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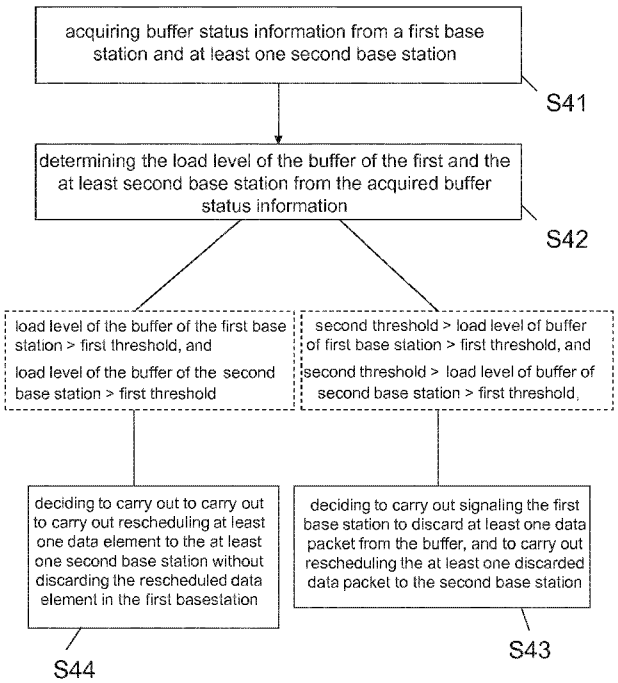
(54) Title: DELAY EQUALIZATION FOR FLUCTUATING INTER-SITE MULTIFLOW LINKS

Fig. 4



(57) Abstract: The present invention addresses apparatuses, methods and computer program product for enhancing multiflow links in wireless communication system, thereby equalizing and shortening a delay and shortening a transmission for fluctuating inter-site multiflow links. The present invention includes acquiring buffer status information from a first base station and at least one second base station, determining the load level of the buffer of the first and the at least second base station from the acquired buffer status information, deciding, in case the determined load level of the buffer of the first base station is higher than a predetermined first threshold and higher than the determined load level of the second base station, to carry out signaling the first base station to discard at least one data element from the buffer, and to carry out rescheduling the at least one discarded data element to the second base station, and deciding, in case the determined load level of the buffer of the first base station and the determined load level of the second base station are each higher than the predetermined first threshold and lower than a second predetermined threshold, to carry out rescheduling at least one data element to the at least one second base station without discarding the rescheduled data element in the first basestation.

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Description

Title

Delay equalization for fluctuating inter-site multiflow links

Field of the invention

The present invention generally relates to wireless communication, and more specifically relates to techniques for enhancing multiflow links in wireless communication system, thereby equalizing and shortening a delay, and shortening a transmission for fluctuating inter-site multiflow links.

Background

Prior art which is related to this technical field can e.g. be found in technical specifications according to 3GPP Release 11, in particular, the work item called "HSDPA Multiflow tx".

In general, multiflow enables that the cell edge users' data rates and robustness are improved by receiving transmissions also from neighbouring cells.

In inter-site multiflow the data that is ultimately transmitted by the cells is split to the two cells at the level of radio link control (RLC) protocol data units (PDUs) in the radio network controller (RNC). The radio network controller will provide radio link control protocol data units to each base station (nodeB) according to their flow control requests (also referred to as "credits").

However, inter-site multiflow introduces additional challenges for the flow control.

That is, in case of single flow, the radio link controller layer relies upon the medium access control with enhanced high speed (MAC-ehs) that delivers radio

link control protocol data units in sequence and a missing protocol data unit (the radio link controller receives a protocol data unit with a sequence number (SN) that is higher than next expected sequence number) triggers a receiver to send a radio link control negative acknowledgement message (RLC NACK).

However, in case of multiflow there are two independent medium access control with enhanced high speed (MAC-ehs) entities and therefore, due to scheduling and hybrid automatic repeat request (HARQ) retransmission etc. delays at MAC-ehs, radio link control protocol data units may arrive out of order to user equipment's radio link control layer, which could then cause a radio link control negative acknowledgement message and thus to unnecessary radio link control retransmission. This is also referred to as "skew".

There are already solutions to minimize the skew problems where either the network or the user equipment (UE) detects a missing protocol data unit and starts a "skew timer", and retransmission is performed only after this timer expires (thus hoping that the missing protocol data unit has enough time to arrive before the retransmission is triggered).

Despite the skew timer, from end-to-end performance point of view it is desirable to minimize the skew to avoid jitter, which can e.g. lead to transmission control protocol (TCP) slow starts.

Another aspect impacting multiflow throughput is that (especially in bursty traffic) the transmissions by the cells should be managed to end at the same time. That is, the situation should be avoided where one cell has buffered data that it still has to transmit for some time, while the other cell is idle, which would be contradicting the gain mechanism of Multiflow. That situation may come about if following the last forwarding of packets from RNC to nodeBs the link or load conditions of a nodeB changed, and one nodeB's transmission rate drops or increases significantly with respect to the other. As a consequence the delay for the last packets leaving the nodeB will be different, and one of the nodeBs will be idle while the other will be still transmitting.

Thus in multiflow, unlike in non-multiflow, it is very important to balance the delays incurred by the two nodeB buffers.

Summary of the Invention

Therefore, it is an object underlying the present invention to provide a delay equalization for fluctuating inter-site multiflow links. In particular, it is an object of the present invention to provide an apparatus, a method and a computer program product for enhancing multiflow links in wireless communication system, thereby equalizing and shortening a delay and shortening a transmission time for fluctuating inter-site multiflow links.

According to a first aspect of the present invention, there is provided a method, which comprises acquiring buffer status information from a first base station and at least one second base station, determining the load level of the buffer of the first and the at least second base station from the acquired buffer status information, deciding, in case the determined load level of the buffer of the first base station is higher than a predetermined first threshold and higher than the determined load level of the buffer of the second base station, to carry out signaling the first base station to discard at least one data element from the buffer, and to carry out rescheduling the at least one discarded data element to the second base station to process the at least one rescheduled discarded data element, and deciding, in case the determined load level of the buffer of the first base station and the determined load level of the buffer of the second base station are each higher than the predetermined first threshold and lower than a second predetermined threshold, to carry out signaling the first base station and the second base station to bicast at least one data element by the first base station and the second base station.

According to a second aspect of the present invention, there is provided an apparatus, comprising acquisition means for acquiring buffer status information from a first base station and at least one second base station, determination

means for determining the load level of the buffer of the first and the at least second base station from the acquired buffer status information, deciding means for deciding, in case the determined load level of the buffer of the first base station is higher than a predetermined first threshold and higher than the determined load level of the buffer of the second base station, to carry out signaling the first base station to discard at least one data element from the buffer and to carry out rescheduling the at least one discarded data element to the second base station, and for deciding, in case the determined load level of the buffer of the first base station and the determined load level of the buffer of the second base station are each higher than the predetermined first threshold and lower than a second predetermined threshold, to carry out signaling the first base station and the second base station to bicast at least one data element by the first base station and the second base station.

According to a third aspect of the present invention, there is provided a method, which comprises detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information, transmitting, in case the buffer load level exceeds a preset threshold, a notification to a radio network controller, indicating at least one data element present in the buffer, and in case of receiving a discard request from the radio network controller, discarding the at least one data element from the buffer.

