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(54) **RADIO LINK CONTROL UNACKNOWLEDGED MODE HEADER OPTIMIZATION**

OPTIMIERUNG DER KOPFDATEN EINES RADIO LINK CONTROL IM UNACKNOWLEDGED MODE

OPTIMISATION D'EN-TETE EN MODE NON ACCUSE DE RECEPTION A COMMANDE DE LIAISON RADIO

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Description

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority of United States Provisional Patent Application Serial No. 60/710,193, filed on August 23, 2005. The subject matter of the above referenced application is incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to optimizing radio link control unacknowledged-mode protocol data unit headers, for example, to better support packet switched voice transmissions or transmission of other real time packet switched services over Wideband CDMA air interface.

Description of the Related Art

[0003] With Voice-over-IP (VoIP) there are typically several different radio link control (RLC) Service Data Unit (SDU) sizes. Figure 1a illustrates a measured example distribution for a 12.2 kbit/s adaptive multi rate (AMR) voice codec. The voice codec itself produces equal size packets but a robust header compression (ROHC) produces variable size SDUs. In order to optimize the RLC overhead, for the example in Figure 1a, the following RLC Protocol Data Unit (PDU) sizes could be selected: 11, 15, 36, 40 and 98 octets. RLC PDU sizes of 11 and 36 octets may be used for the most frequent RLC SDU sizes, silence indicator (SID) and speech frames, respectively. RLC PDU sizes of 15 and 40 octets may be used for several, less frequent, RLC SDU sizes. It is noted that there are quite significant amounts of RLC SDUs which are 2 octets smaller than the RLC PDU sizes, 13 and 38 octets (SDU sizes), respectively.

[0004] For a RLC SDU which is two octets smaller than the RLC PDU, the beginning of the RLC SDU is indicated with special length indicator (LI), where LI=1111100 or LI=0000000 if the previous RLC SDU was also two octets smaller than the RLC PDU. Therefore, there is no room to indicate the end of the RLC SDU and that has to be indicated in the next RLC PDU with LI=0000000. As such, if the next PDU is lost, a receiver cannot be sure whether the RLC SDU was completely there or not.

SUMMARY OF THE INVENTION

[0005] An embodiment of the present invention is directed to a method including inserting, in an unacknowledged mode entity of a radio link control, at least one service data unit to a protocol data unit of an appropriate size. The method also includes providing at least one indicator for defining boundaries between the at least one service data unit within the protocol data unit, the at least one indicator including a length indicator for indicating that a first data octet of the

[0006] Document EP1195923A2 discloses a radio communication system having a radio link control layer. packet data unit is a first octet of a first service data unit and at least one other octet of the packet data unit is the last octet of another service data unit, the first service data unit being either the same or different from the other service data unit.

[0007] Another embodiment of the invention is directed to an unacknowledged mode entity including a inserting unit configured to insert in a radio link control entity, at least one service data unit to a protocol data unit of an appropriate size. The entity also includes a providing unit configured to provide at least one indicator including a length indicator for indicating that a first data octet of the protocol data unit is a first octet of a first service data unit and at least one other octet of the protocol data unit is the last octet of another service data unit, the first service data unit being either the same or different from the other service data unit.

[0008] Another embodiment of the invention relates to an apparatus inserting means to insert in a radio link control entity, at least one service data unit to a protocol data unit of an appropriate size. The apparatus also includes providing means to provide at least one indicator including a length indicator for indicating that a first data octet of the protocol data unit is a first octet of a first service data unit and at least one other octet of the protocol data unit is the last octet of another service data unit, the first service data unit being either the same or different from the other service data unit.

[0009] A computer program product embodied on a computer readable medium, the computer program product comprising code portions for inserting, in a radio link control entity, at least one service data unit to a protocol data unit of an appropriate size and providing at least one indicator including a length indicator for indicating that a first data octet of the protocol data unit is a first octet of a first service data unit and at least one other octet of the protocol data unit is the last octet of another service data unit, the first service data unit being either the same or different from the other service data unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention that together with the description serve to explain the principles of the invention, wherein:

Figure 1a illustrates an example RLC service data unit distribution for 12.2 kbit/s AMR codec assuming minimum compressed RTP/UDP/IP header of 3 bytes;
Figure 1b illustrates the architecture of an RLC sublayer;
Figure 1 illustrates Sequence of RLC UMD PDUs showing the usage of the length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 38 or 37 octets;
Figure 2 illustrates Sequence of RLC UMD PDUs showing the usage of the length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 36, 35 or 34 octets;
Figure 3 illustrates Sequence of RLC UMD PDUs showing the usage of the length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 38 or 37 octets;
Figure 4 illustrates Sequence of RLC UMD PDUs showing the usage of the length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 36, 35 or 34 octets;
Figure 5 illustrates Sequence of RLC UMD PDUs showing the usage of the length indicator for the last SDU of 37 octets, RLC PDU size of 39 octets;
Figure 6 illustrates Sequence of RLC UMD PDUs showing the usage of the length indicator, RLC PDU size of 74 octets and two RLC SDUs per PDU;
Figure 7 illustrates Sequence of RLC UMD PDUs showing the usage of the length indicator, RLC PDU size of 39 octets and a sequence of RLC SDU sizes of 40, 34 and 37 octets; Figure 8 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 38 or 37 octets, according to third embodiment of the invention;
Figure 9 illustrates Sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 36, 35 or 34 octets;
Figure 10 illustrates sequence of RLC UMD PDUs showing the usage of length indicator for the last SDU of 37 octets, RLC PDU size of 39 octets;
Figure 11 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 74 octets and two RLC SDUs per PDU;
Figure 12 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and a sequence of RLC SDU sizes of 40, 34 and 37 octets; and
Figure 13 illustrates the steps implement in an embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0011] Reference will now be made to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The present invention relates to optimizing radio link control (RLC) unacknowledged mode (UM) protocol data unit (PDU) headers of WCDMA, for example, for Voice over IP Multimedia Services (VoIMS). Specifically, the present invention relates to optimizing RLC PDU headers to better support packet switched voice transmissions or transmissions of other real time services over WCDMA air interface. It should be noted that while the present application describes the invention as being implemented in a WCDMA type of system, the present invention may be implemented in other systems, such as in 3.9G systems. Therefore, implementation of the invention in WCDMA systems as described in the present application is only one example. It should also be noted that the network side can be implemented in the radio network controller (RNC), as well as in Node B. RNC functions in future systems, such as 3.9G systems may be located elsewhere, such as in a base station.

[0012] Radio link control (RLC) is a link layer protocol that is responsible for error recovery and flow control in UMTS 3G cellular systems. Figure 1b illustrates the architecture of the RLC sublayer. As illustrated in figure 1b, the RLC sublayer includes a transparent mode (TM) entity 102, an unacknowledged mode (UM) entity 104 and an acknowledge mode (AM) entity 106. UM entity 104 and the TM entity 102 can be configured to be a transmitting RLC entity 102a/104a or a receiving RLC entity 102b/104b. The transmitting RLC entity 102a/104a transits RLC protocol data units (PDU) and the receiving RLC entity 102b/104b receives RLC PDU. AM entity 106 includes a transmitting side and a receiving side, where the transmitting side of AM entity 106 transmits RLC PDU and the receiving side of AM entity 106 receives RLC PDU.

[0013] In the UM and TM entities 104 and 102, the transmitting RLC entity 102a/104a acts as a sender and the peer RLC entity 102b/104b acts as a receiver. AM entity 106 acts either as a sender or a receiver depending on the elementary procedure defined between the sender and receiver. The sender is a transmitter of acknowledged mode data (AMD) PDU and the sender and receiver may reside at either the user equipment 108 or the UTRAN 110.

[0014] In UM entity 104, unacknowledged mode data (UMD) PDU is used to convey sequentially numbered PDUs that include RLC service data units (SDU) data. UMD PDUs are used by the RLC when it is configured for unacknowledged data transfer. The transmitting UM entity 104 receives RLC SDU from upper layers through the UM Service Access Point. The transmitting UM entity 106 segments the RLC SDU into UMD PDUs of appropriate size, if the RLC SDU is larger than the length of available space in the UMD PDU. The UMD PDU may include segmented and/or concatenated RLC SDUs and may also include padding to ensure that it is of a valid length. Length indicators are used to define boundaries between the RLC SDUs within the UMD PDU, unless an extension bit already indicates that a UMD PDU includes exactly one complete SDU. The length indicators are also used to define whether padding is included in the UMD PDU. If ciphering is configured and started, an UMD PDU is ciphered, except for the UMD PDU header, before it is submitted to the lower layer. The transmitting UM entity 104b submits UMD PDUs to a lower layer.

[0015] The receiving UM entity 104a receives UMD PDUs through configured logical channels from the lower layer. If the receiving UM entity 104a is configured for out of sequence SDU delivery, it will reassemble SDUs and transfer them to the upper layers as soon as all PDUs that include the SDU have been received, even if the earlier PDU have not yet been received. UM entity 104 stores the PDUs pending the retransmission of the missing PDU by the transmitting UM entity 104a. PDUs are removed from storage after recovery of all of its associated SDUs, or by a sequence number window or a storage timer.

[0016] The RLC PDU is a bit string. Depending on the service provided, the RLC SDU is also a bit string with any non-null length or a bit string with a multiple of 8 bits in length. The RLC SDU is included into the RLC PDU from the first bit onward. When the RLC is operating in the unacknowledged mode, the UMD PDU is used to transfer user data. The length of the data in the unacknowledged mode will be a multiple of 8 bits. The UMD PDU header includes a first octet which includes a sequence number and all other octets that include length indicators. In addition to the sequence number, the first octet of UMD PDU may also include an extension bit (E-bit) that has either a normal E-bit interpretation or the alternative E-bit interpretation, depending on higher layer configuration. The extension bit in all other octets of the UMD PDU always has the normal E-bit interpretation. The UMD PDU also includes a header extension type that indicates if the next octet is data or a length indicator and E-bit.

[0017] Unless the extension bit indicates that a UMD PDU includes a complete SDU which is not segmented, concatenated or padded, the length indicator is used to indicate the last octet of each RLC SDU ending within the PDU. If the extension bit indicates that the UMD PDU includes a complete SDU which is not segmented, concatenated or padded, no length indicators are present in this UMD PDU.

[0018] The length indicator is set to the number of octets between the end of the RLC header and up to and including the last octet of the RLC SDU segment. The length indicator is included in the PDUs to which they refer and the size of the length indicator may be either 7 bits or 15 bits. The length indicator size is determined independently for uplink and downlink. The length indicators which refer to the same PDU are not to be reordered in case of retransmission and are to be in the same order as the RLC SDUs to which they refer. For unacknowledged mode uplink, if the largest uplink UMD PDU size is 125 octets, 7-bit length indicators are to be used, otherwise, 15-bit length indicators are to be used. For unacknowledged mode downlink, the length indicator size provided in the "downlink RLC unacknowledged mode length indicator size" are to be used.

[0018A] Paragraphs [0019] to [0021] and [0024] below describe embodiments not in accordance with the claimed invention.

[0019] In the unacknowledged mode, between modifications of the largest UMD PDU size, the size of the length indicator is the same for all UMD PDUs. A 7-bit length indicator with the value "111 1100" or a 15-bit length indicator with the value "111 1111 1111 1100" is to be used. For example, the 7-bit length indicator with the value "111 1100" or the 15-bit length indicator with the value "111 1111 1111 1100" is to be used if the RLC SDU begins in the beginning of the RLC PDU, if the RLC PDU is transmitted in uplink, if the length indicators are not present for indicating that a RLC SDU ended exactly in the end or one octet short of the previous RLC PDU, if the extension bit does not indicate that the UMD PDU includes a complete SDU which is not segmented, concatenated or padded, if the length indicator is present for indicating that the first data octet in this RLC PDU is the first octet of an RLC SDU and the last octet of this RLC PDU is the last octet of the same RLC SDU, and if the length indicator is present for indicating that the first data octet in this RLC PDU is the first octet of an SDU and the same RLC SDU is one octet short of exactly filling the PDU. In the downlink, if the 7-bit length indicator is used, the receiver is prepared to receive a length indicator with the value "111 1100" and if the 15-bit length indicator is used, the receiver is prepared to receive the length indicator with the value "111 1111 1111 1100". The receiver follows predefined discard rules when the length indicator with value "111 1100" or "111 1111 1111 1100" is present and when it is absent.

[0020] In the case where the end of the last segment of an RLC SDU exactly ends at the end of a PDU and there is no length indicator that indicates the end of the RLC SDU, if the extension bit of the following PDU does not indicate that the UMD PDU includes a complete SDU which is not segmented, concatenated or padded, and if the length indicator of the following PDU does not indicate that the first data octet in that PDU is the first octet of the SDU and the last octet in that PDU is the last octet of the same SDU, and if also the length indicator of the following PDU does not indicated that the first data octet in that RLC PDU is the first octet of an SDU and that the same RLC SDU is one octet short of exactly filling the PDU, a 7-bit length indicator with the value "000 0000" shall be placed as the first length indicator in

the following PDU or a 15-bit length indicator with the value "OOO 0000 0000 0000" shall be placed as the first length indicator in the following PDU.

