



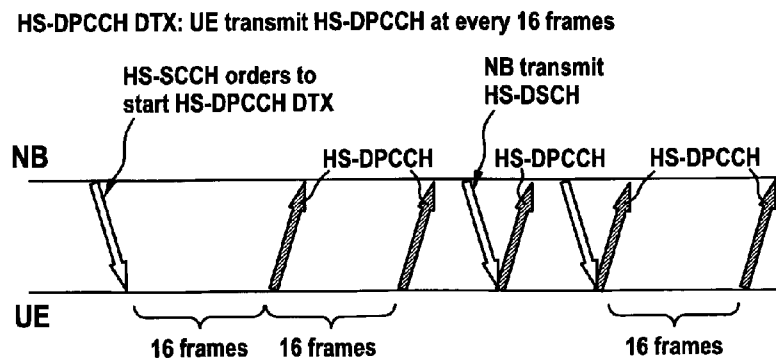
- (51) International Patent Classification:
H04W 24/10 (2009.01)
- (21) International Application Number:
PCT/EP2012/056191
- (22) International Filing Date:
4 April 2012 (04.04.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
1051/DEL/2011 11 April 2011 (11.04.2011) IN
- (71) Applicant (for all designated States except US): **ALCATEL LUCENT** [FR/FR]; 3 avenue Octave Gréard, F-75007 Paris (FR).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **DHINGRA, Vikas** [IN/IN]; Alcatel-lucent India Limited, Nagawara Village, Kasaba Taluk, Outer Ring Road, Bangalore 560045 (IN). **WONG, Shin Horng** [MY/GB]; Alcatel-lucent Telecom Ltd, The Quadrant Stonehill Green, Westlea, Swindon WI SN5 7DJ (GB).
- (74) Agent: **SCIAUX, Edmond**; Alcatel-Lucent International, 32 avenue Kléber, F-92700 Colombes (FR).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— with international search report (Art. 21(3))

(54) Title: POWER SAVING

Fig. 3



(57) Abstract: A method of obtaining an indication of radio condition being experienced by user equipment operating in Cell-FACH or enhanced Cell FACH state in a wireless communication network. A base station and computer program product operable to perform that method. The method comprises the steps of: determining parameters of a feedback cycle according to which said user equipment is operable to periodically transmit an indication of radio condition at said user equipment; transmitting an indication of said feedback cycle parameters to said user equipment; and monitoring for receipt of said periodically transmitted indication of radio condition. It will be appreciated that embodiments provide a possible solution for obtaining radio condition feedback for UE in Enhanced Cell_FACH state without compromising on UE battery savings and reliability of channel quality estimates.

WO 2012/139955 A1

POWER SAVINGFIELD OF THE INVENTION

The present invention relates to a method of obtaining an indication of radio condition,
5 and a computer program product and network node operable to carry out that method.

BACKGROUND

Wireless telecommunications networks are known. In a cellular system, radio coverage
10 is provided by area. Those areas of radio coverage are known as cells. A base station is located in each cell to provide the radio coverage. User equipment in each cell receives information and data from the base station and transmits information and data to the base station.

15 Information and data transmitted by the base station to the user equipment occurs on channels of radio carriers known as downlink carriers. Information and data transmitted by user equipment to the base station occurs on uplink data channels of radio carriers known as uplink carriers.

20 There are various radio states in which user equipment may operate in a UMTS telecommunications network. On initial turning on of user equipment in a cell, it will typically be in "idle mode". Once it synchronises and attaches itself to a base station, it gains a radio resource control (RRC) connection and is referred to as being in connected mode. User equipment in idle mode does not have a Radio Resource
25 Control (RRC) connection.

If user equipment is RRC connected, it can typically be in one of five different RRC states: Cell_DCH, Cell_FACH, Enhanced Cell_FACH, Cell_PCH or URA_PCH.

30 User equipment typically moves into Cell_DCH state when its data traffic is high, since in such a state the user equipment is allocated a dedicated channel on which to transmit and receive data from base station. In UMTS network architecture, user equipment can be in Cell_DCH state, where it is expected to have high volume of data traffic.

35 Allowing user equipment to temporarily send and receive data traffic in a non Cell_DCH state, for example, whilst user equipment is in Cell_FACH or enhanced Cell_FACH states can offer a power saving compared to constant Cell_DCH state use, since no dedicated signalling is required. As a result, user equipment may be able to function with a proportion of down time, rather than being in a dedicated signalling

state and thus is able to use less power. Use of non Cell_DCH states for communication within a communication network can thus offer some power saving but is not without implementation difficulties.

- 5 It is desired to provide a wireless telecommunications network offering improved power efficiency.

SUMMARY

- A first aspect provides a method of obtaining an indication of radio condition being
10 experienced by user equipment operating in Cell-FACH or enhanced Cell FACH state in a wireless communication network, said method comprising the steps of:
determining parameters of a feedback cycle according to which said user equipment is operable to periodically transmit an indication of radio condition at said user equipment;
15 transmitting an indication of said feedback cycle parameters to said user equipment;
and
monitoring for receipt of said periodically transmitted indication of radio condition.

- User equipment may operate in various modes in, for example, a UMTS
20 telecommunications network. On initial turning on of user equipment in a cell, it will typically be in "idle mode". Once it synchronises and attaches itself to a base station, it gains a radio resource control (RRC) connection and is referred to as being in connected mode. User equipment in idle mode does not have a Radio Resource Control (RRC) connection.

- 25 If user equipment is RRC connected, it can be in one of five different RRC states: Cell_DCH, Cell_FACH, Enhanced Cell_FACH, Cell_PCH or URA_PCH states.

- User equipment typically moves into Cell_DCH state when its traffic is high, since in such
30 a state the user equipment is allocated a dedicated channel on which to transmit and receive data from base station. In UMTS network architecture, user equipment can be in Cell_DCH state, where it is expected to have high volume of traffic.

- Historically user equipment operated, when not in Cell_DCH state, using a Random
35 Access Channel (RACH) on the uplink and a base station would operate to communicate with user equipment using a Forward Access Channel (FACH). RACH and FACH had a very small data carrying ability and in W-CDMA or UMTS systems a capability for user equipment and base stations to operate and communicate data traffic therebetween using a shared or common resource on downlink and uplink when

user equipment is in CELL_FACH state has been introduced via Enhanced CELL_FACH and EUL in CELL_FACH. In the uplink the data traffic transmission occurs using an Enhanced Dedicated Channel (EDCH) and in the downlink traffic is sent on a High Speed Downlink Shared Channel (HS-DSCH). Those channels allow user equipment and
5 base stations to communicate and transmit larger data packets between themselves for a time, without the need for user equipment to enter Cell_DCH state. Such an arrangement allows user equipment to remain in the Cell_FACH state longer without transiting to "more dedicated" states, thus allowing a power consumption saving.

10 Furthermore, a HS-DSCH DRX (Discontinuous Receive) capability introduced for use by user equipment in CELL_FACH states allows user equipment to achieve further operational power savings.

The deployment of these enhanced features to the Cell_FACH state can allow "always
15 on" type services, for example, Push to talk over cellular (PoC), Push email and VPN connections, which transmit frequent but small packets between the UE and server, to be supported in CELL_FACH state without the need to enter the CELL_DCH state.

Although enhanced functionality of a Cell_FACH state allows data packets to be sent
20 between a base station and user equipment (and vice versa) whilst the user equipment is in CELL_FACH state, such an arrangement can be wasteful of resources since information which is typically constantly available to a base station in complete dedicated signalling modes, for example, Cell_DCH, is no longer constantly available. As a result, guesses and approximations may be made at a base station to try and
25 ensure communication with user equipment can occur. Thus operation of base station signalling to user equipment is compromised. For example, a base station will typically have access to direct information from user equipment operating in a dedicated signalling mode regarding the radio condition (also known as radio channel propagation conditions) being experienced by that user equipment. Such information
30 regarding radio condition may, for example, comprise Channel Quality Information (CQI) and/or feedback protocol information such as ACK/NACK information. That information can be used by a base station to determine a suitable data packet size to send to user equipment. If user equipment is experiencing good radio condition a large data packet may be sent with a high likelihood of successful receipt. If a poor
35 radio condition is being experienced, a base station may send smaller data packets to that user equipment, to try and ensure the data traffic is successfully received.

In this respect, for user equipment in Cell_FACH or enhanced Cell_FACH states an uplink HS-DPCCH (High Speed Dedicated Physical Control Channel) feedback channel is

critical to support efficient downlink transmission on the HS channels. In the absence of radio condition indicators, such as, for example, Channel Quality Information (CQI) and/or downlink ACK/NACK information carried over an HS-DPCCH channel, blind retransmissions by a base station on a High Speed Downlink Packet Access (HSDPA) channel can lead to significant loss in HSDPA throughput and highly inefficient utilization of available HSDPA resources.

The first aspect recognizes that a method which allows discontinuous HS-DPCCH transmission, offers an indication of radio condition experienced by a UE, by allowing a discontinuous, or periodic discontinuous feedback cycle to occur during periods of DL HSDPA inactivity. In other words, while there is no data traffic to be sent from a base station to UE, the UE is nonetheless operable to continue offering the base station an indication of radio condition being experienced, that feedback being periodically sent to the base station from user equipment. Furthermore, feedback continues to be sent by user equipment, even if there is no data traffic to be sent by the user equipment to the base station. According to embodiments, a UE is instructed by a base station to transmit HS-DPCCH (CQI) based on specific discontinuous cycles, for example, specific timing slots for transmission of UL HS-DPCCH may be communicated to UE by a base station (NodeB) in conjunction with an RNC as appropriate, alternatively a period between transmissions may be specified to UE by a base station in conjunction with an RNC. In some embodiments, user equipment is also operable to send non-discontinuous feedback when there is data traffic in the uplink. Accordingly, a base station can ensure that some recent relevant indication of radio condition experienced by UE to better estimate a suitable manner in which to send a downlink data packet.