According to a fourth aspect of the present invention, there is provided an apparatus, comprising detection means for detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information, and transmission means for transmitting, in case the buffer load level exceeds a preset threshold, a notification to a radio network controller, indicating at least one data element present in the buffer, and discarding means for discarding the at least one data element from the buffer in case of receiving a discard request from the radio network controller.

According to a fifth aspect of the present invention, there is provided a method, which comprises detecting buffer status information from at least one internal

buffer, the buffer status information including buffer load level information, transmitting the buffer status information to a radio network controller, and processing data elements provided by the radio network controller.

According to a sixth aspect of the present invention, there is provided an apparatus, comprising detection means for detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information, transmission means for transmitting the buffer status information to a radio network controller, and processing means for processing data elements provided by the radio network controller.

According to a seventh aspect of the present invention, there is provided a computer program product comprising computer-executable components which, when the program is run on a computer, are configured to carry out the method according to at least one of the first aspect, the method according to the third aspect, and the method according to the fifth aspect.

According to another embodiment of the invention, the nodeB determines a buffer overload situation and discards excess data autonomously (without requesting permission from RNC), but sends an indication to RNC of discarded excess data. The form of the discard notification from nodeB to RNC may have the same form as the discard request from nodeB to RNC or discard request from RNC to nodeB. The advantage here is that a nodeB-RNC handshake on discarding data is avoided. The RNC is still free to resend the discarded data at a suitable time, thereby still balancing delays between nodeBs.

In another embodiment the RNC will not only send a discard request to node B to discard data based on a received nodeB buffer overload report, but may also seek to equalize the delay between nodeBs by adjusting the transmission rates in the nodeB, e.g. by increasing or decreasing the scheduling priorities of the user or of other users in the system.

In another embodiment of the invention the RNC will interact with only one nodeB (not in Multiflow mode). The one nodeB will provide the RNC with UE buffer (over-)load status according to a configured threshold. The RNC may instruct the nodeB to discard excess data or adjust transmission parameters to meet a configured threshold. The nodeB may also autonomously discard excess data with notification to RNC or adjust transmission parameters to meet the configured threshold. The decisions about discarding or rate adaptation may be based also on considerations of traffic priority class of the user in question and other users in the system.

According to certain embodiments of the invention, each apparatus may comprise at least one processor, and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause to carry out the method according to at least one of the first aspect, the method according to the third aspect, and the method according to the fifth aspect.

Advantageous further developments or modifications of the aforementioned exemplary aspects of the present invention are set out in the dependent claims.

According to certain embodiments of the present invention, in the apparatus according to the second aspect, the buffer status information may indicate the buffer load status in terms of at least one of delay, bytes and protocol data unit sequence number. The apparatus may further comprise a setting means for setting a transmission deadline and/or a delay based on the acquired buffer status information. In the apparatus, the acquisition means may be configured such that acquisition of the buffer status information is triggered when it is detected that the channel speed falls below a predetermined threshold. The apparatus may further comprise an estimation means for estimating a delay situation level of the first base station and of the at least one second base station, wherein the estimation is configured such that when it is estimated that each of the delay situation levels of the first base station and of the at least one second base station is lower than a preset threshold, discarding of data elements

is prevented. The apparatus may further comprise at least one of a signaling means for signaling a conformation to the at least one second base station indicating the radio link control data range, and a setting means for setting a common time reference with the first base station and the at least one second base station. The apparatus may further comprise a transmission means for transmitting the buffer status information of the first base station to the at least one second base station and/or for transmitting the buffer status information of the at least second base station to the first base station and/or a transmission means for transmitting the at least one discarded data element from the first base station to the at least one second base station.

Furthermore, according to certain embodiments of the present invention, in the apparatus of the fourth aspect, the discarding means may be configured to discard the at least one data element from the buffer when the detection means detects that the buffer load level exceeds the preset threshold. In the apparatus, the discarding means may be configured such that discarding the at least one data element from the buffer is prevented upon receiving a preventing request from the radio network controller. In the apparatus, acquisition of the buffer status information may be triggered when a preset delay or size threshold is exceeded, or when, at normal flow control, negative credits are signaled.

Brief description of drawings

For a more complete understanding of example embodiments of the present invention, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

Fig. 1 schematically illustrates split scheduling and flow control in multiflow;

Fig. 2 shows a schematic of changing the target buffer size, when the target delay is kept constant but the channel speed or scheduling load is changing;

Fig. 3 shows a schematic of a flow control with negative credits achieved by discarding superfluous packets according to certain embodiments of the present invention;

Fig. 4 shows a principle flowchart of an example for a method according to certain embodiments of the present invention, which may be implemented in a radio network controller; and

Fig. 5 shows a principle configuration of an example for an apparatus according to certain embodiments of the present invention.

Fig. 6 shows a principle flowchart of an example for a method according to certain embodiments of the present invention, which may be implemented in a base station, such as a nodeB; and

Fig. 7 shows a principle configuration of an example for an apparatus according to certain embodiments of the present invention.

Fig. 8 shows a principle flowchart of an example for a method according to certain embodiments of the present invention, which may be implemented in a base station, such as nodeB; and

Fig. 9 shows a principle configuration of an example for an apparatus according to certain embodiments of the present invention.

Fig. 10 schematically shows the buffers of nodeB1 and nodeB2 when the radio network controller has resent superfluous data of nodeB2 on nodeB1.

Description of exemplary embodiments

Exemplary aspects of the present invention will be described herein below. More specifically, exemplary aspects of the present are described hereinafter with

reference to particular non-limiting examples and to what are presently considered to be conceivable embodiments of the present invention. A person skilled in the art will appreciate that the invention is by no means limited to these examples, and may be more broadly applied.

It is to be noted that the following description of the present invention and its embodiments mainly refers to specifications being used as non-limiting examples for certain exemplary network configurations and deployments. Namely, the present invention and its embodiments are mainly described in relation to 3GPP specifications being used as non-limiting examples for certain exemplary network configurations and deployments. In particular, a UMTS/HSDPA communication system is used as a non-limiting example for the applicability of thus described exemplary embodiments. As such, the description of exemplary embodiments given herein specifically refers to terminology which is directly related thereto. Such terminology is only used in the context of the presented non-limiting examples, and does naturally not limit the invention in any way. Rather, any other network configuration or system deployment, etc. may also be utilized as long as compliant with the features described herein.

Hereinafter, various embodiments and implementations of the present invention and its aspects or embodiments are described using several alternatives. It is generally noted that, according to certain needs and constraints, all of the described alternatives may be provided alone or in any conceivable combination (also including combinations of individual features of the various alternatives).

Even if the following exemplary embodiments mostly are directed to a system comprising two nodeBs (base stations), it is to be noted that the system may comprise three or more base stations.

Furthermore, in the present specification, the load level of the buffer is also referred to as credit level. Still further, the term "data element" may refer to e.g. a data packet, a single byte, or a plurality of bytes.

Fig. 1 schematically illustrates a heterogeneous network according to certain embodiments of the present invention.

In Fig. 1, a radio network controller RNC, which may interchange information over an IuB-interface to base stations, such as nodeB1 and nodeB2, processes several radio link control packet data units RLC PDUs related to a user equipment UE1. The radio network controller RNC performs a split scheduling for the data to be processed by any of the base stations nodeB1 and nodeB2. In Fig. 1, the data packets 1 to 4 have already assigned to one of the base stations (i.e. 1 and 2 to node B2; 3 and 4 to nodeB1), and the data packets 5 to 8 are to be scheduled and assigned.