[0021] In the case where a PDU includes a 15 bit length indicator indicating that an RLC SDU ends with one octet left in the PDU, the last octet of the PDU is padded by the sender and ignored by the receiver even though there is no length indicator indicating the existence of padding and is not to be filled with the first octet of the next RLC SDU data. In the case where 15 bit length indicators are used in the PDU and the last segment of an RLC SDU is one octet short of exactly filling the PDU and there are no length indicators that indicate the end of the RLC SDU, if a 15 bit length indicator is used for the following PDU, the length indicator with value "111 1111 1111 1011" is to be placed as the first length indicator in the following PDU. The remaining one octet in the current PDU is to be padded by the sender and ignored by the receiver though there is no length indicator indicating the existence of padding. If a 7-bit length indicator is configured for the following PDU and the RLC is configured for a unacknowledged mode and the extension bit of that PDU does not indicate that the UMO PDU includes a complete SDU which is not segmented, concatenated or padded, and the length indicator of that PDU does not indicate that the first data octet in that PDU is the first octet of an SDU and the last octet in that PDU is that last octet of the same SDU, the length indicator with the value "OOO 0000" is to be placed as the first length indicator in the following PDU and the sequence number is to be incremented by 2 before it is transmitted.

[0022] In unacknowledged mode and acknowledged mode RLC, if a 7 bit length indicator is used in the RLC PDU and one or more padding octets are present in the RLC PDU after the end of the last RLC SDU, the presence of the padding is indicated by including a length indicator with the value "1111111" as the last length indicator in the PDU. If a 15 bit length indicator is used in the RLC PDU and two or more padding octets are present in the RLC PDU after the end of the last RLC SDU, the presence of the padding is indicated by including a length indicator with the value "111 1111 1111 1111" as the last length indicator in the PDU. It should be noted that after the length indicator indicating the presence of padding has been included in the RLC PDU, the length of the pading may be zero.

[0023] In the case where the alternative E-bit interpretation is configured for unacknowledged mode RLC and the RLC PDU includes a segment of a SDU but neither the first octet nor last octet of this SDU, a 7-bit length indicator with the value "111 111O" may be used or a 15 bit length indicator with the value "111 1111 1111 111O" may be used.

[0024] ~~In an embodiment of the invention, in~~ the case where the alternative E-bit interpretation is configured for unacknowledged mode RLC and the first data octet in this RLC PDU is the first octet of an SDU and the last octet in this RLC PDU is the last octet of the same SDU, a 7-bit length indicator with the value "111 1101" may be used or a 15 bit length indicator with the value "111111111111101" may be used. In the case where the alternative E-bit interpretation is configured for unacknowledged mode RLC and the first data octet in this RLC PDU is the first octet of an SDU and the same RLC SDU is one octet short of exactly filling the PDU, a 15 bit length indicator with the value "111 1111 1111 101O" may be used.

[0025] If a length indicator is still awaiting transmission and there is no RLC SDU available, an RLC PDU including this length indicator and the appropriate padding may be transmitted. Predefined values of the length indicator are used to indicate padding.

[0026] In an embodiment of the present invention, the receiver knows in the case where the RLC SDU size is two octets smaller than the RLC PDU size, that the RLC SDU begins and ends in this RLC PDU and can deliver the SDU to higher layers, even if the next RLC PDU is missing. This is especially important in the case of real time packet switched services, like VoIP. All the RLC SDUs that fit into one RLC PDU, that is, they do not require segmentation, can immediately be forwarded to higher layer without the need to wait for the next RLC PDU which may further be delayed for instance due to scheduling. Thus, this can reduce the delay of the RLC SDU, for example, a VoIP packet.

[0027] According to an embodiment of the invention, in the case where the RLC SDU is two octets smaller than the RLC PDU and happens to be the last SDU in a sequence, an additional PDU can be avoided. In a first embodiment of the present invention, the meaning of the special length indicator value 1111100 is changed to indicate that the RLC SDU starts and ends in this RLC PDU. The special LI value of 0000000 is used to indicate for unacknowledged mode that new SDU starts at the beginning of the PDU. The details are shown in the following tables.

Length: 7 bits

[0028]

Bit	Description
0000000	AMD PDU: The previous RLC PDU was exactly filled with the last segment of an RLC SDU and there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU. UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU and the previous RLC PDU was exactly filled with the last segment of an RLC SDU if there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU
1111100	UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU and the last octet in this RLC PDU is the last octet of an RLC SDU (same or different SDU).. AMD PDU: Reserved (PDUs with this coding will be discarded bv this version of the protocol).
1111101	Reserved (PDUs with this coding will be discarded by this version of the protocol).
1111110	AMD PDU: The rest of the RLC PDU includes a piggybacked STATUS PDU. UMD PDU: The RLC PDU contains a segment of an SDU but neither the first octet nor the last octet of this SDU.
1111111	The rest of the RLC PDU is padding. The padding length can be zero.

Length: 15 bits

[0029]

Bit	Description
000000000000000	AMD PDU: The previous RLC PDU was exactly filled with the last segment of an RLC SDU and there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU. UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU, and the previous RLC PDU was exactly filled with the last segment of an RLC SDU if there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU.
111111111111010	UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU and the second last octet in this RLC PDU is the last octet of an RLC SDU (same or different SDU). The remaining one octet in the RLC PDU is ignored.
111111111111011	AMD PDU: The last segment of an RLC SDU was one octet short of exactly filling the previous RLC PDU and there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU. The remaining one octet in the previous RLC PDU is ignored. UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU, and the last segment of an RLC SDU was one octet short of exactly filling the previous RLC PDU if there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU.
111111111111100	UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU and the last octet in this RLC PDU is the last octet of an RLC SDU (same or different SDU). AMD PDU: Reserved (PDUs with this coding will be discarded by this version of the protocol).
111111111111101	Reserved (PDUs with this coding will be discarded by this version of the protocol).
111111111111110	AMD PDU: The rest of the RLC PDU includes a piggybacked STATUS PDU. UMD PDU: The RLC PDU contains a segment of an SDU but neither the first octet nor the last octet of this SDU.
111111111111111	The rest of the RLC PDU is padding. The padding length can be zero.

[0030] According to another embodiment of the invention, the meaning of the special length indicator value 0000000 is changed to indicate that the RLC SDU starts and ends in this RLC PDU. The earlier usage of the special length indicator value of 0000000, to indicate that previous SDU ended in the previous PDU and was not indicated, can be replaced with the usage of LI=1111100, i.e., LI=1111100 indicates that new SDU starts and that implicitly means that previous SDU (if any) ended in the previous PDU, and that either was indicated with length indicator or not.

[0031] According to a third embodiment of the invention, the meaning of the special length indicator values 0000000 and 1111100 are not changed but instead the reserved length indicator=1111101 is used to indicate that the RLC SDU starts and ends in this RLC PDU. This has the advantage that no changes are needed to the usage of those special length indicators currently in use. The details are shown in the following tables.

Length: 7 bits

[0032]

Bit	Description
0000000	The previous RLC PDU was exactly filled with the last segment of an RLC SDU and there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU.
1111100	UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU. AMD PDU: Reserved (PDUs with this coding will be discarded by this version of the protocol).
1111101	UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU and the last octet in this RLC PDU is the last octet of an RLC SDU (same or different SDU). AMD PDU: Reserved (PDUs with this coding will be discarded bv this version of the protocol).
1111110	AMD PDU: The rest of the RLC PDU includes a piggybacked STATUS PDU. UMD PDU: The RLC PDU includes a segment of an SDU but neither the first octet nor the last octet of this SDU.
1111111	The rest of the RLC PDU is padding. The padding length can be zero.

Length: 15 bits

[0033]

Bit	Description
000000000000000	The previous RLC PDU was exactly filled with the last segment of an RLC SDU and there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU.
111111111111010	UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU and the second last octet in this RLC PDU is the last octet of an RLC SDU (same or different SDU). The remaining one octet in the RLC PDU is ignored.
111111111111011	The last segment of an RLC SDU was one octet short of exactly filling the previous RLC PDU and there is no "Length Indicator" that indicates the end of the RLC SDU in the previous RLC PDU. The remaining one octet in the previous RLC PDU is ignored.
111111111111100	UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU. AMD PDU: Reserved (PDUs with this coding will be discarded by this version of the protocol).
111111111111101	UMD PDU: The first data octet in this RLC PDU is the first octet of an RLC SDU and the last octet in this RLC PDU is the last octet of an RLC SDU (same or different SDU). AMD PDU: Reserved (PDUs with this coding will be discarded by this version of the protocol).
111111111111110	AMD PDU: The rest of the RLC PDU includes a piggybacked STATUS PDU. UMD PDU: The RLC PDU includes a segment of an SDU but neither the first octet nor the last octet of this SDU.
111111111111111	The rest of the RLC PDU is padding. The padding length can be zero.

[0034] In the above special length indicators, it is said that the last octet of the PDU can be the last octet of the same SDU which starts in the PDU, i.e., one SDU per PDU, or the last octet of a different SDU, i.e., several SDUs per PDU). The former case is shown in most figures (Fig. 1-5), the latter in Figure 6.

[0035] The following figures illustrate various embodiments of the present invention. The figures show the RLC PDUs of size 39 octets with different RLC SDU sizes, except figure 6 which shows RLU PDU of size 74 octets. The advantage of the invention is seen with the RLC SDU of size 37 octets, as shown in Col. B where SDU start and end are known based on the RLC PDU header, whereas with the example of Col. A the end is known only after receiving the next RLC PDU. There is no change for RLC SDU of size 38 (Figure 1 or Figure 3), for smaller RLC SDU sizes (36, 35, 34, etc.) the only change in the first embodiment is that LI=0000000 is used instead of LI=1111100 (Figure 2).

[0036] The arrows in the figures show how the first and last octet of RLC SDUs are indicated. Solid line illustrates explicit indication, as written in the specification, and dashed line illustrates implicit indication, also according to the specification.

[0037] Figure 1, a first embodiment, illustrates Sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 38 or 37 octets. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and Col. B, shown on the right side, illustrates an example that implements an embodiment of the current invention. The RLC PDU with sequence number (SN) includes RLC SDU of size 38 octets which is indicated with the extension flag (E=0). RLC PDUs with sequence numbers SN+1 and SN+2 include RLC SDU of size 37 octets (i.e., two octets smaller than the RLC PDU size). Col. A (left side) requires special length indicator=0000000 in the next PDU to indicate the end of the RLC SDU, whereas in Col. B, length indicator =1111100 indicates both start and end of the RLC SDU and thus there is no need to wait for the next PDU before delivering the complete SDU to higher layers.

[0038] Figure 2, also the first embodiment, illustrates Sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 36, 35 or 34 octets. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and Col. B, shown on the right side, illustrates an example that implements an embodiment of the current invention. The only change from Col. A is that length indicator=1111100 is changed to length indicator=0000000.

[0039] Figure 3 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 38 or 37 octets, according to another embodiment of the invention. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and Col. B, shown on the right side, illustrates an example that implements an embodiment of the current invention. The RLC PDU with sequence number SN includes RLC SDU of size 38 octets which is indicated with the extension flag (E=0). RLC PDUs with sequence numbers SN+1 and SN+2 include RLC SDU of size 37 octets (i.e., two octets smaller than the RLC PDU size). Col. A (left side) requires special length indicator =0000000 in the next PDU to indicate the end of the RLC SDU, whereas in Col. B length indicator=0000000 indicates both start and end of the RLC SDU and thus there is no need to wait for the next PDU before delivering the complete SDU to higher layers.

[0040] Figure 4 illustrates Sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 36, 35 or 34 octets. As can be seen there is no change for these smaller SDU sizes in this embodiment.

[0041] Figure 5 illustrates sequence of RLC UMD PDUs showing the usage of length indicator for the last SDU of 37 octets, RLC PDU size of 39 octets. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and requires one additional RLC PDU including special LI=0000000 to indicate that SDU ended in the previous RLC PDU and padding to fill the RLC PDU. Col. B, shown on the right side, showing an example that implements an embodiment of the current invention, illustrates that no extra RLC PDU is needed - in this case, the an embodiment of the present invention saves in capacity.

[0042] Figure 6 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 74 octets and two RLC SDUs per PDU. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and Col. B, shown on the right side, illustrates an example that implements an embodiment of the current invention. Here, the special length indicator=0000000 indicates that one SDU starts and another ends in this PDU, whereas Col. A requires the special length indicator=0000000 in the next PDU to indicate that SDU ended exactly in the previous PDU. With the present invention, SDU number sequence numbers can be delivered to higher layers earlier than with the current specification/prior art.

[0043] Figure 7 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and a sequence of RLC SDU sizes of 40, 34 and 37 octets. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and Col. B, shown on the right side, illustrates an example that implements an embodiment of the current invention. The RLC SDU of 40 octets does not fit into RLC PDU of size 39 octets and has to be segmented. Thus, in RLC PDU number SN+1, first octet is not first octet of an SDU and therefore no special length indicator is used to indicate that. Length indicator=0000011 indicates the end of the segmented SDU (three octets). The complete SDU of 34 octets fits into the PDU but it is not possible to indicate the end in this PDU since there is no space for the length indicator. Therefore, length indicator=0000000 is used in the next PDU. This explicitly means that last octet of the previous PDU was the last octet of an SDU. With this invention, length indicator=0000000 or length indicator=1111100 is used, length indicator=0000000 if SDU starts and ends in that PDU and length indicator=1111100 if SDU starts (but last octet is not last octet of SDU), which both implicitly indicate that SDU has ended in the previous PDU. Furthermore, if the RLC SDU of 37 octets happens to be the last SDU in a sequence, the implementation in Col. A still requires an additional RLC PDU which has length indicator=0000000 and padding (not shown in the figure).

