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(54) Title: UPLINK PRESCHEDULING

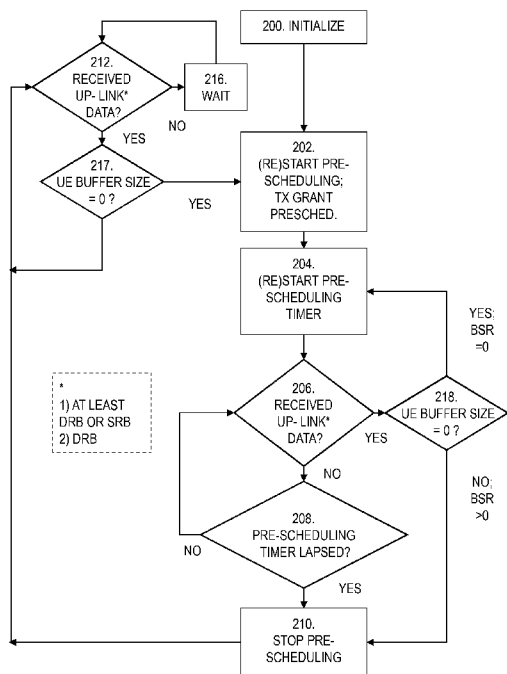


FIG. 5

(57) Abstract: A method for a base station, adapted for scheduling and receiving uplink transmissions from user entities, wherein the base station is being adapted for receiving a scheduling request, SR, and subsequently transmitting a grant, upon which the base station may receive a data transmission from the UE; the base station furthermore being adapted for transmitting grants on a repetitive basis for a user entity although no SR has been received, the transmission of such repetitive transmissions being denoted pre-scheduling. The method comprises the steps of - starting (202) pre-scheduling (I); - starting or restarting (204) a prescheduling timer; - detecting (206) whether uplink data is received, and if not so, detecting whether the prescheduling timer has lapsed; and if the prescheduling timer has lapsed, stopping (218, II) the prescheduling.

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UPLINK PRESCHEDULING

Technical field

- 5 This invention is directed to uplink resource handling for base stations and networks from user entities. More particularly, the invention relates to systems and methods where the uplink rate is regulated by the base station or other nodes or systems.

Background

- 10 It is known that a long latency appears in LTE systems and 3G systems without pre-scheduling.

Cellular communication networks evolve towards higher data rates, together with improved capacity and coverage. In the 3rd Generation Partnership Project (3GPP) standardization body technologies like GSM, HSPA and LTE have been and are currently developed.

LTE uses an access technology based on OFDM (Orthogonal Frequency Division Multiplexing) for the downlink (DL) and Single Carrier FDMA (SC-FDMA) for the uplink (UL)

20 [1]. The resource allocation to user equipments (UEs) on both DL and UL is performed adaptively by the concept of fast scheduling, taking into account the instantaneous traffic pattern and radio propagation characteristics of each UE. Assigning resources in both DL and UL is performed in the scheduler situated in the eNodeB.

- 25 This invention concerns the UL scheduling in LTE. One of the challenges in assigning resources for UL transmissions is that the UE must make the eNodeB aware that there is data pending in the UE buffer. The standard procedure for this in LTE is shown in Figure 1. Step one is that the UE sends a scheduling request (SR). The SR can be sent on a dedicated SR channel (D-SR) or on the contention based Random Access Channel
- 30 (RA-SR). A D-SR requires that the UE is UL synchronized and that the UE has been assigned a SR channel on the Physical Uplink Control Channel (PUCCH). Both of these procedures results in a delay. Next step is that the eNodeB responds with a grant, including information on what time/frequency resources the UE shall use. With support from the link adaptation function also the transport block size, modulation, coding and
- 35 antenna scheme is selected, i.e. the link adaptation is performed in the eNodeB and the selected transport format is signalled together with information of the user ID to the UE.

Fig. 1 shows a procedure for the UE to request resources (Scheduling Request, SR) for UL data transmission. The resource (GRANT) granted by the eNodeB can be of variable size, i.e. the UL transmission (DATA) that follows by the UE can contain various number of bits. At least, however, a buffer status report (BSR) from the UE should be included. In case it is possible to include more bits of information, the UE includes data in addition to the BSR. If $BSR > 0$ it indicates if the UE has more data awaiting to be transmitted. If $BSR = 0$, there is no data in the buffer.

Delay sensitive traffic is one of the most important use cases for LTE. Such traffic scenarios are for example online gaming and ping etc. The growing market for online games and their significant share in the internet traffic puts latency requirement in LTE radio interface to ensure experience of the end user.

The current procedure to acquire UL resources is time consuming. Assuming that no UL grant is currently available for the UE when data becomes ready for transmission but that the UE has a dedicated SR resource, the following steps (according to Figure 1) have to be performed before the data is available in the eNodeB:

1. UE: Transmission of a SR (D-SR or RA-SR). Expected delay 5-15 ms depending on PUCCH SR configuration for this UE.
2. eNB: Issuing an UL grant. Expected delay 2 ms.
3. UE: Decode grant information, issue a transmission. Expected delay 4 ms.
4. Transmission of BSR. Expected delay 1 ms
5. eNB: Decode BSR, issue a grant for further data. Expected delay 3-4 ms.
6. UE: Decode grant information, issue a transmission. Expected delay 4 ms.
7. Transmission of data. Expected delay 1 ms.
8. eNB: Decode transmission. Expected delay 3-4 ms.

The total time between when data is available for transmission at the UE until the same data is available at the eNB: $(5-15\text{ms}) + 2\text{ms} + 4\text{ms} + 1\text{ms} + (3-4\text{ms}) + 4\text{ms} + 1\text{ms} + (3-4\text{ms}) = 23-35\text{ ms}$.

The conclusion is that the time for delivering the delay sensitive traffic is long and involves a substantial amount of radio signalling.

Fig. 2 is a basic view of the ping delay known from the art.

Prior art document WO 2013/085441 discloses a predictive scheduling method applied for a mobile station. Depending on the situation within a cell, an operator can determine to apply predictive scheduling, based on e.g. a Quality of Service parameter like the parameter Quality Class Indicator (QCI) used in LTE, for certain users or mobile stations.

- 5 An uplink transmission scheme of a mobile station is determined. The scheme may be based on a service type indicator or on an operator preconfigured parameter, i.e. based on the reason for applying predictive scheduling. For a mobile station for which it has been decided to apply predictive scheduling, the predictive scheduling can be initiated, i.e. started (or re-started in case it has been previously stopped) with the purpose of re-
- 10 ducing the delay of uplink or/and downlink data transmission. An example of uplink initiated predictive scheduling are receipt of data from a mobile station wherein the buffer status report indicates an empty buffer and/or an indication that a channel quality metric such as path loss is within a certain interval or below a threshold. Examples of downlink initiated predictive scheduling are detecting that a channel quality metric such as path
- 15 loss is within a certain interval or above a threshold, and/or an indication that there is data in the downlink buffer. The uplink transmission scheme comprises in this situation an interval between sending of consecutive periodic messages comprising an uplink transmission grant for the mobile station. A mobile with a good channel quality may be scheduled with a shorter interval between sending of grants, whereas a mobile with a
- 20 poorer channel quality may be scheduled with a longer interval.

In WO 2013/085441, after receiving a number of consecutive messages indicating an empty mobile station buffer, BSR=0, it is determined to stop applying predictive scheduling to the mobile station. After the predictive scheduling has been switched off, the mobile station operates in ordinary mode for a period of time, during which the mobile station is in discontinuous reception (DRX) inactivity mode. DRX is a mechanism that saves

25 power in a mobile station. It allows the station to turn off its receiver and transmitter according to predefined rules while maintaining a connection to the base station. After a further period of time in DRX inactivity mode, the mobile station enters DRX sleep mode. The mobile station is thereafter woken up by a pending scheduling request SR.

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Summary

One problem in predictive scheduling systems in the art is that the predictive scheduling is still prone to a high to medium battery consumption

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It is a first object of the invention to improve the uplink resource allocation for a base station in which latency is improved without power consumption being substantially increased in the user entity.

10 This object has been accomplished by a method for a base station, adapted for scheduling and receiving uplink transmissions from user entities, wherein the base station is being adapted for receiving a scheduling request, SR, and subsequently transmitting a grant, upon which the base station may receive a data transmission from the UE; the base station furthermore being adapted for transmitting grants on a repetitive basis
 15 for a user entity although no SR has been received, the transmission of such repetitive transmissions being denoted pre-scheduling.

The method comprises the steps of

- starting prescheduling;
- starting or re-starting a prescheduling timer;
- 20 - detecting whether uplink data is received, and if not so, detecting whether the pre-scheduling timer has lapsed; and if the prescheduling timer has lapsed, stopping the prescheduling.

Once prescheduling is started, the method may comprise

- 25 - detecting the user entity, UE, data buffer size for the received uplink data, and wherein if the UE data buffer size is zero,
- re-starting the pre-scheduling timer, and if not so,
- stopping the prescheduling.

30 After the prescheduling is stopped, the method may comprise

- detecting if uplink data is received and detecting if the UE data buffer is zero, and
- if both uplink data is received and if the UE data buffer is zero,
- restarting prescheduling and
- restarting the prescheduling timer.

35

The method may comprises the step of - issuing a grant signal forcing the UE to a DRX mode upon the prescheduling being stopped.

5 The prescheduling timer value may be set so as to depend on a packet delay budget, and wherein a long pre-scheduling timer value is defined for short packet delay budget value and wherein a short pre-scheduling timer value is defined for a long packet delay budget value.

The following further steps may be comprised

- 10
- starting a Connected Mode Inactivity Timer, CMIT,
 - starting prescheduling and issuing unsolicited grants,
 - if synchronisation with the UE is lost, Idle Mode is activated for the UE and pre-scheduling is stopped; if synchronization is not lost, the CMIT timeout is checked, and if no timeout applies, - continuing prescheduling.

15

A state of regular scheduling may be performed, upon receiving a search request, SR.