In one embodiment, said parameters comprise an indication of period between adjacent transmissions of indication of radio condition. Accordingly, said parameters indicate how frequently radio condition feedback might be required by the network and may be set in accordance with a variety of UE environment conditions. In one embodiment, said step of determining comprises a step of collating information regarding whether said user equipment is operating on a fast or slow channel and determining at least one of said feedback channel parameters in dependence upon said channel speed. The parameters may include information relating to the nature of the periodic radio condition feedback reporting cycles. For example, a fast channel will require frequent updates of CQI compared to a slower channel and hence, controlling the nature of an implemented periodic radio condition feedback regime allows a base station to control the frequency of CQI updates.

In one embodiment, said parameters comprise an indication of an upper limit in respect of said indication of period between adjacent transmissions of indication of radio condition. It will be appreciated that if the radio condition feedback, for example, a CQI update, is too infrequent, the previous radio condition indication, for example, CQI update, from the feedback messaging, (HS-DPCCH transmission when UE last woke up) will typically no longer represent the radio conditions when a data packet transmission is to be made on the downlink channel. It is possible that the previous CQI update may give an optimistic condition of the radio channel leading to a high HS-DSCH transport block being sent to a UE resulting in error. According to some embodiments, the threshold value can be set by the base station or RNC based upon, for example, last known UE speed (i.e. Doppler). In one embodiment, said upper limit is determined in dependence upon an indication of speed of physical movement of said user equipment.

In one embodiment, said indication of said feedback cycle parameters is addressed to a group of user equipment. Transmission of HS-DPCCH can, in some embodiments, be tied to a UE unique identifier, such as, for example, a H-RNTI, or a group identifier such as, for example, a group H-RNTI. Such embodiments can ensure that radio condition feedback messages within a cell are spread to avoid unnecessary peaks in signaling traffic. Such spreading is achieved by addressing instructions to operate in a periodic feedback mode appropriately to one, or more than one UE, as is already achieved in a similar manner to cycles used in CPC and Paging Occasion. Such embodiments aim to avoid simultaneous transmissions of HS-DPCCH amongst all UE in a cell.

A second aspect provides a computer program product operable, when executed on a computer, to perform the method of the first aspect.

A third aspect provides a base station operable to obtain an indication of radio condition being experienced by user equipment operating in Cell-FACH or enhanced Cell FACH state in a wireless communication network, said base station comprising:

- determination logic operable to determine parameters of a feedback cycle according to which said user equipment is operable to periodically transmit an indication of radio condition at said user equipment;
- transmission logic operable to transmit an indication of said feedback cycle parameters to said user equipment; and
- monitoring logic operable to monitor for receipt of said periodically transmitted indication of radio condition.

In one embodiment, said parameters comprise an indication of period between adjacent transmissions of indication of radio condition.

5 In one embodiment, said determination logic is operable to collate information regarding whether said user equipment is operating on a fast or slow channel and determining at least one of said feedback channel parameters in dependence upon said channel speed.

10 In one embodiment, said parameters comprise an indication of an upper limit in respect of said indication of period between adjacent transmissions of indication of radio condition.

In one embodiment, said upper limit is determined in dependence upon an indication of speed of physical movement of said user equipment.

15

In one embodiment, said indication of said feedback cycle parameters is addressed to a group of user equipment.

20 A fourth aspect provides a method of transmitting an indication of radio condition being experienced by user equipment operating in Cell_FACH or enhanced Cell_FACH state in a wireless communication network, said method comprising the steps of:
monitoring for receipt of an indication of feedback cycle parameters; and
periodically transmitting an indication of radio condition being experienced by said user equipment in accordance with said received indication of feedback cycle
25 parameters.

Accordingly, user equipment may be operable to periodically transmit an indication of radio condition being experienced to a base station. That indication may be sent periodically and the frequency of such a transmission is determined in accordance with
30 parameters set by a wireless communication network.

In one embodiment, the method comprises the step of monitoring for receipt of downlink data traffic and, if downlink data traffic is received, implementing transmission of an indication of radio condition in each radio frame whilst said downlink data traffic
35 is received. Accordingly, in addition to periodically transmitting feedback information, such that downlink traffic may be sent with some degree of efficiency at any point, such a method allows for specific and targeted updates of radio condition information to be sent within a network when may be most desirable, ie when there is downlink

traffic, thus ensuring specific and targeted information reaches a base station to allow downlink data traffic messages to be sent efficiently.

5 In one embodiment, the method comprises the step of determining that there is uplink data traffic to be transmitted and implementing transmission of an indication of radio condition in each radio frame whilst said uplink data traffic is transmitted. Accordingly, in addition to periodically transmitting feedback information, such that downlink traffic may be sent with some degree of efficiency at any point, such a method allows for specific and targeted updates of radio condition information to be sent within a
10 network when user equipment may already be active and transmitting messages and/or data within the network, thus ensuring specific and targeted information reaches a base station to allow downlink data traffic messages to be sent efficiently.

In one embodiment, the method comprises the step of determining whether said user
15 equipment is operating in a discontinuous reception mode and adjusting said feedback cycle within said feedback parameters to fit within operational parameters of said discontinuous reception mode.

20 Currently, a UE in CELL_FACH with low traffic activity will move into DRX to save battery power. Although it is possible for such UE to continue to transmit periodic radio condition feedback reporting cycles, for example, HS-DPCCH DTX (based on its preset cycle) during full DRX, such an arrangement may reduce the amount of battery power that can be saved in DRX.

25 Accordingly, in some embodiments, the periodic radio condition feedback reporting cycles, for example, HS-DPCCH DTX, is a function of the UE DRX in CELL_FACH. In some embodiments, if the periodic radio condition feedback reporting is longer than that of the UE DRX cycle, then the UE is operable to maintain its discontinuous feedback cycle activity. The DTX and reporting radio condition cycles can be synched such that a UE
30 need only wake up once to listen for possible receptions and to transmit radio condition feedback information, for example, HS-DPCCH. (NOTE: depending on the DTX cycle, the UE may not transmit HS-DPCCH at certain wake up periods). Accordingly, in some embodiments, a UE DRX cycle is not disrupted by periodic feedback cycle transmissions. Since the periodic radio condition feedback reporting cycle, for
35 example, HS-DPCCH DTX cycle is maintained, such embodiments can ensure provision of an acceptable radio condition indicator, for example, CQI update, for efficient base station and network operation. In some embodiments, a UE or base station may be operable to can shorten a periodic radio condition feedback reporting cycle, for

example, HS-DPCCH DTX, such that it transmits radio condition feedback at every wake up period during DRX.

5 It will be appreciated that in some embodiments is not necessary to ensure periodic radio condition feedback reporting cycles, for example, HS-DPCCH DTX, and UE DRX cycles are always synchronised. Accordingly, in some embodiments, it is allowed to have asynchronous cycles. However, as mentioned above, such arrangements may not offer a best optimized solution from a UE battery savings perspective.

10 In some embodiments, if the periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX cycle, is shorter than the UE DRX cycle, a UE may be operable to either stop its feedback activity or move into use of a longer periodic radio condition feedback cycle, depending on the UE DRX cycle.

15 In some embodiments, a UE periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX and DRX cycle, is such that it must be in sync with a UE DRX cycle and therefore in the scenario where the feedback cycle is shorter than DRX cycle, a UE may only transmit radio condition feedback information when it wakes up during its DRX cycle. This effectively causes the UE to move into a longer HS-DPCCH DTX
20 cycle.

In some embodiments, a UE may stop periodic radio condition feedback activity completely, for example, if a UE DRX cycle is determined to be longer than a predetermined threshold. It will be appreciated that if the radio condition feedback, for
25 example, a CQI update, is too infrequent, the previous radio condition indication, for example, CQI update, from the feedback messaging, (HS-DPCCH transmission when UE last woke up) will typically no longer represent the radio conditions when a data packet transmission is to be made on the downlink channel. It is possible that the previous CQI update may give an optimistic condition of the radio channel leading to
30 a high HS-DSCH transport block being sent to a UE resulting in error. According to some embodiments, the threshold value can be set by the base station or RNC based upon, for example, last known UE speed (i.e. Doppler).

In some embodiments, a UE can be operable to resume a periodic radio condition
35 feedback reporting cycle, for example, HS-DPCCH DTX, when it exits a DRX mode. That is to say, a UE may be operable to use a periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX cycle, before it moves into DRX and, on exiting DRX may revert to that feedback reporting cycle. NOTE: In some embodiments, if a UE exits DRX due to a HS-DSCH (i.e. downlink) reception, it may transmit radio condition

feedback continuously. In some embodiments, if a UE exits DRX due to an E-DCH (i.e. uplink) transmission, then it may continue with the original periodic radio condition feedback cycle.

5 In one embodiment, said indication of radio condition is measured and transmitted more than once at each transmission of said feedback cycle.