[0044] Figure 8 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 38 or 37 octets, according to third embodiment of the invention. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and Col. B, shown on the right side, illustrates an example that implements an embodiment of the current invention. The RLC PDU with sequence number SN includes RLC SDU of size 38 octets which is indicated with the extension flag (E=0). RLC PDUs with sequence

numbers SN+1 and SN+2 include RLC SDU of size 37 octets (i.e., two octets smaller than the RLC PDU size). Col. A (left side) requires special length indicator =0000000 in the next PDU to indicate the end of the RLC SDU, whereas in Col. B length indicator=1111101 indicates both start and end of the RLC SDU and thus there is no need to wait for the next PDU before delivering the complete SDU to higher layers.

[0045] Figure 9 illustrates Sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and RLC SDU sizes of 36, 35 or 34 octets. As can be seen there is no change for these smaller SDU sizes in this embodiment.

[0046] Figure 10 illustrates sequence of RLC UMD PDUs showing the usage of length indicator for the last SDU of 37 octets, RLC PDU size of 39 octets. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and requires one additional RLC PDU including special LI=0000000 to indicate that SDU ended in the previous RLC PDU and padding to fill the RLC PDU. Col. B, shown on the right side, showing an example that implements an embodiment of the current invention, illustrates that no extra RLC PDU is needed since LI=1111101 indicates both the start and the end of the SDU - in this case, the an embodiment of the present invention saves in capacity.

[0047] Figure 11 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 74 octets and two RLC SDUs per PDU. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and Col. B, shown on the right side, illustrates an example that implements an embodiment of the current invention. Here, the special length indicator=1111101 indicates that one SDU starts and another ends in this PDU, whereas Col. A requires the special length indicator=0000000 in the next PDU to indicate that SDU ended exactly in the previous PDU. With the present invention, SDU number SN can be delivered to higher layers earlier than with the current specification/prior art.

[0048] Figure 12 illustrates sequence of RLC UMD PDUs showing the usage of length indicator, RLC PDU size of 39 octets and a sequence of RLC SDU sizes of 40, 34 and 37 octets. Col. A shown on the left side, illustrates an example that does not implement an embodiment of the current invention and Col. B, shown on the right side, illustrates an example that implements an embodiment of the current invention. The RLC SDU of 40 octets does not fit into RLC PDU of size 39 octets and has to be segmented. Thus, in RLC PDU number SN+1, first octet is not first octet of an SDU and therefore no special length indicator is used to indicate that. Length indicator=0000011 indicates the end of the segmented SDU (three octets). The complete SDU of 34 octets fits into the PDU but it is not possible to indicate the end in this PDU since there is no space for the length indicator. Therefore, length indicator=0000000 is used in the next PDU (Col. A). This explicitly means that last octet of the previous PDU was the last octet of an SDU. With the present invention, length indicator=0000000 or length indicator=1111100 or length indicator=1111101 is used in the next PDU (SN+2 in this example), length indicator=1111101 if SDU starts and ends in that PDU, and length indicator=1111100 if SDU starts (but last octet is not last octet of SDU), which both implicitly indicate that SDU has ended in the previous PDU or length indicator=0000000 if no data follows. Furthermore, if the RLC SDU of 37 octets happens to be the last SDU in a sequence, the implementation in Col. A still requires an additional RLC PDU which has length indicator=0000000 and padding (not shown in the figure).

[0049] Figure 13 illustrates the steps implement in an embodiment of the present invention.. In Step 1310, the RLC entity inserts at least one service data unit to a protocol data unit of an appropriate size. In Step 1320, the RLC entity provides at least one indicator that includes a length indicator for indicating that a first data octet of the protocol data unit is a first octet of a first service data unit and at least one other octet of the protocol data unit is the last octet of another service data unit, the first service data unit being either the same or different from the other data unit.

[0050] The RLC entities typically reside in the UE and in the network side in RNC. RLC in the network side could be implemented also in the Node B (base station). The present invention applies to both up and downlink, i.e., the transmitting RLC can be in the UE and the receiving in the network (RNC or base station) or vice versa.

[0051] The network should signal (e.g., using RRC signaling) to the user equipment whether new or old interpretation is used. Network knows which user equipments are new user equipments and uses this new feature only for them. New user equipments have to support both interpretations, new network at least the above mentioned signaling. The default should be the old signaling (i.e., if no signaling from network then user equipment should assume old interpretation).

[0052] As explained above, the invention provides both a method and corresponding equipment consisting of various modules providing the functionality for performing the steps of the method. The modules may be implemented as hardware, or may be implemented as software or firmware for execution by a computer processor. In particular, in the case of firmware or software, the invention can be provided as a computer program product including a computer readable storage structure embodying computer program code (i.e., the software or firmware) thereon for execution by the computer processor.

[0053] It should be appreciated by one skilled in art, that the present invention may be utilized in any device that optimizes radio link control (RLC) unacknowledged mode (UM) PDU headers of WCDMA for VoIMS i.e.,to better support PS voice transmissions WCDMA air interface. As noted above, while the present application describes the invention as being implemented in a WCDMA type of system, the present invention may be implemented in other systems, such as

in 3.9G systems. The foregoing description has been directed to specific embodiments of this invention. It will be apparent; however, that other variations and modifications may be made to the described embodiments, with the attainment of some or all of their advantages.

Claims

1. A method comprising:

inserting, in a radio link control, RLC, entity, at least one service data unit, SDU, to a protocol data unit ,PDU, of an appropriate size;
characterized in that it further comprises:

providing at least one indicator including a length indicator for indicating that a first data octet of the protocol data unit , PDU, is a first octet of a first service data unit and at least one other octet of the protocol data unit, PDU, is the last octet of another service data unit, the first service data unit being either the same or different from the other service data unit,
wherein the at least one other octet is the last octet of the protocol data unit, PDU (i.e. one SDU per PDU or several SDUs per PDU).

2. The method of claim 1, wherein the radio link control, RLC, entity is an unacknowledged mode, UM, entity.

3. The method of any preceding claim, wherein providing at least one indicator further comprises providing the length indicator of at least one of 7 or 15 bits.

4. The method of any preceding claim, wherein providing at least one indicator further comprises providing the length indicator with a value of "0000000" to indicate that the first data octet of the protocol data unit, PDU, is the first octet of a first service data unit and the last octet of the protocol data unit, PDU, is the last octet of the other service data unit, the first service data unit being either the same or different from the other service data unit.

5. The method of any of claims 1 to 3, wherein providing at least one indicator further comprises providing the length indicator with a value of "1111100" to indicate that the first data octet of the protocol data unit, PDU, is the first octet of a first service data unit and the last octet of the protocol data unit, PDU, is the last octet of the other service data unit, the first service data unit being either the same or different from the other service data unit.

~~**6.** The method of any of claims 1 to 3, wherein providing at least one indicator further comprises providing the length indicator with a value of "1111101" to indicate that the first data octet in a current protocol data unit, PDU, is the first octet of the first service data unit and the last octet in the current protocol data unit, PDU, is the last octet of the first service data unit.~~

~~**7.** The method of claim 6, further comprising providing the length indicator with a value of "1111101" when the first service data unit is two octets smaller than the current protocol data unit, PDU.~~

~~**8.**~~**6.** The method of any of claims 1 to 3, wherein providing at least one indicator further comprises providing the length indicator with a value of "1111101" to indicate that the first data octet in a current protocol data unit ,PDU, is the first octet of the first service data unit and the last octet in the current protocol data unit, PDU, is the last octet of the other service data unit, the first service data unit being either the same or different from the other service data unit.

~~**9.** The method of any of claims 1 to 3, wherein providing at least one indicator further comprises providing the length indicator with a value of "111 1111 1111 1101" to indicate that the first data octet in a current protocol data unit, PDU, is the first octet of the first service data unit and the last octet in the current protocol data unit, PDU, is the last octet of the first service data unit~~.

~~**10.** The method of claim 9, further comprising providing the length indicator with a value of "111 1111 1111 1101" when the first service data unit is three octets smaller than the current protocol data unit, PDU.~~

~~**11.** The method of any of claims 1 to 3, wherein providing at least one indicator further comprises providing the length indicator with a value of "111 1111 1111 101O" to indicate that the first data octet in a current protocol data unit, PDU, is the first octet of the first service data unit and that a second last octet of the current protocol data unit, PDU,~~

~~is the last octet of the first service data unit.~~

~~12. The method of claim 11, further comprising providing the length indicator with a value of "111 1111 1111 101O" when the first service data unit is four octets smaller than the current protocol data unit, PDU.~~

~~13.~~7. The method of any preceding claim, further comprising providing a higher layer signalling to a user equipment to identify whether or not the length indicator is used.

~~14.~~8. An apparatus comprising:

means for inserting, in a radio link control entity, at least one service data unit, SDU, to a protocol data unit, PDU, of an appropriate size;
characterized in that it further comprises:

means for providing at least one indicator including a length indicator for indicating that a first data octet of the protocol data unit, PDU, is a first octet of a first service data unit and at least one other octet of the protocol data unit, PDU, is the last octet of another service data unit, the first service data unit being either the same or different from the other service data unit,
wherein the at least one other octet is the last octet of the protocol data unit, PDU (i.e. one SDU per PDU or several SDUs per PDU).
.

~~15.~~9. The apparatus of claim ~~14~~8, wherein the radio link control entity is an unacknowledged mode, UM, entity.

~~16.~~10. The apparatus of any of claims ~~14~~8 to ~~15~~9, wherein the means for providing provides at least one indicator further comprises providing the length indicator of at least one of 7 or 15 bits.

~~17.~~11. The apparatus of any of claims ~~14~~8 to ~~16~~10, wherein the means for providing provides the length indicator with a value of "0000000" to indicate that the first data octet of the protocol data unit, PDU, is the first octet of the first service data unit and the last octet of the protocol data unit, PDU, is the last octet of the other service data unit, the first service data unit being either the same or different from the other service data unit.

~~18.~~12. The apparatus of any of claims ~~14~~8 to ~~16~~10, wherein the means for providing provides the length indicator with a value of "1111100" to indicate that the first data octet of the protocol data unit, PDU, is the first octet of the first service data unit and the last octet of the protocol data unit, PDU, is the last octet of the other service data unit, the first service data unit being either the same or different from the other service data unit.

~~19. The apparatus of any of claims 14 to 16, wherein the means for providing provides the length indicator with a value of "1111101" to indicate that the first data octet in a current protocol data unit, PDU, is the first octet of the first service data unit and the last octet in the current protocol data unit, PDU, is the last octet of the first service data unit.~~

~~20. The apparatus of claim 19, wherein the means for providing provides the length indicator with a value of "1111101" when the first service data unit is two octets smaller than the current protocol data unit, PDU.~~

~~21.~~13. The apparatus of any of claims ~~14~~8 to ~~16~~10, wherein the means for providing provides the length indicator with a value of "1111101" to indicate that the first data octet in a current protocol data unit, PDU, is the first octet of the first service data unit and the last octet in the current protocol data unit, PDU, is the last octet of the other service data unit, the first service data unit being either the same or different from the other service data unit.

~~22. The apparatus of any of claims 14 to 16, wherein the means for providing provides the length indicator with a value of "111 1111 1111 1101" to indicate that the first data octet in a current protocol data unit, PDU, is the first octet of the first service data unit and the last octet in the current protocol data unit, PDU, is the last octet of the first service data unit.~~

~~23. The apparatus of claim 22, wherein the means for providing provides the length indicator with a value of "111 1111 1111 1101" when the first service data unit is three octets smaller than the current protocol data unit, PDU.~~

~~24. The apparatus of any of claims 14 to 16, wherein the means for providing provides the length indicator with a value of "111 1111 1111 101O" to indicate that the first data octet in a current protocol data unit, PDU, is the first octet of the first service data unit and that a second last octet of the current protocol data unit, PDU, is the last octet of the~~

~~first service data unit.~~

~~**25.** The apparatus of claim 24, wherein the means for providing the length indicator with a value of "111 1111 1111 101O" when the first service data unit is four octets smaller than the current protocol data unit, PDU.~~

26.14. The apparatus of any of claims ~~14~~ 8 to ~~25~~13, wherein the means for inserting comprise an inserting unit and the means for providing comprise a providing unit.

27.15. A computer program comprising program code means adapted to perform steps of any of claims 1 to ~~13~~ 7 when the program is run on a processor.

Patentansprilche

1. Verfahren umfassend:

Einfugen, in einer Radio Link Control Einheit, RLC, mindestens einer Service Data Unit, SDU, in eine Protocol Data Unit, PDU, mit einer geeigneten Gror..e;
dadurch gekennzeichnet, dass das Verfahren ferner umfasst:

Bereitstellen mindestens eines lndikators, umfassend einen Langenindikator zum Aufzeigen, dass ein erstes Datenoktett der Protocol Data Unit, PDU, ein erstes Oktett einer ersten Service Data Unit ist und mindestens ein anderes Oktett der Protocol Data Unit, PDU, das letzte Oktett einer anderen Service Data Unit ist, wobei die erste Service Data Unit entweder der anderen Service Data Unit gleicht oder von dieser verschieden ist und
wobei das mindestens eine andere Oktett das letzte Oktett der Protocol Data Unit, PDU, ist.