20 A high rate pre-scheduling mode may be entered, if in a state of a regular scheduling, uplink data and BSR=0 is received. The high rate prescheduling state has a higher average rate of prescheduling grants than the average rate of prescheduling grants during prescheduling. The pre-scheduling is preceded by the high rate pre-scheduling.

According to one option during the high rate prescheduling, the rate of transmitting pre-scheduling grants decreases.

25

As another option, during the high rate prescheduling, the rate of transmitting pre-scheduling grants is constant.

There is moreover provided a base station comprising processing means operative to:

- 30
- starting prescheduling;
 - starting or re-starting a prescheduling timer;
 - detecting whether uplink data is received, and if not so, detecting whether the pre-scheduling timer has lapsed; and if the prescheduling timer has lapsed, stopping the prescheduling.

35 The processing means may be further operative to, once prescheduling is started,

- detecting the user entity, UE, data buffer size for the received uplink data, and wherein if the UE data buffer size is zero,
- re-starting the pre-scheduling timer, and if not so,
- stopping the prescheduling.

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There is also provided a computer program

Further advantages of the invention will appear from the following detailed description of the invention.

10

Brief description of the drawings

- Fig. 1 shows basic signalling of a prior art LTE network,
- 5 fig. 2 shows the latency for a scenario for an exemplary LTE prior art solution,
- fig. 3 shows a latency figure for a scenario in which pre-scheduling is used,
- fig. 4 shows a first embodiment of a method according to the invention,
- 10 fig. 5 shows a second embodiment of a method according to the invention,
- fig. 6 shows a third embodiment of a method according to invention,
- 15 fig. 7 shows a fourth embodiment of a method according to the invention,
- fig. 8 shows further aspects of the method shown in in fig. 5,
- fig. 9 is fifth embodiment of the invention,
- 20 fig. 10 shows a further embodiment to the fifth embodiment,
- fig. 11 shows a scenario according to the fifth embodiment,
- 25 fig. 12 - 16 show various scenarios for embodiments according to invention,
- fig. 17 shows a scheduling entity for an exemplary base station according to the invention, and
- 30 fig. 18 shows an implementation having functional modules.

Detailed description

By performing pre-scheduling, that is, sending an UL grant to the UE in advance of receiving a scheduling request the latency is substantially improved.

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Pre-scheduling can be performed when the UL load is low, i.e. when there is not enough UL data in the UE buffers within the cell, to utilize all UL PRBs. In that case, UL grants are given to the UE even though the eNode B assess that the UE buffer is empty. It is noted that it is better to grant UEs which is known to have data in the buffer, compared to taking a chance and give a prescheduled grant to a UE that may not have data to transmit.

10

In 3GPP it is specified that when a UE is given an UL grant of a specific size, the UE has to transmit data of that particular size. If the UE has no data in the buffer the UE will transmit padding.

15

This padding can drain the UE battery if prescheduling continues for a long time, and it prevents the UE from entering DRX sleep mode.

It also creates more UL interference, although this is normally not an issue since pre-scheduling is typically only performed in low load.

20

According to an aspect of the present invention, pre-scheduling is applied and a measure of inactivity is measured for the UE whereby after a certain time of inactivity (no UL data received) the prescheduling is stopped. When prescheduling is stopped, the UE can enter DTX sleep mode. Prescheduling is started again if UL data is received.

25

Embodiments of the invention offer a way to minimize the effect of excessive battery consumption when prescheduling is used. Moreover, it makes it possible to enter DRX sleep mode in the UE. Since DRX sleep mode can be entered, ANR measurements can be performed.

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In figs. 4 and 5, two embodiments of methods the invention are shown. The methods pertain to controlling pre-scheduling of the base station for uplink transmissions.

In step 200, the routine is initialized and in step 202, pre-scheduling is started, involving repetitive transmission of unsolicited grants towards the UE. The routine continues in

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step 204 in which a pre-scheduling timer is started (or re-started as will be explained later).

In step 206, a loop is undertaken in which it is resolved whether up-link data is received from the UE, and if not, whether the pre-scheduling timer has lapsed. If the latter is not
5 the case, it is again resolved whether up-link data is received.

If in 208, the prescheduling timer has lapsed, the prescheduling stops, step 210. If it has not lapsed, the routine goes to 206.

10 If in step 206, fig. 4, uplink data is received, it goes to step 204 and otherwise to step 208.

If in step 206, fig. 5, uplink data is received, it may be investigated in optional step 218, whether the UE data buffer equals zero (Buffer Size =0). UE data buffer is reported
15 through the "BSR" (buffer status report) according to 3GPP TS36.321 V12.3.0, chapter 6.1.3.1 in which the parameter is denoted Buffer Size. If so, the routine goes to step 204 – restart prescheduling timer - if not so, the routine goes to step 210 – stop prescheduling.

20 In step 206, uplink data may be based on DRB data alone or at least any of DRB and SRB data.

When the pre-scheduling stops, existing known UE routines lead to the UE entering a DRX sleep mode, potentially after a given period.

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In fig. 4, after the step 210, a check is made for uplink data, 212. Upon uplink data is being received, the routine goes to 202. Otherwise (No), the routine awaits uplink data.

In fig. 5, after step 210, the routine goes to 212, in which again it is investigated whether
30 uplink data is received. This is awaited, in step 216, until fulfilled, and upon confirmed, it is checked whether the UE data buffer is zero, step 217. As long as the UE data buffer is not zero, uplink data is awaited in step 212, and when the UE buffer is zero for the received uplink data, the prescheduling is started again in step 202.

A further embodiment of the routine is further shown in fig. 4. Here, the optional step 214 is comprised after step 210, where a grant signal forcing the UE to DRX sleep mode is transmitted. This will effectuate that the UE enters the DRX sleep mode.

- 5 A still further embodiment is shown in fig. 6. The QoS Class Identifier, QCI value, as known from 3GPP TS23.203, V13.1.0 (2014-09), table 6.1.7 is used in a mapping for determining the value of the prescheduling timer value. The QCI value is mapping to the Packet Delay Budget, and the prescheduling timer is set is such that the lower the Packet Delay Budget, the longer the prescheduling timer value is set, according to an
- 10 advantageous embodiment of the invention. This means that a longer time base will be provided for short latencies whereas a reduced time base for services requiring a longer packet delay budget. Thereby, the power consumption of the UE is further optimized; the short latency services are allowed a somehow larger power consumption.
- 15 The mapping may for instance be performed as in the following example:

Qcl	Priority	Packet Delay Budget	Prescheduling timer
3	3	50 ms	20 s
1	2	100 ms	5 s
6	6	300 ms	1 s

Additional Qcl values may be selected having regard to choosing appropriate pre-scheduling timer values.

20

The following steps are undertaken, initialize 100; detect Qcl value 104, set the pre-scheduling timer value according to the Qcl value according to the selected mapping 106. After this step, the routine may continue in step 200 of fig. 4/5.

- 25 In fig. 7, a further embodiment routine is shown. This routine is working in parallel with the routines shown in figs. 4, 5 and 6.

In step 300 the routine is initialized and the in step 304, a Connected Mode Inactivity Timer, CMIT, is started. Prescheduling is started, and unsolicited grants are issued.

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If synchronisation with the UE is lost, step 308, Idle Mode is activated for the UE and prescheduling is stopped. If synchronization is not lost, the CMIT timeout is checked, step 310, and if no timeout applies, the routine goes back to 308.

- 5 According to the invention, the prescheduling timer value CMIT timer value is considerably shorter than the CMIT timer value. It should be understood, that the prescheduling timer could also be selected to be larger than the CMIT timer value.

10 In fig. 8, aspects of the method shown in in fig. 5 are shown further. Four states (I, II, III, IV) for the up-link scheduling in the base station are shown.

Entering a first state (I), the prescheduling timer is started and pre-scheduling is performed, corresponding to steps 201 and 204.

- 15 In a second state (II), no scheduling is performed; corresponding to step 210.

In a third state (III), the UE is in DRX sleep mode.

20 In a fourth state (IV), regular scheduling is undertaken corresponding to steps 212, 214 and 216 / fig. 11.

The conditions for exiting the first state (I) are: If up-link data is received 206 and BSR greater than 0, enter state four. If no up-link data is received, and the prescheduling timer lapses, enter state two. If uplink data is received and BSR =0, the prescheduling timer is restarted, state 1 is re-entered. Optionally, if an SR is received, enter the fourth state (IV).

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The conditions for exiting the second state (II) are: If a DRX inactivity timer has lapsed, state UE DRX sleep mode is entered. If a SR is received, enter the fourth state (IV).

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The conditions for exiting the third state (III) are: receiving a SR, enter the fourth state (IV).

The conditions for exiting the fourth state (IV) are: If uplink data is received and BSR =0, enter state I. If BSR greater than 0, re-enter the fourth state (IV).

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In fig. 9, a further embodiment is shown in which additionally a high rate prescheduling state (V) is provided. This embodiment comprises some of the same feature as the embodiment shown in fig. 8, and similar features will therefore not be explained further here.

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In fig. 9, in state IV, if uplink data is received and BSR=0, state IV is exited and state V is entered.

In state V is no uplink data is received and a high rate timer lapses, state I is entered.

Optionally, in state V, if a SR is received, state IV is entered.

10

Having regard to the above explained flow diagrams and scenarios there is provided the following functionality:

A method for a base station, adapted for scheduling and receiving uplink transmissions from user entities, wherein the base station is being adapted for receiving a scheduling request, SR, and subsequently transmitting a grant, upon which the base station may receive a data transmission from the UE;

the base station furthermore being adapted for transmitting grants on a repetitive basis for a user entity although no SR has been received, the transmission of such repetitive transmissions being denoted pre-scheduling.

The method comprises the steps of

- starting 202 prescheduling I;
- starting or re-starting 204 a prescheduling timer;
- detecting 206 whether uplink data is received, and if not so, detecting whether the pre-scheduling timer has lapsed; and if the prescheduling timer has lapsed, stopping 218, II the prescheduling.

Once prescheduling is started 202, I, the method may comprise

- detecting 218 the user entity, UE, data buffer size for the received uplink data, and wherein if the UE data buffer size is zero,
- re-starting 210 the pre-scheduling timer, and if not so,
- stopping 210 the prescheduling.

