the present invention may comprise an operation of receiving a medium access control
15 control element indicative of said discontinuous reception related configuration setting.

As mentioned above, according to exemplary embodiments of the present invention, a state of the configuration option, i.e., ON or OFF, may be communicated as the discontinuous reception related configuration setting and may thus be received via a
20 radio resource control message or a medium access control control element.

However, according to exemplary embodiments of the present invention, the configuration option/item as is as (i.e. "Active Time upon filled buffer/triggered BSR" or "Active Time upon filled buffer/triggered BSR possible") may be communicated as the
25 discontinuous reception related configuration setting via a radio resource control message, while a state of the configuration option, i.e., ON or OFF, may be communicated as the discontinuous reception related configuration setting via a medium access control control element, and may thus be activated or deactivated subsequently by such medium access control control element.

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That is, according to a variation of the procedure shown in Figure 5, exemplary details of the obtaining operation (S51) are given, which are inherently independent from each other as such.

Such exemplary obtaining operation (S51) according to exemplary embodiments of the present invention may comprise an operation of receiving a radio resource control message indicative of said discontinuous reception related configuration setting (e.g. "Active Time upon filled buffer/triggered BSR possible"), and an operation of receiving
5 a medium access control control element indicative of activation of said discontinuous reception related configuration setting (e.g. "Active Time upon filled buffer/triggered BSR ON").

According to exemplary embodiments of the present invention, it is decided to activate
10 monitoring of said control channel for said scheduled resources if said discontinuous reception related configuration setting indicates that pre-scheduling of resources is intended.

According to a further variation of the procedure shown in Figure 5, exemplary details
15 of the detecting operation (S52) are given, which are inherently independent from each other as such.

Such exemplary detecting operation (S52) according to exemplary embodiments of the present invention may comprise an operation of acquiring a buffer status report trigger
20 indicative of that said data buffer is not empty.

According to still further exemplary embodiments of the present invention, the buffer status report trigger triggers a regular buffer status report mentioned above.

According to a further variation of the procedure shown in Figure 5, exemplary
25 additional operations are given, which are inherently independent from each other as such. According to such variation, an exemplary method according to exemplary embodiments of the present invention may comprise an operation of entering an active time state upon deciding to activate monitoring of said control channel for said
30 scheduled resources.

According to a further variation of the procedure shown in Figure 5, exemplary
additional operations are given, which are inherently independent from each other as such. According to such variation, an exemplary method according to exemplary
35 embodiments of the present invention may comprise an operation of identifying, when

monitoring said control channel for said scheduled resources, pre-scheduling uplink grants as information about said scheduled resources.

Figure 3 is a block diagram illustrating an apparatus according to exemplary
5 embodiments of the present invention. The apparatus may be a network node 30 such
as a base station for a mobile communications network allowing discontinuous
reception of a control channel carrying information on scheduled resources, comprising
a deciding circuitry 31 and a delivering circuitry 32. The deciding circuitry 31 decides
whether pre-scheduling of resources is intended. The delivering circuitry 32 delivers,
10 based on a result of said deciding circuitry 31, a discontinuous reception related
configuration setting.

Here, it is again noted that whether pre-scheduling of resources is intended means
whether the network plans to schedule blindly (i.e. blind scheduling, pre-scheduling, the
15 network plans to schedule without a scheduling request, etc.).

According to exemplary embodiments of the present invention, the delivering may be
implemented using e.g., RRC signaling and/or using e.g., MAC signaling.

20 Figure 4 is a block diagram illustrating an apparatus according to exemplary
embodiments of the present invention. In particular, Figure 4 illustrates a variation of
the apparatus shown in Figure 3. The apparatus according to Figure 4 may (marked
with dashed lines) thus further comprise a transmitting circuitry 41 and/or a
communicating circuitry 42.

25 In an embodiment at least some of the functionalities of the apparatus shown in Figure
3 (or Figure 4) may be shared between two physically separate devices forming one
operational entity. Therefore, the apparatus may be seen to depict the operational
entity comprising one or more physically separate devices for executing at least some
30 of the described processes.

Figure 6 is a schematic diagram of a procedure according to exemplary embodiments
of the present invention. The apparatus according to Figure 3 (and Figure 4) may
perform the method of Figure 6 but is not limited to this method. The method of Figure

6 may be performed by the apparatus of Figure 3 (or Figure 4) but is not limited to being performed by this apparatus.

5 As shown in Figure 6, a procedure (for a network node of a mobile communications network allowing discontinuous reception of a control channel carrying information on scheduled resources) according to exemplary embodiments of the present invention comprises an operation of deciding (S61) whether pre-scheduling of resources is intended, and an operation of delivering (S62), based on a result of said deciding (S61), a discontinuous reception related configuration setting.

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According to a variation of the procedure shown in Figure 6, exemplary details of the delivering operation (S62) are given, which are inherently independent from each other as such.

15 Such exemplary delivering operation (S62) according to exemplary embodiments of the present invention may comprise an operation of transmitting a radio resource control message indicative of said discontinuous reception related configuration setting.

20 According to a variation of the procedure shown in Figure 6, exemplary details of the delivering operation (S62) are given, which are inherently independent from each other as such.

25 Such exemplary delivering operation (S62) according to exemplary embodiments of the present invention may comprise an operation of transmitting a medium access control control element indicative of said discontinuous reception related configuration setting.

30 Similar to the terminal related description above, according to a variation of the procedure shown in Figure 6, exemplary details of the delivering operation (S62) are given, which are inherently independent from each other as such.

35 Such exemplary delivering operation (S62) according to exemplary embodiments of the present invention may comprise an operation of transmitting a radio resource control message indicative of said discontinuous reception related configuration setting (e.g. "Active Time upon filled buffer/triggered BSR possible"), and an operation of transmitting a medium access control control element indicative of said discontinuous

reception related configuration setting (e.g. "Active Time upon filled buffer/triggered BSR ON").

5 According to exemplary embodiments of the present invention, said discontinuous reception related configuration setting indicates that pre-scheduling of resources is intended.

10 According to a further variation of the procedure shown in Figure 6, exemplary additional operations are given, which are inherently independent from each other as such. According to such variation, an exemplary method according to exemplary embodiments of the present invention may comprise an operation of communicating, on said control channel, pre-scheduling uplink grants as information on said scheduled resources.

15 Subsequently, exemplary embodiments of the present invention are described in more concrete terms with reference to Figures 8 and 9.

20 Figure 8 shows a schematic diagram of signaling sequences according to exemplary embodiments of the present invention, and in particular illustrates pre-scheduling UL grants with Active Time starting already when data arrives in the data buffer or when a BSR is triggered. BSR in this case would be a so called regular BSR.

