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GSM FAX & DATA SERVICES

MESSAGE SEQUENCE CHARTS

RLP

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4. Description of L2R/RLP interface changed
5. State Variable V(D) added
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8. Correction: RNR not cleared by UA, REJ or SREJ
9. RLP_DETACH_CNF added
10. 14.4 kbps added

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1.2 Abbreviations

ACI	AT Command Interpreter
AGCH	Access Grant Channel
AT	Attention sequence "AT" to indicate valid commands of the ACI
BCCH	Broadcast Control Channel
BCS	Binary Coded Signals
BS	Base Station
BSIC	Base Station Identification Code
C/R	Command/Response
C1	Path Loss Criterion
C2	Reselection Criterion
CBCH	Cell Broadcast Channel
CBQ	Cell Bar Qualify
CC	Call Control
CCCH	Common Control Channel
CCD	Condat Coder Decoder
CKSN	Ciphering Key Sequence Number
CRC	Cyclic Redundancy Check
DCCH	Dedicated Control Channel
DISC	Disconnect Frame
DL	Data Link Layer
DM	Disconnected Mode Frame
DTX	Discontinuous Transmission
EA	Extension Bit Address Field
EL	Extension Bit Length Field
EMMI	Electrical Man Machine Interface
EOL	End Of Line
F	Final Bit
F&D	Fax and Data Protocol Stack
FACCH	Fast Associated Control Channel
FHO	Forced Handover
GP	Guard Period
GSM	Global System for Mobile Communication
HDLC	High level Data Link Control
HISR	High level Interrupt Service Routine
HPLMN	Home Public Land Mobile Network
I	Information Frame
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
ITU	International Telecommunication Union
IWF	Interworking Function
Kc	Authentication Key
L	Length Indicator
LAI	Location Area Information
LISR	Low level Interrupt Service Routine
LPD	Link Protocol Discriminator
M	More Data Bit
MCC	Mobile Country Code
MM	Mobility Management
MMI	Man Machine Interface
MNC	Mobile Network Code

MS	Mobile Station
MSG	Message phase in the GSM 3.45 protocol
N(R)	Receive Number
N(S)	Send Number
NCC	National Colour Code
NECI	New Establishment Causes included
OTD	Observed Time Difference
P	Poll Bit
P/F	Poll/Final Bit
PCH	Paging Channel
PCO	Point of Control and Observation
PDU	Protocol Description Unit
PL	Physical Layer
PLMN	Public Land Mobile Network
RACH	Random Access Channel
REJ	Reject Frame
RNR	Receive Not Ready Frame
RR	Radio Resource Management
RR	Receive Ready Frame
RTD	Real Time Difference
RTOS	Real Time Operating System
SABM	Set Asynchronous Balanced Mode
SACCH	Slow Associated Control Channel
SAP	Service Access Point
SAPI	Service Access Point Identifier
SDCCH	Slow Dedicated Control Channel
SIM	Subscriber Identity Module
SMS	Short Message Service
SMSCB	Short Message Service Cell Broadcast
SS	Supplementary Services
T.4	CCITT Standardisation for Document coding of Group 3 Facsimile Apparatus
TAP	Test Application Program
TCH	Traffic Channel
TCH/F	Traffic Channel Full Rate
TCH/H	Traffic Channel Half Rate
TDMA	Time Division Multiple Access
TE	Terminal Equipment - e. g. a PC
TMSI	Temporary Mobile Subscriber Identity
UA	Unnumbered Acknowledgement Frame
UI	Unnumbered Information Frame
V(A)	Acknowledgement State Variable
V(R)	Receive State Variable
V(S)	Send State Variable
VPLMN	Visiting Public Land Mobile Network

1.3 Terms

Entity:	Program which executes the functions of a layer
Message:	A message is a data unit which is transferred between the entities of the same layer (peer-to-peer) of the mobile and infrastructure side. Message is used as a synonym to protocol data unit (PDU). A message may contain several information elements.
Primitive:	A primitive is a data unit which is transferred between layers on one component (mobile station or infrastructure). The primitive has an operation code which identifies the primitive and its parameters.
Service Access Point:	A Service Access Point is a data interface between two layers on one component (mobile station or infrastructure).

2 Overview

The Protocol Stacks are used to define the functionality of the GSM protocols for interfaces. The GSM specifications are normative when used to describe the functionality of interfaces, but the stacks and the subdivision of protocol layers does not imply or restrict any implementation.

The protocol stack for fax and data transmission consists of several entities. Each entity has one ore more service access points, over which the entity provides a service for the upper entity. The entity, which is described in this document, is coloured grey in the following figure :

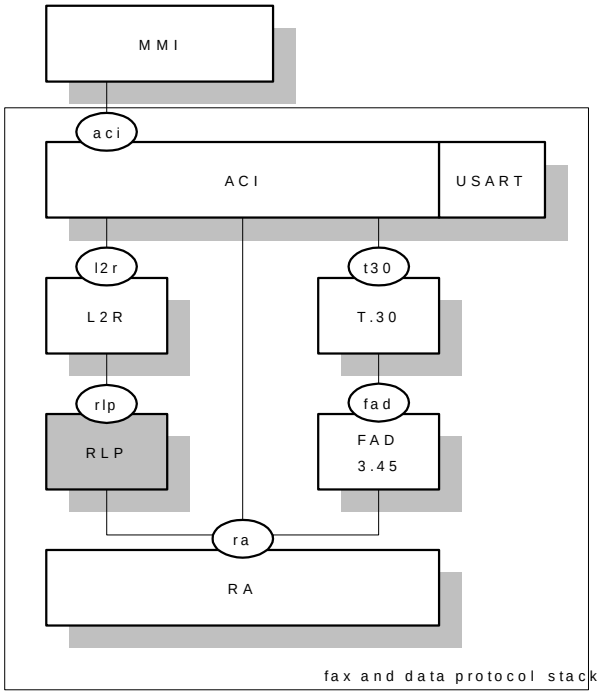


Figure 2-1: Architecture of the fax and data protocol stack

The information units passed via the SAPs are called primitives and consists of an operation code and several parameters. See the Users Guide for details.

The entities of the fax and data protocol stack are:

2.1 RA - Rate Adaptation

This entity performs an adaptation between an asynchronous or synchronous data stream with several bit rates on to the fixed bit rate used at the TCH. This is performed by the rate adaptation functions RA1' and RA0 described in GSM 04.21.

2.2 RLP - Radio Link Protocol

This entity provides a Layer 2 protocol for asynchronous reliable data transfer as specified in GSM 04.22. It includes error correction, sequence numbers and a mechanism for repeating corrupted and lost messages.

2.3 L2R - Layer 2 Relay Functionality

The L2R provides relay functions in order to adapt the character-oriented data received from the TE via USART to the bit-oriented RLP protocol.

2.4 FAD 03.45 - Fax Adaptation Protocol

The fax adaptation protocol, as specified in GSM 03.45, provides synchronisation with the BCS and MSG modems of the peer entity. It uses byte repetition in conjunction with a voting algorithm to handle corruption on the TCH data stream. The non-transparent fax protocol in accordance with GSM 03.46 is not part of this implementation.

The fax adapter enables T.30 to send BCS at 300 BPS and T.4 MSG in 2400, 4800, 7200 and 9600 BPS.

2.5 T.30 - Fax Protocol Entity

The protocol uses binary coded signals packed in HDLC frames to set up and release a connection in the message phase of the FAX transmission. This entity is specified in the ITU-T.30. The main tasks of this unit are:

- Building the HDLC frames with CRC.
- Performing bit stuffing/de-stuffing.
- Executing a sequence of 5 phases: 1.) set up, 2.) pre-message procedures, 3.) transmission/reception, 4.) post message procedures, 5.) waiting for call release.

2.6 ACI - AT Command Interpreter

The ACI is specified in GSM 07.07. It is responsible for call establishment via the GSM voice protocol stack and terminal adaptation for asynchronous transparent character-oriented data transmission. The ACI is able to receive AT commands and send the replies over the USART driver to a remote PC. This makes it possible to control the voice and data protocol stack from a remote application running on a PC. The ACI also provides a unique interface for an internal MMI in the MS.

2.7 USART - Universal Synchronous Asynchronous Receiver Transmitter Driver

The USART is a hardware component that facilitates a connection between the mobile station and terminal equipment (e.g. a PC). This interface uses some of the circuits described in V.24.

The data exchange provided by this unit is serial and asynchronous (synchronous communication is not in the scope of this document). A driver that uses interrupts to manage a circular buffer for the sending and receiving direction is necessary in order to use this component in the F&D. The driver has to be able to perform flow control.

3 Introduction

3.1 Modes

A RLP entity can be in one of two modes

- Asynchronous Balanced Mode (ABM)
- Asynchronous Disconnected Mode (ADM)

3.1.1 Asynchronous Balanced Mode (ABM)

This is the operational mode of the RLP layer. Commands can be sent at any time from either side without explicit permission of the other side. In ABM numbered information transfer is allowed.

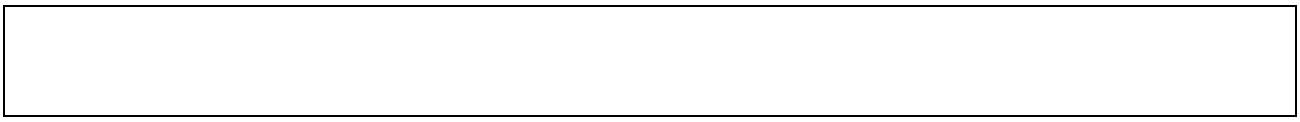
3.1.2 Asynchronous Disconnected Mode (ADM)

This is the disconnected mode of the RLP layer. The set of possible commands and responses is restricted to SABM, UA, DM, UI, TEST NULL, and XID. Data can be exchanged by unnumbered information only. Numbered information transfer is limited to ABM.

3.2 Basic Frame Structure

An RLP-frame has a fixed length of either 240 (TCH/F9.6 channel coding) or 576 bits (TCH/F14.4 channel coding) consisting of a header (16 bits), an information field (either 200 or 536 bits) and an FCS (frame check sequence) field (24 bits). As a benefit of using string alignment with underlying radio transmission there is no need for frame delimiters (like flags etc.) in RLP. In consequence there is no 'bit-stuffing' necessary in order to achieve code transparency. Frames cannot be aborted while being transmitted.

a) 240 bit frame size



a) 576 bit frame size

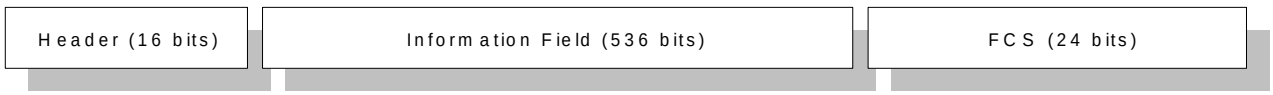


Figure 3-1: Frame Structure

3.2.1 Order of transmission

The RLP frame is passed to the RA entity as a series of octets. Each octet is transferred with the least significant bit first. This corresponds to the way the L2R entity is using the information field and to the way information is coded in the header and in the information field of XID frames (see below).

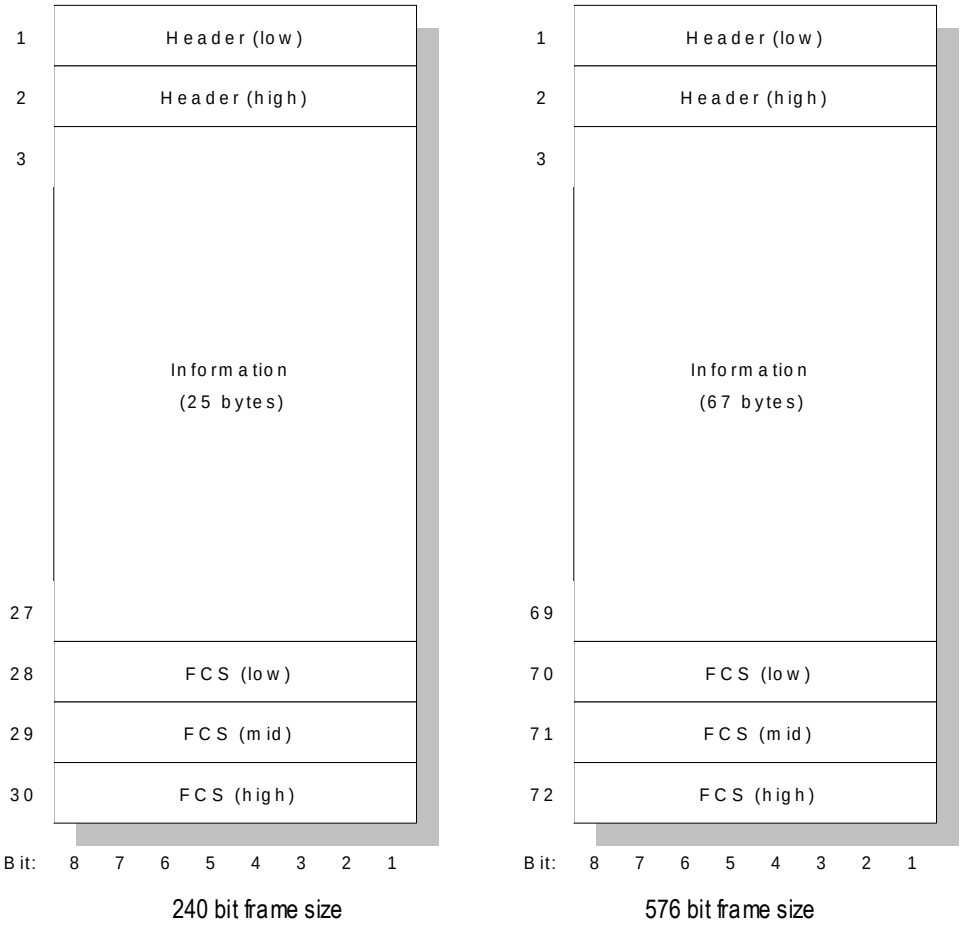


Figure 3-1: RLP frame, byte structure

The low order bytes of the Header and of the FCS come first in the frame. In this way the complete 16 or 24 bit word is transmitted starting with the least significant bit up to the most significant bit. It should be noted, that the FCS must be transmitted with the highest order term first. Therefor the FCS is generated in reverse bit order, i.e. bit 1 contains the most significant bit and bit 24 the least significant bit.

3.3 RLP Header

A RLP-header carries one out of three types of control information:

- unnumbered protocol control information (U frames),
- supervisory information (S frames) or
- user information carrying supervisory information piggy backed (I+S frames).

In order to provide a reliable transfer of user data, sequence numbers N(R) and N(S) are used (numbered information transfer).

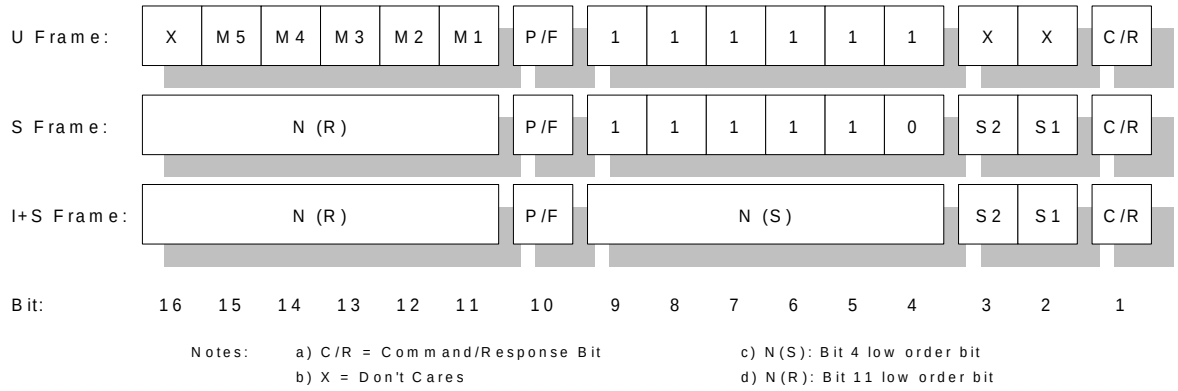


Figure 3-2: RLP header format

3.3.1 Frame formats

3.3.1.1 Information transfer format - I+S format

The I+S format is used to perform an information transfer between layer 3 entities. The functions of N(S), N(R) and P/F are independent; that is, each I+S frame has an N(S) sequence number, an N(R) sequence number which may or may not acknowledge additional I+S frames received by the RLP entity, and a P/F bit that may be set to '0' or '1'.

The sequence numbers N(S) and N(R) range from 0 to 61. As a result the three frame formats can be distinguished by the N(S) bit field (bit 9..4). For the I+S format the value is in the range from 0..61. For the S frame it is 62 and for the U frame 63.

3.3.1.2 Supervisory format - S format

The S format is used to perform data link supervisory control function such as: acknowledge I+S frames, request transmission of I+S frames, and request a temporary suspension of transmission of I+S frames. The functions of N(R) and P/F are independent; that is, each supervisory frame has an N(R) sequence number which may or may not acknowledge additional I+S frames received by the RLP entity, and a P/F bit that may be set to '0' or '1'.

3.3.1.3 Unnumbered format - U format

The U format is used to provide additional data link control functions and unacknowledged information transfer. This format does not contain sequence numbers. It does include a P/F bit that may be set to '0' or '1'.

3.3.2 Order of transmission

The header is transmitted from right to left, i.e. bit 1 is transferred first and bit 16 last. Because of the byte oriented way, in which data are passed to the RA entity, the two header bytes must be swapped, i.e. the low order byte comes first in the frame.

3.3.3 Command/response bit, C/R

This bit indicates, whether the frame is a command or a response. For a command the C/R bit is set to '1', for a response it is set to '0'.

3.3.4 Poll/Final bit, P/F

All frames contain P/F, the Poll/Final bit. The P/F bit serves a function in both command frames and response frames. In command frames the P/F bit is referred to as the P bit. In response frames it is referred to as the F bit.

The P bit set to '1' is used by the RLP entity to create (poll) a response frame from the peer RLP entity. The F bit set to '1' is used by a RLP entity to indicate the response frame transmitted as a result of a soliciting (poll) command.

3.3.5 Coding of commands and responses

The command or response type is encoded in the M5 - M1 and S2 - S1 fields according to the following tables.

Com-mand/Response	M5	M4	M3	M2	M1
SABM	0	0	1	1	1
UA	0	1	1	0	0
DISC	0	1	0	0	0
DM	0	0	0	1	1
NULL	0	1	1	1	1
UI	0	0	0	0	0
XID	1	0	1	1	1
TEST	1	1	1	0	0

Table 3-1: Commands/Responses in U-Frames

Com-mand/Response	S2	S1
RR	0	0
REJ	1	0
RNR	0	1
SREJ	1	1

Table 3-2: Commands/Responses in S- and I+S-Frames

The following table shows all the different commands and responses of a RLP entity.

