

[0001] MEDIUM ACCESS CONTROL LAYER ARCHITECTURE
 FOR SUPPORTING ENHANCED UPLINK

[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 invention is related to medium access control (MAC) layer architecture and functionality for supporting enhanced uplink (EU) in the wireless communication system.

[0004] BACKGROUND

[0005] Methods for improving uplink (UL) coverage, throughput and transmission latency are being investigated in Release 6 of the Third Generation Partnership Project (3GPP). In order to successfully implement these methods, scheduling and assigning of UL physical resources have been moved from a radio network controller (RNC) to the Node-B such that the Node-B can make decisions and manage UL radio resources on a short-term basis more efficiently than the RNC, even if the RNC retains overall control of the Node-B.

[0006] One or more independent UL transmissions are processed on the enhanced dedicated channel (E-DCH) between the WTRU and a universal mobile telecommunication systems (UMTS) terrestrial radio access network (UTRAN) within a common time interval. One example of this is a MAC layer hybrid-automatic repeat request (H-ARQ) or a simple MAC layer ARQ operation where each individual transmission may require a different number of retransmissions to be successfully received by the UTRAN.

[0007] SUMMARY

[0008] The present invention is related to an improved MAC layer architecture and functionality for supporting EU. A new MAC entity for EU called a MAC-e entity is defined and incorporated into a WTRU, a Node-B and an RNC. The WTRU MAC-e handles H-ARQ transmissions and retransmissions, priority handling, MAC-e multiplexing, and transport format combination (TFC)

selection. The Node-B MAC-e entity handles H-ARQ transmissions and retransmissions, enhanced dedicated channel (E-DCH) scheduling and MAC-e demultiplexing. The RNC MAC-e entity provides in-sequence delivery and handles combining of data from different Node-Bs.

[0009] The WTRU MAC-e comprises an EU rate request/assignment entity, a priority handling entity, a TFC selection entity and an H-ARQ entity. The EU rate request/assignment entity sends a rate request to a Node-B for transmitting a data via E-DCH and for processing a rate grant received from the Node-B. The priority handling entity manages assignment of the data and an H-ARQ process in accordance with priority of the data to be transmitted. The TFC selection entity selects a TFC for the data. The H-ARQ entity retransmits the data in accordance with a transmission feedback from the Node-B. The Node-B MAC-e comprises a scheduler, a demultiplexer and an H-ARQ entity.

[0010] BRIEF DESCRIPTION OF THE DRAWINGS

[0011] A more detailed understanding of the invention may be had from the following description of a preferred embodiment, given by way of example and to be understood in conjunction with the accompanying drawing wherein:

[0012] Figure 1 is a block diagram of a wireless communication system in accordance with the present invention;

[0013] Figure 2 is a block diagram of a protocol architecture of a WTRU in accordance with the present invention;

[0014] Figure 3 is a block diagram of MAC-e architecture in a WTRU in accordance with the present invention;

[0015] Figure 4 is a block diagram of MAC-e architecture in a Node-B in accordance with the present invention; and

[0016] Figure 5 is a block diagram of MAC-e architecture of a WTRU and a Node-B along with signaling process between the WTRU and the Node-B in accordance with the present invention.

[0017] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] Hereafter, the terminology "WTRU" includes but is not limited to a user equipment, 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.

[0019] 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.

[0020] Figure 1 is a block diagram of a wireless communication system 10 in accordance with the present invention. The system 10 comprises a WTRU 100, a Node-B 200 and an RNC 300. The RNC 300 controls overall EU operation by configuring EU parameters for the Node-B 200 and the WTRU 100 such as initial transmit power level, maximum allowed EU transmit power or available channel resources per Node-B. Between the WTRU 100 and the Node-B 200, an E-DCH 102 is established for supporting EU transmissions.

[0021] For E-DCH transmissions, the WTRU 100 sends a rate request to the Node-B 200 via an UL EU signaling channel 104. In response, the Node-B 200 sends a rate grant to the WTRU 100 via a downlink (DL) EU signaling channel 106. After EU radio resources are allocated for the WTRU 100, the WTRU 100 transmits E-DCH data via the E-DCH 102. In response to the E-DCH transmissions, the Node-B sends an acknowledge (ACK) or non-acknowledge (NACK) for H-ARQ operation via the DL EU signaling channel 106. The Node-B 200 may also respond with rate grants to the WTRU 100 in response to E-DCH data transmissions.

