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(54) Title: METHOD OF AND TRANSMITTING DEVICE FOR TRANSMITTING A DATA BLOCK

![Fig. 5](Continued on next page)

(57) Abstract: A method of transmitting a data block (DB4, DB6) of a type from a transmitting device (for example a transmitting network node) to a receiving device (for example a receiving network node), in particular during a temporary block flow, is disclosed. Furthermore, a transmitting device to perform the inventive method is disclosed. The transmitting device is capable of receiving at least two different types of positive/negative acknowledgements for data blocks of said type from said receiving device and the reaction of the transmitting device to the positive/negative acknowledgements depends on the type of the said received positive/negative acknowledgement.
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Description

Method of and transmitting device for transmitting a data block

FIELD OF THE INVENTION

The invention relates to a method of transmitting a data block of a type from a transmitting device to a receiving device, in particular during a temporary block flow. Furthermore, the invention is related to a transmitting device for transmitting a data block of a type to a receiving device, in particular during a temporary block flow.

BACKGROUND OF THE INVENTION

Although the physical data connections of modern networks, e.g. the cables, fiber optic cables, get better and better, errors during data transmission cannot be avoided. For this reason, numerous possibilities for error detection and error correction have been developed, e.g. the cyclic redundancy check (CRC). However, the problem of erroneous data blocks still persists.

As an example for these networks, enhanced general packet radio service (EGPRS) networks are exhibited hereinafter. However, the invention is not limited to this kind of networks and skilled in the art will easily apply the teachings of this invention to other networks. In this context, reference is made to the standard ETSI TS 144 060 V7.12.0, Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS);
Mobile Station (MS) – Base Station System (BSS) interface;
Radio Link Control / Medium Access Control (RLC/MAC)
protocol; (3GPP TS 44.060 version 7.12.0 Release 7), which
is herewith incorporated by reference, particularly
chapter 9.1.8.2.4, interpretation of the bitmap'. In
particular, also definitions, messages, message flows, and
abbreviations, which are used in this application, can be
found in this standard.

In this enhanced general packet radio service standard a
kind of fast inband signaling has been added recently in
addition to the traditional packet downlink
acknowledgment (PDAN) and the packet uplink
acknowledgement (PUAN). This fast inband signaling
contains a short bitmap for positive and negative
acknowledgements of radio link control blocks (RLC blocks)
and thus speeds up the retransmission of incorrectly
received RLC blocks, wherein an RLC block is an example
for a data block or a data unit.

This new signaling is called 'fast acknowledged/not
acknowledged reporting', FANR for short, and will, if
used, substantially increase the frequency of
acknowledged/negatively acknowledged reporting (ACK/NACK
reporting). However, these reports are not as well
protected against undetectable decoding errors as the PDAN
and PUAN because their CRC is weaker.

Considering a 'transmitting endpoint', transmitting
network node', 'transmitting device' or simply
'transmitter', i.e. one that transmits data blocks and
receives acknowledgement data, and a 'receiving endpoint',
'receiving network node', 'receiving device' or simply
'receiver', i.e. one that receives data blocks and transmits acknowledgement data (which may be piggy-backed onto other data blocks), a particular risk is that a transmitting endpoint may incorrectly consider a piggy
backed acknowledgement (PAN), also referred to as 'piggy-backed Ack/Nack', to be included in a data block which it decodes, because an incorrect sequence of bits, which are decoded, causes the CRC check to pass. This may happen for example when a header bit is misinterpreted as PAN field (the PAN field indicates the presence of a PAN field and is arranged in the header of a data block). This is referred to as a 'false positive'. A 'false positive' PAN can also occur when a PAN is included, but when the bit error rate (BER) is too high for successful channel decoding and when the (decoded) CRC nevertheless is correct. Since the payload and the PAN in a radio block can address different mobile stations (MS), a high BER can be expected e.g. for an MS at the cell border if the payload transmission addresses an MS close to the base station and when the transmission uses 32-QAM (quadrature amplitude modulation). The combination of more frequent reporting and weaker protection will lead to more undetected errors which, in many cases, will cause an abnormal temporary block flow release (TBF release). A particular problem is that this release can rely on existing timers which are set to several seconds (e.g. 5 seconds).

Although the CRC size inside the PAN can be increased, e.g. from 6 to 10, to reduce the probability of a 'false positive' acknowledgement, said probability never will be zero. In some cases, the CRC is XOR-ed with the temporary flow identity (TFI) for the destination MS. If a different
MS, which is multiplexed on the same resources, tries to decode the PAN applying a XOR with its (different) TFI, the CRC properties can be weakened. Thus, several error events may occur per hour in a multislot EGPRS transmission.

The result of the reception of a 'false positive' may be:

1. That an RLC transmitting endpoint incorrectly believes a block has been acknowledged negatively
2. That an RLC transmitting endpoint incorrectly believes a block has been acknowledged positively

Case 1 causes unnecessary retransmissions. Case 2 could cause the transmit window to advance further than the receive window. In this case:

a) the transmitting endpoint will transmit blocks with higher SSNs (starting sequence numbers) than the peer (receiving endpoint) expects, and
b) the transmitting endpoint will not re-transmit blocks which the peer (receiving endpoint) expects.

Case b) could eventually end in a TBF deadlock, if one device, i.e. the receiving device, expects retransmissions, but the other device, i.e. the transmitting device, has discarded the block (s) from its memory, in particular its transmit buffer.

One option is to further increase the CRC length which would reduce the occurrence rate of such errors. However, this would also reduce the number of bits available for payload. It is therefore proposed to take measures on protocol side to minimize the impact of such error events.

