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Technical Report

3rd Generation Partnership Project;
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Report on Hybrid ARQ Type II/III
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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

This technical report captures the results of the work on the work item “Hybrid ARQ Type II/III”. This includes technical solutions and their comparison. The report covers impacts on all RAN WGs.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[<seq>] <doctype> <#>[([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

[1] 3G TS 25.123: "Example 1, using sequence field".

[2] 3G TR 29.456 (V3.1.0): "Example 2, using fixed text".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

Definition format

***<defined term>**: <definition>.*

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Symbol format

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

Abbreviation format

<ACRONYM> <Explanation>

4 Background and Introduction

5 Overview of Hybrid ARQ Type II/III

5.1 General Mechanism

There are different variants of hybrid ARQ methods. The terms hybrid ARQ type I, type II, and type III are used according to the following definition:

Type I hybrid ARQ

The ARQ method used in current 3GPP specifications is referred to as HARQ type I. In this basic HARQ type I the CRC is added and the data is encoded with a forward error correction (FEC) code. In the receiver the FEC code is decoded and the quality of the packet is checked (CRC check). If there are errors in the packet, a retransmission of the packet (RLC-PDU) is requested. The erroneous packet is discarded and retransmissions use the same coding as the first transmission.

Type II hybrid ARQ

The type II HARQ is a so-called Incremental Redundancy ARQ scheme. This means that an RLC-PDU that is to be retransmitted is not discarded but is combined with some incremental redundancy information provided by the transmitter for subsequent decoding.
For type II HARQ the retransmissions are typically not identical with the original transmission. The retransmitted part carries additional redundancy information for error correction purposes. This additional redundancy is combined with the previously received packet and the resulting code word with a higher coding gain is decoded. In hybrid ARQ type II, the retransmitted amount of redundancy is different for each retransmission, and retransmissions can in general only be decoded after combination with previous transmissions.
Type II hybrid ARQ requires that when RLC-PDU are transferred their sequence numbers are signalled with a better error protection than the data part of the RLC-PDU. This is because several versions of the RLC-PDU may need to be combined in the physical layer before it can be decoded and any identifier contained within the RLC-PDU detected.

Type III hybrid ARQ

Like type II hybrid ARQ, type III hybrid ARQ also belongs to the incremental redundancy ARQ schemes. This means that retransmissions concerning one RLC-PDU are not discarded but kept at the receiver for combination with additional information before decoding.
With type II hybrid ARQ, retransmissions containing additional incremental code bits sent for a RLC-PDU, which was initially received with errors, are in general not self decodable. In situations where the transmitted RLC-PDU can be severely damaged, for example, due to interference, it is desirable to have a scheme where any additional information sent is self decodable. In type III HARQ each retransmission is self-decodable. Thus, the data can be recovered from the retransmitted packet without combining if it is transmitted with sufficient quality.

Type III places similar requirements on the signalling protocol for external RLC-PDU identification and on the physical layer as type II hybrid ARQ.

Two subcases of hybrid ARQ type III can be distinguished:

- with multiple redundancy versions
  Different versions of a RLC-PDU are created. Different puncture bits are used in each version. If transmission of the first fails then the second version is sent. Transmission of further versions or repeat transmissions of the already transmitted versions may be made and combined.

- with one redundancy version
  In this subcase of HARQ type III, the same FEC coding is used for each retransmission, similar to the operation of HARQ type I. However, the erroneous packets are stored in the receiver and combined with retransmissions of the packet. This is a kind of incremental redundancy coding scheme in the form of a repetition code.

5.2 Termination of Retransmission

Two alternative approaches to realize hybrid ARQ are presented in this document for consideration.

The first option uses hybrid ARQ type II/III retransmissions at RLC layer. This option is based on the present termination of retransmission protocols, i.e. utilizing the retransmission mechanism defined in release '99 with the current termination points and adding Type II/III functionality as an add-on to the current protocol. This first option is described in chapter 6.

The second option uses hybrid ARQ type II/III retransmissions at Layer 1. It adds fast hybrid ARQ type II/III functionality to Node B. With this approach the release '99 RLC is not affected. This second option is described in chapter 7.

6 Layer 2 and Layer 3 Operation with Hybrid ARQ Type II/III Retransmission at RLC

6.1 Protocol Architecture

This section gives a general overview of function split for HARQ type II/III in the UE, the Node B, the Controlling or Drift RNC, and the Serving RNC in the UL and DL direction.

The following major functions are shown in table 1 and table 2:

- TX buffering: The buffering of data which should be (re)transmitted at the transmitting side.
- Parameter setting for Redundancy Version selection: It is selected with which redundancy version a certain (re-)transmission of a PDU is done.
- RX soft decision buffering for combining: Buffering of the received initial and retransmitted data for the combining at the receiver side.
- RX buffering for RLC-SDU reassembly: Buffering of the RLC-PDUs to reassemble them to RLC-SDUs.
- Combining of retransmissions: Combining of the initially transmitted and retransmitted data for error correction.

	UE	Node B	CRNC / DRNC	SRNC
TX buffering	RLC	-	-	-
Parameter setting for Redundancy Version selection	RLC	-	-	-
RX soft decision buffering for combining	-	Layer 1	-	-
RX buffering for RLC-SDU reassembly	-	-	-	RLC
Combining of retransmissions	-	Layer 1	-	-

Table 1: Function split for hybrid ARQ type II/III in the UE, NodeB, CRNC/DRNC, and SRNC in UL direction

	UE	Node B	CRNC / DRNC	SRNC
TX buffering	-	-	-	RLC
Parameter setting for Redundancy Version selection	-	-	-	RLC
RX soft decision buffering for combining	Layer 1	-	-	-
RX buffering for RLC-SDU reassembly	RLC	-	-	-
Combining of retransmissions	Layer 1	-	-	-

Table 2: Function split for hybrid ARQ type II/III in the UE, NodeB, CRNC/DRNC, and SRNC in DL direction

To perform the HARQ type II / III operation the physical layer requires additional side information, e.g. sequence number, redundancy version, and logical channel identification. The setting of these parameters should be under control of RLC. A coordinated data flow of user data and side information from RLC to MAC and L1 is required (see figure 1). The physical layer can encode the data and the side information separately, and map them on one, or possibly even different physical channels. At the receiver the buffering and recombining of the data is performed.