After the prescheduling is stopped 201, the method may comprise

- detecting if uplink data is received 212 and detecting if the UE data buffer is zero 217, and

- if both uplink data is received and if the UE data buffer is zero,
- restarting prescheduling 202 and
- restarting 204 the prescheduling timer.

5 The method may comprise the step of issuing 214 a grant signal forcing the UE to a DRX mode upon the prescheduling being stopped 210.

The prescheduling timer value may be set so as to depend 106 on a packet delay budget, and wherein a long pre-scheduling timer value is defined for short packet delay
 10 budget value and wherein a short pre-scheduling timer value is defined for a long packet delay budget value.

The following further steps may be comprised

- starting a Connected Mode Inactivity Timer 304, CMIT,
- 15 - starting prescheduling and issuing unsolicited grants,
- if synchronisation with the UE is lost 308, Idle Mode is activated for the UE and pre-scheduling is stopped 312; if synchronization is not lost, the CMIT timeout is checked, 310 and if no timeout applies, - continuing prescheduling.

20 A state of regular scheduling IV may be performed, upon receiving a search request, SR.

A high rate pre-scheduling mode V may be entered, if in a state of a regular scheduling, uplink data 212 and BSR=0 is received. The high rate prescheduling state has a higher
 25 average rate of prescheduling grants than the average rate of prescheduling grants during prescheduling V. The pre-scheduling I is preceded by the high rate pre-scheduling V.

According to one option during the high rate prescheduling V, the rate of transmitting prescheduling grants decreases.

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As shown in fig. 10 this can be embodied as shown in fig. 10.

A parameter is defined in step 501. $\text{PRESC_INT}(t) = \text{START_PRESC_INT} + (\text{STOP_PRESC_INT} - \text{START_PRESC_INT}) * (t/T_{\text{MAX}2})$, TRUNCATED, $t=0..T_{\text{MAX}2}$.

35 In step 502 502. TX GRANT PRE-SCD is issued. In step 503. $t=T_{\text{MAX}24}$ is tested. If yes 504 the process stops. If no the process goes to 501.

As explained in fig. 11, the high rate prescheduling

As another option, during the high rate prescheduling (V), the rate of transmitting pre-
 5 scheduling grants is constant.

According to the invention there is also provided a base station (800), adapted for scheduling and receiving uplink transmissions from user entities, wherein the base station is being adapted for receiving a scheduling request, SR, and subsequently transmitting a grant, upon which the base station may receive a data transmission from the UE;
 10 the base station furthermore being adapted for transmitting grants on a repetitive basis for a user entity although no SR has been received, the transmission of such repetitive transmissions being denoted pre-scheduling.

15 The bases station comprising processing means operative to:

- starting (202) prescheduling (I);
- starting or re-starting (204) a prescheduling timer;
- detecting (206) whether uplink data is received, and if not so, detecting whether the prescheduling timer has lapsed; and if the prescheduling timer has lapsed, stopping
 20 (218, II) the prescheduling.

The processing means may be further operative to, once prescheduling is started (202, I),

- detecting (218) the user entity, UE, data buffer size for the received uplink data, and wherein if the UE data buffer size is zero,
- 25 - re-starting (210) the pre-scheduling timer, and if not so,
- stopping (210) the prescheduling.

The processing means may be further operative to, after the prescheduling is stopped (201),

- 30 - detecting if uplink data is received (212) and detecting if the UE data buffer is zero (217), and
- if both uplink data is received and if the UE data buffer is zero,
- restarting prescheduling (202) and
- restarting (204) the prescheduling timer.

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The processing means may be further operative to,

- issuing (214) a grant signal forcing the UE to a DRX mode upon the prescheduling being stopped (210).

The prescheduling timer value may be set so as to depend (106) on a packet delay budget, and wherein a long prescheduling timer value is defined for short packet delay budget value and wherein a short pre-scheduling timer value is defined for a long packet delay budget value.

The processing means may be further operative to

- starting a Connected Mode Inactivity Timer (304), CMIT,
- starting prescheduling and issuing unsolicited grants,
- if synchronisation with the UE is lost (308), Idle Mode is activated for the UE and prescheduling is stopped (312); if synchronization is not lost, the CMIT timeout is checked, (310) and if no timeout applies, - continuing prescheduling.

A base station is furthermore provided, wherein a state of regular scheduling () is performed, upon receiving a search request, SR.

A high rate pre-scheduling mode (V) is entered in the base station, if in a state of a regular scheduling, uplink data (212) and BSR=0 is received, the high rate prescheduling state having a higher average rate of pre-scheduling grants than the average rate of prescheduling grants during prescheduling (V), such that pre-scheduling (I) is preceded by the high rate pre-scheduling (V).

The processing means may comprise a processor (801) and a memory (802) and wherein said memory (802) is containing instructions executable by said processor.

There is moreover provided a computer program comprising instructions for carrying out the steps according to any of the methods described above.

The following scenarios may be appearing using any of the embodiments mentioned above wherein some steps of the routine are indicated for corresponding signals and events. For the economy of the presentation, redundant events will not be repeated.

Fig. 12, Scenario 1:

- UE is active

- The prescheduling timer 204 is started when prescheduling grants 202 (Grant_{1-x} (PRESCHED)) are initiated and it keeps running as long as there is no UL DRB data / BSR=0 received.
 - No uplink data is received in the PUSCH_{1-x}(BSR=0), 206.
 - 5 - Stop pre-scheduling 210 after the prescheduling timer value expires, 208, if no data has received from the UE (alternatively from the expected QCI).
 - When the prescheduling timer no longer is running, prescheduling stops.
 - UE enters DRX sleep after "UE DRX inactivity Timer" expires
- 10 Fig. 13, Scenario 2 (c.f. fig.5 embodiment):
- UE is active
 - Restart 204 the prescheduling timer when DRB data in PUSCH₂ with BSR=0, c.f. 206 and 218, has been received within the period.
- 15 Fig. 14, Scenario 3:
- Send a grant to the UE forcing it to "DRX sleep" "immediately", 214. This prevents the UE from using the "UE DRX inactivity Timer". Forcing the UE to DRX sleep is in 3GPP TS 36.321 V12.3.0 called DRX Command MAC control element.
- 20 Fig. 15, Scenario 4:
- UE is originally in DRX sleep. SR is triggered (since UE received data in its UL buffer) and UE enters ordinary scheduling mode (UE active).
 - When the DRB data is received the prescheduling timer starts (similar to scenario 2)
 - 25 - UE inactivity timer expires and UE DRX sleep mode is adopted

As an alternative "received DRB data" can be any type of received data (also SRB).

Fig. 16, Scenario 5:

- 30 - Directly after Radio Bearer setup (a UE becomes "connected") then prescheduling timer and prescheduling is started, i.e. SRB transmission trigger the timer.

Scenario 6:

- 35 - Same as scenario 5, but SRB is not enough to trigger the prescheduling and the activation of the prescheduling timer.
- Instead wait for DRB activation before these are started.

- For ANR this is useful. This means the UE can quickly enter DRX if there is no DRB activity and then the corresponding UE measurements for ANR can be performed.

In conclusion, according to some embodiments the following is undertaken

- 5 - Measure inactivity during UL prescheduling phase
- The prescheduling timer is used to control for how long to run prescheduling, without any UL activity
- Restart prescheduling timer if there is UL activity
- Force UE to DRX sleep immediately when prescheduling is stopped
- 10 - Base inactivity on received DRB data, SRB data or both

Fig. 17 shows a scheduling entity 800 for a bases station 805 according to embodiments of the invention comprising a synchronisation unit 804, a processing unit 801 carrying out the steps described above, a memory unit 802 for storing instructions of said steps, and an input / output unit 803 for effectuating the transmission and reception of signalling.

Fig. 18 shows a UL scheduling entity comprising a starting prescheduling module 901, a starting or restarting prescheduling timer module 902; an uplink detection module and 904 and a timer lapse detection module 904.

ABBREVIATIONS

	ANR	Automatic Neighbour Cell Relations
	DRB	Data Radio Bearer
5	SRB	Signalling Radio Bearer
	PRB	Physical Resource Block
	DRX	Discontinuous Reception
	Qcl	Quality of Service class Identifier
	QoS	Quality of Service
10	BSR	Buffer Status Report
	PUSCH	Physical Uplink Shared Channel
	GSM	Global System for Mobile communication
	HSPA	High Speed Packet Access
	LTE	Long Term Evolution

15

Claims

1. A method for a base station, adapted for scheduling and receiving uplink transmissions from user entities, wherein the base station is being adapted for receiving a scheduling request, SR, and subsequently transmitting a grant, upon which the base station may receive a data transmission from the UE;
the base station furthermore being adapted for transmitting grants on a repetitive basis for a user entity although no SR has been received, the transmission of such repetitive transmissions being denoted pre-scheduling, the method comprising the steps of
- starting (202) prescheduling (I);
 - starting or re-starting (204) a prescheduling timer;
 - detecting (206) whether uplink data is received, and if not so, detecting whether the prescheduling timer has lapsed; and if the prescheduling timer has lapsed, stopping (218, II) the prescheduling.
2. Method according to embodiment 2, once prescheduling is started (202, I), wherein
- detecting (218) the user entity, UE, data buffer size for the received uplink data, and wherein if the UE data buffer size is zero,
 - re-starting (210) the pre-scheduling timer, and if not so,
 - stopping (210) the prescheduling.
3. Method according to embodiment 1 or 2, wherein after the prescheduling is stopped (201),
- detecting if uplink data is received (212) and detecting if the UE data buffer is zero (217), and
 - if both uplink data is received and if the UE data buffer is zero,
 - restarting prescheduling (202) and
 - restarting (204) the prescheduling timer.
4. Method according to any of embodiment 1 – 3, wherein
- issuing (214) a grant signal forcing the UE to a DRX mode upon the prescheduling being stopped (210).