The problem of stalled windows (where a transmitting device is hindered from transmitting further blocks, due
to waiting for an acknowledgement of earlier transmitted blocks) is already known. The solution is to simply wait for an acknowledgement, which may indicate negative acknowledgements for some data blocks (in which case these are then retransmitted) and/or positive acknowledgements for other data blocks (which may allow the transmitting entity to discard some buffered blocks and possibly advance the transmit window, allowing new blocks to be transmitted for the first time). A drawback of this method is that the transmission of some data blocks is delayed.

However, the present invention addresses a new problem caused by the relatively high probability that an acknowledgement indication may suffer from a 'false positive' detection. This increased 'false positive' probability arises from, for example, the specific nature of the fast ACK/NACK reporting scheme used in EGPRS networks, whereby a very small ACK/NACK field is piggy-backed on existing data blocks, and the ACK/NACK field is coded independently of the rest of the block.

Accordingly, the object of the invention is to provide an improved method of and an improved transmitting device for data transmission in a network.

OBJECT AND SUMMARY OF THE INVENTION

According to the invention, this object is achieved by a method according to claim 1 and a device according to claim 21.

Accordingly, a method of transmitting a data block of a type from a transmitting device (for example a
transmitting network node) to a receiving device (for example a receiving network node) is disclosed, wherein the transmitting device is capable of receiving at least two different types of positive/negative acknowledgements for said data block of said type from said receiving device and wherein the reaction to the positive/negative acknowledgements after reception/decoding of the transmitting device depends on the type of said received positive/negative acknowledgement.

Accordingly, also a transmitting device for transmitting a data block of a type to a receiving device, in particular network node, is disclosed, the transmitting device being designed for receiving at least two different types of positive/negative acknowledgements for said data block of said type from said receiving device and for reacting to the positive/negative acknowledgements after the reception/decoding of the same depending on the type of said received positive/negative acknowledgement.

The invention offers the advantage that the transmitting device is able to receive acknowledgements, which may be positive or negative acknowledgements, of at least two different types, each having different characteristics and thus having different tendencies for errors. For example a positive acknowledgement may be corrupted on the transmission path to the transmitting device so that a negative (and thus wrong) acknowledgement is received there. However, also a negative acknowledgement may be corrupted on the transmission path to the transmitting device so that a positive (and thus wrong) acknowledgement is received there. An acknowledgment which, after decoding, contains errors which cannot be detected is also
referred to as a 'false positive'. Knowledge of the relative probability of 'false positives' associated with different types of acknowledgements is used to determine how to treat different types of acknowledgements, in particular when positive/negative acknowledgements of different types indicate conflicting acknowledgement status of the same transmitted data block. This gives advantage over prior art systems as a kind of redundancy is used to find out if a, for example, positive acknowledgement is plausible.

It should be noted at this point, that the acknowledgements may be part of one single protocol. It should also be noted that the at least two different types of positive/negative acknowledgements may refer to data blocks of the same type, said type being for example data blocks of one of the protocol layers.

Finally, it should be noted that the invention is not limited to just two types of acknowledgments but also applies to three or more types.

Preferred embodiments of the invention can be found in the dependent claims as well as in the description and the figures.

It is advantageous if the transmitting device receives and processes at least two different types of positive/negative acknowledgement information, wherein each type of positive/negative acknowledgement information comprises one or more positive acknowledgements and/or negative acknowledgements of a single type relating to individual data blocks of said type. Accordingly, a plurality of acknowledgements of a first type can be
transmitted in positive/negative acknowledgement information of a first type, and one or more acknowledgements of a second type can be transmitted in positive/negative acknowledgement information of a second type. The invention is not limited to acknowledgements of single data blocks but also applies to a set of acknowledgements for several data blocks of the same type. This method of acknowledging is efficient to acknowledge a lot of data blocks in one go.

In this context, it is also advantageous if said type of positive acknowledgement and/or negative acknowledgement is characterized by the type of said positive/negative acknowledgement information in which it is included.

One should note that the present invention is based on the earlier application GB0721519.7 and in this earlier application the general term Acknowledgement' variously has been used for Acknowledgement' as well as for Acknowledgement information'. However, as the meaning is unambiguously clear considering the context the term is used, one skilled in the art will easily substitute Acknowledgement' for Acknowledgement' or Acknowledgement information' as the case may be.

Furthermore it is advantageous if the second type of positive/negative acknowledgement is more reliable than the first type. If both types are equally error-prone, then a contradiction of the two types indicates that something is wrong whereas in this advantageous embodiment, the more reliable acknowledgement also indicates what is more likely to be right or wrong.
In this context it is advantageous, if the second type of acknowledgement is coded such that reception and/or correct decoding and/or correct detection of decoding errors of this type is more reliable than that of the first type of acknowledgement.

In another advantageous embodiment of the invention, for the second type of positive/negative acknowledgement information it is less probable than for the first type that a consistency check applied to the positive/negative acknowledgement information passes even though the decoded positive/negative acknowledgement information is incorrect. This is an advantageous example of how reliability of the acknowledgements can be specified. Consistency checks are commonly used which is why the invention can be implemented with low technical effort.

In yet another preferred embodiment of the invention, the consistency check is a cyclic redundancy check. This is a further specification of what a consistency check can be. Again, implementing the invention can take place with low technical effort.

It is advantageous if a positive acknowledgement contained within an acknowledgement field (containing a plurality of positive and/or negative acknowledgements) is ignored if a positive or negative acknowledgement contained therein is classified as unreliable. In an advantageous embodiment, all positive acknowledgements contained within an acknowledgement field are ignored if a positive or negative acknowledgement contained therein is classified as unreliable.
It is beneficial if the transmitting device ignores all positive acknowledgements contained within positive/negative acknowledgement information of the first type which has been classified as unreliable. This offers the advantage that it ensures that the data blocks associated with the unreliable positive acknowledgements are not discarded by the transmitting device and may be retransmitted if subsequent positive/negative acknowledgement information or a positive/negative acknowledgement indicates that the data blocks were not received correctly by the receiving device.