The data assigned to each base station nodeB1 and nodeB2 are held in a buffer for tx data of UE1, and are to be processed by means of a Tx scheduler. Thereafter, the respective scheduled data is transmitted to the assigned user equipment UE1 over the Uu-interface. In the UE1, RLC re-assembly and/or RLC in-sequence delivery may be carried out.

As becomes apparent from the illustration shown in Fig. 1, flow control requests are sent at certain intervals, the flow control period. In non-multiflow HSDPA the intention of the flow control is to limit the amount of data stored in the nodeB for the purpose of supporting mobility. In general it is desirable to have a minimal amount of data in the nodeB to support high mobility. On the other hand, this would require a very short flow control period which would create more control traffic on the IuB interface, and lead also to high computational load at the RNC. Thus, there is typically a certain flow control period, which in turn then influences the amount of data that the nodeB should buffer.

As already indicated above, in multiflow, unlike in non-multiflow, it is very important to balance the delays incurred by the two nodeB buffers.

The delay will be a function of the scheduling load that the nodeB is experiencing, as well as the data rate at which a link can be served (a function of the channel quality)

An unequal delay incurred by the two nodeBs is impacting the performance in two ways:

Firstly, the skew is increased. A larger skew may have adverse effects on TCP/IP protocols. Even if scheduling at the radio network controller might reduce the skew again, is likely to be complex and potentially not robust with fluctuating links.

Secondly, in bursty traffic at the end of a burst, one nodeB may end up having a considerable data to transmit while the other has already finished. This may lead to raw throughput performance loss even when compared to non-Multiflow.

Above problems can be tackled by the RNC managing and setting the target delay in the nodeBs. However, as the channel conditions may vary, one nodeB may find that its buffer contents do not meet the delay target any longer. With a legacy flow control approach the nodeB would then respond with 0 flow control credits. However, for bursty traffic at the end of a burst this still may incur throughput losses as a weaker link is used when a stronger link would be available, see e.g. Figure 2.

Fig. 2 shows schematic of changing target buffer size [bytes], when the target delay is kept constant but the channel speed or scheduling load is changing. In particular, Fig. 2 shows the desired buffer size according to channel speed at time t0 and the desired buffer size according to channel speed at time t1.

Next, according to certain embodiments of the present invention, delay equalization by nodeB notification and RNC confirm is explained.

The invention according to certain embodiments may be described by following steps:

1. The nodeB is indicating to the radio network controller RNC
   a. when there is too much data in its buffers
   b. what amount of data is too much, in delay or bytes or in terms of packet data unit sequence number PDU SN, in order to meet an approximate transmission deadline or delay.
2. The RNC makes a decision what to do with the data
3. In case the RNC wishes to equalize the delay, it can
   a. send appropriate signaling to nodeB2 to discard superfluous packets and reschedule the packets on a different route. This could be applicable when RNC determines that the other link is better than the one under consideration and is not overloaded.
   b. reschedule packets on a different route without requesting nodeB2 to discard superfluous packets, thereby bicasting the packets. This could be applicable when RNC determines that the other link is equally bad, but not overloaded.
   c. do nothing. This could be applicable when the other nodeB (nB1) has already indicated that there is too much data in its buffers as well.

The above procedure may amount to "flow control with negative credits". Figure 3 exemplary shows such "flow control with negative credits" achieved by discarding superfluous packets.

According to an option shown in Fig. 3 as one of certain embodiments of the present invention, the nodeB may send a notification to the RNC. This may be done as flow control with negative credits, such as "x too many bytes in buffer". Further, the RNC considers whether to discard the too many bytes in nodeB2. Still further, the RNC may know how many bytes it has sent to nodeB2 before the nodeB2 negative flow control indication. It informs the nodeB2 to discard RLC PDUs with SN > 2.

To support faster reaction, a threshold may be configured by RNC to trigger the nodeB signalling an under- or over run outside a flow control loop. In particular, this out-of-period signalling could be applied when the end of a burst is being reached.

According to further certain embodiments of the present invention, an autonomous packet drop is explained.

In a variant very similar to above method, the nodeB after having determined the amount of superfluous data will autonomously drop that data and send a corresponding indication to the RNC as in the variant above. The advantage is somewhat simpler implementation at the nodeB, the disadvantage that nodeB2 does not have a view of the situation at nodeB1

Fig. 4 shows a principle flowchart of an example for a method according to certain embodiments of the present invention.

In Step S41, buffer status information from a first base station and at least one second base station is acquired.

In Step S42, the load level of the buffer of the first and the at least second base station from the acquired buffer status information is determined.

In Step S43, in case the determined load level of the buffer of the first base station is higher than a predetermined first threshold and higher than the determined load level of the buffer of the second base station, it is decided to carry out signaling the first base station to discard at least one data element from the buffer, and to carry out rescheduling the at least one discarded data element to the second base station.

In Step S44, in case the determined load level of the buffer of the first base station and the determined load level of the buffer of the second base station are each higher than the predetermined first threshold and lower than a second

predetermined threshold, it is decided to carry out rescheduling at least one data element to the at least one second base station without discarding the rescheduled data element in the first basestation.

Fig. 5 shows a principle configuration of an example for an apparatus according to certain embodiments of the present invention. The apparatus 50 comprises acquisition means 51 for acquiring buffer status information from a first base station and at least one second base station, determination means 52 for determining the load level of the buffer of the first and the at least second base station from the acquired buffer status information, and deciding means 53 for deciding, in case the determined load level of the buffer of the first base station is higher than a predetermined first threshold and higher than the determined load level of the buffer of the second base station, to carry out signaling the first base station to discard at least one data element from the buffer, and to carry out rescheduling the at least one discarded data element to the second base station, and for deciding, in case the determined load level of the buffer of the first base station and the determined load level of the buffer of the second base station are each higher than the predetermined first threshold and lower than a second predetermined threshold, to carry out rescheduling at least one data element to the at least one second base station without discarding the rescheduled data element in the first basestation.

Fig. 6 shows a principle flowchart of an example for a method according to certain embodiments of the present invention.

In Step S61, buffer status information from at least one internal buffer is detected, wherein the buffer status information includes buffer load level information.

In Step S62, in case the buffer load level exceeds a preset threshold, a notification to a radio network controller is transmitted, indicating at least one data element present in the buffer.

In Step S63, in case of receiving a discard request from the radio network controller, the at least one data element is discarded from the buffer.

Fig. 7 shows a principle configuration of an example for an apparatus according to certain embodiments of the present invention. The apparatus 70 comprises a buffer 73, detection means 71 for detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information, and transmission means 72 for transmitting, in case the buffer load level exceeds a preset threshold, a notification to a radio network controller, indicating at least one data element present in the buffer, and discarding means for discarding the at least one data element from the buffer in case of receiving a discard request from the radio network controller.

Fig. 8 shows a principle flowchart of an example for a method according to certain embodiments of the present invention.

In Step S81, buffer status information from at least one internal buffer is detected, wherein the buffer status information includes buffer load level information.

In Step S82, the buffer status information is transmitted to a radio network controller.

