ETSI TS 101 761-4 V1.2.1 (2000-12)

Technical Specification

Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Data Link Control (DLC) Layer; Part 4: Extension for Home Environment

Reference
RTS/BRAN-0020004-4R1

Keywords
access, broadband, hiperlan, IP, layer 2, MAC, radio

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://www.etsi.org/ipr).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Specification (TS) has been produced by ETSI Project Broadband Radio Access Networks (BRAN).

The present document describes the extension of the basic specifications of Data Link Control (DLC) of HIPERLAN/2 systems for home applications. Separate ETSI documents provide details on the system overview, the physical layer, the basic DLC layer functions, the convergence sublayers and the conformance test requirements defined for HIPERLAN/2.

The present document is part 4 of a multi-part deliverable covering the HIPERLAN Type 2; Data Link Control (DLC) Layer, as identified below:

Part 1: "Basic Data Transport Functions".

Part 2: "Radio Link Control sublayer".

Part 3: "Extension for Business Environment".

Part 4: "Extension for Home Environment".

Part 5: "Profile for Home Environment".

Introduction

The H/2 system is confined to the two lowest layers of the open systems interconnection (OSI) model, the physical and the data link control layer. An overall description of the H/2 system is given in TR 101 683 (see Bibliography). The PHY layer is described in TS 101 475 [3].

The basic DLC layer functions are specified in two different documents (TS 101 761-1 [1] and TS 101 761-2 [2]). Document TS 101 761-1 [1] describes Transport and Logical Channels, Error Control, MAC, and mapping between PHY and MAC of H/2 system. Document TS 101 761-2 [2] deals with Radio Link Control (RLC) protocols to control radio resources, terminal association and connection establishment. The inter-working with higher layers is handled by convergence layers (CLs) on top of the DLC layer. The common part of packet and cell based convergence layer are defined in TS 101 493-1 and TS 101 763-1 (see Bibliography), respectively.

1 Scope

The present document specifies the extension of the basic DLC layer functions in TS 101 761-1 [1] and TS 101 761-2 [2] for direct mode operation in home environment. This DLC home extension specification gives first an overview of the H/2 home system concept. It then describes additional rules and elements to transport DM data over the channels introduced in TS 101 761-1 [1]. Forward Error Correction (FEC) is introduced in the DLC layer to achieve a much lower bit error rate for isochronous packet transport without ARQ. The present document also extends the RLC protocols in TS 101 761-2 [2] to support Constant Bit Rate (CBR) traffic by fixed slot allocation, to enable parameter negotiation for multicast connections, to enable association of multiple CLs for wireless terminals, and to enable direct link (DiL) Power Control. Furthermore, It describes some RLC protocols which are only specific for DM operation in home environment, such as DiL Link Quality Calibration, Dynamic CC Selection, and CC Responsibility Handover. Besides, a PIN and time-window based authentication key distribution protocol is specified for HIPERLAN2 Home Devices (H/2-HDs). The DM services can be used by the IEEE 1394 CL (TS 101 493-3 and TS 101 493-4 (see Bibliography)) for wireless bridging of different IEEE 1394 buses.

The present document does not contain algorithms, which are only performed locally in a device, but describes rules and elements to transport data over the air interface. The goal is to provide interoperability between devices of different manufacturers.

The present document does not address the requirements and technical characteristics for conformance testing. These are covered in a separate set of documents.

2 References

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

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

[1] ETSI TS 101 761-1: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Data Link Control (DLC) Layer; Part 1: Basic Data Transport Functions".

[2] ETSI TS 101 761-2: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Data Link Control (DLC) Layer; Part 2: Radio Link Control (RLC) sublayer".

[3] ETSI TS 101 475: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Physical (PHY) Layer".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Access Feedback Channel: transport channel where the results of access attempts made in the random access phase of the previous MAC frame is conveyed.

Association Control Function: group of control functions on top of the RLC that is responsible for the handling of the association between WT and CC.

ASsociation control CHannel: logical channel in uplink that conveys new association and re-association request messages.

Access Point: term Access Point used in the basic specifications is replaced by the term Central Controller throughout the present document to reflect that in home environment multiple H/2 devices can act as the access point to a fixed network, whereas the whole H/2 network is still controlled by a single entity, the Central Controller.

Basic WT: H/2 home device, which is able to associate with a CC and to communicate with the CC in the control plane and with other H/2 home devices in the user and control planes. A basic WT is unable to become the CC.

Broadcast CHannel: transport channel that broadcasts control information.

Broadcast Control Channel: logical channel that broadcasts control information which is relevant for the current MAC frame.

CC-capable WT: H/2 home device, which can act either as a Central Controller, or as a basic WT. When it is acting as the CC with respect to the control plane, it supports all features of a basic WT.

Central Controller: provides control functionality equivalent to that of an access point in TS 101 761-1 [1] and TS 101 761-2 [2] but is not necessarily attached to a fixed network. This term is used where the central controller functionality is embedded in a WT.

Centralized Mode: in centralized mode, all data transmitted or received by a mobile terminal have to pass the centralized controller, even if the data exchange is between mobile terminals associated to the same centralized controller.

DLC connection: HIPERLAN/2 DLC operation is connection oriented. A DLC connection carries user or control data and is identified by a DLC connection identifier.

DLC User Connection: DLC user connection is uniquely identified by the DLC connection ID and the MAC ID of the mobile terminal in CM. In DM two MAC IDs are necessary.

DLC User Connection Control: group of control functions on top of the RLC that is responsible for the handling of DLC user connections.

Downlink phase: part of the Downlink transmission of a MAC Frame during which user and control data is transmitted from the access point or central controller to mobile terminals. The data transmitted can be user as well as control data in unicast, broadcast and multicast modus.

Direct Mode: data exchanged between two WTs associated with the same CC takes place without passing but under control of the central controller.

Direct link phase: part of a MAC frame that only contains the data exchanged directly between two WTs in a direct link.

Encryption Function: function that is responsible for keeping user data and part of RLC signalling between WT and CC in centralized mode and between WTs in direct mode confidential.