For-mat	Com-mand/Response	C/R	16	15 14 13 12 11	10	9 8 7 6 5 4	3 2	1
U	SABM	C	X	0 0 1 1 1	1	1 1 1 1 1 1	X X	1
	UA	R	X	0 1 1 0 0	F	1 1 1 1 1 1	X X	0
	DISC	C	X	0 1 0 0 0	P	1 1 1 1 1 1	X X	1
	DM	R	X	0 0 0 1 1	F	1 1 1 1 1 1	X X	0
	NULL	C	X	0 1 1 1 1	P[1)]	1 1 1 1 1 1	X X	1
	UI	C	X	0 0 0 0 0	P[1)]	1 1 1 1 1 1	X X	1
	XID	C/R	X	1 0 1 1 1	P/F	1 1 1 1 1 1	X X	1/0
	TEST	C/R[2)]	X	1 1 1 0 0	P/F	1 1 1 1 1 1	X X	1/0[2)]
S	RR	C/R	N (R)		P/F	1 1 1 1 1 0	0 0	1/0
	REJ	C/R[3)]	N (R)		P/F	1 1 1 1 1 0	1 0	1/0[3)]
	RNR	C/R	N (R)		P/F	1 1 1 1 1 0	0 1	1/0
	SREJ	C/R[3)]	N (R)		P/F	1 1 1 1 1 0	1 1	1/0[3)]
I + S	RR	C/R	N (R)		P/F	N(S)	0 0	1/0
	REJ	C/R[3)]	N (R)		P/F	N(S)	1 0	1/0[3)]
	RNR	C/R	N (R)		P/F	N(S)	0 1	1/0
	SREJ	C/R[3)]	N (R)		P/F	N(S)	1 1	1/0[3)]

Implementation specific Notes: 1) NULL and UI frames are always generated with the P bit set to '0'.
2) TEST commands are not generated.
3) REJ and SREJ frames are always sent as a command.

Table 3-3: Contents of Header

3.3.6 Unnumbered frames, U

3.3.6.1 Set asynchronous balanced mode (SABM) command

The SABM command is used to establish or to reset a link for numbered information transfer. The RLP layer is switched from ADM to ABM.

No information field is permitted with the SABM command. The P bit is always set to '1'.

A RLP entity confirms acceptance of a SABM command by the transmission of an UA response at the next opportunity. Upon acceptance of this command, the RLP entity's send state variable V(S), acknowledge state variable V(A) and receive state variable V(R) are set to '0'.

Previously transmitted I+S frames that are unacknowledged, when this command is carried out, remain unacknowledged and shall be discarded. It is in the responsibility of a higher layer (for example, layer 3) to recover from the possible loss of the contents of such I+S frames.

3.3.6.2 Unnumbered acknowledgement (UA) response

The UA response is used by a RLP entity to acknowledge the receipt and acceptance of the mode setting commands (SABM or DISC). Received mode setting commands are not carried out until the UA response is transmitted.

No information field is permitted with the UA response.

3.3.6.3 Disconnect (DISC) command

The DISC command is transmitted in order to terminate the numbered information transfer. Local end release is performed without sending a DISC command. No information field is permitted with the DISC command.

Before carrying out the command, the RLP entity receiving the DISC command confirms the acceptance of a DISC command by transmitting an UA response. The RLP entity sending the DISC command terminates the numbered information transfer when it receives the acknowledging UA or DM response.

Previously transmitted I+S frames that are unacknowledged, when this command is carried out remain unacknowledged and shall be discarded. It is in the responsibility of a higher layer (for example, layer 3) to recover from the possible loss of the contents of such I+S frames.

3.3.6.4 Disconnected mode (DM) response

The DM response is used by a RLP entity to report to its peer that it is in ADM. A RLP entity shall transmit a DM response after receiving a SABM, which it cannot carry out.

No information field is permitted with the DM response.

3.3.6.5 Unnumbered information (UI) command

When a layer 3 entity requests unacknowledged information transfer, the UI unnumbered command is used to send information to its peer without affecting RLP variables. UI command frames do not carry a sequence number, Therefore, the UI frame may be lost without notification to the layer 3 entity if a RLP exception occurs during transmission of the command. Unnumbered information can be sent in ADM and ABM. The current implementation of L2R does not support unnumbered information. Therefore UI commands are not generated and received UI frames are discarded by the L2R entity. Nonetheless unnumbered information is supported by RLP. In the current implementation RLP would send UI frames always with the P bit set to '0', if it would receive a RLP_UI_REQ from the upper layer.

3.3.6.6 Exchange Identification (XID) command and response

This frame is used to negotiate parameters of the RLP and L2R entities. Negotiation can be started from either side. One RLP entity sends a XID command to its peer. The information field contains a set of parameters, which the RLP wants to negotiate, as well as the proposed values. The other RLP entity answers with a XID response, in which the parameters are either accepted by returning the requested values, or higher or lower values are offered. The sense of negotiation for each parameter is fixed.

As long as a parameter has not been negotiated about, a default value will be applied.

If both the RLP entities are sending a XID command simultaneously, the XID commands are discarded and the negotiation will be repeated after some time. The mobile station restarts the negotiation after T1, while the base station shall wait twice as long.

The parameters of the current version of the RLP entity (version 1) are listed in Table 3-4. Up to now there are 3 versions of RLP defined.

- RLP version 0: single-link basic version;
- RLP version 1: single-link extended version (V42bis data compression);
- RLP version 2: multi-link version (HSCSD).

Parameter Name	Type	Length	Range	Format 87654321	Units	Sense of Negotia-tion	Valid in Versions
RLP Version No.	1	1	0..255	bbbbbbbb	/	down	>= 0
IWF to MS window size	2	1	0..61	00bbbbbb	/	down	>= 0
MS to IWF window size	3	1	0..61	00bbbbbb	/	down	>= 0
Acknowledge Timer (T1)	4	1	0..255	bbbbbbbb	10 ms	up	>= 0
Retransmission attempts (N2)	5	1	0..255	bbbbbbbb	/	up	>= 0
Reply delay (T2)	6	1	0..255	bbbbbbbb	10 ms	up	>= 0
Compression P_T [1)] P_0 [2)] P_1 low [4)] high [4)] P_2 [5)]	7	4	0 0..3 512.. 65535 6..250	aaaa 00bb cccccccc cccccccc dddddddd	/ / / /	none [3)] down down	>= 1

Notes:
1) Type of data compression
   0 = V.42bis
   other values are reserved
2) V.42bis data compression request
   0 compress in neither direction
   1 compress in initiator-responder direction only
   2 compress in responder-initiator direction only
   3 compress in both directions
   It should be noted, that throughout the system a different coding scheme according to V.25 ter [6] is used, in which „1“ means compress in transmit direction only and „2“ means compress in receive direction only
3) The sense of negotiation is „down“, with the exception that a „2“ cannot be negotiated into a „1“.
4) V.42bis number of possible codewords
5) V.42bis maximum encodable data string length

Table 3-4: XID parameters

The parameters appear in the information field of the frame. Each parameter consists of a number of octets. The first octet is the type and length information followed by the octets containing the parameter value. The length field gives the number of octets of the parameter value. Like any other data in the information field each octet is transmitted from right to left, i.e. bit 1 is transferred first. The parameter list starts in the first octet of the information field. The parameters follow on contiguously. The list is delimited by a parameter type 0.

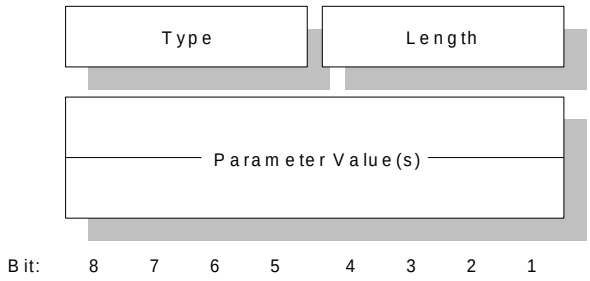


Figure 3-3: XID parameter format

3.3.6.7 Test (TEST) command and response

TEST frames are there for testing and debugging. In this implementation the mobile does not send TEST commands, but of course has to reply to TEST commands with a TEST response. In this case the information field of the command is just returned in the response.

3.3.6.8 Null information (NULL) command

NULL frames are sent, when there is an opportunity for sending, but no frame is ready to be sent. This happens

- in ADM, when no UI, TEST or XID frame is ready and
- in ABM in reset state when no UI frame is ready.

In ABM in the connection established state a S frame with RR (receiver ready) or RNR (receiver not ready) will be sent at the first opportunity instead of a NULL frame. If again a S frame has to be filled in, which is just a repetition of the previous S

frame, this frame will be passed to the physical layer, but DTX will be signalled. Then the physical layer may invoke the DTX function instead of transmitting the frame.

The P bit of a NULL frame is always set to '0'.

3.3.6.9 Remap (REMAP) command and Response

A REMAP exchange can only take place in ABM state. It is initiated by the mobile-end. It followes a change of channel coding due to cell transition(handover), where the neighbour cells perform different channel codes. Therefore the bit frame size must be changed. The channel coding is changing from either TCH/F9.6 (240 bit frame size) to TCH/F14.4 (576 bit frame size) or vice versa (2-1 frame structure).

After the RLP entity is receiving a REMAP request from upper layer, it sends a REMAP command on every sending opportunity until a responding REMAP-frame is received from the network-end. The mobile-end RLP waits in the synchronisation state for the REMAP response. This state is supervised by a timer (N2*T1). In the synchronisation state S and I+S frames should be ignored. U-frames are handled according to the defined procedures. If the mobile-end does not receive a REMAP response within N2*T1 measured from the first transmission of the first REMAP command, it enters ADM. After successful REMAP exchange the mobile-end resumes with the operation mode. The new channel coding is performed.

The REMAP U-frame format is shown in Figure 3-4. The mobile-end indicates the N(R) number of the frame from which the network-end should resend the information mapped into the new bit frame size. The network-end indicates the N(R) number of the frame from which the mobile end should remap the information into the new bit frame size. XID parameters may be renegotiated. A zero byte delimits the XID parameters.

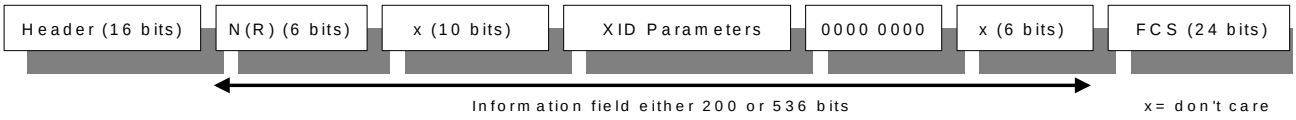


Figure 3-4: REMAP U-frame format

3.3.7 Supervisory frame (S) and numbered information transfer and supervisory frames combined (I+S)

I+S frames carry numbered user information together with supervisory information ('piggy-backing'). The supervisory information is mainly an acknowledge or not acknowledge of received frames and transmits the state of the receiver (ready/not read).

When there are no user data to be transmitted, then the received frames must still be acknowledged. In this case S frames are sent. They carry the same supervisory information as an I+S frame, but the information field is not used. The information field is discarded by the receiver.

I+S frames and S frames are only exchanged in ABM.

3.3.7.1 Receive ready (RR) command/response

The receive ready (RR) command/response is used by a RLP entity to

- indicate it is ready to receive an I+S frame,
- acknowledge previously received I+S frames numbered up to and including N(R)-1,
- clear a busy condition that was indicated by a previous RNR frame of this RLP entity.

In addition to indicating the status of a RLP entity, the RR command with the P bit set to '1' may be used by the RLP entity to ask for the status of its peer RLP entity.

3.3.7.2 Receive not ready (RNR) command/response

The receive not ready (RNR) command/response is used by a RLP entity to indicate a busy condition; that is, a temporary inability to accept additional incoming I+S frames. The value of N(R) in the RNR frame acknowledges I+S frames numbered up to and including N(R)-1.

Acknowledgement of subsequent I+S frames which are transmitted, before the indication of the peer receiver busy is received, will be made in subsequent exchanges, if they arrive after the peer receiver busy condition has been cleared.

In addition to indicating the status of a RLP entity, the RNR command with the P bit set to '1' may be used by the RLP entity to ask for the status of its peer RLP entity.

3.3.7.3 Reject (REJ) command/response

The reject (REJ) command/response is used by a RLP entity to request retransmission of I+S frames starting with the frame numbered N(R). The value of N(R) in the REJ frame acknowledges I+S frames numbered up and including N(R)-1. New I+S frames pending initial transmission shall be transmitted following the retransmitted I+S frames.

Only one REJ exception condition for a given direction of information transfer shall be established at a time. The REJ exception condition is cleared (reset) upon the receipt of an I+S frame with N(S) equal to N(R) of the REJ frame. It is also cleared on timeout and on reset (SABM).

In addition to indicating the status of a RLP entity, the REJ command with the P bit set to '1' may be used by the RLP entity to ask for the status of its peer RLP entity.

3.3.7.4 Selective reject (SREJ) command/response

The selective reject (SREJ) command/response is provided for more efficiency than a REJ command/response. With a SREJ frame the retransmission of a single frame can be requested. Here the value N(R) does not indicate any acknowledgement of received frames, but is merely the number of the frame which should be retransmitted.

The current implementation supports both SREJ and REJ frames. First RLP uses SREJ frames to request a missing frame. If the number of outstanding SREJted frames exceeds a predefined value, then REJ is used.

3.4 Variables and Sequence Numbers

All calculations for the frame numbers N(S) and N(R) are done with modulus 62 arithmetic. Therefore these fields and internal variables can take on the values 0 through 61. The values 62 and 63 of the 6 bit fields N(S) and N(R) are reserved for marking U and S frames. As a result the maximum window size k is 61, i.e. a maximum of 61 information frames may be outstanding at any time in each direction[1]. Besides the window size may be negotiated by the RLP entities to be lower than this.

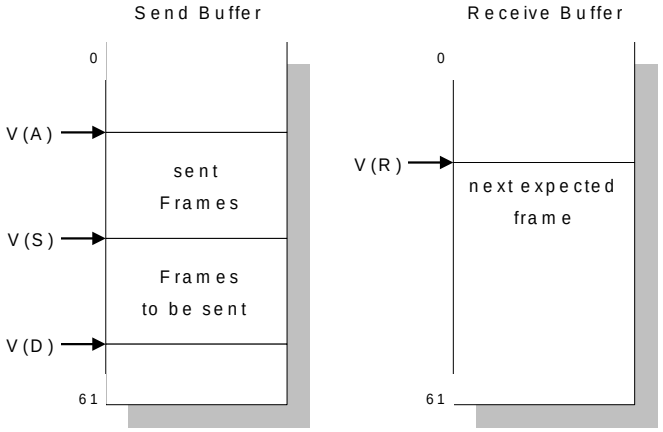


Figure 3-5: State Variables for Send and Receive Buffer

3.4.1 Send State Variable V(S)

Each RLP entity has an associated send state variable V(S) for numbered information transfer. The send state variable denotes the sequence number of the next in-sequence I+S frame to be transmitted.

The value of the send state variable is incremented by 1 with each successive I+S frame transmission, and may not exceed V(A) by more than the maximum number of outstanding I+S frames k.

3.4.2 Acknowledge State Variable V(A)

Each RLP entity has an associated acknowledge state variable V(A) for numbered information transfer.

The acknowledge state variable identifies the last frame that has been acknowledged by its peer. The value of the acknowledge state variable is updated by valid N(R) values received from its peer. A valid N(R) is one that is in the range V(A) <= N(R) <= V(S).

[1] The window size must be one less than the buffer size. Otherwise the condition V(A) = V(S) = V(D) could be interpreted as 'buffer is empty' or as 'buffer is full with sent frames' or as 'buffer is full with frames to be sent'.

3.4.3 Data Request State Variable V(D)

The Data Request State Variable denotes the slot number in the send buffer, which is used in the next RLP_DATA_REQ. With RLP_DATA_REQ each frame is stored in the slot, that is indicated by V(D) and V(D) is incremented by 1. Frames with a slot number n with V(S) <= n < V(D) are waiting for transmission.

3.4.4 Send Sequence Number N(S)

Only I+S frames contain N(S), the send sequence number of the transmitted I+S frame. At the time when an in-sequence I+S frame is designated for transmission, the value of N(S) is set to the current value of the sending state variable V(S).

3.4.5 Receive State Variable V(R)

Each RLP entity has an associated receive state variable V(R) for numbered information transfer. The receive state variable denotes the sequence number of the next in-sequence I+S frame expected to be received. The value of the receive state variable is incremented by one on receipt of every error-free, in-sequence I+S frame, whose send sequence number N(S) equals the receive state variable V(R). Each received frame is put into the receive buffer in the slot, which is indicated by V(R).

3.4.6 Receive Sequence Number N(R)

All I+S frames and S frames contain N(R), the expected send sequence number of the next received I+S frame.

At the time when a frame is designated for transmission, the value of N(R) is set to the current value of the receive state variable V(R). N(R) indicates that the RLP entity transmitting the N(R) has correctly received all I+S frames numbered up to and including N(R)-1.

3.5 Frame Check Sequence (FCS)

Each RLP frame contains a 24 bit frame check sequence, which is the ones complement of the modulo 2 sum of

a) the remainder of

$$X^{216}(X^{23}+X^{22}+X^{21}+X^{20}+X^{19}+X^{18}+X^{17}+X^{16}+X^{15}+X^{14}+X^{13}+X^{12}+X^{11}+X^{10}+X^{9}+X^{8}+X^{7}+X^{6}+X^{5}+X^{4}+X^{3}+X^{2}+X+1)$$

divided modulo 2 by the generator polynomial

$$X^{24}+X^{23}+X^{21}+X^{20}+X^{19}+X^{17}+X^{16}+X^{15}+X^{13}+X^{8}+X^{7}+X^{5}+X^{4}+X^{2}+1$$

and

b) the remainder of the division modulo2 by the generator polynomial

$$X^{24}+X^{23}+X^{21}+X^{20}+X^{19}+X^{17}+X^{16}+X^{15}+X^{13}+X^{8}+X^{7}+X^{5}+X^{4}+X^{2}+1$$

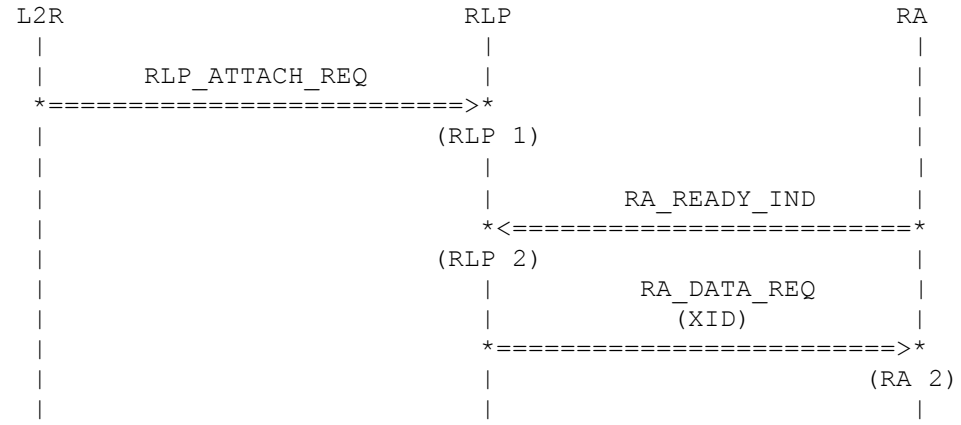
of the product of X^{24} by the content of the frame, excluding the FCS field.