[0022] Figure 2 is a block diagram of protocol architecture of the E-DCH 102 in accordance with the present invention. A new MAC entity for EU called MAC-e is created in the WTRU 100, the Node-B 200 and the RNC 300 to handle all functions related to the transmission and reception of an E-DCH. A MAC-e entity 120 is incorporated into the WTRU 100 between a MAC-d entity 130 and a

physical layer (PHY) entity 110. The MAC-e 120 in the WTRU handles H-ARQ transmissions and retransmissions, priority handling, MAC-e multiplexing, and TFC selection. A MAC-e 220 entity is incorporated into the Node-B 200 which handles H-ARQ transmissions and retransmissions, E-DCH scheduling and MAC-e demultiplexing. A MAC-e entity 320 is incorporated into the RNC 300 to provide in-sequence delivery and to handle combining of data from different Node-Bs.

[0023] Figure 3 is a block diagram of the MAC-e 120 architecture in a WTRU 100 in accordance with the present invention. The WTRU MAC-e 120 comprises an EU rate request/assignment entity 122, a priority handling entity 124, a TFC selection entity 126 and an H-ARQ entity 128. It should be noted that Figure 3 is provided as an example of preferred embodiment of the present invention and that the entities shown in Figure 3 may be incorporated into a common MAC functional entity and that the functions may be implemented by more or less functional entities.

[0024] The EU rate request/assignment entity 122 is responsible for requesting radio resources from the Node-B 200 when the WTRU 100 has E-DCH data waiting to be transmitted via the E-DCH 102. The EU rate request could be one of a traffic volume indicator, a requested data rate, a TFC index, and traffic volume measurement (TVM) quantities for each data flow. The rate request can be sent to the Node-B 200 via either physical or MAC layer signaling. Rate requests are generated based on radio link control (RLC) data TVM. The TVM may include traffic volume of data for E-DCH transmissions or optionally may further include data awaiting retransmission with active H-ARQ processes.

[0025] When the WTRU 100 receives a rate grant, (i.e., rate and/or time scheduling), from the Node-Bs 200, (the WTRU may receive the rate grant from more than one Node-B), the EU rate request/assignment entity 122 notifies the priority handling entity 124 that resources are available for transmission of the data. The received rate grants determine the E-DCH transport format combination set (TFCS) subset, and/or start time, and duration (optional).

[0026] By sending the rate request, the WTRU 100 may ask the Node-B

200 to change the set of allowed UL TFCs within the TFCS, and the Node-B 200 can change the allowed UL TFCs within the TFCS by sending the rate grant. The WTRU 100 may send a scheduling information update to the Node-B 200 to provide buffer occupancy and/or available transmit power information so that a scheduling entity 222 in the Node-B 200 may determine appropriate TFCS indicator and transmission time interval. For fast rate scheduling by persistency control, the Node-B 200 may send parameters that represent the available interference the system can tolerate and thus prevent WTRUs in rate control mode from introducing additional interference. One way this can be accomplished is for the Node-B 200 to signal the allowed transmit power the WTRU 100 may use for EU transmissions in the rate grant.

[0027] The priority handling entity 124 manages the assignment of data flows and H-ARQ processes according to the priority of the data. Based on transmission feedback from associated DL EU signaling, either a new transmission or retransmission is determined. Furthermore, a queue identity (ID) and transmission sequence number (TSN) for each MAC protocol data unit (PDU) is determined. The TSN is unique to each priority class within an E-DCH, and is incremented for each new data block. Optionally, the priority handling entity 124 may preempt retransmission of lower priority data. A new transmission of higher priority data can be initiated instead of a pending retransmission of lower priority data at any time to support priority handling.

[0028] The TFC selection entity 126 selects a TFC for the data to be transmitted on the E-DCH 102 according to the information signaled in the rate grants, and multiplexes multiple MAC-d flows into one MAC-e PDU. The rate grant may be either absolute grant or relative grant. The absolute grant provides an absolute limitation of the maximum amount of UL resources that the WTRU may use. The relative grant increases or decreases the resource limitation compared to the previously used value.

[0029] The TFC selection is subject to maximum allowed transmit power, and the corresponding TFCS subset allowed by the rate grants from the Node-B 200. TFC selection is based on logical channel priorities such that the TFC

selection maximizes the transmission of higher priority data. The allowed combinations of MAC-d flows in one MAC-e PDU, which is configured by the RNC, are also considered in selecting the TFC.

[0030] The H-ARQ entity 128 handles all the tasks that are required for H-ARQ protocols. The H-ARQ entity 128 is responsible for storing MAC-e payloads and retransmitting them in the case of a failed transmission. The H-ARQ entity 128 may support multiple instances, (H-ARQ processes), of the H-ARQ protocol. There may be more than one H-ARQ process for the EU configured at the WTRU 100.