Error control: responsible for detection of transmission errors and, where appropriate, for the retransmissions. One error control instance is provided per DLC connection.

Frame CHannel: transport channel that is broadcast and which carries the frame control channel.

Frame Control Channel: logical channel that contains the information how the resources are allocated in the current MAC frame. Its content changes in general dynamically from frame to frame.

H/2 Home Device: device which supports at least the mandatory features in the H/2 basic specifications TS 101 761-1 [1] and TS 101 761-2 [2] and the home extension features in the present document. There are two types of H/2 home devices: basic WT or CC-capable WT. This generic term is also used if no difference is made between the device acting as the CC and the devices acting as WTs.

Logical channel: generic term for any distinct data path. A set of logical channel types is defined for different kinds of data transfer service as offered by MAC. Each logical channel type is defined by the type of information it carries. Logical channels can be considered to operate between logical connection end points.

MAC Frame: periodical structure in time that appears on the air interface and that determines the communication of HIPERLAN/2 devices. It consists of a sequence of traffic channels and its composition has to follow a number of rules.

Mobile Terminal: the term Mobile Terminal used in the basic specifications is replaced by the term Wireless Terminal throughout the present document to reflect that in home environment not all H/2 terminals need to be mobile.

Non HE-compliant Device: H/2 device, which meets the basic DLC specifications in TS 101 761-1 [1] and TS 101 761-2 [2] but not the DLC HE specification in the present document.

PDU train: sequence of transport channels delivered to the physical layer.

PHY mode: PHY mode corresponds to a signal constellation (modulation alphabet) and a code rate combination.

Random Access CHannel: logical channel in the uplink of the MAC frame in which the WTs can send signalling data for the DLC or the RLC.

Random CHannel: transport channel in the uplink of the MAC that carries the logical channels random access channel and association control channel.

Random access Feedback CHannel: logical channel where the result of an access attempt made in the previous MAC frame is conveyed.

Random Access Phase: period of the MAC Frame where any WT can try to access the system. The access to this phase is based on a contention scheme.

Radio Link Control sublayer: control plane of the DLC, which contains control protocol that offers transport services for the RRC, ACF and DUCC.

Radio Resource Control: group of control functions on top of the RLC that is responsible for the handling of radio resources.

Resource grant: allocation of transmission resources by a central controller.

Resource request: message from a terminal to a central controller in which the current buffer status is transmitted to request for transmission opportunities in the uplink or direct link phase.

Subnet: smallest configuration in an H/2 home system, which is characterized by an active CC sending BCCH on a certain frequency. A subnet is created after a CC is selected and ready to accept association requests from other H/2-HDs.

Transport Channel: basic element to construct PDU trains. Transport channels describe the message format.

Uplink phase: part of the MAC frame in which data is transmitted from mobile terminals to a central controller.

Wireless Terminal: H/2 home device, which is not acting as a central controller for a subnet.

3.2 Symbols

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

F_P	Probing Frame
TS_{CAN}	Frequency Scanning Time (per frequency)
T_{FS}	Frequency Switching Time
P	Probing Period
g(x)	Code Generator Polynomial
p(x)	Field Generator Polynomial

3.3 Abbreviations

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

ABIR	ARQ Bandwidth Increase Request
ACF	Association Control Function
ACH	Access feedback CHannel
AP	Access Point
ARQ	Automatic Repeat Request
ARB	ARQ feedback message request bit
ASCH	ASsociation control CHannel
BCCH	Broadcast Control CHannel
BCH	Broadcast Channel
BE	Business Extension
BER	Bit Error Rate
CC	Central Controller
CL	Convergence Layer
CM	Centralized Mode
CRC	Cyclic Redundancy Code
C-SAP	Control Service Access Point
DCCH	Dedicated Control CHannel
DES	Data Encryption Standard
DFS	Dynamic Frequency Selection
DiL	Direct Link
DL	Downlink
DLC	Data Link Control
DLCC	DLC Connection
DUC	DLC User Connection
DUCC	DLC User Connection Control
DM	Direct Mode
EC	Error Control
FCCH	Frame Control CHannel
FCH	Frame CHannel
FEC	Forward Error Correction
FCA	Fixed Capacity Agreement
FSA	Fixed Slot Allocation
FSA-RG	Fixed Slot Allocation Resource Grant
H/2	HIPERLAN type 2
H/2-HD	H/2 Home Device
MD5	Message Digest #5
HE	Home Environment
HEE	Home Environment Extension
IE	Information Element
IV	Initialization Vector
LCCH	Link Control CHannel
LCH	Long transport CHannel
LSB	Least Significant Bit
MAC	Medium Access Control
MAC-ID	MAC-IDentifier
MSB	Most Significant Bit
MT	Mobile Terminal
NET-ID	NETwork-IDentifier
NOP-ID	Network OPerator IDentifier
OFDM	Orthogonal Frequency Division Multiplexing
PC	Power Control
PDU	Protocol Data Unit
RCH	Random Channel
RFCH	Random access Feedback CHannel
RLC	Radio Link Control Protocol
RG	Resource Grant
RR	Resource Request

RRC	Radio Resource Control
RSS	Received Signal Strength
RSS2	RSS measured in Direct Mode
SAP	Service Access Point
RBCH	RLC Broadcast CHannel
SCH	Short transport CHannel
SSK	Session Secret Key
TS	Technical Specification
U-SAP	User Service Access Point
UBCH	User Broadcast CHannel
UDCH	User Data Channel
UL	Uplink
UMCH	User Multicast CHannel
WT	Wireless Terminal

4 Overview

4.1 H/2 Home Network Architecture

The H/2 home network is compliant to the ETSI/BRAN framework architecture, namely each H/2 device consists of the PHY, the DLC, and one or multiple CLs. The home environment specific DLC services are realized based upon the basic functions specified in TS 101 761-1 [1], TS 101 761-2 [2] and TS 101 475 [3], and the DLC HE functions specified in the present document. The application layer in an H/2 home device makes use of the DLC services through an application specific CL. In particular, the 1394 CL (TS 101 493-3 and TS 101 493-4 (see Bibliography)) is used to support IEEE 1394 based applications.