The FCS is generated in such a way, that the highest order term appears in the least significant bit of the 24 bit word. Since the FCS bytes are placed in the RLP frame in reverse order and since each byte is transmitted starting with the least significant bit, the highest order term of the FCS is transmitted first, as required in GSM 04.22 [13].

4 Protocol

4.1 ADM and Detached State

4.1.1 Attachment of RLP

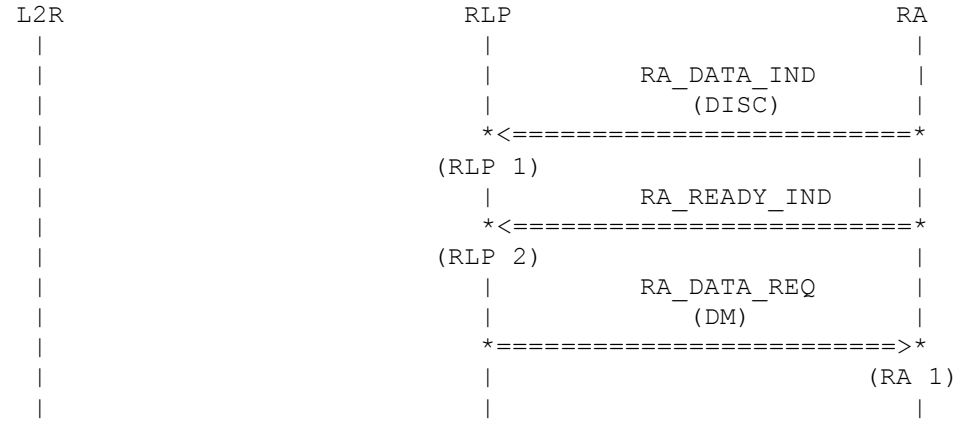


(RLP 1)
The RLP receives the RLP_ATTACH_REQ and is switched to the ADM and attached state. This is the only event, by which RLP can exit the ADM and detached state. The RA entity should be activated by a RA_ACTIVATE_REQ from the ACI entity before switching the RLP entity into the ADM and attached state.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 2)
RLP sends a XID Frame to negotiate the parameters with the peer RLP. Usually this will be a command with the P bit set to '1'. It might also be a response with the F bit set to '1', if previously a XID command has been received but not yet answered. This may happen, when the peer RLP is sending a XID command at the very time, when this activation procedure takes place. Then RLP would receive a RA_DATA_IND (XID) just before the RA_READY_IND.

4.1.2 Reception of DISC Frame in Detached State

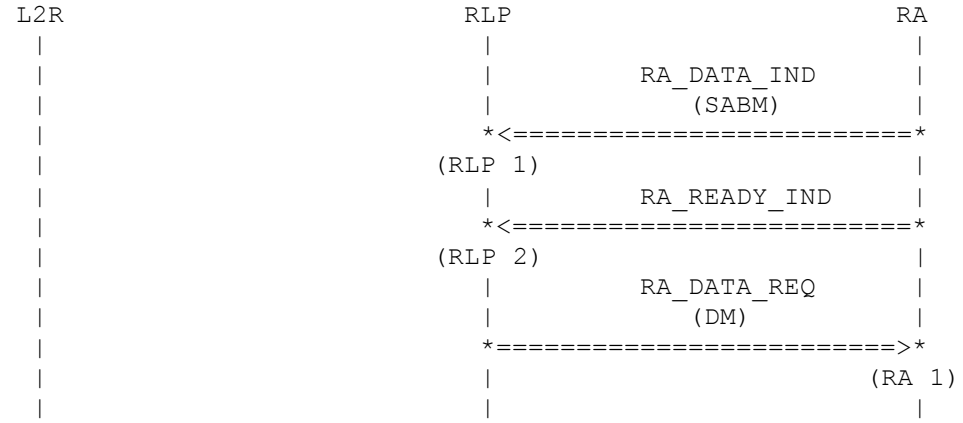


(RLP 1)
The RLP receives a DISC command. RLP stores the P-bit. RLP will have to send a DM response at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent now.

(RA 1)
RLP sends a DM response with the F-bit set according to the stored P-bit. This means, that RLP is in the disconnected mode (ADM) already.

4.1.3 Reception of SABM Frame in Detached State

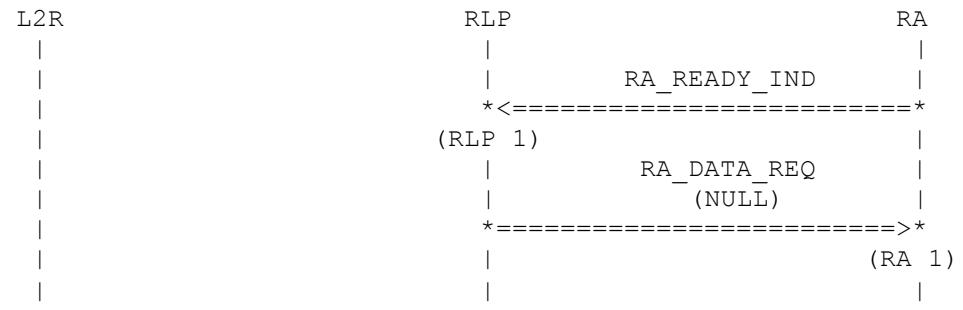


(RLP 1)
The RLP receives a SABM command. RLP will have to send a DM response at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent now.

(RA 1)
RLP sends a DM response. This means, that currently RLP can not be switched to ABM. The F-bit is set to '1'.

4.1.4 Reception of Ready Indication in Detached State

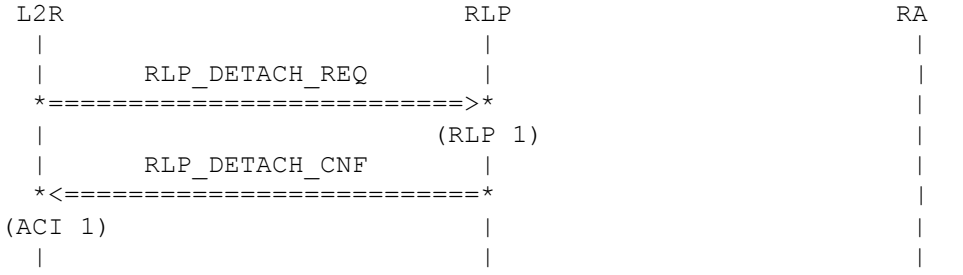


(RLP 1)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a NULL Frame, since no other information is to be transferred.

4.1.5 Entering ADM and detached state

The ADM and detached state can be entered at any time from any state by a RLP_DETACH_REQ from the upper layer. This is the standard means, by which the RLP entity is reset after an error has occurred (RLP_ERROR_IND).

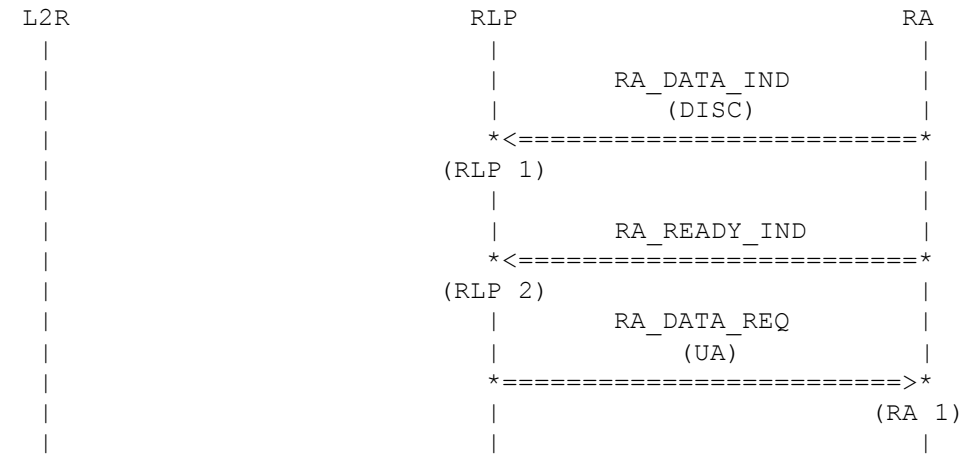


(RLP 1)
The RLP receives the RLP_DETACH_REQ and is switched to the ADM and detached state.

(ACI 1)
RLP acknowledges the RLP_DETACH_REQ by a RLP_DETACH_CNF.

4.2 ADM and attached state

4.2.1 DISC command received

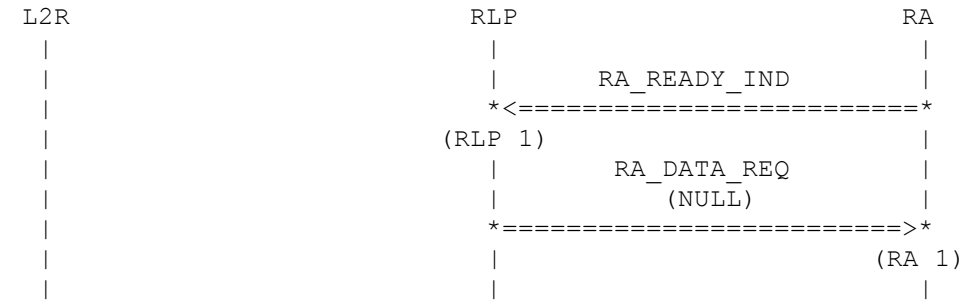


(RLP 1)
The RLP receives a DISC command. RLP stores the P-bit. RLP will have to send an UA response at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set according to the stored P-bit of the DISC command. RLP is in the ADM and attached state.

4.2.2 Ready Indication received



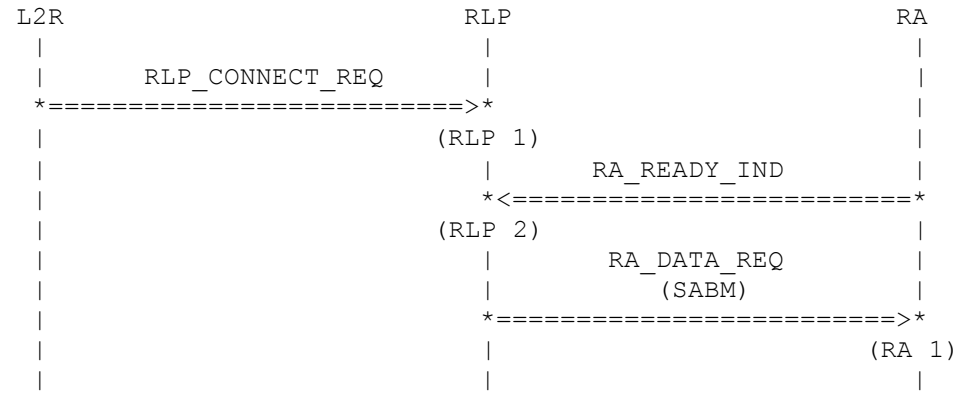
(RLP 1)
RLP is waiting for a SABM command or for a RLP_CONNECT_REQ, but it receives the indication, that a frame can be sent.

(RA 1)
RLP sends a NULL frame, since no other information is to be transferred.

4.3 Mobile Originated Connect Request

The mobile originated connect procedure is used to switch the RLP entities of the mobile and the base station into the ABM state, where numbered information can be exchanged. The connect procedure starts from the ADM and attached state.

4.3.1 Initiation

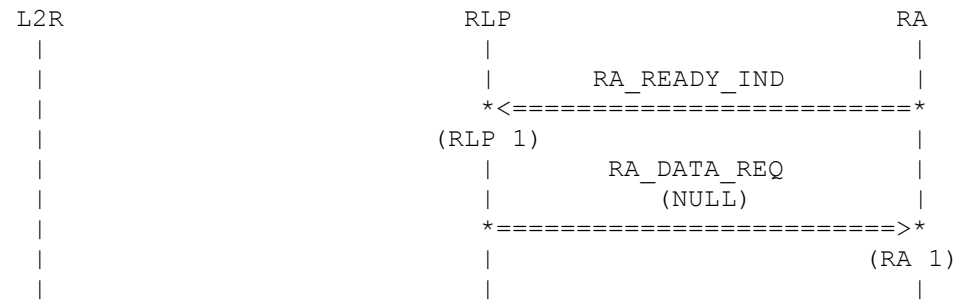


(RLP 1)
RLP is requested to connect to its peer. RLP will have to send a SABM command at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a SABM command with the P-bit set to '1'.

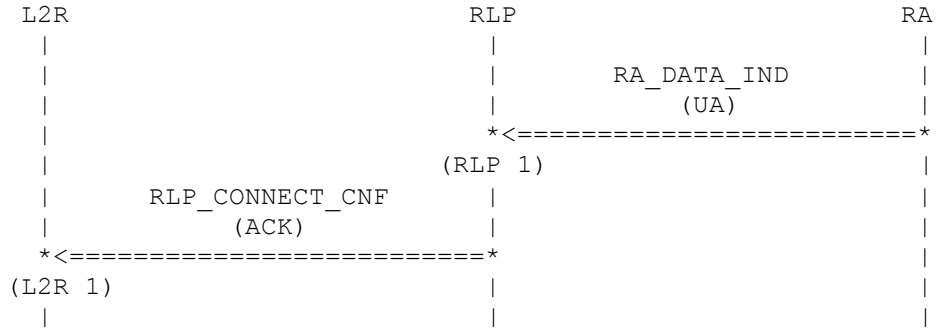
4.3.2 Ready Indication during waiting for response



(RLP 1)
RLP is waiting for the UA or DM frame as a response to the SABM command, but it receives the indication, that a frame can be sent.

(RA 1)
RLP sends a NULL frame, since no other information is to be transferred.

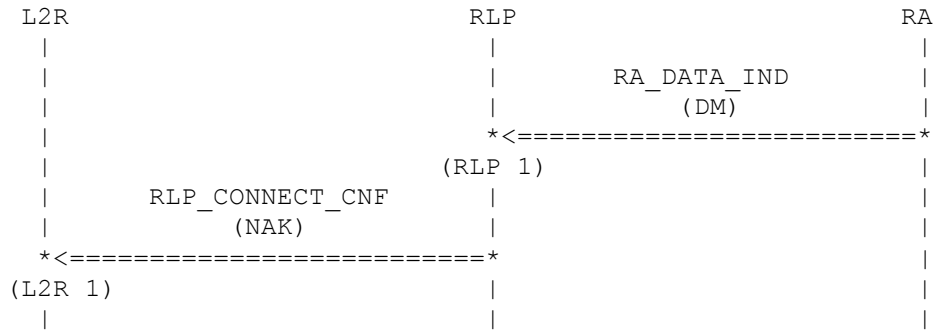
4.3.3 Reception of UA



(RLP 1)
RLP receives an UA response with a F-bit set to '1' as an acknowledge to the SABM command.

(L2R 1)
RLP confirms the establishment of the connection to L2R. RLP resets its internal variables and is in the ABM state.

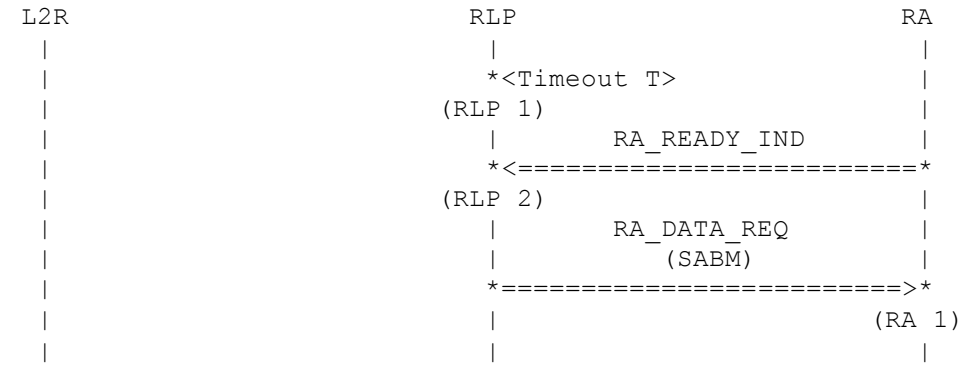
4.3.4 Reception of DM



(RLP 1)
RLP receives an DM response with a F-bit set to '1' as a non-acknowledge to the SABM command.

(L2R 1)
RLP indicates to L2R, that a connection could not be established. RLP is in the ADM and attached state again.

4.3.5 Timeout of timer T, max. retransmissions not reached

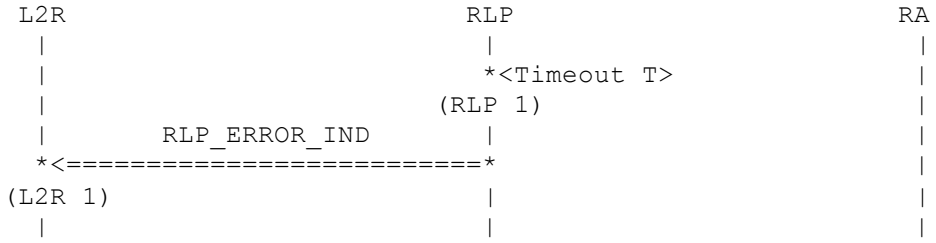


(RLP 1)
Timer T expires. RLP will have to repeat the SABM command at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP repeats the SABM command with the P-bit set to '1'.