2. Verfahren nach Anspruch 1, wobei die Radio Link Control Einheit, RLC, eine Unacknowledged Mode Einheit, UM, ist.

3. Verfahren nach einem der vorhergehenden Anspruche, wobei das Bereitstellen mindestens eines Jndikators ferner das Bereitstellen des Langenindikators mit 7 und/oder 15 Bits umfasst.

4. Verfahren nach einem der vorhergehenden Anspruche, wobei das Bereitstellen mindestens eines lndikators ferner das Bereitstellen des Langenindikators mit einem Wert "0000000" umfasst, um aufzuzeigen, dass das erste Datenoktett der Protokoll Data Unit, PDU, das erste Oktett einer ersten Service Data Unit ist und das letzte Oktett der Protocol Data Unit, PDU, das letzte Oktett einer anderen Service Data Unit ist, wobei die erste Service Data Unit entweder der anderen Service Data Unit gleicht oder von dieser verschieden ist.

5. Verfahren nach einem der vorherigen Anspruche 1 bis 3, wobei das Bereitstellen mindestens eines lndikators ferner das Bereitstellen des Langenindikators mit einem Wert "1111100" umfasst, um aufzuzeigen, dass das erste Datenoktett der Protocol Data Unit, PDU, das erste Oktett einer ersten Service Data Unit ist und das letzte Oktett der Protocol Data Unit, PDU das letzte Oktett einer anderen Service Data Unit ist, wobei die erste Service Data Unit entweder der anderen Service Data Unit gleicht oder von dieser verschieden ist.

6. Verfahren nach einem der Anspruche 1 bis 3, wobei das Bereitstellen mindestens eines lndikators ferner das Bereitstellen des Langenindikators mit einem Wert "1111101" umfasst, um aufzuzeigen, dass das erste Datenoktett in einer aktuellen Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit und das letzte Oktett in der aktuellen Protocol Data Unit, PDU, das letzte Oktett der ersten Service Data Unit ist.

7. Verfahren nach Anspruch 6, ferner umfassend das Bereitstellen des Langenindikators mit einem Wert "1111101", wenn die erste Service Data Unit zwei Oktette schmaler als die aktuelle Protocol Data Unit, PDU, ist.

8. Verfahren nach einem der Anspruche 1 bis 3, wobei das Bereitstellen mindestens eines lndikators ferner das Bereitstellen des Langenindikators mit einem Wert "1111101" umfasst, um aufzuzeigen, dass das erste Datenoktett in einer aktuellen Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit und das letzte Oktett in der aktuellen Protocol Data Unit, PDU, das letzte Oktett der anderen Service Data Unit ist, wobei die erste Service Data Unit entweder der anderen Service Data Unit gleicht oder von dieser verschieden ist.

9. Verfahren nach einem der Ansprüche 1 bis 3, wobei das Bereitstellen mindestens eines Indikators ferner das Bereitstellen des Längenindikators mit einem Wert "111 1111 1111 1101" umfasst, um aufzuzeigen, dass das erste Datenoktett in einer aktuellen Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit ist und das letzte Oktett in der aktuellen Protocol Data Unit, PDU, das letzte Oktett der ersten Service Data Unit ist.

10. Verfahren nach Anspruch 9, ferner umfassend das Bereitstellen des Längenindikators mit einem Wert "111 1111 1111 1101", wenn die erste Service Data Unit drei Oktette schmaler als die aktuelle Protocol Data Unit, PDU, ist.

11. Verfahren nach einem der Ansprüche 1 bis 3, wobei das Bereitstellen mindestens eines Indikators ferner das Bereitstellen des Längenindikators mit einem Wert "111 1111 1111 1010" umfasst, um aufzuzeigen, dass das erste Datenoktett in einer aktuellen Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit ist und das ein vorletztes Oktett der aktuellen Protocol Data Unit, PDU, das letzte Oktett der ersten Service Data Unit ist.

12. Verfahren nach Anspruch 11, ferner umfassend das Bereitstellen des Längenindikators mit einem Wert "111 1111 1111 1010", wenn die erste Service Data Unit vier Oktette schmaler als die aktuelle Protocol Data Unit, PDU, ist.

13. Verfahren nach einem der vorhergehenden Ansprüche, ferner umfassend das Bereitstellen einer Signalisierung in einem höheren Layer an ein Endgerät zum Identifizieren, ob der Längenindikator verwendet wird oder nicht.

14. Vorrichtung umfassend:

Mittel zum Einfügen, in einer Radio Link Control Einheit, mindestens einer Service Data Unit, SDU, in eine Protocol Data Unit, PDU, mit einer geeigneten Größe; **dadurch gekennzeichnet, dass** die Vorrichtung ferner umfasst:

Mittel zum Bereitstellen mindestens eines Indikators, umfassend einen Längenindikator zum Aufzeigen, dass ein erstes Datenoktett der Protocol Data Unit, PDU, ein erstes Oktett einer ersten Service Data Unit und mindestens ein anderes Oktett der Protocol Data Unit, PDU, das letzte Oktett einer anderen Service Data Unit ist, wobei die erste Service Data Unit entweder der anderen Service Data Unit gleicht oder von dieser verschieden ist und
wobei das mindestens eine andere Oktett das letzte Oktett der Protocol Data Unit, PDU, ist.

15. Verfahren nach Anspruch 14, wobei die Radio Link Control Einheit eine Unacknowledged Mode Einheit, UM, ist.

16. Vorrichtung nach einem der Ansprüche 14 bis15, wobei das Mittel zum Bereitstellen das Bereitstellen mindestens eines Indikators umfasst, der ferner das Bereitstellen des Längenindikators mit 7 und/oder 15 Bits umfasst.

17. Vorrichtung nach einem der Ansprüche 14 bis 16, wobei das Mittel zum Bereitstellen den Längenindikator mit einem Wert "0000000" bereitstellt, um aufzuzeigen, dass das erste Datenoktett der Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit ist und das letzte Oktett der Protocol Data Unit, PDU, das letzte Oktett der anderen Service Data Unit ist, wobei die erste Service Data Unit entweder der anderen Service Data Unit gleicht oder von dieser verschieden ist.

18. Vorrichtung nach einem der Ansprüche 14 bis 16, wobei das Mittel zum Bereitstellen den Längenindikator mit einem Wert "1111100" bereitstellt, um aufzuzeigen, dass das erste Datenoktett der Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit ist und das letzte Oktett der Protocol Data Unit, PDU, das letzte Oktett der anderen Service Data Unit ist, wobei die erste Service Data Unit entweder der anderen Service Data Unit gleicht oder von dieser verschieden ist.

19. Vorrichtung nach einem der Ansprüche 14 bis 16, wobei das Mittel zum Bereitstellen den Längenindikator mit einem Wert "1111101" bereitstellt, um aufzuzeigen, dass das erste Datenoktett in einer aktuellen Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit und das letzte Oktett in der aktuellen Protocol Data Unit, PDU, das letzte Oktett der ersten Service Data Unit ist.

20. Vorrichtung nach Anspruch 19, wobei das Mittel zum Bereitstellen den Längenindikator mit einem Wert "1111101" bereitstellt, wenn die erste Service Data Unit zwei Oktette kleiner als die aktuelle Protocol Data Unit, PDU, ist.

21. Vorrichtung nach einem der Ansprüche 14 bis 16, wobei das Mittel zum Bereitstellen den Längenindikator mit einem

Wert "1111101" bereitstellt, um aufzuzeigen, dass das erste Datenoktett in einer aktuellen Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit ist und das letzte Oktett in der aktuellen Protocol Data Unit, PDU, das letzte Oktett der anderen Service Data Unit ist, wobei die erste Service Data Unit entweder der anderen Service Data Unit gleicht oder von dieser verschieden ist.

22. Vorrichtung nach einem der Ansprüche 14 bis 16, wobei das Mittel zum Bereitstellen den Längenindikator mit einem Wert "111 1111 1111 1101" bereitstellt, um aufzuzeigen, dass das erste Datenoktett in einer aktuellen Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit ist und das letzte Oktett in der aktuellen Protocol Data Unit, PDU, das letzte Oktett der ersten Service Data Unit ist.

23. Vorrichtung nach Anspruch 22, wobei das Mittel zum Bereitstellen den Längenindikator mit einem Wert "111 1111 1111 1101" bereitstellt, wenn die erste Service Data Unit drei Oktette kleiner als die aktuelle Protocol Data Unit, PDU, ist.

24. Vorrichtung nach einem der Ansprüche 14 bis 16, wobei das Mittel zum Bereitstellen den Längenindikator mit einem Wert "111 1111 1111 1010" bereitstellt, um aufzuzeigen, dass das erste Datenoktett in einer aktuellen Protocol Data Unit, PDU, das erste Oktett der ersten Service Data Unit ist und dass ein vorletztes Oktett der aktuellen Protocol Data Unit, PDU, das letzte Oktett der ersten Service Data Unit ist.

25. Vorrichtung nach Anspruch 24, wobei das Mittel zum Bereitstellen den Längenindikator mit einem Wert "111 1111 1111 1010" bereitstellt, wenn die erste Service Data Unit vier Oktette kleiner als die aktuelle Protocol Data Unit, PDU, ist.

26. Vorrichtung nach einem der Ansprüche 14 bis 25, wobei das Mittel zum Einfügen eine Einfügeeinheit und das Mittel zum Bereitstellen eine Bereitstelleinheit umfassen.

27. Computerprogramm umfassend Programmcode, der eingerichtet ist, die Schritte einen der Ansprüche 1 bis 13 durchzuführen, wenn das Programm in einem Prozessor läuft.

Revendications

1. Procédé comprenant le fait de :

   insérer, dans une entité de commande de liaison radio RLC, au moins une unité de données de service SDU, dans une unité de données de protocole PDU, d'une dimension appropriée ;

   caractérisé en ce qu'il comprend de plus, le fait de :

   mettre en oeuvre au moins un indicateur incluant un indicateur de longueur pour indiquer qu'un premier octet de données de l'unité de données de protocole PDU est un premier octet d'une première unité de données de service et qu'au moins un autre octet de l'unité de données de protocole PDU est le dernier octet d'une autre unité de données de service, la première unité de données de service étant, soit la même que, soit différente de, l'autre unité de données de service, dans lequel le, au moins un, autre octet est le dernier octet de l'unité de données de protocole, PDU.

2. Procédé selon la revendication 1, **caractérisé en ce que** l'entité de commande de liaison radio, RLC, est une entité en mode sans accusé de réception, UM.

3. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'étape de mise en oeuvre d'au moins un indicateur comprend en outre, de conférer à l'indicateur de longueur au moins l'une des valeurs de 7 ou de 15 bits.

4. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'étape de mise en oeuvre d'au moins un indicateur comprend en outre, de conférer à l'indicateur de longueur une valeur de « 0000000 » afin d'indiquer que le premier octet de données de l'unité de données de protocole, PDU, est le premier octet d'une première unité de données de service et que le dernier octet de l'unité de données de protocole, PDU, est le dernier octet de l'autre unité de données de service, la première unité de données de service étant, soit la même que, soit

différente de, l'autre unité de données de service.

5. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** l'étape de mise en oeuvre d'au moins un indicateur comprend de plus, de conférer à l'indicateur de longueur une valeur de « 1111100 » pour indiquer que le premier octet de données de l'unité de protocole, PDU, est le premier octet d'une première unité de données de service et que le dernier octet de l'unité de données de protocole, PDU, est le dernier octet de l'autre unité de données de service, la première unité de données de service étant, soit la même que, soit différente de, l'autre unité de données de service.

6. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** l'étape de mise en oeuvre d'au moins un indicateur comprend, de plus, de conférer à l'indicateur de longueur une valeur de « 1111101 » pour indiquer que le premier octet de données dans une unité de données de protocole en cours, PDU, est le premier octet de la première unité de données de service et que le dernier octet dans l'unité de données de protocole en cours, PDU, est le dernier octet de la première unité de données de service.

7. Procédé selon la revendication 6 comprenant de plus, l'étape de conférer à l'indicateur de longueur une valeur de « 1111101 » lorsque la première unité de données de service est de deux octets plus petite que l'unité de données de protocole en cours, PDU.

8. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** l'étape de mise en oeuvre d'au moins un indicateur comprend de plus, le fait de conférer à l'indicateur de longueur une valeur de « 1111101 » pour indiquer que le premier octet de données dans une unité de données de protocole en cours, PDU, est le premier octet de la première unité de données de service et que le dernier octet dans l'unité de données de protocole en cours, PDU, est le dernier octet de l'autre unité de données de service, la première unité de données de service étant, soit la même que, soit différente de, l'autre unité de données de service.

9. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** l'étape de mise en oeuvre d'au moins un indicateur comprend de plus, de conférer à l'indicateur de longueur une valeur de « 111 1111 1111 1101 » pour indiquer que le premier octet de données dans une unité de données de protocole en cours, PDU, est le premier octet de la première unité de données de service et que le dernier octet dans l'unité de données de protocole en cours, PDU, est le dernier octet de la première unité de données de service.

10. Procédé selon la revendication 9, comprenant de plus l'étape de conférer à l'indicateur de longueur une valeur de « 111 1111 1111 1101 » lorsque la première unité de données de service est de trois octets plus petite que l'unité de données de protocole en cours, PDU.

11. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** l'étape de mise en oeuvre d'au moins un indicateur comprend de plus, de conférer à l'indicateur de longueur une valeur de « 111 1111 1111 1010 » pour indiquer que le premier octet de données dans une unité de données de protocole en cours, PDU, est le premier octet de la première unité de données de service et qu'un second dernier octet de l'unité de données de protocole en cours, PDU, est le dernier octet de la première unité de données de service.

12. Procédé selon la revendication 11 comprenant de plus le fait de conférer à l'indicateur de longueur une valeur de « 111 1111 1111 1010 » lorsque la première unité de données de service est de quatre octets plus petite que l'unité de données de protocole en cours, PDU.

13. Procédé selon l'une quelconque des revendications précédentes, comprenant de plus l'étape de mettre en oeuvre une signalisation en couche supérieure à une installation d'utilisateur pour identifier si l'indicateur de longueur est, ou non, utilisé.

14. Système comprenant :

des moyens pour insérer, dans une entité de commande de liaison radio, au moins une unité de données de service, SDU, dans une unité de données de protocole, PDU, d'une dimension appropriée ; et
caractérisé en qu'il comprend de plus :

des moyens pour fournir au moins un indicateur incluant un indicateur de longueur pour indiquer qu'un premier octet de données de l'unité de données de protocole, PDU, est un premier octet d'une première

unité de données de service et qu'au moins un autre octet de l'unité de données de protocole, PDU, est le dernier octet d'une autre unité de données de service, la première unité de données de service étant, soit la même que, soit différente de, l'autre unité de données de service.

15. Système selon la revendication 14, **caractérisé en ce que** l'entité de commande de liaison radio est une entité en mode sans accusé de réception, UM.

16. Système selon l'une quelconque des revendications 14 à 15 **caractérisé en ce que** les moyens pour fournir au moins un indicateur, comprennent en outre, le fait de fournir l'indicateur de longueur sur au moins un des 7 ou 15 bits.

17. Système selon l'une quelconque des revendications 14 à 16, dans lequel les moyens pour fournir l'indicateur de longueur fournissent une valeur de « 0000000 » audit indicateur pour indiquer que le premier octet de données de l'unité de données de protocole, PDU, est le premier octet de la première unité de données de service et que le dernier octet de l'unité de données de protocole, PDU, est le dernier octet de l'autre unité de données de service, la première unité de données de service étant, soit la même que, soit différente de, l'autre unité de données de service.

18. Système selon l'une quelconque des revendications 14 à 16, **caractérisé en ce que** les moyens pour fournir l'indicateur de longueur confèrent audit indicateur de longueur une valeur de « 1111100 » pour indiquer que le premier octet de données de l'unité de données de protocole, PDU, est le premier octet de la première unité de données de service et que le dernier octet de l'unité de données de protocole, PDU, est le dernier octet de l'autre unité de données de service, la première unité de données de service étant, soit la même que, soit différente de, l'autre unité de données de service.

19. Système selon l'une quelconque des revendications 14 à 16, **caractérisé en ce que** les moyens pour fournir l'indicateur de longueur confèrent audit indicateur de longueur une valeur de « 1111101 » pour indiquer que le premier octet de données dans une unité de données de protocole en cours, PDU, est le premier octet de la première unité de données de service et que le dernier octet dans l'unité de données de protocole en cours , PDU, est le dernier octet de la première unité de données de service.

20. Système selon la revendication 19, **caractérisé en ce que** les moyens pour fournir l'indicateur de longueur confèrent audit indicateur de longueur une valeur de « 1111101 » lorsque la première unité de données de service est de deux octets plus petite que l'unité de données de protocole en cours, PDU.

21. Système selon l'une quelconque des revendications 14 à 16, **caractérisé en ce que** les moyens pour fournir l'indicateur de longueur confèrent audit indicateur de longueur une valeur de « 1111101 » pour indiquer que le premier octet de données dans une unité de données de protocole en cours, PDU, est le premier octet de la première unité de données de service et que le dernier octet dans l'unité de données de protocole en cours , PDU, est le dernier octet de l'autre unité de données de service, la première unité de données de service étant, soit la même que, soit différente de, l'autre unité de données de service.

22. Système selon l'une quelconque des revendications 14 à 16, **caractérisé en ce que** les moyens pour fournir l'indicateur de longueur confèrent audit indicateur de longueur une valeur de « 111 1111 1111 1101 » pour indiquer que le premier octet de données dans une unité de données de protocole en cours, PDU, est le premier octet de la première unité de données de service et que le dernier octet dans l'unité de données de protocole en cours , PDU, est le dernier octet de la première unité de données de service.

23. Système selon la revendication 22, **caractérisé en ce que** les moyens pour fournir l'indicateur de longueur confèrent audit indicateur de longueur une valeur de « 111 1111 1111 1101 » lorsque la première unité de données de service est de trois octets plus petite que l'unité de données de protocole en cours, PDU.

24. Système selon l'une quelconque des revendications 14 à 16, **caractérisé en ce que** les moyens pour fournir l'indicateur de longueur confèrent audit indicateur de longueur une valeur de « 111 1111 1111 1010 » pour indiquer que le premier octet de données dans une unité de données de protocole en cours, PDU, est le premier octet de la première unité de données de service et qu'un second dernier octet de l'unité de données de protocole en cours , PDU, est le dernier octet de la première unité de données de service.

25. Système selon la revendication 24, **caractérisé en ce que** les moyens pour fournir l'indicateur de longueur confèrent audit indicateur de longueur une valeur de « 111 1111 1111 1010 » lorsque la première unité de données de service

est de quatre octets plus petite que l'unité de données de protocole en cours, PDU.

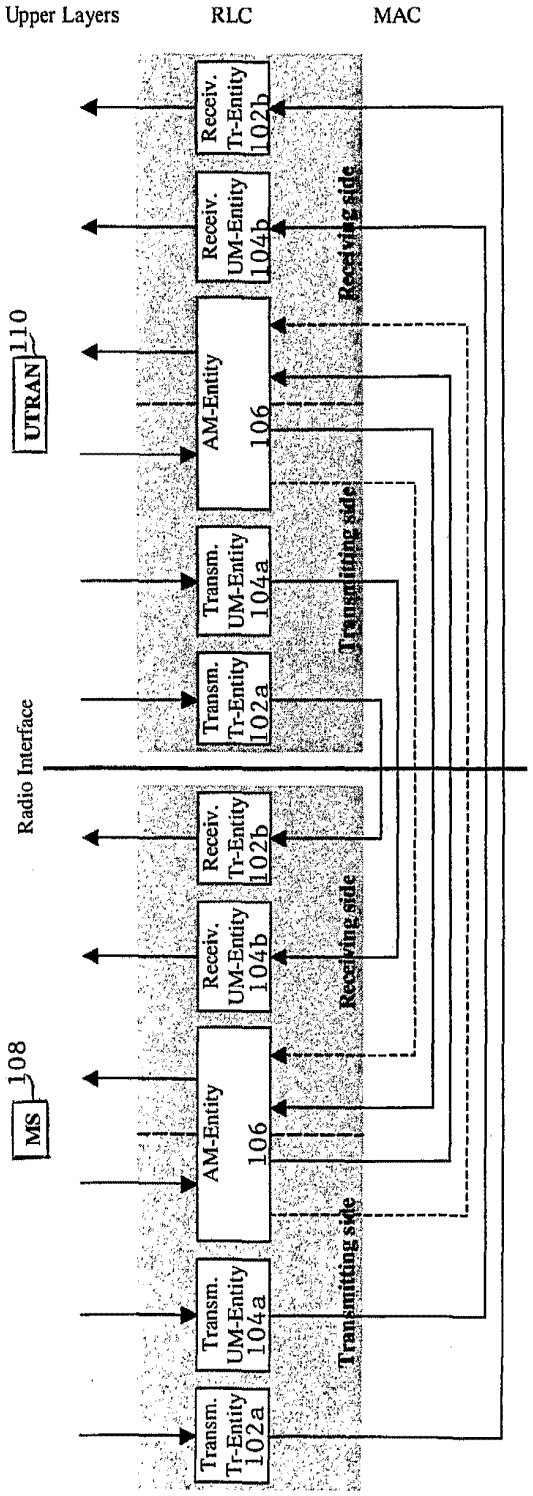
26. Système selon l'une quelconque des revendications 14 à 25, **caractérisé en ce que** les moyens d'insertion comprennent une unité d'insertion et les moyens de mise en oeuvre comprennent une unité de mise en oeuvre.

27. Programme informatique comprenant des moyens de code programme conçus pour exécuter les étapes du procédé selon l'une quelconque des revendications 1 à 13 lorsque le programme est en cours d'exécution sur un processeur.

RLC SDU size	Number of SDUs	Percentage		
97	2	0.02 %		
95	1	0.01 %		
40	1	0.01 %		
39	340	2.93 %		
38	502	4.32 %		
37	127	1.09 %		
36	286	2.46 %		
35	8847	76.18 %		
14	433	3.73 %		
13	463	3.99 %		
12	53	0.46 %		
11	39	0.34 %		
10	520	4.48 %		

Figure 1-a RLC SDU distribution for 12.2 kbit/s AMR codec assuming minimum compressed RTP/UDP/IP header of 3 bytes.

FIGURE 1-B


Upper Layers
RLC
MAC
UTRAN 110
MS 108
Radio Interface
Transm. Tr-Entity 102a
Transm. UM-Entity 104a
AM-Entity 106
Receiv. UM-Entity 104b
Receiv. Tr-Entity 102b
Transmitting side
Receiving side

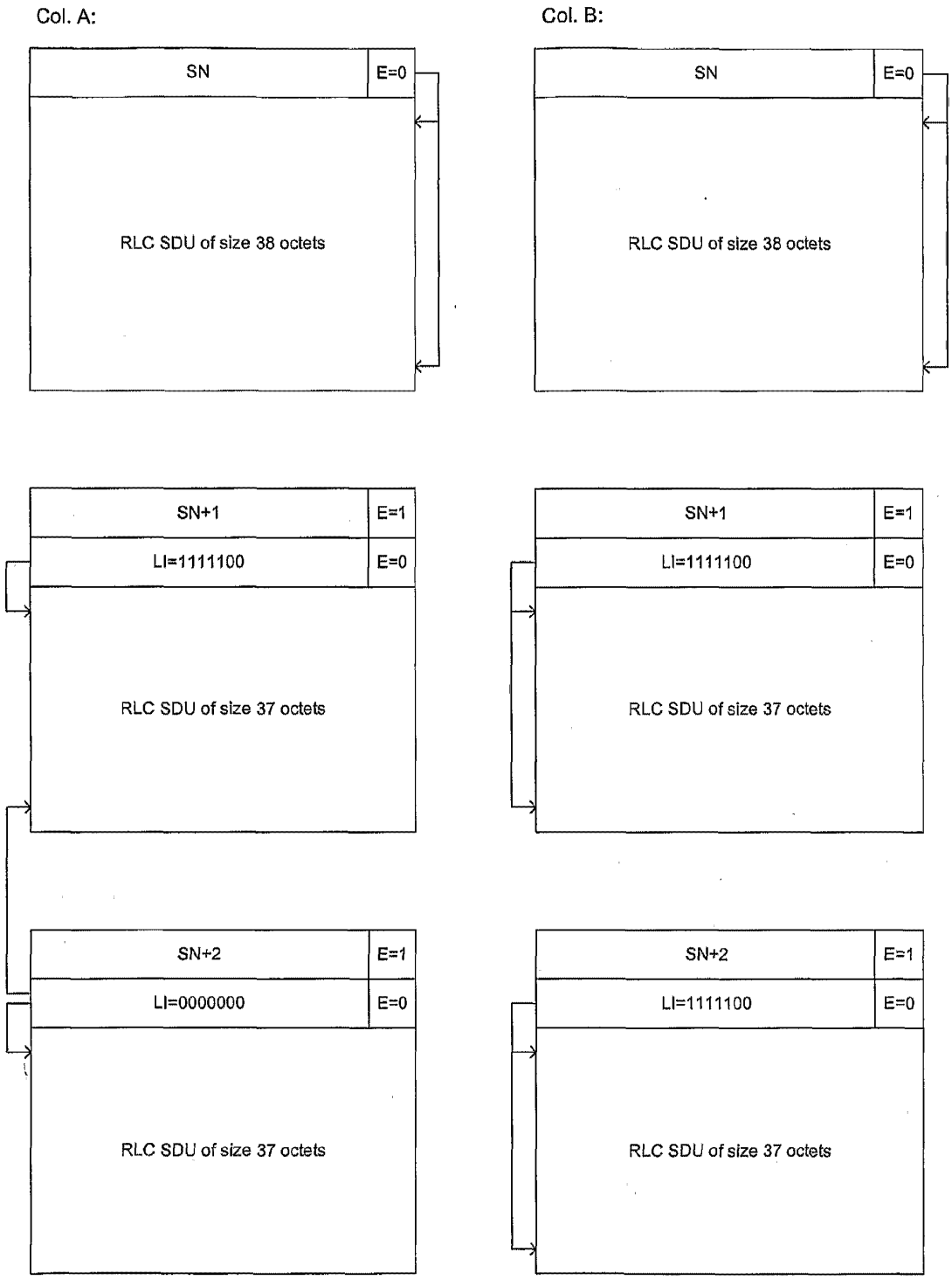


Figure 1 Sequence of RLC UMD PDUs showing the usage of LI, RLC PDU size of 39 octets and RLC SDU sizes of 38 or 37 octets