4.1.1 The single subnet model

Unlike infrastructure based configuration, the H/2 home system is designed as an adhoc LAN, which can be put into operation in a plug-and-play manner. The H/2 home system utilizes the H/2 basic features in TS 101 761-1 [1] and TS 101 761-2 [2] by defining the following equivalence between the adhoc LAN configuration and the infrastructure based configuration:

- A subnet in the adhoc LAN configuration is equivalent to a cell in the infrastructure based configuration;
- A central controller in the adhoc LAN configuration is equivalent to the access point in the infrastructure based configuration.

Thus, the smallest configuration in an H/2 home system consists of a single subnet. It is assumed that a single subnet is enough to cover near future applications in typical private homes. At each point in time only one H/2 WT can act as the CC in a subnet.

A subnet is created when the CC starts to generate valid BCCH, and allows other devices to associate with the network. All devices of a subnet shall be synchronized to the frequency chosen by the CC, and access the channel using the MAC frame structure given in BCCH and FCCH by the CC. The selection of the CC is dynamic, and seamless handover of the Central Controller (CC) responsibility from one CC-capable WT to another is possible.

To obtain a unified control framework for both infrastructure and adhoc modes of operation, the control plane is kept centralized for all general features in ad hoc mode. That means that only the CC can instruct a WT to do something. However, distributed control is also made possible for some home extension features by introducing logical control channels, which can be used for direct exchange of control messages between WTs.

In the user plane, H/2 ad hoc mode makes extensive use of direct link user connections. This significantly improves the resource efficiency, since in a typical home environment most user traffic is of intra-cell nature. As in the infrastructure mode, the 8-bit MAC-ID is used to differentiate devices in a subnet, and the 6-bit DLCC-ID plus the source and destination MAC-IDs are used to differentiate connections between a pair of devices, or broadcast/multicast connections originating from any WT in ad hoc mode.

The present document deals only with a single subnet model, in which each WT can listen to the CC. This ensures that the control plane functions specified in TS 101 761-1 [1] and TS 101 761-2 [2] are mostly reusable. For user plane, DM is used, provided that two WTs can reach each other directly. A link quality calibration process helps to track the connectivity between any two devices by measuring the associated RF link quality. The CC is used as a user data relay for a pair of WTs, if direct link between these two WTs is not possible. Even this user data relaying is performed during the direct link phase between the WTs and the CC.

The above single subnet model can be extended to support hidden terminals. In the context of the H/2 home system, hidden terminals are defined as terminals that cannot directly listen to the CC. However, hidden terminal support is beyond the scope of this release of the DLC HE specification.

4.1.2 The multiple subnets model

If the capacity of a single subnet is insufficient, or the home is too large to be covered by a single subnet, multiple subnets operating on different frequencies can be applied. Each subnet is under the control of its own CC, and works independently of the other subnet(s). DFS is used to enable dynamic selection of the RF channel. Different subnets are differentiated by different AP-IDs, and all subnets belonging to the same owner shall use the same NET-ID.

Different subnets can be interconnected either by a fixed network, or by H/2 bridging devices. Since user connections can be set up directly between any two WTs in a subnet, it is not necessary to use the CC to forward user traffic between different subnets. Potentially any device in a subnet can be configured as a bridging device to another subnet. A WT can associate with two overlapping subnets to become the bridging node between these subnets, provided it can be synchronized to the BCCHs of the two subnets alternatively.

The inter-cell handover procedure specified in TS 101 761-2 [2] can be utilized to support mobility of H/2 home devices beyond the boundary of a single subnet. Inter-cell handover can be done either with or without fixed network support.

Support for multiple subnets is beyond the scope of this release of the DLC HE specification.

4.2 Service Types to be supported

The H/2 DLC services are generic to support a variety of high-speed multimedia applications. Features especially important for home environment include, but are not limited to:

- Connection oriented high speed transmission for all application types;
- Low delay, low delay jitter, and low bit error rate delivery of real time packets;
- Isochronous and asynchronous services;
- Acknowledged and unacknowledged asynchronous packet transfer;
- Adhoc networking with QoS support;
- Access to external networks (e.g. ADSL, DVB) from any H/2 home device;
- Dynamic frequency selection and power control;
- User-friendly security concept.

These features are enabled by the present document together with TS 101 761-1 [1], TS 101 761-2 [2] and TS 101 475 [3]. In later releases, the H/2 home system intends to provide:

- Mobility support;
- Hidden terminal support;
- Multiple subnets interconnect;
- Directional antennas;
- Add-on CL servers for different types of applications.

For each type of applications, a convergence layer is required to convert the DLC SDU into a format, which is accessible by the specific application layer, and vice versa. Support for Ethernet, IEEE 1394 and ATM based applications is specified in TS 101 493-1, TS 101 493-2, TS 101 493-3, TS 101 493-4, TS 101 763-1 and TS 101 763-2 (see Bibliography). Support for other applications, such as USB-based applications, can be added later on.

4.3 Types of Devices supported

For ado networking in home environment two, and only two H/2-HDs types are defined for the single subnet model:

1) Basic WT;

2) CC–capable WT.

A basic WT is a user device that is able to associate with a CC and to communicate with the CC and other WTs in the control plane, and with other H/2-HDs in the user plane under the control of the CC. A basic WT consists of all DLC layer functions defined by the basic specs in TS 101 761-1 [1] and TS 101 761-2 [2] plus the functions defined in the present document. A basic WT shall support DM.

A CC–capable WT can act either as a Central Controller, or as a basic WT. When it acts as the CC, it is capable of performing all control plane functions specified in TS 101 761-1 [1], TS 101 761-2 [2] and in the present document for the role of AP, or CC, respectively. Furthermore, for each supported CL all required CL functions at the AP side, or CC side, respectively, need to be implemented in the CC-capable WT. Support for handover functions in TS 101 761-2 [2] is optional for CC-capable WTs. A CC-capable WT acting as CC shall also be able to communicate with other WTs in the user plane as a basic WT. That means that it shall support all basic WT functions, additionally.