5. Method according any of embodiments 1 – 4, wherein the prescheduling timer value is set so as to depend (106) on a packet delay budget, and wherein a long pre-scheduling timer value is defined for short packet delay budget value and wherein a short pre-scheduling timer value is defined for a long packet delay budget value.
- 5
6. Method according any of embodiments 1 - 5, comprising the steps of
- starting a Connected Mode Inactivity Timer (304), CMIT,
 - starting prescheduling and issuing unsolicited grants,
 - if synchronisation with the UE is lost (308), Idle Mode is activated for the UE and pre-scheduling is stopped (312); if synchronization is not lost, the CMIT timeout is checked, (310) and if no timeout applies, - continuing prescheduling.
- 10
7. Method according to any previous claim, wherein a state of regular scheduling () is performed, upon receiving a search request, SR.
- 15
8. Method according to claim 7, wherein a high rate pre-scheduling mode (V) is entered, if in a state of a regular scheduling, uplink data (212) and BSR=0 is received, the high rate prescheduling state having a higher average rate of pre-scheduling grants than the average rate of prescheduling grants during prescheduling (V), such that pre-scheduling (I) is preceded by the high rate pre-scheduling (V).
- 20
9. Method according to claim 8, wherein during the high rate prescheduling (V), the rate of transmitting prescheduling grants decreases.
- 25
10. Method according to claim 8, wherein during the high rate prescheduling (V), the rate of transmitting prescheduling grants is constant.
- 30

11. A base station (800), adapted for scheduling and receiving uplink transmissions from user entities, wherein the base station is being adapted for receiving a scheduling request, SR, and subsequently transmitting a grant, upon which the base station may receive a data transmission from the UE;
- 5 the base station furthermore being adapted for transmitting grants on a repetitive basis for a user entity although no SR has been received, the transmission of such repetitive transmissions being denoted pre-scheduling, the bases station comprising processing means operative to:
- starting (202) prescheduling (I);
 - 10 - starting or re-starting (204) a prescheduling timer;
 - detecting (206) whether uplink data is received, and if not so, detecting whether the prescheduling timer has lapsed; and if the prescheduling timer has lapsed, stopping (218, II) the prescheduling.
- 15 12. Base station according to embodiment 2, the processing means being further operative to
- once prescheduling is started (202, I), wherein
 - detecting (218) the user entity, UE, data buffer size for the received uplink data, and wherein if the UE data buffer size is zero,
 - 20 - re-starting (210) the pre-scheduling timer, and if not so,
 - stopping (210) the prescheduling.
13. Base station according to embodiment 1 or 2, the processing means being further operative to:
- 25 wherein after the prescheduling is stopped (201),
- detecting if uplink data is received (212) and detecting if the UE data buffer is zero (217), and
 - if both uplink data is received and if the UE data buffer is zero,
 - restarting prescheduling (202) and
 - 30 - restarting (204) the prescheduling timer.
14. Base station according to any of embodiment 1 – 3, the processing means being further operative to,
- issuing (214) a grant signal forcing the UE to a DRX mode upon the prescheduling being stopped (210).
 - 35

15. Base station according any of embodiments 1 – 4, the processing means being further operative to:
the prescheduling timer value is set so as to depend (106) on a packet delay budget, and wherein a long prescheduling timer value is defined for short packet delay budget value and wherein a short pre-scheduling timer value is defined for a long packet delay budget value.
16. Base station according any of embodiments 1 - 5, the processing means being further operative to
- starting a Connected Mode Inactivity Timer (304), CMIT,
 - starting prescheduling and issuing unsolicited grants,
 - if synchronisation with the UE is lost (308), Idle Mode is activated for the UE and pre-scheduling is stopped (312); if synchronization is not lost, the CMIT timeout is checked, (310) and if no timeout applies, - continuing prescheduling.
17. Base station according to any previous claim, wherein a state of regular scheduling (I) is performed, upon receiving a search request, SR.
18. Base station according to claim 7, wherein a high rate pre-scheduling mode (V) is entered, if in a state of a regular scheduling, uplink data (212) and BSR=0 is received, the high rate prescheduling state having a higher average rate of pre-scheduling grants than the average rate of prescheduling grants during prescheduling (V), such that pre-scheduling (I) is preceded by the high rate pre-scheduling (V).
19. Base station according to claim 8, wherein during the high rate prescheduling (V), the rate of transmitting prescheduling grants decreases.
20. Base station according to claim 8, wherein during the high rate prescheduling (V), the rate of transmitting prescheduling grants is constant.
21. Base station according to any of claims 10 – 20, wherein the processing means comprise a processor (801) and a memory (802) and wherein said memory (802) is containing instructions executable by said processor.

22. Computer program comprising instructions for carrying out the steps according to any of claims 1 – 10.

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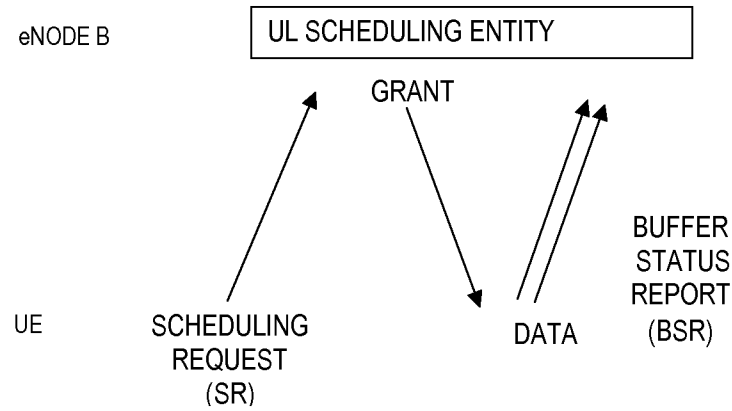