In some embodiments, when UE transmits a radio condition feedback indicator on, for example, HS-DPCCH, in accordance with a periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX, it may be operable to transmit a radio
10 condition feedback indicator, for example, CQI, for more than one sub-frame. Such an arrangement may allow a base station to perform averaging over few radio condition indicators (eg CQI values) during each feedback burst and thus obtain a more reliable non-instantaneous estimate of radio channel conditions being experienced by UE.

15 A fifth aspect provides a computer program product, operable, when executed on a computer, to perform the method of the fourth aspect.

A sixth aspect provides user equipment operable to transmit an indication of radio condition being experienced by said user equipment operating in Cell-FACH or
20 enhanced Cell FACH state in a wireless communication network, said user equipment comprising:

monitoring logic operable to monitor for receipt of an indication of feedback cycle parameters; and

25 transmission logic operable to periodically transmit an indication of radio condition being experienced by said user equipment in accordance with said received indication of feedback cycle parameters.

In one embodiment, said monitoring logic is operable to monitor for receipt of downlink data traffic and, if downlink data traffic is received, said transmission logic is operable
30 to implement transmission of an indication of radio condition in each radio frame whilst said downlink data traffic is received.

In one embodiment, said user equipment further comprises determination logic operable to determine that there is uplink data traffic to be transmitted and said
35 transmission logic is further operable to implement transmission of an indication of radio condition in each radio frame whilst said uplink data traffic is transmitted.

In one embodiment, said user equipment further comprises determination logic operable to determine whether said user equipment is operating in a discontinuous

reception mode and adjustment logic operable to adjust said feedback cycle within said feedback parameters to fit within operational parameters of said discontinuous reception mode.

- 5 In one embodiment, wherein said indication of radio condition is measured and transmitted more than once at each transmission of said feedback cycle.

Further particular and preferred aspects are set out in the accompanying independent and dependent claims. Features of the dependent claims may be combined with
10 features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described further, with reference to
15 the accompanying drawings, in which:

Figure 1 illustrates the main components of a wireless telecommunications network according to one embodiment;

Figure 2 illustrates a set of radio resource control states of user equipment suitable for use in the wireless telecommunications network of Figure 1; and

- 20 Figures 3 to 7 illustrate schematically various example implementations of radio condition enquiry methods for use in the wireless telecommunications network of Figure 1.

DESCRIPTION OF THE EMBODIMENTS

25 Figure 1 illustrates schematically the main components of a wireless telecommunications system 10 according to one embodiment. User equipment 50 roam through the wireless telecommunications system. Base stations 20 are provided which support areas of radio coverage 30. A number of such base stations 20 are provides and distributed geographically in order to provide a wide area of coverage to
30 user equipment 50. When user equipment is within an area served by a base station 30, communications may be established between the user equipment and the base station over associated radio links. Each base station typically supports a number of sectors within the geographical area of service 30.

35 Typically a different antenna within a base station supports each associated sector. Each base station 20 has multiple antennas. It will be appreciated that Figure 1 illustrates a small subset of a total number of user equipment and base stations that may be present in a typically communications system.

The wireless communications system is managed by a radio network controller (RNC) 40. The radio network controller 40 controls operation of the wireless telecommunications system by communicating with a plurality of base stations over a backhaul communications link 60. The RNC also communicates with user equipment 50 via each base station and thus effectively manages a region of the entire wireless communications system.

User equipment communicates with base station 20 by transmitting data and information on channels known as "uplink" or "reverse" channels, and base station 20 communicates with user equipment 50 by transmitting data and information on radio channels known as "downlink" or "forward" channels.

In addition to "continuously on" operation, user equipment 50 may operate in a "discontinuous reception" (DRx) or "discontinuous transmission" (DTx) mode. Such modes allow user equipment 50 to save battery power when the UE is in an inactive period (for example, when user equipment is in an idle state).

During discontinuous reception user equipment 50 shuts down its reception antenna and periodically wakes up to receive possible data traffic and information, for example, paging messages, from wireless telecommunications network 10 via data sent on downlink channels to user equipment 50 from base station 20. If the messages received by user equipment 50 in the wake-up periods are deemed to exceed a threshold, or indicate that base station 20 wishes to send more information to user equipment 50, user equipment is operable to exit from the discontinuous reception mode.

Similarly, a discontinuous transmission (DTx) mode may be implemented by user equipment. In such a case, when in a substantially idle mode, user equipment shuts down its transmitter and only wakes up periodically to transmit packets of data to the network 10 via uplink channels to the base station 20.

In order to synchronise operation of user equipment 50 in a cell 30 served by a base station 20, the base station 20 has its own reference time frames, and indicates the system time frames to user equipment when they first connect. The reference time frames are not correlated between base stations. The reference time frames in known wireless telecommunications systems, for example, UMTS and LTE architecture systems, is achieved by use of a system frame number. A system frame number (SFN) is used to identify the framing and timing of a cell served by a base station. System frame number cycles through a range of values from 0 to 4095 in UMTS and 0 to 1023 in LTE.

DTx and DRx cycles can be specified by reference to a SFN. Use of SFN to control discontinuous transmission or reception cycles maximum cycle length of 4096 radio frames. Since one radio frame lasts 10ms, this means that the maximum cycle length
5 for a UMTS network is 40.96 seconds.

By way of background, Figure 2 illustrates schematically various radio states in which user equipment 50 may operate in a UMTS telecommunications network. On initial turning on of user equipment in a cell 30, it will typically be in "idle mode" 100. Once it
10 synchronises and attaches itself to a base station 20, it gains a radio resource control (RRC) connection and is referred to as being in connected mode 200. User equipment in idle mode does not have a Radio Resource Control (RRC) connection.

If user equipment is RRC connected 200, it can be in one of five different RRC states:
15 Cell_DCH (201), Cell_FACH (202), Enhanced Cell_FACH (203), Cell_PCH (204) and URA_PCH (205) states.

User equipment typically moves into Cell_DCH (201) state when its traffic is high, since in such a state the user equipment is allocated a dedicated channel on which to transmit
20 and receive data from base station 20. In UMTS network architecture, user equipment can be in Cell_DCH state, where it is expected to have high volume of traffic.

Historically user equipment operated, when not in Cell_DCH state, using a Random Access Channel (RACH) on the uplink and a base station would operate to
25 communicate with user equipment using a Forward Access Channel (FACH). RACH and FACH had a very small data carrying ability and in W-CDMA or UMTS systems a capability for user equipment and base stations to operate and communicate data traffic therebetween using a shared or common resource on downlink and uplink when user equipment is in CELL_FACH state has been introduced via Enhanced CELL_FACH
30 and EUL in CELL_FACH. In the uplink the data traffic transmission occurs using an Enhanced Dedicated Channel (EDCH) and in the downlink traffic is sent on a High Speed Downlink Shared Channel (HS-DSCH). Those channels allow user equipment and base stations to communicate and transmit larger data packets between themselves for a time, without the need for user equipment to enter Cell_DCH state. Such an
35 arrangement allows user equipment to remain in the Cell_FACH state longer without transiting to "more dedicated" states, thus allowing a power consumption saving.

Furthermore, a HS-DSCH DRX (Discontinuous Receive) capability introduced for use by user equipment in CELL_FACH states allows user equipment to achieve further operational power savings.

- 5 The deployment of these enhanced features to the Cell_FACH state can allow "always on" type services, for example, Push to talk over cellular (PoC), Push email and VPN connections, which transmit frequent but small packets between the UE and server, to be supported in CELL_FACH state without the need to enter the CELL_DCH state.
- 10 Although enhanced functionality of a Cell_FACH state allows data packets to be sent between a base station and user equipment (and vice versa) whilst the user equipment is in CELL_FACH state, such an arrangement can be wasteful of resources since information which is typically constantly available to a base station in complete dedicated signalling modes, for example, Cell_DCH, is no longer constantly available.
- 15 As a result, guesses and approximations may be made at a base station to try and ensure communication with user equipment can occur. Thus operation of base station signalling to user equipment is compromised. For example, a base station will typically have access to direct information from user equipment operating in a dedicated signalling mode regarding the radio condition (also known as radio channel
- 20 propagation conditions) being experienced by that user equipment. Such information regarding radio condition may, for example, comprise Channel Quality Information (CQI) and/or feedback protocol information such as ACK/NACK information. That information can be used by a base station to determine a suitable data packet size to send to user equipment. If user equipment is experiencing good radio condition a
- 25 large data packet may be sent with a high likelihood of successful receipt. If a poor radio condition is being experienced, a base station may send smaller data packets to that user equipment, to try and ensure the data traffic is successfully received.

In this respect, for user equipment in Cell_FACH or enhanced Cell_FACH states an uplink

30 HS-DPCCH (High Speed Dedicated Physical Control Channel) feedback channel is critical to support efficient downlink transmission on the HS channels. In the absence of radio condition indicators, such as, for example, Channel Quality Information (CQI) and/or downlink ACK/NACK information carried over an HS-DPCCH channel, blind retransmissions by a base station on a High Speed Downlink Packet Access (HSDPA)

35 channel can lead to significant loss in HSDPA throughput and highly inefficient utilization of available HSDPA resources.