In a beneficial embodiment of the invention, an acknowledgement information or acknowledgement field (containing a plurality of positive and/or negative acknowledgements) is ignored if a positive or negative acknowledgement contained therein is classified as unreliable.

In another embodiment, the transmitting device ignores all information contained within positive/negative acknowledgement information of the first type which positive/negative acknowledgement information has been classified as unreliable. Here, not only any positive acknowledgement but also any negative acknowledgement within the unreliable unit of positive/negative acknowledgement information is ignored.

It is advantageous if the transmitting device signals to the receiving device that it has classified positive/negative acknowledgement information of the first type as unreliable. It may be useful to inform the
receiving device so that also the receiving device can take necessary steps to avoid a problem.

In a further advantageous embodiment of the invention, the transmitting device requests the receiving device to transmit positive/negative acknowledgement information of the second type if it has classified previously received positive/negative acknowledgement information of the first type as unreliable. In this case, the check, whether an acknowledgement of the first type is wrong may be done 'on demand'. As one can imagine, second type acknowledgement information requires additional transmission bandwidth. Thus, it can be useful to check whether everything is right by sending second type acknowledgement information only from time to time or when positive/negative acknowledgement information of the first type is classified as unreliable.

In yet another advantageous embodiment of the invention, in particular during a temporary block flow (TBF), the transmitting device stores the data block to be sent in a memory and said data block is kept stored in said memory if an acknowledgment of a first type, in particular a piggy backed acknowledgement (PAN), is received from the receiving device indicating that said data block has been received correctly and said data block is removed from said memory if an acknowledgment of a second type, in particular a packet downlink acknowledgement (PDAN) or a packet uplink acknowledgement (PUAN), is received from the receiving device indicating that said data block has been received correctly. This embodiment offers the advantage that the transmitting device is able to retransmit data blocks, which have been positively acknowledged by means
of an acknowledgement of the first type, if subsequently it turns out that the positive acknowledgement is unreliable, i.e. if the acknowledgement is 'false positive'. According to prior art, the connection would have to be closed, as the states at both devices are out of synchronization and could not be re-synchronized without the measures of the invention. The longer the blocks remain stored, the lower is the risk that a retransmission is not possible. As the buffering capacity of a device must be provided for transmitting anyway, no expensive equipment is required for the invention. For example, the transmitting nodes in an EGPRS network have to have a buffer for the entire window size (although in some cases fewer than window size blocks are 'outstanding', i.e. have been transmitted but have not yet been positively acknowledged).

In an advantageous embodiment, the data block is resent if a positive acknowledgement is classified as unreliable. It can happen that a positive acknowledgement of a data block which has been decoded by the transmitting device is wrong in reality. In other words, the receiving device did not transmit such a positive acknowledgement, but due to channel conditions and/or decoding errors and/or limitations of a consistency check, the transmitting device believes that the receiving device transmitted such an acknowledgement. This case is an example for a 'false positive' acknowledgement. However, by means of the invention such a false positive acknowledgement can be detected, and subsequently the data block is sent once more.
In a further beneficial embodiment, the removal of said data blocks from said memory is independent from receiving an acknowledgment of a first type and occurs on receiving an acknowledgement of a second type.

It is advantageous if the positive/negative acknowledgement information of the first type is classified as unreliable if it contains a positive acknowledgement for the data block and previously received positive/negative acknowledgement information contained a negative acknowledgement for said data block. Furthermore, it is advantageous if the positive/negative acknowledgement information of the first type is classified as unreliable if it contains a negative acknowledgement for the data block and previously received positive/negative acknowledgement information contained a positive acknowledgement for said data block. Here, a false acknowledgement is detected by the contradiction of a first positive acknowledgement and a second negative acknowledgment or vice versa. In this context it is advantageous if the acknowledgement of the first type is contained within a piggy backed acknowledgement (PAN) and the acknowledgement of the second type is contained within a packet downlink acknowledgement (PDAN) or a packet uplink acknowledgement (PUAN) for a data block. PAN, PDAN and PUAN are or will be used in EGPRS networks anyway and can provide an additional function now.

Furthermore, it is advantageous if the positive/negative acknowledgement information of the second type is transmitted within a packet downlink ACK/NACK message, packet downlink ACK/NACK Type 2 message or packet uplink ACK/NACK message.
Furthermore, it is advantageous if the positive/negative acknowledgement information is transmitted within a piggy-backed ACK/NACK field.

It is advantageous if the acknowledgement of the first type is contained within a piggy backed acknowledgement (PAN) and the acknowledgement of the second type is contained within a packet downlink acknowledgment (PDAN) or a packet uplink acknowledgement (PUAN). Accordingly, a positive acknowledgement contained within a PAN does not lead to a removal whereas a positive acknowledgement contained within a PDAN/PUAN does lead to a removal of a stored data block.

In yet another advantageous embodiment, the transmitting device classifies positive/negative acknowledgement information of a first type as unreliable if it contains a positive acknowledgement for a data block which has not been transmitted by the transmitting device. This is a very clear indication of a transmission error and thus suitable for the invention. A further advantage is that no extra information has to be exchanged between the devices to detect a false positive acknowledgement.

Furthermore, it is advantageous if the connection, in particular the temporary block flow, is closed, if the transmitting device receives an indication from the receiving device that a data block has not been received correctly and if said data block has been removed from said memory of the transmitting device. It may happen, that a data block is not stored in the transmit buffer of the transmitting device when an incorrect reception of the
data block is detected. For example, said data block has been overwritten by a newer data block. In such a case, the connection is closed and restarted.

It is also advantageous, if said positive acknowledgement is classified as unreliable if the receiving device receives a data block with a sequence number greater than the highest sequence number in a receive window. This is a further clear indication of a transmission error and thus suitable for the invention as well. Again, no extra information has to be exchanged between the devices to detect a 'false positive' acknowledgement.