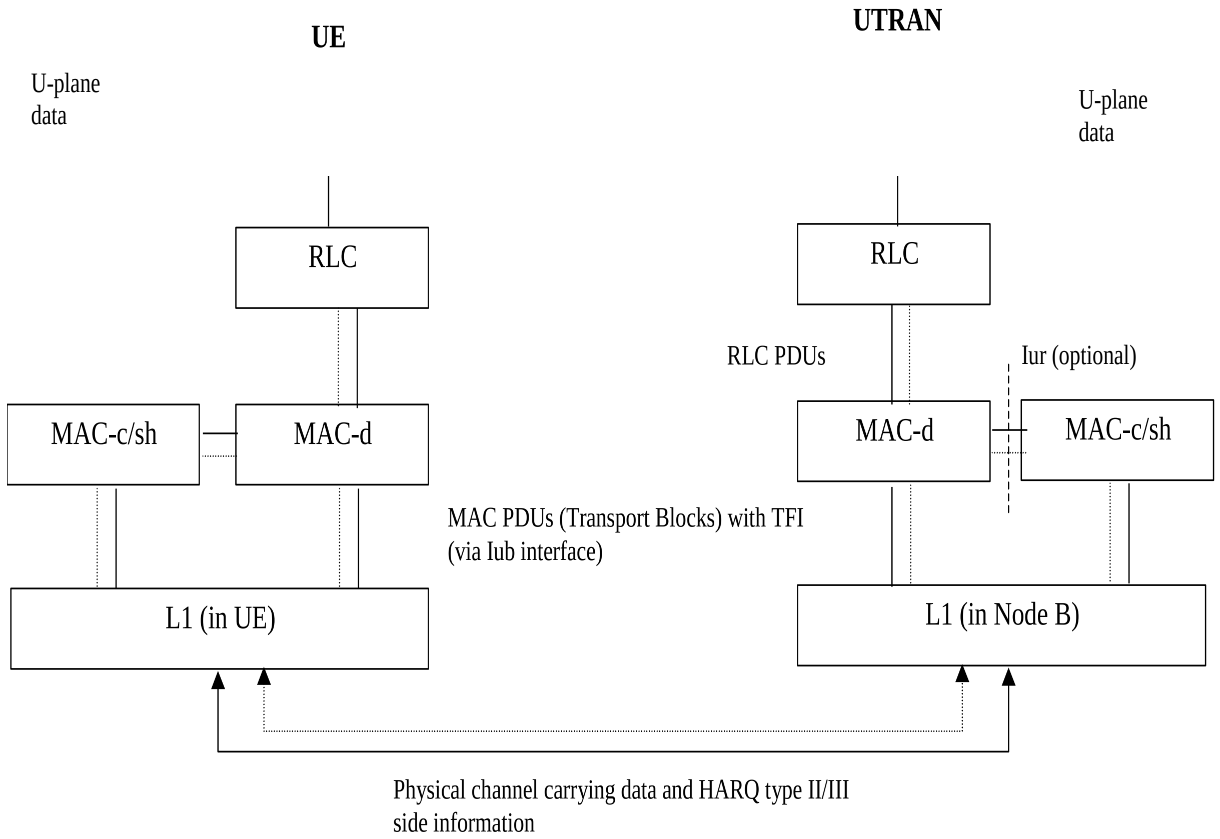

Figure 1 Protocol stack overview for hybrid ARQ type II/III.

Dotted lines visualise the transport of necessary side information for hybrid ARQ type II/III operation between RLC and the Physical Layer. Solid lines show the transport of user data.

Two different models for handling the additional requirements for hybrid ARQ type II/III in Layer 2 and Layer 3 have been proposed and are described in this report.

Case A: One logical channel is used for the transfer of user data and side information between RLC and MAC, and one transport channel is used for the transfer of user data and side information between MAC and physical layer.

Case B: Two separate logical channels are used for the transfer of user data and side information between RLC and MAC, and two separate transport channels are used for the transfer of user data and side information between MAC and physical layer.

6.2 Usage of logical channels and transport channels

6.2.1 Usage of logical channels and transport channels with Case A

The necessary side information for hybrid ARQ type II/III operation is included in the same logical channel as the RLC PDU data. This logical channel can be mapped to the following transport channels:

a) DTCH can be mapped onto the DCH.

b) DTCH can be mapped onto the DSCH

c) DTCH can be mapped onto the DSCH, but with transmission of side information over DPCH

d) DTCH can be mapped onto the USCH

As already possible in release 99, a second logical channel can be used for RLC control PDUs. The use of this second logical channel is independent from the hybrid ARQ type II/III operation.

6.2.2 Usage of logical channels and transport channels with Case B

The hybrid ARQ user data and side information can be produced onto two PDUs, respectively. User data and side information can be transmitted to MAC-d as following cases:

a) DTCH can be mapped onto the DCH.

b) DTCH can be mapped onto the DSCH

c) DTCH can be mapped onto the DCH and DSCH

The HARQ user data and side information are produced as each RLC PDU and are mapped onto two signals. Since RLC and MAC-d are located in a RNC, the co-ordination between both signals is a kind of implement issue(for example, using an indicator between HARQ user data and side information).

6.3 Usage of transport channels and physical channels

6.3.1 Usage of transport channels and physical channels with Case A

The hybrid ARQ user data and side information can be transmitted on the dedicated or shared channels. Following cases can be considered.

a) DCH can be mapped onto the DPCH

b) DSCH can be mapped onto the PDSCH

c) DSCH can be mapped onto the PDSCH + DPCH

d) USCH can be mapped onto the PUSCH

ad a) , b), and d) The HARQ user data and side information is mapped onto the same Physical Channel. Since one physical channel is always generated by a common processing chain in Layer 1, no special co-ordination of the user data and the side information at the physical layer is needed, as long as the MAC and RLC layer ensure a synchronised delivery of user data and side information to the Layer 1.

ad c) The hybrid ARQ type II/III user data can be mapped on a different physical channels than the side information. This scenario is especially interesting for the transmission of the user data over the downlink shared channel, while the side information is transmitted over a more reliable dedicated channel. The use of two independent physical channels requires special attention for the co-ordination of the transmissions on both channels, because the data flow through MAC and Layer 1 may be different. This is the case for the simultaneous use of DCH and DSCH, which may be influenced by variable and unknown delays, e.g. transmission over the Iur interface and scheduling in MAC-c/sh of the controlling RNC.

6.3.2 Usage of transport channels and physical channels with Case B

The hybrid ARQ user data and side information can be transmitted on the dedicated or shared channels. Following cases can be considered.

a) DCH can be mapped onto the DPCH

b) DSCH can be mapped onto the PDSCH

c) DCH and DSCH can be mapped onto the DPCH and PDSCH, respectively

ad a) and b) The HARQ user data and side information are mapped onto the same Physical Channel(s). Since one physical channel is always generated by a common processing chain in Layer 1, no special co-ordination of the user data and the side information at the physical layer is needed, as long as the MAC ensures a synchronised delivery of one(or two) signal(s) to the Layer 1.

ad c) The HARQ user data and side information can be separated at MAC and be mapped onto two different transport channels(i.e. DSCH and DCH). When there are both MAC-d and MAC-c/sh in one RNC, the synchronisation between DSCH and DCH can be done according to the scheduling result of MAC-c/sh. Each transport channel can be mapped onto the related physical channel (i.e. DSCH onto PDSCH, DCH onto DPCH).

6.4 Examples of Interlayer Procedures

6.4.1 Examples of Interlayer Procedures for Case A

6.4.1.1 Data Transfer on Uplink

Following Figure is a modification of "Data Transfer on USCH" as specified in [2]. Additional detail of the data transfer in the user plane is shown . The shaded area of the Figure corresponds to a single uplink transmission

MAC-Data-REQ → USCH:Data → MAC-Data-IND

and is equally valid for usage on other transport channels, e.g. DCH.

If the transmission on the Uu interface is corrupted, the physical layer on the receiving side needs to retrieve the Hybrid ARQ parameter list of the corrupted data in order to perform Type II operation. Therefore, it is needed that the parameter values be stronger encoded on the physical layer than the associated data. Subsequent retransmissions send incremental redundancy to the already transferred data. Which redundancy version of the data is sent is indicated through the redundancy version parameter ("Red.Vers.") which is signalled together with all the transmissions. Each time an incremental redundancy version of the data is received, the physical layer attempts to decode the concatenated versions of all previous transmissions.