25 More particularly, Figure 8 shows that according to exemplary embodiments of the present invention the UE switches to Active Time already when BSR is triggered. As is shown in Figure 8, thus the UE can receive the pre-scheduling UL grant (indicated by solid arrow) earlier than with the approach discussed in relation to Figure 7. For the illustration of Figure 8 it is assumed that application of the principle "Active Time (immediately) after BSR trigger" or "Active Time after UL data arrival" is configured by RRC signaling.

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As discussed above, according to the present invention, it is decided to activate monitoring of the control channel, if it is recognized that the data buffer is not empty, e.g., if a buffer status report is triggered.

In particular, according to exemplary embodiments of the present invention, if the discontinuous reception related configuration setting reveals that the principle according to the present invention ("Active Time (immediately) after BSR trigger", "Active Time after UL data arrival") is activated/set, the Active Time is entered and running when, during discontinuous reception, a regular buffer status report is triggered and is not cancelled.

In other words, when a DRX cycle is configured, the Active Time includes the time while, among others, a regular BSR is triggered and is not cancelled in case the principle according to the present invention ("Active Time (immediately) after BSR trigger", "Active Time after UL data arrival") is set.

Figure 9 shows a schematic diagram of signaling sequences according to exemplary embodiments of the present invention, and in particular illustrates pre-scheduling UL grants for TCP ACKs (TCP: transmission control protocol; ACK: acknowledgement) and MAC CE signaling to "activate" use of Active Time after BSR trigger.

More particularly, Figure 9 shows a sequence according exemplary embodiments of the present invention for TCP as an example. After receiving the TCP packet in downlink (DL) and after sending a hybrid automatic repeat request (HARQ) ACK (and in most cases also the radio link control (RLC) ACK), the UE can go to sleep earlier (there is no need to extend the Active Time such that TCP ACK could be sent during the same Active Time).

In this example, MAC CE is used to signal to the UE that Active Time should be started already when BSR is triggered (and also that eNB intends to use pre-scheduling). The MAC CE can be sent together with the DL data (TCP packet) or separately. eNB starts sending pre-scheduling UL grants when it expects that the UE could be ready to send the TCP ACK. UE is not receiving the pre-scheduling UL grants when UE sleeps. When TCP ACK arrives in the UE buffer, it triggers BSR and according to exemplary embodiments of the present invention, that triggered BSR starts Active Time. Subsequently the UE starts monitoring PDCCH and receives the next pre-scheduling UL grant and can send the TCP ACK faster than with an approach as discussed with respect to Figure 7.

35

Taking pre-scheduling for TCP ACK as an example, it allows the UE to go back to sleep after receiving the DL data with shorter inactivity timer, or by the network sending UE a DRX Command MAC CE. Otherwise the inactivity timer would have to be long enough to cover the whole processing time in application layer to keep the UE awake.

5

The difference from starting active time upon SR transmission is that the eNB does not know when exactly BSR is triggered, but there will be no UL transmission before BSR is triggered anyway (especially if taking into account other enhancement like skipping the UL transmission when BSR is empty), so no need to monitor PDCCH before that from UE point of view. eNB scheduling can start before or after that based on its scheduler decision and its estimation of UE processing time.

10

As a result, according to exemplary embodiments of the present invention, a latency reduction is achieved without increasing UE power consumption. Accordingly, it can be benefited from pre-scheduling even in case the UE uses DRX.

15

According to further exemplary embodiments of the present invention, the SR periodicity can be set longer, since with a working pre-scheduling approach as proposed above, there is no need to go for a 1ms SR periodicity to reduce (or keep low) the latency.

20

Hence, a resource efficient approach is proposed according to exemplary embodiments of the present invention with protocol and signaling enhancements, compared to the pre-scheduling solutions allowed by the standard today, both with and without preserving the current transmission time interval (TTI) length and processing times.

25

According to still further exemplary embodiments, an inactivity timer related to DRX which may normally be started when UE receives PDCCH indicating a new transmission, may alternatively be started (or restarted) only upon a further event. Namely, if PDCCH indicates a new transmission and the UE has data to be sent (i.e. the data buffer is not empty), in case the principle according to the present invention ("Active Time (immediately) after BSR trigger", "Active Time after UL data arrival") is activated/set, this inactivity timer related to DRX is (re)started.

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In more concrete terms, according to exemplary embodiments of the present invention, if the PDCCH indicates a new transmission (DL, UL or SL) and for UL the UE has UL data to send when "pre-scheduling" is configured, drx-InactivityTimer is to be started or restarted. In other words, drx-InactivityTimer is not started if the UE has no UL data and if the UE does not use the UL grant, i.e., does not transmit anything. However, if the UE has no data in the buffer but anyway transmits something, e.g., an empty BSR, then drx-InactivityTimer could be started. Alternatively, sending only an empty BSR (BSR indicating that UE has no data in the data buffer) without any data could be defined not to start the drx-InactivityTimer.

In so doing, power consumption of the UE can be reduced.

The above-described procedures and functions may be implemented by respective functional elements, processors, or the like, as described below.

In the foregoing exemplary description of the network entity, only the units that are relevant for understanding the principles of the invention have been described using functional blocks. The network entity may comprise further units that are necessary for its respective operation. However, a description of these units is omitted in this specification. The arrangement of the functional blocks of the devices is not construed to limit the invention, and the functions may be performed by one block or further split into sub-blocks.

When in the foregoing description it is stated that the apparatus, i.e. network entity (or some other means) is configured to perform some function, this is to be construed to be equivalent to a description stating that a (i.e. at least one) processor or corresponding circuitry, potentially in cooperation with computer program code stored in the memory of the respective apparatus, is configured to cause the apparatus to perform at least the thus mentioned function. Also, such function is to be construed to be equivalently implementable by specifically configured circuitry or means for performing the respective function (i.e. the expression "unit configured to" is construed to be equivalent to an expression such as "means for").

In Figure 10, an alternative illustration of apparatuses according to exemplary embodiments of the present invention is depicted. As indicated in Figure 10, according

to exemplary embodiments of the present invention, the apparatus (terminal) 10' (corresponding to the terminal 10) comprises a processor 101, a memory 102 and an interface 103, which are connected by a bus 104 or the like. Further, according to exemplary embodiments of the present invention, the apparatus (network node) 30' (corresponding to the network node 30) comprises a processor 105, a memory 106 and an interface 107, which are connected by a bus 108 or the like, and the apparatuses may be connected via link 109, respectively.

The processor 101/105 and/or the interface 103/107 may also include a modem or the like to facilitate communication over a (hardwire or wireless) link, respectively. The interface 103/107 may include a suitable transceiver coupled to one or more antennas or communication means for (hardwire or wireless) communications with the linked or connected device(s), respectively. The interface 103/107 is generally configured to communicate with at least one other apparatus, i.e. the interface thereof.

The memory 102/106 may store respective programs assumed to include program instructions or computer program code that, when executed by the respective processor, enables the respective electronic device or apparatus to operate in accordance with the exemplary embodiments of the present invention.

