Title

Transparent-RLC Concept Paper (Version 1)

Source

AT&T Wireless

Abstract

This contribution proposes a concept paper for transparent RLC (Radio Link Control). It uses the following three-part template adopted in GAHW-010241 [11]: identify requirements, recommend concept, and identify impact on specifications.

The requirements section uses the model proposed by Alan Cooper in *The Inmates are Running the Asylum – Why High-Tech Products Drive Us Crazy and How to Restore the Sanity*.

Questions and comments appear in magenta within angled brackets, *e.g.*, <comment>.

Proposals appear in blue, *e.g.*, proposal.

This contribution is available in *Acrobat* and *Word* formats. The *Acrobat* format is smaller and has fewer display artifacts.

Recommendation

For information.

History

Document	Date	Description	Editor
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1. Requirements

This document presents requirements for T-RLC (Transparent Radio Link Control). Based on these requirements, it develops concepts, and from the concepts, assesses the impact on new and existing standards. To focus requirements, it proposes persona, as suggested by Alan Cooper in *The Inmates are Running the Asylum* [1].

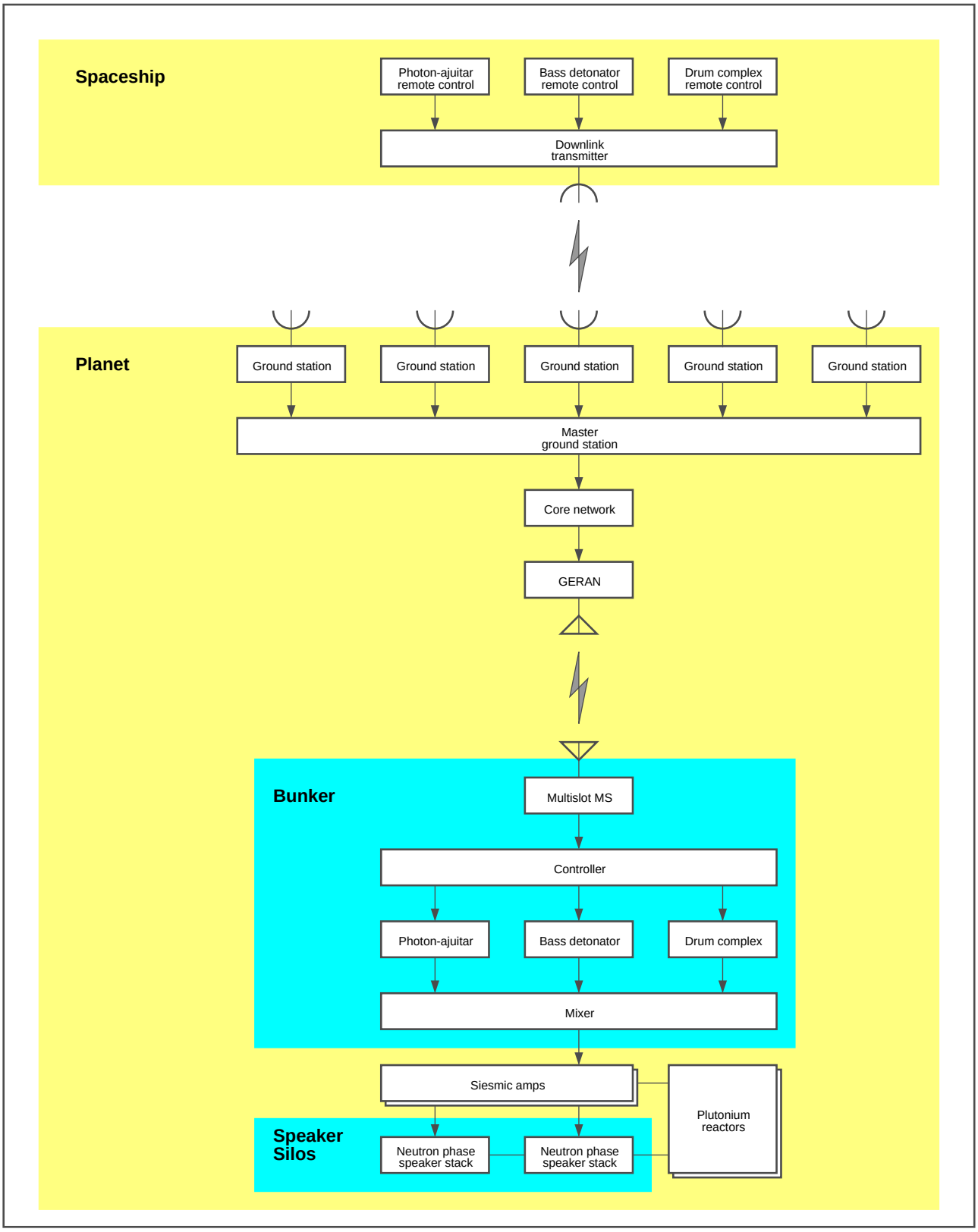
1.1 Persona

According to the *Hitchhiker's Guide to the Galaxy* [12], *Disaster Area*, a plutonium rock band from the *Gagrakacka Mind Zones*, is not only the loudest rock band in the galaxy, but in fact is the loudest noise of any kind. Regular concertgoers judge that the best sound balance is usually heard from within large concrete bunkers 37 miles from the stage. The musicians play their instruments by remote control from within a heavily insulated spaceship that stays in orbit around the planet, or more frequently, around a completely different planet. Many worlds have now banned *Disaster Area's* act, most commonly because the band's public-address system contravenes local strategic-arms-limitations treaties.