In Step S83, data elements provided by the radio network controller are processed.

Fig. 9 shows a principle configuration of an example for an apparatus according to certain embodiments of the present invention. The apparatus 90 comprises a buffer 94, detection means 91 for detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information, transmission means 92 for transmitting the buffer status information to a radio network controller, and processing means 93 for processing data elements provided by the radio network controller.

According to certain embodiments of the present invention, indication of superfluous data could be done in a variety of ways:

- at normal flow control instances negative credits are signaled.
- an indication is triggered when and by how much a certain delay or size threshold has been exceeded
- the calculation of superfluous data can be also carried out at the RNC, in case the RNC is provided with information beyond the (positive) flow control, e.g. relating to the channel speed. Here a certain level of inaccuracy may remain.

Furthermore, according to certain embodiments of the present inventions, the step of RNC making a decision may be based not only on the amount of exceed delay in the nodeB2, but also the estimated delay situation in nodeB1. For instance, if both nodeBs are reporting worse conditions no data needs to be discarded

Still further, according to certain embodiments of the present inventions, the step of discarding data in the nodeB can be implemented either by the

- RNC signalling an explicit confirm, indicating the RLC data range (number of bytes at given time e.g. CFN, or RLC SN range), or by a
- common time reference between nodeB and RNC allowing to synchronize the negative flow control info with certain RLC PDUs sent by the RNC

For instance, if the nodeB has signalled "X too many bytes at t1", the RNC knows that up to t1 there were X bytes contained for instance in RLC PDUs 3 and 4. It may then signal to the nB2 to remove all PDUs with RLC SN > 2.

Alternatively the RNC signals to the nodeB2 to remove all bytes since the time of nodebB2's negative flow control indication, and resends the RLC SNs > 2 on

nodeB1. This would have the advantage of the nodeB2 not having to check RLC SNs in the buffer.

Fig. 10 schematically shows the step of discarding data in the nodeB in case the RNC has resent the superfluous data of nodeB2 on nodeB1. In particular, the RNC has chosen to put dropped packets into nodeB'S queue at t2.

In the following, a summary of required messages and their possible implementation according to certain embodiments of the present invention is shown.

	Message	Src, dest	Reason	Options for implementation
1	Negative credit flow control	nB, RNC	Delay equalization	a) negative range for credits (modification to existing „capacity allocation" message, e.g. by using one of the spare bits, see 3gpp 25.435)
2				b) new IE with negative credits (add message)
3				c) time stamp indicating when the negative credits were calculated (new message with CFN)
5	Threshold configuration	RNC, nB	To support faster reaction time in case of long flow control periods	Excess target delay (underrun or overrun) (RL setup and reconfiguration messages, new IE)
6	Discard indication	RNC, nB	Confirmation of discard	a) discard RLC SN > N (new message), or modification of "HS-DSCH data frame with flush bit"
7				b) credits discard confirm (recommended in conjunction with time stamp) (new message)
8	Drop indication	nB, RNC	Support of variant 2	a) dropped RLC SN > N (new message), or modification of "capacity allocation", with usage of additional spare bit to distinguish from negative credits ("drop request")
9				b) negative credits with time stamp

It is to be noted that not using a time stamp is expected to work as well but may be less performing. This is so as a time stamp signaled by the nodeB is helpful to reference the point in time when there was too much data in the nodeB, because when the indication from nodeB to RNC arrives at the RNC in the meantime new data may have arrived at the nodeB. On the other hand, one may also use guard

time intervals around preset indication signaling instances preventing the sending of new data. Or, one may simply accept that new data has arrived to the nodeB, and wait for the next flow control instance to send new negative credits.

Furthermore, it is to be noted that having a standardized target delay in the nodeBs is desirable for this invention, but not mandatory.

In the foregoing exemplary description of the apparatus, only the units that are relevant for understanding the principles of the invention have been described using functional blocks. The apparatuses may comprise further units that are necessary for its respective function. However, a description of these units is omitted in this specification. The arrangement of the functional blocks of the apparatuses is not construed to limit the invention, and the functions may be performed by one block or further split into sub-blocks.

According to exemplarily embodiments of the present invention, a system may comprise any conceivable combination of the thus depicted devices/apparatuses and other network elements, which are arranged to cooperate as described above.

Embodiments of the present invention may be implemented in software, hardware, application logic or a combination of software, hardware and application logic. The software, application logic and/or hardware generally, but not exclusively, may reside on the devices' modem module. In an example embodiment, the application logic, software or an instruction set is maintained on any one of various conventional computer-readable media. In the context of this document, a "computer-readable medium" may be any media or means that can contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer or smart phone, or user equipment.

As used in this application, the term "circuitry" refers to all of the following: (a) hardware-only circuit implementations (such as implementations in only analog

and/or digital circuitry) and (b) to combinations of circuits and software (and/or firmware), such as (as applicable): (i) to a combination of processor(s) or (ii) to portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and (c) to circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present. This definition of 'circuitry' applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" would also cover, for example and if applicable to the particular claim element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in server, a cellular network device, or other network device.

The present invention relates in particular but without limitation to mobile communications, for example to environments under HSDPA, UMTS, LTE, WCDMA, WIMAX and WLAN and can advantageously be implemented in controllers, base stations, user equipments or smart phones, or personal computers connectable to such networks. That is, it can be implemented as/in chipsets to connected devices, and/or modems thereof.

If desired, the different functions discussed herein may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the above-described functions may be optional or may be combined.

Although various aspects of the invention are set out in the independent claims, other aspects of the invention comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

It is also noted herein that while the above describes example embodiments of the invention, these descriptions should not be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present invention as defined in the appended claims.

The following meanings for the abbreviations used in this specification apply:

3GPP	3rd Generation Partnership Project
MAC-ehs	medium access control-enhanced high speed (HSDPA MAC layer)
MF	Multiflow
nB	nodeB
PDU	protocol data unit
RLC	radio link control
RNC	radio network controller
SN	sequence number

What is claimed is:

1. A method, comprising:

acquiring buffer status information from a first base station and at least one second base station;

determining the load level of the buffer of the first and the at least second base station from the acquired buffer status information;

deciding, in case the determined load level of the buffer of the first base station is higher than a predetermined first threshold and higher than the determined load level of the buffer of the second base station, to carry out signaling the first base station to discard at least one data element from the buffer, and to carry out rescheduling the at least one discarded data element to the second base station; and

deciding, in case the determined load level of the buffer of the first base station and the determined load level of the buffer of the second base station are each higher than the predetermined first threshold and lower than a second predetermined threshold, to carry out rescheduling at least one data element to the at least one second base station without discarding the rescheduled data element in the first basestation.

2. The method according to claim 1, wherein the buffer status information indicates the buffer load status in terms of at least one of delay, bytes and protocol data unit sequence number.

3. The method according to claim 1 or 2, wherein acquisition of the buffer status information is triggered when it is detected that the channel speed falls below a predetermined threshold.

4. The method according to any of claims 1 to 3, further comprising estimating a delay situation level of the first base station and of the at least one second base station, wherein, when it is estimated that each of the delay situation levels of

the first base station and of the at least one second base station is higher than a preset threshold, discarding of data elements is prevented.

5. The method according to any of claims 1 to 4, wherein the step of discarding at least one data element comprises at least one of signaling a confirmation to the at least one second base station indicating the radio link control data range, and setting a common time reference with the first base station and the at least one second base station.

