

[0001] METHOD AND APPARATUS FOR RECOGNIZING RADIO
LINK FAILURES ASSOCIATED WITH HSUPA AND HSDPA CHANNELS

[0002] FIELD OF INVENTION

[0003] The present invention is related to a wireless communication system including a wireless transmit/receive unit (WTRU) and a Node-B. More particularly, the present invention is related to a method and system for recognizing radio link (RL) failures associated with high speed uplink packet access (HSUPA) and high speed downlink packet access (HSDPA) channels established between the WTRU and the Node-B.

[0004] BACKGROUND

[0005] In a third generation partnership project (3GPP) wireless communication system, signaling radio bearers (SRBs) are used to maintain a connection, (i.e., an RL), between a WTRU and a Universal Terrestrial Radio Access Network (UTRAN). When reception of the physical channel connecting the WTRU and Node-B is below a quality threshold or can not be detected, (i.e., the physical channel that allows for signaling information to be exchanged between the WTRU and UTRAN has failed), an RL failure is declared, and the WTRU and the UTRAN initiate procedures to reestablish the connection between the WTRU and the UTRAN.

[0006] In order to realize the loss of the SRBs and take a proper action, the WTRU and the UTRAN constantly monitor for an occurrence of an RL failure. A primary objective of the RL failure detection procedure is to detect failure of the transport channels (TrCHs) and physical channels to which the SRBs are mapped.

[0007] In the 3GPP wireless communication system, SRBs are mapped to dedicated transport channels (DCHs) which are in turn mapped to dedicated physical channels (DPCHs). A DPCH comprises a dedicated physical control channel (DPCCH) and a dedicated physical data channel (DPDCH).

[0008] The criteria to detect the status of the DPCHs and DCHs includes estimation of the DPCCH quality, (and comparison to a predetermined

threshold), and/or collection of statistics of correct reception of data packets on a DPCH based on cyclic redundancy check (CRC). When the criteria are met, the WTRU and the UTRAN invoke a procedure to release and reestablish the connection between the WTRU and the UTRAN.

[0009] In the 3GPP wireless communication system, both continuous services, (e.g., speech), and interactive services, (e.g., web browsing), are supported. Dedicated channels are efficient for supporting continuous services, while shared channels are efficient for supporting interactive services. The shared channels provide more efficient use of radio resources and improved quality of service (QoS) for interactive services. However, when the service is mapped to shared channels, the use of dedicated channels for SRBs is inefficient since the traffic requirement is not continuous.

[0010] In 3GPP wireless communication systems, HSUPA and HSDPA primarily utilize high speed shared channels for services that do not require continuous channel allocations. These channels utilize fast physical and medium access control (MAC) layer signaling between the WTRU and the Node-B for channel assignment and hybrid-automatic repeat request (H-ARQ) for efficient and fast recovery of failed transmissions.

[0011] If the SRBs are supported by either HSUPA or HSDPA channels rather than dedicated channels, it is possible that SRBs may fail, even though dedicated channels are still operating. Furthermore, the criteria to detect the dedicated channel failure may not be met even though the HSUPA or HSDPA channels supporting the SRBs are not operating. In this case, RL failure will not be detected even though the SRBs have already lost connectivity.

[0012] SUMMARY

[0013] The present invention is related to a method and system for detecting RL failures between a WTRU and a Node-B when SRBs are supported by HSUPA or HSDPA. When SRBs are supported by the HSUPA, the WTRU monitors at least one of an absolute grant channel (AGCH), a relative grant channel (RGCH) and an H-ARQ information channel (HICH) and recognizes an

RL failure based on detection of improper operation of at least one of the AGCH, the RGCH and the HICH. The Node-B monitors at least one of an enhanced uplink dedicated physical control channel (E-DPCCH) and an enhanced uplink dedicated physical data channel (E-DPDCH) and recognizes the RL failure based on detection of improper operation of at least one of the E-DPDCH and the E-DPCCH.