FIG. 1

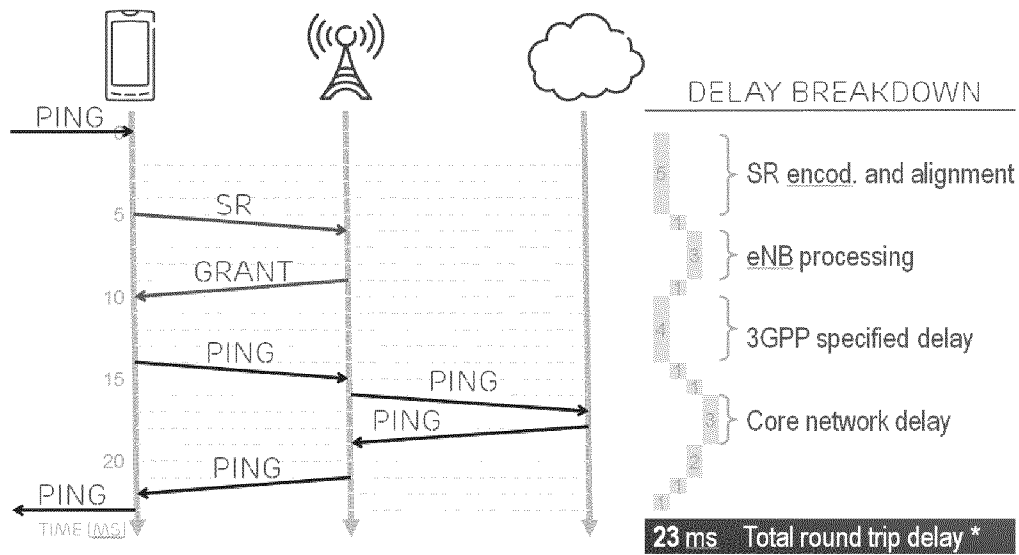


FIG. 2

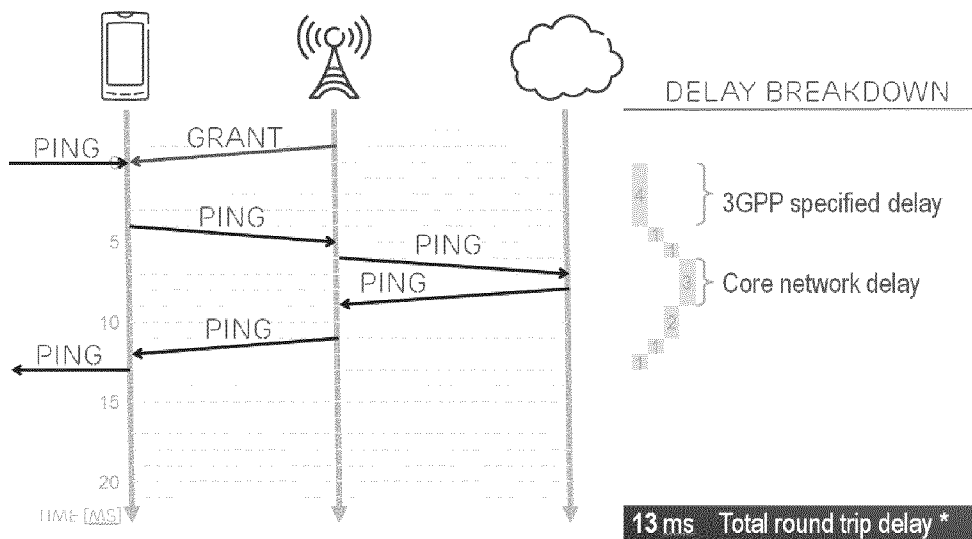


FIG. 3

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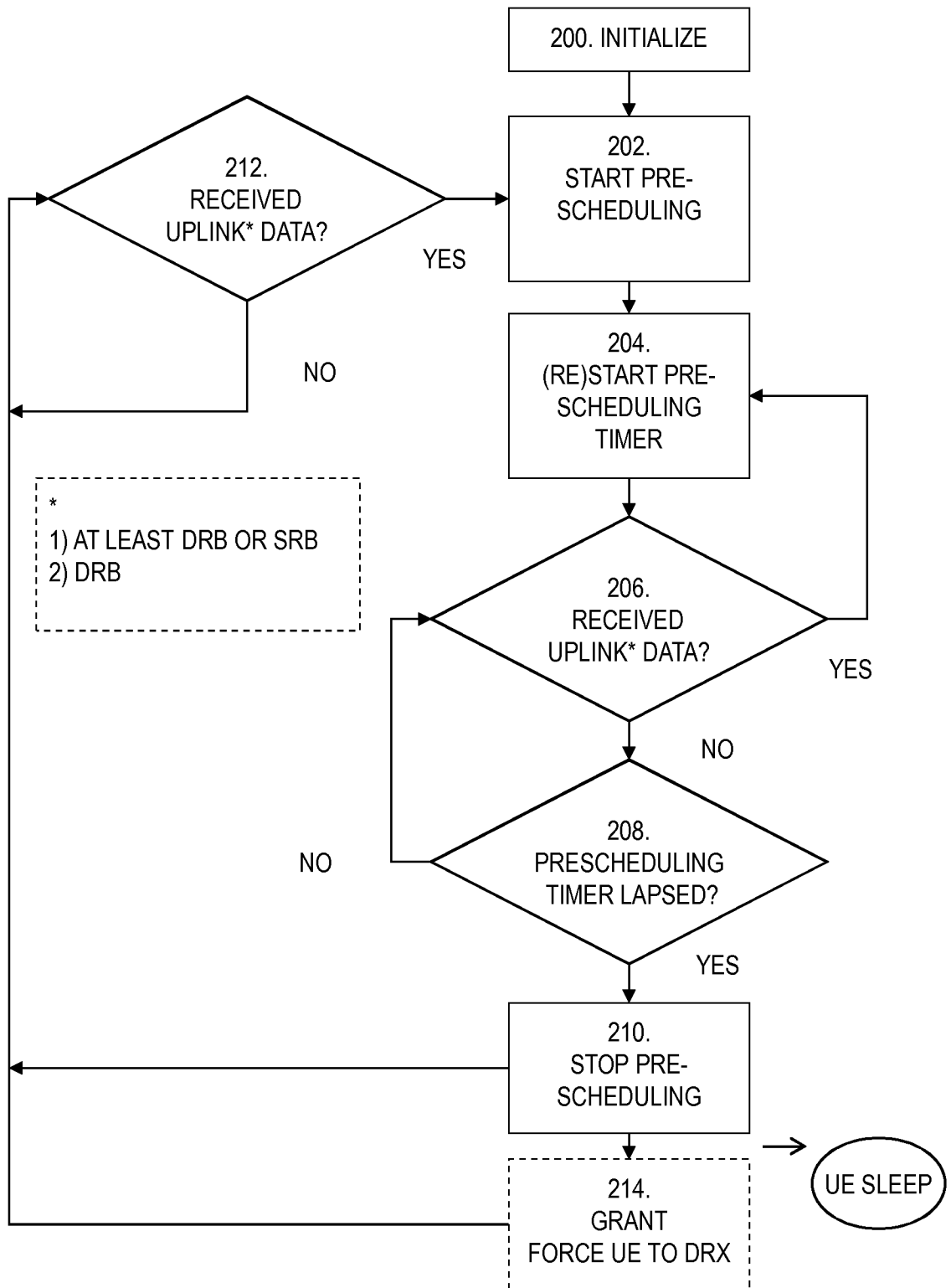


FIG. 4

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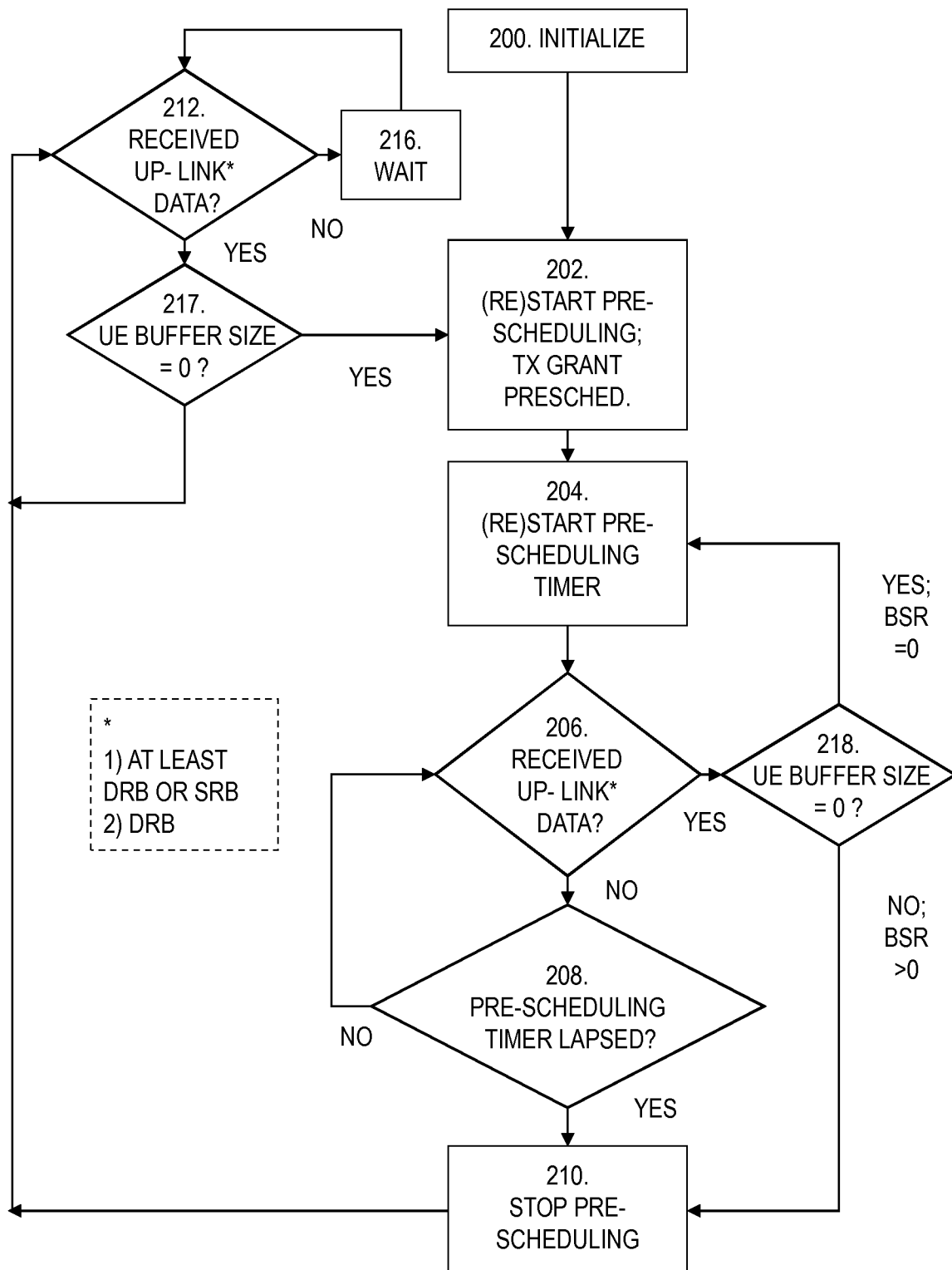


FIG. 5

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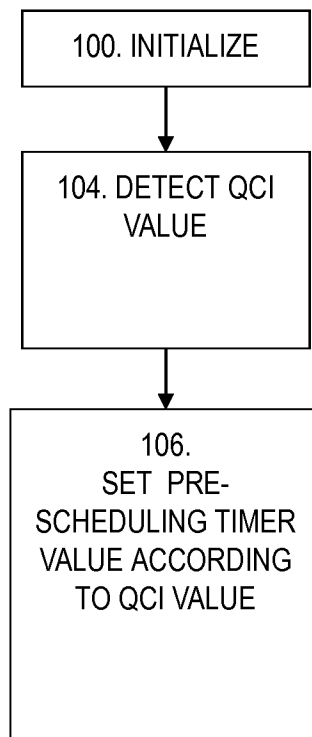


FIG. 6

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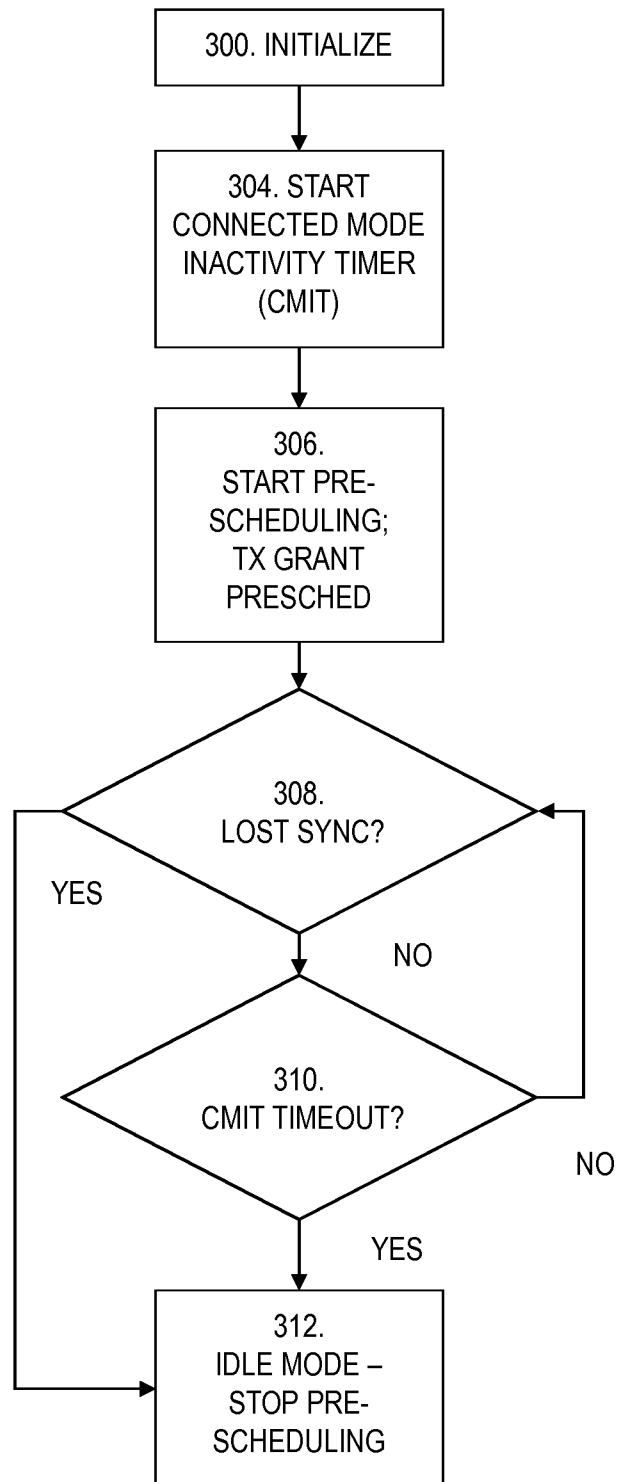


