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(54) METHOD FOR PROCESSING TRAFFIC DATA IN A WIRELESS COMMUNICATIONS SYSTEM

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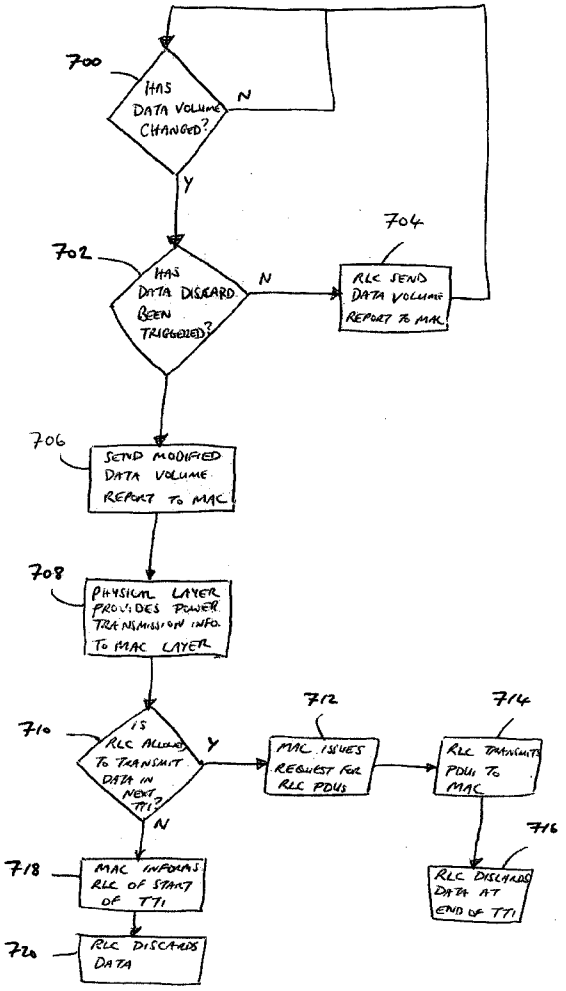
(57) ABSTRACT

The present invention concerns a method of processing traffic data in Layer 2 of a wireless communications system, whereby the MAC layer is arranged, after receipt of a traffic data volume report from the RLC layer, to process said data volume report and to then issue an acknowledgement message to the RLC layer. The method ensures that the RLC and MAC layers are synchronised with respect to traffic data processing. The MAC layer may be arranged to issue an acknowledgement to the RLC layer only where it determines from processing a data volume report that the RLC layer is not permitted to transmit data in a next or subsequent corresponding TTI. The present invention also concerns a process for data discard in a Radio Link Control (RLC) layer of a Wideband Code Division Multiple Access (WCDMA) wireless communications system such as a Universal Mobile Telecommunications System (UMTS). The process involves, responsive to the triggering of a data discard operation, determining whether the RLC layer is permitted to transmit data. Where it is determined that the RLC layer is not permitted to transmit data in a next or subsequent TTI, the method includes the step of informing the RLC layer that data is not required.



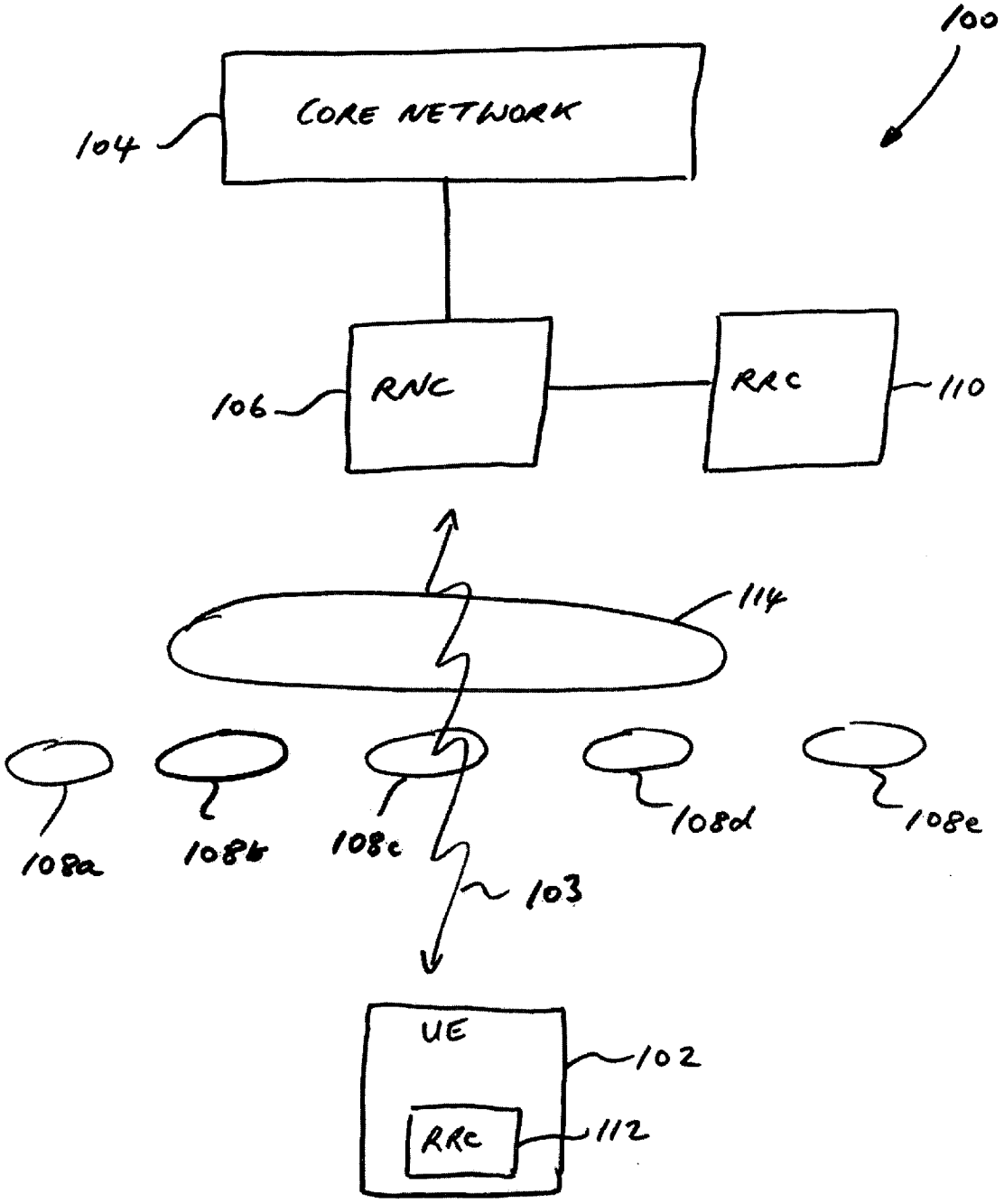

100
CORE NETWORK
104
RNC
106
RRC
110
114
108a
108b
108c
108d
108e
103
UE
102
RRC
112

FIGURE 1.

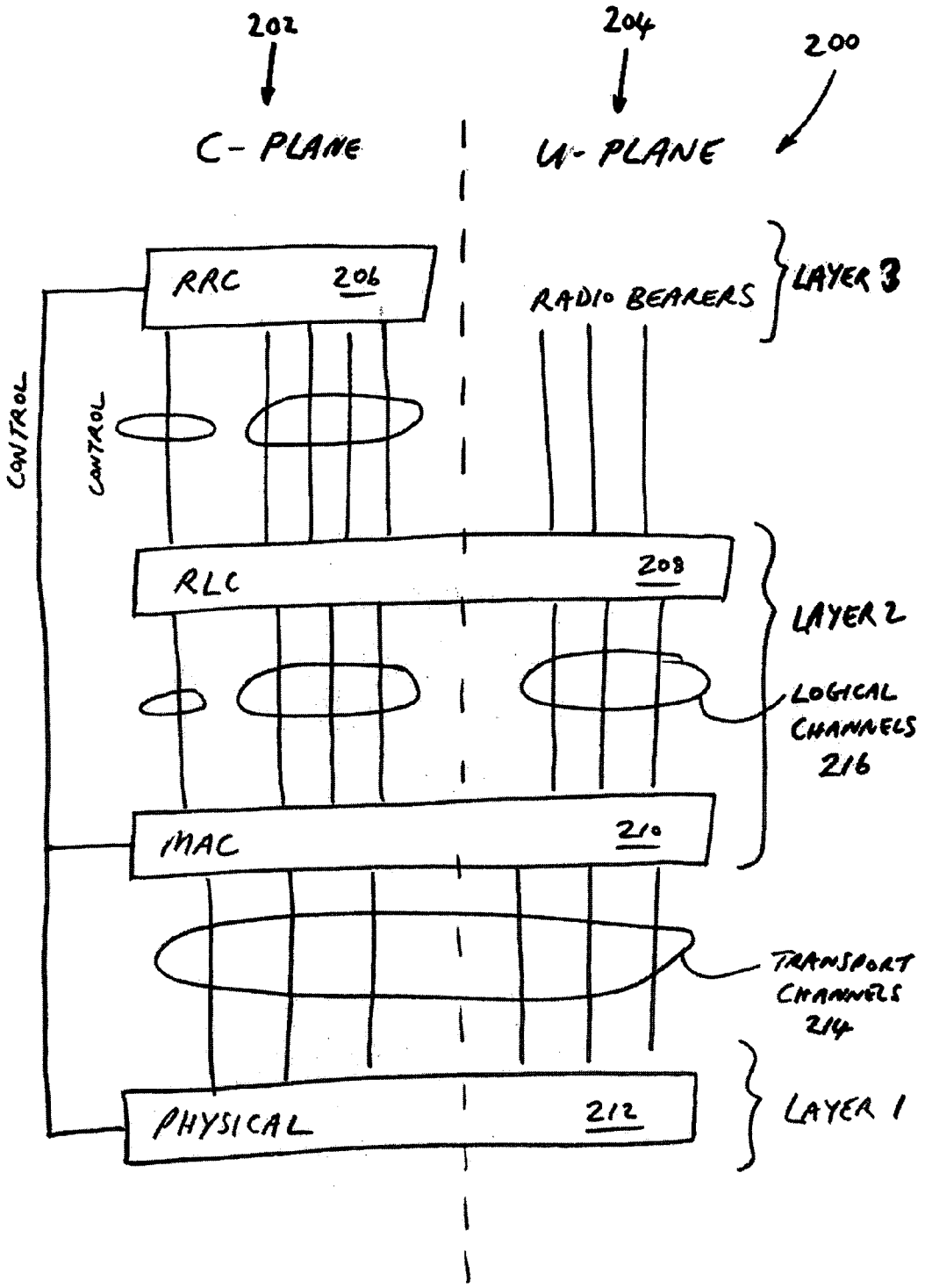

202
204
200
C- PLANE
U- PLANE
RRC
206
RADIO BEARERS
LAYER 3
CONTROL
CONTROL
RLC
208
LAYER 2
LOGICAL CHANNELS 216
MAC
210
TRANSPORT CHANNELS 214
PHYSICAL
212
LAYER 1

