[0001] # METHOD AND APPARATUS FOR ASSIGNING HYBRID-AUTOMATIC REPEAT REQUEST PROCESSES

[0002] ## FIELD OF INVENTION

[0003] The present invention is related to a wireless communication system including at least one wireless transmit/receive unit (WTRU), at least one Node-B and a radio network controller (RNC). More particularly, the present invention is related to a method and apparatus for assigning automatic repeat request (ARQ)/hybrid automatic repeat request (H-ARQ) processes in the WTRU for supporting enhanced uplink (EU) transmissions.

[0004] ## BACKGROUND

[0005] Methods for improving uplink (UL) coverage, throughput and transmission latency are being investigated in the Third Generation Partnership Project (3GPP). In order to achieve these goals, scheduling and assigning of UL physical resources will be moved from the RNC to the Node-B.

[0006] The Node-B can make decisions and manage UL radio resources on a short-term basis better than the RNC. However, the RNC still retains coarse overall control of the cell with EU services so that the RNC can perform functions such as call admission control and congestion control.

[0007] A new medium access control (MAC) entity called MAC-e is created in a WTRU and the Node-B to handle the transmission and reception of enhanced dedicated channel (E-DCH) transmissions. There may be several independent uplink transmissions processed between the WTRU and UMTS terrestrial radio access network (UTRAN) within a common time interval. One example of this is MAC layer H-ARQ or MAC layer ARQ operation where each individual transmission may require a different number of transmissions to be successfully received by the UTRAN. Proper assignment of data blocks to ARQ/H-ARQ processes for transmission is necessary for operation of the EU services. This function includes rules for retransmitting failed transmissions, prioritization between different logical channels and provisioning of quality of service (QoS) related parameters.

[0008] SUMMARY

[0009] The present invention is related to a method and apparatus for assigning an ARQ/H-ARQ process in a WTRU for supporting EU transmissions. After parameters associated with the ARQ/H-ARQ processes are configured, the WTRU assigns an ARQ/H-ARQ process for a selected data. After transmitting the data, the WTRU determines whether feedback information for the data has been received. The WTRU releases the ARQ/H-ARQ process if an acknowledgement (ACK) message has been received, and retransmits the data if a non-acknowledgement (NACK) message or no feedback information has been received in a predetermined time period while incrementing a transmission counter in the WTRU. When a transmission limit has been reached, the WTRU may discard the data or reinitiate the transmission. An ARQ/H-ARQ process assigned for transmission of lower priority data may be preempted for transmission of higher priority data when there is no available ARQ/H-ARQ process.

[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 operating in accordance with the present invention;

[0013] Figure 2A is a flow diagram of an EU transmission process implemented by the system of Figure 1 for assigning an ARQ or H-ARQ process in accordance with one embodiment of the present invention;

[0014] Figure 2B is a flow diagram of an EU feedback reception process implemented by the system of Figure 1;

[0015] Figure 3A is a flow diagram of an EU transmission process implemented by the system of Figure 1 for assigning an ARQ or H-ARQ process using preemption and re-initiation procedures in accordance with another

embodiment of the present invention; and

[0016] Figure 3B is a flow diagram of an EU feedback reception process implemented by the system of Figure 1.

[0017] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] 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.

[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] Hereafter, for simplicity, the present invention will be explained with reference to H-ARQ operation. However, it should be noted that the present invention is equally applicable to ARQ operation without affecting the functionality of the present invention.

[0021] Figure 1 is a block diagram of a wireless communication system 100 operating in accordance with the present invention. The system 100 includes at least one WTRU 102, at least one Node-B 104 and an RNC 106. The RNC 106 controls overall EU operation by configuring EU parameters for the Node-B 104 and the WTRU 102, such as priority of each TrCH, MAC-d flow or logical channel mapped on an E-DCH, maximum number of transmissions for each TrCH or logical channel, maximum allowed EU transmit power or available channel resources per Node-B 104. The WTRU 102 sends a channel allocation request via the UL EU channel 110 and receives channel allocation information via the DL EU signaling channel 112. The WTRU 102 transmits E-DCH data via a UL EU channel 110 to the Node-B 104 in accordance with the channel allocation information. The Node-B 104 sends feedback information on the data block via the DL EU signaling channel 112 to the WTRU 102.