Figure 1 shows the configuration of *Disaster Area's* next concert over and on the red world of *Kakrafoon.* This document assumes GERAN will provide the final link to the bunkered instruments physically located below the speaker silos.

As anyone who has played the photon-ajuitar will tell you, timing is critical, far more important than timing for the bass detonator or megabang drum complex. For this reason, the photon-ajuitar control stream requires a slightly higher quality of service than the other two streams. Also, reproducing the nuance of the photon-ajuitar requires the highest data rate of the 3 instruments. The bass detonator requires the next-highest rate, and the megabang drum complex requires the lowest rate. The relative ratio of data rates is as follows: 4, 2, 1.

Figure 1: Disaster Area's Kakrafoon Concert Configuration



1.2 User-based requirements

T-RLC shall allow data to be transported with small end-to-end delay.

T-RLC shall allow data to be transported with small variation in delay, *i.e.*, it shall support isochronous operation.

T-RLC shall allow multiple data streams to be transported with small relative delay, *e.g.*, stream 1, 2, and 3 may be delayed by 5 seconds, but the difference in their delays shall not exceed 40 ms. These streams may have various bit rates.

1.3 System-based requirements

No protocol information shall be added to T-RLC PDUs, *i.e.*, a T-RLC PDU shall not have a header.

T-RLC may provide segmentation and reassembly.

T-RLC may provide time-based SDU discard. SDUs shall be discarded without peer-to-peer signalling.

T-RLC may be stopped and continued.

1.4 User-based scenarios

The following user-based scenarios will be used to develop the concepts in § 2:

- Transport streaming control data from three remote controls, located in the spaceship, to their corresponding three instruments located in concrete bunkers below the planet's surface.

1.5 System-based scenarios

The following system-based scenarios will be used to develop the concepts in § 2:

- Configure T-RLC for use by a radio bearer.
- Release T-RLC.

2. Concept

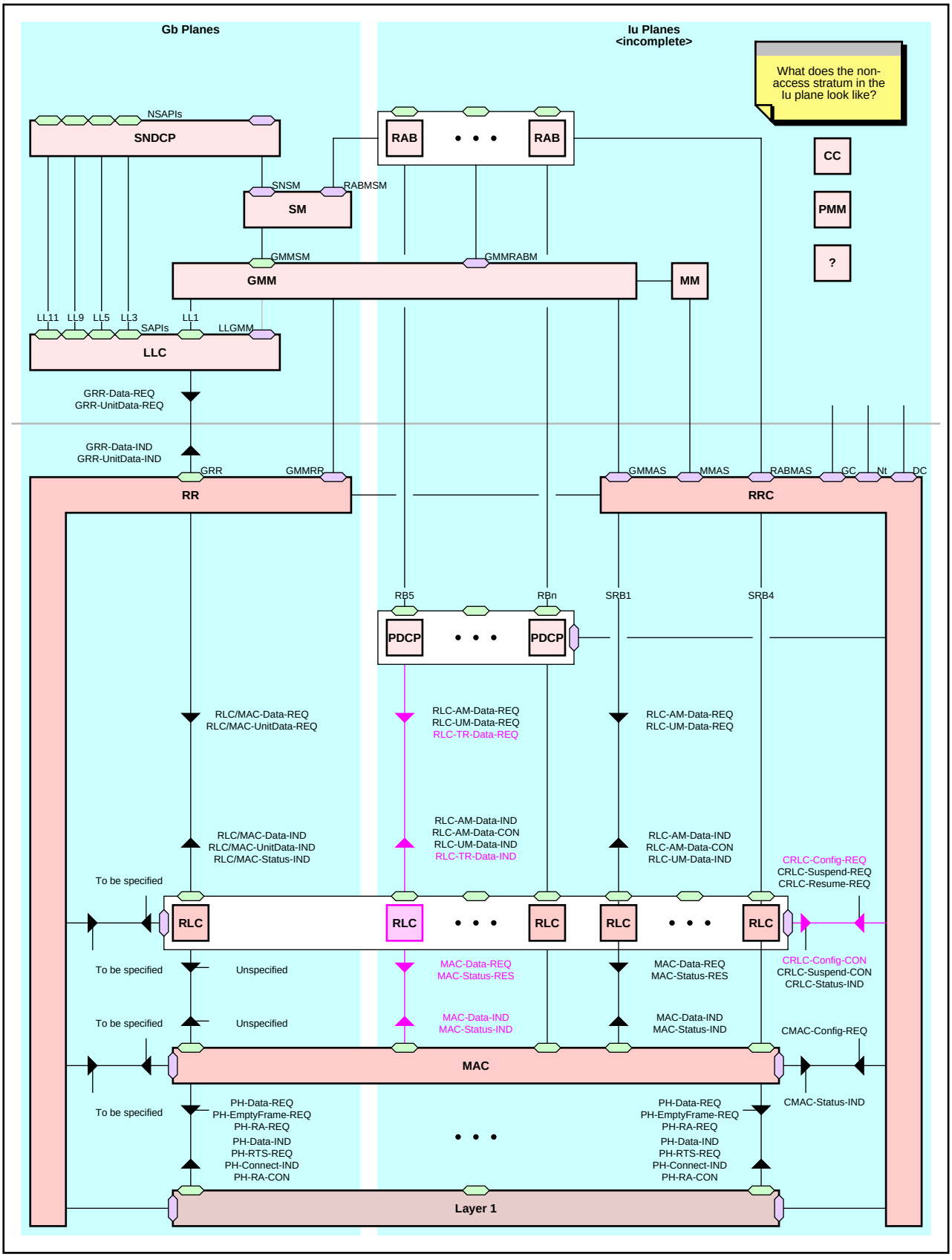
This section uses concepts from X.200 [13], X.210 [14], Z.100 [15], and Z.120 [16]. These concepts are not intended to unnecessarily constrain implementations.