FIGURE 2

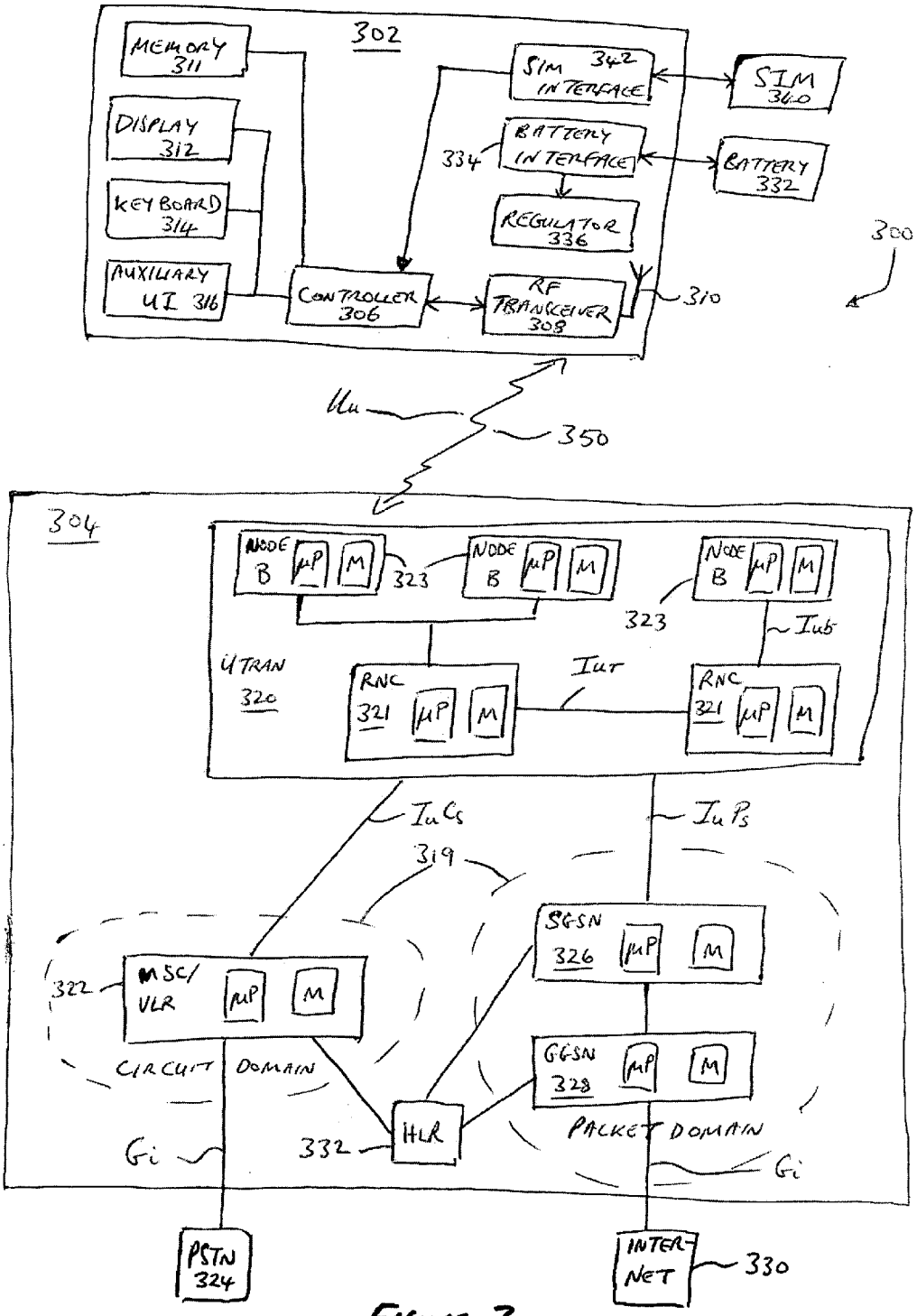

302
MEMORY 311
DISPLAY 312
KEYBOARD 314
AUXILIARY UI 316
CONTROLLER 306
SIM INTERFACE 342
SIM 340
BATTERY INTERFACE
334
BATTERY 332
REGULATOR 336
RF TRANSCEIVER 308
310
300
Uu
350
304
NODE B
μP
M
323
UTRAN 320
RNC 321
Iur
Iub
IuCs
IuPs
319
MSC/VLR
322
CIRCUIT DOMAIN
SGSN 326
GGSN 328
PACKET DOMAIN
HLR
332
Gi
PSTN 324
INTERNET
330