The acting CC for a subnet is dynamically selected among all active CC-capable WTs. User interaction to prefer a special CC-capable WT to become the active CC is possible. Seamless handover of the CC responsibility from one CC-capable WT to another is also possible.

5 DM transmission and reception functions

5.1 Logical channels and their characteristics

H/2 home devices shall support all logical channels defined in clause 5.1 and clause 6.1 of TS 101 761-1 [1]. Implementation of direct link UDCH, LCCH, UBCH, UMCH, DCCH and RBCH are mandatory. The DiL UDCH and DiL LCCH shall be used for unicast user communication between any two H/2-HDs, and the associated link control, respectively. The DiL UBCH and DiL UMCH shall be used for user broadcast from any one H/2-HD to all other H/2-HDs supporting the same CL, and for user multicast from any one H/2-HD to a group of other H/2-HDs, respectively. DiL DCCH shall be used for RLC message exchange between any two H/2-HDs, or from a DM sender to a group of DM receivers in case of DiL multicast. DiL RBCH shall be used for distribution of RLC messages from any one H/2-HD to all other H/2-HDs. UL DCCH is used for the transmission of RLC messages from a WT to the CC, unicast DL DCCH for transmission of RLC messages from the CC to a particular WT, and DL RBCH is used for transmission of RLC messages from the CC to all WTs.

In order to use DiL UBCH or DiL UMCH a WT shall perform the respective join procedure in TS 101 761-2 [2].

H/2-HDs shall also support downlink multicast using DL DCCH to send control messages from the CC to a group of WTs, what is not specified in TS 101 761-1 [1]. In this case, the multicast MAC-ID assigned during the multicast join procedure in TS 101 761-2 [2] shall be used for downlink DCCH.

NOTE: Unlike DiL DCCH, downlink DCCH is identified by a single MAC-ID.

It is mandatory that all H/2-HDs use DiL UDCH, or DiL UMCH, or DiL UBCH for exchange of user packets with one or more other H/2-HD, even if the peer entity is the CC. An H/2-HD may use uplink or downlink UDCH/UMCH/UBCH to send or receive user packets, if the peer device is not subject to the home extension specification in the present document.

5.2 Transport channels and their characteristics

H/2 home devices shall support all transport channels defined in clauses 5.2 and 6.2 of TS 101 761-1 [1]. Implementation of direct link LCH and SCH are mandatory. The LCH is allocated in the DiL phase to transport user data for the connections related to the DiL UDCH, DiL UBCH, and DiL UMCH, and long control packets for the connections related to the DiL DCCH and DiL RBCH. The SCH is allocated in the DiL phase to transport short control packets for the connections related to the DiL LCCH, DiL DCCH and DiL RBCH.

Possible PHY modes for different transport channels are given in clause 6.8.1 of TS 101 761-1 [1]. The PHY mode for LCH related to DiL UDCH, DiL UMCH, DiL UBCH and DiL DCCH is one of all possible PHY modes as defined in TS 101 475 [3]. The PHY mode for LCH related to DiL RBCH is set to the most robust one (BPSK ½). The PHY mode for SCH related to DiL LCCH and DiL DCCH is set to BPSK ½, or BPSK ¾, or QPSK ¾. The PHY mode for SCH related to DiL RBCH is set to the most robust one (BPSK ½).

5.3 Mapping between logical and transport channels

The mapping between direct link logical and transport channels is given in clause 5.3 of TS 101 761-1 [1]. Unlike centralized mode, the DiL LCCH does not include RR for direct link connections. The RRs for DiL LCH and DiL SCH shall be sent on the uplink DCCH using SCH, or RCH.

5.4 Mapping between MAC frame and PHY frame

The mapping between MAC frame and PHY frame is defined in clause 6.9 of TS 101 761-1 [1].

One preamble shall be added at the beginning of each direct link PDU train. The preamble of the direct link PDU train shall have a length of 4 OFDM symbols, see TS 101 475 [3].

A direct link PDU train shall consist of all LCHs and SCHs belonging to the same pair of source and destination MAC-IDs. A set of SCHs and LCHs is granted for each DLCC by one RG. An WT shall receive not more than one direct link PDU train containing UDCHs, DCCHs, and LCCHs per MAC frame per source MAC-ID, i.e. all corresponding DLCCs shall be grouped in a single PDU train. It may receive the RBCH, UMCHs and UBCHs from the same sender in separate PDU trains. Since DCCH can also be used for downlink multicast in the HEE, a WT may receive a multicast downlink DCCH and a unicast downlink DCCH in separate PDU trains.

A guard time between two consecutive DiL PDU trains shall always be inserted by the CC scheduler in order to cope with propagation delays, if the two PDU trains have different source MAC-IDs. A guard time may not be inserted if two subsequent PDU trains have the same source MAC-IDs.

The duration of one OFDM symbol is equal to 4 µs if the long cyclic prefix is used, or 3,6 µs if the short cyclic prefix is used. Both long and short cyclic prefixes are mandatory to support by all H/2-HDs. The long cyclic prefix is used for all SCHs and LCHs carrying BCCH, FCCH, RFCH, ASCH, RBCH, DCCH, UBCH and corresponding LCCH, and UMCH without QoS negotiation by an explicit DUC setup procedure.

The short cyclic prefix is the default value for all UDCH and UMCH connections, which are setup by an explicit DUC setup procedure. If during connection setup not otherwise negotiated, the short cyclic prefix is used for all SCHs and LCHs that carry UDCH and the corresponding LCCH, and UMCH with QoS negotiation.

Within one PDU train SCH and LCH can use different cyclic prefix durations depending on what they carry, for example if they carry DCCH and UDCH.

5.5 DLC Addressing for Home Environment

The general DLC addressing concept in clause 5.6 of TS 101 761-1 [1] applies to the H/2 home devices (home WT and CC-capable WT). The MAC-ID is assigned by the acting CC. When a subnet is created, the first active CC also internally assigns a MAC-ID to itself.