In general terms, the respective devices/apparatuses (and/or parts thereof) may represent means for performing respective operations and/or exhibiting respective functionalities, and/or the respective devices (and/or parts thereof) may have functions for performing respective operations and/or exhibiting respective functionalities.

When in the subsequent description it is stated that the processor (or some other means) is configured to perform some function, this is to be construed to be equivalent to a description stating that at least one processor, potentially in cooperation with computer program code stored in the memory of the respective apparatus, is configured to cause the apparatus to perform at least the thus mentioned function. Also, such function is to be construed to be equivalently implementable by specifically configured means for performing the respective function (i.e. the expression "processor configured to [cause the apparatus to] perform xxx-ing" is construed to be equivalent to an expression such as "means for xxx-ing").

According to exemplary embodiments of the present invention, an apparatus representing the terminal 10 comprises at least one processor 101, at least one memory 102 including computer program code, and at least one interface 103 configured for communication with at least another apparatus. The processor (i.e. the
5 at least one processor 101, with the at least one memory 102 and the computer program code) is configured to perform obtaining a discontinuous reception related configuration setting (thus the apparatus comprising corresponding means for obtaining), to perform detecting information indicative of a filling state of a data buffer (thus the apparatus comprising corresponding means for detecting), and to perform
10 deciding, based on said discontinuous reception related configuration setting, to activate monitoring of said control channel for said scheduled resources, if said information indicative of said filling state of said data buffer indicates that said data buffer is not empty (thus the apparatus comprising corresponding means for deciding).

15 According to exemplary embodiments of the present invention, an apparatus representing the network node 30 comprises at least one processor 105, at least one memory 106 including computer program code, and at least one interface 107 configured for communication with at least another apparatus. The processor (i.e. the
20 at least one processor 105, with the at least one memory 106 and the computer program code) is configured to perform deciding whether pre-scheduling of resources is intended (thus the apparatus comprising corresponding means for deciding), and to perform delivering, based on a result of said deciding, a discontinuous reception related configuration setting (thus the apparatus comprising corresponding means for delivering).

25 For further details regarding the operability/functionality of the individual apparatuses, reference is made to the above description in connection with any one of Figures 1 to 9, respectively.

30 For the purpose of the present invention as described herein above, it should be noted that

- method steps likely to be implemented as software code portions and being run using a processor at a network server or network entity (as examples of devices, apparatuses and/or modules thereof, or as examples of entities including apparatuses
35 and/or modules therefore), are software code independent and can be specified using

any known or future developed programming language as long as the functionality defined by the method steps is preserved;

- generally, any method step is suitable to be implemented as software or by hardware without changing the idea of the embodiments and its modification in terms of the functionality implemented;

- method steps and/or devices, units or means likely to be implemented as hardware components at the above-defined apparatuses, or any module(s) thereof, (e.g., devices carrying out the functions of the apparatuses according to the embodiments as described above) are hardware independent and can be implemented using any known

or future developed hardware technology or any hybrids of these, such as MOS (Metal Oxide Semiconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL (Emitter Coupled Logic), TTL (Transistor-Transistor Logic), etc., using for example ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) components, CPLD (Complex Programmable Logic Device) components or DSP (Digital Signal Processor) components;

- devices, units or means (e.g. the above-defined network entity or network register, or any one of their respective units/means) can be implemented as individual devices, units or means, but this does not exclude that they are implemented in a distributed fashion throughout the system, as long as the functionality of the device, unit or means is preserved;

- an apparatus like the user equipment and the network entity /network register may be represented by a semiconductor chip, a chipset, or a (hardware) module comprising such chip or chipset; this, however, does not exclude the possibility that a functionality of an apparatus or module, instead of being hardware implemented, be implemented as software in a (software) module such as a computer program or a computer program product comprising executable software code portions for execution/being run on a processor;

- a device may be regarded as an apparatus or as an assembly of more than one apparatus, whether functionally in cooperation with each other or functionally independently of each other but in a same device housing, for example.

In general, it is to be noted that respective functional blocks or elements according to above-described aspects can be implemented by any known means, either in hardware and/or software, respectively, if it is only adapted to perform the described functions of

the respective parts. The mentioned method steps can be realized in individual functional blocks or by individual devices, or one or more of the method steps can be realized in a single functional block or by a single device.

- 5 Generally, any method step is suitable to be implemented as software or by hardware without changing the idea of the present invention. Devices and means can be implemented as individual devices, but this does not exclude that they are implemented in a distributed fashion throughout the system, as long as the functionality of the device is preserved. Such and similar principles are to be considered as known to a skilled person.

Software in the sense of the present description comprises software code as such comprising code means or portions or a computer program or a computer program product for performing the respective functions, as well as software (or a computer program or a computer program product) embodied on a tangible medium such as a computer-readable (storage) medium having stored thereon a respective data structure or code means/portions or embodied in a signal or in a chip, potentially during processing thereof.

20 The present invention also covers any conceivable combination of method steps and operations described above, and any conceivable combination of nodes, apparatuses, modules or elements described above, as long as the above-described concepts of methodology and structural arrangement are applicable.

25 In view of the above, there are provided measures for latency enhancement in discontinuous reception scenarios. Such measures exemplarily comprise obtaining a discontinuous reception related configuration setting, detecting information indicative of a filling state of a data buffer, and deciding, based on said discontinuous reception related configuration setting, to activate monitoring of a control channel for scheduled resources, if said information indicative of said filling state of said data buffer indicates that said data buffer is not empty.

Even though the invention is described above with reference to the examples according to the accompanying drawings, it is to be understood that the invention is not restricted thereto. Rather, it is apparent to those skilled in the art that the present

invention can be modified in many ways without departing from the scope of the inventive idea as disclosed herein.

List of acronyms and abbreviations

5		
	3GPP	3 rd Generation Partnership Project
	ACK	acknowledgement
	BSR	buffer status report
	CE	control element
10	DL	downlink
	DRX	discontinuous reception
	eNB	evolved NodeB, eNodeB
	HARQ	hybrid automatic repeat request
	LTE	Long Term Evolution
15	LTE-A	Long Term Evolution Advanced
	MAC	medium access control
	PDCCH	Physical downlink control channel
	RLC	radio link control
	RRC	radio resource control
20	SR	scheduling request
	TCP	transmission control protocol
	TTI	transmission time interval
	UE	user equipment
	UL	uplink

25

Claims

1. A method for a communication endpoint of a mobile communications network, said communication endpoint utilizing discontinuous reception of a control channel carrying
5 information on scheduled resources, the method comprising
 obtaining a discontinuous reception related configuration setting,
 detecting information indicative of a filling state of a data buffer, and
 deciding, based on said discontinuous reception related configuration setting, to
activate monitoring of said control channel for said scheduled resources, if said
10 information indicative of said filling state of said data buffer indicates that said data
buffer is not empty.
2. The method according to claim 1, wherein
 in relation to said obtaining, said method further comprises
15 receiving a radio resource control message indicative of said discontinuous
reception related configuration setting.
3. The method according to claim 1, wherein
 in relation to said obtaining, said method further comprises
20 receiving a medium access control control element indicative of said
discontinuous reception related configuration setting.
4. The method according to any of claims 1 to 3, wherein
 it is decided to activate monitoring of said control channel for said scheduled
25 resources if said discontinuous reception related configuration setting indicates that
pre-scheduling of resources is intended.
5. The method according to any of claims 1 to 4, wherein
 in relation to said detecting, said method further comprises
30 acquiring a buffer status report trigger indicative of that said data buffer is not
empty.
6. The method according to claim 5, wherein said buffer status report trigger triggers a
regular buffer status report.