[0014] When SRBs are supported by the HSDPA, the WTRU monitors at least one of a high speed shared control channel (HS-SCCH) and a high speed physical downlink shared channel (HS-PDSCH) and recognizes an RL failure based on detection of improper operation of at least one of the HS-SCCH and the HS-PDSCH. The Node-B monitors a high speed dedicated physical control channel (HS-DPCCH) and recognizes an RL failure based on detection of improper operation of the HS-DPCCH.

[0015] BRIEF DESCRIPTION OF THE DRAWINGS

[0016] A more detailed understanding of the invention may be had from the following description, given by way of example and to be understood in conjunction with the accompanying drawings wherein:

[0017] Figure 1 is a wireless communication system including a WTRU and a Node-B which communicate via HSUPA channels established in accordance with the present invention;

[0018] Figure 2 is a block diagram of an exemplary WTRU used in the system of Figure 1;

[0019] Figure 3 is a block diagram of an exemplary Node-B used in the system of Figure 1;

[0020] Figure 4 is a scheme for recognizing an RL failure at the WTRU utilizing the HSUPA channels of the system of Figure 1;

[0021] Figure 5 is a scheme for recognizing an RL failure at the Node-B utilizing the HSUPA channels of the system of Figure 1;

[0022] Figure 6 shows HSDPA channels established between the WTRU and the Node-B of the system of Figure 1;

[0023] Figure 7 is a scheme for recognizing an RL failure at the WTRU utilizing the HSDPA channels of Figure 6; and

[0024] Figure 8 is a scheme for recognizing an RL failure at the Node-B utilizing the HSDPA channels of Figure 6.

[0025] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Hereafter, the terminology "WTRU" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, or any other type of device capable of operating in a wireless environment. When referred to hereafter, the terminology "Node-B" includes but is not limited to a base station, a site controller, an access point or any other type of interfacing device in a wireless environment.

[0027] The features of the present invention may be incorporated into an integrated circuit (IC) or be configured in a circuit comprising a multitude of interconnecting components.

[0028] Figure 1 is a diagram of a wireless communication system 100 including a WTRU 102 and a Node-B 104 which communicate via HSUPA channels established between the WTRU 102 and the Node-B 104 in accordance with the present invention. Between the WTRU 102 and the Node-B 104, an E-DPDCH 106, an AGCH 108, an RGCH 110 (optional), an HICH 112 and an E-DPCCH 114 are established.

[0029] Figure 2 is a block diagram of an exemplary WTRU 102 used in the system 100 of Figure 1. The WTRU 102 includes a transceiver 202, a controller 204 and a measurement unit 206.

[0030] Figure 3 is a block diagram of an exemplary Node-B 104 used in the system 100 of Figure 1. The Node-B 104 includes a transceiver 302, a controller 304, a measurement unit 306, a scheduler 308 and an H-ARQ processing unit 310.

[0031] In accordance with one embodiment of the present invention, the transceiver 202 of the WTRU 102 sends a rate request with scheduling information to the Node-B 104 via the E-DPCCH 114 and the E-DPDCH 106.

The transceiver 302 of the Node-B 104 receives the rate request and the scheduler 308 analyses the rate request and generates and sends a scheduling assignment to the WTRU 102 via the AGCH 108, (or optionally via the RGCH 110), to control the uplink access and maximum rate that the WTRU 102 is allowed to transmit. The transceiver 202 of the WTRU 102 sends uplink (UL) data to the Node-B 104 via the E-DPCCH 114 and the E-DPDCH 106. When the transceiver 302 of the Node-B 104 receives the UL data, the H-ARQ processing unit 310 of the Node-B 104 generates H-ARQ feedback to the WTRU 102 via the HICH 112. The controller 204 of the WTRU 102 and the controller 304 of the Node-B 104 detect the RL failure in accordance with the present invention, which will be explained in detail hereinafter.

[0032] Referring to Figure 1, certain radio bearers (RBs) may be assigned a guaranteed bit rate that does not require a rate request and Node-B scheduling. When configured for a guaranteed bit rate, the rate request on the E-DPCCH 114 and/or the E-DPDCH 106, and the scheduling grant transmitted on the AGCH 108 and/or the RGCH 110, is not required for transmission of UL data.