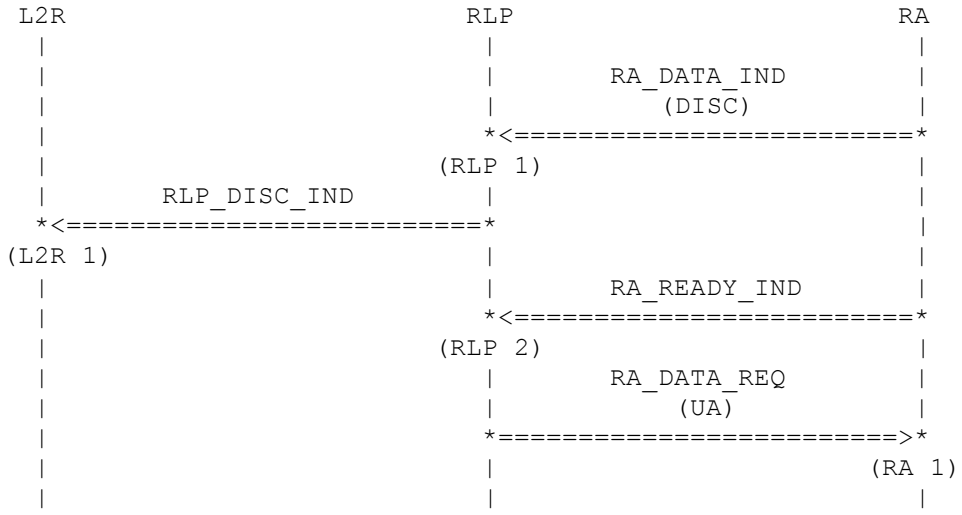
4.3.6 Timeout of timer T, max. retransmissions reached



(RLP 1)
Timer T expires.

(L2R 1)
RLP indicates an error to L2R. RLP is in the permanent error state, which can be left only by RLP_DETACH_REQ and RLP_DISC_REQ.

4.3.7 Collision of connection establishment and disconnection



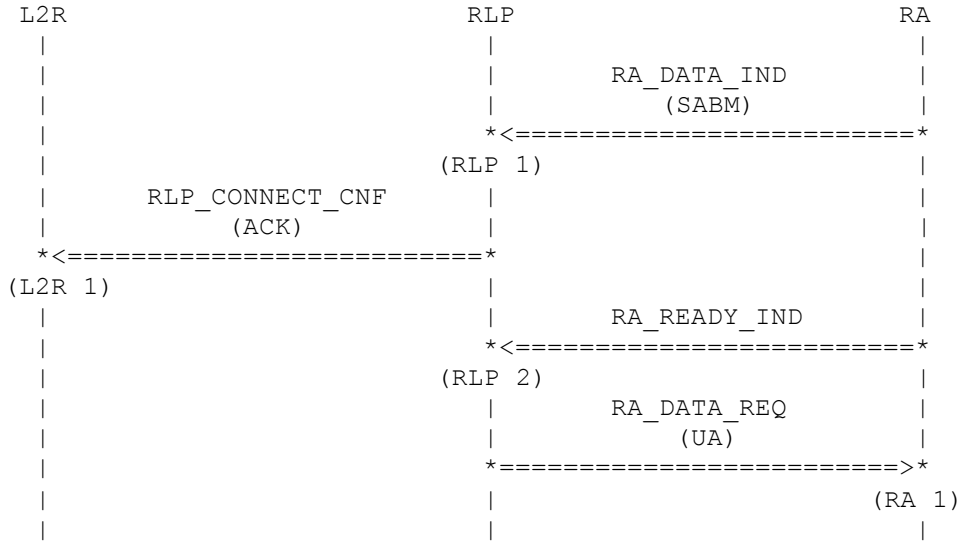
(RLP 1)
The RLP receives a DISC command. RLP stores the P-bit. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP indicates to L2R, that the base station wants to disconnect. This is also a non-acknowledge for the previous RLP_CONNECT_REQ.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set according to the stored P-bit of the DISC command. RLP is in the ADM and attached state.

4.3.8 Collision of both sides connection establishment



(RLP 1)
The RLP receives a SABM command. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP confirms the establishment of the connection to L2R. RLP resets its internal variables and is in the ABM state.

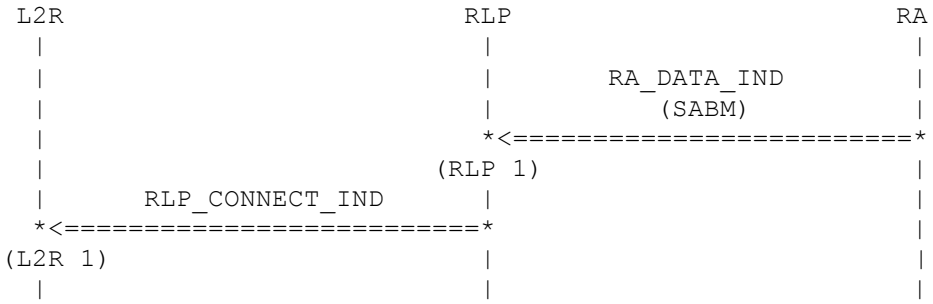
(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set to '1'.

4.4 Mobile Terminated Connection Establishment

Like the mobile originated connect procedure the mobile terminated connect procedure is used to switch the RLP entities of the mobile and the base station into the ABM state, where numbered information can be exchanged. The connect procedure starts from the ADM and attached state.

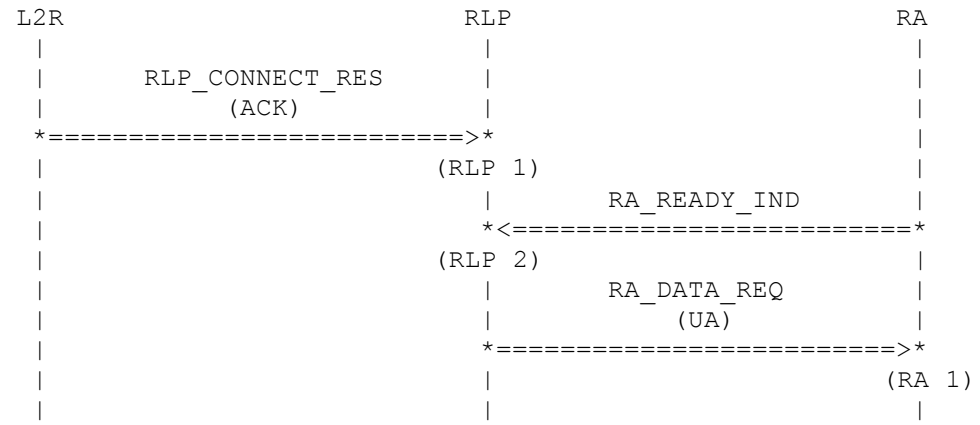
4.4.1 Initiation



(RLP 1)
The RLP receives a SABM command.

(L2R 1)
RLP indicates to L2R that a connection for numbered information transfer to the base station is requested.

4.4.2 Positive Response from upper layer

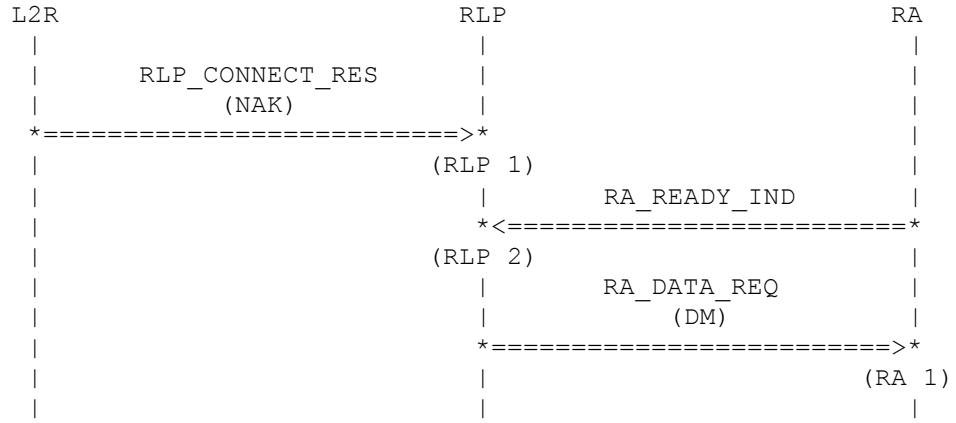


(RLP 1)
The RLP receives a positive response from L2R. RLP will have to send an UA response at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set to '1'. RLP resets its internal variables and is in the ABM state.

4.4.3 Negative Response from upper layer

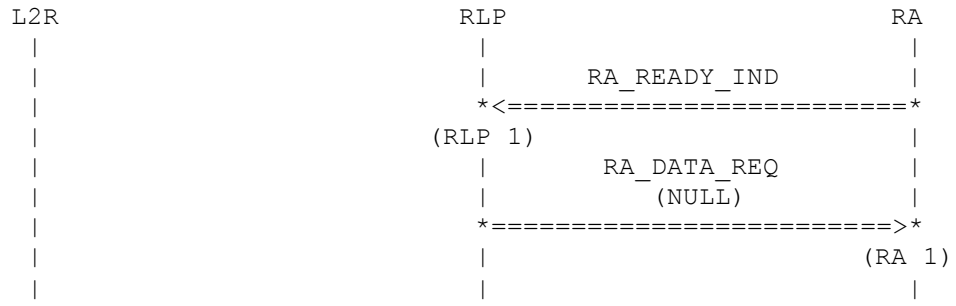


(RLP 1)
The RLP receives a negative response from L2R. RLP will have to send a DM response at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a DM response with the F-bit set to '1'. RLP is in the ADM and attached state again.

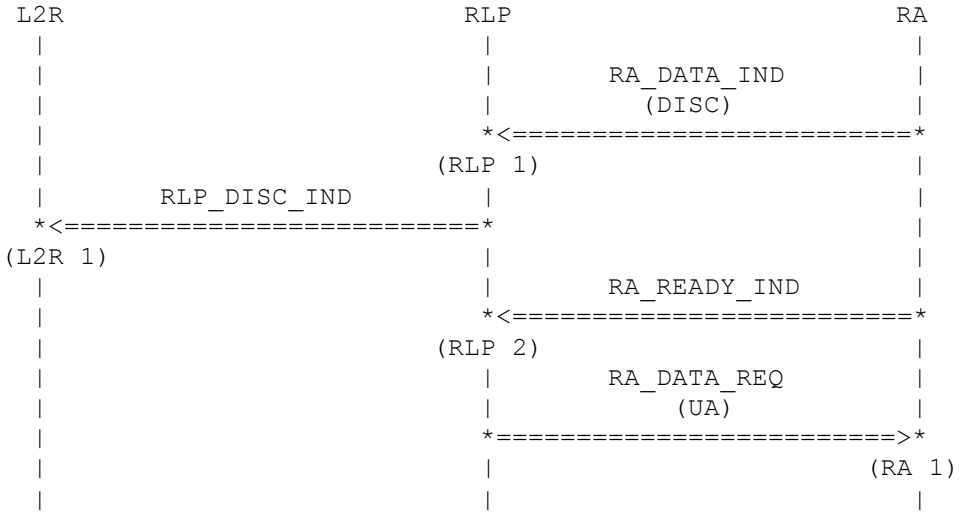
4.4.4 Ready Indication during waiting for response from upper layer



(RLP 1)
RLP is waiting for a response from the upper layer, but it receives the indication, that a frame can be sent.

(RA 1)
RLP sends a NULL frame, since no other information is to be transferred.

4.4.5 Receiving DISC Frame during waiting for response from upper layer



(RLP 1)
The RLP receives a DISC command. RLP stores the P-bit. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP indicates to L2R, that the base station wants to disconnect. The current connect procedure is aborted.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set according to the stored P-bit of the DISC command. RLP is in the ADM and attached state.

4.5 Connection Established State

This is the state, in which numbered information can be exchanged between the RLP peers. In the following diagrams the S or I+S frames, which are sent by RLP, are not specified in closer detail.

In general RLP sends the following commands/responses as S and I+S frames:

- a RR command/response, if RLP is ready to receive data,
- a RNR command/response, if RLP is not ready to receive data,
- a SREJ command, if one or more frames have not been received correctly.
- a REJ command, if one or more frames have not been received correctly and the number of outstanding SREJted frames exceeds a predefined value.

RLP is usually always ready to receive data.

S or I+S frames are sent as a command (C bit = '1'), unless previously a S or I+S command with the P bit set to '1' has been received, which has not been answered yet. In this case the frame is sent as a response (C bit = '0') and the F bit is set to '1'.

On the following conditions a frame, which has to be sent by RLP, will be marked with the DTX flag:

- the frame does not contain user information (S frame) and
- it is a command and
- the command/response type is RR or RNR and
- it is a mere repetition of the last S or I+S frame which has been sent by the RLP entity.

In this case the frame does not carry any new information and the transmission may be omitted. Therefore the DTX flag in the RA_DATA_REQ primitive is set. It is the choice of the RA entity either to continue with the transmission or to perform the DTX function.

4.5.1 The low water condition

All data, which are to be sent by RLP, are placed in a frame organised buffer. The space in the buffer is not released immediately after sending the data, but only after receiving an acknowledgement for this data from the base station. In case of transmission failure the buffered data are sent again.

Since the buffer capacity is limited as well as the rate, at which buffered data can be sent, the flow of data from the upper layer into the buffer must be controlled. Therefore an indication (RLP_READY_IND) is sent to the upper layer, whenever the amount of buffered data in RLP is below a certain threshold.

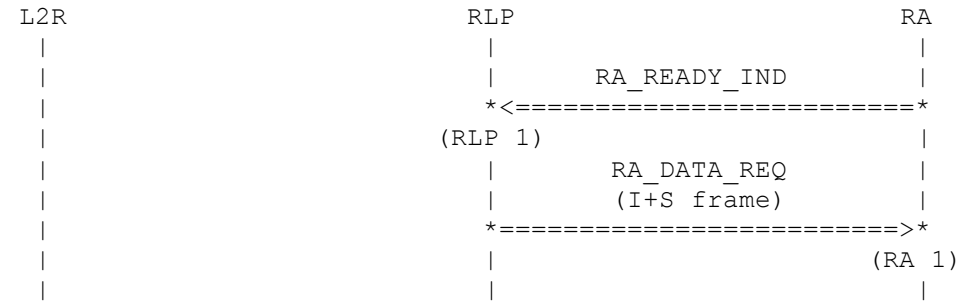
The number of frames per primitive is set up by the upper layer. As soon as this number of frames is available, the upper layer sends the data with a RLP_DATA_REQ. If the upper layer can not collect this amount of data within a certain time, a timer expires in the upper layer and all data, which are available at this time will be transferred.

More precisely speaking RLP sends the RLP_READY_IND, when

- RLP has received a RA_READY_IND and has sent a numbered information frame to RA or it could have sent a frame, but no buffered data were available
- and there is enough space in the buffer of RLP to hold all frames of a completely filled RLP_DATA_REQ
- and RLP is not already waiting for a RLP_DATA_REQ after previously sending a RLP_READY_IND.

This complex condition is also called low water condition in this document.

4.5.2 Numbered information is sent

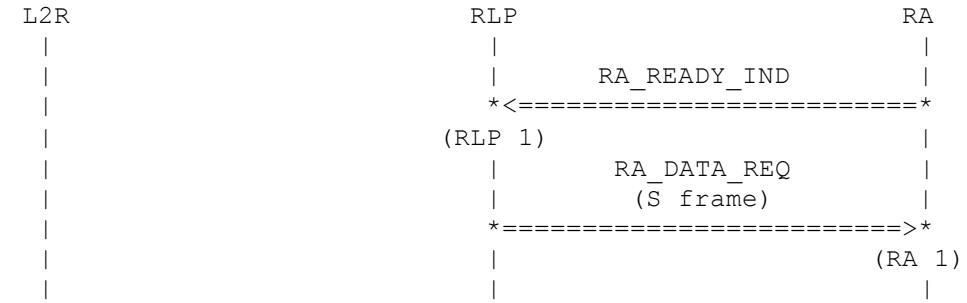


(RLP 1)
RLP receives the indication, that a frame can be sent.

(RA 1)
The remote receiver is ready and the window size has not been reached. Therefore RLP is sending buffered data in an I+S frame.

If the low water condition is fulfilled, a RLP_READY_IND will be sent to the upper layer next (s. 4.5.1 and 4.5.4).

4.5.3 A supervisory frame is sent



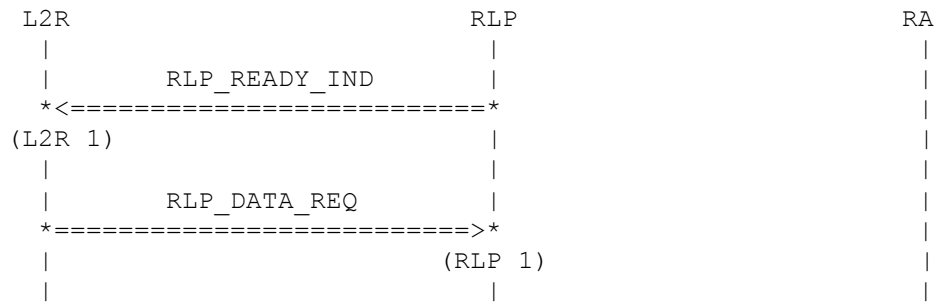
(RLP 1)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP cannot send the data because of one of these reasons:
- there are no data available for sending or
- the number of maximum outstanding frames - the window size - in this direction has been reached or
- the remote receiver is not ready, i.e. it has previously sent a RNR command/response.

Therefore RLP is sending a supervisory frame (S frame), by which previously received frames are acknowledged. If data are available, they remain in the buffer.

If the data are not sent because of the first reason and the low water condition is fulfilled, a RLP_READY_IND will be sent to the upper layer next (s. 4.5.1 and 4.5.4).

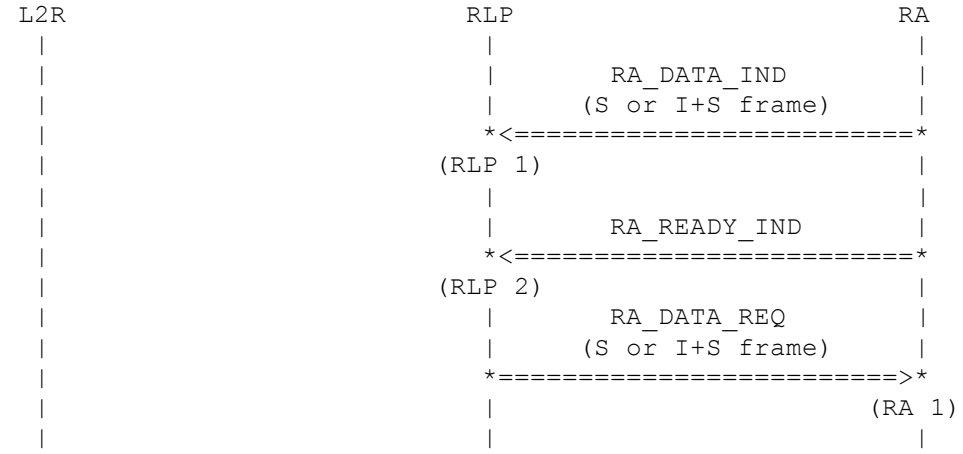
4.5.4 Low water condition is fulfilled



(L2R 1)
RLP indicates to L2R, that it is ready to accept data. This primitive is sent, when the low water condition is fulfilled.