7. The method according to any of claims 1 to 6, further comprising
entering an active time state upon deciding to activate monitoring of said control
channel for said scheduled resources.
- 5 8. The method according to any of claims 1 to 7, further comprising
identifying, when monitoring said control channel for said scheduled resources,
scheduling uplink grants as information about said scheduled resources.
9. The method according to any of claims 1 to 8, wherein
- 10 the method is operable at or by a terminal, user equipment, mobile station or
modem, and/or
the method is operable in at least one of a LTE and a LTE-A cellular system,
and/or
said control channel is a physical downlink control channel.
- 15 10. A method for a network node of a mobile communications network allowing
discontinuous reception of a control channel carrying information on scheduled
resources, the method comprising
deciding whether pre-scheduling of resources is intended, and
- 20 delivering, based on a result of said deciding, a discontinuous reception related
configuration setting.
11. The method according to claim 10, wherein
in relation to said delivering, said method further comprises
- 25 transmitting a radio resource control message indicative of said discontinuous
reception related configuration setting.
12. The method according to claim 10, wherein
in relation to said delivering, said method further comprises
- 30 transmitting a medium access control control element indicative of said
discontinuous reception related configuration setting.
13. The method according to any of claims 10 to 12, wherein
said discontinuous reception related configuration setting indicates that pre-
- 35 scheduling of resources is intended.

14. The method according to any of claims 10 to 13, further comprising
communicating, on said control channel, pre-scheduling uplink grants as
information on said scheduled resources.
- 5
15. The method according to any of claims 10 to 14, wherein
the method is operable at or by a base station or access node of a cellular
system, and/or
the method is operable in at least one of a LTE and a LTE-A cellular system,
10 and/or
said control channel is a physical downlink control channel.
16. An apparatus for a mobile communications network, said apparatus utilizing
discontinuous reception of a control channel carrying information on scheduled
15 resources, the apparatus comprising
an obtaining circuitry configured to obtain a discontinuous reception related
configuration setting,
a detecting circuitry configured to detect information indicative of a filling state of
a data buffer, and
20 a deciding circuitry configured to decide, based on said discontinuous reception
related configuration setting, to activate monitoring of said control channel for said
scheduled resources, if said information indicative of said filling state of said data buffer
indicates that said data buffer is not empty.
- 25 17. The apparatus according to claim 16, further comprising
a receiving circuitry configured to receive a radio resource control message
indicative of said discontinuous reception related configuration setting.
18. The apparatus according to claim 16, further comprising
30 a receiving circuitry configured to receive a medium access control control
element indicative of said discontinuous reception related configuration setting.
19. The apparatus according to any of claims 16 to 18, wherein

it is decided to activate monitoring of said control channel for said scheduled resources if said discontinuous reception related configuration setting indicates that pre-scheduling of resources is intended.

- 5 20. The apparatus according to any of claims 16 to 18, further comprising
an acquiring circuitry configured to acquire a buffer status report trigger
indicative of that said data buffer is not empty.
- 10 21. The apparatus according to claim 20, wherein said buffer status report trigger
triggers a regular buffer status report.
- 15 22. The apparatus according to any of claims 16 to 21, further comprising
an entering circuitry configured to enter an active time state upon deciding, by
said deciding circuitry, to activate monitoring of said control channel for said scheduled
resources.
- 20 23. The apparatus according to any of claims 16 to 22, further comprising
an identifying circuitry configured to identify, when monitoring said control
channel for said scheduled resources, pre-scheduling uplink grants as information
about said scheduled resources.
- 25 24. The apparatus according to any of claims 16 to 23, wherein
the apparatus is operable as or at a terminal, user equipment, mobile station or
modem, and/or
the apparatus is operable in at least one of a LTE and a LTE-A cellular system,
and/or
said control channel is a physical downlink control channel.
- 30 25. An apparatus for a mobile communications network allowing discontinuous
reception of a control channel carrying information on scheduled resources, the
apparatus comprising
a deciding circuitry configured to decide whether pre-scheduling of resources is
intended, and
a delivering circuitry configured to deliver, based on a result of said deciding
35 circuitry, a discontinuous reception related configuration setting.

26. The apparatus according to claim 25, further comprising
a transmitting circuitry configured to transmit a radio resource control message
indicative of said discontinuous reception related configuration setting.
- 5 27. The apparatus according to claim 25, further comprising
a transmitting circuitry configured to transmit a medium access control control
element indicative of said discontinuous reception related configuration setting.
- 10 28. The apparatus according to any of claims 25 to 27, wherein
said discontinuous reception related configuration setting indicates that pre-
scheduling of resources is intended.
- 15 29. The apparatus according to any of claims 25 to 28, further comprising
a communicating circuitry configured to communicate, on said control channel,
pre-scheduling uplink grants as information on said scheduled resources.
- 20 30. The apparatus according to any of claims 25 to 29, wherein
the apparatus is operable as or at a base station or access node of a cellular
system, and/or
the apparatus is operable in at least one of a LTE and a LTE-A cellular system,
and/or
said control channel is a physical downlink control channel.
- 25 31. An apparatus for a mobile communications network, said apparatus utilizing
discontinuous reception of a control channel carrying information on scheduled
resources, the apparatus comprising
at least one processor,
at least one memory including computer program code, and
30 at least one interface configured for communication with at least another
apparatus,
the at least one processor, with the at least one memory and the computer
program code, being configured to cause the apparatus to perform:
obtaining a discontinuous reception related configuration setting,
35 detecting information indicative of a filling state of a data buffer, and

deciding, based on said discontinuous reception related configuration setting, to activate monitoring of said control channel for said scheduled resources, if said information indicative of said filling state of said data buffer indicates that said data buffer is not empty.

5

32. The apparatus according to claim 31, wherein

the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

10 receiving a radio resource control message indicative of said discontinuous reception related configuration setting.

33. The apparatus according to claim 31, wherein

the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

15 receiving a medium access control control element indicative of said discontinuous reception related configuration setting.

34. The apparatus according to any of claims 31 to 33, wherein

20 it is decided to activate monitoring of said control channel for said scheduled resources if said discontinuous reception related configuration setting indicates that pre-scheduling of resources is intended.

35. The apparatus according to any of claims 31 to 34, wherein

25 the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

acquiring a buffer status report trigger indicative of that said data buffer is not empty.