FIG. 7

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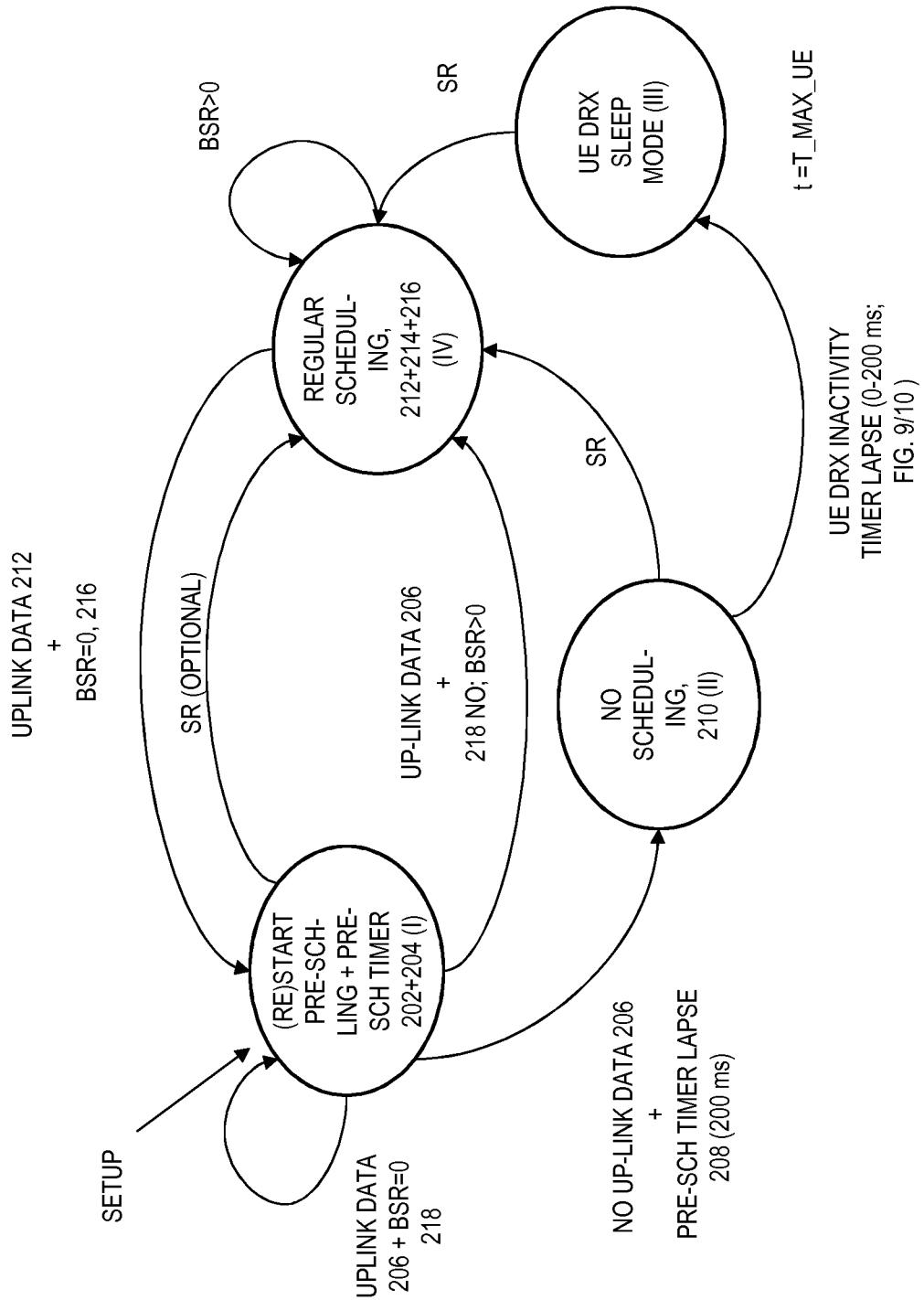


FIG. 8

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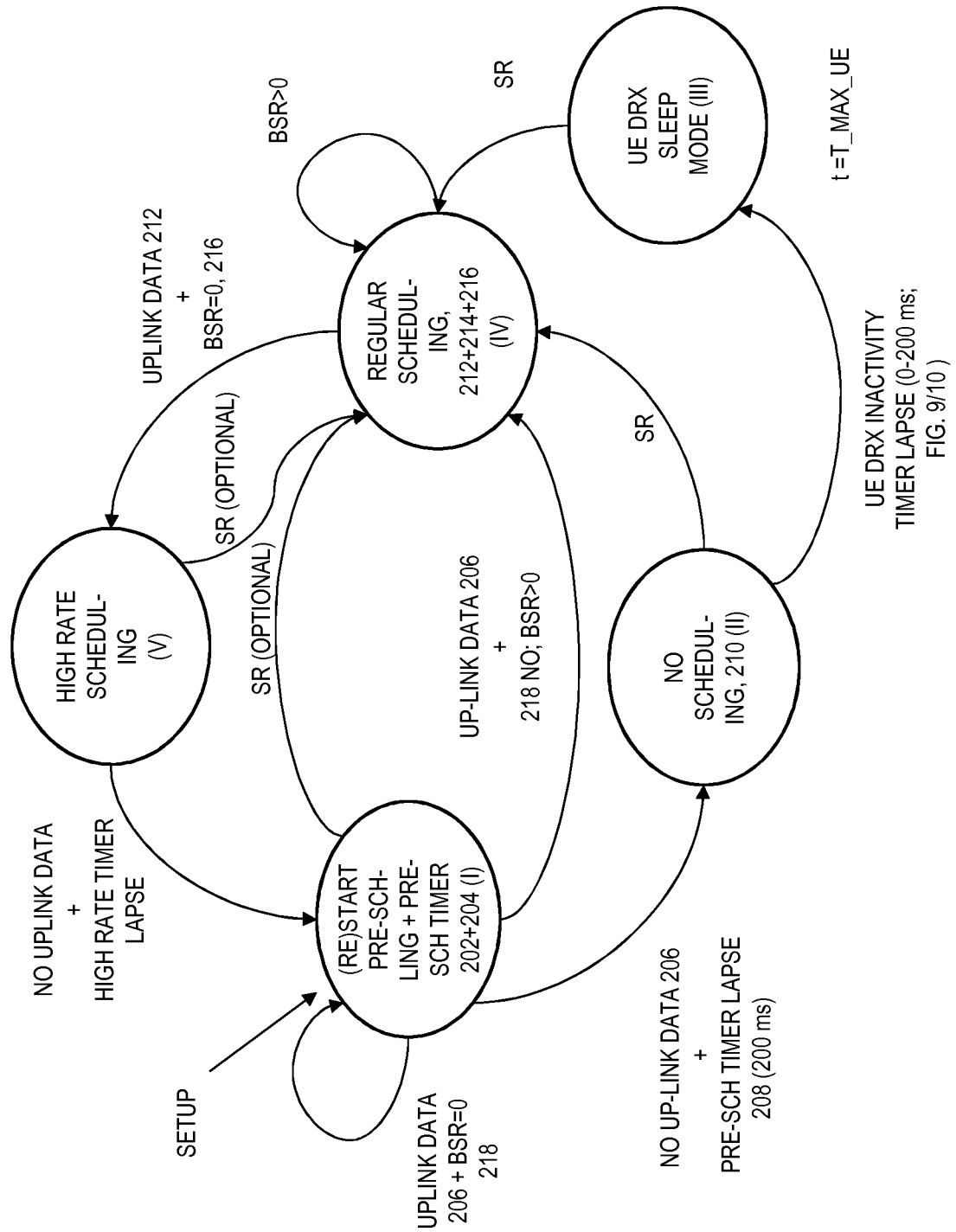