FIGURE 3

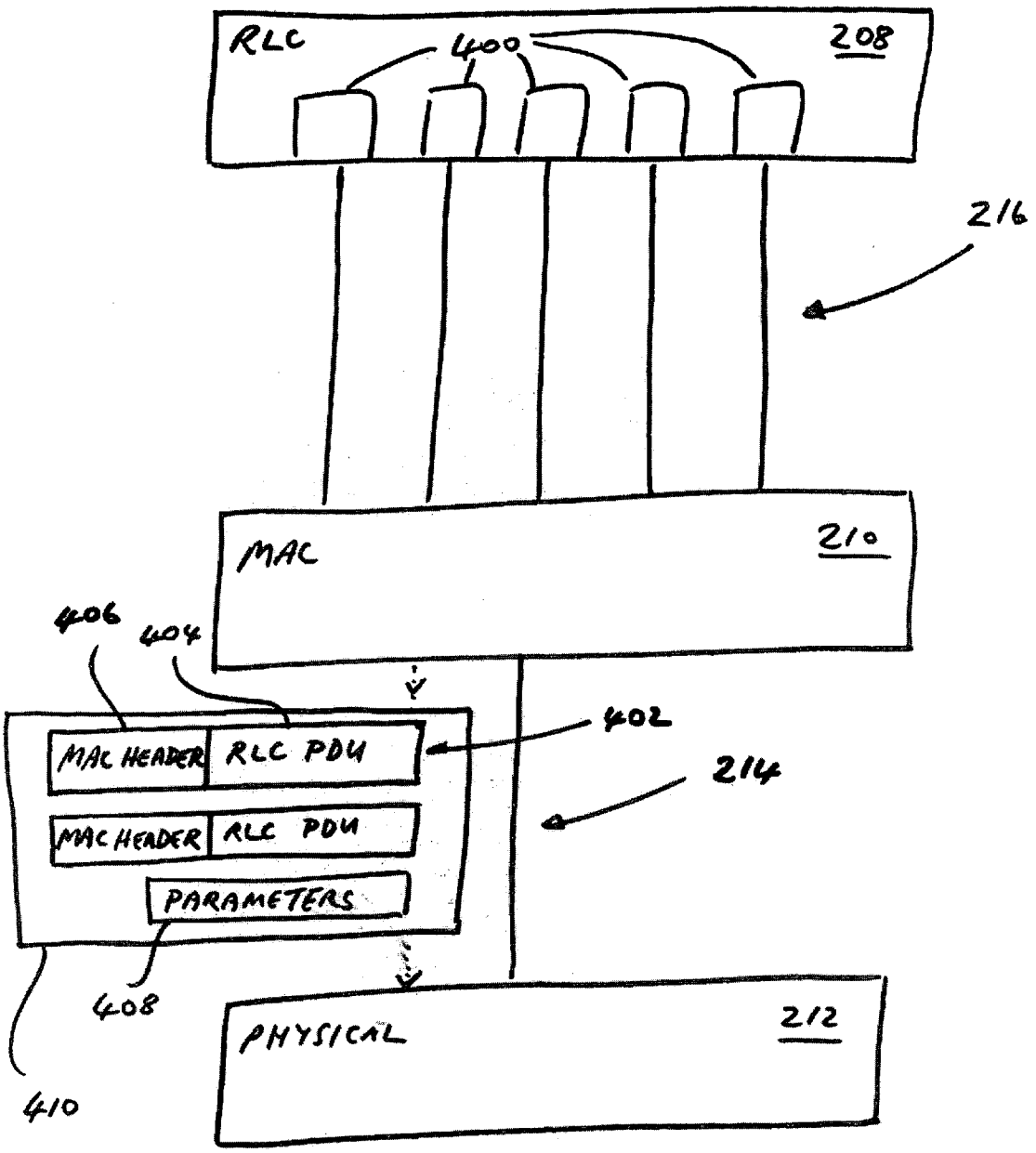

RLC
400
208
216
MAC
210
406
404
402
MAC HEADER
RLC PDU
214
MAC HEADER
RLC PDU
PARAMETERS
408
410
PHYSICAL
212

FIGURE 4

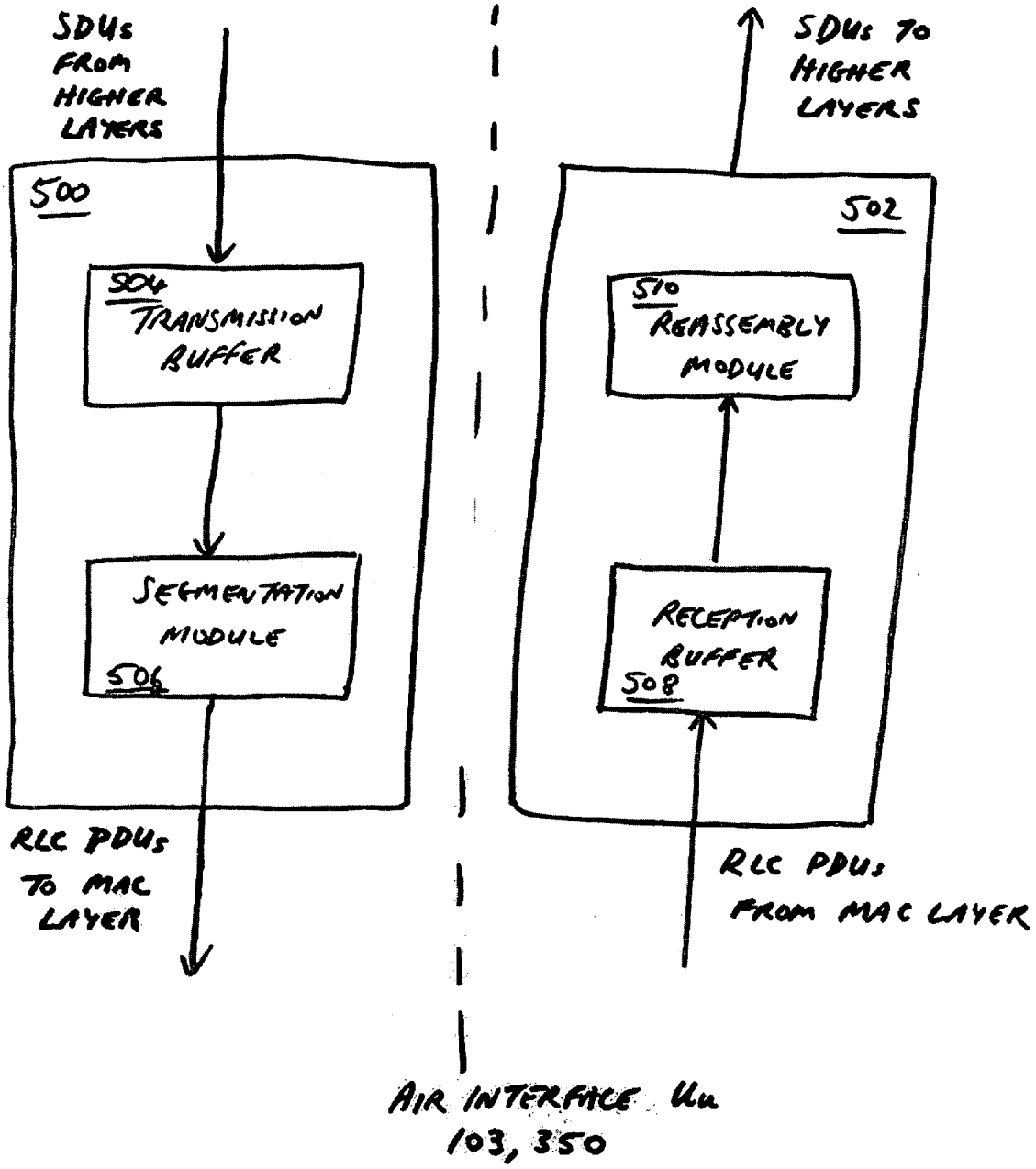

SDUs FROM HIGHER LAYERS
500
504 TRANSMISSION BUFFER
SEGMENTATION MODULE 506
RLC PDUs TO MAC LAYER
SDUs TO HIGHER LAYERS
502
510 REASSEMBLY MODULE
RECEPTION BUFFER 508
RLC PDUs FROM MAC LAYER
AIR INTERFACE Uu
103, 350

FIGURE 5

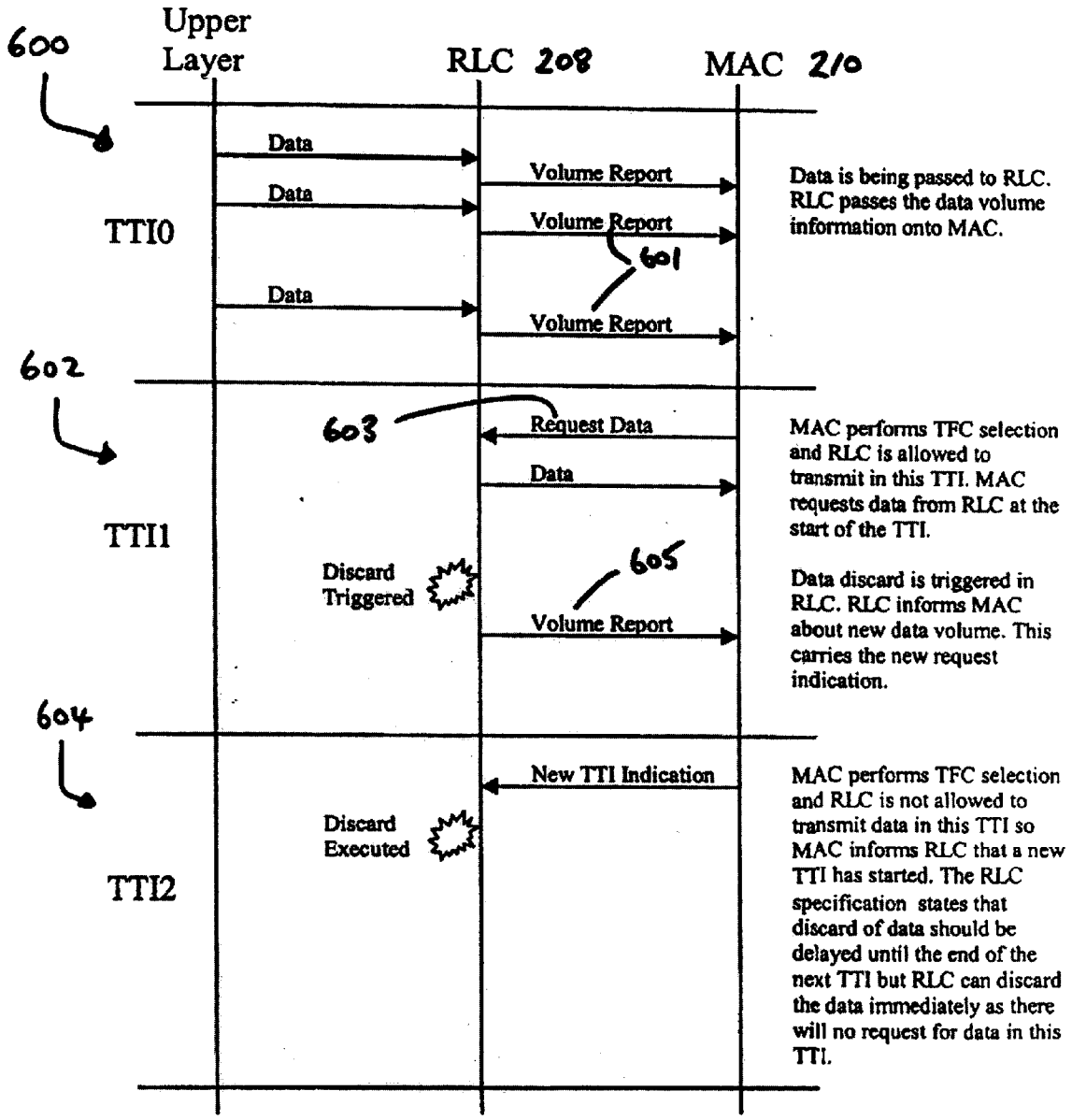

600
Upper Layer
RLC 208
MAC 210
Data
Data
Data
Volume Report
Volume Report
Volume Report
601
TTI0
Data is being passed to RLC. RLC passes the data volume information onto MAC.
602
603
Request Data
Data
TTI1
MAC performs TFC selection and RLC is allowed to transmit in this TTI. MAC requests data from RLC at the start of the TTI.
Discard Triggered
605
Volume Report
Data discard is triggered in RLC. RLC informs MAC about new data volume. This carries the new request indication.
604
New TTI Indication
Discard Executed
TTI2
MAC performs TFC selection and RLC is not allowed to transmit data in this TTI so MAC informs RLC that a new TTI has started. The RLC specification states that discard of data should be delayed until the end of the next TTI but RLC can discard the data immediately as there will no request for data in this TTI.

FIGURE 6.