2.1 Position in protocol stack

Figure 2 shows the position of T-RLC in the GERAN protocol stack. T-RLC, its interlayer reference points, and its related interlayer service primitives appear in magenta.

T-RLC, part of the RLC layer, resides between PDCP (Packet-Data Convergence Protocol) and MAC (Medium Access Control). Under RRC control, the RLC layer manager (RLCM) configures RLC to contain none to multiple T-RLC entities.

Figure 2: T-RLC position in GERAN protocol stack



2.2 Services provided by T-RLC

T-RLC provides the following services to the upper layers:

- Transparent data transport.
- Discard of stale T-RLC SDUs.

2.3 Services expected from MAC

T-RLC requires the following services from MAC:

- Data transport.
- Scheduling.
- T-RLC PDU size selection.
- MAC SDU group identification (used for T-RLC SDU reassembly).
- Ciphering.

2.4 Structure

Figure 3 shows a reference model for T-RLC. This model, commonly known as a functional block diagram, is not intended to constrain implementations.

Figure 3: T-RLC reference model

<insert model when § 2.8 is developed.>

2.5 Functions

T-RLC provides the following functions:

- Segmenting individual T-RLC SDUs into multiple transmitted T-RLC PDUs. Reassembling multiple received T-RLC PDUs into individual T-RLC SDUs.

  Since T-RLC has no header that would support reassembly, RRC will have to configure MAC to know how many T-RLC PDUs (MAC SDUs) constitute a T-RLC SDU. RRC peers will have to agree on the segmenting scheme at service establishment and then appropriately configure MAC peers. MAC peers will likely keep track of the T-RLC segments by monitoring frame numbers, *e.g.*, every four frames starting at frame 0 constitute the four T-RLC PDUs that carry the segments of a T-RLC SDU. <Do we support adaptive modulation and coding?>

- Discarding stale T-RLC SDUs. Each SDU has its own timer, but each timer has the same configurable start value.

2.6 Signals

T-RLC uses three types of signals:

- T-RLC SDUs received from higher layers.
- T-RLC PDUs sent via lower layers to the T-RLC peer.
- Service primitives for providing service to higher layers, for providing interfunction communication within the RLC layer, and for obtaining service from layer 1.

2.6.1 T-RLC SDUs

A T-RLC SDU is a bit string of length greater than 0. A T-RLC SDU may be segmented.

A T-RLC SDU segment is a bit string of length greater than 0 and less than or equal to the length of its source T-RLC SDU.

2.6.2 T-RLC PDUs

A T-RLC PDU is a bit string of length signalled by MAC. It contains one T-RLC SDU segment. Unlike most PDUs, it does not contain a header.