For a given DM transmitter, the DiL DLCC-ID is unique for a particular receiver MAC-ID.

The NET-ID in the BCCH shall be regarded as the owner identifier of the H/2 home system. The NET-ID shall be a random number. During the installation process (see clause 6.9), each new H/2-HD device to be installed shall store the NET-ID of its network, which is broadcast in the BCCH. Different subnets shall use the same NET-ID. The allowed range is 0 to 959.

When a subnet is to be created, the selected CC shall generate the AP-ID randomly. The device identifier, for example the IEEE EUI-64, of this CC shall be used as the seed of the random number generation. However, before the CC starts operation, it shall scan all possible frequencies and try to decode the associated BCCH to check if its randomly generated AP-ID is already used by another CC. This can be done in combination with the CC selection procedure in clause 6.7. A new AP-ID shall be generated, if the old one is already occupied by another CC.

In this release of the DLC HE TS no sectorized MAC Frame as described in clause 5.4 of TS 101 761-1 [1] is considered for the CC. Therefore, Sector-ID = 0 and # of sectors = 1 shall be set in the BCCH.

The DiL RBCH is identified by the source MAC ID of the transmitting WT, destination MAC ID = 0 and DLCC ID = 0.

The DiL DCCH is identified by the source and destination MAC IDs of the concerned WTs and DLCC ID = 0.

The DiL UMCH is identified by the source MAC ID of the transmitting WT, the destination multicast MAC ID (in the range of 224...254) and DLCC ID = 63.

The DiL UBCH is identified by the source MAC ID of the transmitting WT, the destination broadcast MAC ID (in the range of 1...223) and DLCC ID = 63.

For DiL UDCH, the destination MAC ID is used to identify an outgoing connection for the transmitting terminal and a source MAC ID identifies an incoming connection for the receiving terminal. It is permitted to have outgoing simplex connections with the same DLCC ID to different destination MAC IDs and to have incoming simplex connections with the same DLCC ID from different source MAC IDs. However, between a source and destination MAC ID pair, both directions of a bi-directional UDCH shall use the same DLCC ID.

The DiL LCCH is identified by the source and destination MAC IDs of the concerned WTs and the DLCC ID of the related connection.

The direct link UDCH, LCCH, UBCH, UMCH, DCCH and RBCH are announced in the FCH.

5.6 Use of DiL logical channels

5.6.1 Overview of the MAC frame

The MAC frame structure is given in clause 5.4 of TS 101 761-1 [1]. For H/2 home devices, the implementation of DiL phase is mandatory. Support of sectored antennas is beyond the scope of the present document.

The basic MAC frame structure for H/2-HDs is shown in Figure 1. Each MAC frame shall consist of the transport channels BCH, FCH, ACH and at least one RCH. If user data is to be transmitted, a DiL phase shall be provided. If downlink control data is to be transmitted (DL RBCH and/or DL DCCH), a DL phase shall be provided. If uplink control data is to be transmitted (UL DCCH), an UL phase shall be provided. A BCH, an ACH, a minimum length FCH and at least one RCH shall exist in every MAC frame. The duration of the BCH is fixed. The duration of the FCH, DL phase, DiL phase, UL phase and the number of RCHs are dynamically adapted by the CC depending on the current traffic situation. The order shall be: BCH – FCH - ACH - DL phase – DiL phase - UL phase – RCHs, from the point of view of a WT.

NOTE: The specified order is from a WT's point of view. This means that a CC may e.g. have several DL, DiL, and UL phases and mix the phases, as long as the order is kept for each individual WT.

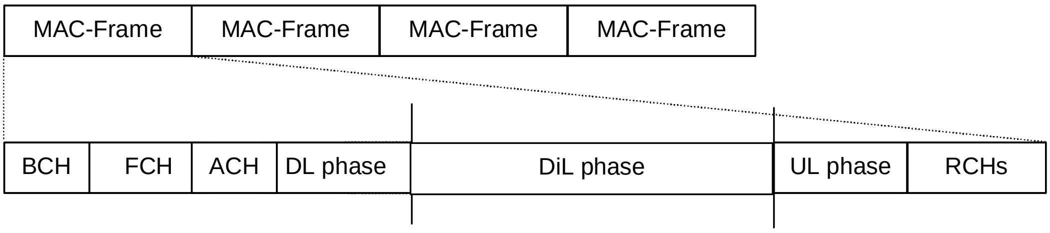

Figure 1: Direct Mode MAC frame structure

Detailed rules for the composition of MAC frames are given in clause 6.3.2 of TS 101 761-1 [1].

5.6.2 Resource request and resource grant for direct link

Resource Requests for direct link LCH and SCH are transmitted in RCH or in uplink DCCH using SCH with DLCC - ID = 0. No RR for DiL shall be sent in DiL LCCH. The rules for composing and transmitting RR for DiL are described in clause 6.2.9.1.2 of TS 101 761-1 [1]. A RR for DiL is always related to a simplex connection whose direction is determined by the source and destination MAC-IDs in RRs.

Resource Grants for direct link LCH and SCH are described in clause 6.2.2.2 of TS 101 761-1 [1]. Like centralized mode, they are sent in FCCH. RG for DiL is always related to a simplex connection whose direction is determined by the source and destination MAC-IDs in RG.

5.6.3 DiL LCCH for ARQ

Direct link LCCH is defined in clauses 5.1.10 and 6.2.9 of TS 101 761-1 [1]. It is only used for the ARQ protocol performed between two H/2-HDs in DM. The acknowledged mode of error control, the ARQ protocol, is described in clause 6.4.2 of the TS 101 761-1 [1]. The ARQ protocol of HIPERLAN/2 is symmetric. The ARQ protocol is the same for two WTs in DM and for one WT and the CC in DM. ARQ feedback and the discard message for DiL have the same format as those for downlink. As in DL LCCH there is no ABIR in the ARQ feedback message in DiL LCCH. This is because the receiver of a DiL UDCH is not able to signal an increase in ARQ feedback bandwidth requirement to the CC by means of ARQ feedback messages in the DiL LCCH. Thus, the scheduler in the CC has to schedule sufficient DiL LCCH resources for ARQ feedback transmission.