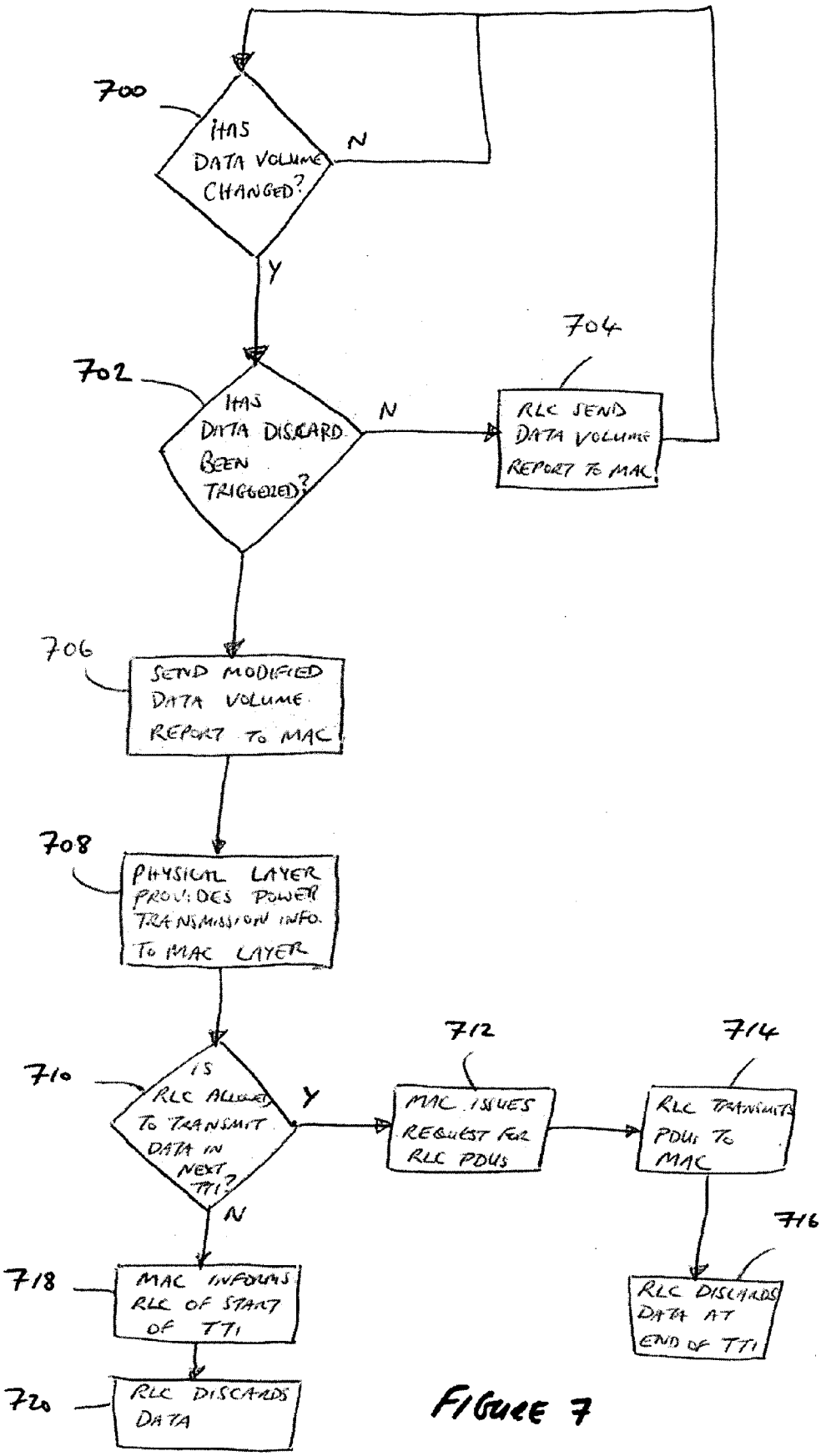

700
HAS DATA VOLUME CHANGED?
N
Y
702
HAS DATA DISCARD BEEN TRIGGERED?
N
704
RLC SEND DATA VOLUME REPORT TO MAC
706
SEND MODIFIED DATA VOLUME REPORT TO MAC
708
PHYSICAL LAYER PROVIDES POWER TRANSMISSION INFO. TO MAC LAYER
710
IS RLC ALLOWED TO TRANSMIT DATA IN NEXT TTI?
Y
N
712
MAC ISSUES REQUEST FOR RLC PDUs
714
RLC TRANSMITS PDUs TO MAC
716
RLC DISCARDS DATA AT END OF TTI
718
MAC INFORMS RLC OF START OF TTI
720
RLC DISCARDS DATA

FIGURE 7

METHOD FOR PROCESSING TRAFFIC DATA IN A WIRELESS COMMUNICATIONS SYSTEM

FIELD OF THE INVENTION

[0001] The present invention comprises an improved method for processing traffic data at Layer 2 in a wireless communications system and particularly, but not exclusively to an improved process for data discard in a Radio Link Control (RLC) layer of a Wideband Code Division Multiple Access (WCDMA) wireless communications system such as a Universal Mobile Telecommunications System (UMTS). Background to the Invention.

[0002] The UMTS network architecture consists of three components, namely the Core Network, the UMTS Terrestrial Radio Access Network (UTRAN) and the User Equipment (UE). In UTRAN, three protocol layers are specified. These comprise: Layer 1, the physical layer which uses WCDMA on the radio link interface; Layer 2, the link layer containing Medium Access Control (MAC), Radio Link Control (RLC) and Packet Data Convergence Protocol (PDCP) sub-layers; and Layer **3**, the Radio Resource Control (RRC) which exists in the control plane only. These layers are mirrored in the UE at the other end of the radio link with the UTRAN.

[0003] The physical layer transforms radio frames between the Node B and the UE. One radio frame, which may include several RLC Packet Data Units (PDUs), is sent during each Transmission Time Interval (TTI). Through an attribute of the transport format, the MAC layer decides by means of a Transport Format Combination (TFC) selection process which PDUs to send in each TTI. Three types of service are provided by the RLC protocol comprising Transparent Mode (TM), Unacknowledged Mode (UM) and Acknowledged Mode (AM). The RRC is responsible for the transport format and also determines the transmission mode of the RLC.

[0004] The RLC performs segmentation/reassembly of RLC Service Data Units (SDUs), into/from smaller RLC PDUs. The three RLC operations needed to make flow control more efficient are a polling mechanism, a status transmission mechanism and a SDU discard mechanism.

[0005] The SDU discard function allows the sender (UTRAN or UE) to discard RLC SDUs when the transmission of the RLC SDUs does not succeed for a period of time or for a number of transmissions. The SDU discard function therefore helps avoid buffer overflow which might result in following RLC SDUs being discarded as a result of the buffer being full. There are several alternative operation modes of the RLC data discard function. Upper layers control which operation mode is used for each RLC entity. The data discard operation modes include, for example, "timer based discard with explicit signalling" applicable to AM transmission only and "timer based discard without explicit signalling" applicable to TM and UM transmission. SDU discard function is always configured for AM transmission, but may not always be configured for TM and UM transmission.

[0006] SDUs buffered in the RLC layer which are to be discarded should not, however, be discarded where the MAC layer has started its TFC selection. When TFC selection has started, the RLC layer delays discarding the data until the end of the next TTI. The problem encountered with this process is that the RLC layer is not made aware of when the MAC layer has started its TFC selection. The RLC layer will receive an indication from the MAC layer when a TFC selection has ended and the RLC layer is required to provide the MAC layer with data for the corresponding TTI. However, when no data from the RLC layer is to be transmitted in that corresponding TTI, the MAC layer does not send any indication of end of TFC selection to the RLC layer. This may occur for a number of consecutive TTIs and thus, since the RLC layer does not receive any indication from the MAC layer of end of TFC selection for the series of TTIs, the RLC layer cannot discard the data during that time. This impacts the Quality of Service (QoS) offered by the RLC layer as data will not be discarded as specified. Also, new data being received in the RLC layer from upper layers may be discarded as a result of RLC buffer overflow whilst the RLC layer awaits an indication from the MAC layer of end of TFC selection.

OBJECT OF THE INVENTION

[0007] It is an object of the invention to mitigate and/or obviate problems associated with the existing arrangement as described above.

[0008] It is a further object of the invention to minimise the time between the RLC layer triggering a data discard operation and actually performing the discard operation.

SUMMARY OF THE INVENTION

[0009] In a first main aspect, the present invention provides a method of processing traffic data in a medium access control (MAC) layer of a wireless communications system, the method comprising the steps of: receiving a traffic data volume report at the MAC layer; processing said data volume report; and following processing of said report, issuing an acknowledgement message to the entity from which the report was received. The entity issuing the data volume report comprises a radio link control (RLC) layer of the wireless communications system.

[0010] Preferably, the MAC layer is arranged to issue an acknowledgement message to the entity from which the report was received only where it is determined from the data volume report that said entity is not permitted to transmit traffic data to the MAC layer in a next or subsequent corresponding transmission time interval (TTI).

[0011] In a second main aspect, the present invention provides a method of discarding data in a radio link control (RLC) layer of a wireless communications system, comprising the steps of: triggering a data discard operation in a first transmission time interval (TTI); determining for a next or a subsequent TTI whether the RLC layer is permitted to transmit data; and where the determination is made that the RLC layer is not permitted to transmit data in the next or subsequent TTI, the method includes the steps of: informing the RLC layer that data is not required; and performing the data discard operation.

[0012] Consequently, the present invention mitigates the problem associated with the current SDU discard process whereby the data discard operation may, in effect, be suspended for a series of consecutive TTIs.

[0013] Preferably, the RLC layer is informed that data is not required for the next or subsequent TTI after completion of a current Transport Format Combination (TFC) selection process.

[0014] Preferably, the data discard operation is performed immediately upon the RLC layer being informed that data is not required.

[0015] Advantageously, this reduces the time delay between a data discard operation being triggered and being performed and reduces the likelihood of following SDUs from upper layers being discarded through RLC buffer overflow.

[0016] The method may include arranging for a Medium Access Control (MAC) layer to inform the RLC layer that data is not required. The indication that data is not required may comprises an indication of the start of the next TTI.

[0017] Preferably, the triggering of the data discard operation in the first TTI causes said RLC layer to issue a request to said MAC layer in said first TTI for the MAC layer to inform the RLC layer that data is not required for the next or subsequent TTI.

[0018] The request issued by said RLC layer in said first TTI may be contained in a data volume report.

[0019] In a third main aspect, the present invention provides a radio network controller (RNC) for a wireless communications network, comprising: means for triggering a data discard operation in a first transmission time interval (TTI); means for determining for a next or a subsequent TTI whether the RLC layer is permitted to transmit data; means responsive to said determining means and being arranged where said determining means determines that the RLC layer is not permitted to transmit data in the next or subsequent TTI to inform the RLC layer that data is not required; and means for performing the data discard operation.