[0033] Still referring to Figure 1, when allowed to transmit in the uplink, either by reception of a scheduling grant or by a configured guaranteed bit rate, the WTRU 102 utilizes H-ARQ procedures for transmission. There may be several H-ARQ processes operating independently between the WTRU 102 and the Node-B 104. In the WTRU 102, each H-ARQ process transmits a block of data via the E-DPDCH 106 and waits for H-ARQ feedback on the HICH 112, (i.e., a positive acknowledgement (ACK) or a negative acknowledgement (NACK)), from the Node-B 104.

[0034] In the Node-B 104, if the CRC check on the received data block is successful, an ACK is transmitted. Otherwise, a NACK may optionally be transmitted via the HICH 112 for each H-ARQ transmission. If a NACK is received by the WTRU 102, a previous data block is retransmitted as long as the maximum number of retransmissions is not exceeded. If an ACK is received or the maximum number of retransmission is exceeded, the WTRU H-ARQ process may be assigned a new transmission. The rate requests and scheduling

assignments may coincide with uplink data transmissions, and several independent H-ARQ transmissions and ACK/NACK feedback may overlap.

[0035] In accordance with the present invention, the WTRU 102 and the Node-B 104 utilizes new criteria for recognizing an RL failure. Figure 4 illustrates a scheme for recognizing an RL failure at the WTRU 102 utilizing the HSUPA channels of the wireless communication system 100, as shown in Figure 1. The WTRU 102 utilizes criteria based on reception on the AGCH 108, the RGCH 110 and the HICH 112 according to specified procedures known to the WTRU 102. The transceiver 202 of the WTRU 102 sends a rate request 402 to the Node-B 104 for uplink transmission in accordance with a rate request and scheduling procedure. In response, the scheduler 308 of the Node-B 104 sends scheduling assignments 406, (which is shown as a failed transmission in Figure 4), back to the WTRU 102 via an AGCH or a RGCH. The scheduling assignments 406 may or may not be successfully received. If the WTRU 102 does not receive any scheduling assignments 406 or HARQ feedback 404 after sending the rate request 402, (preferably multiple times or over a specified period), the WTRU 102 recognizes that the rate request and scheduling procedure has failed and declares a radio link failure which invokes a procedure for recovering the connection.

[0036] The measurement unit 206 of the WTRU 102 shown in Figure 2 may also measure channel quality on the AGCH 108 and the RGCH 110. If the channel quality on the AGCH 108 or the RGCH 110 falls below a predetermined threshold for a predetermined period of time, the WTRU 102 recognizes that the rate request and scheduling procedure has failed and declares an RL failure which invokes a procedure for recovering the RL. The quality of the AGCH 108 and the RGCH 110 may be evaluated based on signal-to-interference ratio (SIR), received energy per chip (E_b)/power density in the band (N_o), block error rate (BLER) or any other relevant criteria.

[0037] If the WTRU 102 successfully receives a scheduling assignment 406, the WTRU 102 initiates a UL data transmission 408 in accordance with the UL scheduling assignment 406. In response to the UL data transmission 408, the Node-B 104 sends H-ARQ feedback 410 on the HICH 112, (which is shown as a

failed transmission in Figure 4), to the WTRU 102. If the WTRU 102 fails to receive an ACK on the HICH 112, (preferably multiple times or over a specified period), the WTRU 102 recognizes that the UL data transmission and H-ARQ procedure has failed and declares an RL failure which invokes a procedure for recovering the RL. If the ACK/NACK ratio of the UL data transmission falls below a predetermined threshold, the WTRU 102 may also recognize that the RL has failed.

[0038] The measurement unit 206 of the WTRU 102, as shown in Figure 2, also monitors channel quality on the HICH 112. If the channel quality on the HICH 112 falls below a predetermined threshold for a predetermined period of time, the WTRU 102 recognizes that the UL data transmission and H-ARQ procedure has failed and declares an RL failure which invokes a procedure for recovering the RL. The quality of the HICH 112 may be evaluated based on SIR, E_b/N_o , BLER or any other relevant criteria.