(RLP 1)
L2R passes data to RLP, which should be sent as numbered information. The data are stored in a buffer.

4.5.5 Numbered information or a supervisory frame is received



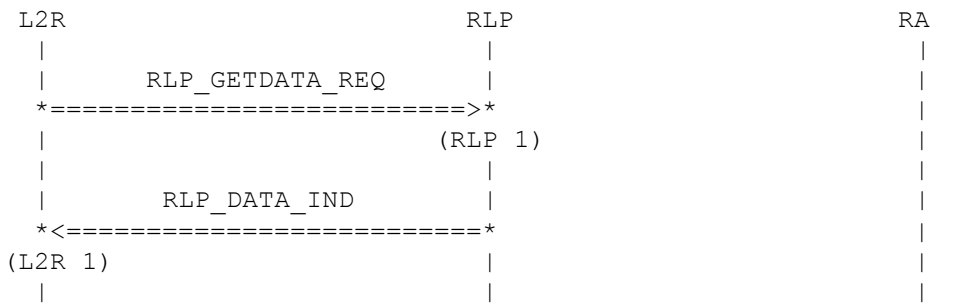
(RLP 1)
RLP receives a supervisory frame (S frame) or numbered information in an I+S frame. In case of numbered information, the data are stored in the receive buffer. They will be delivered to the L2R entity on request.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a S frame as an answer to the received I+S frame. In case there are still some buffered data to be sent, RLP sends an I+S frame instead of the S frame.

If the low water condition is fulfilled, a RLP_READY_IND will be sent to the upper layer next (s. 4.5.1 and 4.5.4).

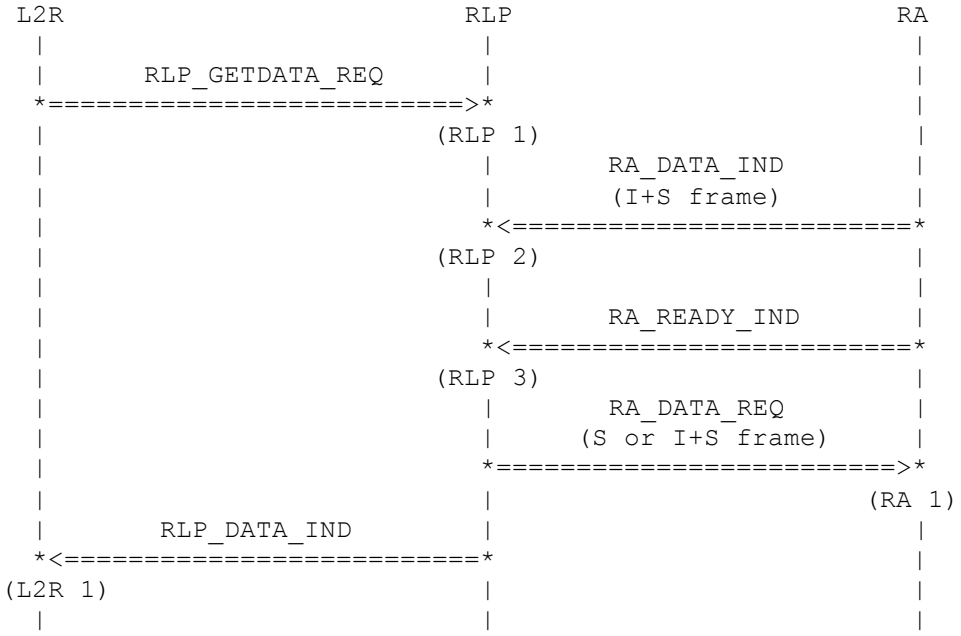
4.5.6 Data is requested from upper layer, data are available



(RLP 1)
RLP is requested to pass data from the receive buffer to the upper layer. There are enough frames in the buffer, to fill a RLP_DATA_IND.

(L2R 1)
RLP passes the data to the upper layer.

4.5.7 Data is requested from upper layer, data are available with delay



(RLP 1)
RLP is requested to pass data from the receive buffer to the upper layer. There are not enough frames in the buffer to fill a RLP_DATA_IND completely.

(RLP 2)
RLP receives numbered information in an I+S frame. The data are stored in the receive buffer. It is assumed, that now the required amount of frames is in the receive buffer.

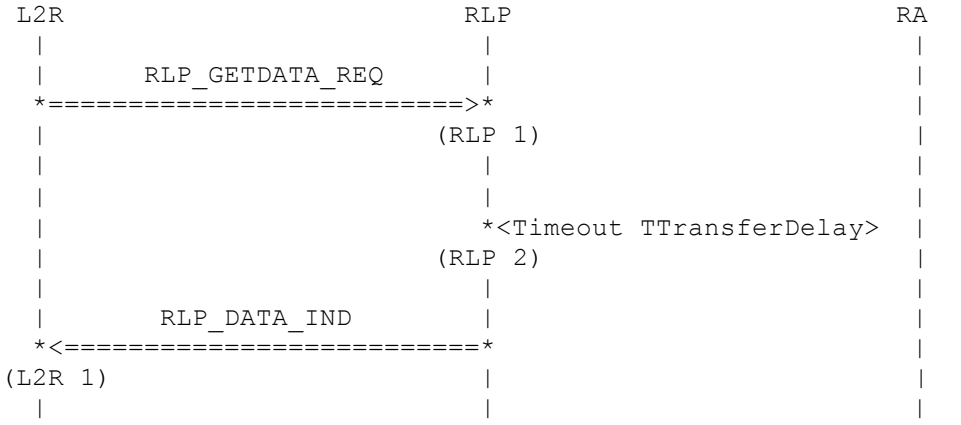
(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a S frame as an answer to the received I+S frame. In case there are still some buffered data to be sent, RLP sends an I+S frame instead of the S frame.

(L2R 1)
RLP passes the data to the upper layer.

If the low water condition is fulfilled, a RLP_READY_IND will be sent to the upper layer next (s. 4.5.1 and 4.5.4).

4.5.8 Data is requested from upper layer, data are not available

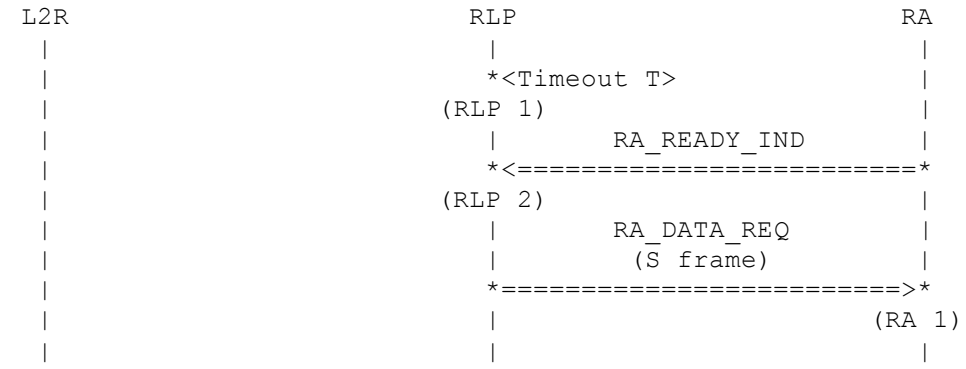


(RLP 1)
RLP is requested to pass data from the receive buffer to the upper layer. There are not enough frames in the buffer to fill a RLP_DATA_IND completely.

(RLP 2)
The timer TTransferDelay which has been started in step RLP 1 expires. This means, that RLP could not collect the required number of frames.

(L2R 1)
RLP delivers all frames, which are available now, to the upper layer. If no frames are there, an empty primitive is sent.

4.5.9 Timeout of timer T, max. retransmissions not reached



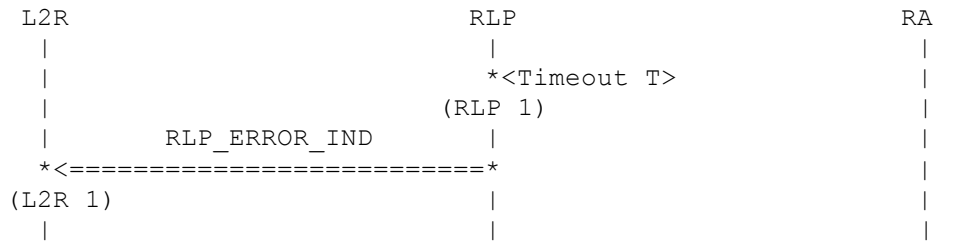
(RLP 1)
Timer T expires. This timer is started,
- when an I+S frame is sent. In this case RLP is expecting a S or I+S frame, which acknowledges the frame.
- Or when a frame with the P bit set to '1' is sent. In this case RLP is expecting a response with the F bit set to '1'.

The timer is always reset, when the expected type of frame is received. An expiry of the timer means that an outstanding answer is still missing.
RLP will send a RR or RNR command at the next opportunity. The P bit will be set to '1', thus requesting the peer again to send its current state in a S or I+S frame.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a RR or RNR command depending on the state of the own receiver. The P-bit is set to '1' and the timer is re-started.

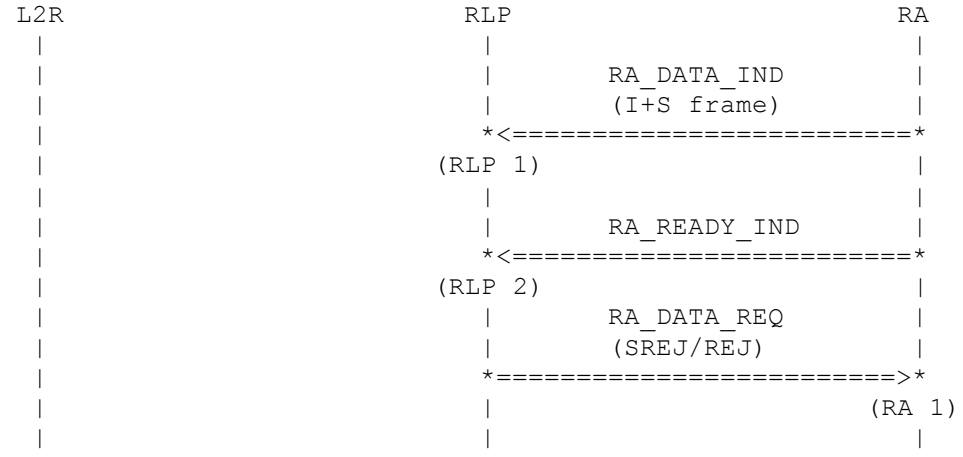
4.5.10 Timeout of timer T, max. retransmissions reached



(RLP 1)
Timer T expires.

(L2R 1)
RLP indicates an error to L2R. RLP is in the permanent error state, which can be left only by RLP_DETACH_REQ and RLP_DISC_REQ.

4.5.11 An out of sequence frame is received

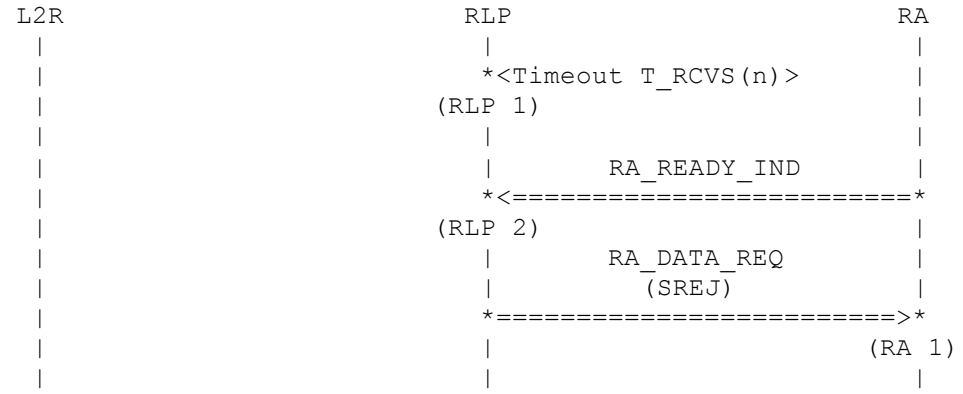


(RLP 1)
RLP receives an I+S frame. The sequence number N(S) is not the one which is expected by RLP. RLP will send a SREJ or REJ command to request the repetition of all outstanding data frames (I+S frames).

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP is sending a SREJ or REJ command. The sequence number N(R) is set to the value of the variable V(R), i.e. it represents the number of the frame which is expected by the RLP. In case of a SREJ frame the corresponding timer T_RCVS(N(S)) is set, otherwise the timer T_RCVR is set.

4.5.12 Timeout of timer T_RCVS(n) after sending a SREJ frame, max. retransmissions not reached

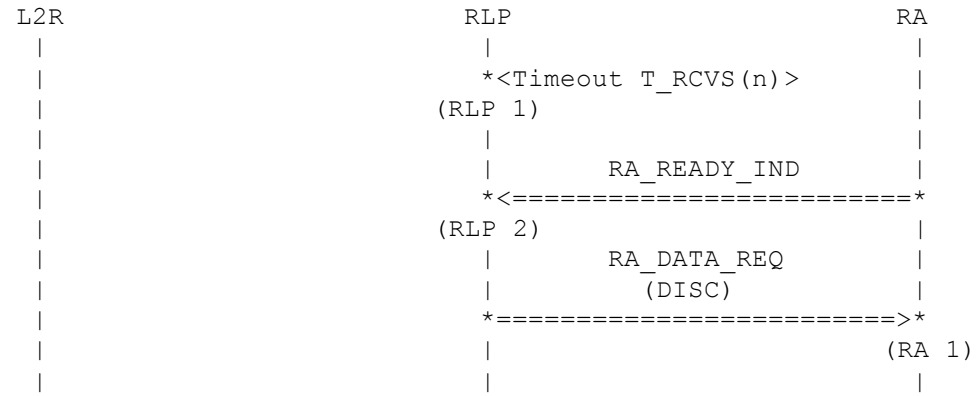


(RLP 1)
Timer T_RCVS(n) expires. The maximum number of retransmissions is not reached yet. RLP will repeat the SREJ command at the next oppotunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP is repeating the SREJ command. The SREJ timer T_RCVS(N(S)) is restartet.

4.5.13 Timeout of timer T_RCVS(n) after sending a SREJ frame, max. retransmissions reached

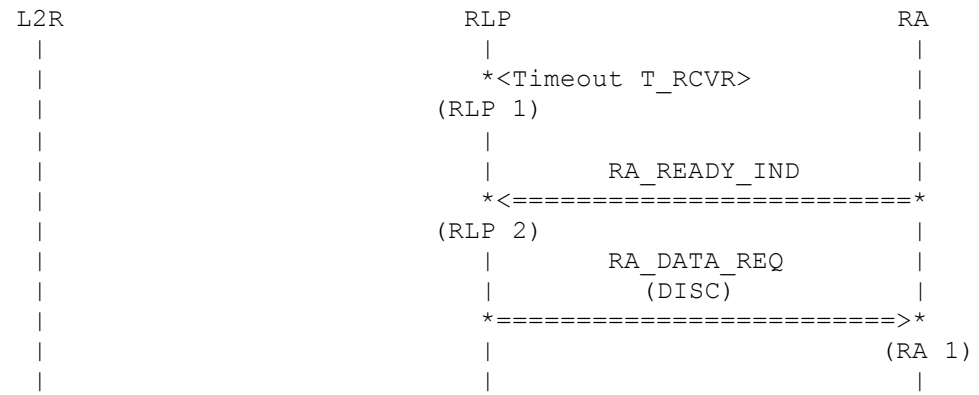


(RLP 1)
Timer T_RCVS(n) expires. The maximum number of retransmissions is reached. RLP will disconnect at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an DISC command. The P-bit is set to '1' unless a P/F bit exchange is pending already. RLP is in the disconnection initiated state.

4.5.14 Timeout of timer T_RCVR after sending a REJ frame

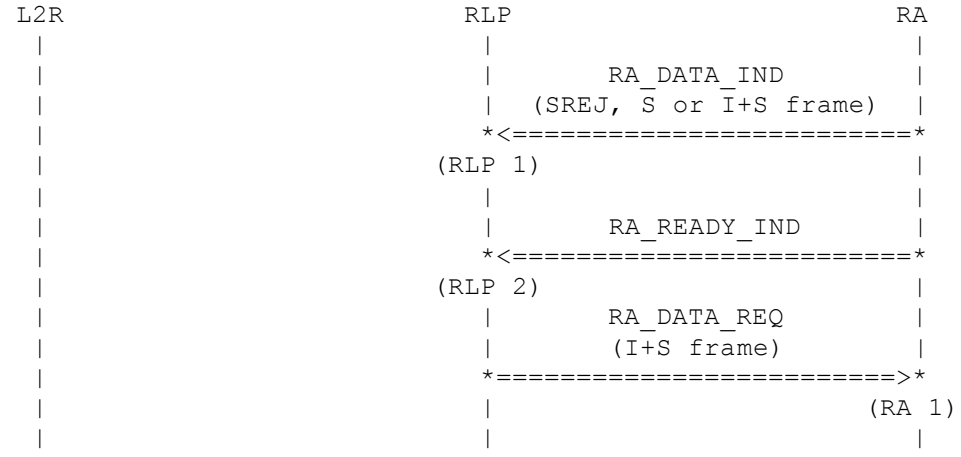


(RLP 1)
Timer T_RCVR expires. Since a REJ command is not repeated, RLP will disconnect at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an DISC command. The P-bit is set to '1' unless a P/F bit exchange is pending already. RLP is in the disconnection initiated state.

4.5.15 A frame is rejected (SREJ frame received)



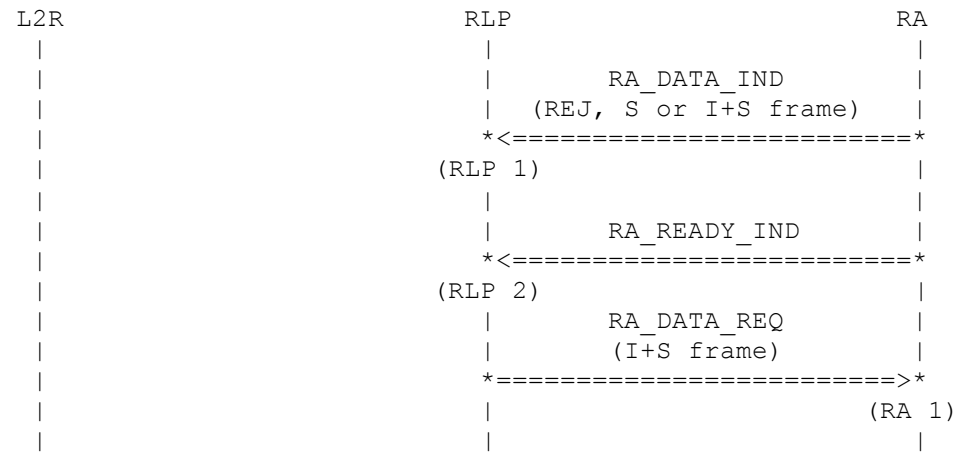
(RLP 1)
The base station has received an I+S frame out of sequence. It requests the repetition of the first outstanding frame with a SREJ command (S or I+S frame). RLP will have to send the requested frame again. In case of an I+S frame the data are stored in the receive buffer. They will be delivered to the L2R entity on request.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP is sending the outstanding frame again. In case of more than one received SREJ frames all outstanding frames will be sent one after the other.