[0020] In a fourth main aspect, the present invention provides a user equipment (UE) for a wireless communications network, comprising: means for triggering a data discard operation in a first transmission time interval (TTI); means for determining for a next or a subsequent TTI whether the RLC layer is permitted to transmit data; means responsive to said determining means and being arranged where said determining means determines that the RLC layer is not permitted to transmit data in the next or subsequent TTI to inform the RLC layer that data is not required; and means for performing the data discard operation.

[0021] The user equipment may comprise a mobile communications device.

[0022] In a fifth main aspect, the present invention provides a computer readable medium comprising code means executable on a processor of the radio network controller in accordance with the third main aspect for implementing the methods of the first and second main aspects.

[0023] In a sixth main aspect, the present invention provides a computer readable medium comprising code means executable on a processor of the user equipment of the fourth main aspect for implementing the methods of the first and second main aspects.

[0024] Further aspects and features of the present invention will be apparent from the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] A description of the present invention will follow with reference to the accompanying drawings, of which:

[0026] **FIG. 1** is a block schematic diagram of a UTRAN system architecture;

[0027] **FIG. 2** is a block schematic diagram illustrating a radio interface protocol architecture for the air interface between a UE and the UTRAN;

[0028] **FIG. 3** is a block schematic diagram which illustrates components of the UE and the UMTS network;

[0029] **FIG. 4** is a is a block schematic diagram illustrating a part of the radio interface protocol architecture of **FIG. 2**;

[0030] **FIG. 5** is a block schematic diagram illustrating the RLC entities for TM transmission;

[0031] **FIG. 6** illustrates messages exchanged between the RLC and MAC layers with respect to successive transmission time intervals (TTIs) in accordance with the data discard process of the present invention; and

[0032] **FIG. 7** is a flow diagram illustrating the steps of the data discard process of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0033] The foregoing and further features of the present invention will be more readily understood from a description of a preferred embodiment, by way of example thereof, with reference to the accompanying figures.

[0034] The so-called third generation mobile communications system is presently evolving. This is a next generation global mobile communications system that is generally based on the core network technology of the existing Global System for Mobile Communications (GSM). Various telecommunications standards bodies and telecommunications equipment vendors from around the world have agreed to collaborate on what is known as the Third Generation Partnership Project (3GPP). The 3GPP encompasses a number of research fields including the Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network (UTRAN). UMTS is the European form of the third generation mobile communications system.

[0035] The following description of the UTRAN with reference to FIGS. **1** to **5** is provided as background to the present invention and by way of explanation thereof.

[0036] Referring to **FIG. 1**, a UTRAN **100** connects a User Equipment (UE) **102** over a wireless interface **103** to a core network **104** which provides services to subscribers (users of UEs). The UE **102** may comprise a mobile wireless device as will be familiar to a skilled artisan. The UE **102** is connected to the core network **104** through a Radio Network Controller (RNC) **106** which controls a plurality of cells **108***a-e* within which the UE **102** can operate as it moves within respective geographical areas of said cells **108***a-e*.

The UTRAN **100** comprises a number of RNCs **106** although only one is shown in the figure for reasons of convenience.

[**0037**] Each of the RNC **106** and the UE **102** has a respective Radio Resource Controller **110**, **112** associated therewith. The RNC RRC **110** provides various functions including establishment, maintenance and release of radio access resources for UEs **102** within the cells controlled by the RNC RRC **110** and may include an information broadcast function for all such UEs **102**. The UE RRC **112** co-operates with the RNC RRC **110** to establish, maintain and release radio access resources allocated to its UE **102**.

[**0038**] Each cell **108***a-e* comprises a respective geographical area in which radio coverage is provided by a respective base station commonly referred to as a Node B (not shown) located within said cell. The Node B's are controlled by their respective RNCs **110**.

[**0039**] In the UTRAN **100**, cells **108***a-e* can be grouped to provide what might be considered a higher level cell or geographical coverage. A UTRAN Registration Area (URA) **11** may comprise one or more of cells **108***a-e* controlled by an RNC **110** or a number of cells from different RNCs, although the URA **114** as illustrated in **FIG. 1** is shown as comprising cells **108***b-d* for reasons of convenience. There can be many URAs although only one is illustrated.

[**0040**] Referring now to **FIG. 2**, shown is a 3GPP radio interface protocol architecture **200** for the air interface **103** between the UE **102** and the RNC **106**. The protocol architecture **200** comprises a control plane (C-plane) **202** and a user plane (U-plane) **204**. The C-plane **202** is used for signalling and the U-plane **204** for transmission of user information. The C-plane **202** includes a RRC layer **206** at Layer **3** of the protocol architecture, a Radio Link Control (RLC) layer **208** and a Medium Access Control (MAC) layer **210** at Layer 2 and a physical layer **212** at Layer 1 thereof. The U-plane **204** shares the RLC layer **208** and the MAC layer **210** at Layer 2.

[**0041**] The physical layer **212** provides the MAC layer **210** with transport channels **214** whilst the MAC layer **210** provides the RLC layer **208** with logical channels **216**. Logical control channels are provided when information for the C-plane **202** is to be transported and traffic channels are provided when user information on the U-plane **204** is to be transported. The MAC layer **210** also provides a radio resource reconfiguration service when the RNC RRC **110** requests a radio resource reconfiguration or a MAC parameter change.

[**0042**] The RLC layer **208** provides radio access establishment and release services. The RNC RRC **110** controls the Layer 3 signal processing between the RNC **104** and the UE **102** to establish, maintain and release radio access resources (radio bearers) between the UE **102** and UTRAN **100**.

[**0043**] The air interface protocol layers as aforedescribed provide many other services and perform many other functions as will be familiar to a skilled artisan and as described in the 3GPP specifications relating to the air interface architecture protocol stack.

[**0044**] **FIG. 3** is a block diagram of a communication system **300**, which includes a UE **302** that communicates through a wireless communication network **304**. UE **302** preferably includes a visual display **312**, a keyboard **314**, and perhaps one or more auxiliary user interfaces (UI) **316**, each of which is coupled to a controller **306**. Controller **306** is also coupled to radio frequency (RF) transceiver circuitry **308** and an antenna **310**.

[**0045**] Typically, controller **306** is embodied as a central processing unit (CPU), which runs operating system software in a memory component **311**. Controller **306** will normally control overall operation of UE **302**, whereas signal processing operations associated with communication functions are typically performed in RF transceiver circuitry **308**. Controller **306** interfaces with UE display **312** to display received information, stored information, user inputs, and the like. Keyboard **314**, which may be a telephone type keypad or full alphanumeric keyboard, is normally provided for entering data for storage in UE **302**, information for transmission to network **304**, a telephone number to place a telephone call, commands to be executed on mobile device **302**, and possibly other or different user inputs.

[**0046**] UE **302** sends communication signals to and receives communication signals from network **304** over a wireless link (air interface) **350** via antenna **310**. RF transceiver circuitry **308** performs functions such as modulation/demodulation and possibly encoding/decoding and encryption/decryption.

[**0047**] UE **302** includes a battery interface **334** for receiving one or more rechargeable batteries **332**. Battery **332** provides electrical power to electrical circuitry in UE **302**, and battery interface **332** provides for a mechanical and electrical connection for battery **332**. Battery interface **332** is coupled to a regulator **336**, which regulates power to the device. When UE **302** is fully operational, an RF transmitter of RF transceiver circuitry **308** is typically keyed or turned on only when it is sending to a network, and is otherwise turned off to conserve resources. Similarly, an RF receiver of RF transceiver circuitry **308** is typically periodically turned off to conserve power until it is needed to receive signals or information (if at all) during designated time periods.

[**0048**] UE **302** operates using a Subscriber Identity Module (SIM) **340** which is connected to or inserted in UE **302** at a SIM interface **342**. SIM **340** is one type of a conventional "smart card" used to identify an end user (or subscriber) of UE **302** and to personalize the device, among other things. Without SIM **340**, the UE terminal is not fully operational for communication through wireless network **304**. By inserting SIM **340** into UE **302**, an end user can have access to any and all of his/her subscribed services. SIM **340** generally includes a processor and memory for storing information. Since SIM **340** is coupled to SIM interface **342**, it is coupled to controller **306** through communication lines **344**. In order to identify the subscriber, SIM **340** contains some user parameters such as an International Mobile Subscriber Identity (IMSI). An advantage of using SIM **340** is that end users are not necessarily bound by any single physical mobile device (UE). SIM **340** may store additional user information for the mobile device as well, including datebook (or calendar) information and recent call information.

[**0049**] UE **302** may consist of a single unit, such as a data communication device, a cellular telephone, a multiple-

function communication device with data and voice communication capabilities, a personal digital assistant (PDA) enabled for wireless communication, or a computer incorporating an internal modem. Alternatively, UE **302** may be a multiple-module unit comprising a plurality of separate components, including but in no way limited to a computer or other device connected to a wireless modem. In particular, for example, in the mobile device block diagram of **FIG. 3**, RF transceiver circuitry **308** and antenna **310** may be implemented as a radio modem unit that may be inserted into a port on a laptop computer. In this case, the laptop computer would include display **312**, keyboard **314**, one or more auxiliary UIs **316**, and controller **306** embodied as the computer's CPU. It is also contemplated that a computer or other equipment not normally capable of wireless communication may be adapted to connect to and effectively assume control of RF transceiver circuitry **308** and antenna **310** of a single-unit device such as one of those described above.