[0022] In accordance with the present invention, the assignment of an H-ARQ process for supporting a data transmission is controlled by the WTRU 102. The Node-B 104 provides allocation of physical resources for which the WTRU 102 determines what data will be transmitted using which H-ARQ process. The WTRU 102 includes a pool of H-ARQ processes 114, a controller 116 and a transmission counter 118.

[0023] The controller 116 controls the overall assignment of H-ARQ processes including selecting data for transmission based on priority, assigning one of the available H-ARQ processes 114 to the selected data and releasing H-ARQ processes 114 when the data transmission is successfully completed.

[0024] The transmission counter 118 indicates the number of transmissions for a given H-ARQ process, which is equivalent to a receive sequence number (RSN). The transmission counter 118 may also be used to as a new data indicator (NDI).

[0025] In one embodiment, a preemption procedure is used to manage E-DCH transmissions, whereby the assignment of the H-ARQ processes is based on absolute priority. The highest priority class traffic and the earliest transmission number within the same priority class takes precedence over other transmissions. The transmission of a data block is also subject to a maximum number of H-ARQ transmissions for each E-DCH TrCH, or each logical channel mapped to an E-DCH TrCH. An H-ARQ process servicing a lower priority data transmission may be superceded by a higher priority data transmission.

[0026] In another embodiment, a re-initiation procedure is used to manage E-DCH transmissions, whereby if at least one of a transmission time limit and a maximum number of transmissions has been reached, the lower priority data transmission may be reassigned to an H-ARQ process.

[0027] Figure 2A is a flow diagram of an EU transmission process 200 implemented by the system 100 of Figure 1 for assigning H-ARQ processes 114 in accordance with one embodiment of the present invention. When a radio access bearer (RAB) is configured to operate on an E-DCH, parameters related to assigning H-ARQ processes 114 in the WTRU 102 are configured by the RNC 106

to support EU data transmissions (step 202). The parameters include, but are not limited to, priority of each logical channel, MAC-d flow or TrCH mapped to an E-DCH, and maximum number of H-ARQ transmissions for each TrCH, MAC-d flow or logical channel mapped to an E-DCH.

[0028] For each transmit time interval (TTI) at step 204, the WTRU 102 then determines whether physical resources have been allocated for the WTRU 102 for supporting EU operation (step 206). If physical resources have not been allocated at step 206, the process 200 returns to step 204 until the next TTI occurs. If physical resources have been allocated at step 206, the WTRU 102 selects a data block for transmission (step 208). For new data transmissions, the highest priority data block is selected for each assigned H-ARQ process. In step 210, the WTRU 102 then determines a transmission status of the selected data. The transmission status is set as either "new transmission" or "retransmission."

[0029] If, in step 210, the WTRU 102 determines that the transmission status of the selected data is "retransmission", the same H-ARQ process 114 that was used for the previous transmission remains assigned to the data block, the transmission counter 118 in the WTRU 102 is incremented, and an NDI of the transmission is set to "old data" to indicate that the assigned H-ARQ process 114 retransmits data identical to what was transmitted previously, in order to allow for combining at the Node-B 104 (step 212). The process 200 then returns to step 204 until the next TTI occurs.

[0030] If, in step 210, the WTRU 102 determines that the transmission status of the selected data block is "new transmission", the WTRU 102 assigns an available H-ARQ process 114 to the selected data block and sets an NDI to indicate "new data" (step 214). The data block is then transmitted using the assigned H-ARQ process and the transmission counter 118 in the WTRU 102 is incremented (step 216). The process 200 then returns to step 204 until the next TTI occurs.

[0031] Figure 2B is a flow diagram of an EU feedback reception process 250 implemented by the system 100 of Figure 1. In step 252, the WTRU 102 determines whether feedback information for a previously transmitted data block

has been received. If the WTRU 102 received an ACK message, the corresponding H-ARQ process 114 is released and is available for supporting another data transmission (step 254). If the WTRU 102 received a NACK message of a feedback timeout occurs, the WTRU 102 determines whether the transmission counter 118 in the WTRU 102 has reached a predetermined maximum number of H-ARQ transmissions (step 256).