[0039] If either of the AGCH 108 or the RGCH 110 reduces the SRB or other RBs utilizing HSUPA to a data rate below an acceptable threshold, the WTRU recognizes that the RL has failed.

[0040] If the SRBs supported by HSUPA channels are not assigned a guaranteed bit rate, and therefore the WTRU 102 is required to send a rate request, and scheduling assignments are sent back in response to the rate request, the reception on the AGCH 108 and the RGCH 110 is used to determine RL failure. Otherwise, if the SRBs supported by HSUPA channels are assigned a guaranteed bit rate, the reception criteria of the AGCH 108 and the RGCH 110 for RL failure may not be applied.

[0041] Multiple RGCHs 110 and HICHs 112 may be configured for the WTRU 102 and, in each cell, the RGCH 110 and the HICH 112 may utilize a common physical channel. RL failure based on HICH transmissions can be declared only if the reception is not achieved on any of the HICH channels. An exception may apply if an HICH transmission has failed on the primary serving Node-B. RL failure based on the RGCH transmissions may be declared if any one RGCH 110 reduces the rate below the predetermined threshold.

[0042] Criteria for RL failure detection in the WTRU 102 is specified for UTRAN configuration changes that result in disabling HSUPA transmission in the WTRU 102. When SRBs are utilizing HSUPA, UTRAN controlled configuration changes which result in disabling HSUPA operation in the WTRU 102 are used as an additional RL failure detection criteria.

[0043] Figure 5 illustrates a scheme for detecting RL failure at the Node-B 104 utilizing the HSUPA channels of the wireless communication system 100, as shown in Figure 1. The Node-B 104 utilizes criteria based on reception on the E-DPDCH 106 and the E-DPCCH 114. The transceiver 202 of the WTRU 102 sends a rate request 502, (which is shown as a failed transmission in Figure 5), to the Node-B 104 for enhanced uplink transmission. The WTRU 102 sends rate requests 502 upon arrival of new HSUPA data to transmit and may also be configured to send a rate request 502 periodically. The periodicity configured for WTRU rate request reporting in advance of and/or following an initial rate request resulting in the transmission of scheduling information may be known to the Node-B 104. WTRU rate requests 502 may also be generated in response to a request from the Node-B 104. In response to a rate request 502, the Node-B sends H-ARQ feedback 504 to the WTRU 102 over the HICH 112, and also sends a UL scheduling assignment 506 to the WTRU 102 over the AGCH 108 or the RGCH 110. Based on specified rate request procedures, the Node-B 104 may use the knowledge of lost rate requests 502, (including a periodic request or a polled request), as criteria for RL failure detection.

[0044] The measurement unit 306 of the Node-B 104, as shown in Figure 3, also measures channel quality of the E-DPCCH 114 from the WTRU 102. If the channel quality of the E-DPCCH 114 remains below a predetermined threshold for a predetermined period of time, the Node-B 104 may also declare RL failure. The Node-B 104 may also use knowledge of when the E-DPCCH 114 is known to be active based on knowledge of scheduled and non-scheduled grants signaled to the WTRU 102. The quality of the E-DPCCH 114 may be evaluated based on SIR, E_b/N_o , BLER or any other relevant criteria.

[0045] As shown in Figure 5, in response to receiving the UL scheduling assignment 506, the WTRU 102 sends a UL data transmission 508, (which is shown as a failed transmission in Figure 5) to the Node-B 104. If the Node-B 104 receives no response following the transmission of the UL scheduling assignment 506, (preferably after several consecutive failures or a statistical failure threshold is reached), the Node-B 104 may declare RL failure. If the Node-B 104 has knowledge of synchronous H-ARQ retransmissions followed by H-ARQ feedback 504 including a NACK, or if the Node-B 104 receives an old data packet followed by H-ARQ feedback 504 including an ACK, (preferably after several consecutive failures or a statistical failure threshold is reached), the Node-B 104 may declare RL failure. The Node-B 104 may also use an ACK/NACK ratio on final data retransmissions from the WTRU 102 as criteria for RL failure.