Finally, it is advantageous if the transmitting device uses the Radio Link Control / Medium Access Control protocol for Enhanced General Packet Radio Service with the Fast Acknowledgement/Negative Acknowledgement Reporting feature also known as Reduced Latency. Said protocol already offers messages which can be used for the purpose of the invention which is why an implementation of the same can take place with low technical effort.

It should be noted at this point that the embodiments and advantages presented for the inventive method mutatis mutandis apply to the inventive device.

It should also be noted that embodiments of the invention disclosed herein can be combined in any desired way.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described and shown in the schematic Figures hereinafter.
BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows possible cases when a data block is received which is or is not expected;

Figure 2 shows possible cases when a PAN is received;
Figure 3 shows possible cases when a PDAN/PUAN is received;
Figure 4 shows a first typical message flow, in which acknowledgement information contains only one acknowledgement;
Figure 5 shows a second message flow, in which acknowledgement information contains a number of acknowledgements;
Figure 6 shows a third message flow, in which acknowledgement information contains a number of acknowledgements.

DESCRIPTION OF EMBODIMENTS

In the Figs, the same elements and elements with the same function are referenced with the same reference sign if not stated otherwise. Furthermore, the transmitting device is referred to as transmitting network node and the receiving device is referred to as receiving network device hereinafter. However, this specification may not be construed to limit the broad scope of the invention.

The invention has a number of different aspects:
1. Storage of blocks that have been acknowledged:
A transmitting device stores blocks even after they have been acknowledged, in particular if that acknowledgement was by means of a PAN.

2. PUAN / PDAN sent in response to unexpected block:
A data block which is received but was not expected because if falls in front of the receive window is indicative of a 'false positive' and this triggers (directly or indirectly) a PUAN / PDAN to be sent.

3. A PAN covering unexpected block is treated 'cautiously': A PAN which refers to blocks in a manner which is not expected is treated in a fail-safe manner, so that the transmit window is not advanced, and the probability that necessary retransmissions can be made is increased.

4. Fast closure/reset of out-of-sync TBFs: Rather than relying on existing timers to detect a TBF deadlock, a signal is transmitted to the peer entity as soon as practical after realizing that the receiving device waits for a retransmission of a block which the transmitting device no longer has buffered.

5. Reception of inconsistent PDAN/PUAN - process with priority over existing state: Since in most cases a PDAN/PUAN is transmitted more robustly than a PAN, PDAN/PUAN information should take precedence over previous state. This may require the transmit window to move 'backwards'.

Case 1: Storage of blocks that have been acknowledged: One requirement to avoid deadlocks is that RLC transmitting endpoints maintain data blocks in the transmit buffer, even after they have been acknowledged by a PAN (no such requirement would exist for blocks acknowledged by a PDAN/PUAN due to the very much lower probability of a 'false positive' PDAN / PUAN). The capability of maintaining data blocks in the transmit buffer needs not to be signaled to the peer entity.
Furthermore, maintaining data blocks in the transmit buffer normally does not cause extra effort since buffering capacity must be provided for the entire window size WS anyway (however, in some cases fewer than window size blocks are 'outstanding', i.e. have been transmitted but have not yet been positively acknowledged). Said storing of data blocks enables the transmitting device to retransmit blocks, which have been acknowledged positively, if subsequently it turns out that the acknowledgement is false, that is to say was contained within a 'false positive' PAN. Without this storage, the TBF would have to be closed (see case 4), since the states at the network nodes are mismatched and cannot be resynchronized (without restarting the TBF). The longer the blocks are stored, the lower is the risk that a retransmission is not possible.

Case 2: PUAN / PDAN sent in response to unexpected block: In RLC acknowledged mode, the receive window is defined as the range of WS (window size) consecutive sequence numbers starting with the sequence number corresponding to the oldest block which has not yet been received. The receipt of a block with a sequence number greater than the highest sequence number in the receive window indicates that the transmit window of the peer (transmitting) device has advanced further than the receive window of the receiving device. This indicates that the transmitting device has incorrectly advanced its window, based on a 'false positive' PAN. This situation is depicted in Fig. 1, which shows a first, a second and a third data block DBl..DB3, a receive window state variable V(Q) and a receive window RW. The sequence numbers of the data blocks DBl..DB3 increase from left to right in the Fig. 1, and the third
data block DB3 has a sequence number higher than the highest sequence number in the receive window. V(Q) is the oldest block (i.e. block with lowest sequence number) which has not been correctly received by the receiving device. This is applicable to RLC acknowledged mode.

However, the definition for non-persistent mode is similar, but more complex.

In response to this, an endpoint (network node) which receives an RLC block DB3, which is ahead of the receive window RW, sends an according message to the peer entity. For example, it sends a PUAN / PDAN at the first opportunity, which includes the beginning of the window (BOW).

Alternatively (and particularly applicable if the receiving device of the data blocks is the mobile station, which currently transmits PDANs only in response to a poll from the network), the endpoint informs the peer entity about the reception of an unexpected data block. The 'packet mobile TBF status', containing an appropriate cause, e.g. 'Receive and transmit windows not synchronized', may be used for this cause. The peer entity (i.e. the network) then polls for a PDAN and indicates (to the mobile station) that the PDAN should contain the beginning of the receive window.

If the indication to the peer entity is in the form of a PUAN/PDAN, such a message must be treated with higher priority than previous PANs. If, for example, the PUAN/PDAN indicates a NACK, this takes priority over any previous ACK.
In RLC non-persistent mode, the receive window is defined differently so that no particular block is ever considered 'unexpected' by a receiving device. The approach specified here would therefore not apply to RLC non-persistent mode.

RLC endpoints may retransmit blocks that have been previously correctly received, e.g. if an acknowledgement has not yet been received when the block is retransmitted. Therefore only the data block DB3 on the right end of Fig.1 is considered erroneous.