Transmission of HS-DPCCH is possible in CELL_FACH in an opportunistic manner, such that radio condition information is sent to a base station only when a UE has data to

send on the E-DCH (Enhanced Dedicated Channel). That is to say, it is possible to implement a system whereby radio condition feedback information is only sent to a base station when there is a data packet to be sent on the uplink. It will be appreciated that such a system may mean that in most cases, when an HS-DPCCH is sent, there may be no downlink data to send from a base station back to user equipment. In such a case, it will be appreciated that the radio condition feedback information (or HS-DPCCH) can be of little or no use. Furthermore if a DL transmission on a HS channel does not overlap with an UL transmission on E-DCH, the HS transmissions will typically occur happen via blind retransmissions in the absence of any ACK/NACK or CQI information.

It is possible to remove a dependence of a HS-DPCCH transmission (feedback information) from uplink data packet transmission on the E-DCH. Some arrangements which remove that dependence assume a continuous HS-DPCCH transmission by UE, that is to say transmission every TTI of a feedback message, whilst a UE is in Enhanced Cell_FACH state. It will be appreciated that such a system results in radio condition feedback, for example, CQI and ACK/NACK transmission where there is downlink HSDPA transmissions to be made, but also such feedback transmission by UE when there is no downlink HSDPA transmission. Such an arrangement is similar to a typical feedback scheme followed by UE operating according to 3GPP in a Cell_DCH state.

However, a clear drawback of such a scheme is that it is not efficient from UE battery power saving perspective. Since a UE would be expected to continuously transmit HS-DPCCH (CQI) even during periods in which there is no DL transmission, and UE may be unable to go enter Discontinuous Transmit or Receive (DTX/DRX) states which allow a battery power saving.

Proposals to transmit HS-DPCCH (radio condition feedback) completely independently of UL E-DCH transmission for Enhanced Cell_FACH tend to solve problems related to inefficient utilization of HSDPA resources and loss in HSDPA throughput but as a result of continuous transmission of HS-DPCCH even during periods of DL inactivity, they can be taxing in terms of UE Battery consumption.

A further proposed scheme uses High Speed Shared Control Channel (HS-SCCH) orders sent by a base station to instruct a UE to start HS-DPCCH transmissions as and when required by a NodeB (base station). Such a scheme may have drawbacks: There will be a delay between HS-SCCH order and start of HSDPA transmission for actual payload because a NodeB will typically need to average few CQI values, or other indicators of radio condition experienced by a UE, in order to have sufficient estimate of radio

channel quality at the UE before commencing actual HSDPA transmission. Before starting actual HSDPA transmission, a NodeB sends an HS-SCCH order to UE instructing that the UE starts HS-DPCCH (CQI) transmission. The UE commences feedback transmissions and the base station waits to receive a predetermined number of
5 feedback CQI values. The base station averages the CQI feedback values to obtain an estimate of DL channel quality. A data packet is then sent (a DL HSDPA transmission), based upon the estimated channel quality.

According to such a method, an HS-SCCH order will start a continuous transmission of
10 HS-DPCCH at the UE, that is to say a feedback transmission every TTI. Given the bursty nature of expected traffic in CELL_FACH, to save UE battery power and avoid excessive transmission of HS-DPCCH, additional orders may be required to stop HS-DPCCH transmission at a UE after DL data transmission. As increasing numbers of UE operate in Enhanced Cell_FACH state (given the suitability of CELL_FACH to handle bursty traffic)
15 such a method may require a large number of HS-SCCH orders to be sent by a base station (e.g. before and after a burst of data) for user equipment within its coverage area. Each HS-SCCH order a base station transmits consumes a proportion of available DL cell power. That cell power is limited. Furthermore, each UE being sent an HS-SCCH order occupies one HS-SCCH physical channel. Those channels are shared across all
20 UE in a cell and thus are a limited resource. Use of HS-SCCH orders to start and stop radio condition feedback according to some methods thus offers limited scalability of operation. Since there is no UL feedback for the transmission of HS-SCCH orders, such methods may also result in blind re-transmissions of HS-SCCH orders in order to guarantee reliable reception by UE.

25 Described embodiments operate to allow discontinuous HS-DPCCH transmission, offering an indication of radio condition experienced by a UE, that discontinuous, or periodic discontinuous feedback occurring during periods of DL HSDPA inactivity. In other words, while there is no data traffic to be sent from a base station to UE, the UE is
30 nonetheless operable to continue offering the base station an indication of radio condition being experienced, that feedback being periodically sent to the base station from user equipment. Furthermore, feedback continues to be sent by user equipment, even if there is no data traffic to be sent by the user equipment to the base station. According to embodiments, a UE is instructed by a base station to transmit HS-DPCCH
35 (CQI) based on specific discontinuous cycles, for example, specific timing slots for transmission of UL HS-DPCCH may be communicated to UE by a base station (NodeB) in conjunction with an RNC as appropriate, alternatively a period between transmissions may be specified to UE by a base station in conjunction with an RNC. In some embodiments, user equipment is also operable to send non-discontinuous feedback

when there is data traffic in the uplink. Accordingly, a base station can ensure that some recent relevant indication of radio condition experienced by UE to better estimate a suitable manner in which to send a downlink data packet.

- 5 Embodiments may allow UE to operate in a complete DTX/DRX state, thus ensuring further power saving. The DTX/DRX mode may be implemented in some embodiments such that a UE is able to operate in such discontinuous modes except when it has to transmit HS-DPCCH (or radio condition feedback). In some embodiments, HS-DPCCH periodic feedback cycles can be controlled by the network to offer a balance
10 between UE battery savings and reliability of channel quality feedback maintained at a NodeB.

Transmission of HS-DPCCH can, in some embodiments, be tied to a UE unique identifier, such as, for example, a H-RNTI, or a group identifier such as, for example, a group H-
15 RNTI. Such embodiments can ensure that radio condition feedback messages within a cell are spread to avoid unnecessary peaks in signaling traffic. Such spreading is achieved by addressing instructions to operate in a periodic feedback mode appropriately to one, or more than one UE, as is already achieved in a similar manner to cycles used in CPC and Paging Occasion. Such embodiments aim to avoid
20 simultaneous transmissions of HS-DPCCH amongst all UE in a cell.

In some embodiments, an inactivity timer after a burst of HS-DSCH can be set by an order or instruction originating at a base station or RNC or may be set by the UE itself. Such an inactivity timer may be set so that operation of the UE is such that when the
25 timer expires, and no further downlink data traffic is received during the inactivity period, radio condition feedback (HS-DPCCH) is then transmitted in a discontinuous, periodic cycle to a base station. In some embodiments such an inactivity timer may be set so that operation of the UE is such that when the timer expires, and no further uplink data traffic is transmitted during the inactivity period, radio condition feedback (HS-
30 DPCCH) is then transmitted in a discontinuous, periodic cycle to a base station

In some such embodiments, when a UE is already performing periodic feedback reporting cycles, the transmission of radio condition feedback, HS-DPCCH, due to such operation shall not be counted as activity within the period. Otherwise, UE may never
35 move into a periodic feedback reporting scheme.

In some embodiments, periodic radio condition feedback reporting cycles, for example, HS-DPCCH DTX, can be activated and deactivated using a HS-SCCH group

order transmitted by a base station. In embodiments, use of an HS-SCCH order differs to the method described above in that:

- 1) The order instructs commencement of a periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX, and does not result in continuous transmission by a UE of radio condition feedback messages, for example, HS-DPCCH.
- 2) The order is transmitted to a group of UE (using common H-RNTI in CELL_FACH) instead of specific UE. NOTE: This does not preclude an order to one specific UE.
- 3) The order necessarily includes information relating to the nature of the periodic radio condition feedback reporting cycles. Note: A fast channel will require frequent updates of CQI compared to a slower channel and hence, controlling the nature of an implemented periodic radio condition feedback regime allows a base station to control the frequency of CQI updates.
- 4) The HS-SCCH order can start the periodic radio condition feedback reporting cycles, for example, HS-DPCCH DTX, for example, HS-DPCCH DTX process, immediately, or start it after an inactivity timer (as described above).

Currently, a UE in CELL_FACH with low traffic activity will move into DRX to save battery power. Although it is possible for such UE to continue to transmit periodic radio condition feedback reporting cycles, for example, HS-DPCCH DTX (based on its preset cycle) during full DRX, such an arrangement may reduce the amount of battery power that can be saved in DRX.

Accordingly, in some embodiments, the periodic radio condition feedback reporting cycles, for example, HS-DPCCH DTX, is a function of the UE DRX in CELL_FACH. In some embodiments, if the periodic radio condition feedback reporting is longer than that of the UE DRX cycle, then the UE is operable to maintain its discontinuous feedback cycle activity. The DTX and reporting radio condition cycles can be synched such that a UE need only wake up once to listen for possible receptions and to transmit radio condition feedback information, for example, HS-DPCCH. (NOTE: depending on the DTX cycle, the UE may not transmit HS-DPCCH at certain wake up periods). Accordingly, in some embodiments, a UE DRX cycle is not disrupted by periodic feedback cycle transmissions. Since the periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX cycle is maintained, such embodiments can ensure provision of an acceptable radio condition indicator, for example, CQI update, for efficient base station and network operation. In some embodiments, a UE or base station may be operable to shorten a periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX, such that it transmits radio condition feedback at every wake up period during DRX.

It will be appreciated that in some embodiments is not necessary to ensure periodic radio condition feedback reporting cycles, for example, HS-DPCCH DTX, and UE DRX cycles are always synchronised. Accordingly, in some embodiments, it is allowed to have asynchronous cycles. However, as mentioned above, such arrangements may not offer a best optimized solution from a UE battery savings perspective.