5.6.4 DiL DCCH for RLC

Direct link DCCH is defined in clauses 5.1.6 and 6.2.5 of TS 101 761-1 [1], and used for RLC message exchange between any two H/2-HDs in DM, or from a DM sender to a group of DM receivers. It is mapped to either DiL LCH or DiL SCH. This logical channel will be used, for example, by DiL power control and link quality calibration.

5.6.5 DiL RBCH for RLC

Direct link RBCH is defined in clauses 5.1.5 and 6.2.4 of TS 101 761-1 [1], and used for RLC message broadcast from any one H/2-HD to all other H/2-HDs. It is mapped to either DiL LCH or DiL SCH. This logical channel will be used, for example, by link quality calibration.

5.7 MAC protocol for DM

In the Direct Mode the direction of logical channels is distributed as shown in Figure 2.

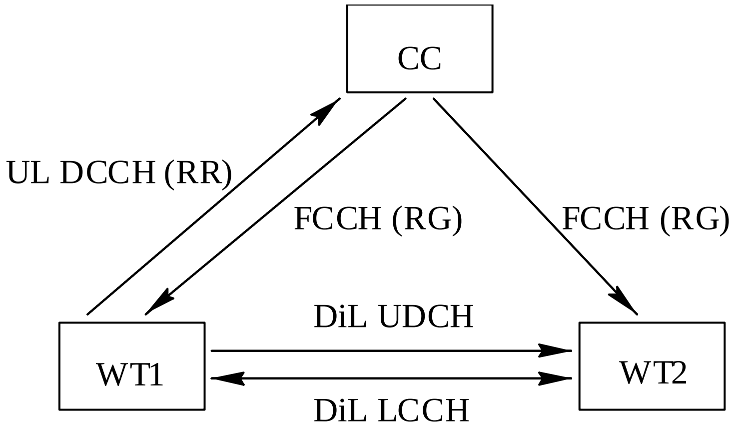

Figure 2: Direct Mode MAC protocol principle

In Figure 2 WT 1 has a DiL connection to WT 2. As in centralized mode Resource Grants (RGs) are transmitted by the CC in the FCCH. Resources granted for DiL connections are related to DiL UDCH for User data and related to DiL LCCH for ARQ control messages (ARQ feedback and discard). PDUs in the DiL UDCH and discard PDUs in the DiL LCCH are directly transmitted from WT 1 to WT 2. ARQ feedback PDUs are directly transmitted from WT 2 to WT 1. The CC does not listen to the DiL UDCH and DiL LCCH if it is not a peer entity of the DiL connection.

NOTE 1: The CC itself can act as a WT and thus it can be the source and/or destination of DiL connections.

Resources for the DiL LCCH in case of ARQ feedback shall not be requested using RRs. The scheduling of sufficient resources for ARQ feedback is the task of the scheduler in the CC.

Resources for the DiL LCCH for transmission of a discard message are requested with a RR for DiL. RRs for DiL are transmitted in the RCH or UL DCCH (DLCC - ID = 0).

Resource requests shall be used for DiL UDCH, DiL RBCH, DiL DCCH, DiL UMCH, DiL UBCH, and, in case of discard messages, also used for DiL LCCH. The rules for generating RR for DiL are described in clause 6.2.9.1.2 of TS 101 761-1 [1]. The priority rules for using granted DiL SCH is described in clause 6.2.2.2 of TS 101 761-1 [1]. The general MAC protocol described in clause 6.3 of TS 101 761-1 [1] applies to H/2-HDs.

NOTE 2: If the CC itself is requesting resources for DiL UDCH, DiL RBCH, DiL DCCH, DiL UMCH, DiL UBCH, and, in case of discard messages, for DiL LCCH, these resources are requested internally and no DiL RR is transmitted. The message for requesting resources internally in the CC is implementation-specific and outside the scope of the present document.

5.8 EC protocol for DM

5.8.1 General

The EC protocol is described in clause 6.2.2.2 of TS 101 761-1 [1]. The general aspects and the usage of EC in DM are described here. Additionally an FEC mode is supported.

The CC and WT shall support four error control modes:

1) Acknowledged mode;

2) Repetition mode;

3) Unacknowledged mode;

4) FEC mode.

DiL UDCHs for a certain connection shall either be sent in acknowledged mode, unacknowledged mode, or FEC mode. The negotiation during connection setup is defined by the corresponding DUC setup procedure. In case of the acknowledged mode, an implicit bi-directional DiL LCCH is set up.

DiL UMCH shall either use the unacknowledged mode or the FEC mode.

DiL DCCH on LCH and DiL RBCH on LCH shall use the unacknowledged mode.

DiL UBCHs shall either be sent in repetition mode or unacknowledged mode. In the case where multiple convergence layers are supported, the DiL UBCHs may use different error control modes. In the case of the repetition mode, an implicit unidirectional DiL LCCH is set up corresponding to a DiL UBCH.

The figures below illustrate the possible setups. In these examples, the terms "transmitter" and "receiver" mean that the data transmission under consideration is from the transmitter to the receiver, although e.g. a connection using the DiL UDCH may be bi-directional. The RR message control flow is not considered here.

Figure 3 illustrates the situation in the case of the acknowledged mode. A corresponding DiL LCCH is available which is used for ARQ feedback messages from the receiver to the transmitter and for discard messages from the transmitter to the receiver.