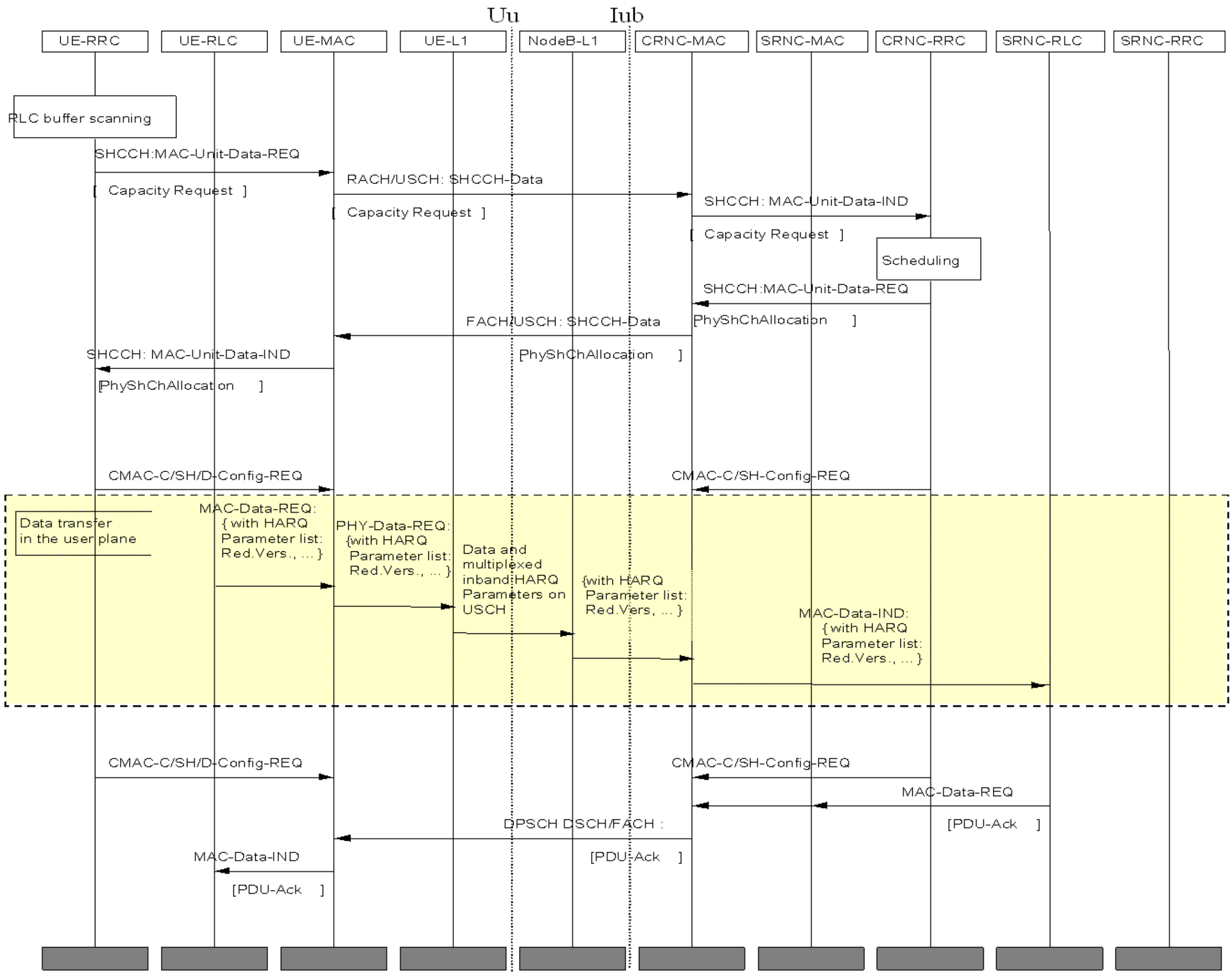

Figure 2 Example procedure for uplink data transfer using hybrid ARQ type II/III on USCH.

The relevant part in the shaded area is equally valid for usage on other transport channel, e.g. DCH.

6.4.1.2 Data Transfer on Downlink

The following figure is a modification of the “Data Transfer on DSCH” as specified in [2]. Additional detail of the data transfer in the user plane is shown. The shaded area of the figure corresponds to a single downlink transmission

MAC-Data-IND ← DSCH:Data ← MAC-Data-REQ

and is equally valid for usage on other transport channel, e.g. DCH.

In case of corrupted transmission on the Uu interface, the same procedure which was already described for the uplink case (in section 6.3.1) applies.

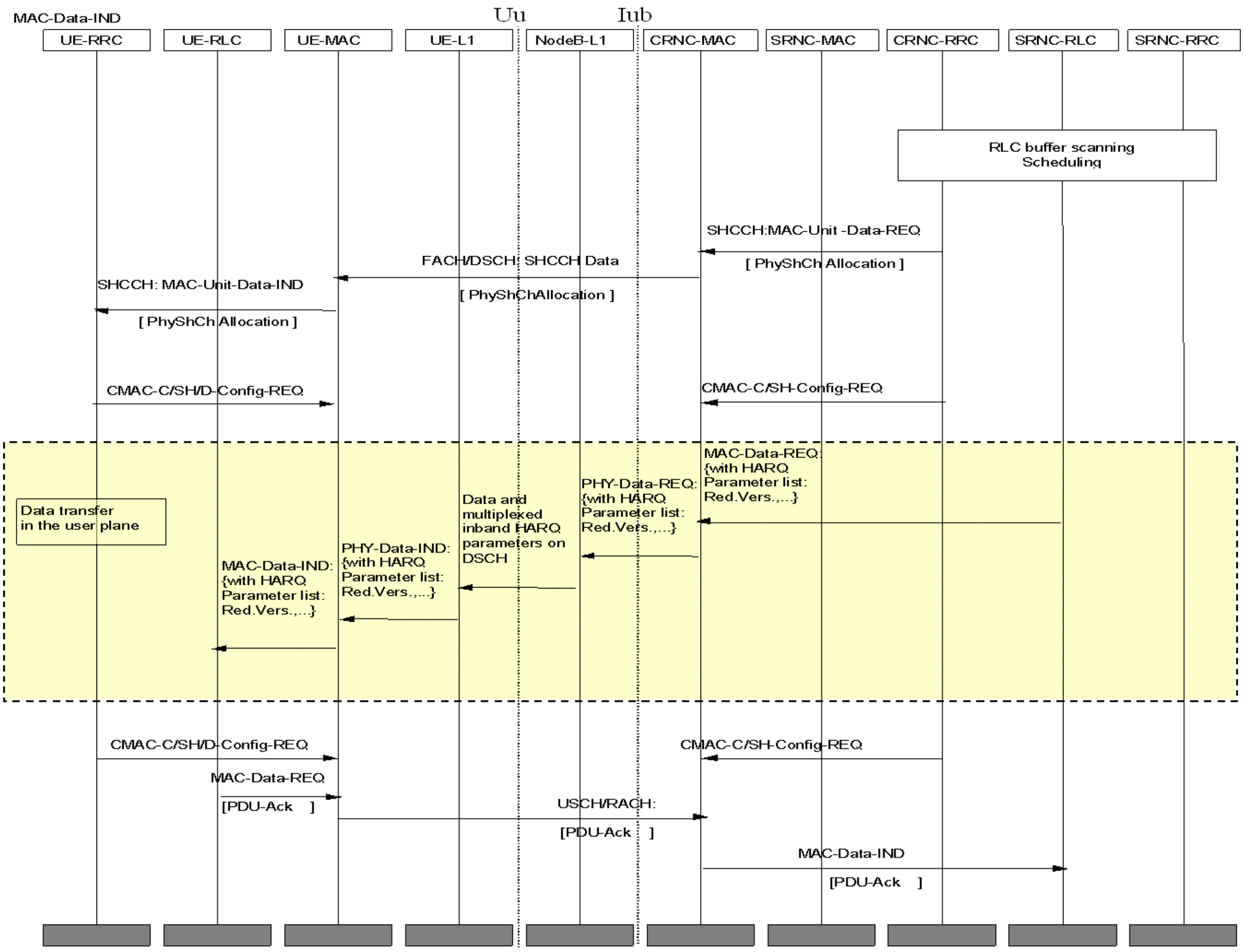

Figure 3 Example procedure for downlink data transfer using hybrid ARQ type II/III on DSCH in TDD mode.

The relevant part in the shaded area is equally valid for usage on other transport channel, e.g. DCH.

6.4.1.3 Data Transfer on Downlink with DCH+DSCH

Several ways for operating hybrid ARQ type II/III with user data transmission over a downlink shared channel while transmitting the side information necessary for combining at the receiver (e.g. sequence number, redundancy version) over a more reliable dedicated physical channel are possible.

It is important to assure that the user data and the corresponding side information are transmitted synchronously over both channels to allow correct decoding at the receiver. Due to the different handling of dedicated and shared channels in the MAC layer, this synchronisation is difficult to achieve by using different logical channels.

Also, additional problems arise if the controlling RNC is not equal to the serving RNC, because the Iur interface with high transmission delays has to be involved. In the case of an involved Iur interface, it is suggested not to split data and side information on different channels.