In some embodiments, if the periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX cycle, is shorter than the UE DRX cycle, a UE may be operable to either stop its feedback activity or move into use of a longer periodic radio condition feedback cycle, depending on the UE DRX cycle.

In some embodiments, a UE periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX and DRX cycle, is such that it must be in sync with a UE DRX cycle and therefore in the scenario where the feedback cycle is shorter than DRX cycle, a UE may only transmit radio condition feedback information when it wakes up during its DRX cycle. This effectively causes the UE to move into a longer HS-DPCCH DTX cycle.

In some embodiments, a UE may stop periodic radio condition feedback activity completely, for example, if a UE DRX cycle is determined to be longer than a predetermined threshold. It will be appreciated that if the radio condition feedback, for example, a CQI update, is too infrequent, the previous radio condition indication, for example, CQI update, from the feedback messaging, (HS-DPCCH transmission when UE last woke up) will typically no longer represent the radio conditions when a data packet transmission is to be made on the downlink channel. It is possible that the previous CQI update may give an optimistic condition of the radio channel leading to a high HS-DSCH transport block being sent to a UE resulting in error. According to some embodiments, the threshold value can be set by the base station or RNC based upon, for example, last known UE speed (i.e. Doppler).

In some embodiments, a UE can be operable to resume a periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX, when it exits a DRX mode. That is to say, a UE may be operable to use a periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX cycle, before it moves into DRX and, on exiting DRX may revert to that feedback reporting cycle. NOTE: In some embodiments, if a UE exits DRX due to a HS-DSCH (i.e. downlink) reception, it may transmit radio condition feedback continuously. In some embodiments, if a UE exits DRX due to an E-DCH (i.e.

uplink) transmission, then it may continue with the original periodic radio condition feedback cycle.

5 In some embodiments, when UE transmits a radio condition feedback indicator on, for example, HS-DPCCH, in accordance with a periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX, it may be operable to transmit a radio condition feedback indicator, for example, CQI, for more than one sub-frame. Such an arrangement may allow a base station to perform averaging over few radio condition indicators (eg CQI values) during each feedback burst and thus obtain a more reliable
10 non-instantaneous estimate of radio channel conditions being experienced by UE.

Summary

- 1) A periodic radio condition feedback reporting cycle, for example, HS-DPCCH DTX, is defined for UE operating in a CELL_FACH state, with a periodic feedback
15 cycle defined by the network. Different UE can have different cycles.
- 2) UE may moves into a periodic radio condition feedback reporting cycle after an inactivity timer (for example, no HS-DSCH transmissions)
- 3) UE may move into a periodic radio condition feedback reporting cycle when signalled by the network (for example, by using a HS-SCCH order or HS-SCCH
20 group order)
- 4) Radio condition feedback messages themselves may not be counted as activity when determining the inactivity timer. (NOTE: Different inactivity timers may be used for implementation of periodic feedback cycles and UE DRX operation, there is no requirement for those inactivity timers to be identical)
- 25 5) The network can be operable to signal to a UE to stop periodic radio condition feedback(for example, via HS-SCCH order)
- 6) A periodic radio condition feedback reporting cycle can be asynchronous to that of DRX at a UE
- 7) A periodic radio condition feedback reporting cycle can be sync with DRX at a
30 UE
- 8) When UE moves into DRX and if an implemented periodic radio condition feedback reporting cycle is longer or equal to that of the DRX cycle, the UE can sync its periodic radio condition feedback reporting cycle with DRX and maintain (or shorten) its periodic radio condition feedback reporting cycle
- 35 9) When a UE moves into DRX and if its periodic radio condition feedback reporting cycle is shorter than that of the DRX cycle, the UE can sync its periodic radio condition feedback reporting cycle with DRX and extend its periodic radio condition feedback reporting cycle

- 10) When a UE moves into DRX and if its periodic radio condition feedback reporting cycle is shorter than that of the DRX cycle and the DRX cycle is longer than a predetermined threshold, if the UE needs to sync its periodic radio condition feedback reporting cycle and DRX cycle, the UE will stop its periodic radio condition feedback. This threshold can be determined by the network.
- 11) The UE may resume its original periodic radio condition feedback reporting cycle when it exits a DRX state
- 12) A UE can transmit more than one radio condition feedback indicator during each transmission period in its DTX cycle to allow the network to have an average of radio condition being experienced by the UE.

Example 1

In this example the network configures the following:

- 1) HS-DPCCH DTX cycle of 16 radio frames (i.e. UE transmit a HS-DPCCH every 160 ms)
- 2) DRX cycle of 8 radio frames (i.e. when UE moves into DRX, it wakes up every 80 ms to listen for reception)
- 3) Inactivity time to move into DRX of 100 ms

The NB signals periodic radio condition feedback reporting cycle parameters to a UE, for example, via a HS-SCCH order (or group order) or through appropriate Layer3 signalling. In accordance with the instruction, the UE sends CQI updates via HS-DPCCH transmissions every 16 frames as shown in Figure 3. After two HS-DPCCH receptions, the NB sends a HS-DSCH packet to the UE. In this example, the NB can use the information obtained from the CQI sent from the UE in the 2 HS-DPCCH. On receiving a HS-DSCH, the UE is also operable to send a HS-DPCCH. When the NB stops sending HS-DSCH, the UE is operable to resume its periodic feedback activity and reverts to operation in which it sends an update after every 16 radio frames.

If there is no UE or network activity for 100 ms and the UE moves into DRX. NOTE: The HS-DPCCH DTX is not counted as activity, otherwise, the UE will never move into DRX. The DRX and HS-DPCCH DTX activities are as shown in Figure 4. The HS-DPCCH is sent only when the UE wakes up from DRX, that is the HS-DPCCH DTX is now synced with that of the DRX. In the example shown, the last HS-DPCCH DTX cycle is broken, such that instead of transmitting 16 ms after the last HS-DPCCH transmission prior to the start of DRX, the UE transmits at 16 frames after the start of DRX. The update rate of CQI is then not affected, (i.e. CQI update at every 16 frames is maintained).

If UTRAN has configured UE to send CQI for two (or more) sub-frames during each CQI burst, UE will transmit HS-DPCCH accordingly thereby allowing NodeB to have average estimate of radio channel conditions. This is as shown in Figure 5 in which a UE as shown
5 is operable to transmit two consecutive HS-DPCCHs when it wakes up.

NOTE: The HS-DPCCH DTX can be made to be in-sync with the DRX cycle by using the same UE ID (e.g. H-RNTI) to calculate the wake up time (but with different cycle length).

10 **Example 2**

In this example the network configures the following:

- 1) HS-DPCCH DTX cycle of 16 radio frames (i.e. UE transmit a HS-DPCCH every 160
ms)
- 15 2) DRX cycle of 32 radio frames
- 3) Inactivity time to move into DRX of 100 ms
- 4) A 2nd inactivity time of 500 ms in which the UE moves into an extended DRX
- 5) Extended DRX cycle of 128 frames
- 6) A maximum CQI update period threshold of 400 ms (i.e. CQI update that are
20 spaced more than 400 ms apart is not acceptable)

As in Example 1, the NB starts off the HS-DPCCH DTX with a DTX cycle of 16 frames as shown in Figure 3. After an inactivity timer, the UE moves into DRX as shown in Figure 6, in which the UE wakes up every 32 frames to listen for possible reception. To minimize
25 the UE wake up time to transmit and/or received (and maximize battery savings), the UE is operable to sync its HS-DPCCH DTX cycle with that of the DRX and thus only transmits a HS-DPCCH whenever the UE wakes up from the DRX cycle. In this illustrated embodiment, the UE HS-DPCCH DTX cycle is increased from 16 frames to 32 frames.
NOTE: The UE can move to a longer DTX cycle (e.g. 64 frames) but in this example, it is
30 deemed more useful for the UE to have a DTX cycle as close as possible to the original cycle of 16 frames.

There is an inactivity of 500 ms and the UE moves into an extended DRX cycle as shown in Figure 7. In order to sync with the UE DRX cycle, the HS-DPCCH DTX cycle needs to
35 be 128 frames or 1280 ms. This is larger than the maximum predetermined CQI update period of 400 ms. Since a CQI update of 1280 ms does not offer any benefits to the network, the UE stops HS-DPCCH transmission (i.e. stops HS-DPCCH activity). After some time, an E-DCH uplink transmission (shown as an arrow in Figure 7) is sent and this causes the UE to exit the DRX state. Since there was no downlink transmission, the UE does not

need to respond in this implementation with a HS-DPCCH. However, the UE will resume its original HS-DPCCH DTX state and transmits HS-DPCCH every 16 frames.

5 It will be appreciated that embodiments provide a possible solution for obtaining radio condition feedback for UE in Enhanced Cell_FACH state without compromising on UE battery savings and reliability of channel quality estimates. Embodiments proposed do not require any additional DL channels and power and thus may be more suited to a higher number of UE in a cell operating in Enhanced Cell_FACH state.

10 Embodiments may help in reducing the delay that may be required with best existing solution to initiate HSDPA transmission. This improves latency of the system. Moreover, embodiments do not require any new codes or DL cell power and thus can perform much better in situations where a large number of UE in a cell use an Enhanced Cell_FACH state.

15 Embodiments provide a solution for transmission of HS-DPCCH during DL HSDPA inactivity periods for UE in Enhanced Cell_FACH state.