[0031] In accordance with the present invention, a synchronous H-ARQ is preferably implemented. Therefore, H-ARQ operation is based on synchronous DL ACK and NACK and synchronous retransmissions in the UL.

[0032] Figure 4 is a block diagram of MAC-e 220 architecture in a Node-B 200 in accordance with the present invention. The Node-B MAC-e 220 comprises a scheduler 222, a demultiplexer 224 and an H-ARQ entity 226. In the Node-B, one MAC-e entity 220 is preferably provided for each WTRU and one scheduler is preferably provided for each cell. The scheduler 222 manages E-DCH cell resources between WTRUs.

[0033] The scheduler 222 manages E-DCH resources between WTRUs and H-ARQ processes. Based on rate requests from WTRUs 100, the scheduler 222 generates rate grants and sends them to the WTRUs 100 via DL EU signaling channels 106. The rate grant provides information that determines the set of TFCs from which the WTRU 100 may choose and indicates the maximum resource that a WTRU is allowed to use for E-DCH transmissions. The scheduler 222 controls reception of rate request and transmission of rate grants on a corresponding EU signaling channel. Alternatively, a separate control entity (not shown) may be provided in the Node-B MAC-e 220 for reception of the rate requests and transmission of rate grants and the scheduler 222 may be provided out of the Node-B MAC-e 220.

[0034] The demultiplexer 224 demultiplexes MAC-e PDUs into MAC-d PDUs. MAC-d flow to MAC-e PDU multiplexing is supported in the WTRU 100.

Multiple MAC-d flows can be configured for one WTRU and can be multiplexed in the same MAC-e PDU. The combination of MAC-d flows that can be multiplexed in one MAC-e PDU is configured by the RNC 300. The multiplexed MAC-e PDUs are demultiplexed into MAC-d flows by the demultiplexer 224. The Node-B demultiplexing may result in MAC-d or RLC PDU reordering, and MAC-e PDU reordering may be performed by the RNC 300.

[0035] Reordering may be performed either in the Node-B MAC-e where the H-ARQ process number is known, or in the RNC MAC-e. Referring back to Figure 2, the RNC MAC-e 320 includes a reordering entity for reordering received MAC-e PDUs according to the received transmission sequence number (TSN). MAC-e PDUs with consecutive TSNs are delivered to the disassembly function and PDUs with a missing lower TSN are not delivered to the disassembly function. The disassembly function removes the MAC-e header before sending it to a higher layer. The RNC 300 includes a plurality of reordering queues for reordering PDUs with different priority classes.

[0036] In the case that the reordering is performed in the RNC MAC-e, the Node-B 200 passes the H-ARQ process number with the successfully decoded data to the RNC 300. The H-ARQ process may also be implicitly known by the time of reception at Node-B passed to the RNC. The H-ARQ process number may be implicitly derived from either a system frame number (SFN) or a connection frame number (CFN) along with the knowledge of the H-ARQ process allocation scheme in the WTRU 100.

[0037] The H-ARQ entity 226 generates ACKs and NACKs indicating the delivery status of E-DCH transmissions. One H-ARQ entity may support multiple instances of stop and wait H-ARQ protocols.

[0038] Figure 5 is a block diagram of MAC-e architecture of a WTRU 100 and a Node-B 200 along with signaling processes between the WTRU 100 and the Node-B 200 in accordance with the present invention. When the WTRU MAC-e 120 receives data from WTRU RLC layer 140 to be transmitted via an E-DCH 102 at step 502, the EU rate request entity 122 sends a rate request to the Node-B 200 (step 504). The Node-B 200 responds with a rate grant (step 506). Upon

receipt of the rate grant, the EU rate request entity 122 notifies the priority handling unit 124 that radio resources are available for transmission of the data (step 508). The priority handling unit 124 then multiplexes data and assigns an H-ARQ process according to the priority of the data, and a TFC for the data is selected by the TFC selection entity (steps 510, 512). The data is transmitted with the assigned H-ARQ process via the E-DCH 102 (step 514). The Node-B 200 sends a feedback signal through DL EU signaling channel 106 (step 516). If the feedback is a NACK, the data may be autonomously retransmitted (step 518), or may be retransmitted after another rate grant is received (step 520).

[0039] 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.

[0040] While the present invention has been described in terms of the preferred embodiment, other variations which are within the scope of the invention as outlined in the claims below will be apparent to those skilled in the art.