The benefit of this embodiment is that the other endpoint can find out if the windows are out of synchronization.

Case 3) PAN covering unexpected block is treated 'cautiously':

The treatment of a PAN, which refers to previously transmitted blocks by their sequence number, (rather than, for example, by the time at which they were transmitted) is proposed to be modified as follows. A PAN which refers to a block which is outside of the transmit window (i.e. a block with sequence number lower than the lowest sequence number in the window, or higher than the highest sequence number which has been transmitted, but taking into account - i.e. ignoring - 'padding' bits which cannot be distinguished from NACKs for blocks which the RLC receiving device has not yet received) indicates either that that PAN or a previously-received PAN is not a genuine PAN, but is a 'false positive' reception. A NACK for a lower sequence number than the lowest sequence number in the window is a special case of the more general condition that, if a previously positively acknowledged block is subsequently negatively acknowledged, something
is wrong. Furthermore, even if an ACK refers to a block sequence number (BSN) inside the window, a fail safe mode should also be chosen if this BSN has not been transmitted yet. These cases are illustrated in Fig. 2, which shows a first and a second negative acknowledgement N1 and N2, a positive acknowledgement A3, an acknowledge state variable V(A) and a range of blocks which have been transmitted TB. The first negative acknowledgement N1 is related to a first data block DB1, for which previously a positive acknowledgement has been received, and the second negative acknowledgement N2 is related to the second data block DB2, for which previously a positive acknowledgement has been received. It should be noted that the negative acknowledgements N1 and N2 are contained in a PAN in this example, as a PUAN with an inconsistent negative acknowledgement is not considered to be an error. Finally, it should be noted that V(A) is the oldest block (i.e. block with lowest sequence number) which has not been positively acknowledged by the receiving device and which still may be retransmitted.

A plausibility check can be applied in a very similar way to a time-based PAN. Violation of the following requirements should lead to a cautious treatment.

- An RLC block which has previously been acknowledged should not be negatively acknowledged.
- RLC blocks should not be acknowledged for transmission times at which no block has been sent (a very evident violation being an ACK for a transmission time in the future). It is expected that almost all 'false positives' will fail the plausibility check.
Two treatments are possible. In both cases, the intention is to prevent the advance of the transmit window as a result of the reception of this PAN:

1. The PAN is completely ignored.

2. Only NACKs within the PAN are treated, i.e. no blocks shall be considered as positively acknowledged based only on the contents of this PAN.

The advantages of such a method are:
- if the most recently received PAN is a 'false positive', then no positive acknowledgements are inferred, and so blocks which have not otherwise been acknowledged will remain stored in the transmitting device's buffer for retransmission.
- if it was a previous PAN which was the 'false positive', this approach minimizes the risk that earlier blocks will be removed from the transmitting device's buffer and maximizes the possibility that the necessary retransmissions will be possible.

A further enhancement (which is not necessarily linked to the previous paragraph) is that the situation is signaled to the peer entity, to trigger a complete PDAN / PUAN which should start at the beginning of the window, to avoid confusion in the transmitting device. In the case where the PAN is received by the mobile station, this may be by means of a 'packet mobile TBF status' message, with an appropriate (new) cause indication (e.g. 'PAN not consistent with transmit window'). In the case where the PAN is received by the network, this may be by means of a poll for a complete PDAN including the 'first partial bitmap' (i.e. mandating that the mobile station explicitly indicates what is the beginning of the receive window). As a result, a questionable PAN will be dealt with in a fail
safe way (ACKs are ignored), and the transmission of a highly reliable ACK/NACK message is triggered in many cases.

PUANs/PDANs may cover blocks below the transmit window if a PAN was received shortly before the PUAN/PDAN. A PDAN refers to blocks received up to the time when the poll was received; an event-based PAN may cover later blocks than this, but maybe received first. Similarly for 'time-based' FANR, a time-based PAN may be generated in the network after a PUAN but may arrive first). Therefore no inference of a 'false positive' should occur regarding a PDAN/PUAN which appears to refer to blocks 'below' the transmit window.

Case 4) Fast closure/reset of out-of-sync TBFs:
If a transmitting device determines that it cannot synchronize with the receiving device (e.g. it has received a PUAN which indicates a NACK for a block which is no longer stored), means for closing the TBF (or possibly resetting it, so that no resource re-assignment is carried out) are provided.

Existing messages can be used where possible (e.g. 'packet TBF release', where the release is initiated by the network). A specific cause value can be used to identify the reasoning for the release. A further enhancement is to indicate that, although the RLC state is to be reset, the resources assigned (at the medium access control layer) are to be retained unchanged. So, the transmission does not have to wait for a timeout. Data transfer may be able to continue without the need for resource reassignment.
Case 5: Reception of inconsistent PDAN/PUAN:

If an RLC endpoint receives an ACK/NACK bitmap in a PDAN/PUAN which is inconsistent with previously received information (i.e. it negatively acknowledges a block which was previously considered positively acknowledged) then this can also be an indication of a previously received 'false positive' PAN. These cases are depicted in Fig. 3, which is identical to Fig. 2 but without the positive acknowledgement A3 and wherein the negative acknowledgements N1 and N2 are not contained in a PAN message but in a PUAN/PDAN message.

In this case the endpoint considers the PDAN/PUAN as correct and updates V(B), V(A) and V(S) accordingly. This may result in a block needing to be retransmitted which was previously considered acknowledged. There are two possibilities:
- the RLC transmitting device still has the block buffered (for example because the procedure described for case 1 above has been followed); normal procedures resume.
- the RLC transmitting device no longer has the block buffered; in this case it signals to its peer that the TBF should be released (see case 4 above)

It is possible that a PAN (especially a time-based PAN) correctly resulted in a block being considered acknowledged and was received before a PUAN/PDAN which was
constructed at a time when the block had not been received at the base station system (BSS). However, this case is protected by the current requirements whereby no information is derived from a PUAN/PDAN regarding blocks which were (re-)transmitted recently such that the PDAN/PUAN could not possibly take those transmissions into account.