20 Embodiments may require an alteration to 3GPP standards. Such a change to the standard may comprise a change in accordance with the following:

1 Introduction

A WI was approved in [1] to further enhance the CELL_FACH state. The areas of improvements are as follows:

- 25
- Downlink related improvements of resource utilisation, throughput, latency and coverage
 - Uplink related improvements of resource utilisation, throughput, latency and coverage
 - UE battery life improvements & signalling reduction

30 This contribution will focus on downlink related improvements, specifically on the efficient transmission of HS-DPCCH.

2 Discussions

35 The HS-DPCCH physical channel carries CQI, PCI and HARQ ACK/NACK related to HS-DSCH traffic. Since MIMO is not used in CELL_FACH only CQI and HARQ ACK/NACK are relevant in this WI. In Rel-8, HS-DPCCH feedback was introduced in CELL_FACH, making the availability of frequent CQI and HARQ ACK/NACK. This allows the NB to schedule HS-DSCH transport block that match the channel RF conditions and enable the HARQ

process to function more efficient (compared to pre Rel-8 HS-DSCH implementation in CELL_FACH).

In Rel-8, HS-DPCCH is only transmitted if there is an UL DCCH or DTCH transmission on the common E-DCH resources. Since the transmission of UL DCCH/DTCH does not
5 necessary follows a DL DCCH/DTCH transmission, especially if the DL transmission is in a RLC UM mode, this leads to an absence of HARQ ACK/NACK and a lack of CQI, which reduces the efficient use of HS-DSCH resources. Also, HS-DSCH transmission may occur before an UL DCCH/DTCH transmission (or after a long period of UL inactivity) and without CQI, a HS-DSCH transport block size, based on poor (or blind) and usually
10 pessimistic estimates of the radio condition, is used. Furthermore, the transmission of UL DCCH/DTCH may not lead to a transmission of HS-DSCH and hence the HS-DPCCH packet (used for CQI transmission) is not utilised.

It was proposed in [2] to remove the dependency of HS-DPCCH transmission with UL DCCH/DTCH transmissions. Instead, the HS-DPCCH should be transmitted whenever a
15 downlink HS-DSCH packet is transmitted. This ensures that a HARQ ACK/NACK is always transmitted fore very HS-DSCH packet and CQI are provided for subsequent packets.

Proposal 1: HS-DPCCH transmissions should be independent of UL DCCH/DTCH transmission

20 **Proposal 2: A HS-DSCH transmission to the UE should be followed by a HS-DPCCH transmission from the UE**

The first HS-DSCH packet after a period of inactivity may need to be transmitted based on old CQI or based on blind estimation of the radio condition. After which, HS-DPCCH will be transmitted as in Proposal 2 above. This is acceptable for low traffic activity.
25 Since smartphone traffic is likely to be bursty in nature, they will likely be put in enhanced CELL_FACH. As the number of UE in CELL_FACH increased and their traffic activity increased, the nature of bursty traffic will result in many (first) HS-DSCH transmissions without an accurate CQI. Furthermore, the NB usually requires a few CQI updates to average out instantaneous radio channel conditions and thus, optimally
30 schedule the UE with appropriate transport block size. In [3], it is proposed that HS-DPCCH is transmitted all the time and this is started (and possibly stopped) using HS-SCCH orders. This approach should be investigated further and should avoid transmitting excessive amount of HS-DPCCH.

35 **3 Conclusion**

In this contribution, we discussed on improving the efficiency of HS-DPCCH transmissions. It is proposed:

Proposal 1: HS-DPCCH transmissions should be independent of UL DCCH/DTCH transmission

Proposal 2: A HS-DSCH transmission to the UE should be followed by a HS-DPCCH transmission from the UE

References

- 5 [1] R2-110436, "Further Enhancements to CELL_FACH," Ericsson, ST-Ericsson, Qualcomm Inc., RAN#51
- [2] R1-105979, "HS-DPCCH Transmission in Enhanced CELL_FACH," Alcatel-Lucent, Alcatel-Lucent Shanghai Bell, RAN1#63
- 10 [3] R2-110890, "Introducing further enhancements to CELL_FACH operation," Qualcomm Inc., RAN2#73

A person of skill in the art would readily recognise that steps of various above-described methods can be performed by programmed computers. Herein, some embodiments are also intended to cover program storage devices, e.g., digital data storage media, which are machine or computer readable and encode machine-executable or

15 computer-executable programs of instructions, wherein said instructions perform some or all of the steps of said above-described methods. The program storage devices may be, e.g., digital memories, magnetic storage media such as a magnetic disks and magnetic tapes, hard drives, or optically readable digital data storage media. The embodiments are also intended to cover computers programmed to perform said

20 steps of the above-described methods.

The functions of the various elements shown in the Figures, including any functional blocks labelled as "processors" or "logic", may be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions may be

25 provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term "processor" or "controller" or "logic" should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor (DSP) hardware, network processor,

30 application specific integrated circuit (ASIC), field programmable gate array (FPGA), read only memory (ROM) for storing software, random access memory (RAM), and non volatile storage. Other hardware, conventional and/or custom, may also be included. Similarly, any switches shown in the Figures are conceptual only. Their function may be carried out through the operation of program logic, through dedicated logic, through

35 the interaction of program control and dedicated logic, or even manually, the particular technique being selectable by the implementer as more specifically understood from the context.

It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of illustrative circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may
5 be substantially represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the
10 invention and are included within its spirit and scope. Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without
15 limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

CLAIMS

1. A method of obtaining an indication of radio condition being experienced by user equipment operating in Cell-FACH or enhanced Cell FACH state in a wireless communication network, said method comprising the steps of:
5 determining parameters of a feedback cycle according to which said user equipment is operable to periodically transmit an indication of radio condition at said user equipment;
transmitting an indication of said feedback cycle parameters to said user equipment;
10 and
monitoring for receipt of said periodically transmitted indication of radio condition.
2. A method according to claim 1, wherein said parameters comprise an indication of period between adjacent transmissions of indication of radio condition.
15
3. A method according to claim 1, wherein said step of determining comprises a step of collating information regarding whether said user equipment is operating on a fast or slow channel and determining at least one of said feedback channel parameters in dependence upon said channel speed.
20
4. A method according to any preceding claim, wherein said parameters comprise an indication of an upper limit in respect of said indication of period between adjacent transmissions of indication of radio condition.
- 25 5. A method according to claim 4, wherein said upper limit is determined in dependence upon an indication of speed of physical movement of said user equipment.
6. A method according to any preceding claim, wherein said indication of said feedback cycle parameters is addressed to a group of user equipment.
30
7. A computer program product operable, when executed on a computer, to perform the method of any one of claims 1 to 6.
- 35 8. A base station operable to obtain an indication of radio condition being experienced by user equipment operating in Cell-FACH or enhanced Cell FACH state in a wireless communication network, said base station comprising:

determination logic operable to determine parameters of a feedback cycle according to which said user equipment is operable to periodically transmit an indication of radio condition at said user equipment;

- 5 transmission logic operable to transmit an indication of said feedback cycle parameters to said user equipment; and
monitoring logic operable to monitor for receipt of said periodically transmitted indication of radio condition.

9. A method of transmitting an indication of radio condition being experienced by user equipment operating in Cell_FACH or enhanced Cell_FACH state in a wireless communication network, said method comprising the steps of:
10 monitoring for receipt of an indication of feedback cycle parameters; and
periodically transmitting an indication of radio condition being experienced by said user equipment in accordance with said received indication of feedback cycle
15 parameters.

10. A method according to claim 9, comprising the step of monitoring for receipt of downlink data traffic and, if downlink data traffic is received, implementing transmission of an indication of radio condition in each radio frame whilst said downlink data traffic
20 is received.

11. A method according to claim 9 or claim 10, comprising the step of determining that there is uplink data traffic to be transmitted and implementing transmission of an indication of radio condition in each radio frame whilst said uplink data traffic is
25 transmitted.