FIG. 9

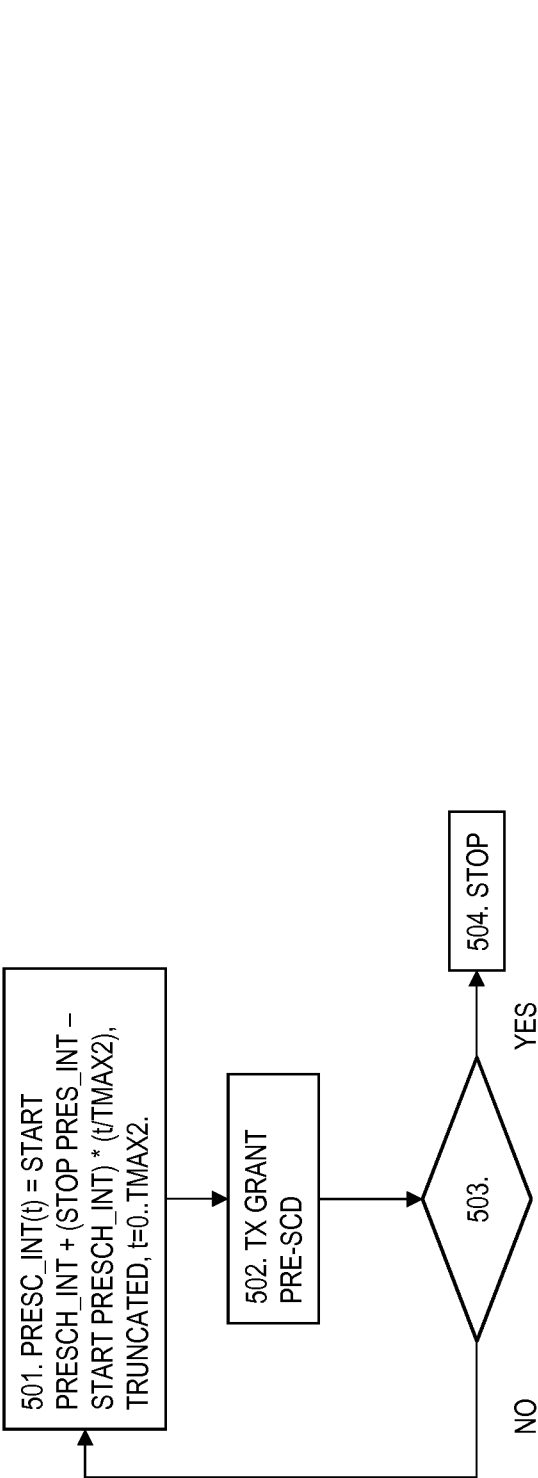


Fig. 10

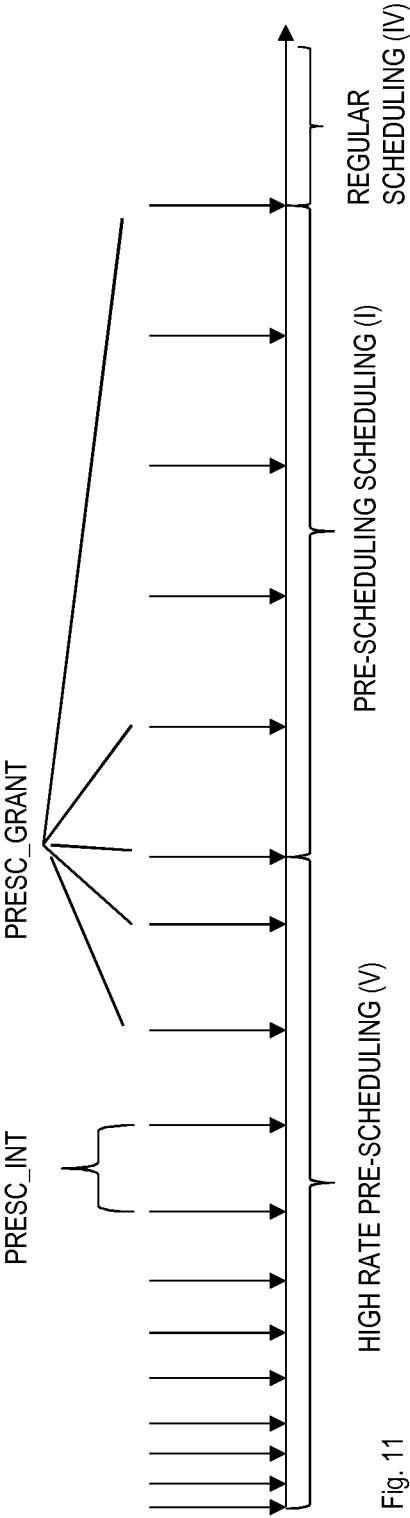


Fig. 11

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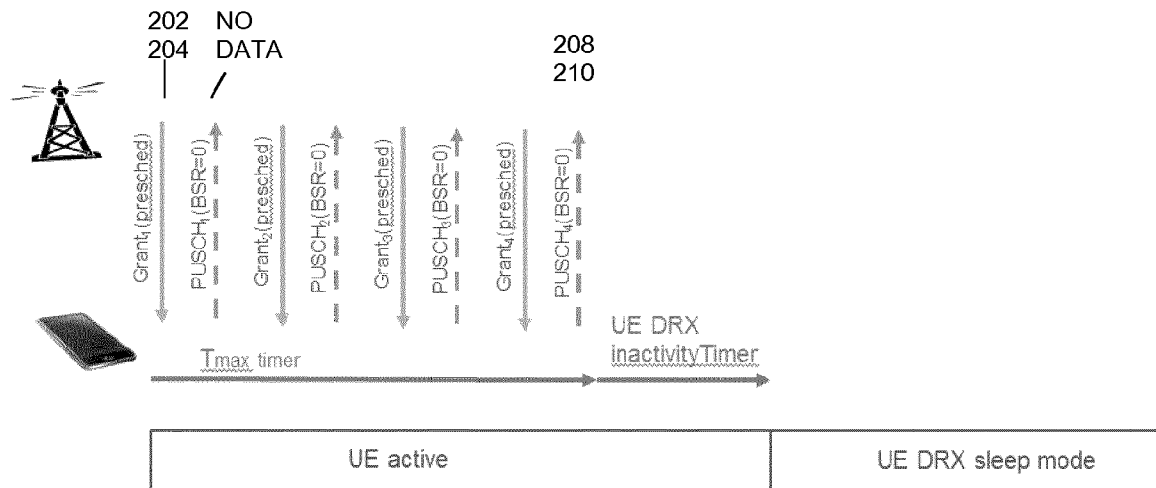


FIG. 12 – SCENARIO 1

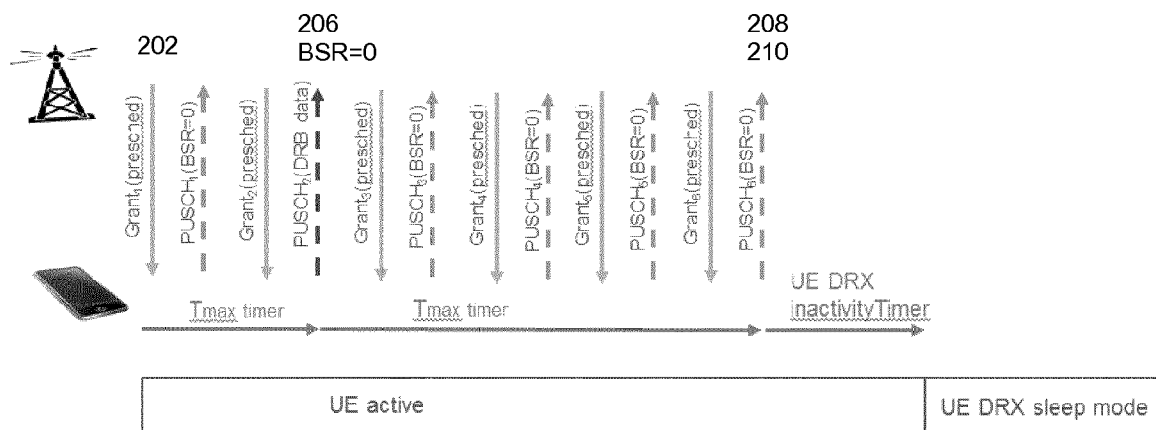


FIG. 13 – SCENARIO 2

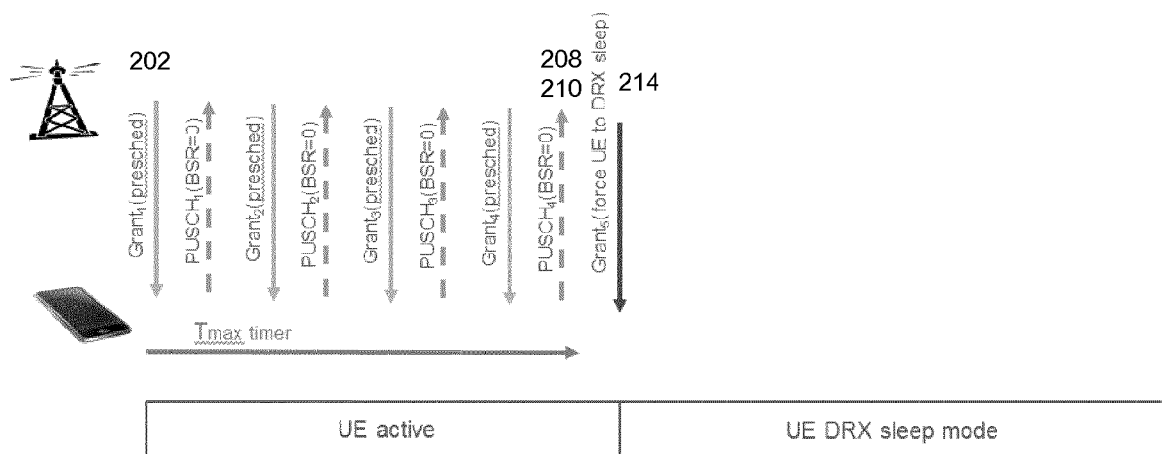


FIG. 14 – SCENARIO 3

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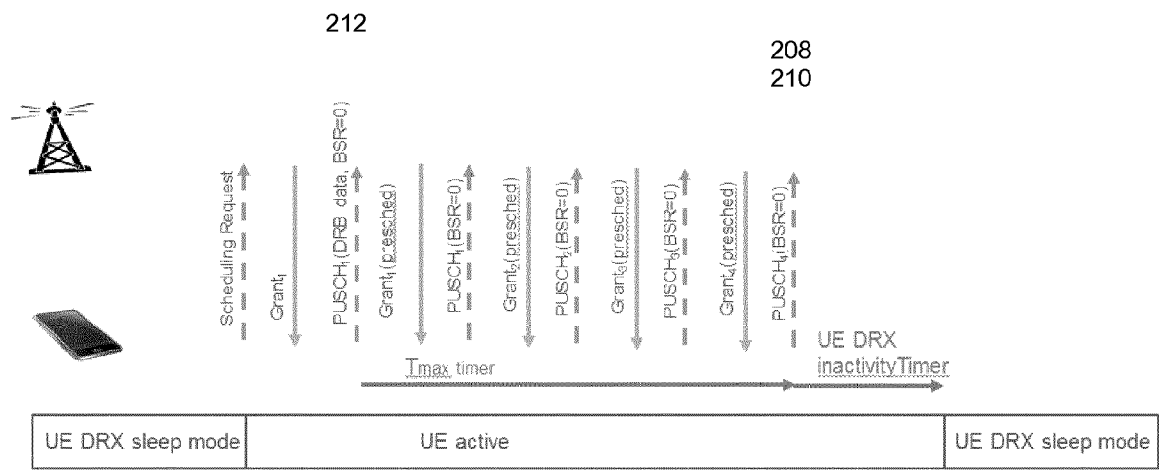