[0032] If the number of H-ARQ transmissions indicated by the transmission counter 118 in the WTRU 102 has not reached a predetermined maximum number at step 256, the transmission status of the data block is set as a "retransmission" (step 258).

[0033] If the maximum number of H-ARQ transmissions is reached at step 256, the WTRU discards the data at the MAC layer and releases the associated H-ARQ process (step 260).

[0034] Figure 3A is a flow diagram of an EU transmission process 300 implemented by the system 100 of Figure 1 for assigning H-ARQ processes 114 using preemption and re-initiation procedures in accordance with another embodiment of the present invention. When a RAB is configured to operate on an E-DCH, parameters related to assigning H-ARQ processes 114 in the WTRU 102 are configured by the RNC 106 to support EU data transmissions (step 302).

[0035] For each transmit time interval (TTI) at step 304, the WTRU 102 then determines whether physical resources have been allocated for the WTRU 102 for supporting EU operation (step 306). A priority class is configured for each logical channel, MAC-d flow or TrCH mapped to an E-DCH, whereby the highest priority data block is always serviced first. If physical resources have not been allocated at step 306, the process 300 returns to step 304 until the next TTI occurs. If physical resources have been allocated at step 306, the WTRU 102 selects for transmission the data block having the highest priority from all possible data that can be transmitted in the current TTI, (i.e., new data, previous unsuccessful transmissions and interrupted transmissions), (step 308). If several data blocks having the same highest priority are available for transmission, the WTRU 102 may prioritize the data block having the earliest sequence number or

the data block having the highest number of transmissions. This operation assists "first-in first-out" (FIFO) processing and minimizes the delay for any data transmission. In step 310, the WTRU 102 then determines a transmission status of the selected data. The transmission status is set as either "new transmission," "retransmission" or "interrupted transmission."

[0036] If the data block has not been previously transmitted, or an H-ARQ transmission is restarted, the transmission status is set as a "new transmission" in step 310. If the data block has been transmitted but was not successfully delivered, (and not interrupted by a higher priority data block), the transmission status of the data is set as a "retransmission" at step 310. The WTRU 102 may optionally implement preemption of an H-ARQ process assigned to support higher priority data. An H-ARQ process already assigned for lower priority data which needs to be transmitted may be preempted with higher priority data when there is no other H-ARQ process available. If the H-ARQ process assigned to the data block is preempted, the lower priority data is blocked from transmission in the current TTI and the transmission status of the blocked data is set as an "interrupted transmission" at step 310.

[0037] If, in step 310, the WTRU 102 determines that the transmission status of the selected data is "retransmission", the same H-ARQ process 114 that was used for the previous transmission remains assigned to the data block, a transmission counter 118 is incremented and an NDI of the transmission is set to "old data" to indicate that the assigned H-ARQ process 114 retransmits data identical to what was transmitted previously, in order to allow for combining at the Node-B 104 (step 312). The process 300 then returns to step 304 until the next TTI occurs.

[0038] If, in step 310, the WTRU 102 determines that the transmission status of the selected data block is "new transmission", the WTRU 102 determines whether there are any H-ARQ processes 114 available (step 314). If an H-ARQ process is available, (or a process supporting lower priority data is available), one of the available H-ARQ processes 114 is selected (step 316). If the transmission status of the selected data block is a "new transmission," the WTRU

102 selects an available H-ARQ process 114 (step 316). The WTRU 102 assigns the selected H-ARQ process 114 to the selected data block and sets an NDI to indicate "new data" (step 318). The data block is then transmitted using the assigned H-ARQ process and the transmission counter 118 in the WTRU 102 is incremented (step 320). The process 300 then returns to step 304 until the next TTI occurs.