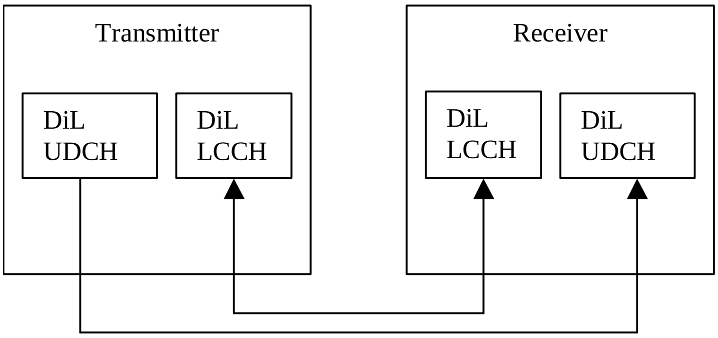

Figure 3: Illustration of the data and control flow in acknowledged mode

Figure 4 illustrates the situation in the case of the repetition mode. In this case, an implicit unidirectional DiL LCCH for discard messages from the transmitter to the receiver is available.

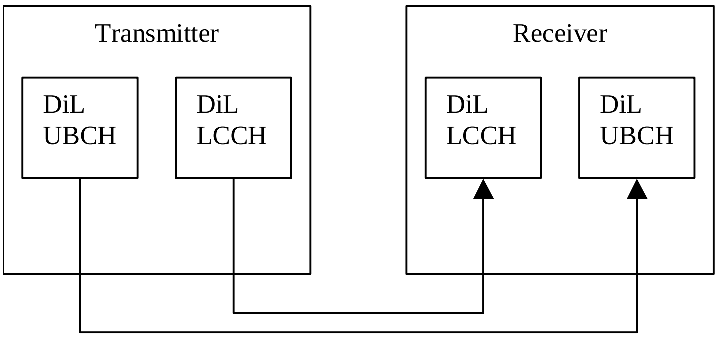

Figure 4: Illustration of the data and control flow in repetition mode

Figure 5 illustrates the situation in the case of the unacknowledged mode. The data flows only from the transmitter to the receiver, no control data flow for ARQ feedback or discard messages is allowed.

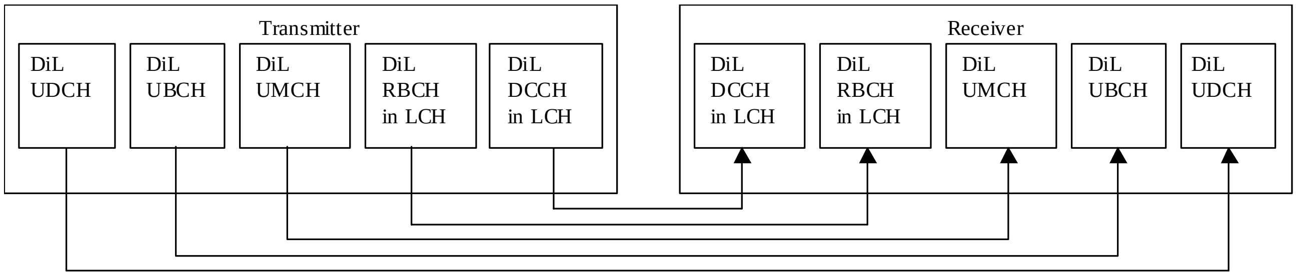

Figure 5: Illustration of the data and control flow in unacknowledged mode

Figure 6 illustrates the situation in the case of the FEC mode. The data flows only from the transmitter to the receiver, no control data flow for ARQ feedback or discard messages is allowed.

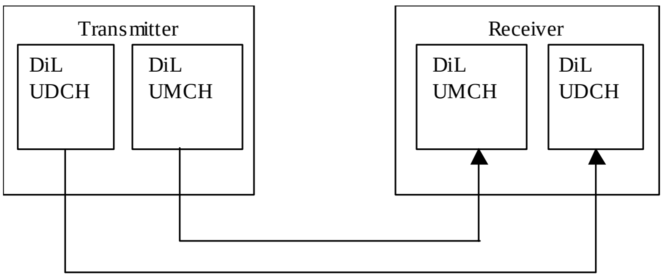

Figure 6: Illustration of the data and control flow in FEC mode

5.8.2 Error Control (EC) protocol for the acknowledged mode

The acknowledged mode uses an ARQ protocol and is described in clause 6.4.2 of TS 101 761-1 [1]. Most parts of the ARQ procedures of the transmitter and receiver are the same for CM and DM. Some special treatments for the direct link connections are summarized below.

5.8.2.1 Handling of Dynamic ARQ bandwidth allocation for DM

The number of SCHs available for ARQ feedback messages may change from MAC frame to MAC frame. Therefore the number of bitmap blocks that can be signalled in a frame changes dynamically, as determined by the CC scheduler.

In CM the destination of UL ARQ feedback is the CC and thus the CC scheduler. Therefore, it is possible to signal increased ARQ feedback capacity needs by setting the ABIR bit to 1 in the UL ARQ feedback message. In DM the destination of DiL ARQ feedback is the peer WT and not the CC scheduler. Therefore, the ABIR bit is not available for the direct link.

NOTE: The calculation of the amount of extra SCH capacity granted by the scheduler in the CC is out of the scope of the present document.

5.8.2.2 Setting of the ARB in the RR for DiL

In the case of a WT as a transmitter which is completely stopped (e.g. it has new LCHs to transmit but transmission is suspended by flow control or due to a stalled window), the WT may send a RR for DiL with #LCH = 0 and ARB = 1. Upon reception of such a RR for DiL, the CC scheduler should allocate appropriate resources for the receiving WT to transmit ARQ feedback messages. This allows the transmitter to inform the CC scheduler that it does not get sufficient feedback from the receiver.

5.8.2.3 Receiver actions in case of insufficient ARQ feedback resources (informative)

If the receiver detects that it does not get enough resources granted for ARQ feedback transmission, it may perform the following action (informative):

- The receiver may request a more robust PHY mode for this specific connection, by setting a more robust PHY mode in a RR for this DiL connection. The #LCH and #SCH shall be set to zero, if no resources are to be requested. With a more robust PHY mode the number of reception errors may be decreased and thus the amount of ARQ feedback to signal negative acknowledgement. The amount of necessary CumAcks is not affected by the PHY mode setting.

In DM a Receiver cannot signal directly to the CC scheduler that the ARQ feedback resources are insufficient (see clause 5.8.2.1).