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CLAIMS

What is claimed is:

1. A medium access control entity for enhanced uplink (MAC-e) in a wireless transmit/receive unit (WTRU) that communicates with a Node-B, the MAC-e comprising:

a rate request/assignment entity for sending a rate request to the Node-B to transmit data via an enhanced dedicated channel (E-DCH) and for processing a rate grant received from the Node-B in response to the rate request;

a priority handling entity for managing assignment of the data and a hybrid-automatic repeat request (H-ARQ) process in accordance with priority of the data to be transmitted;

a transport format combination (TFC) selection entity for selecting a TFC for the data; and

an H-ARQ entity for retransmitting the data in accordance with a transmission feedback from the Node-B.

2. The MAC-e of claim 1 wherein the rate request is performed by sending one of a traffic volume indicator, a requested data rate, a TFC index, and traffic volume measurement quantity for each data.

3. The MAC-e of claim 1 wherein the rate request is transmitted via physical layer signaling.

4. The MAC-e of claim 1 wherein the rate request is transmitted via MAC layer signaling.

5. The MAC-e of claim 1 wherein the rate request is determined by considering radio link control (RLC) data traffic volume.

6. The MAC-e of claim 5 wherein the rate request is determined by further considering data awaiting retransmission in the H-ARQ process.

7. The MAC-e of claim 1 wherein the rate grant informs at least one of E-DCH transport format combination set (TFCS) subset and start time of the E-DCH transmissions.

8. The MAC-e of claim 7 wherein the rate grant further includes the duration of the E-DCH transmissions.

9. The MAC-e of claim 1 wherein the TFC is selected in accordance with at least one of a maximum allowed transmit power and a corresponding transport format combination set (TFCS) subset allowed by the rate grant.

10. The MAC-e of claim 1 wherein the priority handling entity initiates assignment of data flows after receiving a notice from the rate request/assignment entity.

11. The MAC-e of claim 1 wherein a retransmission of lower priority data may be preempted for a new transmission of higher priority data whereby a new transmission of higher priority data may be initiated instead of a retransmission of lower priority data at any time.

12. The MAC-e of claim 1 wherein retransmission of the data which is not successfully delivered is initiated autonomously without a further rate request.

13. The MAC-e of claim 1 wherein retransmission of the data which is not successfully delivered is not autonomously retransmitted, whereby another rate request is transmitted for retransmission of the data.

14. The MAC-e of claim 1 wherein the rate request/assignment entity sends information regarding at least one of buffer occupancy and available transmit power information to the Node-B.

15. The MAC-e of claim 1 wherein the H-ARQ entity implements synchronous H-ARQ, whereby transmission of the feedback and the retransmission are synchronized in the WTRU and the Node-B.

16. The MAC-e of claim 1 wherein the rate grant is an absolute grant, which provides an absolute limitation of the maximum amount of UL resources that the WTRU may use.

17. The MAC-e of claim 1 wherein the rate grant is a relative grant, which increases or decreases the resource limitation compared to the previously used value.

18. A medium access control entity for enhanced uplink (MAC-e) in a Node-B that communicate with a wireless transmit/receive unit (WTRU), the MAC-e comprising:

- a scheduler for managing enhanced dedicated channel (E-DCH) resources between WTRUs in a cell and hybrid-automatic repeat request (H-ARQ) entities for a WTRU and receiving a rate request from a WTRU and sending a rate grant to a WTRU in response to the rate request;

- a demultiplexer for demultiplexing MAC-e protocol data units (PDUs); and

- an H-ARQ process for generating and sending a transmission feedback in response to E-DCH transmissions from the WTRU.

19. The MAC-e of claim 18 wherein the demultiplexer results in dedicated channel MAC (MAC-d) PDU reordering.

20. The MAC-e of claim 18 wherein the demultiplexer results in radio link control (RLC) PDU reordering.

21. The MAC-e of claim 18 wherein the scheduler does not include priority handling.

22. The MAC-e of claim 18 wherein one MAC-e is provided for each WTRU in the Node-B.

23. The MAC-e of claim 22 wherein one scheduler is provided for each cell covered by the Node-B such that the scheduler manages E-DCH resources for WTRUs in the cell.

24. The MAC-e of claim 23 wherein a separate controller is provided for performing a function of receiving the rate request and sending a rate grant performed by the scheduler.