2.6.3 Service Primitives

T-RLC uses the following service primitives:

Primitive	Route	Description
`CRLC-Config-CON`	RRC←RLCM	RLCM (RLC Manager) confirms configuration of RLC elements.
`CRLC-Config-REQ`	RRC→RLCM	RRC requests configuration of RLC elements.
`MAC-Data-IND`	T-RLC←MAC	MAC indicates it is delivering an SDU received from its peer.
`MAC-Data-REQ`	T-RLC→MAC	T-RLC requests MAC transport data to the T-RLC peer.
`MAC-Status-IND`	T-RLC←MAC	MAC indicates one of the following: it is polling for data, it is ready to transport data.
`MAC-Status-RES`	T-RLC→MAC	T-RLC responds that it has data to send.
`RLC-TR-Data-IND`	PDCP←T-RLC	T-RLC indicates it is delivering an SDU received from its peer.
`RLC-TR-Data-REQ`	PDCP→T-RLC	The higher layer requests T-RLC transport data to the higher-layer peer.
`RLC-TR-Kill-REQ`	RCLM→T-RLC	RLCM requests T-RLC kill itself.
`RLC-TR-Kill-CON`	RCLM←T-RLC	T-RLC confirms it is about to die.
`RLC-TR-Ready-IND`	RCLM←T-RLC	T-RLC indicates it is ready to transport data.

2.7 Sequences

Sequences in this section derive from the requirements and scenarios of § 1. Figures contain the sequence diagrams. A table following each figure describes message events in the sequence, including the values of directly relevant information elements.

Within each sequence diagram, the following conventions apply:

- Magenta arrows indicate control signals.
- Green arrows indicate user data.
- Heavy vertical lines indicate a stimulus-response relationship between messages.

Unless stated otherwise, the following conditions apply for each sequence:

- Data for the photon-ajuitar will be carried by T-RLC$_1$.
- Data for the bass detonator will be carried by T-RLC$_2$.
- Data for the megabang drum complex will be carried by T-RLC$_3$.

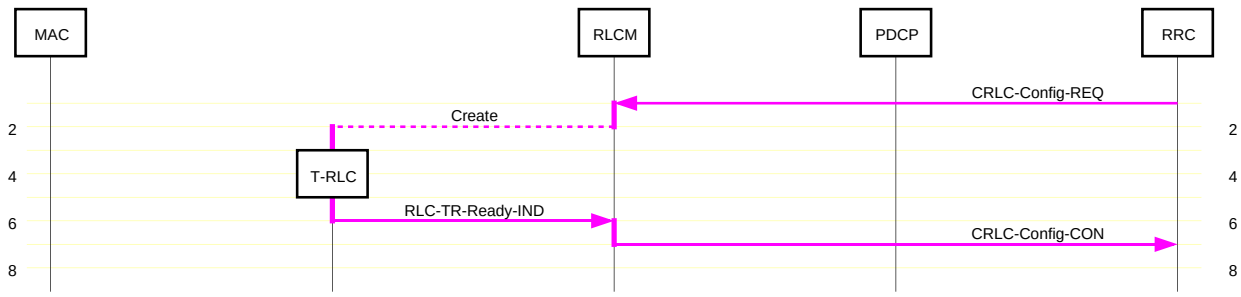
2.7.1 Configure T-RLC

This sequence corresponds to the following system-based scenario:

- Configure T-RLC for use by a transparent radio bearer.

Figure 4 shows RRC configuring the RLC layer to support a transparent radio bearer. To configure 3 transparent radio bears, the sequence would be repeated three times.

Figure 4: Configure T-RLC



Line	Description	Direction
1	CRLC-Config-REQ *{action, RBid, SDU-discard timer, QoS}* RRC requests that RLCM set up a transparent RLC to handle data flow from PDCP. • *Action* indicates *setup*. If a T-RLC already exists for this radio bearer and *action* indicates *setup*, RLCM will not reset the T-RLC. • *RBid* identifies the radio bearer. • *SDU discard timer* indicates the time an SDU will remain in the T-RLC input buffer before being discarded. If a T-RLC already exists for this radio bearer, a new value for *SDU discard timer* applies to all SDUs: those presently buffered and new SDUs. • *QoS* indicates the quality of service to be provided by T-RLC.	RLCM←RRC
2	Create *{SDU discard timer, QoS}* RLCM creates a T-RLC process to handle the transparent data flow. • *SDU discard timer* indicates the time an SDU will remain in the T-RLC input buffer before being discarded. • *QoS* indicates the quality of service to be provided by the created T-RLC.	T-RLC←RLCM
6	RLC-TR-Ready-IND The created TRLC indicates that is ready to transport data.	T-RLC→RLCM
7	CRLC-Config-CON *{RBid}* RLCM confirms the transparent RLC is ready to transport data. • *RBid* identifies the radio bearer.	RLCM→RRC