If after this the low water condition is fulfilled, a RLP_READY_IND will be sent to the upper layer next (s. 4.5.1 and 4.5.4).

4.5.16 A frame is rejected (REJ frame received)



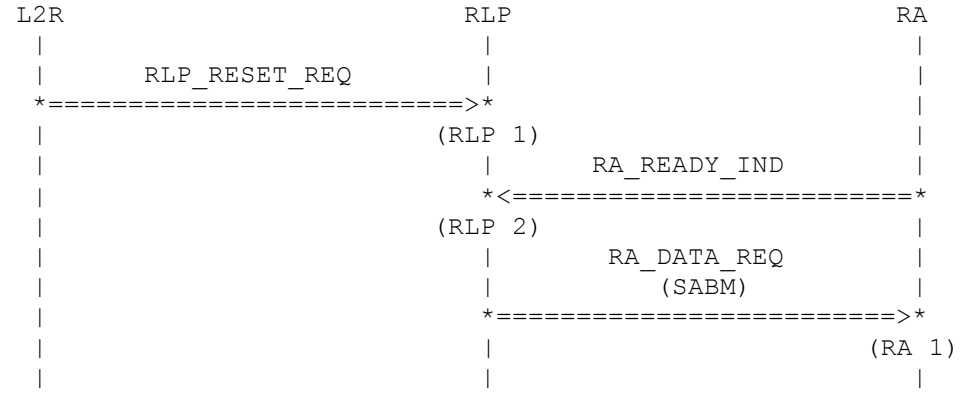
(RLP 1)
The base station has received an I+S frame out of sequence. It requests the repetition of all outstanding frames with a REJ command (S or I+S frame). RLP will have to send all numbered information again, which has not been received by the peer RLP. In case of an I+S frame the data are stored in the receive buffer. They will be delivered to the L2R entity on request.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP is sending the first outstanding frame again. Afterwards all other outstanding frames will be sent - at least the one, which has caused the out of sequence error.

If after this the low water condition is fulfilled, a RLP_READY_IND will be sent to the upper layer next (s. 4.5.1 and 4.5.4).

4.5.17 Request to reset from upper layer

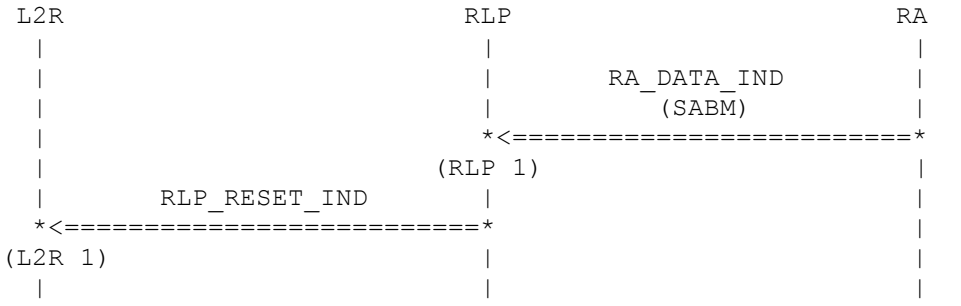


(RLP 1)
RLP is requested to reset the connection. RLP will have to send a SABM command at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a SABM command with the P-bit set to '1'. RLP is in the pending reset request state.

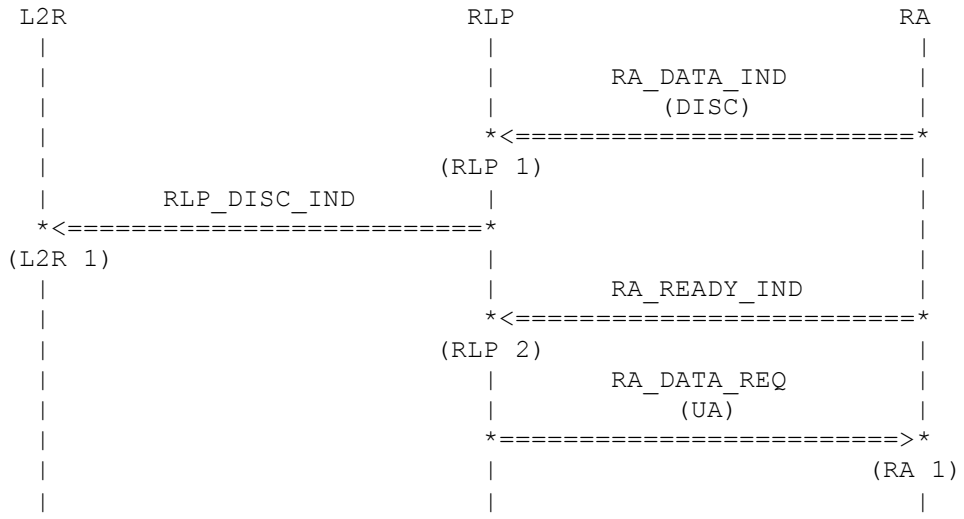
4.5.18 Request to reset from peer RLP



(RLP 1)
The RLP receives a SABM command.

(L2R 1)
RLP indicates the request to reset to L2R. RLP is in the pending reset indication state.

4.5.19 Disconnection



(RLP 1)
The RLP receives a DISC command. RLP stores the P-bit. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP indicates to L2R, that the base station wants to disconnect.

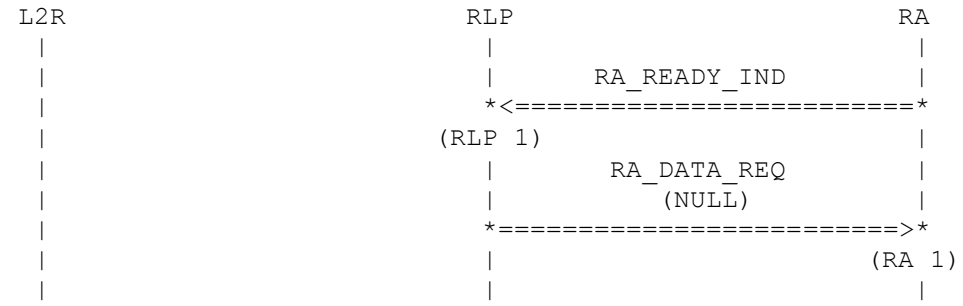
(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set according to the stored P-bit of the DISC command. RLP is in the ADM and attached state.

4.6 Pending reset request state

This state is entered after the upper layer has requested to reset the RLP link. When the reset is performed, all internal variables regarding numbered information exchange are cleared. Numbered information may be lost.

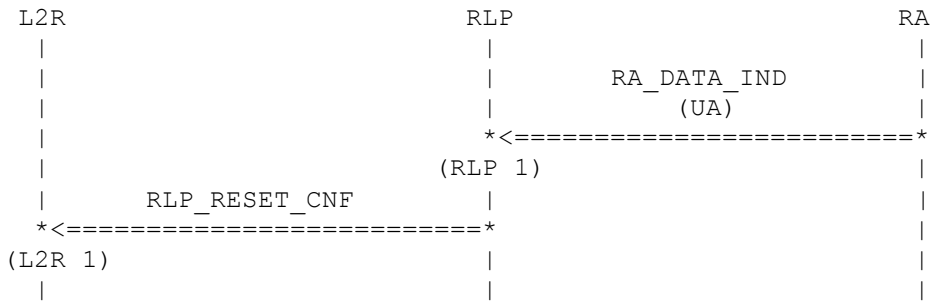
4.6.1 Ready Indication during waiting for response



(RLP 1)
RLP is waiting for the UA frame as a response to the SABM command, but it receives the indication, that a frame can be sent.

(RA 1)
RLP sends a NULL frame, since no other information is to be transferred.

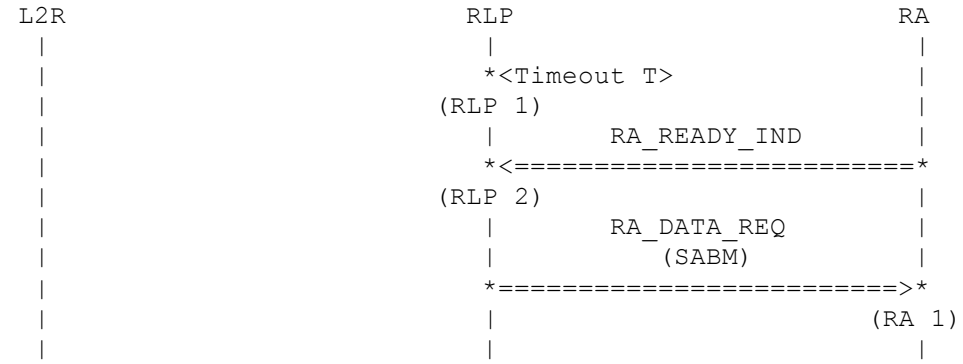
4.6.2 Reception of UA



(RLP 1)
RLP receives an UA response with a F-bit set to '1' as an acknowledge to the SABM command.

(L2R 1)
RLP confirms the reset to L2R. RLP resets its internal variables and is in the ABM state.

4.6.3 Timeout of timer T, max. retransmissions not reached

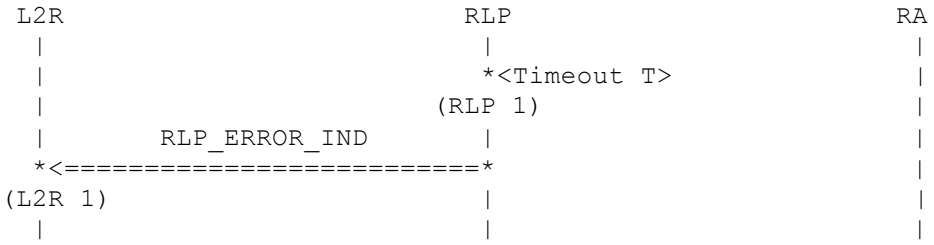


(RLP 1)
Timer T expires. RLP will have to repeat the SABM command at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP repeats the SABM command with the P-bit set to '1'.

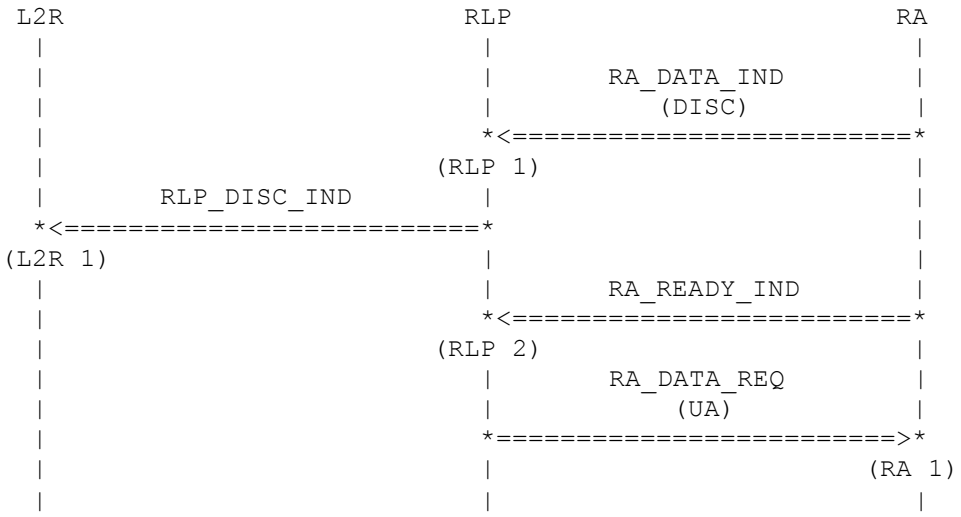
4.6.4 Timeout of timer T, max. retransmissions reached



(RLP 1)
Timer T expires.

(L2R 1)
RLP indicates an error to L2R. RLP is in the permanent error state, which can be left only by RLP_DETACH_REQ and RLP_DISC_REQ.

4.6.5 Collision of reset and disconnection



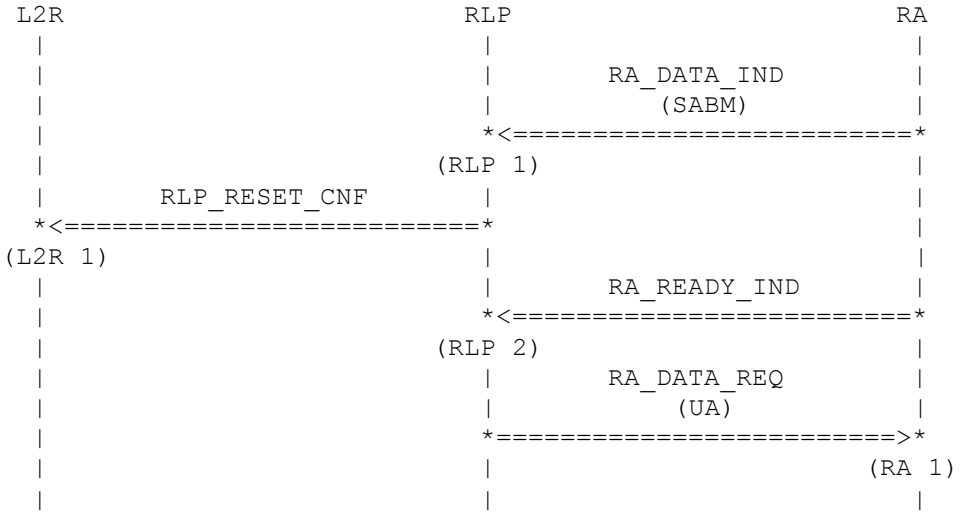
(RLP 1)
The RLP receives a DISC command. RLP stores the P-bit. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP indicates to L2R, that the base station wants to disconnect. This is also a non-acknowledge for the previous RLP_RESET_REQ.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set according to the stored P-bit of the DISC command. RLP is in the ADM and attached state.

4.6.6 Collision of both sides reset request



(RLP 1)
The RLP receives a SABM command. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP confirms the reset to L2R. RLP resets its internal variables and is in the ABM state.

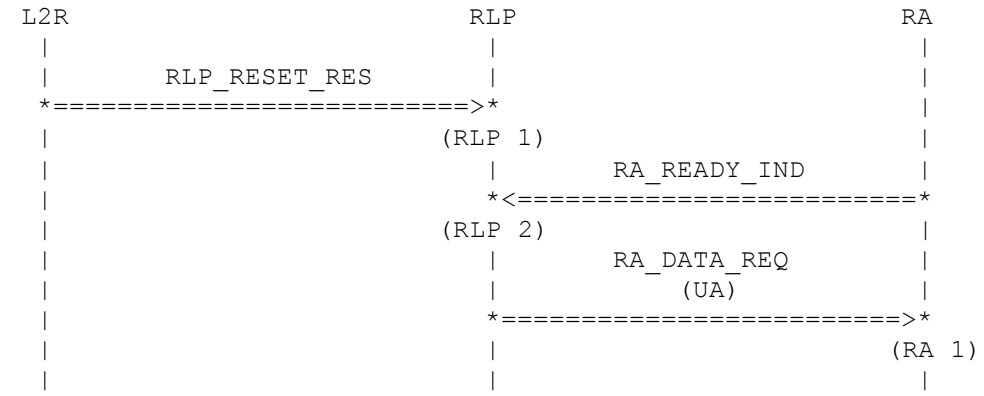
(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set to '1'.

4.7 Pending reset indication state

This state is entered after the peer RLP has requested to reset the RLP link. When the reset is performed, all internal variables regarding numbered information exchange are cleared. Numbered information may be lost.

4.7.1 Reset response from upper layer

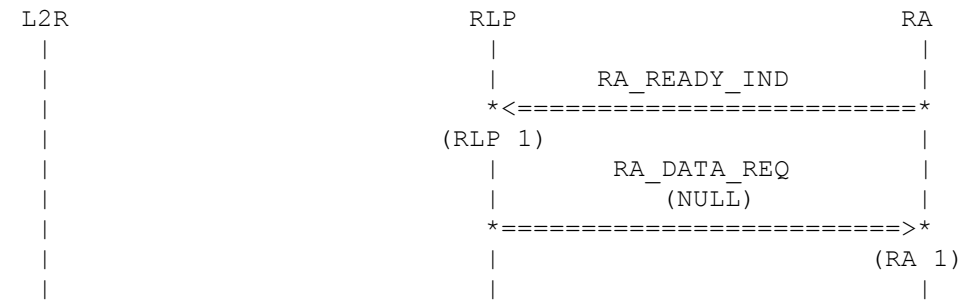


(RLP 1)
The RLP receives a reset response from L2R. RLP will have to send an UA response at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set to '1'. RLP resets its internal variables and is in the ABM state.

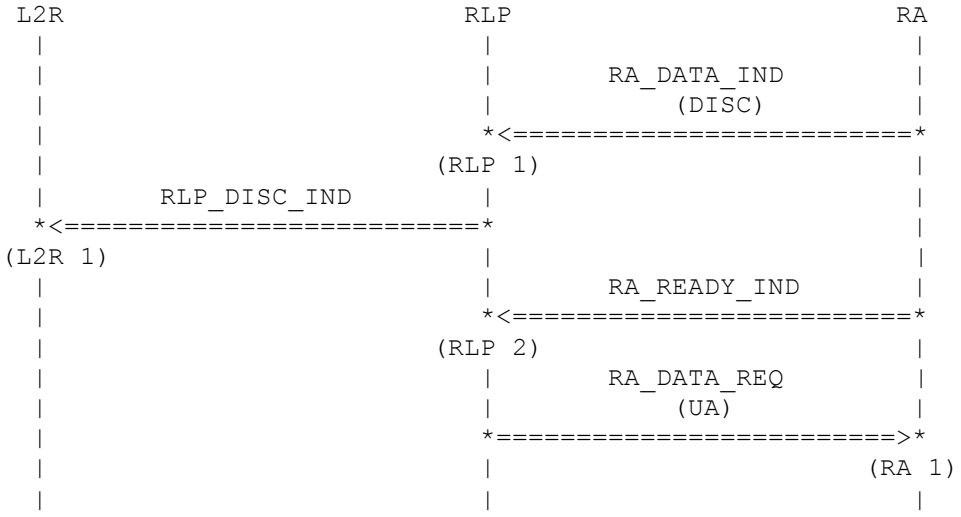
4.7.2 Ready Indication during waiting for response from upper layer



(RLP 1)
RLP is waiting for a response from the upper layer, but it receives the indication, that a frame can be sent.