[0050] UE **302** communicates in and through wireless communication network **304**. In the embodiment of **FIG. 3**, wireless network **304** comprises a UMTS network. The UMTS network **304** comprises a UTRAN **320** and a core network **319** comprising a Mobile Switching Center (MSC) **322** (which may include a Visitor Location Register for roaming UEs), a Home Location Register (HLR) **332**, a Serving General Packet Radio Service (GPRS) Support Node (SGSN) **326**, and a Gateway GPRS Support Node (GGSN) **328**. MSC **322** is coupled to UTRAN **320** and to a landline network, such as a Public Switched Telephone Network (PSTN) **324**. SGSN **326** is coupled to UTRAN **320** and to GGSN **328**, which is in turn coupled to a public or private data network **330** (such as the Internet). HLR **332** is coupled to MSC **322**, SGSN **326**, and GGSN **328**. Each of the devices and systems comprising the UTRAN **320** and the core network has a memory (M) and a micro-processor (μP) for respectively storing and executing software code to implement their specified processes and, where appropriate, the improved data discard process in accordance with the invention.

[0051] UTRAN **320** comprises a number of Radio Network Controllers (RNCs) **321** which each serve respective Node Bs **323**, in a manner familiar to the skilled artisan. Also shown in **FIG. 3** are the designations of the interfaces between the various components of the wireless access network **304** using the recognized designations from the GPRS and UMTS specifications.

[0052] Node Bs **323** of UTRAN **320** provide wireless network coverage for UEs **302** within their respective cells under control of their respective RNCs **321** in accordance with UMTS protocols and parameters.

[0053] The wireless link **350** of **FIG. 3** represents one or more different channels, typically radio bearer or logical channels, between UEs **302** and UTRAN **320**.

[0054] Those skilled in the art will appreciate that a wireless network **304** in actual practice may include hundreds of cells, each served by a Node B **323**, depending upon desired overall expanse of network coverage. All pertinent components may be connected by multiple switches and routers (not shown), controlled by multiple network controllers.

[0055] For all UEs **302** registered with a network operator, permanent data (such as UE **302** user's profile) as well as temporary data (such as UE's **102** current location) are stored in HLR **332**. In case of a voice call to UE **302**, HLR **332** is queried to determine the current location of UE **302**. The VLR of MSC **322** is responsible for a group of location areas and stores the data of those UEs that are currently in its area of responsibility. This includes parts of the permanent UE data that have been transmitted from HLR **332** to the VLR for faster access. However, the VLR of MSC **322** may also assign and store local data, such as temporary identifications. Optionally, the VLR of MSC **322** can be enhanced for more efficient co-ordination of GPRS and non-GPRS services and functionality (e.g. paging for circuit-switched calls which can be performed more efficiently via SGSN **326**, and combined GPRS and non-GPRS location updates).

[0056] Serving GPRS Support Node (SGSN) **326** is at the same hierarchical level as MSC **322** and keeps track of the individual locations of UEs. SGSN **326** also performs security functions and access control. Gateway GPRS Support Node (GGSN) **328** provides interworking with external packet-switched networks and is connected with SGSNs (such as SGSN **326**) via an IP-based GPRS backbone network. SGSN **326** performs authentication and cipher setting procedures based on the same algorithms, keys, and criteria as in existing GSM and UMTS as appropriate. In conventional operation, cell selection may be performed autonomously by UE **302** or the RNC **321** responsible for the device **302** instructing it to select a particular cell. UE **302** informs wireless network **304** when it reselects another cell or group of cells, known as a routing area.

[0057] In order to access GPRS services, UE **302** first makes its presence known to wireless network **304** by performing what is known as a GPRS "attach". This operation establishes a logical link between UE **302** and SGSN **326** and makes UE **302** available to receive, for example, pages via SGSN, notifications of incoming data, or SMS messages over GPRS. In order to send and receive data, UE **302** assists in activating the packet data address that it wants to use. This operation makes UE **302** known to GGSN **328** such that interworking with external data networks can thereafter commence. User data may be transferred transparently between UE **302** and the external data networks using, for example, encapsulation and tunneling. Data packets are equipped with GPRS-specific protocol information and transferred between UE **302** and GGSN **328** via UTRAN **320**.

[0058] Those skilled in the art will appreciate that a wireless network may be connected to other systems, possibly including other networks, not explicitly shown in **FIG. 3**. A network will normally be transmitting at the very least some sort of paging and system information on an ongoing basis, even if there is no actual packet data exchanged. Although the network consists of many parts, these parts all work together to result in certain behaviours at the wireless link.

[0059] Referring now to **FIG. 2** and also to **FIG. 4**, in the MAC layer **210**, multiple logical channels **216** from RLC entities **400** can be multiplexed to a single transport channel **214**. The transport channel **214** defines the way traffic from said logical channels **216** is sent to the physical layer **212** for transmission on the air interface **103**, **350** between the node B **323** and UE **102**, **302**. The basic data unit exchanged

between the MAC layer **210** and the physical layer **212** is called a Transport Block (TB) **402**. It comprises one or more RLC PDUs **404** with a MAC header **406**.

[**0060**] A set of TBs **402** and associated parameters **408** exchanged between the MAC layer **210** and the physical layer **212** during a TTI using the same transport channel **214** is called a Transport Block Set (TBS) **410**. Attributes of a TBS **410** such as TB size, TBS size, type/rate of coding and duration of TTI for a specific transport channel comprise a Transport Format (TF). A transport channel **214** can support different instantaneous bit rates, each of which has an associated TF.

[**0061**] For each transport channel **214** at each TTI, the MAC layer **210** will choose an appropriate TF. Normally, there will be a plurality of transport channels **214** and so the combinations of TFs for said channels **214** comprises a Transport Format Combination (TFC) which is identified by a TFC Indicator (TFCI). A set of all TFCs permitted by the network **100**, **304** comprises a TFC Set (TFCS). The network **100**, **304** provides to the UE **102**, **302** the TFCS to be used by the UE on an uplink part of the air interface **103**, **350**.

[**0062**] TFC selection is performed at the MAC layer in both the RNC**106**, **321** and the UE **102**, **302**. In each case, the RNC and UE MAC layers will choose an appropriate TFC for every TTI based on the status of logical channels **216** and the provided radio resources of the transport channels **214**.

[**0063**] Each logical channel **216** is managed by a RLC entity **400** on each side of the air interface **103**, **350**. In the case of TM transmission, each TM RLC channel, as illustrated in **FIG. 5**, embodied in each of the RNC **106**, **321** and UE **102**, **302** may comprise a transmitting TM entity **500** and a receiving TM entity **502**. The transmitting TM entity **500** comprises a transmission buffer **504** which may be embodied as a Random Access Memory (RAM) or the like in each of the RNC **106**, **321** and UE **102**, **302** and a segmentation module **506** which may be embodied as a processor executing suitable software in each of said RNC and UE. The receiving entity **502** comprises a reception buffer **508** which may be embodied as a RAM and a reassembly module **510** which may be embodied as a processor. For each of the RNC and UE, the RAM and processor embodying their respective reception buffers **508** and the reassembly modules **510** may comprise the same RAM and processor used to implement the transmission buffer **504** and the segmentation module **504**.

[**0064**] SDUs from higher layers are received at the RLC layer **208** and buffered in the transmission buffers **504** of the transmitting entities **500**. If segmentation is not configured then such RLC SDUs are transferred as RLC PDUs to the MAC layer **210**. However, if segmentation is configured, then oversized RLC SDUs are segmented into smaller RLC PDUs prior to being transferred. The RLC PDUs are transferred by the RLC entities **400** without the addition of headers. The receiving entities **502** reassemble the RLC SDUs from the RLC PDUs received over the air interface **103**, **350** and buffered in the reception buffers **508** of the receiving TM entities **502**. RLC entities **400** operating TM transmission may be configured to operate SDU discard whereby SDUs received in the RLC TM transmitting entities **500** that are not transmitted within a predetermined period of time are discarded from the transmission buffers **504**.

[**0065**] Accordingly, each such RLC TM transmitting entity **500** starts a timer known as Timer_Discard for each SDU received from upper layers, schedules the RLC SDUs that have been received from upper layers for transmission and notifies the MAC layer **210** of reception of data from the upper layers. If one or more RLC SDUs have been scheduled for transmission, the transmitting entity **500** informs the MAC layer **210** of the number and size of SDUs available for transmission and, when requested, submits to the MAC layer a requested number of TM RLC PDUs or an SDU. RLC SDUs that are not submitted to the MAC layer **210** are buffered in the transmission buffer **504**.

[**0066**] Upon expiry of the timer Timer_Discard in the transmitting entity **500**, the transmitting entity **500** will discard the timed out RLC SDU from the transmission buffer **504**. However, in accordance with the existing 3GPP specifications, in the case where the TFC selection process in the MAC layer **210** has been initiated, the RLC layer is required to wait until after it has transferred the requested RLC PDUs to the MAC layer **210** before discarding timed out RLC SDUs. Therefore, the RLC layer **208** effectively suspends the intended data discard operation until it receives a request from the MAC layer **210** for RLC PDUs indicating that the MAC layer **210** has completed the TFC selection process for the corresponding TTI. The RLC layer **208** may delay discarding the timed out RLC SDUs until the end of a next TTI.

[**0067**] The MAC layer **210** does not provide any indication to the RLC layer **208** of when it has started a TFC selection process for a TTI or when the TTI has commenced. The RLC layer **208** will only receive an indication that the MAC layer **210** has completed a TFC selection process for a TTI when the RLC layer **204** receives from the MAC layer **210** a request for RLC PDUs. Consequently, where the MAC layer **210** does not issue a request for data from the RLC layer **208** for one or more consecutive TTIs, the RLC layer **208** must await such an indication for a subsequent TTI in which the MAC layer **210** does then issue a request for data before completing the suspended data discard operation.