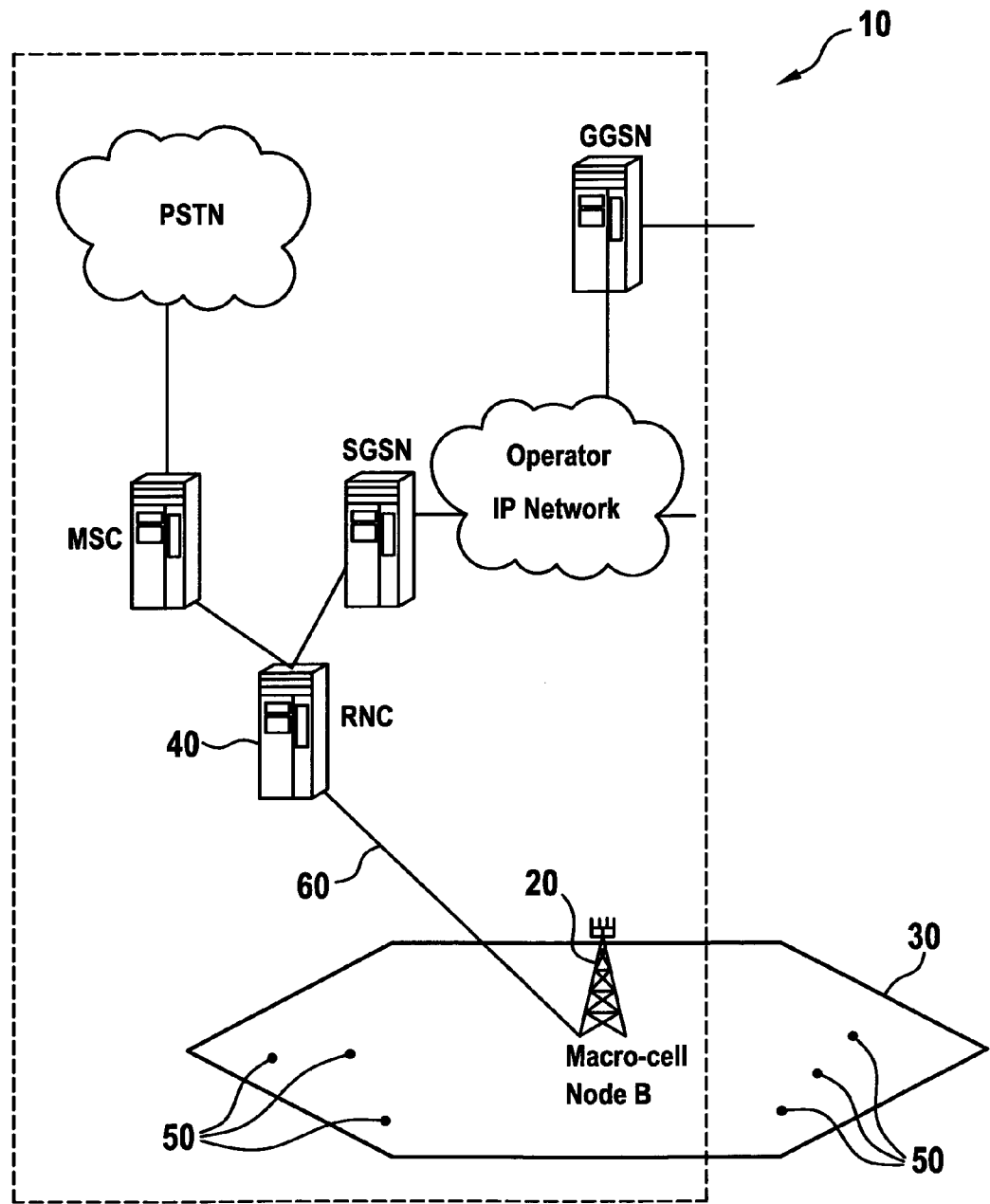
12. A method according to claim 9, comprising the step of determining whether said user equipment is operating in a discontinuous reception mode and adjusting said feedback cycle within said feedback parameters to fit within operational parameters
30 of said discontinuous reception mode.

13. A method according to claim 9, wherein said indication of radio condition is measured and transmitted more than once at each transmission of said feedback cycle.
35

14. A computer program product, operable, when executed on a computer, to perform the method of any one of claims 9 to 13.

15. User equipment operable to transmit an indication of radio condition being experienced by said user equipment operating in Cell-FACH or enhanced Cell FACH state in a wireless communication network, said user equipment comprising:
- 5 monitoring logic operable to monitor for receipt of an indication of feedback cycle parameters; and
- transmission logic operable to periodically transmit an indication of radio condition being experienced by said user equipment in accordance with said received indication of feedback cycle parameters.

Fig. 1



Traditional UMTS Architecture

Fig. 2

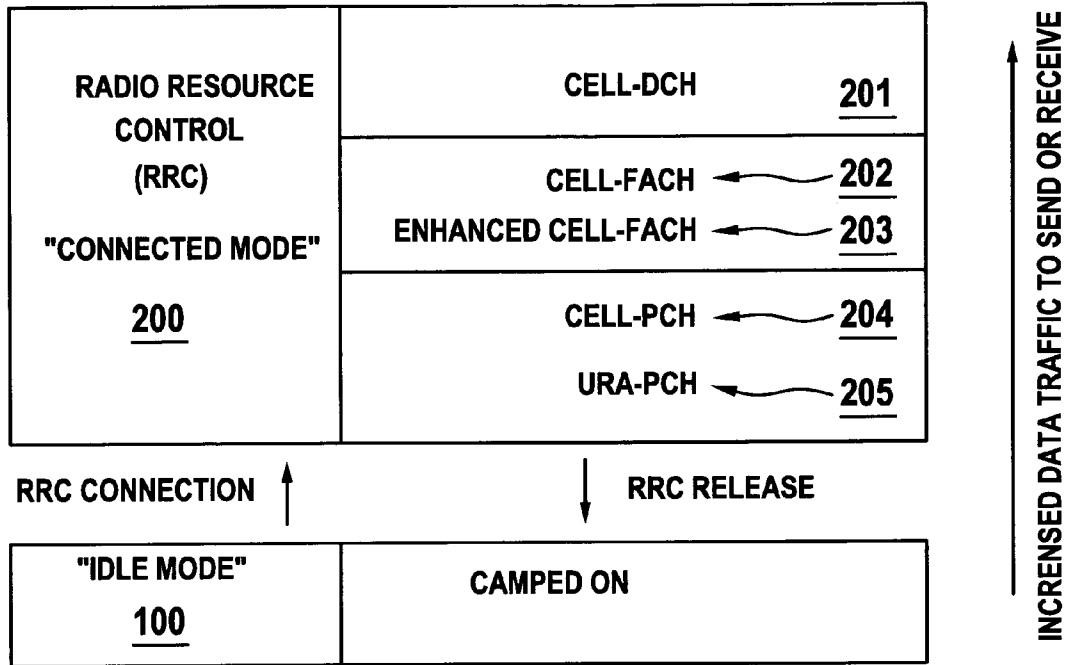


Fig. 3

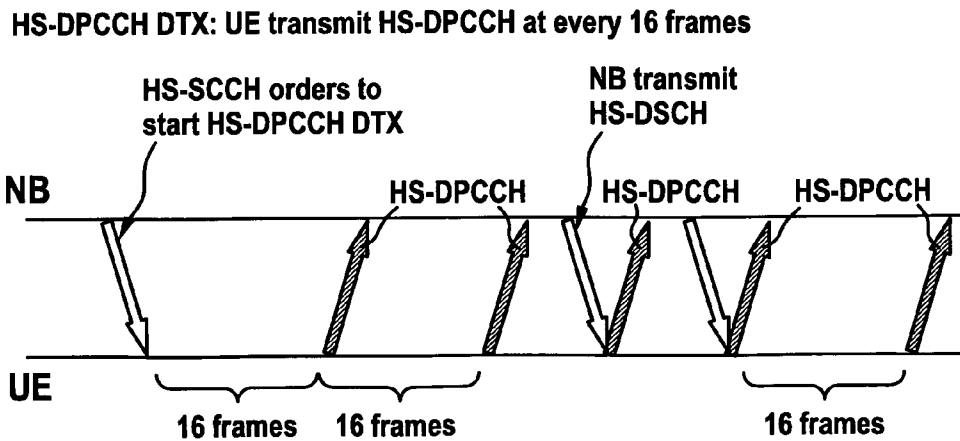


Fig. 4

HS-DPCCH DTX during UE DRX: DTX cycle > DRX cycle

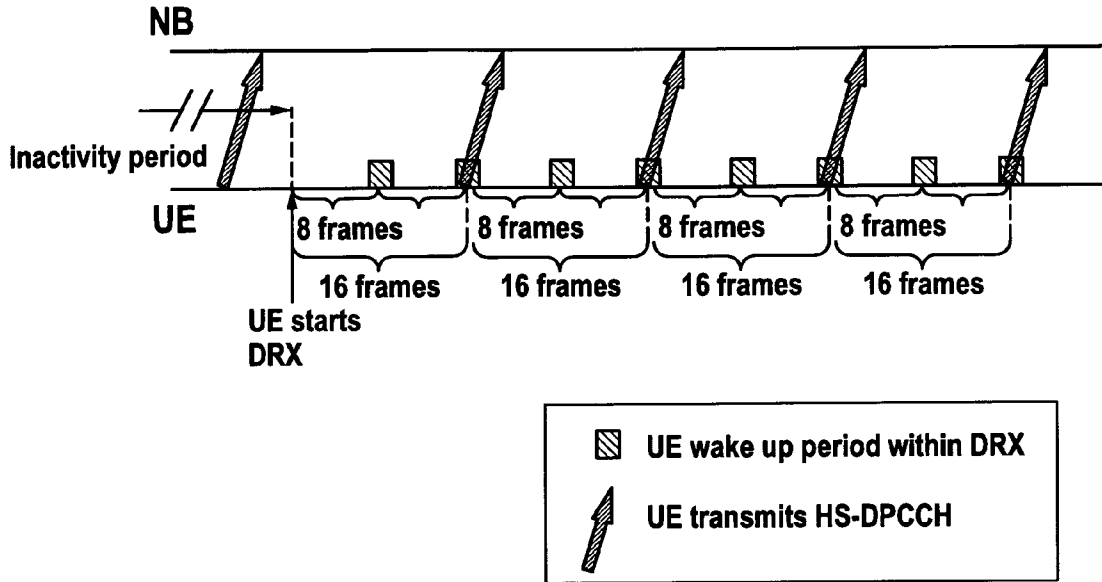


Fig. 5

HS-DPCCH DTX during UE DRX: DTX cycle > DRX cycle (transmit 2 HS-DPCCH per wake up period)