(RA 1)
RLP sends a NULL frame, since no other information is to be transferred.

4.7.3 Receiving DISC Frame during waiting for response from upper layer



(RLP 1)
The RLP receives a DISC command. RLP stores the P-bit. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP indicates to L2R, that the base station wants to disconnect. The current reset procedure is aborted.

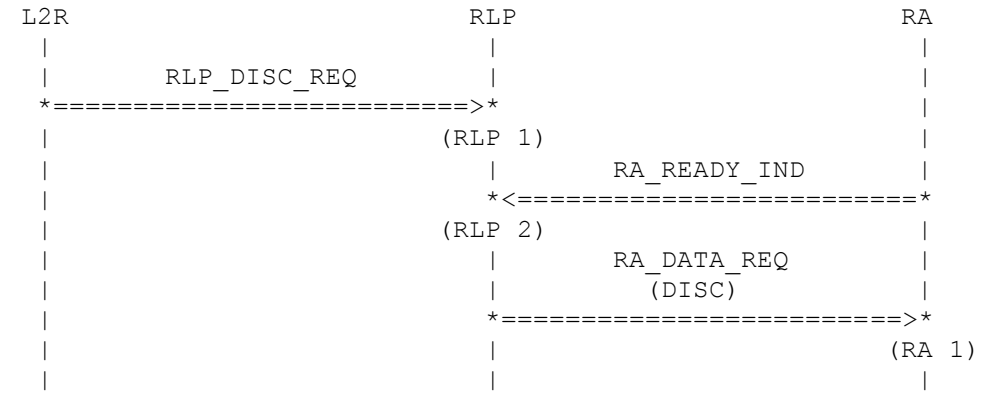
(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set according to the stored P-bit of the DISC command. RLP is in the ADM and attached state.

4.8 Disconnection initiated state

This state can be entered from any other state except from the ADM detached and ADM attached states by a RLP_DISC_REQ from the upper layer.

4.8.1 Entering disconnection initiated state

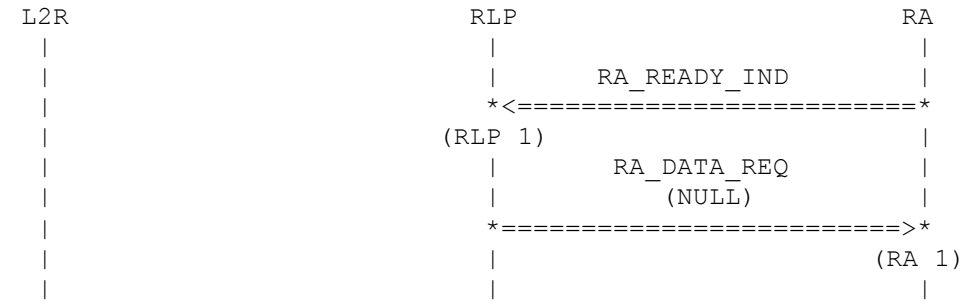


(RLP 1)
The RLP receives a request to disconnect from L2R. RLP will have to send an DISC command at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an DISC command. The P-bit is set to '1' unless a P/F bit exchange is pending already. RLP is in the disconnection initiated state.

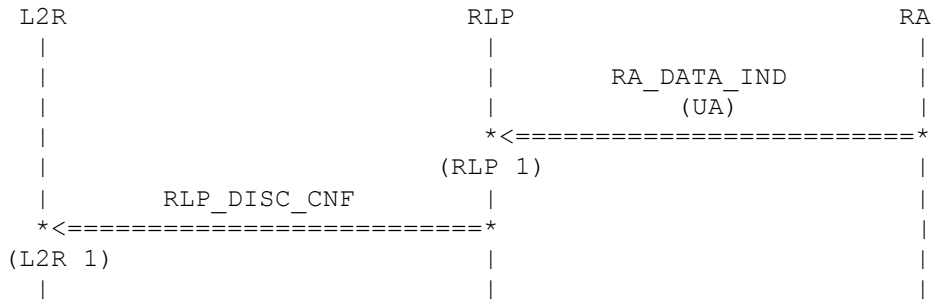
4.8.2 Ready Indication during waiting for response



(RLP 1)
RLP is waiting for the UA frame as a response to the DISC command, but it receives the indication, that a frame can be sent.

(RA 1)
RLP sends a NULL frame, since no other information is to be transferred.

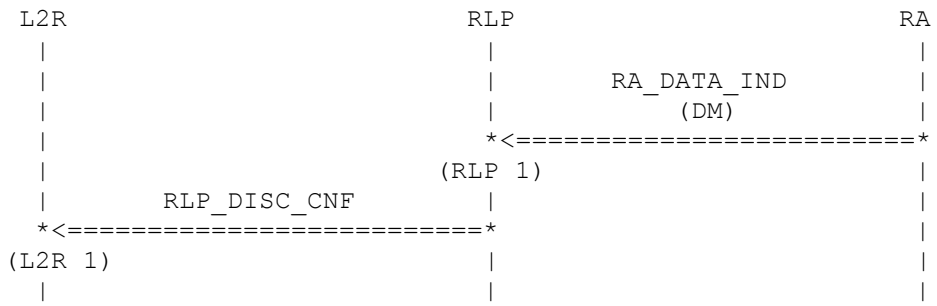
4.8.3 Reception of UA



(RLP 1)
RLP receives an UA response with a F-bit set to same value as in the DISC command. RLP is in the ADM and attached state.

(L2R 1)
RLP confirms the disconnection to L2R. This is always a positive acknowledge. If the disconnect initiated state has been invoked by the RLP entity because of a SREJ or REJ retransmission error, then a RLP_DISC_IND is sent instead of the RLP_DISC_CNF.

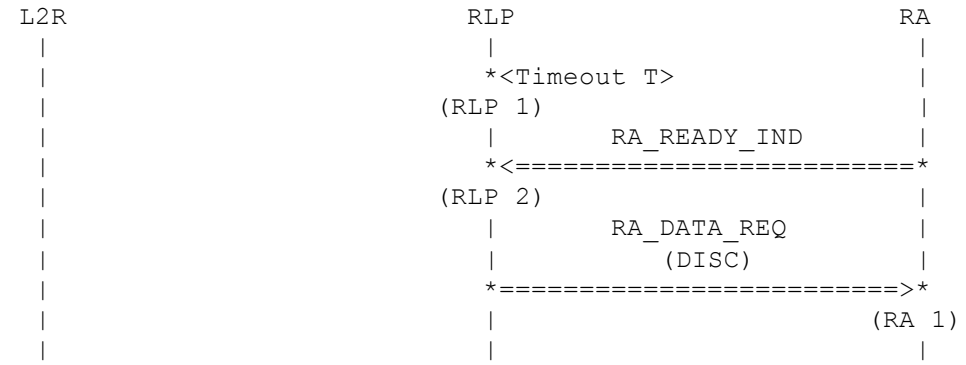
4.8.4 Reception of DM



(RLP 1)
RLP receives a DM response with a F-bit set to same value as in the DISC command. RLP is in the ADM and attached state.

(L2R 1)
RLP confirms the disconnection to L2R. This is always a positive acknowledge. If the disconnect initiated state has been invoked by the RLP entity because of a SREJ or REJ retransmission error, then a RLP_DISC_IND is sent instead of the RLP_DISC_CNF.

4.8.5 Timeout of timer T, max. retransmissions not reached

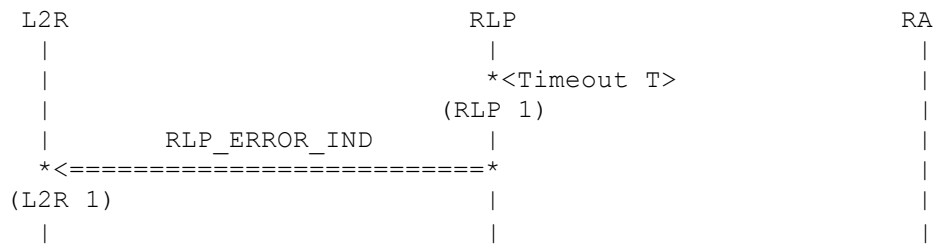


(RLP 1)
Timer T expires. RLP will have to repeat the DISC command at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP repeats the DISC command. The P-bit is set to '1' unless a P/F bit exchange was pending already, when the disconnection initiated state was entered.

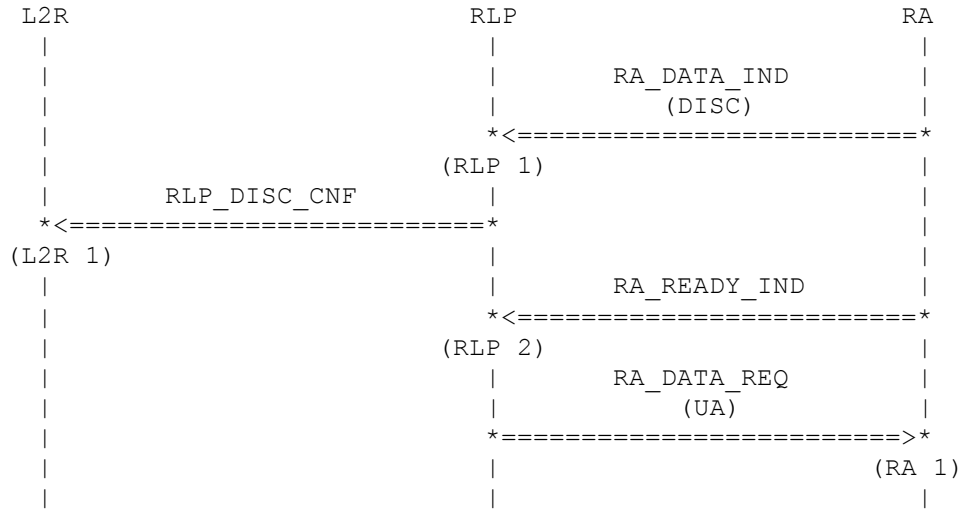
4.8.6 Timeout of timer T, max. retransmissions reached



(RLP 1)
Timer T expires.

(L2R 1)
RLP indicates an error to L2R. RLP is in the permanent error state, which can be left only by RLP_DETACH_REQ and RLP_DISC_REQ.

4.8.7 Collision of both sides disconnect request



(RLP 1)
The RLP receives a DISC command. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP confirms the previous RLP_DISC_REQ. The collision is hidden from the upper layer and from the base station as well. To both of them it looks, as if they have invoked the disconnection alone. If the disconnect initiated state has been invoked by the RLP entity because of a SREJ or REJ retransmission error, then a RLP_DISC_IND is sent instead of the RLP_DISC_CNF.

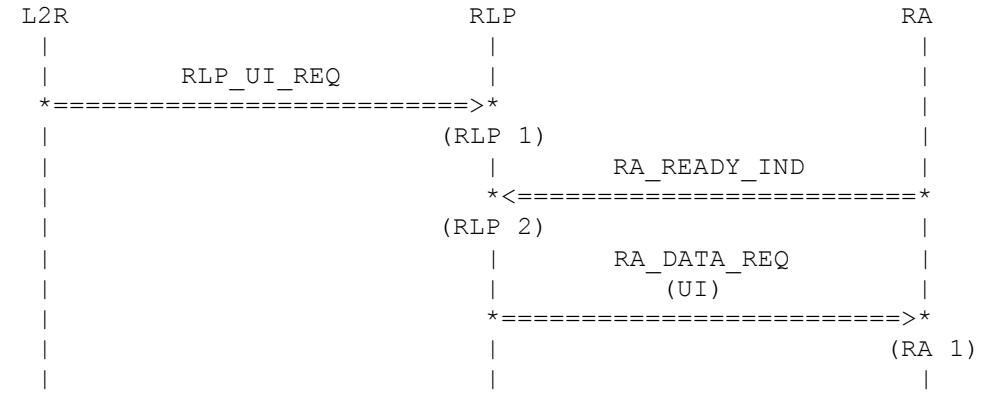
(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set to the same value as the P bit in the received DISC command.

4.9 Handling unnumbered information

Unnumbered information can be exchanged at any time in any state except in the ADM and detached state.

4.9.1 Sending unnumbered information

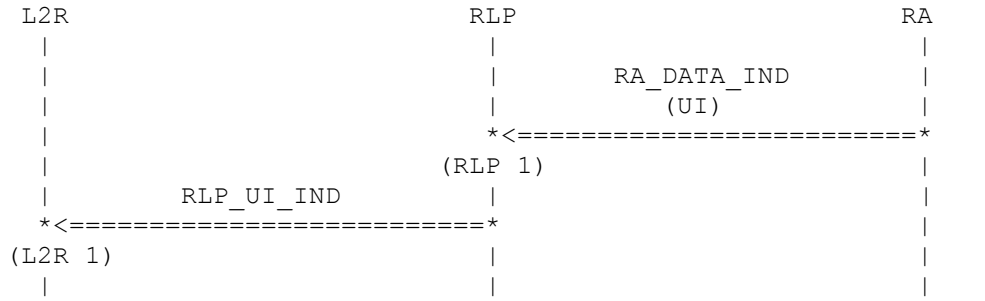


(RLP 1)
The RLP receives data to be transferred as unnumbered information. RLP will have to send an UI command at the next opportunity.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends the data in an UI command. The P-bit is always set to '0' in the current implementation of the RLP.

4.9.2 Unnumbered information is received



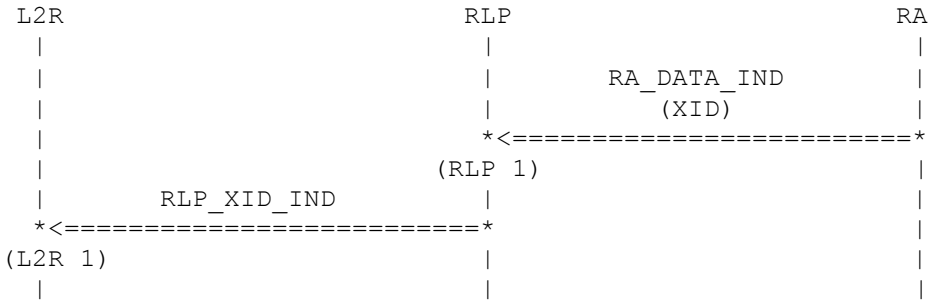
(RLP 1)
RLP receives unnumbered information in an UI frame.

(L2R 1)
The data are passed to the upper layer in a RLP_UI_IND.

4.10 Handling XID

Parameter negotiation with XID is started by RLP when switching to the ADM and attached mode from the detached mode (s. 4.1.1 Attachment of RLP). The response of the base station is covered in this section as well as the negotiation process, when it is started by the base station,.

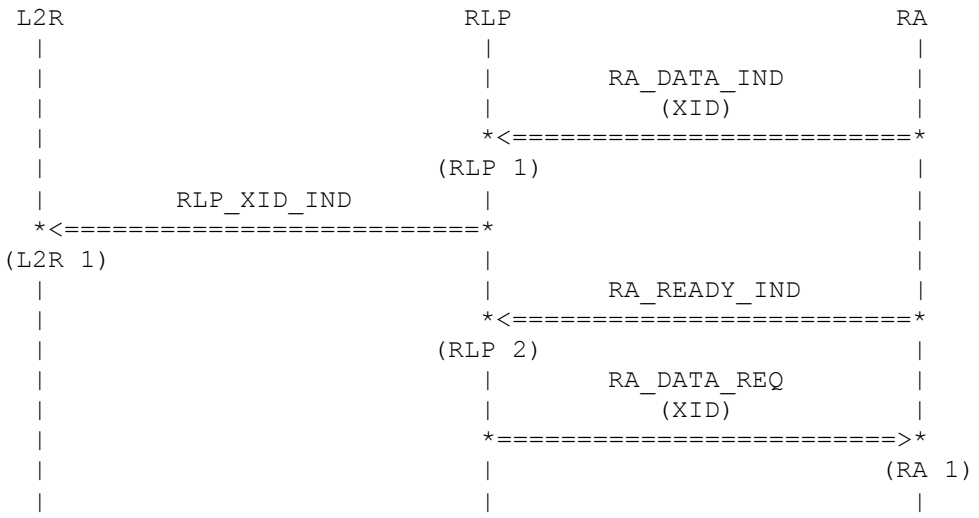
4.10.1 Receiving a XID response



(RLP 1)
RLP has previously sent a XID command. RLP receives now a XID response.

(L2R 1)
The negotiated parameters are passed to the upper layer in a RLP_XID_IND.

4.10.2 Receiving a XID command



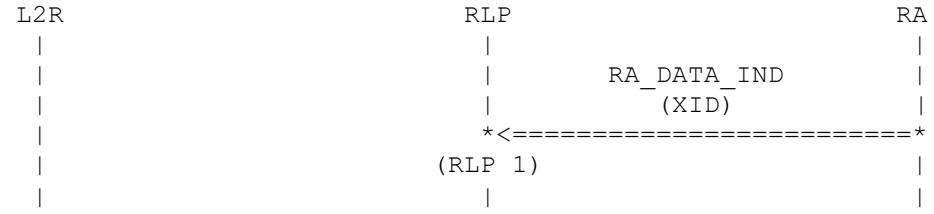
(RLP 1)
RLP has not previously sent a XID command. RLP receives now a XID command.

(L2R 1)
The parameters are passed to the upper layer in a RLP_XID_IND.

(RLP 2)
RLP receives the indication, that a frame can be sent.

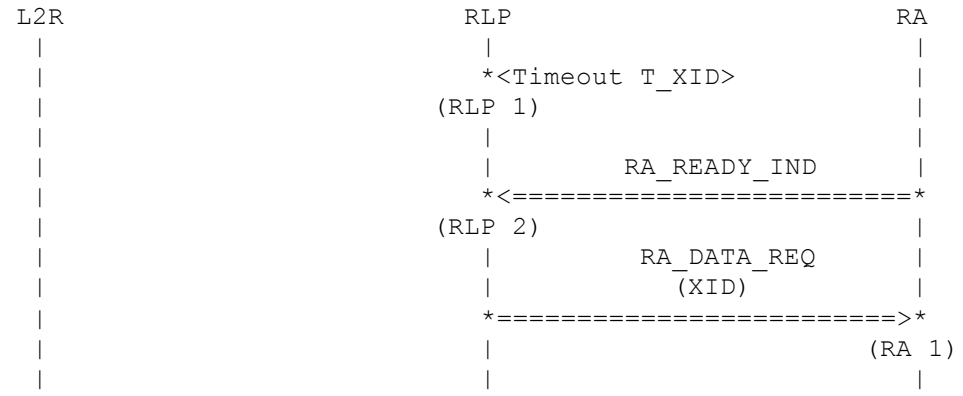
(RA 1)
RLP sends a XID response. The F-bit is set to the same value as the P bit in the received XID command.