[**0068**] The present invention in a first aspect provides an improved method of processing traffic data in Layer 2 whereby the MAC layer **210** is arranged, after receipt of a traffic data volume report from the RLC layer **208**, to process said data volume report and to then issue an acknowledgement message to the RLC layer **208** indicating that the MAC layer has received and processed that data volume report. This improved method ensures that the RLC and MAC layers are synchronised with respect to traffic data processing whereby each is using the same data volume report in contrast to the conventional method whereby the MAC layer receives data volume reports from the RLC layer, processes them but issues no acknowledgement messages to the RLC layer in respect of such processing. Thus, in the conventional arrangement, the RLC layer asynchronously transmits a series of traffic data volume reports to the MAC layer as and when the data volume changes but receives no indication from the MAC layer of which of the series of such reports it is using for processing traffic data. The MAC layer may be arranged to issue an acknowledgement to the RLC layer only where it determines from processing a data volume report that the RLC layer is not permitted to transmit data in a next or subsequent corresponding TTI. Where the MAC

layer determines from processing a data volume report that the RLC layer is permitted to transmit data, it may be arranged to operate in a conventional manner whereby it does not issue any acknowledgement to the RLC layer that it has received and/or processed said data volume report. In a second aspect, the present invention provides an improved data discard process whereby the MAC layer **210** is arranged, after receipt of a reduced data volume report from the RLC layer **208**, to indicate to the RLC layer **208** whether data from the RLC layer **208** is required or not for a next or subsequent TTI. The indication that data is not required may comprise the acknowledgement from the MAC layer that it has processed the reduced data volume report. It may also comprise an indication that a new TTI has started. Where the MAC layer **210** is currently performing a TFC selection process when a reduced data volume report is received, the indication that data is not required is provided after the TFC selection process is completed. Where, after receiving the reduced data volume report, the MAC layer determines that data is required from the RLC layer for a next or subsequent TTI, the MAC layer may be arranged to issue no acknowledgement to the RLC layer on completion of processing the received reduced data volume report thereby causing the RLC layer to operate in a conventional manner. The improved data discard process of the invention need only be invoked where the MAC layer determines from processing a data volume report from the RLC layer that data is not required from the RLC layer for the next or a specified subsequent TTI and issuing an acknowledgement in respect of processing this report. The improved data discard process of the invention can better be understood with reference to **FIG. 6** which illustrates, by way of example only, messages exchanged between the RLC and MAC layers with respect to successive TTIs.

[**0069**] During a first TTI **600**, designated as "TTI**0**" for convenience, as upper layer SDUs (data) are being received at the RLC layer **208**, the RLC layer **208** sends a data volume report **601** to the MAC layer **210** when the data volume in the TM RLC transmission entity transmission buffers **504** changes. The data volume report may consist of the number of bytes (or bits) available for transmission from that RLC entity. The data volume report may also contain PDU sizes as TFC selection may differ depending on say whether two 20 byte PDUs are available rather than one 40 byte PDU. Several such reports may be issued by the RLC layer during a TTI.

[**0070**] The physical layer **212** is arranged to inform the MAC layer **210** each time it is ready to receive data for a new TTI. The MAC layer **210** executes a TFC selection for this TTI and, if the RLC layer **208** is permitted to transmit data, the MAC layer **210** will issue a request **603** to the RLC layer **208** for such data, as illustrated in a second TTI **602**, designated as "TTI**1**" in **FIG. 6**. The RLC layer **208** responds to the MAC request by transmitting the requested RLC PDUs to the MAC layer. Whilst the execution of the TFC selection process and the provision of data by the RLC layer are illustrated in **FIG. 6** as occurring at the start of TTI**1** (**602**) and a next TTI **604** designated as "TT**12**", it will be appreciated that, in practice, the MAC layer starts a TFC selection process for a corresponding TTI and issues a request for data in advance of the start of said corresponding TTI and the RLC layer also provides the requested data in advance of the start of said TTI. This is necessary to ensure that data requested by the MAC layer is delivered to the physical layer in time for transmission in said corresponding TTI. The TFC selection process and data provision steps may be performed a number of radio frames in advance of said TTI which may comprises one or more TTIs.

[**0071**] When the RLC layer **208** is triggered to discard data through timing out of a RLC SDU, for example, the RLC layer **208** passes a further (reduced) data volume report **605** to the MAC layer **210**. This may include an indication to the MAC layer **210** that the RLC layer **208** is to be informed whether data is required or not in a next or subsequent corresponding TTI. The indication that data is not required may comprise an acknowledgement that MAC has completed processing of this data volume report (and determined that the RLC is not permitted to transmit data for a specified TTI) or an indication of when the next TTI starts. The further reduced data volume report consists of the new amount of data available for transmission and may include a flag to indicate that the RLC needs to know whether data is required or not. The new data volume will not include the bytes for the RLC SDU which is to be discarded, i.e. the data volume will have decreased. The MAC layer **210** may use the flag the next time it starts a TFC selection process. As illustrated in **FIG. 6**, the RLC layer will delay performing the triggered data discard operation until after an indication that MAC does not require data has been received in TT**12** (**604**).

[**0072**] If in TT**12** the RLC layer is permitted to transmit data then the MAC layer may be arranged not to issue an acknowledgement to the RLC layer that it has processed the reduced data volume report thereby causing the RLC layer to behave in a conventional manner. This has no negative impact on traffic data processing since the RLC layer is permitted to transmit data on this occasion. If, on the other hand as illustrated in the figure, in TTI**2** the RLC layer is not permitted to transmit data, then in the conventional arrangement the MAC layer would not issue a request for data to the RLC layer resulting in the RLC layer being unaware that the next TTI **604** has started thereby delaying the data discard operation until at least the occurrence of a subsequent TTI in which the RLC layer is permitted to transmit data and thus receives a request for data from the MAC layer. However, in accordance with the present invention as illustrated by way of example only in **FIG. 6**, where the RLC layer is not permitted to transmit data in a next or subsequent corresponding TTI **604**, the MAC layer responds to the reduced volume report issued by the RLC layer after data discard was triggered by informing the RLC layer, after its next TFC selection process for the next or a subsequent TTI **604**, whether data from the RLC layer is required for this TTI **604**. In this example where the RLC is not permitted to transmit data, the MAC layer informs the RLC layer that data is not required for this TTI **604**. The data not required indication comprises, in this example, an indication that the TTI **604** has started, but it may comprise any indication that results in the RLC layer determining that data is not required for that TTI. The RLC layer is arranged to then perform the data discard operation at least before the end of that TTI **604** and preferably immediately upon being informed of the start of that TTI **604**. The RLC layer is able to immediately discard the data to be discarded since it knows that the MAC layer will not request any RLC PDUs for that TTI **604**. Consequently, the delay in discarding data is significantly

reduced and also the problem of RLC data discard being effectively suspended for a series of consecutive TTIs is obviated.

[0073] In the case where the MAC layer **210** receives the reduced data volume report **605** from the RLC layer **208** between TFC selection processes, the MAC layer **210** may be arranged to respond immediately to the flag contained in the reduced data volume report rather than after a next TFC selection to indicate to the RLC layer **208** that data is not required for the next or a subsequent TTI. The RLC layer can then immediately perform the data discard operation in that same TTI.

[0074] Referring now to **FIG. 7**, shown is a flow diagram representative of the improved data discard process in accordance with the invention.

[0075] In a first step **700**, a determination is made as to whether data volumes in the RLC transmission entity transmission buffers **504** have changed. The determination step may be triggered by the arrival of upper layer SDUs at the RLC layer **208** or by the triggering of a data discard operation.

[0076] If it is determined that the data volume of a transmission entity transmission buffer **504** has changed, then in a next step **702** a determination is made as to whether a data discard operation has been triggered by timing out of a buffered SDU, for example. In the case where it is determined that a data discard operation has not been triggered, the method comprises, as a next step **704**, sending a data volume report from the RLC layer to the MAC layer. The method then returns to step **700**.

[0077] However, if it is determined at step **702** that a data discard has been triggered then, as a next step **706**, a modified (reduced) data volume report is sent to the MAC layer. The modified data volume report contains a request (flag) from the RLC layer to the MAC layer to inform it whether data will be required or not from the RLC for a next or a subsequent corresponding TTI, the MAC layer being arranged to inform the RLC of whether data is required or not after it has completed a next TFC selection process for that TTI. In the following description of the process illustrated by **FIG. 7**, it will be assumed that an indication that data is not required comprises an indication of the start of the next TTI.

[0078] In a next step **708**, the physical layer provides the MAC layer with transmission power information which is used by the MAC layer when performing a TFC selection process for the next or subsequent corresponding TTI. In a next step **710**, the MAC layer determines whether the RLC layer is permitted to transmit data in that TTI. In the case that the determination is true, i.e. that the RLC layer is permitted to transmit data, the MAC layer issues a request (step **712**) to the RLC layer for RLC PDUs. The RLC layer transmits (step **714**) the requested PDUs to the MAC layer and discards (step **716**) the data at the end of that TTI.

[0079] However, where it is determined at step **708** that the RLC layer is not permitted to transmit data, the MAC layer informs (step **718**) the RLC layer of commencement of the TTI and the RLC layer performs (step **720**) the discard operation before the end of the TTI. Preferably, the RLC layer performs the data discard operation immediately upon being informed of the start of the TTI.

[0080] The foregoing description of a RLC transmitting entity and the improved RLC data discard process in accordance with the invention was provided in relation to the RLC operating in TM transmission. It should be noted, however, that in the case of UM transmission, the UM RLC entities (not shown) managing the logical channels **216** perform the same basic operations of buffering, segmentation and reassembly as the TM RLC entities **400**. Whilst, the UM RLC entities may also be arranged to perform additional operations such as concatenation, ciphering/deciphering and to add a header to each RLC PDU transferred to the MAC layer **210**, the improved process of the present invention is equally applicable to UM transmission. Similarly, in the case of AM transmission, whilst the AM RLC entity (not shown) comprises a single entity having a transmitting side and a receiving side and whilst the arrangement and operations performed by the single AM RLC entity are more complex than either of the TM RLC entities **400** or the UM RLC entities, it still performs the same basic operations of buffering, segmentation and reassembly and thus the improved process of the present invention is equally applicable thereto.