6. The method according to any of claim 1 to 5, further comprising transmitting the buffer status information of the first base station to the at least one second base station and/or transmitting the buffer status information of the at least second base station to the first base station and/or transmitting the at least one discarded data element from the first base station to the at least one second base station.

7. An apparatus, comprising:

acquisition means configured to acquire buffer status information from a first base station and at least one second base station;

determination means configured to determine the load level of the buffer of the first and the at least second base station from the acquired buffer status information; and

deciding means configured to

decide, in case the determined load level of the buffer of the first base station is higher than a predetermined first threshold and higher than the determined load level of the buffer of the second base station, to carry out signaling the first base station to discard at least one data element from the buffer, and to carry out rescheduling the at least one discarded data element to the second base stationelement; and

decide, in case the determined load level of the buffer of the first base station and the determined load level of the buffer of the second base station are each higher than the predetermined first threshold and lower than a second predetermined threshold, to carry out rescheduling at least one data

element to the at least one second base station without discarding the rescheduled data element in the first basestation.

8. A method, comprising:

detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information;

transmitting, in case the buffer load level exceeds a preset threshold, a notification to a radio network controller, indicating at least one data element present in the buffer; and

in case of receiving a discard request from the radio network controller, discarding the at least one data element from the buffer.

9. The method according to claim 8, further comprising autonomously discarding the at least one data element from the buffer upon detecting that the buffer load level exceeds the preset threshold.

10. The method according to claim 8, wherein discarding the at least one data element from the buffer is prevented upon receiving a preventing request from the radio network controller.

11. The method according to any of claims 8 to 10, wherein acquisition of the buffer status information is triggered when a preset delay or size threshold is exceeded, or when, at normal flow control, negative credits are signaled.

12. An apparatus, comprising:

detection means for detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information; and

transmission means for transmitting, in case the buffer load level exceeds a preset threshold, a notification to a radio network controller, indicating at least one data element present in the buffer; and

discarding means for discarding the at least one data element from the buffer in case of receiving a discard request from the radio network controller.

13. A method, comprising:

detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information;

transmitting the buffer status information to a radio network controller; and

processing data elements provided by the radio network controller.

14. An apparatus, comprising:

detection means for detecting buffer status information from at least one internal buffer, the buffer status information including buffer load level information;

transmission means for transmitting the buffer status information to a radio network controller; and

processing means for processing data elements provided by the radio network controller.

15. A computer program including a program for a processing device, comprising software code portions for performing the steps according to any of claims 1 to 6, 8 to 11 and 13 when the program is run on the processing device.

16. The computer program product according to claim 15, wherein the computer program product comprises a computer-readable medium on which the software code portions are stored, or wherein the program is directly loadable into an internal memory of the processing device.

Fig. 1

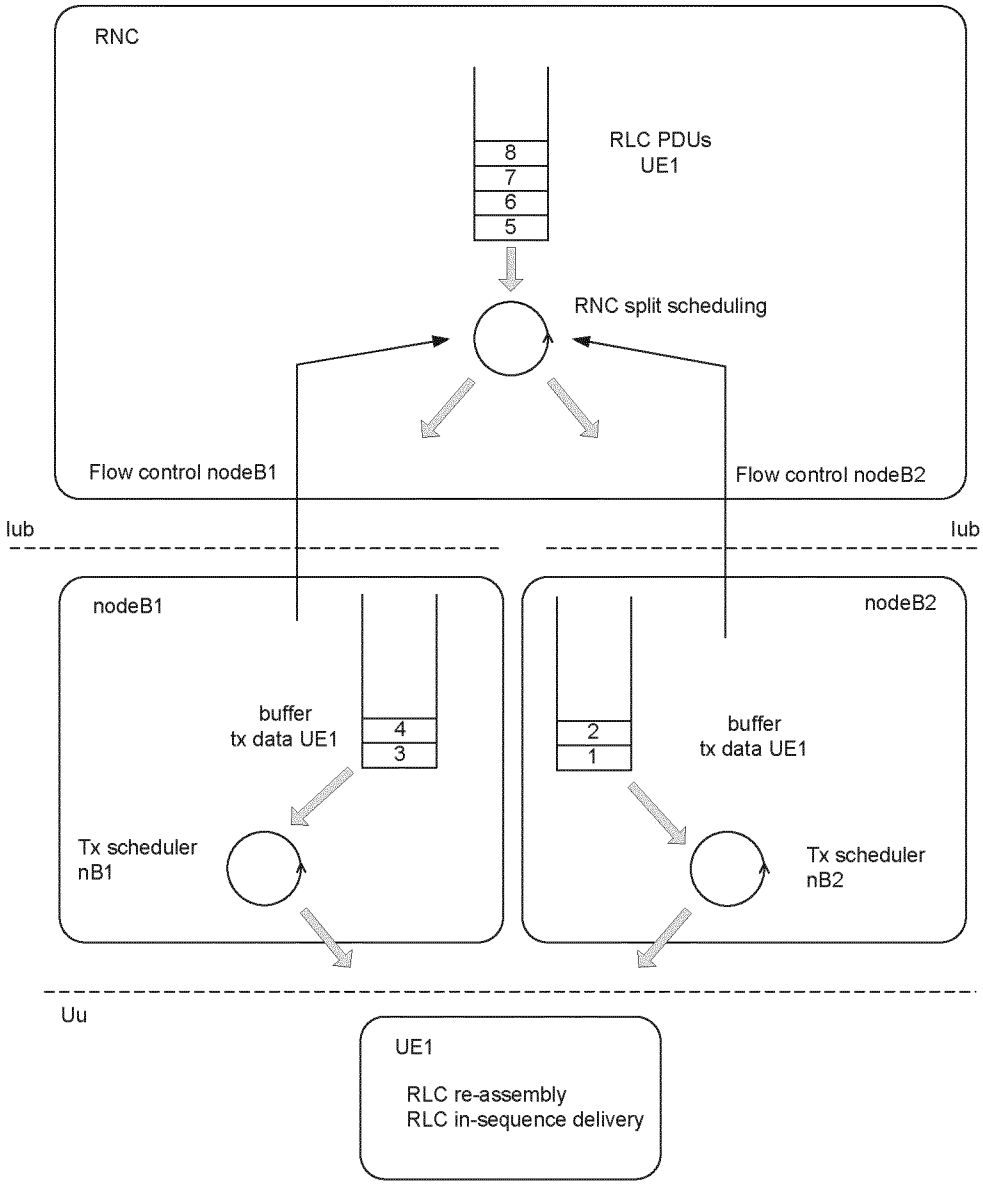

RNC
8
7
6
5
RLC PDUs
UE1
RNC split scheduling
Flow control nodeB1
Flow control nodeB2
Iub
Iub
nodeB1
buffer
tx data UE1
4
3
Tx scheduler
nB1
nodeB2
2
1
buffer
tx data UE1
Tx scheduler
nB2
Uu
UE1
RLC re-assembly
RLC in-sequence delivery