[0039] If, in step 310, the WTRU 102 determines that the transmission status of the selected data block is "interrupted transmission", (which is the case for which preemption is permitted), the WTRU 102 determines whether there are any H-ARQ processes 114 available (step 322). If there are no H-ARQ processes 114 available at step 322, transmission of a lower priority data block is interrupted and a transmission status of the interrupted lower priority data is set to "interrupted transmission" (step 324). The H-ARQ process 114 previously assigned for the lower priority data is assigned for the currently selected data block and an NDI is set to indicate new data (step 318). The data block is then transmitted using the assigned H-ARQ process and the transmission counter 118 in the WTRU 102 is incremented (step 320). The process 300 then returns to step 304 until the next TTI occurs.

[0040] Figure 3B is a flow diagram of an EU feedback reception process 350 implemented by the system 100 of Figure 1. In step 352, the WTRU 102 determines whether feedback information for a previously transmitted data block has been received. If the WTRU 102 received an ACK message, the corresponding H-ARQ process 114 is released and is available for supporting another data transmission (step 354). If the WTRU 102 received a NACK message or a feedback timeout occurs, the WTRU 102 determines whether the number of H-ARQ transmissions indicated by the transmission counter 118 in the WTRU 102 has reached a predetermined maximum number of H-ARQ transmissions (step 356).

[0041] If the maximum number of H-ARQ transmissions has not been reached at step 356, the transmission status of the data block is set as a "retransmission" (step 358).

[0042] If the maximum number of H-ARQ transmissions is reached at step 356, the WTRU 102 has two options 360, 362. In the first option 360, the WTRU 102 discards the data block at the MAC layer and releases the assigned H-ARQ process 114. In the second option 362, the WTRU 102 may set the transmission status of the data block as a "restarted transmission" and starts a new transmission for the data block. The transmission counter 118 is then set to zero and the NDI is set to "new data" (step 364).

[0043] 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.

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CLAIMS

What is claimed is:

1. A method for assigning a plurality of hybrid-automatic repeat request (H-ARQ) processes in a wireless transmit/receive unit (WTRU) for supporting enhanced uplink (EU) data transmissions, the method comprising:

(a) selecting data for transmission;

(b) if the selected data was previously transmitted, retransmitting the selected data using the same H-ARQ process that was used to previously transmit the selected data;

(c) if the selected data is new data that was not previously transmitted, assigning an available H-ARQ process for supporting transmission of the selected data; and

(d) the WTRU transmitting the selected data using the assigned H-ARQ process.

2. The method of claim 1 further comprising:

(e) releasing the assigned H-ARQ process if the WTRU receives feedback information indicating that the transmission of the selected data was successful.

3. The method of claim 1 further comprising:

(e) retransmitting the selected data if the WTRU receives feedback information indicating that the transmission of the selected data was not successful.

4. The method of claim 3 further comprising:

(f) discarding the selected data and releasing the assigned H-ARQ process if the selected data was unsuccessfully transmitted a maximum number of times.

5. The method of claim 3 wherein the WTRU includes a transmission counter for indicating the number transmissions associated with the assigned H-ARQ process, the method further comprising:

(f) incrementing the transmission counter in the WTRU each time the selected data is transmitted; and

(g) if the selected data was unsuccessfully transmitted a maximum number of times, setting the transmission counter to zero and setting a new data indicator (NDI) to indicate new data.

6. The method of claim 1 wherein the data selected in step (a) has a priority higher than any other data available for transmission.

7. The method of claim 6 wherein if an H-ARQ process is not available to support the transmission of the selected higher priority data, the method further comprises:

(e) interrupting the transmission of lower priority data; and

(f) reassigning an H-ARQ process used to support the interrupted transmission to the transmission of the selected higher priority data.

8. The method of claim 1 wherein step (b) further comprises setting a new data indicator (NDI) to indicate old data.

9. The method of claim 1 wherein step (c) further comprises setting a new data indicator (NDI) to indicate new data.

10. The method of claim 1 wherein the WTRU selects data for transmission based on absolute priority of the data.

11. The method of claim 10 wherein the absolute priority is configured for each EU transport channel (TrCH), medium access control for dedicated channel (MAC-d) flow and logical channel.

12. The method of claim 10 wherein the WTRU selects a data block with an earliest sequence number when there is a plurality of data blocks with the same priority.