[0046] Additionally or alternatively, the RL failure may be determined by a radio network controller (RNC). In this case the Node-B 104 provides necessary information to the RNC, such as E-DPCCH quality, rate request reception statistics, H-ARQ data transmission statistics, (i.e., ACK/NACK information), and/or E-DPDCH and E-DPCCH BLER.

[0047] If improper operation of at least one of the E-DPCCH 114 and the E-DPDCH occurs, a failure of data transmission 508 from the WTRU 102 is detected, and the Node-B 104 recognizes that the RL has failed and invokes a procedure for releasing the RL. If the Node-B 104 successfully receives the UL data transmission 508, the Node-B 104 sends H-ARQ feedback 510 to the WTRU 102 on the HICH 112

[0048] Figure 6 shows HSDPA channels established between the WTRU 102 and the Node-B 104. In HSDPA, scheduling assignments for downlink (DL) transmissions is transmitted on a high speed shared control channel (HS-SCCH) 602 from the Node-B 104 to the WTRU 102. Using scheduling information received on the HS-SCCH 602, the WTRU 102 receives the data transmission on a high speed physical downlink shared channel (HS-PDSCH) 604. The WTRU 102 then transmits H-ARQ feedback, (i.e., ACK or NACK), and a channel quality indication (CQI) to the Node-B 104 via a high speed dedicated physical control

channel (HS-DPCCH) 606. This transmission procedure applies to each operational HARQ process in the WTRU 102.

[0049] In accordance with the present invention, the WTRU 102 utilizes criteria for recognizing an RL failure based on reception on the HS-SCCH 602 and the HS-PDSCH 604. Figure 7 illustrates a scheme for recognizing an RL failure at the WTRU 102 utilizing HSDPA in accordance with the present invention. The scheduler 308 of the Node-B 104 sends DL scheduling assignment 702, (which is shown as a failed transmission in Figure 7), to the WTRU 102 via the HS-SCCH 602

[0050] The measurement unit 206 of the WTRU 102, as shown in Figure 2, may also measure channel quality on the HS-SCCH 602. If the channel quality of the HS-SCCH 602 remains below a predetermined threshold over a predetermined period of time, the WTRU 102 declares an RL failure. Use of this criteria is based on WTRU knowledge of HS-SCCH activity .

[0051] Referring to Figure 7, if the WTRU 102 successfully receives the DL scheduling assignment 702 on the HS-SCCH 602, the WTRU 102 attempts to receive data transmission 704, (which is shown as a failed transmission in Figure 7), via the HS-PDSCH 604 in accordance with the received DL scheduling assignment 702. The measurement unit 206 of the WTRU 102 monitors channel quality of the HS-PDSCH 604 and, if the channel quality of the HS-PDSCH 604 remains below a predetermined threshold over a predetermined period of time, the WTRU 102 may declare an RL failure and invoke a procedure for recovering the RL. The channel quality of the HS-SCCH 602 and the HS-PDSCH 604 may be evaluated based on SIR, E_b/N_o , BLER or any other relevant criteria. If the WTRU 102 successfully receives the data transmission 704, the WTRU 102 sends an H-ARQ feedback 706 including an ACK on the HS-DPCCH 606.

[0052] The controller 204 of the WTRU 102, as shown in Figure 2, may further monitor an ACK/NACK ratio from CRC on the HS-PDSCH transmissions. If the ACK/NACK ratio is below a specified threshold, the WTRU 102 may declare an RL failure. The measurement unit 206 and the controller 204 of the WTRU 102 may further generate and send a CQI, preferably based on common

pilot channel (CPICH) reception. If the measured channel quality is below a configured threshold (preferably over a specified time period), the WTRU 102 may declare an RL failure.

[0053] Criteria for the RL failure detection in the WTRU 102 should be specified for UTRAN configuration changes that result in disabling HSDPA reception in the WTRU 102. When SRBs are utilizing HSDPA, UTRAN controlled configuration changes which result in disabling HSDPA operation in the WTRU 102 are used as an additional RL failure detection criteria.