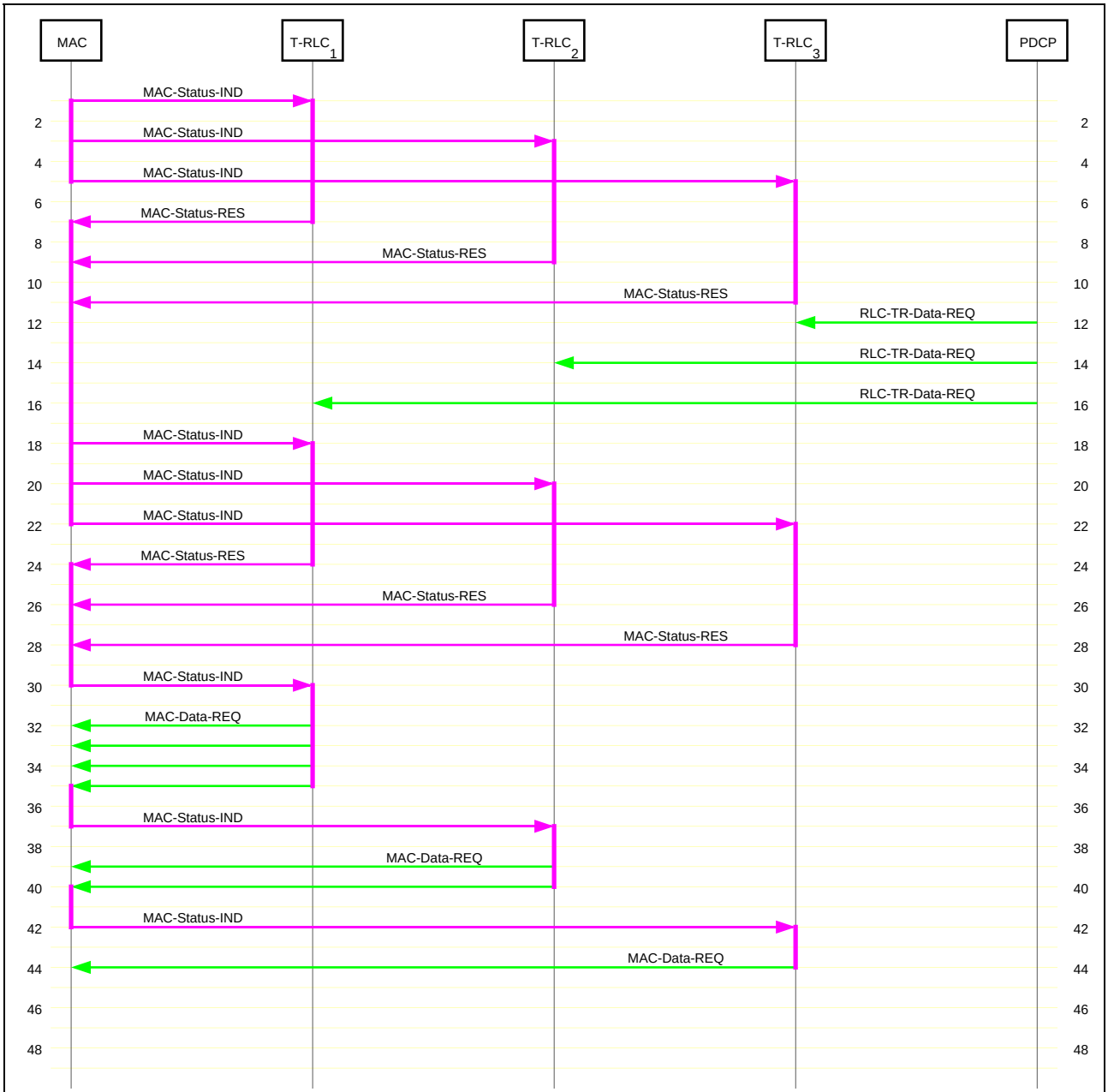
2.7.2 Transmit data

This sequence corresponds to the following system-based scenario:

- Transport control data for three remote controls, located in the spaceship, to their corresponding three instruments located in concrete bunkers below the planet's surface.

Figure 5 shows 3 GERAN T-RLCs transmitting data to the mobile station.

Figure 5: Transmit data



Line	Description	Direction
1	MAC-Status-IND *{purpose, MAC SDU size}* MAC polls T-RLC$_1$ for data. • *Purpose* indicates *poll*. • *MAC SDU size* indicates the number of bits per SDU that MAC is willing to accept for this transmission opportunity.	MAC→T-RLC$_1$
3	MAC-Status-IND *{purpose, MAC SDU size}* Same as line 1 except MAC polls T-RLC$_2$ for data.	MAC→T-RLC$_2$
5	MAC-Status-IND *{purpose, MAC SDU size}* Same as line 1 except MAC polls T-RLC$_3$ for data.	MAC→T-RLC$_3$