13. The method of claim 10 wherein the WTRU selects a data block with the highest number of H-ARQ transmissions when there is a plurality of data blocks with the same priority.

14. The method of claim 1 wherein an H-ARQ process assigned for transmission of lower priority data is preempted for transmission of higher priority data when there is no H-ARQ process available to support the transmission of the higher priority data.

15. A method for assigning a plurality of hybrid-automatic repeat request (H-ARQ) processes in a wireless transmit/receive unit (WTRU) for supporting enhanced uplink (EU) data transmissions, the method comprising:

(a) selecting high priority data for transmission;

(b) interrupting the transmission of lower priority data when an H-ARQ process is not available to be assigned to support transmission of the selected high priority data; and

(c) reassigning an H-ARQ process used to support the interrupted transmission to the transmission of the selected high priority data.

16. A wireless transmit/receive unit (WTRU) for assigning a plurality of hybrid automatic repeat request (H-ARQ) processes for supporting enhanced uplink (EU) transmissions, the WTRU comprising:

(a) a pool of H-ARQ processes for supporting transmission of data;

(b) a transmission counter for indicating the number transmissions associated with an assigned H-ARQ process; and

(c) a controller for selecting data for transmission and assigning an H-ARQ process for supporting transmission of the selected data, wherein:

(i) if the selected data was previously transmitted, the WTRU retransmits the selected data using the same H-ARQ process that was used to previously transmit the selected data;

(ii) if the selected data is new data that was not previously transmitted, the controller assigns an available H-ARQ process for supporting transmission of the selected data; and

(iii) the WTRU transmits the selected data using the assigned H-ARQ process.

17. The WTRU of claim 16 wherein the controller releases the assigned H-ARQ process if the WTRU receives feedback information indicating that the transmission of the selected data was successful.

18. The WTRU of claim 16 wherein the WTRU retransmits the selected data if the WTRU receives feedback information indicating that the transmission of the selected data was not successful.

19. The WTRU of claim 18 wherein the controller discards the selected data and releases the assigned H-ARQ process if the selected data was unsuccessfully transmitted a maximum number of times.

20. The WTRU of claim 18 wherein the controller increments a transmission count each time the selected data is transmitted, the controller sets the transmission counter to zero and the controller sets a new data indicator (NDI) to indicate new data if the selected data was unsuccessfully transmitted a maximum number of times.

21. The WTRU of claim 16 wherein the data selected for transmission by the controller has a priority higher than any other data available for transmission.

22. The WTRU of claim 21 wherein if an H-ARQ process is not available to support the transmission of the selected higher priority data, the controller interrupts the transmission of lower priority data and reassigns an H-ARQ process used to support the interrupted transmission to the transmission of the selected higher priority data.

23. The WTRU of claim 16 wherein the controller sets a new data indicator (NDI) to indicate old data when the WTRU retransmits the selected data using the same H-ARQ process that was used to previously transmit the selected data.

24. The WTRU of claim 16 wherein the controller sets a new data indicator (NDI) to indicate new data when the controller assigns an available H-ARQ process for supporting transmission of the selected data.

25. The WTRU of claim 16 wherein the controller selects data for transmission based on absolute priority of the data.

26. The WTRU of claim 25 wherein the absolute priority is configured for each EU transport channel (TrCH), medium access control for dedicated channel (MAC-d) flow and logical channel.

27. The WTRU of claim 25 wherein the controller selects a data block with an earliest sequence number when there is a plurality of data blocks with the same priority.

28. The WTRU of claim 25 wherein the controller selects a data block with the highest number of H-ARQ transmissions when there is a plurality of data blocks with the same priority.

29. The WTRU of claim 16 wherein an H-ARQ process assigned for transmission of lower priority data is preempted for transmission of higher priority data when there is no H-ARQ process available to support the transmission of the higher priority data.

30. A wireless transmit/receive unit (WTRU) for assigning a plurality of hybrid automatic repeat request (H-ARQ) processes for supporting enhanced uplink (EU) transmissions, the WTRU comprising:

(a) a pool of H-ARQ processes for supporting transmission of data; and

(b) a controller for selecting high priority data for transmission and assigning an H-ARQ process for supporting transmission of the selected data, wherein the controller interrupts the transmission of lower priority data when an H-ARQ process is not available to be assigned to support transmission of the selected high priority data, and the controller reassigns an H-ARQ process used to support the interrupted transmission to the transmission of the selected high priority data.