Fig. 2

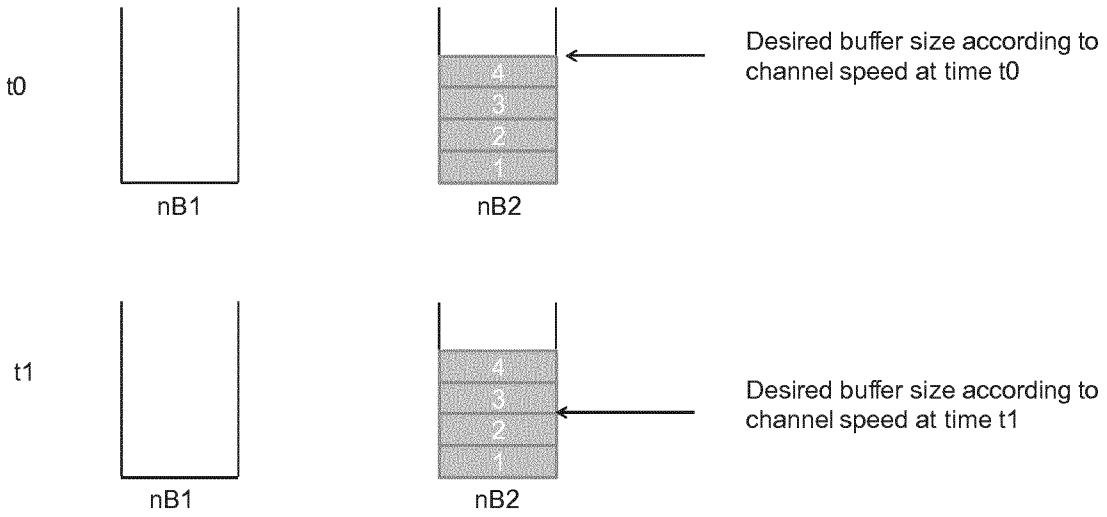
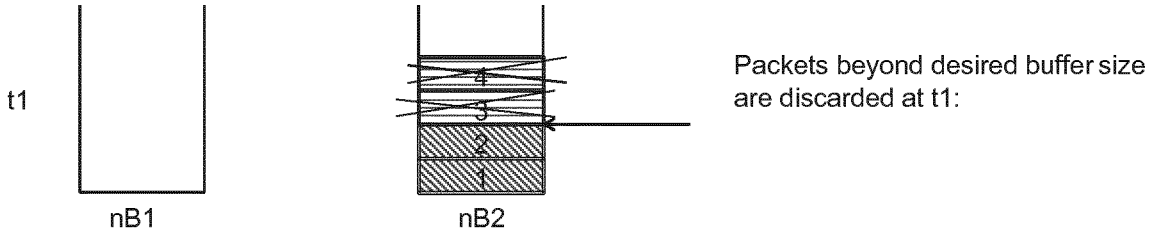

t0
nB1
4
3
2
1
nB2
Desired buffer size according to channel speed at time t0
t1
nB1
4
3
2
1
nB2
Desired buffer size according to channel speed at time t1

Fig. 3



Option 1:

1. nodeB sends notification to RNC. This may be done as negative flow control: x too many bytes in buffer
2. RNC considers whether to discard the too many bytes in nodeB2
3. RNC knows how many bytes it has sent to nB2 before the nB2 negative flow control indication. It informs the nB2 to discard RLC PDUs with SN > 2.

Fig. 4

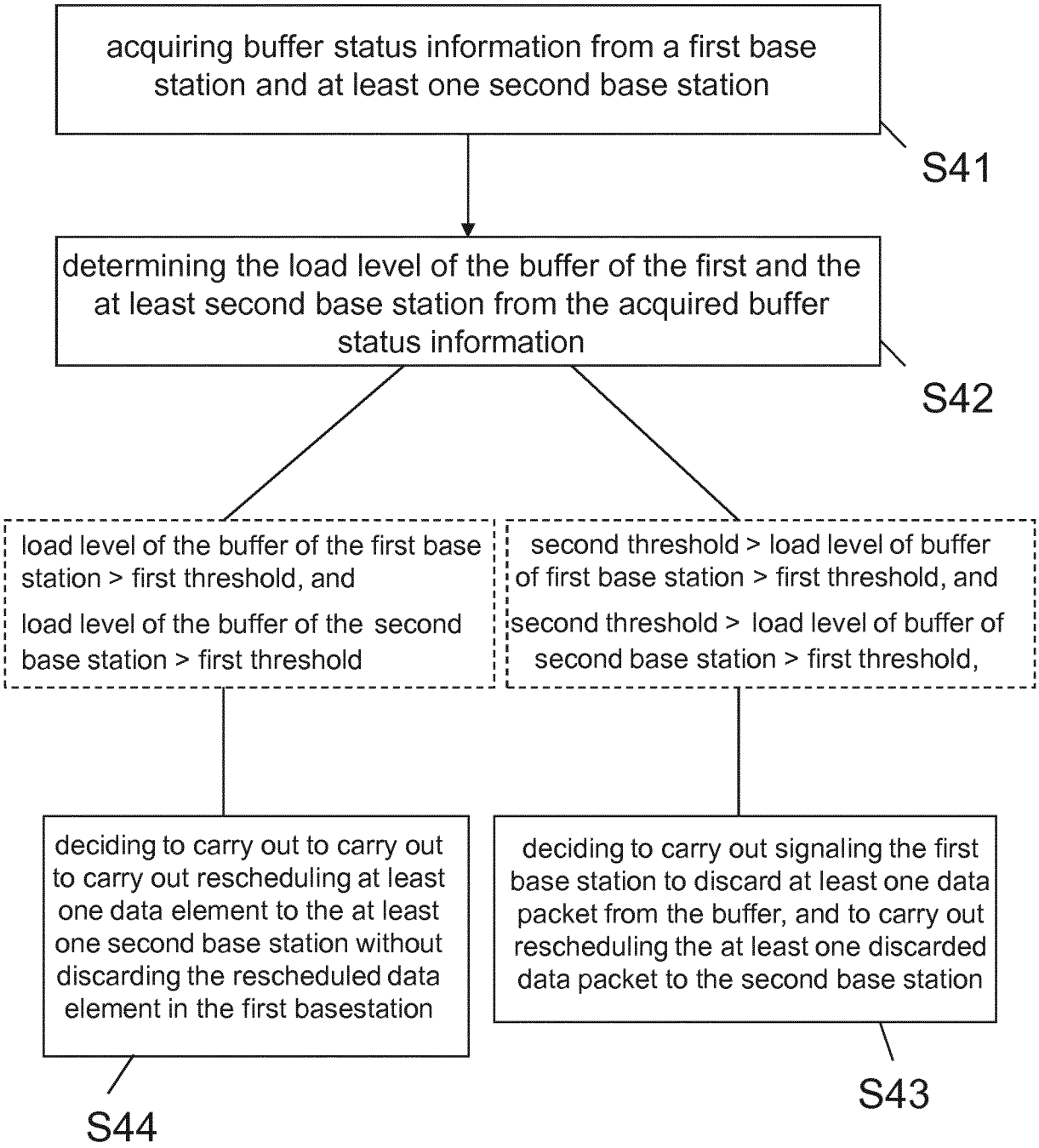

acquiring buffer status information from a first base station and at least one second base station
S41
determining the load level of the buffer of the first and the at least second base station from the acquired buffer status information
S42
load level of the buffer of the first base station > first threshold, and
load level of the buffer of the second base station > first threshold
second threshold > load level of buffer of first base station > first threshold, and
second threshold > load level of buffer of second base station > first threshold,
deciding to carry out to carry out to carry out rescheduling at least one data element to the at least one second base station without discarding the rescheduled data element in the first basestation
S44
deciding to carry out signaling the first base station to discard at least one data packet from the buffer, and to carry out rescheduling the at least one discarded data packet to the second base station
S43