36. The apparatus according to claim 35, wherein said buffer status report trigger

30 triggers a regular buffer status report.

37. The apparatus according to any of claims 31 to 35, wherein

the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

entering an active time state upon deciding to activate monitoring of said control channel for said scheduled resources.

38. The apparatus according to any of claims 31 to 37, wherein

5 the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

identifying, when monitoring said control channel for said scheduled resources, pre-scheduling uplink grants as information about said scheduled resources.

10 39. An apparatus for a mobile communications network allowing discontinuous reception of a control channel carrying information on scheduled resources, the apparatus comprising

at least one processor,

at least one memory including computer program code, and

15 at least one interface configured for communication with at least another apparatus,

the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

deciding whether pre-scheduling of resources is intended, and

20 delivering, based on a result of said deciding, a discontinuous reception related configuration setting.

40. The apparatus according to claim 39, wherein

25 the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

transmitting a radio resource control message indicative of said discontinuous reception related configuration setting.

41. The apparatus according to claim 39, wherein

30 the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

transmitting a medium access control control element indicative of said discontinuous reception related configuration setting.

35 42. The apparatus according to any of claims 39 to 41, wherein

said discontinuous reception related configuration setting indicates that pre-scheduling of resources is intended.

43. The apparatus according to any of claims 39 to 42, wherein

5 the at least one processor, with the at least one memory and the computer program code, being configured to cause the apparatus to perform:

communicating, on said control channel, pre-scheduling uplink grants as information on said scheduled resources.

10 44. A computer program product comprising computer-executable computer program code which, when the program is run on a computer, is configured to cause the computer to carry out the method according to any one of claims 1 to 9 or 10 to 15.

15 45. The computer program product according to claim 44, wherein the computer program product comprises a computer-readable medium on which the computer-executable computer program code is stored, and/or wherein the program is directly loadable into an internal memory of the processor.