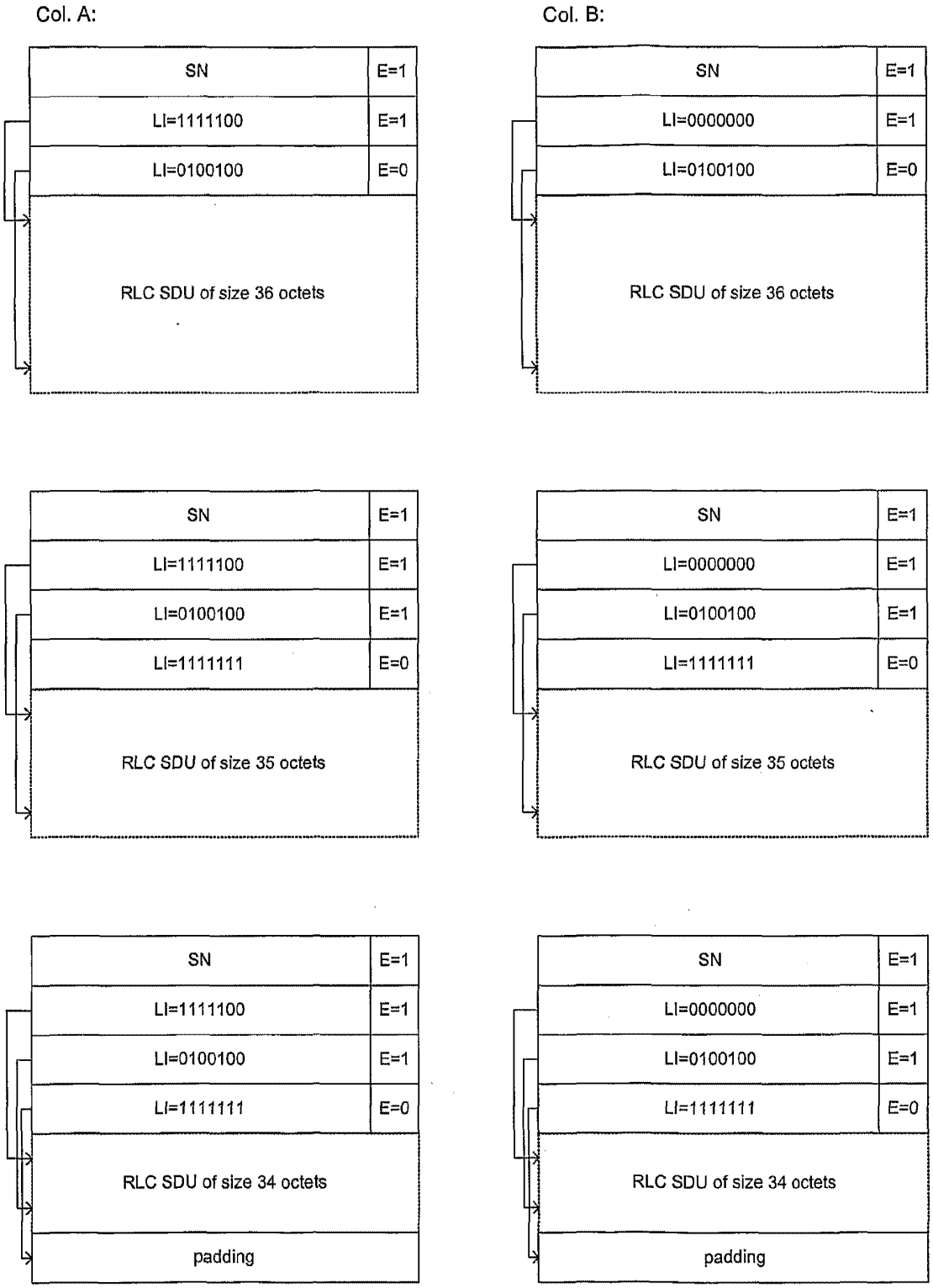


Figure 2 Sequence of RLC UMD PDUs showing the usage of LI, RLC PDU size of 39 octets and RLC SDU sizes of 36, 35 or 34 octets

Figure 3 Sequence of RLC UMD PDUs showing the usage of LI, RLC PDU size of 39 octets and RLC SDU sizes of 38 or 37 octets

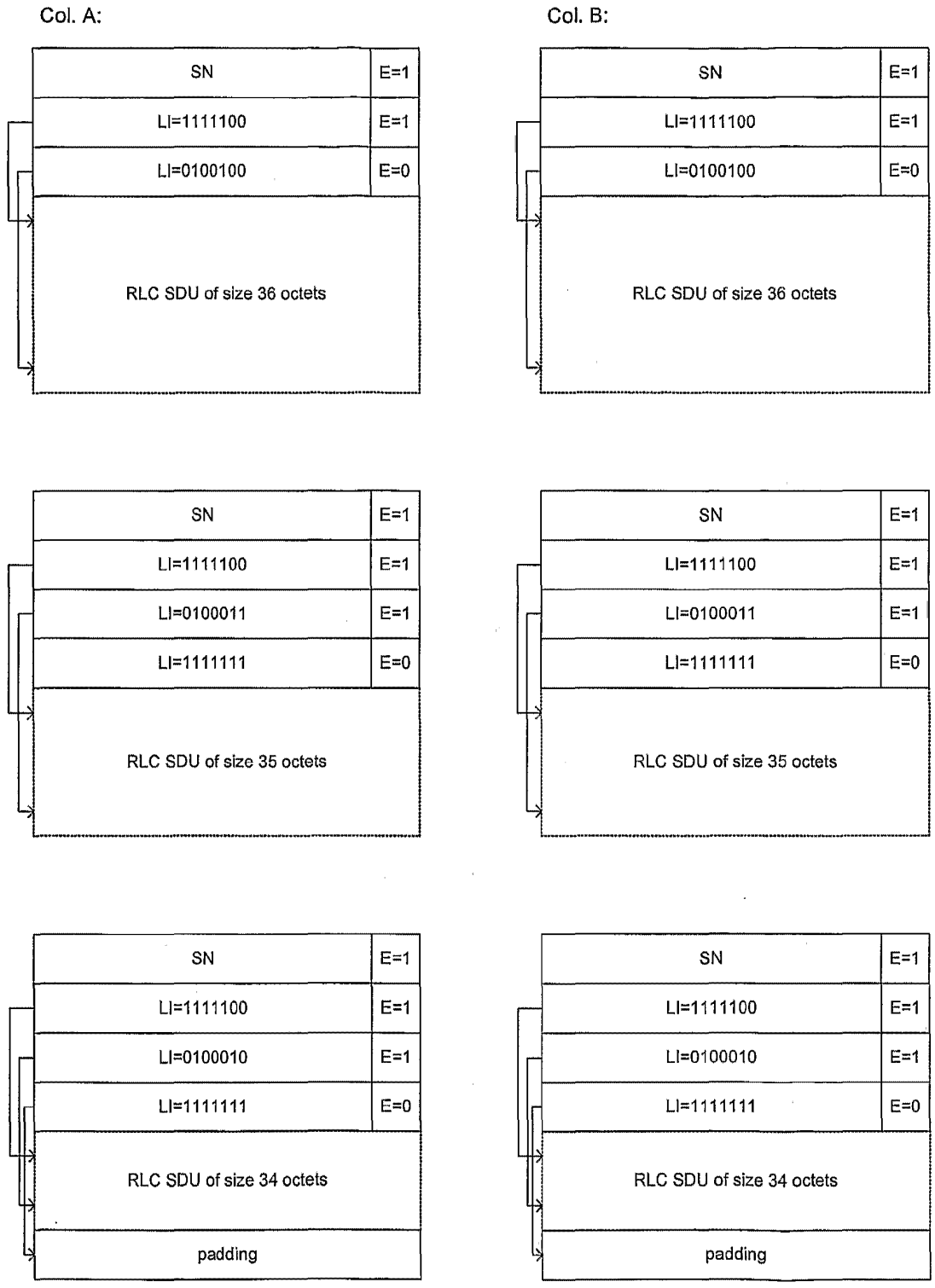


Figure 4 Sequence of RLC UMD PDUs showing the usage of LI, RLC PDU size of 39 octets and RLC SDU sizes of 36, 35 or 34 octets

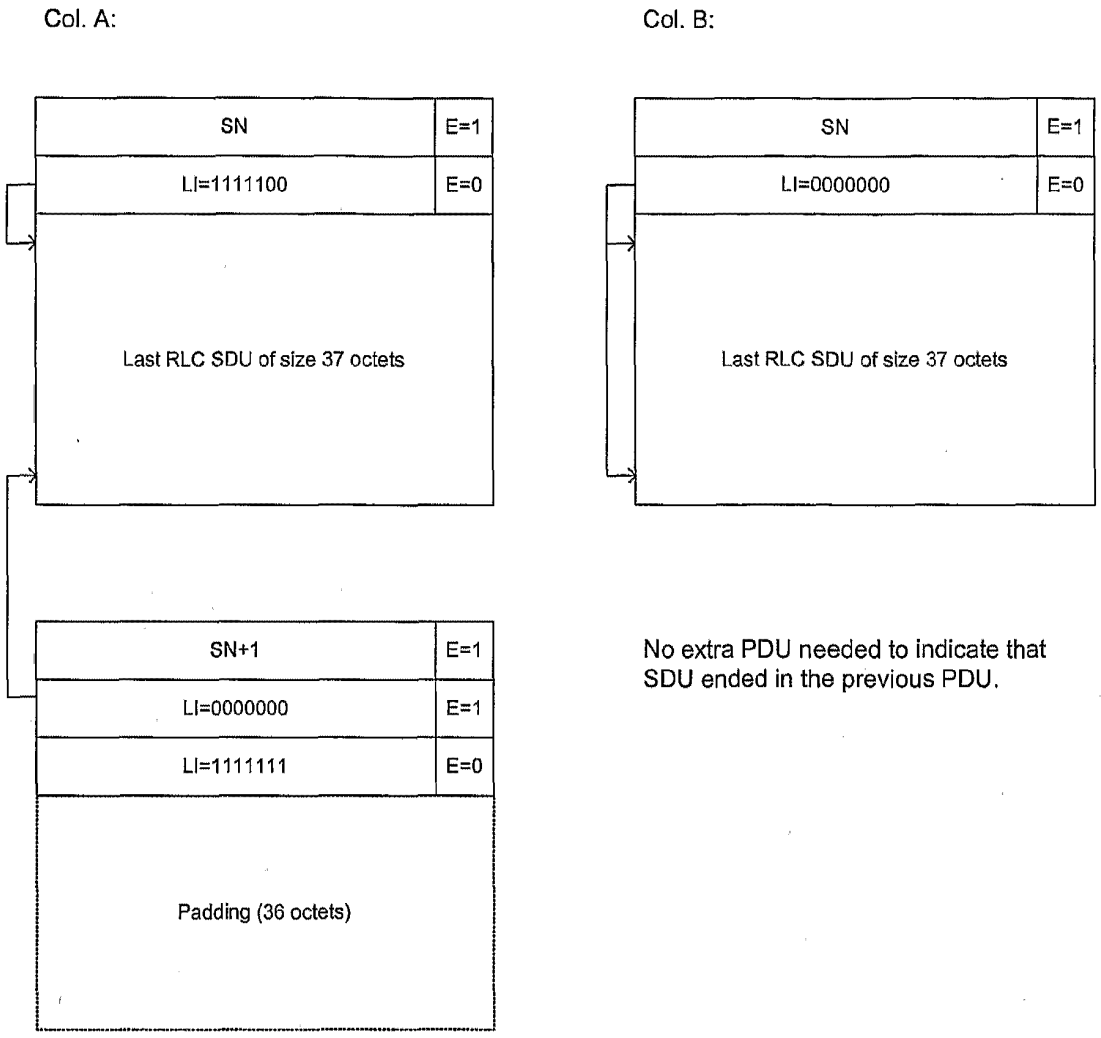


Figure 5 Sequence of RLC UMD PDUs showing the usage of LI for the last SDU of 37 octets, RLC PDU size of 39 octets