Fig. 5

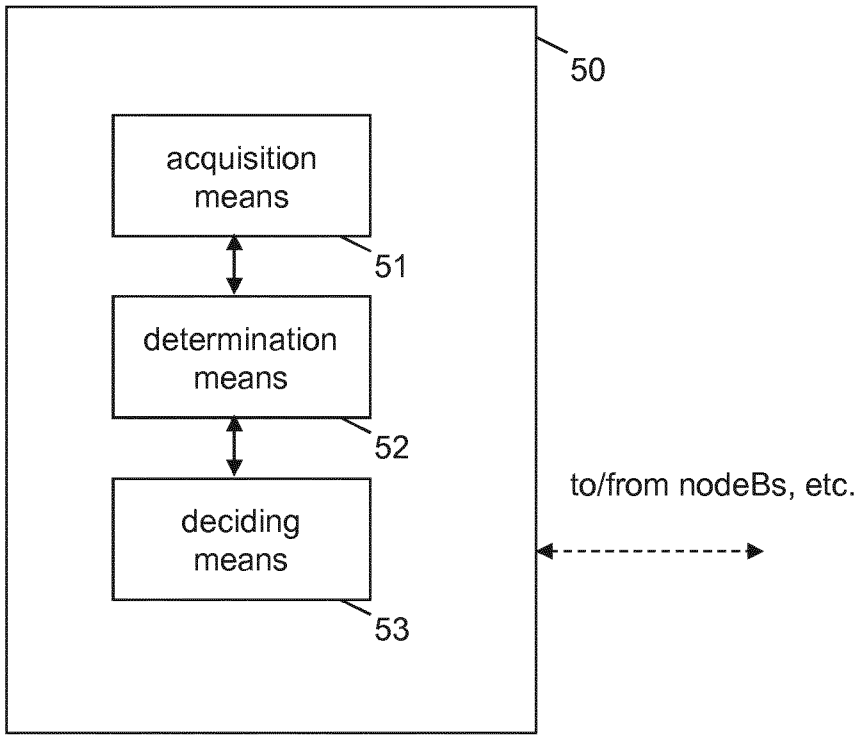

50
acquisition means
51
determination means
52
deciding means
53
to/from nodeBs, etc.

Fig. 6

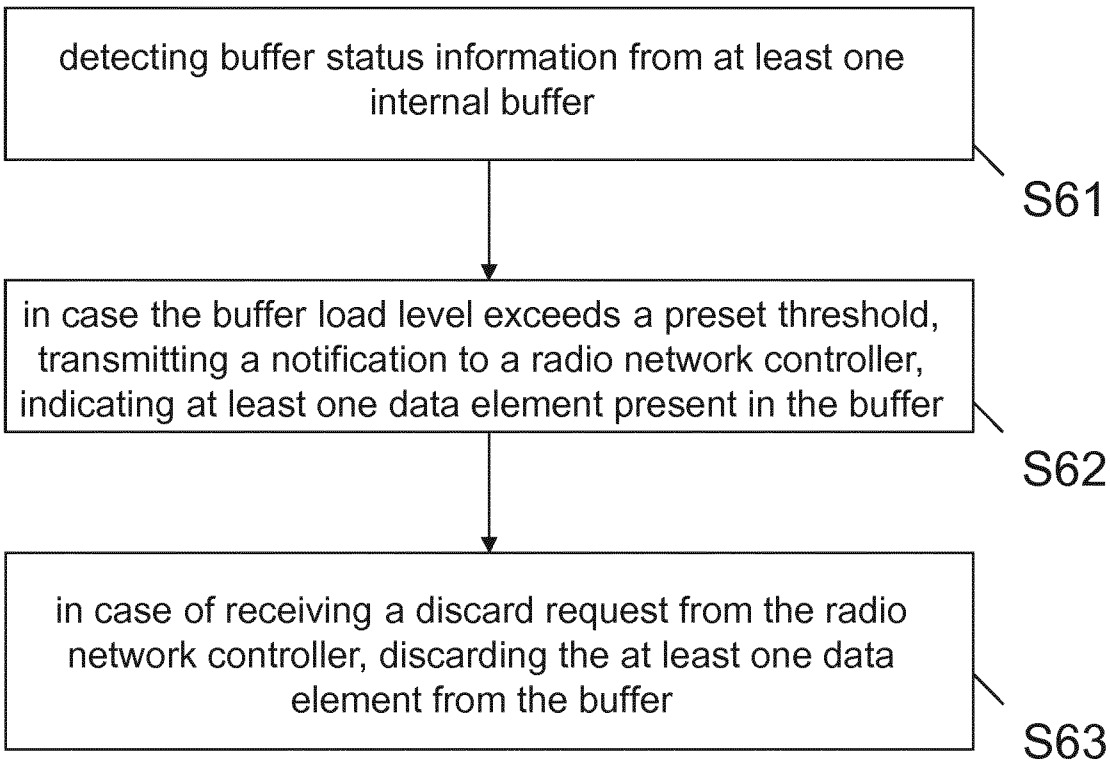

detecting buffer status information from at least one internal buffer
S61
in case the buffer load level exceeds a preset threshold, transmitting a notification to a radio network controller, indicating at least one data element present in the buffer
S62
in case of receiving a discard request from the radio network controller, discarding the at least one data element from the buffer
S63

Fig. 7

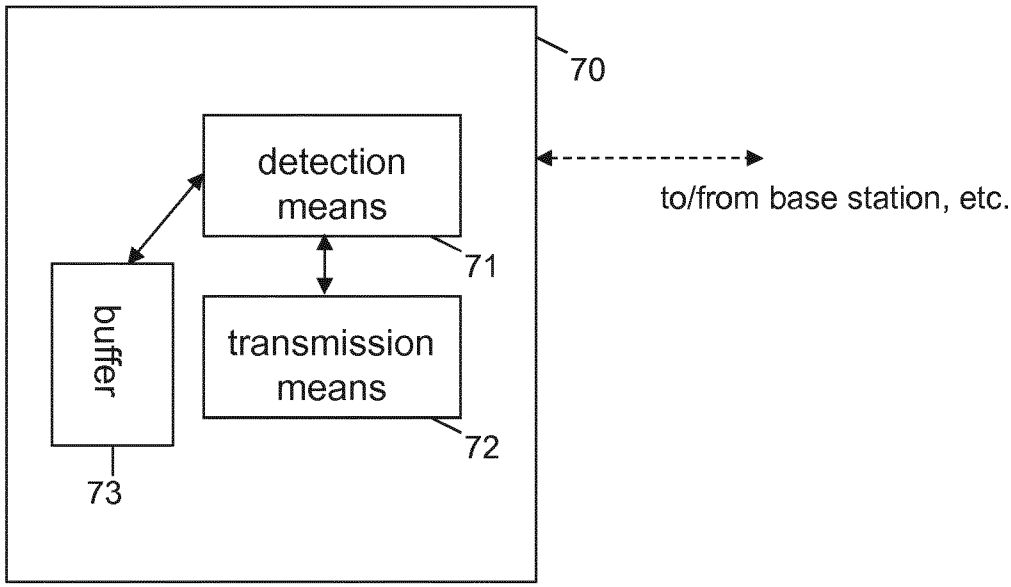

70
detection means
71
transmission means
72
buffer
73
to/from base station, etc.