A similar synchronisation problem on downlink shared channels and dedicated physical channels was already solved in release 99 for the TFCI transmission using logical split of TFCI-word for the transport format on the DSCH. With small extensions, this mechanism could also be used to support the hybrid ARQ type II/III case.

The following text and figure have been copied from 25.303V3.4.0. In the figure, three legends have been added to mark the important details which can be used to transfer side information for hybrid ARQ type II/III on the dedicated physical channel.

In the figure, the parameter "HARQ type II/III side information" has been added to the existing procedure at the appropriate places to show how a transmission of hybrid ARQ type II/III encoded data using this mechanism could work.

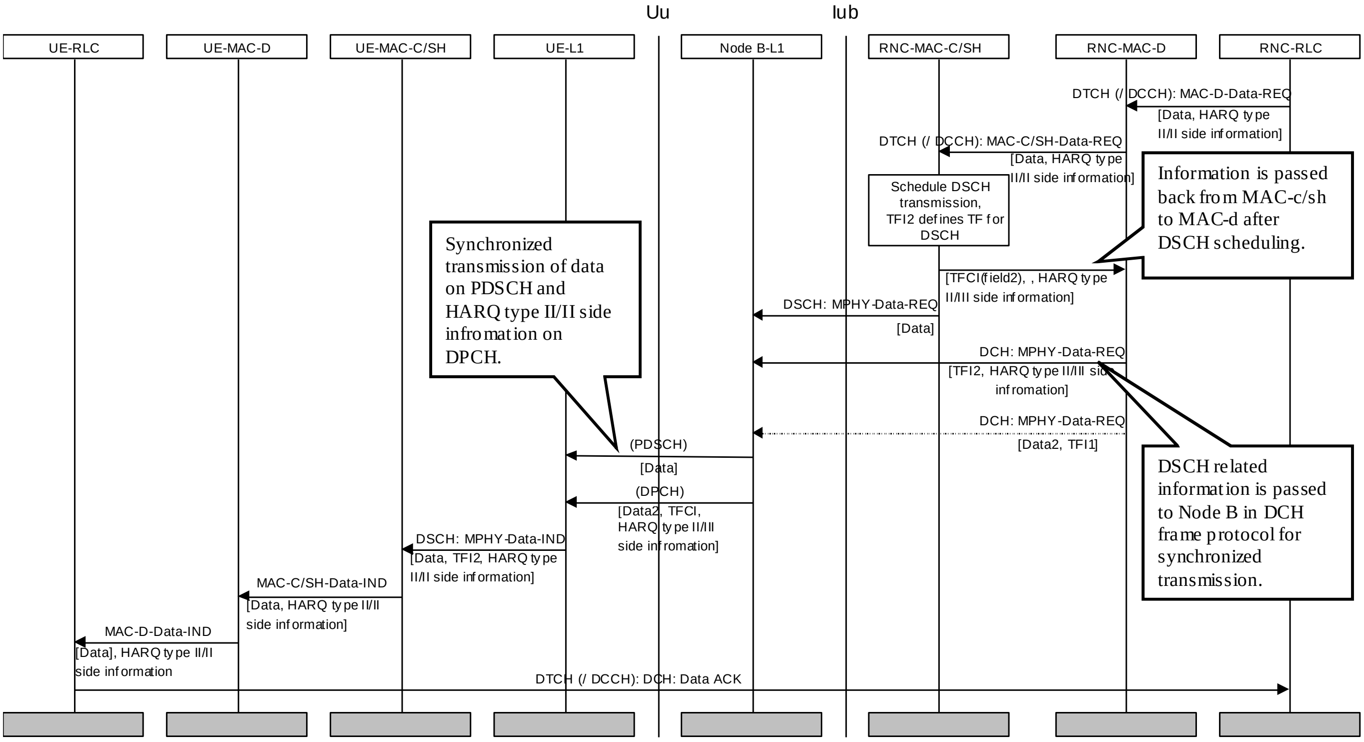

Figure 4 Data flow for Acknowledged-mode data transmission on DSCH using logical split of TFCI-word and split transmission of hybrid ARQ type II/III data and side information.

6.4.2 Examples of Interlayer Procedures for Case B

Following some flowcharts about the HARQ type II/III scheme for case B scheme

The basic scheme is as follows:

- When RLC receives the data, RLC processes the data based on release 99 specification and produces a new PDU including the side information about data PDU, i.e. RLC PDU sequence number, RLC PDU version based on previous signalling.
- Both data PDU and a new PDU including side information, which are produced in RLC, are transmitted to MAC-d.
- DTCH(s) including the side information and data PDU is(are) mapped to DCH transport channel through MAC-d or(and) DSCH transport channel through MAC-d and MAC-c/sh.
- Data PDU and side information are transmitted to a receiver through DPCH or(and) PDSCH.

In this document, each scheme in following cases is explained, when CRNC and SRNC are existed in a system.

Case 1) HARQ user data and side information are transmitted to receiver using one physical channel, DPCH.

Case 2) HARQ user data and side information are transmitted to receiver using one physical channel, PDSCH.

Case 3) HARQ user data and side information are separately transmitted to receiver using two physical channels, DPCH and PDSCH.

These cases are explained at following sections.

6.4.2.1 HARQ user data and side information are transmitted to receiver using one physical channel, DPCH

Case 1

This case can be applied to downlink and uplink HARQ type II/III.

The flowchart for downlink in Case 1

Figure 5 shows a flowchart when the proposed scheme supports downlink.

In this case, RLC produces two signals whose primitive form is one, MAC-DATA-REQ. One of the produced signals includes the HARQ user data and the other includes the side information of the associated HARQ user data.

As shown in figure 5, the flowchart is similar with Release 99.

The difference is as follows:

- When RLC produces data signal, RLC produces two signals, one including HARQ user data and the other including side information.
- Both produced signals are transmitted to Node B through MAC-d.
- When layer 1 of UE receives the data and separates it to HARQ user data part and side information part, the HARQ user data part is stored at buffer of layer 1 and the side information part is transmitted to MAC-d as primitive PHY-DATA-IND. In this point, data indicator, which is a parameter to indicate the relation between HARQ user data and side information, is added to the primitive, PHY-DATA-IND.
- When RLC receives the side information part with data indicator, RLC sends the side information and data indicator to RRC. This operation is done because there is no direct connection between RLC and layer 1.
- RRC sends the received information to Layer 1.

The flowchart for uplink in Case 1

Figure 6 shows a flowchart when the proposed scheme supports uplink.

In this case, the basic functions are same as one of section 2.1.1.

The differences are follows:

- The transmitter and receiver is changed, that is, in section 2.1.1, the transmitter and receiver are UTRAN and UE, respectively. By the way, in this section, they are opposite.
- In receiver, UTRAN, the received data is transmitted from Node B to upper layer through Iub.

6.4.2.2 HARQ user data and side information are transmitted to receiver using one physical channel, PDSCH

As shown in figure 7, this case can be applied to downlink HARQ type II/III.

In this case, the basic functions are same as one of (case 1).

The differences between (case 1) and (case 2) are as follows:

- When MAC-d received data and side information, they are transmitted from MAC-d to MAC-c/sh for using the DSCH.
- The TFI information about DSCH including HARQ user data and side information is transmitted from MAC-c/sh to MAC-d according to Release 99.

6.4.2.3 HARQ user data and side information are separately transmitted to receiver using two physical channels, DPCH and PDSCH

As shown in figure 8, this case can be applied to downlink HARQ type II/III.

In this case, the basic function is similar with one of (case 1).

The differences between (case 1) and (case 3) are as follows:

- When MAC-d received data and side information, the data is transmitted to MAC-c/sh and the side information waits for the response(i.e. TFI of DSCH) of MAC-c/sh.
- Data is transmitted from MAC-c/sh to Node B through PHY-DATA-REQ primitive.
- “The TFI about DSCH and TFI about DCH and side Information” are transmitted from MAC-d to Node B through PHY-DARQ-REQ primitive.
- The HARQ user data and side information are transmitted to UE through PDSCH and DPCH, respectively.