4.10.3 Receiving a XID command (contention)



(RLP 1)
RLP has previously sent a XID command. RLP receives now a XID command from the base station. Since the base station is sending this XID command without considering the XID command of the mobile, a negotiation has not really taken place. Therefore the negotiation will be started again after some time. The mobile station sets a timer (T_XID), which will restart the negotiation after T1, while the base station shall wait twice as long.

4.10.4 Timeout of timer T_XID, max. retransmissions not reached

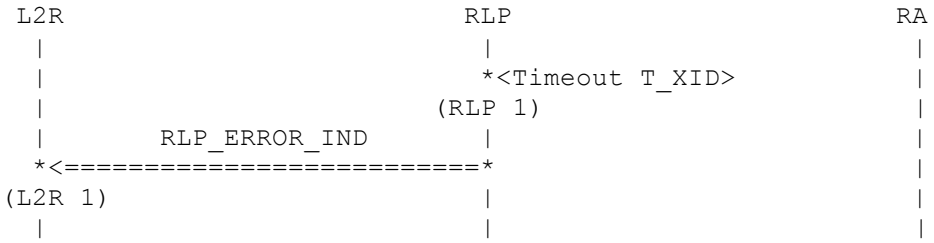


(RLP 1)
Timer T_XID expires. This occurs when a XID command has not been answered successfully by the base station. Either there was no XID response or the base station has simultaneously started the negotiation by sending a XID command.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP repeats the XID command.

4.10.5 Timeout of timer T_XID, max. retransmissions reached



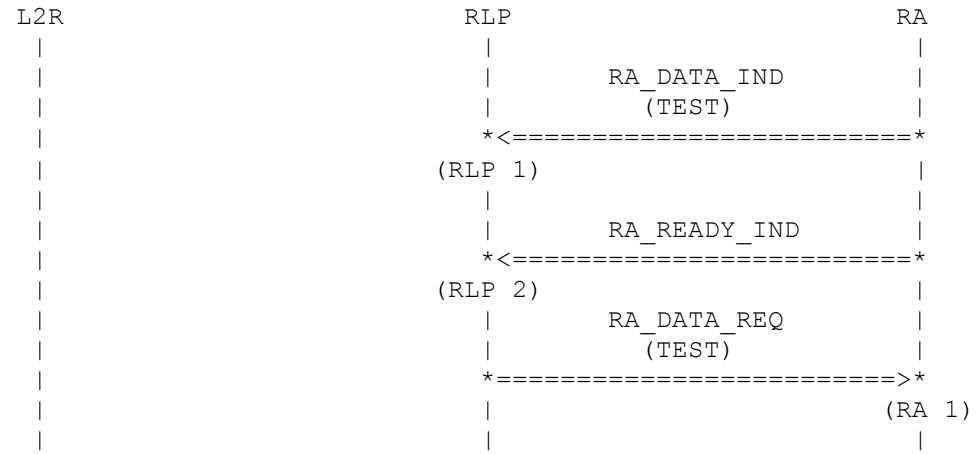
(RLP 1)
Timer T_XID expires.

(L2R 1)
RLP indicates an error to L2R. RLP is in the permanent error state, which can be left only by RLP_DETACH_REQ and RLP_DISC_REQ.

4.11 Handling TEST frames

TEST frames are there for testing and debugging a system. RLP does not support the sending of TEST commands in the current implementation, but it reacts on a TEST command from the base station with a TEST response.

4.11.1 Receiving a TEST command



(RLP 1)
RLP receives a TEST command.

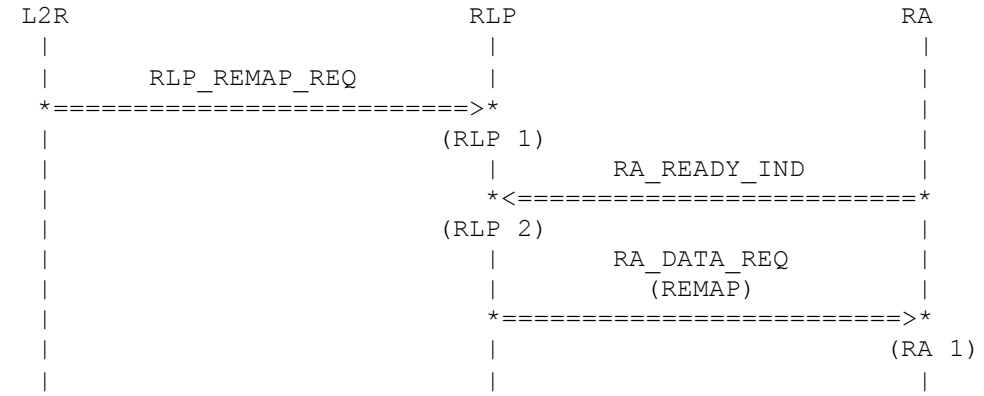
(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a TEST response. The F-bit is set to the same value as the P bit in the received TEST command. The data of the TEST command are returned in the response.

4.12 Synchronisation State (REMAP Exchange)

This state is entered after RLP is receiving a REMAP command from upper layer and passing the request to the peer entity. After REMAP Exchange, the channel coding is changed from TCH/F9.6 to TCH/F14.4 or vice versa. RLP have to map the frame size from 240 bits to 576 bits or vice versa.

4.12.1 Receiving a REMAP command

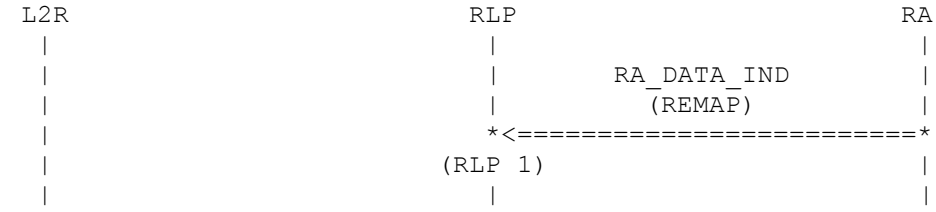


(RLP 1)
RLP receives a REMAP command.

(RLP 2)
RLP receives the indication, that a frame can be sent.

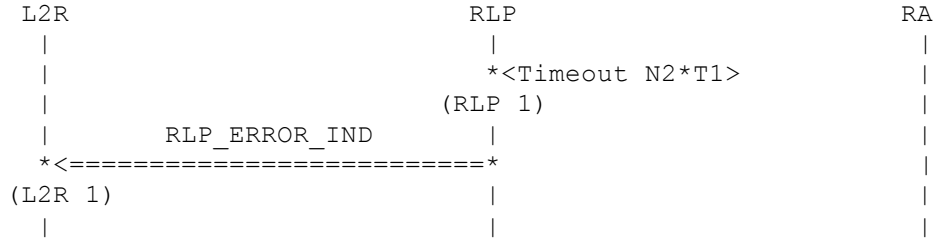
(RA 1)
RLP sends a REMAP command to the peer entity and changes in the synchronisation state.

4.12.2 Receiving a REMAP response



(RLP 1)
RLP receives a REMAP response from the peer entity. RLP leaves the synchronisation state and resumes in the operation mode.

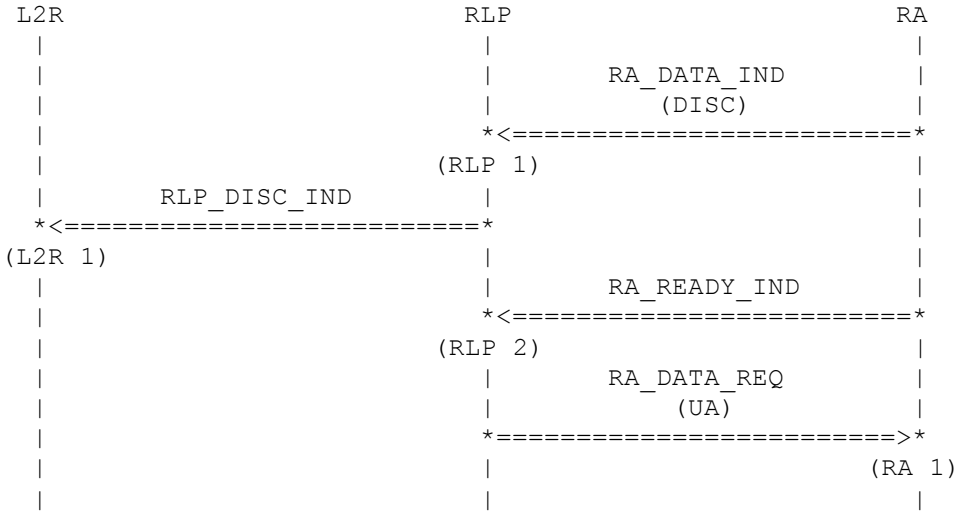
4.12.3 Timeout of timer N2*T1



(RLP 1)
Timer N2*T1 expires.

(L2R 1)
RLP indicates an error to L2R. RLP is in the permanent error state, which can be left only by RLP_DETACH_REQ and RLP_DISC_REQ.

4.12.4 Receiving Disconnection instead REMAP response



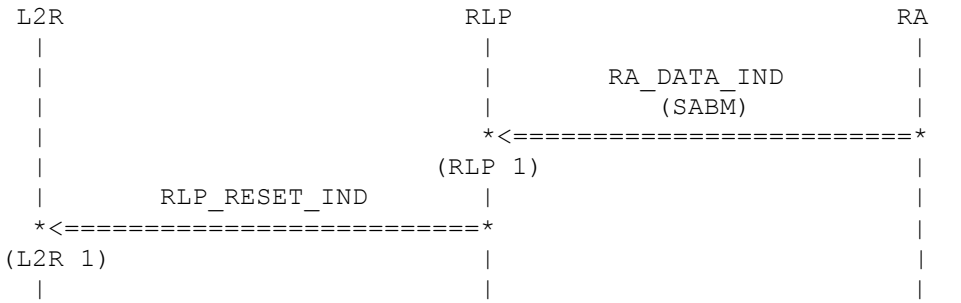
(RLP 1)
The RLP receives a DISC command. RLP stores the P-bit. RLP will have to send an UA response at the next opportunity.

(L2R 1)
RLP indicates to L2R, that the base station wants to disconnect.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends an UA response with the F-bit set according to the stored P-bit of the DISC command. RLP is in the ADM and attached state.

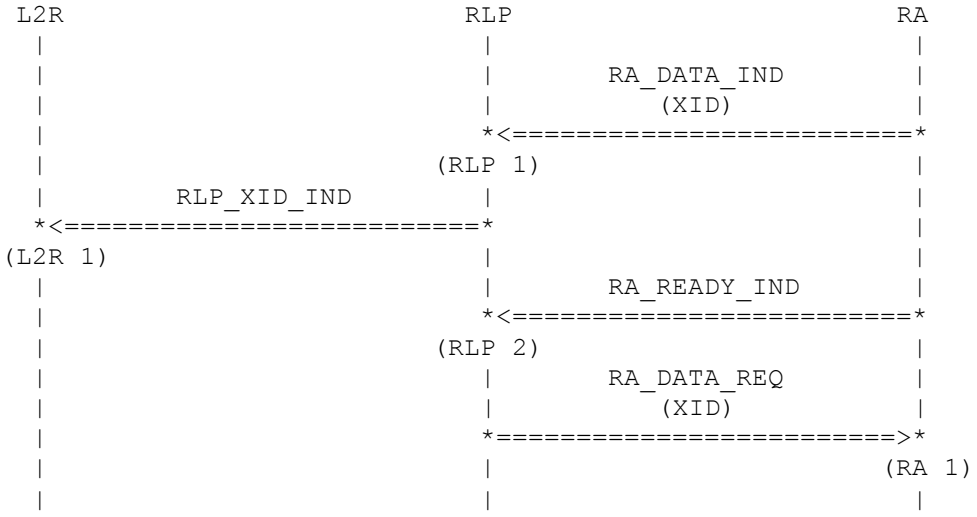
4.12.5 Receiving SABM from peer RLP



(RLP 1)
The RLP receives a SABM command.

(L2R 1)
RLP indicates the request to reset to L2R. RLP is in the pending reset indication state.

4.12.6 Receiving a XID command



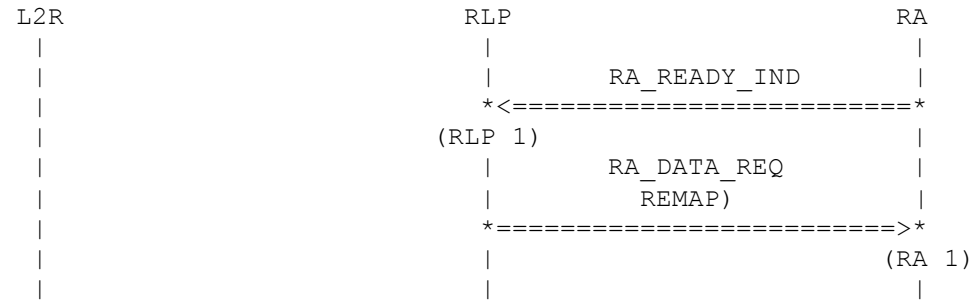
(RLP 1)
RLP has not previously sent a XID command. RLP receives now a XID command.

(L2R 1)
The parameters are passed to the upper layer in a RLP_XID_IND.

(RLP 2)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends a XID response. The F-bit is set to the same value as the P bit in the received XID command.

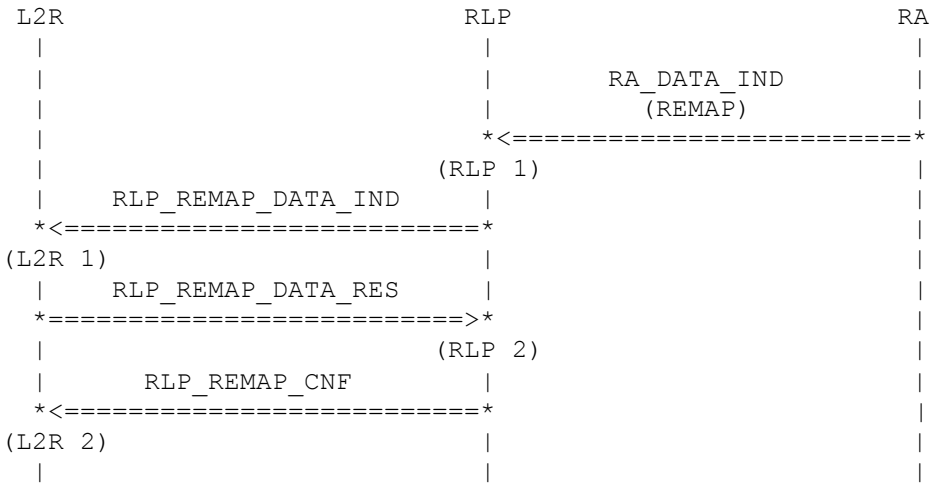
4.12.7 Receiving a Ready indication from lower layer, REMAP response not received



(RLP 1)
RLP receives the indication, that a frame can be sent.

(RA 1)
RLP sends REMAP frame on every sending opportunity, until a responding REMAP frame from the peer entity is received.

4.12.8 Receiving a REMAP response, send buffer is not empty (not sent or/and acknowledged frames)



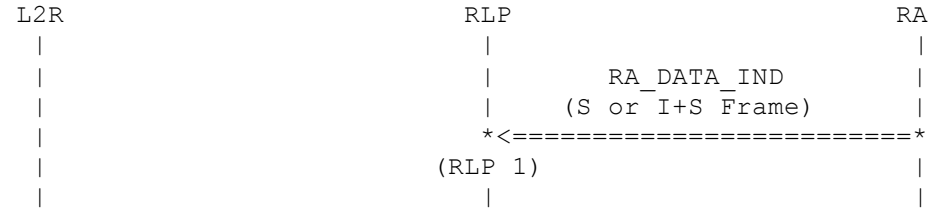
(RLP 1)
RLP receives the REMAP response. In Buffer is a not sent or/and acknowledged frame for lower layer. The frame has to mapped into new frame format. This is task of L2R.

(L2R 1)
RLP sends the frame back to L2R. The offset bit will be incremented.

(RLP 2)
RLP receives the response that a frame can be sent back.

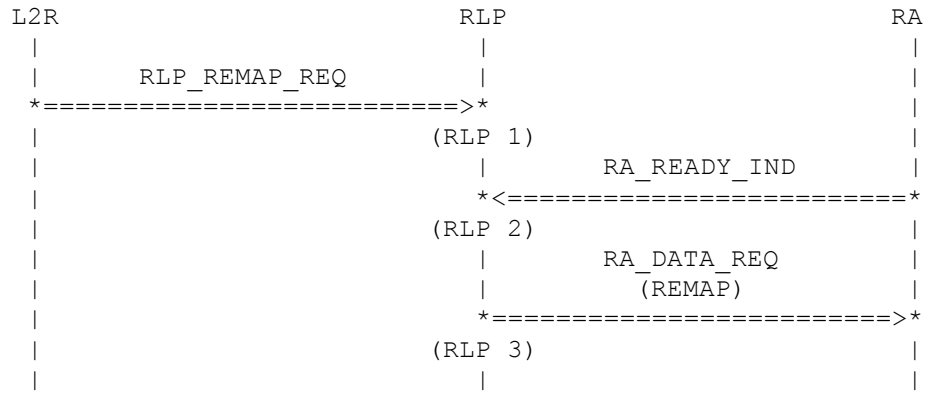
(L2R 2)
If more frames are to be sent back, the REMAP_DATA exchange will be repeated otherwise RLP sends a confirmation that all frames in the send buffer were sent back.

4.12.9 Receiving data instead REMAP response



(RLP 1)
RLP receives a S or I+S frame instead REMAP response. The frame has to be ignored.

4.12.10 Receiving a second REMAP request



(RLP 1)
RLP receives a second REMAP request.

(RLP 2)
RLP receives the response that a frame can be sent back.

(RLP 3)
RLP sends a new REMAP command to the peer entity.

Appendices

A. Acronyms

DS-WCDMA	Direct Sequence/Spread Wideband Code Division Multiple Access

B. Glossary

International Mobile Telecommunication 2000 (IMT-2000/ITU-2000)	Formerly referred to as FPLMTS (Future Public Land-Mobile Telephone System), this is the ITU's specification/family of standards for 3G. This initiative provides a global infrastructure through both satellite and terrestrial systems, for fixed and mobile phone users. The family of standards is a framework comprising a mix/blend of systems providing global roaming. <URL: http://www.imt-2000.org/>