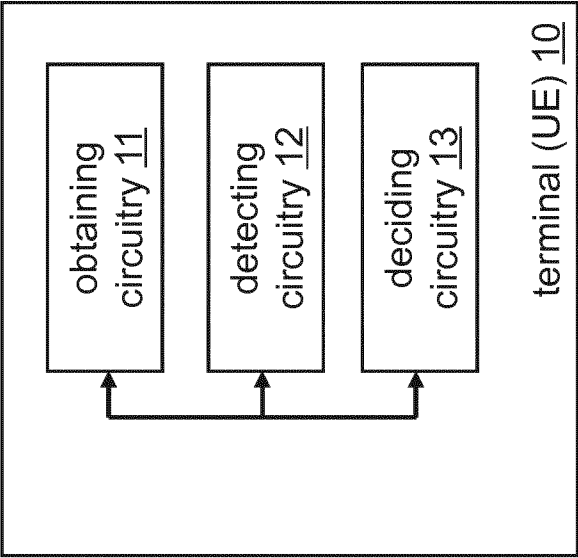


Fig. 1

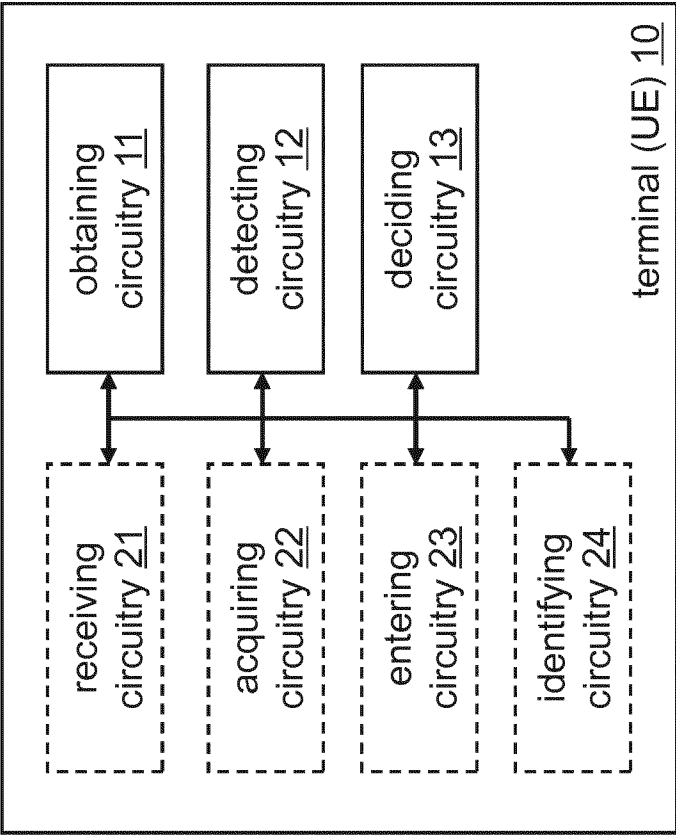


Fig. 2

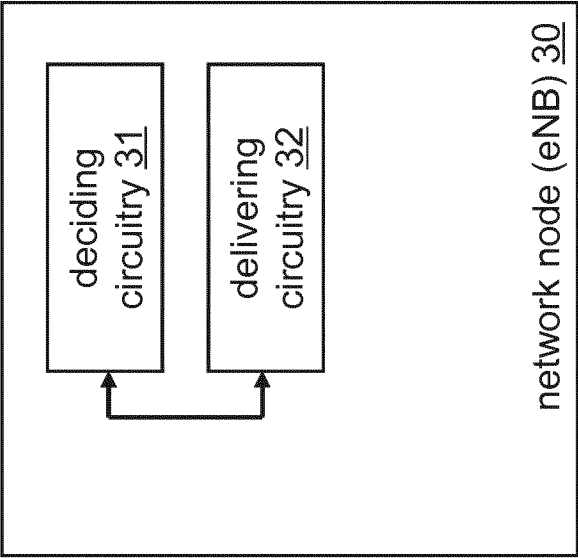


Fig. 3

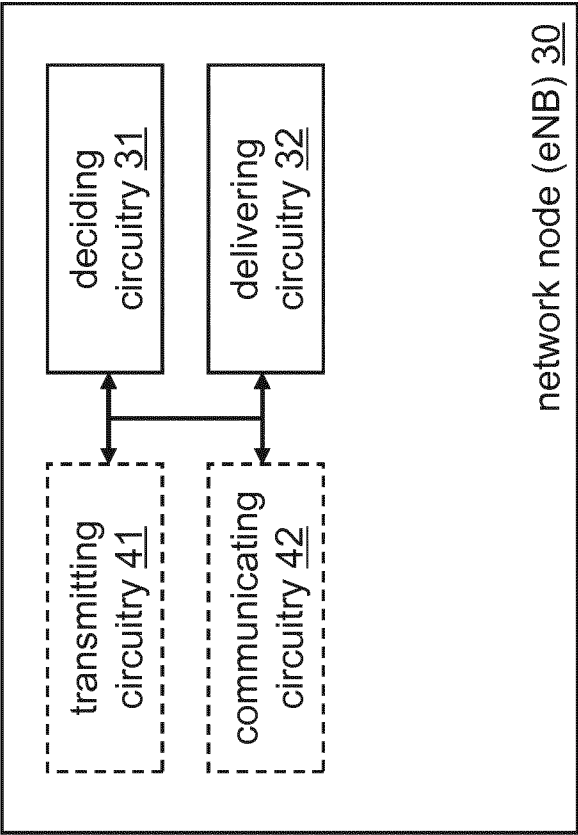


Fig. 4

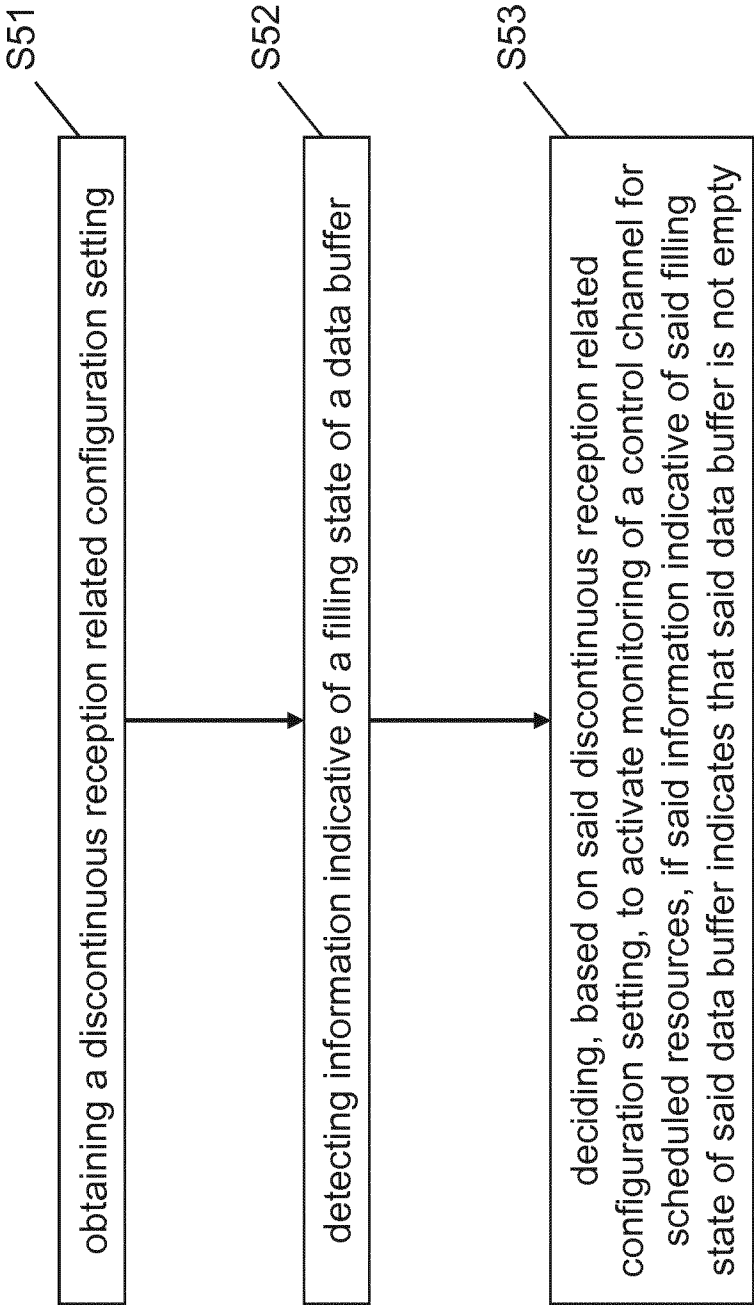


Fig. 5

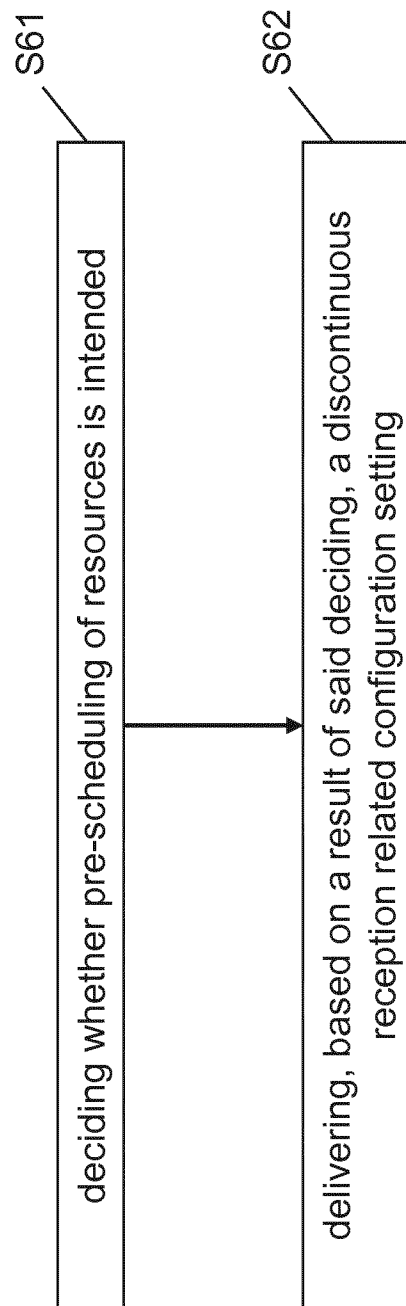


Fig. 6

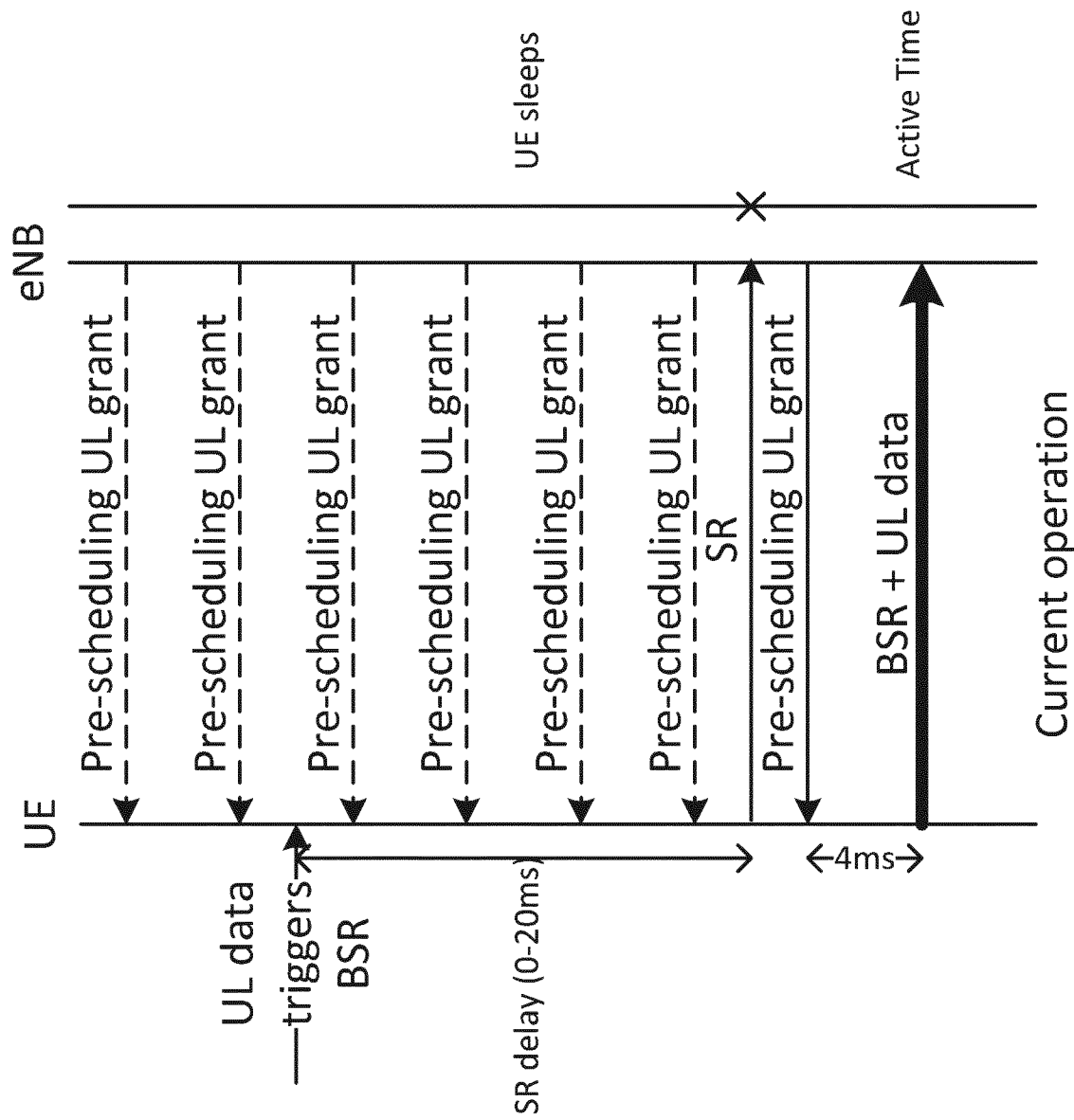


Fig. 7

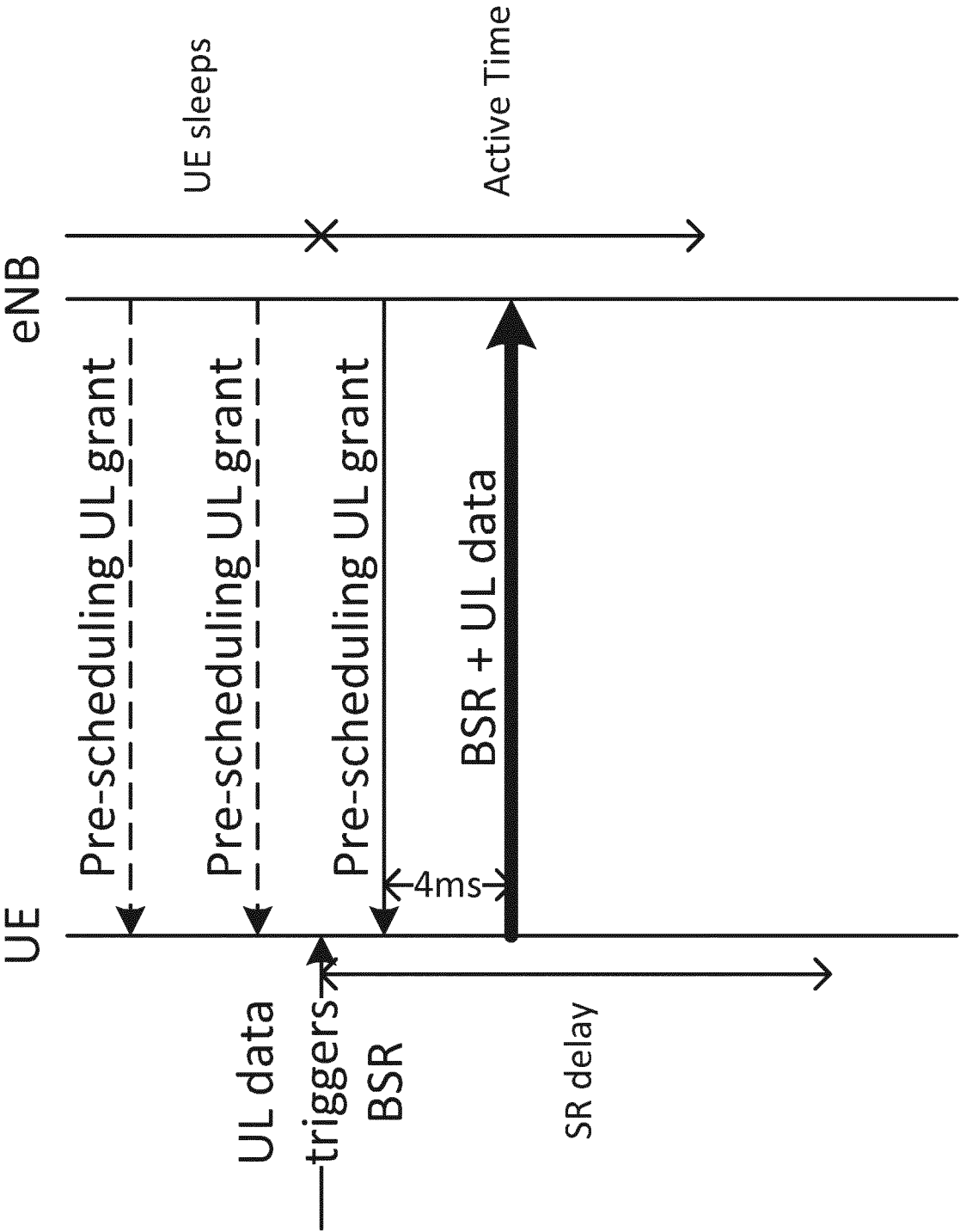


Fig. 8

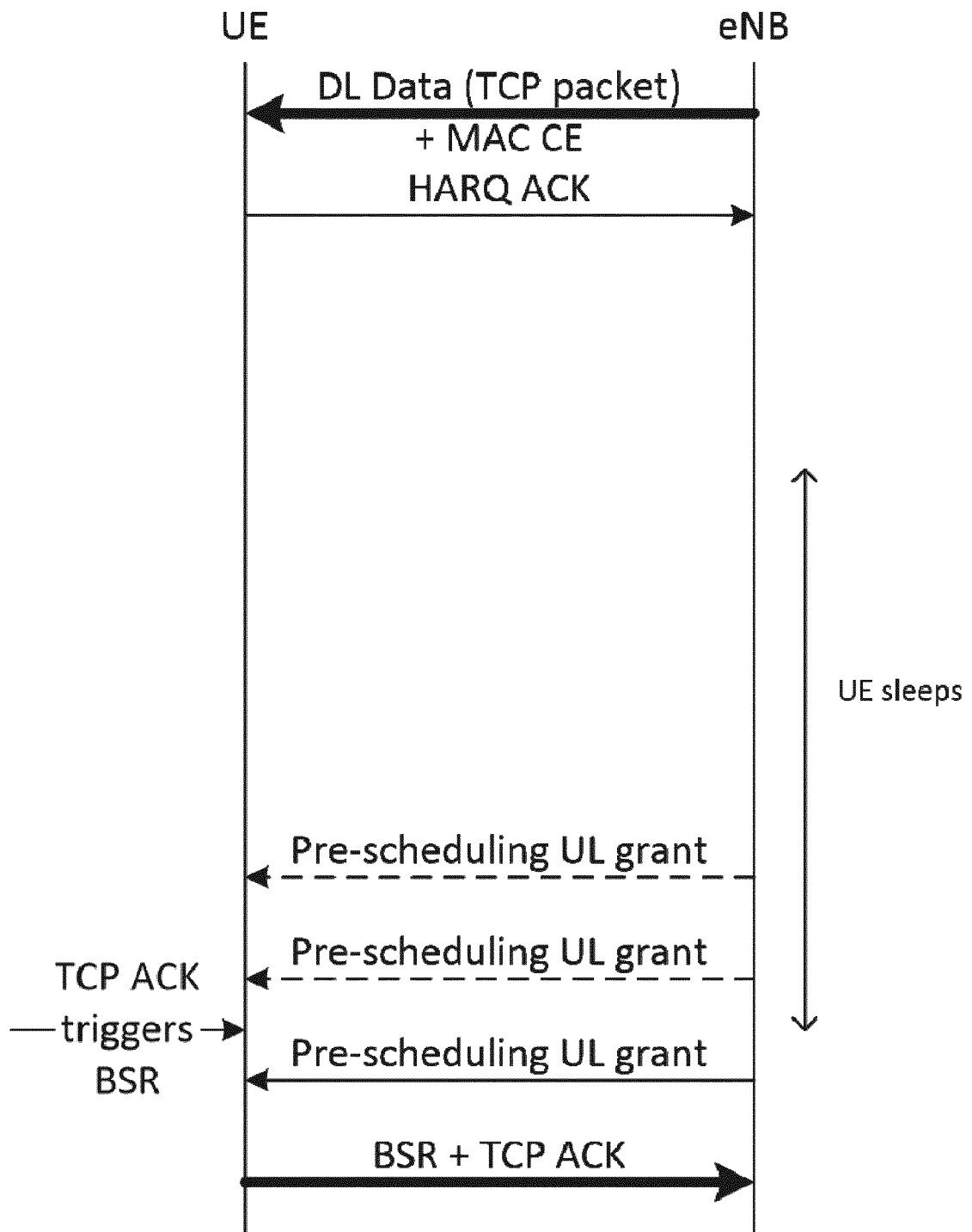


Fig. 9

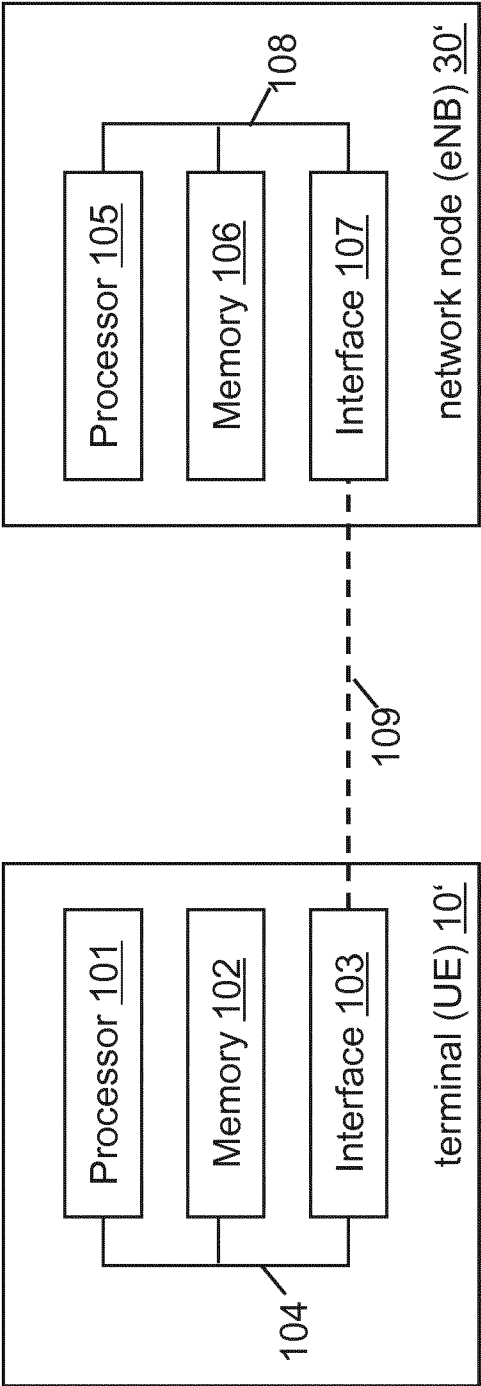


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/068784

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/132685 A2 (NOKIA CORP [FI]; NOKIA INC [US]; KAUKORANTA MIKA [FI]; DALSGAARD LARS) 6 November 2008 (2008-11-06) page 7, line 28 - line 29 page 8, line 8 - line 17 page 9, line 14 - line 19 page 10, line 7 - line 17 page 10, line 33 - page 11, line 2 page 11, line 17 - line 19 figures 1,3	1-45
A	----- US 2014/301373 A1 (CILI GENCER [US] ET AL) 9 October 2014 (2014-10-09) paragraph [0024] paragraph [0042] - paragraph [0050] figure 4B ----- -/-	1-45



Further documents are listed in the continuation of Box C.



See patent family annex.

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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

15 April 2016

Date of mailing of the international search report

22/04/2016

Name and mailing address of the ISA/

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Authorized officer

Marín Saldaña, I

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/068784

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	KYOCERA: "Initial consideration of fast uplink access solution", 3GPP DRAFT; R2-152629_LATENCY-REDUCTION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Fukuoka, Japan; 20150525 - 20150529 24 May 2015 (2015-05-24), XP050972455, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN2/Docs/ [retrieved on 2015-05-24] the whole document -----	1-45

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/068784

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