Examples

Following some call flows about some HARQ schemes f

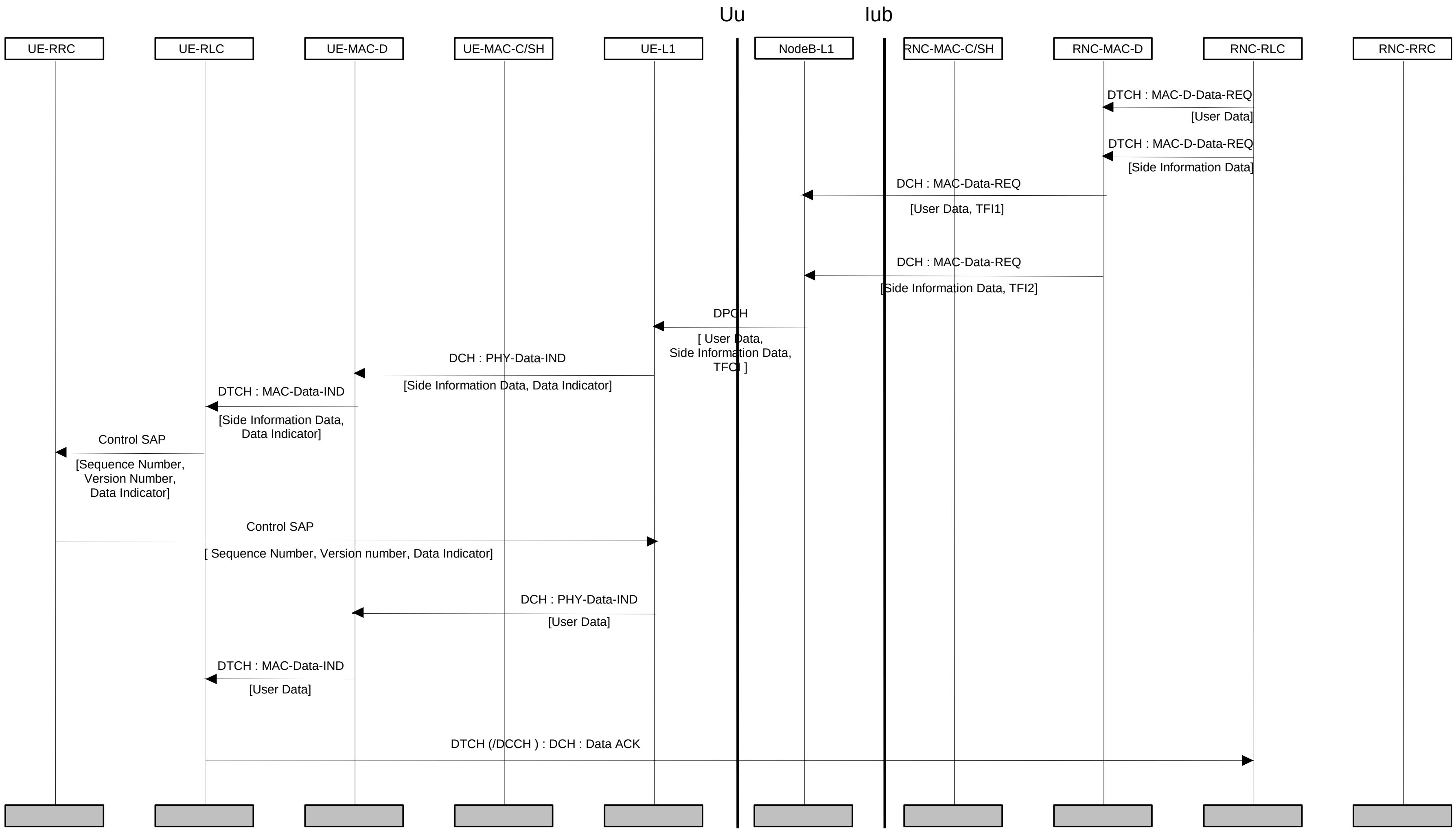

Figure 5 Example downlink procedure when HARQ user data and side information are transmitted to receiver using a one physical channel, DPCH

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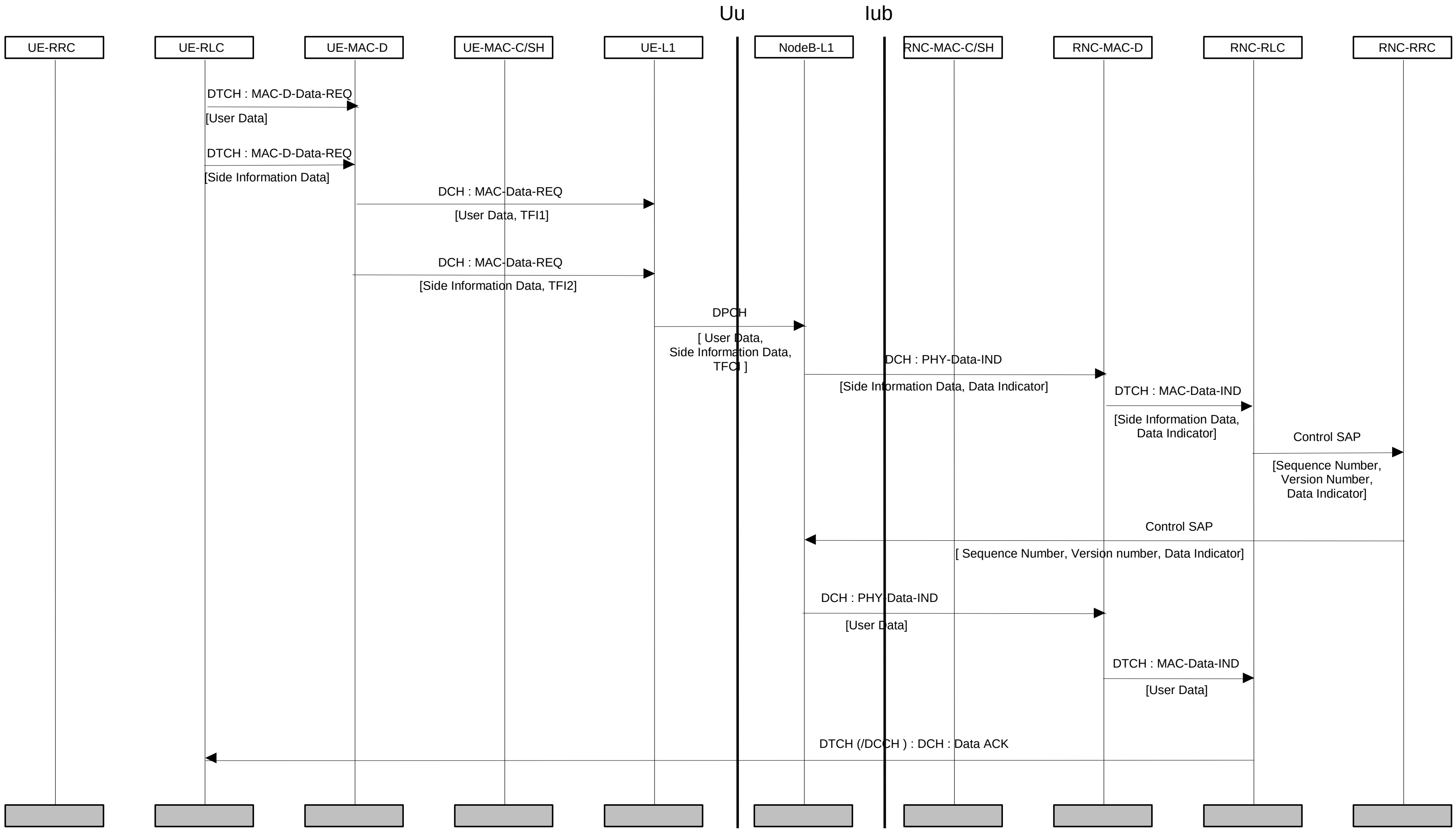

Figure 6 Example uplink procedure when HARQ user data and side information are transmitted to receiver using a one physical channel, DPCH.