For NPM, the TBF needs not to be closed as a result of this situation. The probability of a 'false positive' PDAN/PUAN is negligible due to the higher CRC protection and robust modulation; therefore the possibility that a PDAN/PUAN appears to acknowledge a block which has not yet been transmitted is low.

Fig. 4 now shows a message flow between a transmitting network node and a receiving network node illustrating the invention. First of all, data blocks DB4..DB6 are stored in the transmitting network node. In a second step, the first data block DB4 is transmitted to the receiving network node, which positively acknowledges the reception with a PAN. The transmitting network node receives this PAN but, however, keeps stored the data block DB4. The same procedure happens for DB5 and DB6, except that a negative PAN is received for data block DB5 and a positive PAN is received for data block DB6 by the transmitting network node (e.g. because the PAN(DB5) and PAN(DB6) are corrupted on the transmission path). Note that in the example depicted in Fig. 4 DB5 is not resent although a negative acknowledgement has been received. However, in a further embodiment (not shown), the transmitting network node resends DB5 as a consequence of the negative acknowledgement.
Then, a positive PUAN is sent for the data block DB4. There is no contradiction between the positive PAN and the positive PUAN for DB4. Accordingly, the data block DB4 is removed from the memory. In a next step, a positive PUAN is sent for the data block DB5. There is a contradiction between the negative PAN and the positive PUAN. However, the PUAN is considered as being more reliable and thus gets priority over the PAN. Accordingly, the second data block DB5 is removed as well. Finally, a negative PUAN is sent for the data block DB6. Again there is a contradiction, now between a positive PAN and a negative PUAN and again the PUAN gets priority over the PAN. Accordingly, the data block DB6 is re-sent. Finally, the reception is positively acknowledged by a positive PUAN for the data block DB6. Hence, the data block DB6 is removed from the transmitting network node's memory accordingly.

Fig. 5 shows another example for a communication between a transmitting network node and a receiving network node. First of all, the data blocks DB4..DB6 are stored in the transmitting network node. Then, the data blocks DB4..DB6 are sent to the receiving network node. The receiving network node sends one single PAN for all data blocks DB4..DB6 in this example. To indicate a positive acknowledgement a plus sign is put in front of a data block, to indicate a negative acknowledgement a minus sign is put in front of a data block in the drawing. From the transmitting network node's perspective, the data blocks DB4 and DB5 are (tentatively) positively acknowledged (DB5 based on a wrongly received PAN however), the data block DB6 negatively. Thus, data block DB6 is re-sent. In a
further step, a PUAN is sent for the data blocks DB4..DB6. The data block DB4 is positively acknowledged, the data blocks DB5 and DB6 negatively. One can see that there is a contradiction for the second data block DB5. Accordingly, the positive PAN for data block DB5 is ignored or the tentative positive acknowledgment is taken back and set to a negative acknowledgment respectively. For data block DB4 there is no contradiction. So, data block DB4 is removed from the transmit buffer of the transmitting network node.

For data block DB6 there is no contradiction, but it has been negatively acknowledged twice. Accordingly, the data blocks DB5 and DB6 are re-sent. Subsequently, a PAN and then a PUAN is sent, both positively acknowledging the data blocks DB5 and DB6. Thus, the data blocks DB5 and DB6 are removed from the transmit buffer finally. Again it should be noted that the transmitting node does not necessarily receive the same acknowledgment, which the receiving network sends, as it is the case for data block DB5 in this example.

Fig. 6 shows an example which is quite similar to that shown in Fig. 5, however, a PUAN is sent before a PAN in this example. If a contradiction between acknowledgments occurs (specifically related to data block DB5 again), the complete PAN is ignored. In this example data blocks DB4 and DB5 are positively acknowledged which is why they are removed from the memory. For data block DB6 a negative acknowledgement is received. Accordingly, data block DB6 is resent.

In addition, a positive acknowledgement is classified as wrong, if it refers to a block DB4..DB6 which is outside of a transmit window in Figs 4-6.
One should note, in particular with respect to Figs. 4 to 6, that the acknowledgement (e.g. PAN, PDAN, PUAN) received by the transmitting device is not necessarily the same which has been sent by the receiving device. The acknowledgement can be corrupted on the transmission path or misinterpreted or wrongly decoded by the transmitting device. Hence, it is important what is received not what has been sent. Furthermore, the examples in Fig. 4 to 6 are based on a PUAN as second type of positive/negative acknowledgement or second type of positive/negative acknowledgement information. If the data blocks are transmitted in the opposite direction, i.e. an EGPRS network is the transmitting network node and a mobile station is the receiving network node, a PDAN will be used instead of a PUAN.

The invention is applicable to all kind of networks and in particular for use in GSM BSC or GSM BSS, radio link control for GPRS/EGPRS and in devices implementing the Fast ACK/NACK Reporting (FANR) feature (a.k.a. Reduced Latency).