25. A medium access control entity for enhanced uplink (MAC-e) in a Node-B that communicates with a wireless transmit/receive unit (WTRU), the MAC-e comprising:

a controller for receiving a rate request from a WTRU and sending a rate grant which is generated by a scheduler for managing enhanced dedicated channel (E-DCH) resources between WTRUs in a cell;

a demultiplexer for demultiplexing MAC-e protocol data units (PDUs); and

an H-ARQ process for generating and sending a transmission feedback in response to E-DCH transmissions from the WTRU.

26. A medium access control entity for enhanced uplink (MAC-e) in a radio network controller (RNC), comprising:

means for receiving protocol data units (PDUs), each PDU having a transmission sequence number(TSN); and

a reordering entity for reordering the PDUs according to their TSNs.

27. The MAC-e entity of claim 26 further comprising a plurality of reordering queues for reordering PDUs with different priority classes.

28. A method for processing data in a medium access control entity for enhanced uplink transmissions (MAC-e) in a wireless transmit/receive unit (WTRU) which communicates with a Node-B, the method comprising:

receiving a data for transmission via an enhanced dedicated channel (E-DCH);

transmitting a rate request to a Node-B for transmission of the data;

receiving a rate grant;

assigning a hybrid-automatic repeat request (H-ARQ) process for the data in accordance with a priority;

selecting a transport format combination (TFC) for transmitting the data; and

transmitting the data via the assigned H-ARQ process.

29. The method of claim 28 wherein the rate request is performed by sending one of a traffic volume indicator, a requested data rate, a TFC index, and traffic volume measurement quantity for each data.

30. The method of claim 28 wherein the rate request is transmitted via either physical layer or MAC layer signaling.

31. The method of claim 28 wherein the rate request is determined by considering RLC data traffic volume.

32. The method of claim 31 wherein the rate request is determined by further considering data awaiting retransmission in the H-ARQ process.

33. The method of claim 28 wherein the rate grant informs E-DCH transport format combination set (TFCS) subset and/or start time of the E-DCH transmissions.

34. The method of claim 33 wherein the rate grant further includes the duration of the E-DCH transmissions.

35. The method of claim 28 wherein the TFC is selected in accordance with at least one of a maximum allowed transmit power and a corresponding transport format combination set (TFCS) subset allowed by the channel allocation.

36. The method of claim 28 wherein the priority handling entity initiates assignment of data flows after receiving a notice from the rate request/assignment entity.

37. The method of claim 28 wherein a retransmission of lower priority data may be preempted by a new transmission of higher priority data whereby a new transmission of higher priority data may be initiated instead of a retransmission of lower priority data at any time.

38. The method of claim 28 wherein retransmission of the data which is not successfully delivered is initiated autonomously without further rate request.

39. The method of claim 28 wherein retransmission of the data which is not successfully delivered is not autonomously retransmitted, whereby another rate request is transmitted for retransmission of the data.

40. The method of claim 28 wherein the WTRU sends information regarding at least one of buffer occupancy and available transmit power information to the Node-B.

41. The method of claim 28 wherein transmission of the feedback and the retransmission are synchronized in the WTRU and the Node-B.

42. The method of claim 28 wherein the rate grant is an absolute grant, which provides an absolute limitation of the maximum amount of UL resources that the WTRU may use.

43. The method of claim 28 wherein the rate grant is a relative grant, which increases or decreases the resource limitation compared to the previously used value.

44. A method for processing data in a medium access control entity for enhanced uplink (MAC-e) in a Node-B, the method comprising:

receiving a rate request from a wireless transmit/receive unit (WTRU);
scheduling enhanced dedicated channel (E-DCH) transmissions from the WTRU;

sending a rate grant to the WTRU;

receiving E-DCH transmissions from the WTRU; and

providing a hybrid-automatic repeat request (H-ARQ) feedback for the E-DCH transmissions to the WTRU.

45. The method of claim 44 further comprising a step of demultiplexing a MAC-e protocol data unit (PDU) into multiple dedicated channel MAC (MAC-d) flows.

46. The method of claim 44 wherein the step of scheduling does not include priority handling.

47. The method of claim 44 wherein the Node-B sends a correctly decoded data to the RNC for reordering.

48. The method of claim 47 wherein the Node-B sends an H-ARQ process number for the decoded data to the RNC.

49. The method of claim 47 wherein the RNC derives an H-ARQ process number for the decoded data from either a system frame number or a connection frame number.

50. The method of claim 44 wherein one MAC-e is provided for each WTRU in the Node-B.

51. The method of claim 44 wherein one scheduler is provided for each cell in the Node-B such that each scheduler manages E-DCH resources for WTRUs in the corresponding cell.