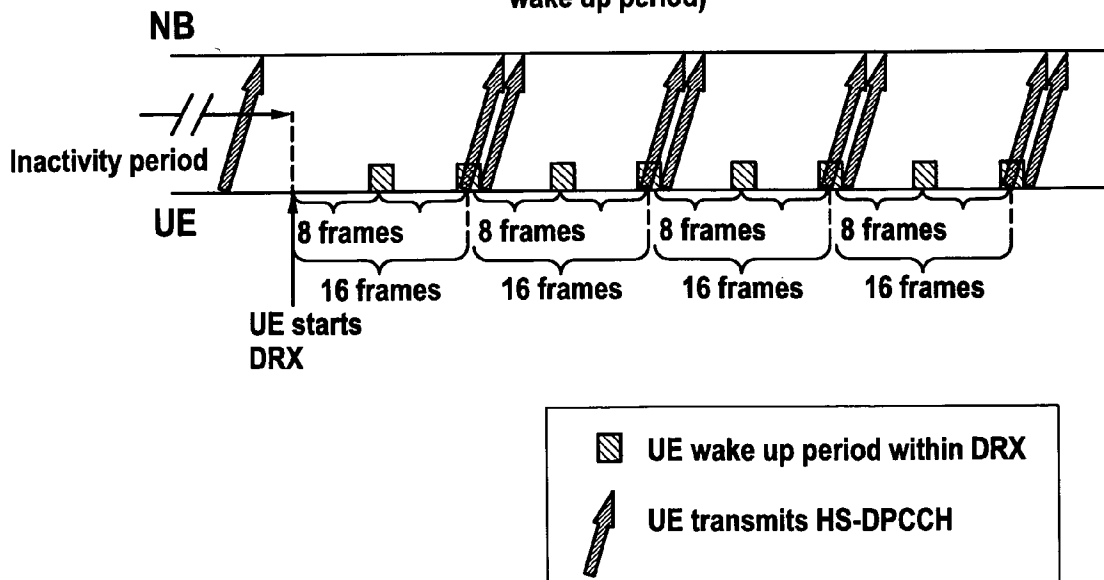


Fig. 6

HS-DPCCH DTX during UE DRX: DTX cycle < DRX cycle

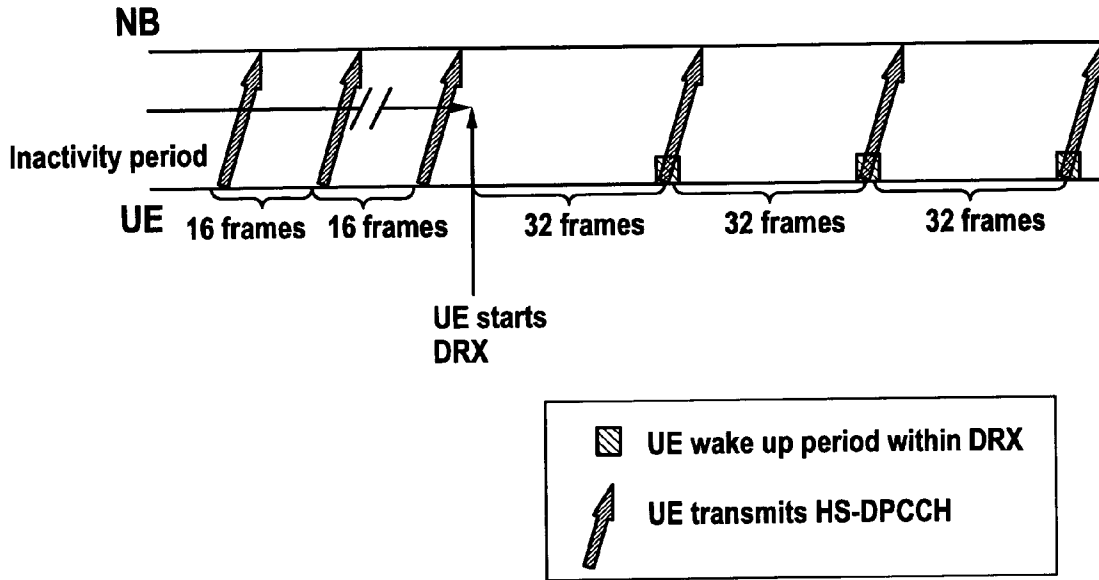
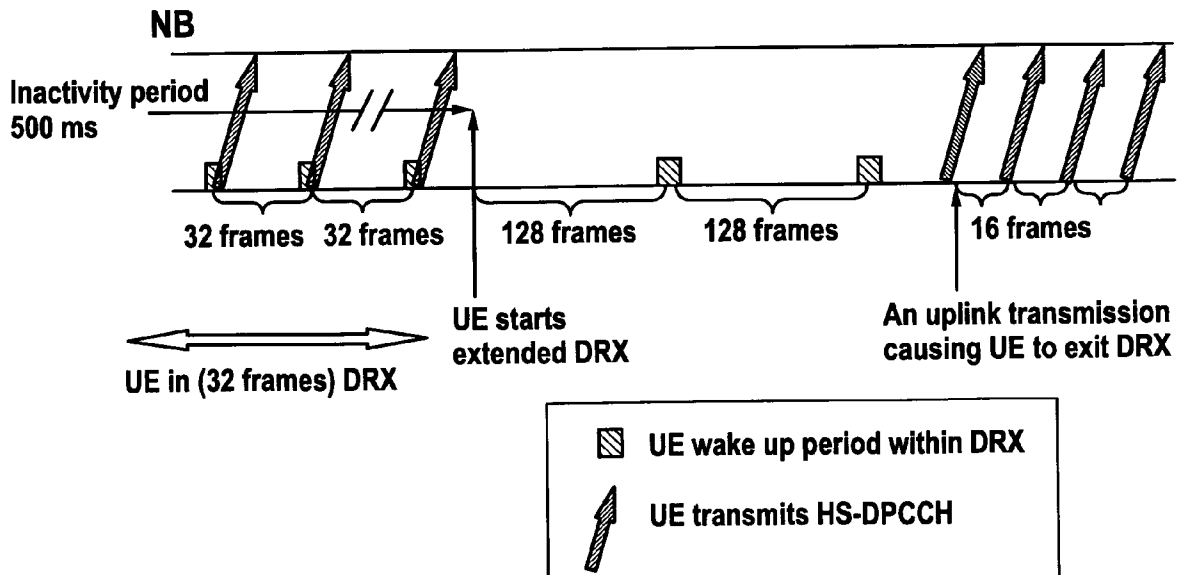


Fig. 7

DRX cycle > Max CQI Update Period



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/056191

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W24/10
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	US 2009/163199 A1 (KAZMI MUHAMMAD [SE] ET AL) 25 June 2009 (2009-06-25)	1-9, 11-15
Y	page 2, paragraph 15 - paragraph 22 page 3, paragraph 47 - paragraph 48 page 4, paragraph 51 - paragraph 62; figure 3 page 5, paragraph 67 - page 7, paragraph 91 ----- -/--	10

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"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
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 7 June 2012	Date of mailing of the international search report 18/06/2012
--	--

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer López García, J
--	---

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/056191

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	3GPP DRAFT; R2-070285 UL IMPACT FOR HS-FACH_R0, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Sorrento, Italy; 20070111, 11 January 2007 (2007-01-11), XP050133374, [retrieved on 2007-01-11]	1,7-9, 14,15
A	page 1, paragraph 1 - page 3, paragraph 4.2	2-6, 10-13
Y	----- QUALCOMM INCORPORATED: "Introducing further enhancements to CELL_FACH operation", 3GPP DRAFT; R2-110890 INTRO FURTHER ENH CELL_FACH, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Taipei, Taiwan; 20110221, 15 February 2011 (2011-02-15), XP050493639, [retrieved on 2011-02-15]	10
A	page 1, paragraph 1 - page 3, paragraph 3	1-9, 11-15
A	----- ALCATEL-LUCENT ET AL: "Efficient HS-DPCCH for Improvements in Enhanced CELL_FACH", 3GPP DRAFT; R2-111954, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Shanghai, China; 20110411, 4 April 2011 (2011-04-04), XP050494352, [retrieved on 2011-04-04]	1-15
A	page 1, paragraph 1 - page 2, paragraph 3	
A	----- HUAWEI ET AL: "Consideration on HS-DPCCH feedback in CELL_FACH state", 3GPP DRAFT; R2-112048 CONSIDERATION ON HS-DPCCH FEEDBACK IN CELL_FACH STATE, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Shanghai, China; 20110411, 5 April 2011 (2011-04-05), XP050494523, [retrieved on 2011-04-05]	1-15
	page 1, paragraph 1 - page 3, paragraph 3	
	----- -/--	

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/056191

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>ERICSSON ET AL: "Overview of CELL_FACH enhancements", 3GPP DRAFT; R2-112323 CELL_FACH_REL-11, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Shanghai, China; 20110411, 5 April 2011 (2011-04-05), XP050494633, [retrieved on 2011-04-05] page 1, paragraph 1 page 3, paragraph 2.3 -----</p>	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/056191

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009163199	A1	25-06-2009	
		AT 533320 T	15-11-2011
		CA 2710158 A1	02-07-2009
		CN 101904194 A	01-12-2010
		EP 2223554 A1	01-09-2010
		EP 2400684 A2	28-12-2011
		JP 2011508512 A	10-03-2011
		US 2009163199 A1	25-06-2009
		US 2012044831 A1	23-02-2012
		WO 2009082335 A1	02-07-2009