Finally, it should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be capable of designing many alternative embodiments without departing from the scope of the invention as defined by the appended claims. In the claims, any reference signs placed in parentheses shall not be construed as limiting the claims. The verb 'comprise' and its conjugations do not exclude the presence of elements or steps other than those listed in any claim or the specification as a whole. The singular
reference of an element does not exclude the plural reference of such elements and vice-versa. In a device claim enumerating several means, several of these means may be embodied by one and the same item of software or hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.
List of references and abbreviations/acronyms:

A3 positive acknowledgement
DB1..DB6 data blocks
N1..N2 negative acknowledgements
RW receive window
TB range of blocks which have been transmitted
V(A) acknowledge state variable
V(Q) receive window state variable

ACK acknowledgement (of an RLC block)
BSC base station controller
BSS base station system
BSN block sequence number
CRC cyclic redundancy check
FANR fast ACK/NACK reporting
NACK negative acknowledgement
NPM non-persistent mode
PAN piggy-backed ACK/NACK
PANI PAN indicator (in the header to signal the presence of a PAN)
PDAN packet downlink ACK/NACK (used generically to include e.g. EGPRS Packet Downlink ACK/NACK, EGPRS Packet Downlink ACK/NACK Type 2, etc.)
PUAN packet uplink ACK/NACK
RLC radio link control
SSN starting sequence number
TBF temporary block flow
TFI temporary flow identifier
WS window size
XOR exclusive or operation
CLAIMS:

1. Method of transmitting a data block (DB4..DB6) of a type from a transmitting device to a receiving device, wherein the transmitting device is capable of receiving at least two different types of positive/negative acknowledgements for said data block (DB4..DB6) of said type from said receiving device and wherein the reaction to the positive/negative acknowledgements after reception/decoding of the transmitting device depends on the type of said received positive/negative acknowledgement.

2. Method according to claim 1, wherein the transmitting device receives and processes at least two different types of positive/negative acknowledgement information, wherein each type of positive/negative acknowledgement information comprises one or more positive acknowledgements and/or negative acknowledgements of a single type relating to individual data blocks of said type.

3. Method according to claim 2, wherein said type of positive acknowledgement and/or negative acknowledgement is characterized by the type of said positive/negative acknowledgement information in which it is included.

4. Method according to any one of the claims 1 to 3, wherein the second type of positive/negative acknowledgement is more reliable than the first type.

5. Method according to any one of the claims 2 to 4, wherein for the second type of positive/negative acknowledgement information it is less probable than for
the first type that a consistency check applied to the positive/negative acknowledgement information passes even though the decoded positive/negative acknowledgement information is incorrect.

6. Method according to claim 5, wherein the consistency check is a cyclic redundancy check.

7. Method according to any one of the claims 2 to 6, wherein the transmitting device ignores all positive acknowledgements contained within positive/negative acknowledgement information of the first type which has been classified as unreliable.

8. Method according to any one of the claims 2 to 6, wherein the transmitting device ignores all information contained within positive/negative acknowledgement information of the first type which positive/negative acknowledgement information has been classified as unreliable.

9. Method according to any one of the claims 2 to 8, wherein the transmitting device signals to the receiving device that it has classified positive/negative acknowledgement information of the first type as unreliable.

10. Method according to any one of the claims 2 to 9, wherein the transmitting device requests the receiving device to transmit positive/negative acknowledgement information of the second type if it has classified previously received positive/negative acknowledgement information of the first type as unreliable.
11. Method according to any one of the claims 2 to 10, wherein the transmitting device stores the data block (DB4..DB6) to be sent in a memory and wherein said data block (DB4..DB6) is kept stored in said memory if a positive/negative acknowledgment information of the first type is received from the receiving device indicating that said data block (DB4..DB6) has been received correctly and wherein said data block (DB4..DB6) is removed from said memory if a positive/negative acknowledgment information of the second type is received from the receiving device indicating that said data block (DB4..DB6) has been received correctly.

12. Method as claimed in claim 11, wherein the data block (DB4..DB6) is resent if a corresponding positive acknowledgement is classified as unreliable.

13. Method according to any one of the claims 2 to 12, wherein the positive/negative acknowledgement information of the first type is classified as unreliable if it contains a positive acknowledgement for the data block and previously received positive/negative acknowledgement information contained a negative acknowledgement for said data block (DB4..DB6).

14. Method according to any one of the claims 2 to 13, wherein the positive/negative acknowledgement information of the first type is classified as unreliable if it contains a negative acknowledgement for the data block and previously received positive/negative acknowledgement information contained a positive acknowledgement for said data block (DB4..DB6).
15. Method according to any one of the claims 2 to 14, wherein the positive/negative acknowledgement information of the second type is transmitted within a Packet Downlink Acknowledgement/Negative Acknowledgement message, Packet Downlink Acknowledgement/Negative Acknowledgement Type 2 message or Packet Uplink Acknowledgement/Negative Acknowledgement message.

16. Method according to any one of the claims 2 to 15, wherein the positive/negative acknowledgement information of the first type is transmitted within a Piggy-Backed Acknowledgement/Negative Acknowledgement field.

17. Method according to any one of the claims 2 to 16, wherein the transmitting device classifies positive/negative acknowledgement information of the first type as unreliable if it contains a positive acknowledgement for a data block which has not been transmitted by the transmitting device.

18. Method according to any one of the preceding claims, wherein the transmitting device uses the Radio Link Control / Medium Access Control protocol for Enhanced General Packet Radio Service using the Fast Acknowledgement/Negative Acknowledgement Reporting feature also known as Reduced Latency.

19. Transmitting device for transmitting a data block (DB4..DB6) of a type to a receiving device, the transmitting device being designed for receiving at least two different types of positive/negative acknowledgements for said data block (DB4..DB6) of said type from said
receiving device and for reacting to the positive/negative acknowledgements after the reception/decoding of the same depending on the type of said received positive/negative acknowledgement.

20. Transmitting device according to claim 19, being designed to receive and process at least two different types of positive/negative acknowledgement information, wherein each type of positive/negative acknowledgement information comprises one or more positive acknowledgements and/or negative acknowledgements of a single type relating to individual data blocks of said type.

21. Transmitting device as claimed in any one of the claims 19 to 20:
- a memory for storing the data block (DB4..DB6) to be sent to the receiving device and
- a controller for keeping said data block (DB4..DB6) in said memory if a positive/negative acknowledgement information of the first type is received from the receiving device indicating that said data block (DB6) has been received correctly and for removing said data block (DB4..DB6) from said memory if a positive/negative acknowledgment of the second type is received from the receiving device indicating that said data block (DB4..DB6) has been received correctly.