7	MAC-Status-RES *{PDUs, priority}* T-RLC$_1$ responds that it has no PDUs to send. • *PDUs* is 0. • *Priority* is 0.	MAC←T-RLC$_1$
9	MAC-Status-RES *{PDUs, priority}* Same as line 7 except T-RLC$_2$ responds.	MAC←T-RLC$_2$
11	MAC-Status-RES *{PDUs, priority}* Same as line 7 except T-RLC$_3$ responds.	MAC←T-RLC$_3$
12	RLC-TR-Data-REQ *{T-RLC SDU}* PDCP requests that T-RLC$_3$ transport a PDCP PDU to the PDCP peer. T-RLC$_3$ starts the discard timer for this RLC SDU. If the timer expires, T-RLC$_3$ will silently discard the T-RLC SDU. T-RLC$_3$ will not discard any SDU for which a segment has been sent to MAC. • *RLC SDU* is the PDU received from PDCP.	T-RLC$_3$←PDCP
14	RLC-TR-Data-REQ *{T-RLC SDU}* Same as line 12 except T-RLC$_2$ services the request.	T-RLC$_2$←PDCP
16	RLC-TR-Data-REQ *{T-RLC SDU}* Same as line 12 except T-RLC$_1$ services the request.	T-RLC$_1$←PDCP
18	MAC-Status-IND *{purpose, MAC SDU size}* Same as line 1.	MAC→T-RLC$_1$
20	MAC-Status-IND *{purpose, MAC SDU size}* Same as line 3.	MAC→T-RLC$_2$
22	MAC-Status-IND *{purpose, MAC SDU size}* Same as line 5.	MAC→T-RLC$_3$
24	MAC-Status-RES *{PDUs, priority}}* T-RLC$_1$ responds that it has 4 PDUs of priority 3 to send, *i.e.*, it has 4 segments of high-priority data. T-RLC$_1$ derives its priority from the QoS established at creation. • *PDUs* is 4. It indicates the number of MAC SDUs of *MAC SDU size* that will transport the T-RLC SDU without truncation or padding. This obviously requires that RRC coordinate among PDCP, RLC, MAC, and PHY. • *Priority* is 3.	MAC←T-RLC$_1$
26	MAC-Status-RES *{PDUs, priority}* T-RLC$_2$ responds that it has 2 PDUs of priority 2 to send, *i.e.*, it has 2 segments of medium-priority data. T-RLC$_2$ derives its priority from the QoS established at creation. • *PDUs* is 2. It indicates the number of MAC SDUs of *MAC SDU size* that will transport the T-RLC SDU without truncation or padding. • *Priority* is 2.	MAC←T-RLC$_2$
28	MAC-Status-RES *{PDUs, priority}* T-RLC$_3$ responds that it has one PDU of priority 2 to send, *i.e.*, it has one segment of medium-priority data. T-RLC$_3$ derives its priority from the QoS established at creation. • *PDUs* is 1. It indicates the number of MAC SDUs of *MAC SDU size* that will transport the T-RLC SDU without truncation or padding. • *Priority* is 2.	MAC←T-RLC$_3$

30	MAC-Status-IND *{purpose, MAC SDU size}* MAC indicates that T-RLC$_1$, the T-RLC with the highest-priority, should send its data. • *Purpose* indicates *ready for data*. • *MAC SDU size* indicates the number of bits per SDU that MAC is willing to accept for this transmission opportunity.	MAC→T-RLC$_1$
32	MAC-Data-REQ *{MAC SDU}* T-RLC$_1$ requests that MAC transport data to the T-RLC$_1$ peer.	MAC←T-RLC$_1$
33	MAC-Data-REQ *{MAC SDU}* Same as line 32.	MAC←T-RLC$_1$
34	MAC-Data-REQ *{MAC SDU}* Same as line 32.	MAC←T-RLC$_1$
35	MAC-Data-REQ *{MAC SDU}* Same as line 32.	MAC←T-RLC$_1$
37	MAC-Status-IND *{purpose, MAC SDU size}* MAC indicates that T-RLC$_2$, a T-RLC with medium priority, should send its data. Since T-RLC$_3$ has the same priority, it could have been serviced instead. • *Purpose* indicates *ready for data*. • *MAC SDU size* indicates the number of bits per SDU that MAC is willing to accept for this transmission opportunity.	MAC→T-RLC$_2$
39	MAC-Data-REQ *{MAC SDU}* T-RLC$_2$ requests that MAC transport data to the T-RLC$_2$ peer.	MAC←T-RLC$_2$
40	MAC-Data-REQ *{MAC SDU}* Same as line 39.	MAC←T-RLC$_2$
42	MAC-Status-IND *{purpose, MAC SDU size}* MAC indicates that T-RLC$_3$, a T-RLC with medium priority, should send its data. • *Purpose* indicates *ready for data*. • *MAC SDU size* indicates the number of bits per SDU that MAC is willing to accept for this transmission opportunity.	MAC→T-RLC$_3$
44	MAC-Data-REQ *{MAC SDU}* T-RLC$_3$ requests that MAC transport data to the T-RLC$_3$ peer.	MAC←T-RLC$_3$