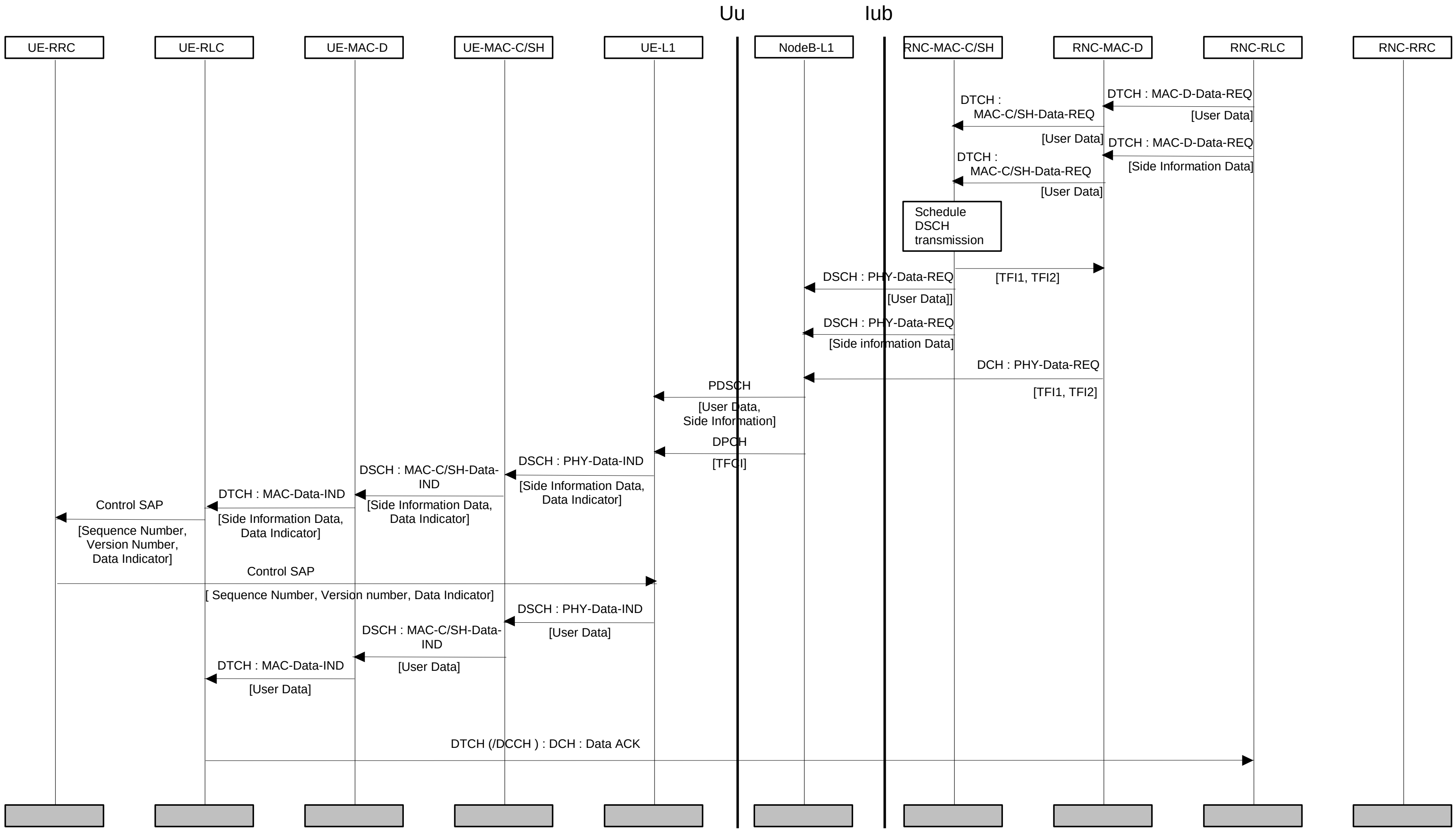

Figure 7 Example downlink procedure when HARQ user data and side information are transmitted to receiver using a one physical cha nnel, PDSCH.

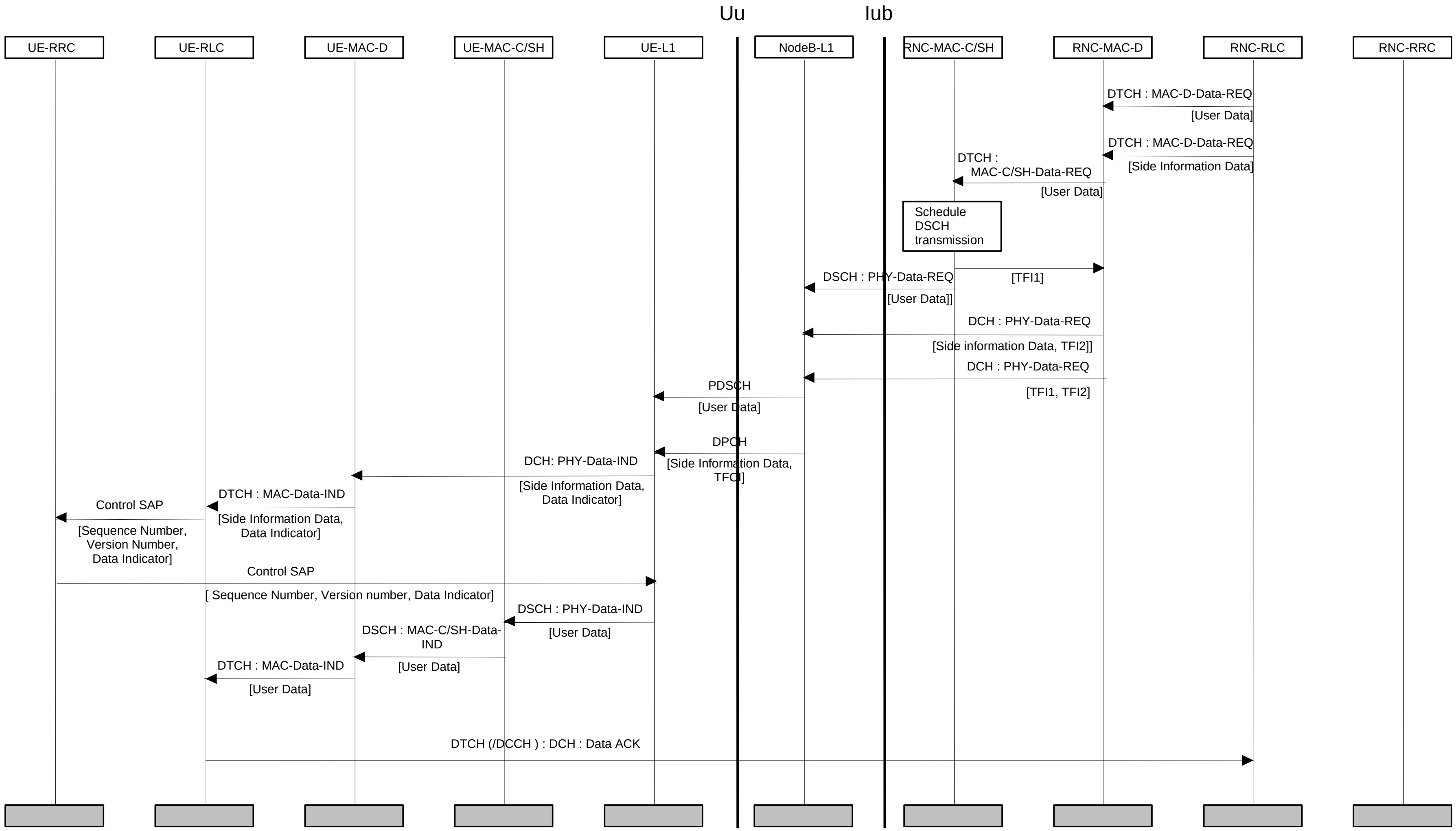

Figure 8 Example downlink procedure when HARQ user data and side information are separately transmitted to receiver using two physical channels, DPCH and PDSCH.