22. Transmitting device as claimed in any one of the claims 19 to 21, which is designed to resend the data block (DB4..DB6) if a corresponding positive acknowledgement from the receiving device is classified as unreliable.
23. Transmitting device as claimed in any one of the claims 19 to 22, wherein the positive/negative acknowledgement information of the second type is transmitted within a Packet Downlink Acknowledgement/Negative Acknowledgement message, Packet Downlink Acknowledgement/Negative Acknowledgement Type 2 message or Packet Uplink Acknowledgement/Negative Acknowledgement message.

24. Transmitting device as claimed in any one of the claims 19 to 23, wherein the positive/negative acknowledgement information of the first type is transmitted within a Piggy-Backed Acknowledgement/Negative Acknowledgement field.

25. Transmitting device as claimed in any one of the claims 19 to 24, designed to classify the positive/negative acknowledgement information of the first type as unreliable if it contains a positive acknowledgement referring to a data block which is outside of a transmit window.
Fig. 1

Fig. 2

Fig. 3
<table>
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<tr>
<th>Transmitting network node</th>
<th>Receiving network node</th>
</tr>
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<td>store data blocks DB4..DB6</td>
<td>send pos PAN (DB4)</td>
</tr>
<tr>
<td>send DB4</td>
<td></td>
</tr>
<tr>
<td>receive pos PAN (DB4)</td>
<td>send pos PAN (DB4)</td>
</tr>
<tr>
<td>keep stored DB4</td>
<td></td>
</tr>
<tr>
<td>send DB5</td>
<td>send pos PAN (DB5)</td>
</tr>
<tr>
<td>receive neg PAN (DB5)</td>
<td></td>
</tr>
<tr>
<td>keep stored DB5</td>
<td>send neg PAN (DB6)</td>
</tr>
<tr>
<td>send DB6</td>
<td></td>
</tr>
<tr>
<td>receive pos PAN (DB6)</td>
<td>send pos PUAN (DB6)</td>
</tr>
<tr>
<td>keep stored DB6</td>
<td></td>
</tr>
<tr>
<td>receive pos PUAN (DB4)</td>
<td>send pos PUAN (DB4)</td>
</tr>
<tr>
<td>remove DB4</td>
<td></td>
</tr>
<tr>
<td>receive pos PUAN (DB5)</td>
<td>send pos PUAN (DB5)</td>
</tr>
<tr>
<td>remove DB5</td>
<td></td>
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<tr>
<td>receive neg PUAN (DB6)</td>
<td>send neg PUAN (DB6)</td>
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<tr>
<td>re-send DB6</td>
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</tr>
<tr>
<td>receive pos PUAN (DB6)</td>
<td>send pos PUAN (DB6)</td>
</tr>
<tr>
<td>remove DB6</td>
<td></td>
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**Fig. 4**
Transmitting network node

store data blocks DB4..DB6
send DB4..DB6 →
receive PAN ←
(+DB4, +DB5, -DB6)
mark DB4 and DB5 as tentatively acknowledged and DB6 as negatively acknowledged
re-send DB6 →
receive PUAN ←
(+DB4, -DB5, -DB6)
mark DB4 as positively acknowledged and DB5 and DB6 as negatively acknowledged
remove DB4
re-send DB5, DB6 →
receive PAN (+DB5, +DB6) ←
mark DB5 and DB6 as tentatively acknowledged
receive PUAN (+DB5, +DB6) ←
remove DB5, DB6

Receiving network node

send PAN (+DB4, -DB5, -DB6)

send PAN (+DB4, +DB6)

send PUAN (+DB5, +DB6)

Fig. 5
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<td>store data blocks DB4..DB6</td>
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<tr>
<td>send DB4..DB6</td>
<td>(+DB4, +DB5, -DB6)</td>
</tr>
<tr>
<td>receive PUAN</td>
<td>←</td>
</tr>
<tr>
<td>(+DB4, +DB5, -DB6)</td>
<td>send PAN</td>
</tr>
<tr>
<td>remove DB4, DB5</td>
<td>(+DB4, +DB5, -DB6)</td>
</tr>
<tr>
<td>receive PAN</td>
<td>←</td>
</tr>
<tr>
<td>(+DB4, -DB5, -DB6)</td>
<td>send PUAN</td>
</tr>
<tr>
<td>ignore the complete PAN</td>
<td>(+DB4, +DB5, +DB6)</td>
</tr>
<tr>
<td>re-send DB6</td>
<td>←</td>
</tr>
<tr>
<td>receive PUAN</td>
<td>send PAN</td>
</tr>
<tr>
<td>(+DB4, +DB5, +DB6)</td>
<td>(+DB4, +DB5, +DB6)</td>
</tr>
<tr>
<td>remove DB6</td>
<td>←</td>
</tr>
<tr>
<td>receive PAN</td>
<td>(+DB4, +DB5, +DB6)</td>
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Fig. 6
A. CLASSIFICATION OF SUBJECT MATTER

INV. H04L1/16

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)

H04L

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 practical, search terms used)

EPO-Internal, WPI Data, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C

See patent family annex

1. Special categories of cited documents
   - 'A' document defining the general state of the art which is not considered to be of particular relevance
   - 'E' earlier document 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

2. Document published prior to the international filing date but later than the priority date claimed

3. Date of the actual completion of the international search
   - 2 April 2009

4. Date of mailing of the international search report
   - 09/04/2009

5. Name and mailing address of the ISA/ European Patent Office, P B 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel (+31-70) 340-2040, Fax (+31-70) 340-3816

6. Authorized officer
   - Micle, Sori n
### DOCUMENTS CONSIDERED TO BE RELEVANT

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