Fig. 8

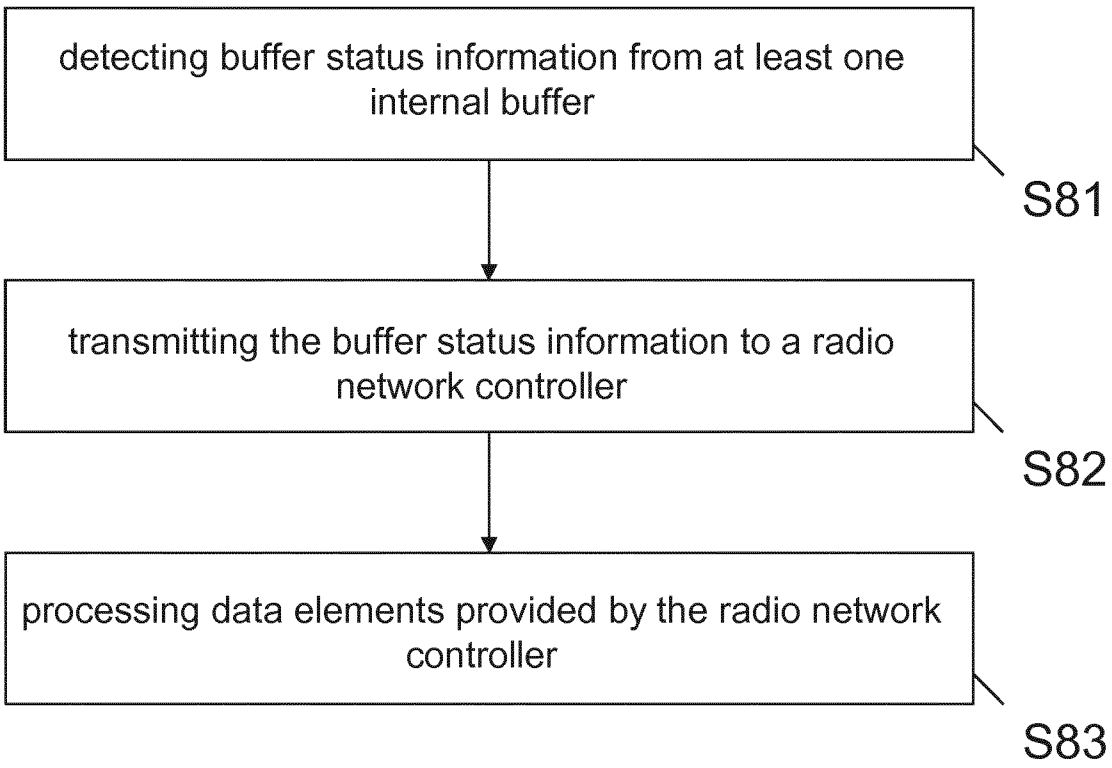

detecting buffer status information from at least one internal buffer
S81
transmitting the buffer status information to a radio network controller
S82
processing data elements provided by the radio network controller
S83

Fig. 9

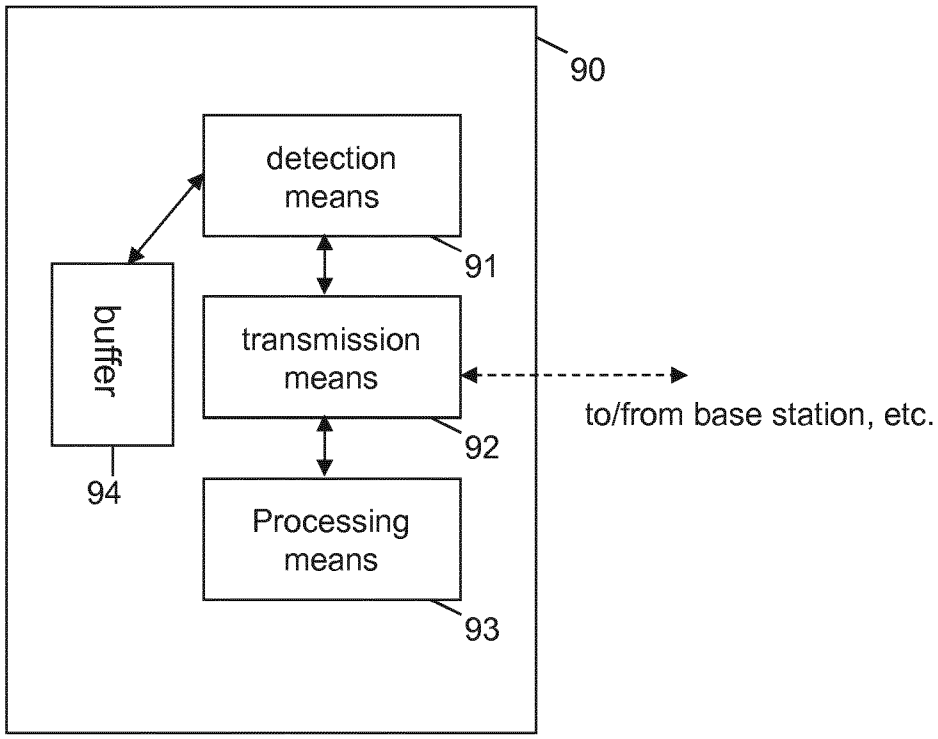
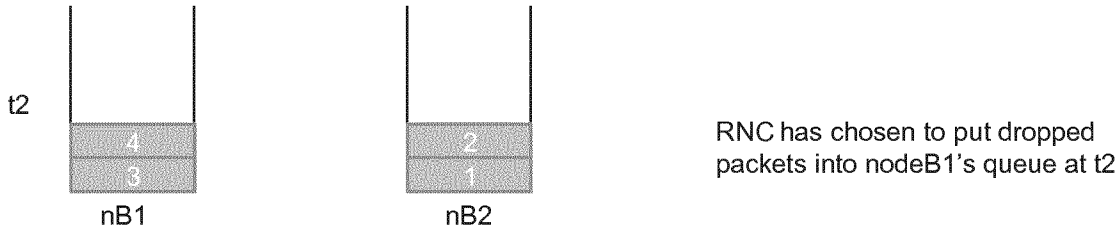

90
detection means
91
buffer
transmission means
92
to/from base station, etc.
94
Processing means
93

Fig. 10


t2
4
3
2
1
nB1
nB2
RNC has chosen to put dropped packets into nodeB1's queue at t2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/057682

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W28/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 03/017711 A1 (ERICSSON TELEFON AB L M [SE]; PEISA JANNE [FI]; WIGELL TOOMAS [FI]; MA) 27 February 2003 (2003-02-27) page 8, line 10 - line 19	1-7
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 July 2013	11/07/2013

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/057682

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	WO 03/096712 A1 (INTERDIGITAL TECH CORP [US]) 20 November 2003 (2003-11-20) paragraph [0016] - paragraph [0029]	8-16
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Information on patent family members

International application No
PCT/EP2013/057682

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INTERNATIONAL SEARCH REPORT

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PCT/EP2013/057682

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