6.5 Services provided by the Physical Layer

6.5.1 Functions of Layer 1

The main functions of the physical layer are listed in [1]. The following additional functions have to be performed for hybrid ARQ type II/III operation:

- redundancy selection, buffering, and combining for hybrid ARQ type II/III data
- encoding/decoding, transmission, and error detection on hybrid ARQ type II/III side information

6.5.2 Interface to Layer 1

6.5.2.1 Interface to Layer 1 for Case A

According to the function split shown in section 6.1, major parts of the functionality for hybrid ARQ type II/III have to be performed in the physical layer. This requires some changes to the interface between MAC and the physical layer, because in addition to the user data, hybrid ARQ type II/III side information for the redundancy selection and to allow combining of retransmissions at the receiver has to be passed from MAC to Layer 1.

The interface between MAC and Layer 1 is described by primitives in [1]. On the transmitting side, data transfer from MAC to Layer 1 is handled by the PHY-DATA-REQ primitive, which passes a TFI (Transport Format Indicator) and a TBS (Transport Block Set) as parameters.

On the receiving side, the PHY-DATA-IND primitive passes the received data with the parameters TFI, TBS, and CRC result from the Layer 1 to the MAC. No indication primitives from MAC to the physical layer are available on the receiving side. This implies, that all necessary side information for hybrid ARQ type II/III operation, i.e. the PDU sequence number and the redundancy version, have to be passed to Layer 1 already on the transmitting side, if major changes to the interface between MAC and physical layer are not desired.

The following extension to the primitives from Release 99 allow hybrid ARQ type II/III operation under these assumptions:

- To the PHY-DATA-REQ primitive on the transmitting side, the parameters of the required side information for hybrid ARQ type II/III are added. If the transport block set contains more than one Transport block , the side information parameters should be submitted for each TB. Therefore, lists for each parameter with one entry per transport block are required. These are:
  - List of PDU sequence number
  - List of Redundancy version
  - List of Logical channel identification equal to the C/T field of the MAC header, if more than one logical channel is mapped on the hybrid ARQ type II/III coded transport channel.
- To the PHY-DATA-IND primitive on the receiving side, for basic operation no parameters have to be added.

  Additional error checking and performance improvements may be possible, if the following parameters are added to the PHY-DATA-IND (ffs):
  - List of PDU sequence number
  - List of Redundancy version
  - List of Logical channel identification equal to the C/T field of the MAC header, if more than one logical channel is mapped on the hybrid ARQ type II/III coded transport channel.

6.5.2.2 Interface to Layer 1 for Case B

In this case, the HARQ user data and side information are separately transmitted from MAC to Layer 1.

On the transmitting side, data transfer from MAC to Layer 1 is handled by the PHY-DATA-REQ primitive, which passes a TFI (Transport Format Indicator) and a TBS (Transport Block Set) as parameters. The HARQ user data and side information are transmitted from MAC to Layer 1 with same primitive format, PHY-DATA-REQ.

On the receiving side, the PHY-DATA-IND primitive passes the received data with the parameters TFI, TBS, and CRC result from the Layer 1 to the MAC. If PHY-DATA-IND includes the side information which is produced by transmitter, an additional information is also inserted at the primitive, PHY-DATA-IND. The role of additional information is to indicate the relation between HARQ user data and side information.

The following extension to the primitives from Release 99 allow hybrid ARQ type II/III operation under these assumptions:

- To the PHY-DATA-REQ primitive on the transmitting side, the parameters of the primitive is as same as one which is defined at Release 99.

- To the PHY-DATA-IND primitive on the receiving side, the parameter for hybrid ARQ type II/III is added. There is:

  - Data indicator which is a parameter to indicator the relation between HARQ user data and side information

6.6 MAC Protocol

6.6.1 MAC Protocol for Case A

No major changes to the MAC protocol have been identified. In case of multiple logical channels mapped on one hybrid ARQ type II/III transport channel, the logical channel identification as contained in the C/T field has to be passed to Layer 1 on the transmitting side to allow separation of data flows form different RLC engines in Layer 1.

6.6.2 MAC Protocol for Case B

No major changes to the MAC protocol have been identified. Some additional functionality can be needed. The details of this additional functionality are ffs.

6.7 RLC Protocol

6.7.1 RLC Protocol for Case A

For the adaptation of the RLC protocol to hybrid ARQ type II/III operation, no major changes have been identified. The RLC PDU format should be the same as for Release 99.

The sequence numbers are handled in the same way as for Release 99.

For the setting of the redundancy version different algorithms can be considered. One of the solution is to increment the redundancy version for each retransmission of a PDU, and to start from the beginning when the highest possible redundancy version has been send. However, other solutions to select the redundancy version may also be possible.

Some additional functionality for the selection of the redundancy version for each hybrid ARQ type II/III PDU is needed. The details of this selection are ffs.

6.7.2 RLC Protocol for Case B

No major changes to the RLC protocol have been identified.

Some additional functionality as following will be needed.

  - Produce about a new PDU for side information of HARQ type II/III

The details of this additional functionality are ffs.

6.8 RRC Protocol

6.8.1 RRC Protocol for Case A

Some additional parameters for the configuration of hybrid ARQ type II/III will be required. No need for new procedures or modifications of the existing procedures has been identified. The details of the additional parameters are ffs.

6.8.2 RRC Protocol for Case B

No major changes to the RRC protocol have been identified.

Some additional functionality as following will be needed.

- Configuration RLC protocol for hybrid ARQ type II/III operation.
- Configuration RLC protocol for producing new PDU including side information of hybrid ARQ type II/III
- Support the interface RRC protocol and RLC protocol for hybrid ARQ type II/III operation
- Support the interface RRC protocol and Physical layer for hybrid ARQ type II/III operation

The details of this additional functionality are ffs.

7 Layer 2 and Layer 3 Operation with Hybrid ARQ Type II/III Retransmission at Layer 1 (Fast Hybrid ARQ)

The fast HARQ operates with an n-channel stop-and-wait protocol. Dual channel, which can be considered the default operation mode, is illustrated in Figure 1. A continuous transmission flow is separated in time into two subchannels, both of which independently execute a stop-and-wait retransmission protocol. The dual-channel structure guarantees continuous transmission, i.e. the protocol doesn't get stalled waiting for acknowledgements, as long as the roundtrip delay for the acknowledgements is short enough so that the response is always available when the slot for the same subchannel occurs again.

Using a dual-channel approach brings benefits in receiver buffering requirements and decreases error probability in combining retransmissions with earlier received blocks:

- Only the amount of data corresponding to two TTI:s needs to be buffered in the receiver: One for each subchannel. If the transmission is not succesful the retransmission takes place in the next TTI for the respective subchannel.
- For the received data there is only two possibilities: It is either a new transmission or a retransmission of the previously transmitted block. Consequently, the soft combining of data can be done reliably.

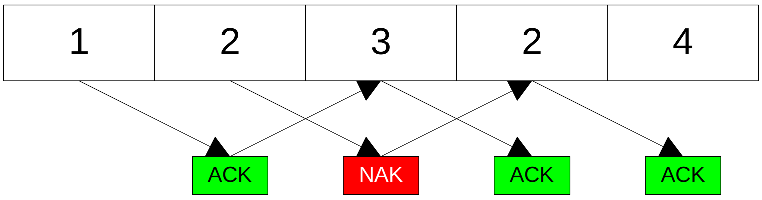

Figure 1 Dual channel stop-and-wait protocol principle.

To perform the fast HARQ operation the physical layer requires some additional side information, e.g. FHARQ sequence number, and redundancy version. The selection of these parameters should be under the control of MAC but the actual parameter values are generated at L1. The physical layer can encode the data and the side information separately, and map them on one, or possibly even different physical channels. At the receiver the buffering and recombining of the data is performed.