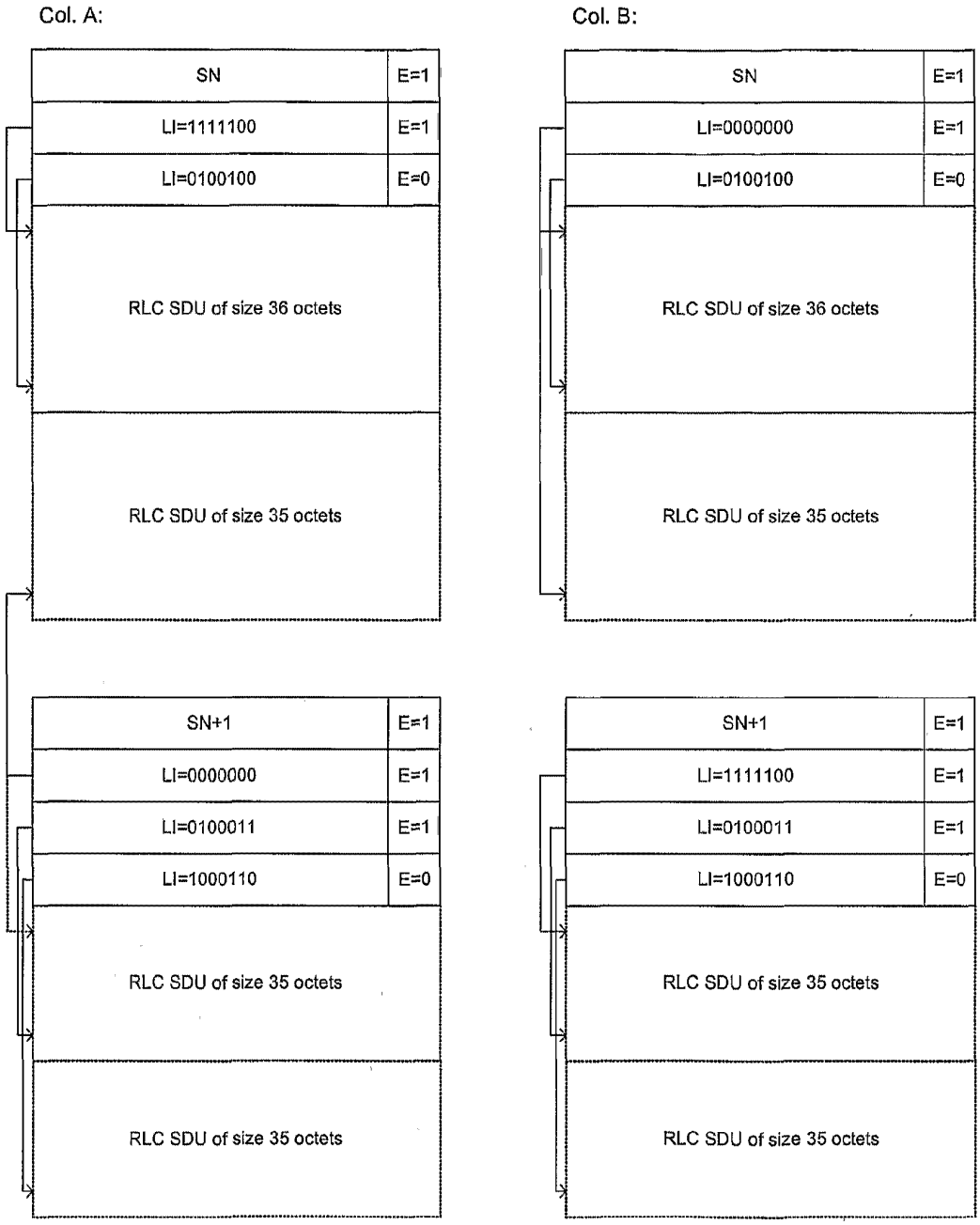


Figure 6 Sequence of RLC UMD PDUs showing the usage of LI, RLC PDU size of 74 octets and two RLC SDUs per PDU

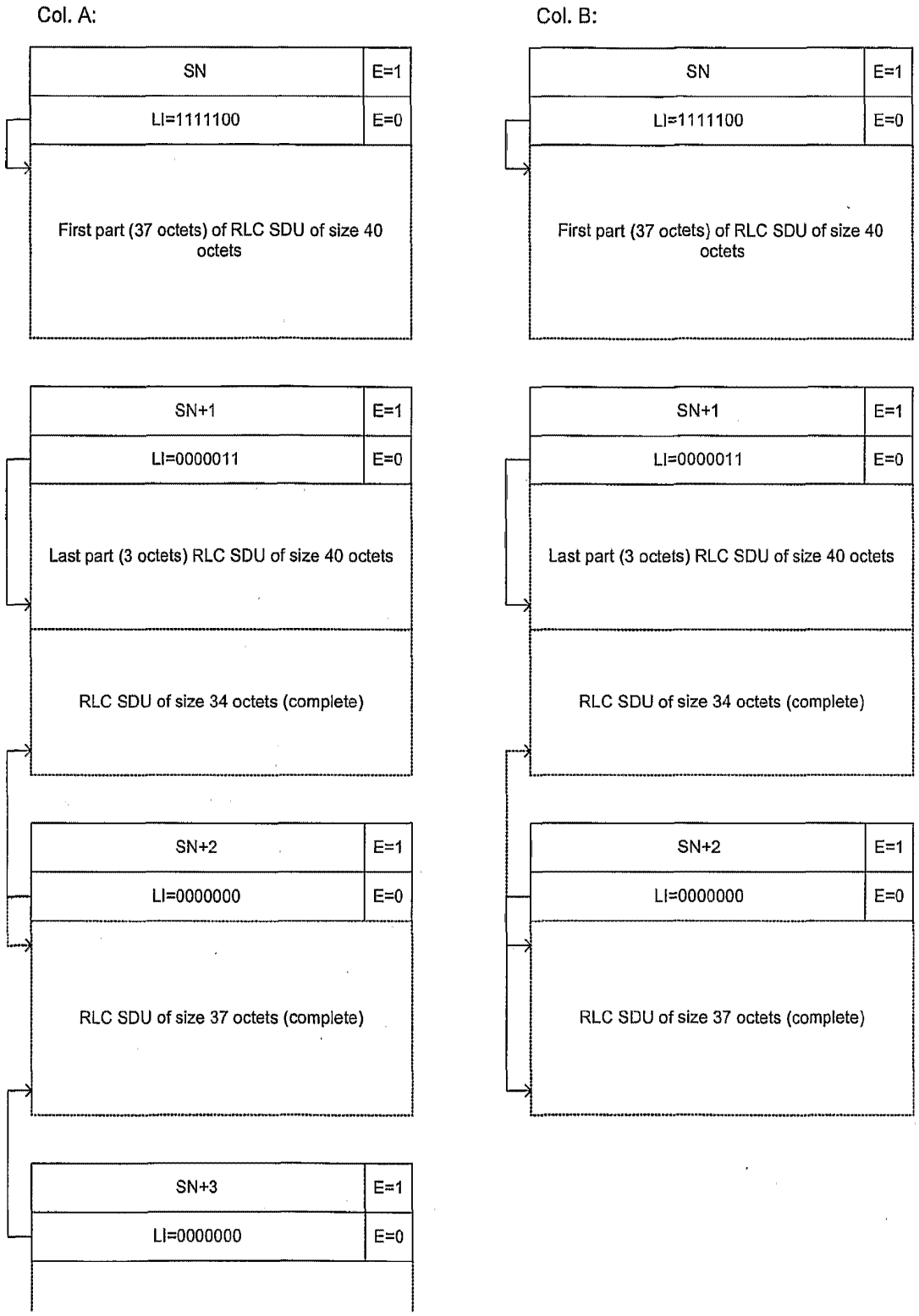


Figure 7 Sequence of RLC UMD PDUs showing the usage of LI, RLC PDU size of 39 octets and a sequence of RLC SDU sizes of 40, 34 and 37 octets

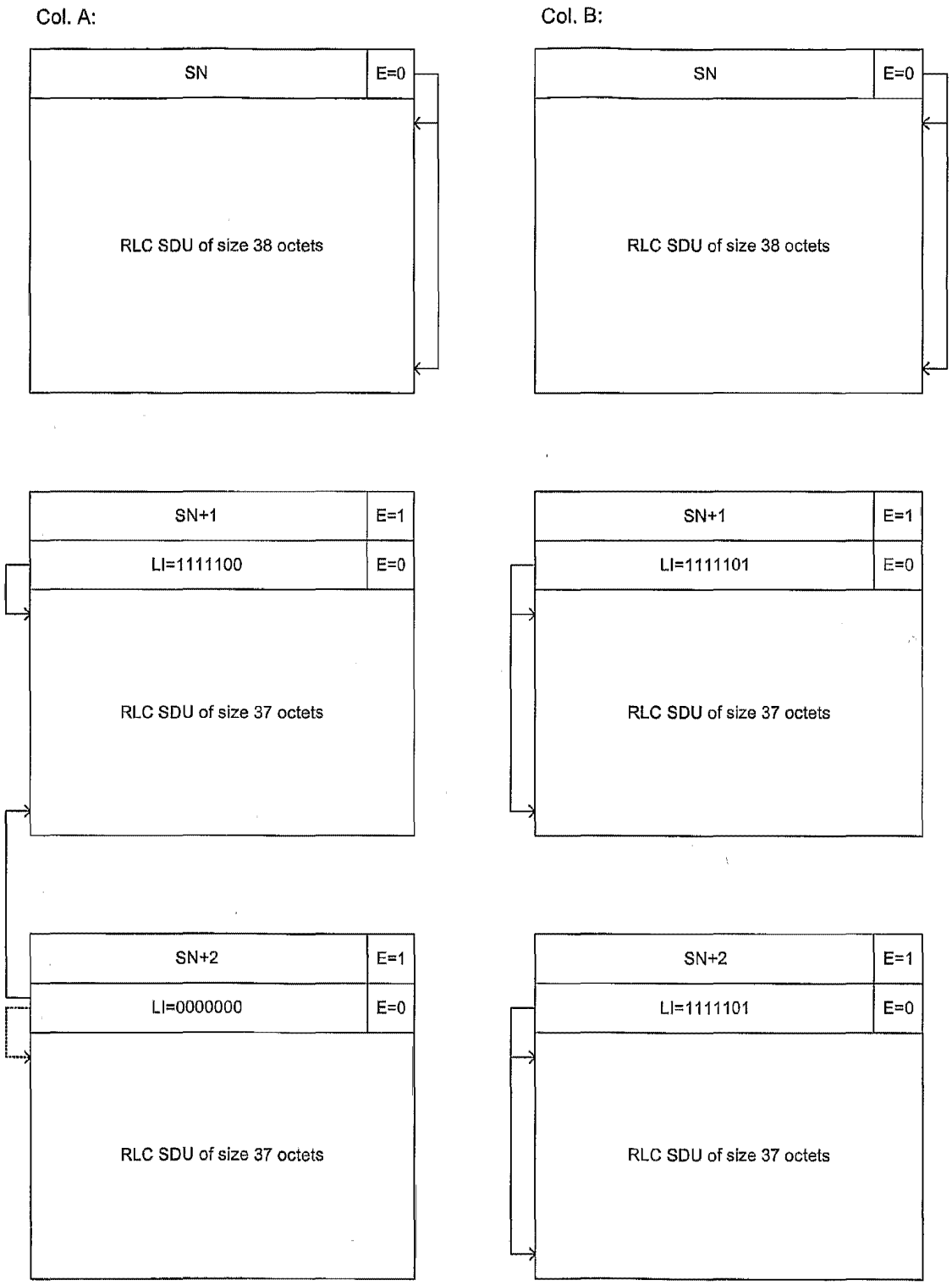

Col. A:
Col. B:
SN
E=0
RLC SDU of size 38 octets
SN
E=0
RLC SDU of size 38 octets
SN+1
E=1
LI=1111100
E=0
RLC SDU of size 37 octets
SN+1
E=1
LI=1111101
E=0
RLC SDU of size 37 octets
SN+2
E=1
LI=0000000
E=0
RLC SDU of size 37 octets
SN+2
E=1
LI=1111101
E=0
RLC SDU of size 37 octets

Figure 8

Col. A:

SN	E=1
LI=1111100	E=1
LI=0100100	E=0
RLC SDU of size 36 octets	

Col. B:

SN	E=1
LI=1111100	E=1
LI=0100100	E=0
RLC SDU of size 36 octets	

SN	E=1
LI=1111100	E=1
LI=0100011	E=1
LI=1111111	E=0
RLC SDU of size 35 octets	

SN	E=1
LI=1111100	E=1
LI=0100011	E=1
LI=1111111	E=0
RLC SDU of size 35 octets	

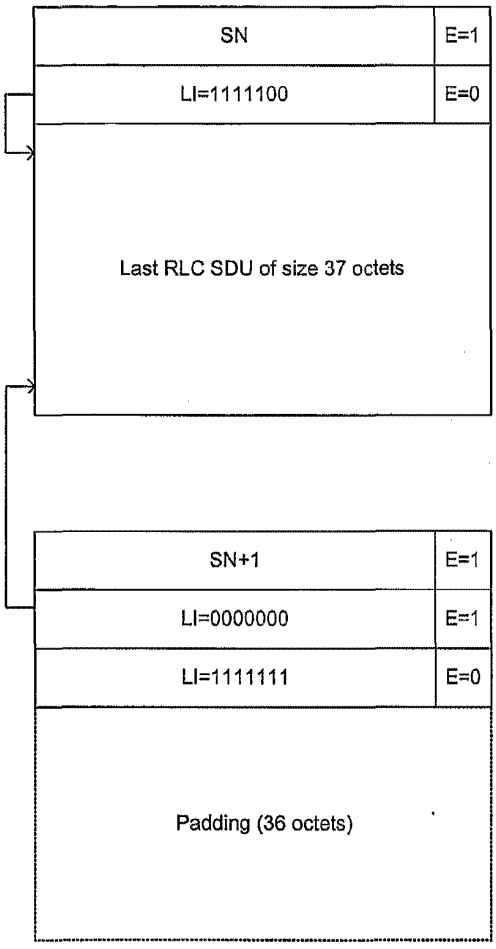
SN	E=1
LI=1111100	E=1
LI=0100010	E=1
LI=1111111	E=0
RLC SDU of size 34 octets	
padding	

SN	E=1
LI=1111100	E=1
LI=0100010	E=1
LI=1111111	E=0
RLC SDU of size 34 octets	
padding	