[0081] It should also be noted that the improved process of the present invention is not limited to RLC arrangements where data discard is triggered by timing out of a buffered SDU, but is applicable to any mechanism of triggering SDU discard such as failure to transmit an SDU within a predetermined number of transmissions, for example.

[0082] In summary, the present invention concerns a method of processing traffic data in Layer 2 of a wireless communications system, whereby the MAC layer is arranged, after receipt of a traffic data volume report from the RLC layer, to process said data volume report and to then issue an acknowledgement message to the RLC layer indicating that the MAC layer has received and processed that data volume report. The method ensures that the RLC and MAC layers are synchronised with respect to traffic data processing whereby each is using the same data volume report in contrast to the conventional method whereby the MAC layer receives data volume reports from the RLC layer, processes them but issues no acknowledgement messages to the RLC layer in respect of such processing. Thus, in the conventional arrangement, the RLC layer asynchronously transmits a series of traffic data volume reports to the MAC layer as and when the data volume changes but receives no indication from the MAC layer of which of the series of such reports it is using for processing traffic data. The MAC layer may be arranged to issue an acknowledgement to the RLC layer only where it determines from processing a data volume report that the RLC layer is not permitted to transmit data in a next or subsequent corresponding TTI. Where the MAC layer determines from processing a data volume report that the RLC layer is permitted to transmit data, it may be arranged to operate in a conventional manner whereby it does not issue any acknowledgement to the RLC layer that it has received and/or processed said data volume report. The present invention also concerns a process for data discard in a Radio Link Control (RLC) layer of a Wideband Code Division Multiple Access (WCDMA) wireless communications system such as a Universal Mobile Telecommunications System (UMTS). The process involves, responsive to the triggering of a data discard operation, determining whether the RLC layer is permitted to transmit data. Where it is deter-

mined that the RLC layer is not permitted to transmit data in a next or subsequent TTI, the method includes the steps of informing the RLC layer that data is not required. This may comprise informing the RLC of the start of the next TTI and performing the data discard operation before the end of said next TTI. Preferably, the data discard operation is performed immediately the RLC layer is informed that data is not required for that TTI. The process of the invention reduces the time delay between the triggering of a data discard operation and the performance of said operation. It also mitigates the problem associated with the conventional discard process whereby the discard operation is, in effect, suspended for a series of consecutive TTIs where the RLC layer is not permitted to transmit data.

1. A method of processing traffic data in a medium access control (MAC) layer of a wireless communications system, the method comprising the steps of:

receiving a traffic data volume report at the MAC layer;

processing said data volume report; and

following processing of said report, issuing an acknowledgement message to the entity from which the report was received.

2. The method of claim 1, wherein the entity issuing the data volume report comprises a radio link control (RLC) layer of the wireless communications system.

3. The method of claim 1, wherein the MAC layer is arranged to issue an acknowledgement message to the entity from which the report was received only where it is determined from the data volume report that said entity is not permitted to transmit traffic data to the MAC layer in a subsequent corresponding transmission time interval (TTI).

4. A method of discarding data in a radio link control (RLC) layer of a wireless communications system, comprising the steps of:

triggering a data discard operation in a first transmission time interval (TTI);

determining for a subsequent TTI whether the RLC layer is permitted to transmit data; and

where the determination is made that the RLC layer is not permitted to transmit data in the subsequent TTI, the method includes the steps of:

informing the RLC layer that data is not required; and

performing the data discard operation.

5. A method as claimed in claim 4, wherein the RLC layer is informed that data is not required for the subsequent TTI after completion of a current Transport Format Combination (TFC) selection process.

6. A method as claimed in claim 4, wherein the RLC layer is informed that data is not required during a next TTI and the data discard operation is performed before the end of said TTI.

7. A method as claimed in claim 4, wherein the step of informing the RLC layer that data is not required for the subsequent TTI comprises informing the RLC layer of the start of the next TTI.

8. A method as claimed in claim 4, wherein the data discard operation is performed immediately upon the RLC layer being informed that data is not required.

9. A method as claimed in claim 4, wherein a Medium Access Control (MAC) layer (**210**) informs the RLC layer that data is not required.

10. A method as claimed in claim 9, wherein the triggering of the data discard operation in the first TTI causes said RLC layer to issue a request to said MAC layer in said first TTI for the MAC layer to inform the RLC layer whether data is required or not in the subsequent TTI.

11. A method as claimed in claim 10, wherein said request issued by said RLC layer in said first TTI is contained in a data volume report.

12. A radio network controller (RNC) for a wireless communications system for processing traffic data in a medium access control (MAC) layer thereof, comprising:

means for receiving a traffic data volume report at the MAC layer;

means for processing said data volume report; and

means for issuing an acknowledgement message to the entity from which the report was received following processing of said report.

13. The radio network controller of claim 12, wherein the entity issuing the data volume report comprises a radio link control (RLC) layer of the RNC.

14. The radio network controller of claim 12, wherein the MAC layer is arranged to issue an acknowledgement message to the entity from which the report was received only where it is determined from the data volume report that said entity is not permitted to transmit traffic data to the MAC layer in a next or subsequent corresponding transmission time interval (TTI).

15. A radio network controller (RNC) for a wireless communications network, comprising:

means for triggering a data discard operation in a first transmission time interval (TTI);

means for determining for a subsequent TTI whether the RLC layer is permitted to transmit data;

means responsive to said determining means and being arranged where said determining means determines that the RLC layer is not permitted to transmit data in the subsequent TTI to inform the RLC layer that data is not required for that TTI; and

means for performing the data discard operation.

16. A radio network controller as claimed in claim 15, wherein the means responsive to the determining means informs the RLC layer that data is not required for the subsequent TTI after completion of a current Transport Format Combination (TFC) selection process.

17. A radio network controller as claimed in claim 15, wherein the means responsive to the determining means informs the RLC layer that data is not required during the next TTI.

18. A radio network controller as claimed claim 15, wherein the means responsive to the determining means is arranged to inform the RLC layer that data is not required in the subsequent TTI by way of informing the RLC layer of the start of the next TTI.

19. A radio network controller as claimed in claim 15 wherein said means for performing the data discard operation is arranged to perform said discard operation immediately upon the RLC layer being informed that data is not required.

20. A radio network controller as claimed in claim 18, wherein the means responsive to said determining means and for informing the RLC layer that data is not required comprises a Medium Access Control (MAC) layer (**210**) of a radio protocol architecture (**100**) of the radio network controller.

21. A radio network controller as claimed in claim 20, wherein the RLC layer is arranged to issue a request to said MAC layer in said first TTI for the MAC layer to inform the RLC layer whether data is required or not in said subsequent TTI in response to the triggering of the data discard operation in the first TTI.

22. A radio network controller as claimed in claim 21, wherein said request issued by said RLC layer in said first TTI is contained in a data volume report.

23. User equipment (UE) for a wireless communications network for processing traffic data in a medium access control (MAC) layer thereof, comprising:

means for receiving a traffic data volume report at the MAC layer;

means for processing said data volume report; and

means for issuing an acknowledgement message to the entity from which the report was received following processing of said report.

24. User equipment as claimed in claim 23, wherein the entity issuing the data volume report comprises a radio link control (RLC) layer of the RNC.

25. User equipment as claimed in claim 23, wherein the MAC layer is arranged to issue an acknowledgement message to the entity from which the report was received only where it is determined from the data volume report that said entity is not permitted to transmit traffic data to the MAC layer in a next or subsequent corresponding transmission time interval (TTI).

26. User equipment (UE) for a wireless communications network, comprising:

means for triggering a data discard operation in a first transmission time interval (TTI);

means for determining for a subsequent TTI whether the RLC layer is permitted to transmit data;

means responsive to said determining means and being arranged where said determining means determines that the RLC layer is not permitted to transmit data in the subsequent TTI to inform the RLC layer that data is not required; and

means for performing the data discard operation.

27. User equipment as claimed in claim 26, wherein the means responsive to the determining means informs the RLC layer that data is not required for the subsequent TTI after completion of a current Transport Format Combination (TFC) selection process.

28. User equipment as claimed in claim 26, wherein the means responsive to the determining means informs the RLC layer that data is not required during said next TTI.

29. User equipment as claimed in claim 26, wherein the means responsive to the determining means is arranged to inform the RLC layer that data is not required by way of informing the RLC layer of the start of said next TTI.

30. User equipment as claimed in claim 26, wherein said means for performing the data discard operation is arranged to perform said discard operation immediately upon the RLC layer being informed that data is not required.

31. User equipment as claimed in claim 29, wherein the means responsive to said determining means and for informing the RLC layer that data is not required comprises a Medium Access Control (MAC) layer (**210**) of a radio protocol architecture of the user equipment.

32. User equipment as claimed in claim 31, wherein the RLC layer is arranged to issue a request to said MAC layer in said first TTI for the MAC layer to inform the RLC layer whether data is required or not for said subsequent TTI in response to the triggering of the data discard operation in the first TTI.

33. User equipment as claimed in claim 32, wherein said request issued by said RLC layer in said first TTI is contained in a data volume report.

34. User equipment as claimed in claim 26 to **33**, wherein said user equipment comprises a mobile communications device.

35. A computer readable medium comprising program code executable on a processor of a radio network controller (RNC) of a wireless communications system to process traffic data in a medium access control (MAC) layer of the wireless communications system, the program code enabling said RNC to:

receive a traffic data volume report at the MAC layer;

process said data volume report; and

following processing of said report, issue an acknowledgement message to the entity from which the report was received

36. A computer readable medium comprising program code executable on a processor of a user equipment (UE) a wireless communications system to process traffic data in a medium access control (MAC) layer of the wireless communications system, the program code enabling said UE to:

receive a traffic data volume report at the MAC layer;

process said data volume report; and

following processing of said report, issue an acknowledgement message to the entity from which the report was received

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