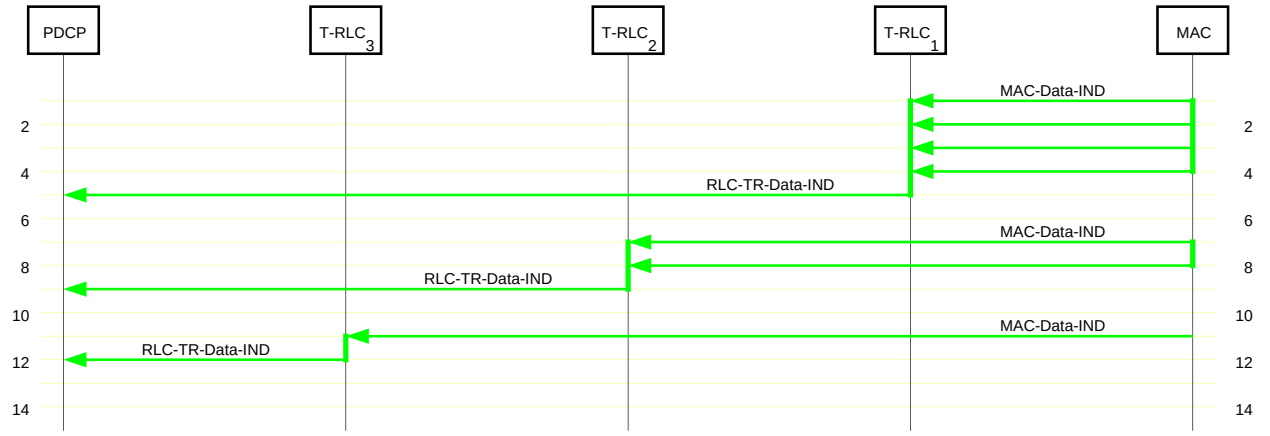
2.7.3 Receive data

This sequence corresponds to the following system-based scenario:

- Transport control data for three remote controls located in the spaceship to their corresponding three instruments located in concrete bunkers below the planet's surface.

Figure 6 shows 3 MS T-RLCs receiving data from GERAN.

Figure 6: Receive data



Line	Description	Direction
1	MAC-Data-IND *{MAC SDU, Status}* MAC indicates it is delivering an SDU received from its peer. • *MAC SDU* contains the received MAC SDU. • *Status* indicates *first* SDU of this group.	$T\text{-}RLC_1 \leftarrow MAC$
2	MAC-Data-IND *{MAC SDU, Status}* MAC indicates it is delivering an SDU received from its peer. • *MAC SDU* contains the received MAC SDU. • *Status* indicates *intermediate* SDU of this group.	$T\text{-}RLC_1 \leftarrow MAC$
3	MAC-Data-IND *{MAC SDU, Status}* Same as line 2.	$T\text{-}RLC_1 \leftarrow MAC$
4	MAC-Data-IND *{MAC SDU, Status}* MAC indicates it is delivering an SDU received from its peer. • *MAC SDU* contains the received MAC SDU. • *Status* indicates *final* SDU of this group. If MAC fails to receive any SDU of the group, *status* indicates *failure*.	$T\text{-}RLC_1 \leftarrow MAC$
5	RLC-TR-Data-IND *{T-RLC SDU}* $T\text{-}RLC_1$ indicates it is delivering an SDU received from its peer. • *T-RLC SDU* is the SDU created by reassembling the group of MAC SDUs (RLC PDUs).	$PDCP \leftarrow T\text{-}RLC_1$
7	MAC-Data-IND *{MAC SDU, Status}* Same as line 1 except MAC indicates to $T\text{-}RLC_2$.	$T\text{-}RLC_2 \leftarrow MAC$
8	MAC-Data-IND *{MAC SDU, Status}* Same as line 4 except MAC indicates to $T\text{-}RLC_2$.	$T\text{-}RLC_2 \leftarrow MAC$
9	RLC-TR-Data-IND *{T-RLC SDU}* Same as line 5 except $T\text{-}RLC_2$ indicates to PDCP.	$PDCP \leftarrow T\text{-}RLC_2$
11	MAC-Data-IND *{MAC SDU, Status}* Same as line 4 except MAC indicates to $T\text{-}RLC_3$.	$T\text{-}RLC_3 \leftarrow MAC$
12	RLC-TR-Data-IND *{T-RLC SDU}* Same as line 5 except $T\text{-}RLC_3$ indicates to PDCP.	$PDCP \leftarrow T\text{-}RLC_3$