[0054] In accordance with the present invention, the Node-B 104 utilizes criteria for recognizing an RL failure based on reception on the HS-DPCCH 606. Figure 8 illustrates a scheme for recognizing an RL failure at the Node-B 104 utilizing HSDPA in accordance with the present invention. The WTRU 102 sends an H-ARQ feedback 806, (which is shown as a failed transmission in Figure 8), after receiving a channel allocation 802 and data transmission 804 from the Node-B 104. The WTRU 102 may additionally be configured for periodic CQI reporting to Node-B 104. Node-B knowledge of the H-ARQ feedback and CQI reporting, by specified signaling procedures, allows Node-B detection of HS-DPCCH failures. The measurement unit 306 of the Node-B 104, as shown in Figure 3, may also monitor channel quality of the HS-DPCCH 606, and if the channel quality of the HS-DPCCH 606 remains below a predetermined threshold over a specified time period, the controller 304 of the Node-B 104 declares an RL failure. The quality of the HS-DPCCH 606 may be evaluated based on SIR, E_b/N_o , BLER or any other relevant criteria.

[0055] The controller 304 of the Node-B 104 may further use the reported CQI or an ACK/NACK ratio as criteria for the RL failure detection. If an average of the reported CQI or an ACK/NACK ratio over a sliding window period is below a threshold, or if an average of the number of discarded MAC-hs transmissions is above a threshold, the controller 304 of the Node-B 104 may declare an RL failure.

[0056] The RL failure may be determined by an RNC. In this case, the Node-B 104 reports necessary information to the RNC such as HS-DPCCH

quality statistics, reported CQI, H-ARQ ACK/NACK indications, or MAC-hs transmission failure indications.

[0057] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the preferred embodiments or in various combinations with or without other features and elements of the present invention.

CLAIMS

1. A method of detecting a radio link (RL) failure, the method comprising:

monitoring at least one high speed uplink packet access (HSUPA) channel, wherein the HSUPA channel includes at least one of an absolute grant channel (AGCH) and a relative grant channel (RGCH), and the AGCH and the RGCH are used for sending scheduling assignments in response to a rate request; and

declaring an RL failure on a condition that the rate request and a scheduling procedure using the HSUPA channel have failed.

2. The method of claim 1 wherein an RL failure occurs when the channel quality of the HSUPA channel remains below a predetermined threshold for a predetermined period of time.

3. The method of claim 2 wherein the channel quality is based on signal-to-interference ratio (SIR).

4. The method of claim 1 wherein the HSUPA channel further includes a hybrid-automatic repeat request (H-ARQ) information channel (HICH).

5. The method of claim 4 wherein the HICH is used to send hybrid-automatic repeat request (H-ARQ) feedback.

6. The method of claim 2 wherein the channel quality is based on received energy per chip (E_b)/power density in the band (N_o).

7. The method of claim 2 wherein the channel quality is based on block error rate (BLER) rate.

8. The method of claim 1 further comprising:
invoking a procedure for reestablishing the RL.

9. A wireless transmit/receive unit (WTRU) configured to:
monitor at least one high speed uplink packet access (HSUPA) channel, wherein the HSUPA channel includes at least one of an absolute grant channel (AGCH) and a relative grant channel (RGCH), and the AGCH and the RGCH are used for sending scheduling assignments in response to a rate request; and
declare an RL failure on a condition that the rate request and a scheduling procedure using the HSUPA channel have failed.
10. The WTRU of claim 9 wherein an RL failure occurs when the channel quality of the HSUPA channel remains below a predetermined threshold for a predetermined period of time.
11. The WTRU of claim 10 wherein the channel quality is based on signal-to-interference ratio (SIR).
12. The WTRU of claim 9 wherein the HSUPA channel further includes a hybrid-automatic repeat request (H-ARQ) information channel (HICH).
13. The WTRU of claim 12 wherein the HICH is used to send hybrid-automatic repeat request (H-ARQ) feedback.
14. The WTRU of claim 10 wherein the channel quality is based on received energy per chip (E_b)/power density in the band (N_o).
15. The WTRU of claim 10 wherein the channel quality is based on block error rate (BLER) rate.
16. The WTRU of claim 9 further configured to:
invoke a procedure for reestablishing the RL.