FIG. 15 – SCENARIO 4

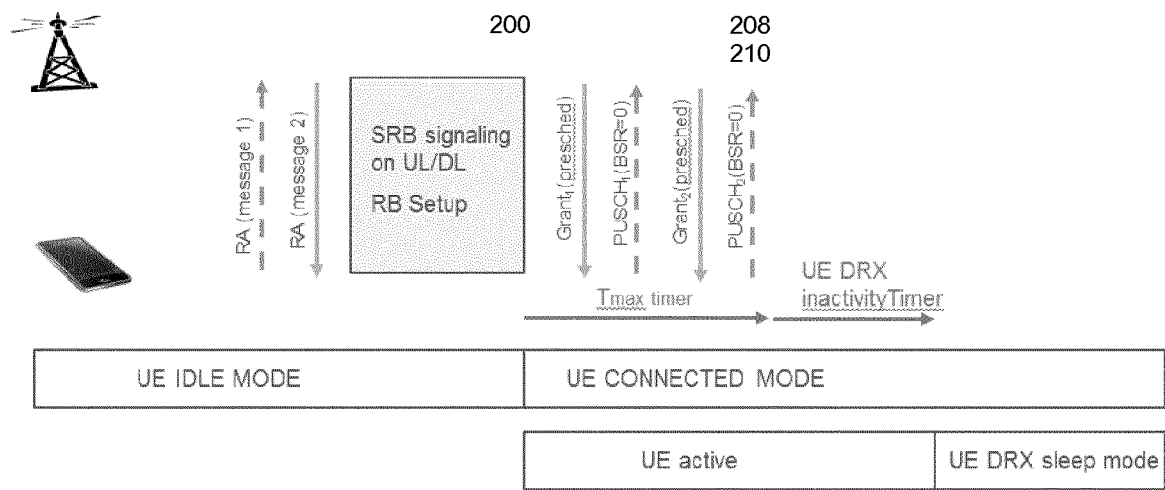


FIG. 16 – SCENARIO 5

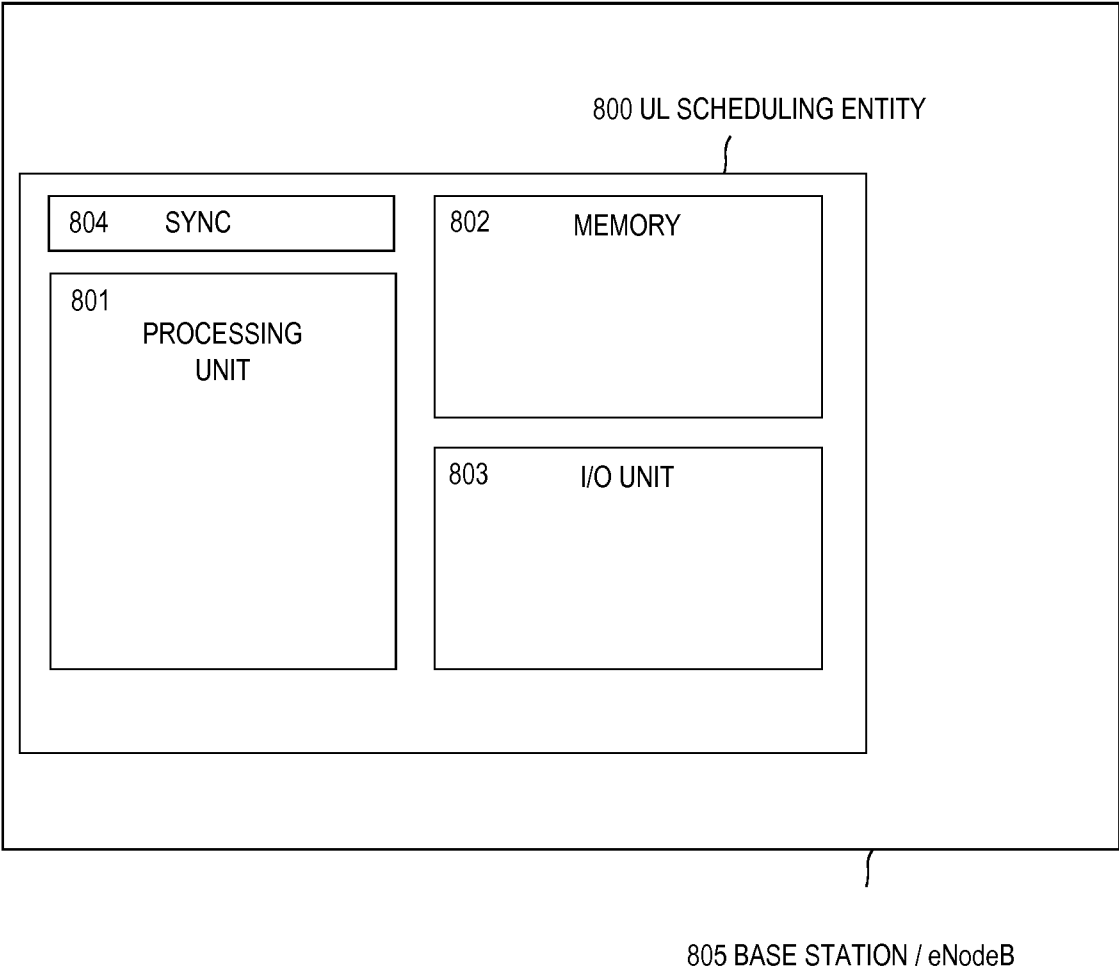


FIG. 17

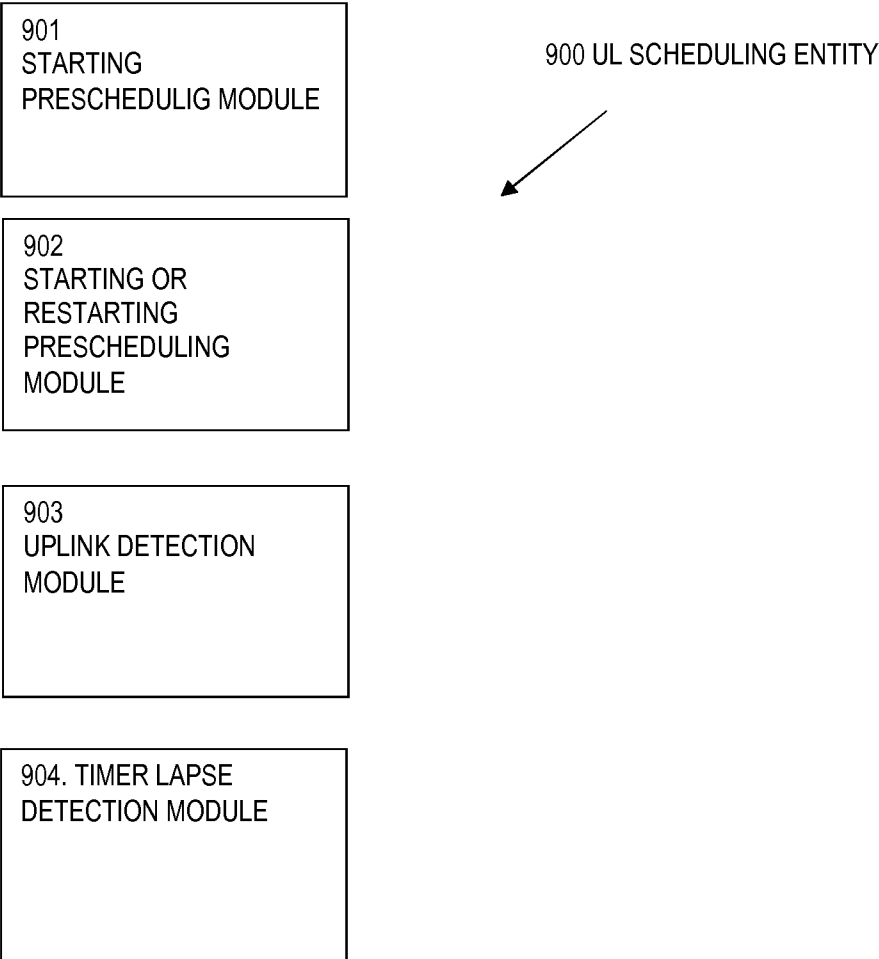


FIG. 18

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/073041

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W72/04

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	ERICSSON ET AL: "Latency improvement comparison", 3GPP DRAFT; R2-094825 (LATENCY IMPROVEMENTS COMPARISON), 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. Shenzhen, China; 20090818, 18 August 2009 (2009-08-18), XP050352833, [retrieved on 2009-08-18] section "4 Pre-allocation" section "5 Conclusions" ----- -/-	1-22



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

9 December 2015

Date of mailing of the international search report

16/12/2015

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Fax: (+31-70) 340-3016

Authorized officer

Puiulet, Alexandru

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/073041

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ERICSSON ET AL: "DRX and IDC gaps for IDC interference avoidance", 3GPP DRAFT; R2-122596 DRX AND MEASUREMENT GAPS FOR IDC INTERFERENCE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Prague, Czech Republic; 20120521 - 20120525, 15 May 2012 (2012-05-15), XP050607338, [retrieved on 2012-05-15] section "2.2.1 SR on PUCCH" section "2.2.2 DRX and CQI reporting" section "2.3.1 Enhancements for DRX" section "2.4 Overall comparison" section "3 Conclusion" -----	1-22
X	US 2014/135027 A1 (KODALI SREE RAM [US] ET AL) 15 May 2014 (2014-05-15) paragraph [0021] - paragraph [0028] paragraph [0055] - paragraph [0063] -----	1-22
X	US 2011/243014 A1 (LEE NEUNG-HYUNG [KR] ET AL) 6 October 2011 (2011-10-06) paragraph [0056] - paragraph [0065] paragraph [0077] - paragraph [0087] -----	1-22

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/073041

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		US 2011243014	A1
			06-10-2011
		US 2014169307	A1
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