7.1 Protocol architecture

This section gives a general overview of function split for fast HARQ in the UE, the Node B, the Controlling or Drift RNC, and the Serving RNC in the DL direction. Fast HARQ is employed in DSCH only.

Table 1 shows which functions should be fulfilled in the DL direction in the entities.

	UE	Node B	CRNC / DRNC	SRNC
TX buffering of RLC-PDUs for AMD service	-			RLC
TX buffering for fast HARQ		Layer 1		
Redundancy selection and Parameter setting	-	Layer 1	-	
RX soft decision buffering for combining	Layer 1	-	-	-
RX buffering for RLC-SDU reassembly	RLC	-	-	-
Combining of retransmissions	Layer 1	-	-	-

Table 1: Functional split for fast hybrid ARQ type II/III in the UE, NodeB, CRNC/DRNC, and SRNC in DL direction

Dotted lines in Figure 2 visualise the transport of necessary side information for fast hybrid ARQ operation. Solid lines show the transport of user data that is to utilize fast hybrid ARQ.

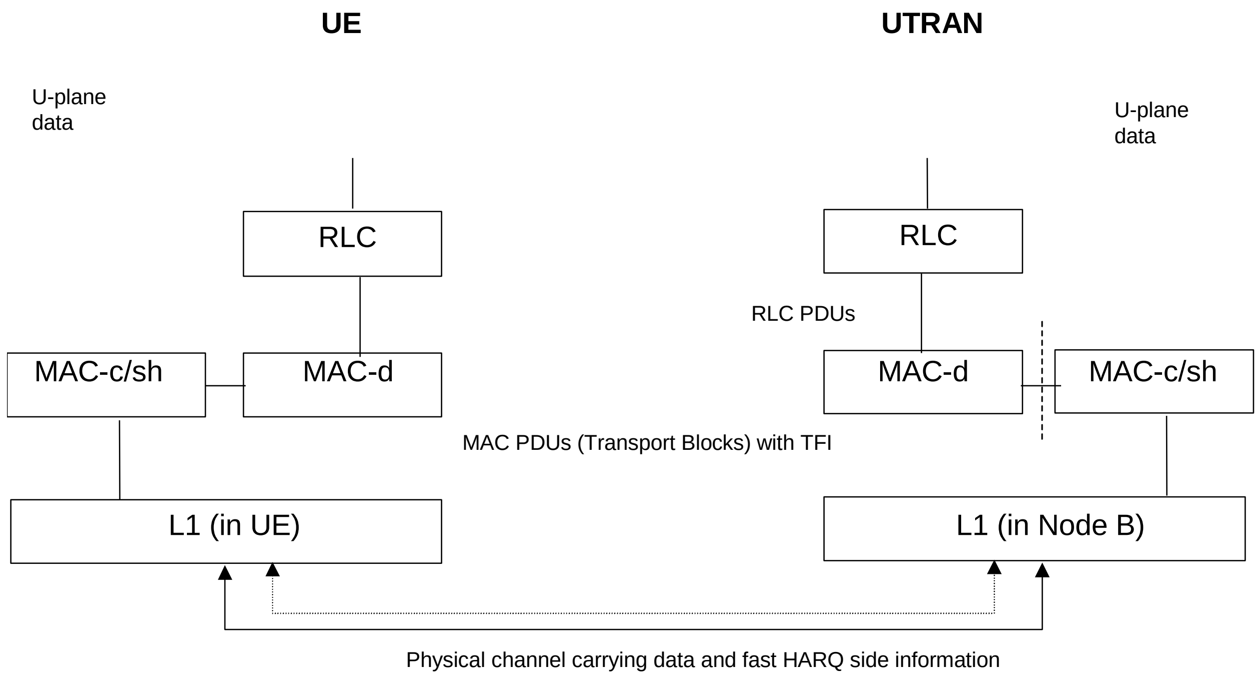

Figure 2 Protocol stack overview for fast hybrid ARQ type II/III.

7.2 Usage of transport channels and physical channels

If fast HARQ is operated as a dual-channel model, the side information must be available very quickly since the retransmission interval is only one frame. The receiver reads the sequence number and redundancy version after which the packet is decoded. The integrity of the packet is checked and an acknowledgement is sent in the current uplink frame. Fast HARQ is planned to be employed on DSCH. Side information and sequence number are added by Layer 1 to facilitate fast decoding at the receiver end.

The fast HARQ feedback information is transmitted once for every TTI. This feedback information can be e.g. inserted into uplink DPDCH frame by reserving a few slots in advance or use some of the dedicated physical control channel (DPCCH) bits in the given slots.

7.3 Services provided by the physical layer

7.3.1 Functions of Layer 1

The main functions of the physical layer are listed in [1]. The following additional functions have to be performed for fast HARQ operation:

- redundancy selection, TX buffering, retransmission control, RX soft decision buffering and combining for data
- encoding/decoding, transmission, and error detection on fast HARQ side information (including fast acknowledgements)
- generation of Acknowledgement PDU & Side Information

7.3.2 Interface to Layer 1

According to the functional split, major parts of the functionality for fast HARQ have to be performed in the physical layer. Some fast HARQ parameters are passed from higher layers, the required changes are FFS.

7.4 MAC protocol

For the basic functionality presented in this document no changes are anticipated to the MAC protocols. Changes related to the interface to Layer 1 are ffs.

7.5 RLC protocol

No changes to RLC protocols have been identified. As with release '99, RLC can operate in transparent mode, UM or AM independent of whether the fast HARQ is being used.

7.6 RRC protocol

Some additional parameters for the configuration of fast HARQ will be required.

8 Physical Layer impacts

8.1 Overview of physical layer mechanisms

8.2 Performance evaluation

8.3 Impacts to UE and Node B complexity

One important aspect to consider is the complexity of introducing HARQ into Release -00. When considering specification changes, the easy way to create HARQ functionality would be to add it on top of the existing RLC ARQ protocol. In this case ACKs are communicated between UE and RNC RLCs, and soft combining is done on L1. However, RLC level round trip delay (ca 120 ms) and polling period (ca 80 ms) for ACKs makes the buffer memory requirement in UE L1 considerable.

The number of symbols to be buffered in L1 receiver can be estimated roughly as follows:

$$buffer = \left(coded\ bits_{RCL\ PDU} \times failed\ PDUs\, in\, TTI \times (latency_{retransmit} + latency_{NACK}) \right)$$

where it is assumed for the sake of clarity that an integer number of RLC PDUs fit into one L1 TTI. The latencies are also considered as multiples of a TTI. For HARQ with soft combining all retransmissions are combined and stored in the same location as the first transmitted symbol, so the number of retransmissions does not directly reflect on the buffering need. Type II HARQ is sending smaller blocks than type I with soft combining, but in practice one has to reserve room for a whole symbol in the receiver for assembling the incremental information; thus type I and type II buffering does not differ a lot if the lowest encoding rate is the same.

In practical cases, with a total latency around 200 ms, there is a need to buffer several tens of ksymbols of soft symbol decisions in the receiver. Depending on how many bits are used to represent a soft symbol in the decoding stage this memory requirement becomes a multiple of the soft symbol memory usage.

9 Impacts on UTRAN Interfaces

9.1 Impacts on Iub

9.2 Impacts on Iur

10 Specification Impacts

History

Document history		
Date	**Version**	**Comment**
July 2000	0.0.0	First draft
August 2000	0.0.1	Table of Contents and Scope added after decision at RAN2#14
August 2000	0.0.2	The text from the e-mail discussion between RAN2#14 and RAN2#15 was added.
August 2000	0.1.0	Version raised to 0.1.0 during RAN2#15
August 2000	0.1.1	The description of fast hybrid ARQ from R2-001762 was included.
August 2000	0.2.0	Agreed result of RAN2#15
September 2000	1.0.0	Changes in v0.2.0 accepted, version to be presented to TSG-RAN #9

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