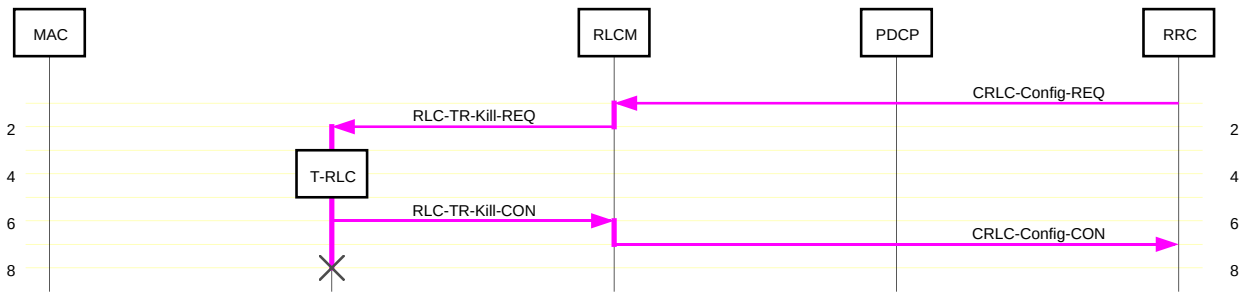
2.7.4 Release T-RLC

This sequence corresponds to the following system-based scenario:

- Release T-RLC.

Figure 7 shows RRC configuring the RLC layer to release a T-RLC. To release 3 transparent radio bears, the sequence would be repeated three times.

Figure 7: Release T-RLC



Line	Description	Direction
1	CRLC-Config-REQ *{action, RBid, SDU-discard timer, QoS}* RRC requests that RLCM release a transparent RLC. • *action* indicates *release.* • *RBid* identifies the radio bearer. • *SDU discard timer* is *null*. • *QoS* is *null*.	RLCM←RRC
2	RLC-TR-Kill-REQ RLCM kills the T-RLC.	T-RLC←RLCM
6	RLC-TR-Kill-CON T-RLC confirms that it is about to die.	T-RLC→RLCM
7	CRLC-Config-CON *{RBid}* RLCM confirms the transparent RLC is released.	RLCM→RRC

2.8 Processes

RLC contains two processes of interest for transparent data transport: RLCM (Radio-Link-Control Manager) and T-RLC (Transparent Radio Link Control).

<This section will be specified when previous sections have been adopted.>

2.8.1 RLC Manager

Although this process desperately needs to be specified, it is presently beyond the scope of this document.

2.8.2 Transparent RLC

2.9 Procedures

This section specifies each of the procedures called in the processes of § 2.8.

3. Impact on specifications

This section is incomplete.

3.1 Changes to 23.060 (GPRS stage 2)

Section	Description

3.2 Changes to 44.060 (GERAN RLC/MAC)

Section	Description

3.3 Changes to 45.002 (L1 Multiplexing)

Section	Description

4. References

1. Cooper, Alan. *The Inmates are Running the Asylum – Why High-Tech Products Drive Us Crazy and How to Restore the Sanity.* Indianapolis: SAMS, 1999.

2. 3GPP TS 23.060. *3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS); Service description; Stage 2.*

3. 3GPP TS 24.008. *3rd Generation Partnership Project; Technical Specification Group Core Network; Mobile radio interface layer 3 specification; Core Network Protocols - Stage 3.*

4. 3GPP TS 25.304. *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UE Procedures in Idle mode and Procedures for Cell Reselection in Connected Mode.*

5. 3GPP TS 25.331. *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; RRC Protocol Specification.*

6. 3GPP TS 25.413. *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu interface RANAP signalling.*

7. 3GPP TS 43.064. *3rd Generation Partnership Project; Technical Specification Group GERAN; Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Overall description of the GPRS radio interface; Stage 2.*

8. 3GPP TS 44.018. *3rd Generation Partnership Project; Technical Specification Group GSM EDGE Radio Access Network; Mobile radio interface layer 3 specification; Radio Resource Control Protocol.*

9. 3GPP TS 44.060. *3rd Generation Partnership Project; Technical Specification Group GSM EDGE Radio Access Network; General Packet Radio Service (GPRS); Mobile Station (MS) – Base Station System (BSS) interface; Radio Link Control / Medium Access Control (RLC/MAC) protocol.*

10. 3GPP TS 45.002. *3rd Generation Partnership Project; Technical Specification Group GERAN; Digital cellular telecommunications system (Phase 2+); Multiplexing and multiple access on the radio path.*

11. GAHW-010241. *Results of RLC/MAC drafting meeting.* Bellevue: GERAN Ad Hoc, 07 May 01.

12 *Hitchhiker's Guide to the Galaxy.* Ursa Minor Beta: Megadodo Publications.
<Apologies to the late Douglas Adams.>

13. ITU-T X.200. *Information Technology – Open Systems Interconnection – Basic Reference Model: The Basic Model.* Geneva: International Telecommunication Union, July 1994.

14. ITU-T X.210. *Information Technology – Open Systems Interconnection – Basic Reference Model: Conventions for the Definition of OSI Services.* Geneva: International Telecommunication Union, November 1993.

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16. ITU-T Z.120. *Message Sequence Chart (MSC).* Geneva: International Telecommunication Union, March 1993.

A. Annex A