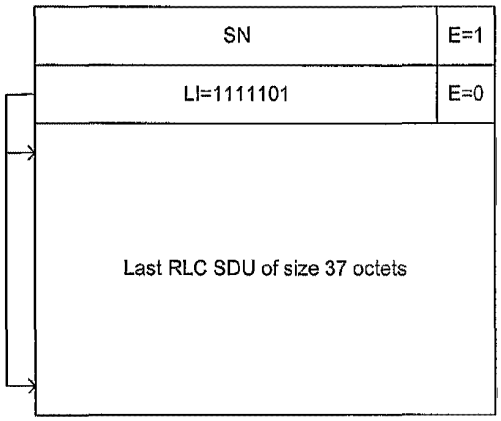
Figure 9

Last SDU in a data burst

Col. A:



Col. B:

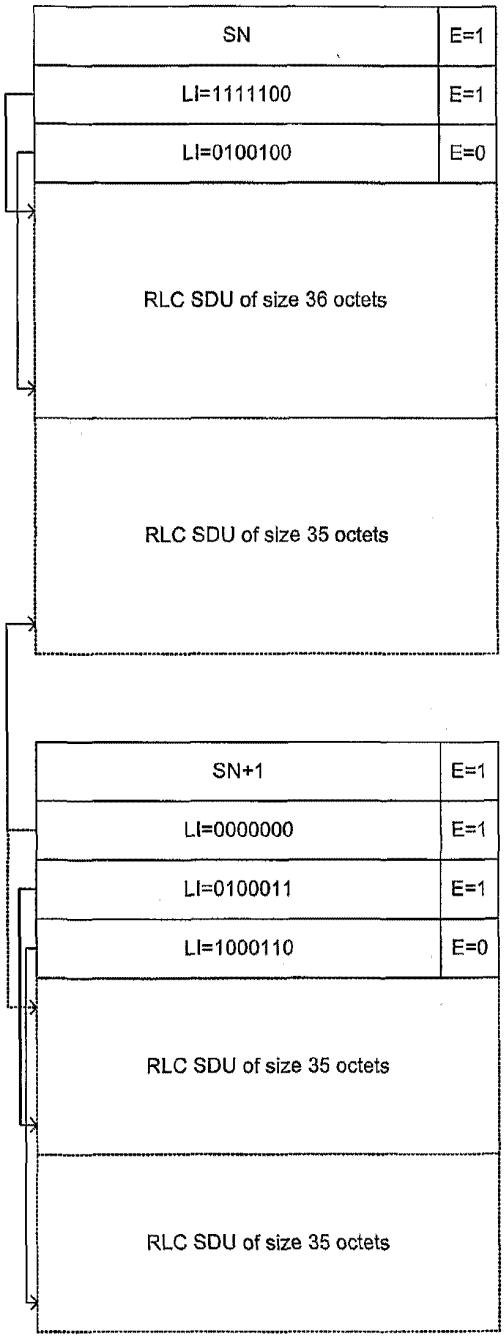


No extra PDU needed to indicate that SDU ended in the previous PDU.

Figure 10

Two complete SDUs per PDU (PDU size 74 octets):

Col. A:



Col. B:

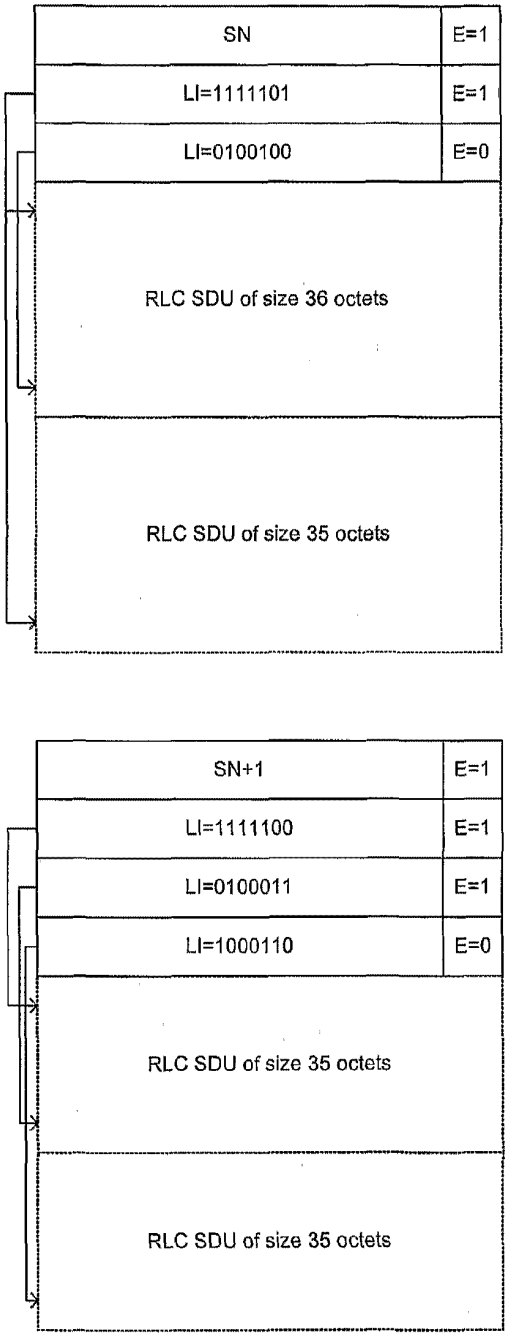


Figure 11

(PDU size 39 octets):

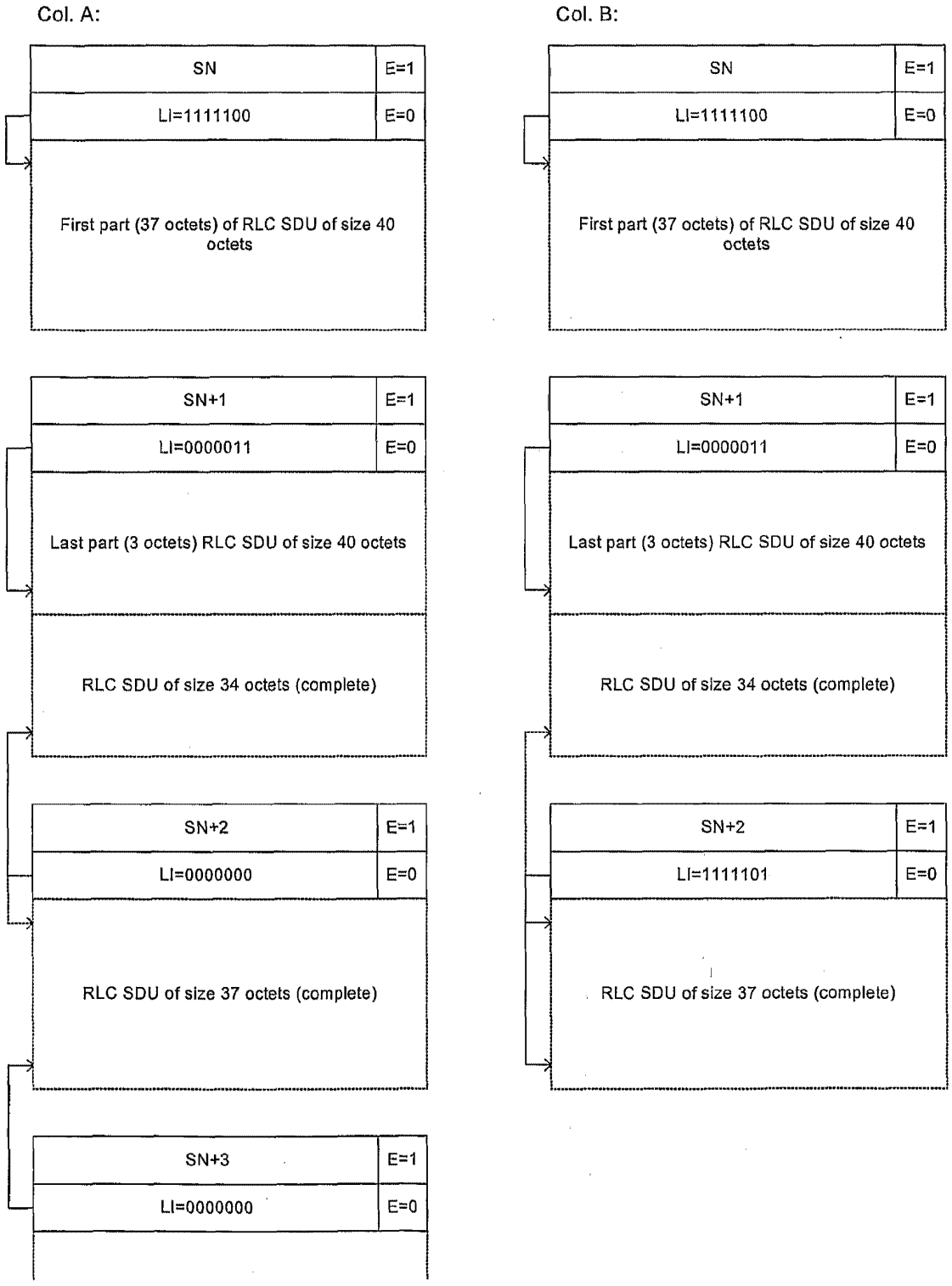


Figure 12

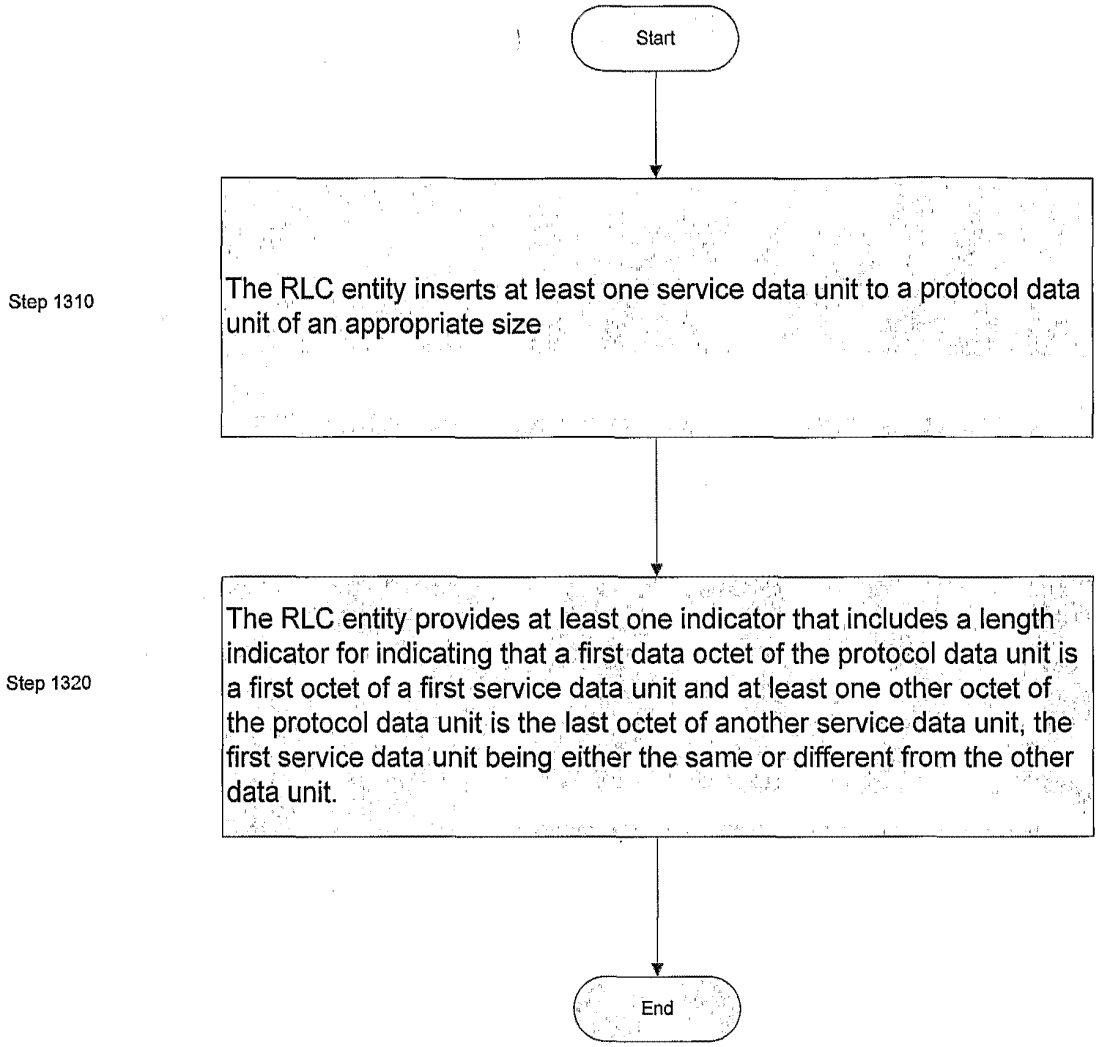

Start
Step 1310
The RLC entity inserts at least one service data unit to a protocol data unit of an appropriate size
Step 1320
The RLC entity provides at least one indicator that includes a length indicator for indicating that a first data octet of the protocol data unit is a first octet of a first service data unit and at least one other octet of the protocol data unit is the last octet of another service data unit, the first service data unit being either the same or different from the other data unit.
End

Figure 13

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 60710193 B **[0001]**
- EP 1195923 A2 **[0006]**