31. The WTRU of claim 30 further comprising:

(c) a transmission counter in communication with the controller, the transmission counter for indicating the number transmissions associated with an assigned H-ARQ process.

32. An integrated circuit (IC) for assigning a plurality of hybrid automatic repeat request (H-ARQ) processes for supporting enhanced uplink (EU) transmissions, the IC comprising:

(a) a pool of H-ARQ processes for supporting transmission of data;

(b) a transmission counter for indicating the number transmissions associated with an assigned H-ARQ process; and

(c) a controller for selecting data for transmission and assigning an H-ARQ process for supporting transmission of the selected data, wherein:

(i) if the selected data was previously transmitted, the IC retransmits the selected data using the same H-ARQ process that was used to previously transmit the selected data;

(ii) if the selected data is new data that was not previously transmitted, the controller assigns an available H-ARQ process for supporting transmission of the selected data; and

(iii) the IC transmits the selected data using the assigned H-ARQ process.

33. The IC of claim 32 wherein the controller releases the assigned H-ARQ process if the IC receives feedback information indicating that the transmission of the selected data was successful.

34. The IC of claim 32 wherein the IC retransmits the selected data if the IC receives feedback information indicating that the transmission of the selected data was not successful.

35. The IC of claim 34 wherein the controller discards the selected data and releases the assigned H-ARQ process if the selected data was unsuccessfully transmitted a maximum number of times.

36. The IC of claim 34 wherein the controller increments the transmission counter each time the selected data is transmitted, and the controller sets the transmission counter to zero and sets a new data indicator (NDI) to indicate new data if the selected data was unsuccessfully transmitted a maximum number of times.

37. The IC of claim 32 wherein the data selected for transmission by the controller has a priority higher than any other data available for transmission.

38. The IC of claim 37 wherein if an H-ARQ process is not available to support the transmission of the selected higher priority data, the controller interrupts the transmission of lower priority data and reassigns an H-ARQ process used to support the interrupted transmission to the transmission of the selected higher priority data.

39. The IC of claim 32 wherein the controller sets a new data indicator (NDI) to indicate old data when the IC retransmits the selected data using the same H-ARQ process that was used to previously transmit the selected data.

40. The IC of claim 32 wherein the controller sets a new data indicator (NDI) to indicate new data when the controller assigns an available H-ARQ process for supporting transmission of the selected data.

41. The IC of claim 32 wherein the controller selects data for transmission based on absolute priority of the data.

42. The IC of claim 41 wherein the absolute priority is configured for each EU transport channel (TrCH), medium access control for dedicated channel (MAC-d) flow and logical channel.

43. The IC of claim 41 wherein the controller selects a data block with an earliest sequence number when there is a plurality of data blocks with the same priority.

44. The IC of claim 41 wherein the controller selects a data block with the highest number of H-ARQ transmissions when there is a plurality of data blocks with the same priority.

45. The IC of claim 32 wherein an H-ARQ process assigned for transmission of lower priority data is preempted for transmission of higher

priority data when there is no H-ARQ process available to support the transmission of the higher priority data.

46. An integrated circuit (IC) for assigning a plurality of hybrid automatic repeat request (H-ARQ) processes for supporting enhanced uplink (EU) transmissions, the IC comprising:

(a) a pool of H-ARQ processes for supporting transmission of data; and

(b) a controller for selecting high priority data for transmission and assigning an H-ARQ process for supporting transmission of the selected data, wherein the controller interrupts the transmission of lower priority data when an H-ARQ process is not available to be assigned to support transmission of the selected high priority data, and the controller reassigns an H-ARQ process used to support the interrupted transmission to the transmission of the selected high priority data.

47. The IC of claim 46 further comprising:

(c) a transmission counter in communication with the controller, the transmission counter for indicating the number transmissions associated with an assigned H-ARQ process.