5.8.2.4 Transmitter actions in case of insufficient ARQ feedback resources (informative)

If the transmitter in DM is stopped, which means that within the transmitters window or flow control (FC) limitation, neither unacknowledged nor negatively acknowledged nor new LCHs are to be transmitted due to lack of ARQ feedback even if the transmitter buffer is not empty, the transmitter may set ARB in the DiL RR as described in clause 5.8.2.2.

If the transmitter in DM is not stopped, it is not allowed to use ARB = 1 and #LCH = 0 to signal to the CC scheduler that it wishes to have more frequent ARQ feedback.

5.8.2.5 Scheduling of sufficient ARQ feedback resources (informative)

The CC scheduler shall schedule sufficient resources for ARQ feedback. The definition of sufficient resources and the scheduling algorithm is outside the scope of the present document. Following informative text is given to indicate the parameters that influence the need for ARQ feedback:

- The minimum necessary ARQ feedback resources are given by the number of transmitted (scheduled) UDCH and the negotiated ARQ window size. At least one LCCH for ARQ feedback has to be scheduled if as many UDCH have been scheduled as the size of the ARQ window. This minimum number is far too low for proper operation.

- The average PDU error rate influences the number of necessary ARQ feedback messages. As this number is not known to the CC scheduler, an estimation has to be made. A worst-case assumption is 10 %, as if Link Adaptation in the Receiver works properly, the Receiver asks for a more robust PHY mode if the PDU error rate exceeds 10 %. Proper operation of the ARQ protocol with an average PDU error rate of more than 10 % is unlikely.

- In order to limit the delay, the CC scheduler shall take into account the last time it has scheduled a DiL LCCH for ARQ feedback. The time between ARQ feedback signalling influences the total ARQ delay.

- If the receiver requests a more robust PHY mode the CC scheduler may check whether it had scheduled sufficient resources for ARQ feedback. By scheduling more resources for ARQ feedback the Receiver may decide to ask for the former PHY mode again, if the reason for asking for a more robust PHY mode has been insufficient resources for ARQ feedback (see clause 5.8.2.2).

In order to improve the system performance the CC scheduler shall spend spare resources for ARQ feedback, if possible.

5.8.3 EC protocol for the repetition and unacknowledged mode

The EC protocol for the repetition mode and the unacknowledged mode is described in clauses 6.4.3 and 6.4.4 of TS 101 761-1 [1], respectively.

There are no differences between DM and CM for the EC protocol for the repetition mode and the unacknowledged mode.

5.8.4 EC protocol for the FEC mode

5.8.4.1 Principles

When setting up a DiL UDCH or UMCH, an H/2-HD can determine if the DLC FEC mode shall be applied to this connection. When the FEC mode is selected, both acknowledged mode and unacknowledged mode are no longer possible for this connection.

The DLC FEC scheme is based on a Reed-Solomon (RS) block code working on a multiple LCH-PDUs. For 8-bit symbols, the block length of the mother code shall be $2^8 - 1 = 255$ bytes. To achieve an error correction capability of 8 bytes per block, 16 bytes of redundancy shall be computed per block, leaving up to 239 bytes for protected data; hence, the mother code is a RS(255, 239) code. Out of these 239 bytes only 200 bytes shall be utilized by the DLC FEC, the rest is padding bytes which shall be only needed for computation but shall not be transmitted. The shortened code is referred to as a RS(216, 200) code.

To suit the DLC FEC scheme, an additional UDCH message format is described which takes into account the specific information added by the FEC. DLC SDUs shall be concatenated in groups of 4 resulting in 200 bytes of protected data, as explained in clause 5.8.4.3.

The performance of the FEC scheme is further enhanced by the insertion of a convolutional interleaver with a depth of 12 DLC PDUs.

NOTE: In DLC FEC mode, the packet error rate may be more affected by the error rate of RR and/or RG for the particular connection than by the residual error probability of the FEC scheme itself. In this case, fixed slot allocation as presented in clause 6.6.1 could be a means to avoid this limitation.

5.8.4.2 UDCH message format

The non-ARQ mode is mainly intended to be used for the UDCH channel. The basic format of such a message is defined in the DLC basic TS (Table 1 and Table 2):

Table 1: Content of the UDCH with CRC

Name	Length (bits)	Purpose
PDU type	2	See Table 2
SN	10	Sequence number (provided by EC function)
Payload	$49,5 \times 8$	Payload field, i.e. DLC SDU
CRC	24	CRC-24 checksum
Total:	**54 x 8**	

Table 2: LCH Type field

PDU type	Purpose
00	Normal DLC PDU (carries UDCH, DCCH and RBCH)
01	Dummy LCH
10	Future use
11	Future use

In case the DLC FEC is used, the UDCH message format is as shown in Table 3.

Table 3: Content of the UDCH with FEC

Name	Length (bits)	Purpose
PDU type	2	See Table 2
Sync	2	Sync bits needed by FEC function
Payload	$49,5 \times 8$	Payload field (DLC SDU)
FEC	32	One quarter of the RS redundancy
Total:	**54 x 8**	

	8	7	6	5	4	3	2	1
1	PDU type		Sync		MSB			
2								
3								
4					Payload			
5								
	⋮				⋮			⋮
50								
51					FEC			
52								
53								
54								

Figure 7: UDCH transfer syntax with FEC

5.8.4.3 RS word generation

Every RS word is constructed from data of 4 LCH PDUs of 54 bytes. An RS word shall be obtained from 4 consecutive payload fields of 49,5 bytes each, originating from the upper layer, or generated by the DLC in case of dummy RS words.

The PDU type shall be correctly set according to the Table 2, depending on the nature of the payload. If the payload is generated by the DLC as dummy, the PDU type for dummy LCH, which is 01, shall be used.

In FEC mode, dummy LCH PDUs shall not be discarded, but shall be passed to the deinterleaver.

The sync field is set according to Table 4. As can be seen, one sync field out of four is inverted from 00 to 11.

Table 4: LCH Sync field

Sync field	Purpose
11	PDU #1
00	PDU #2, #3 and #4

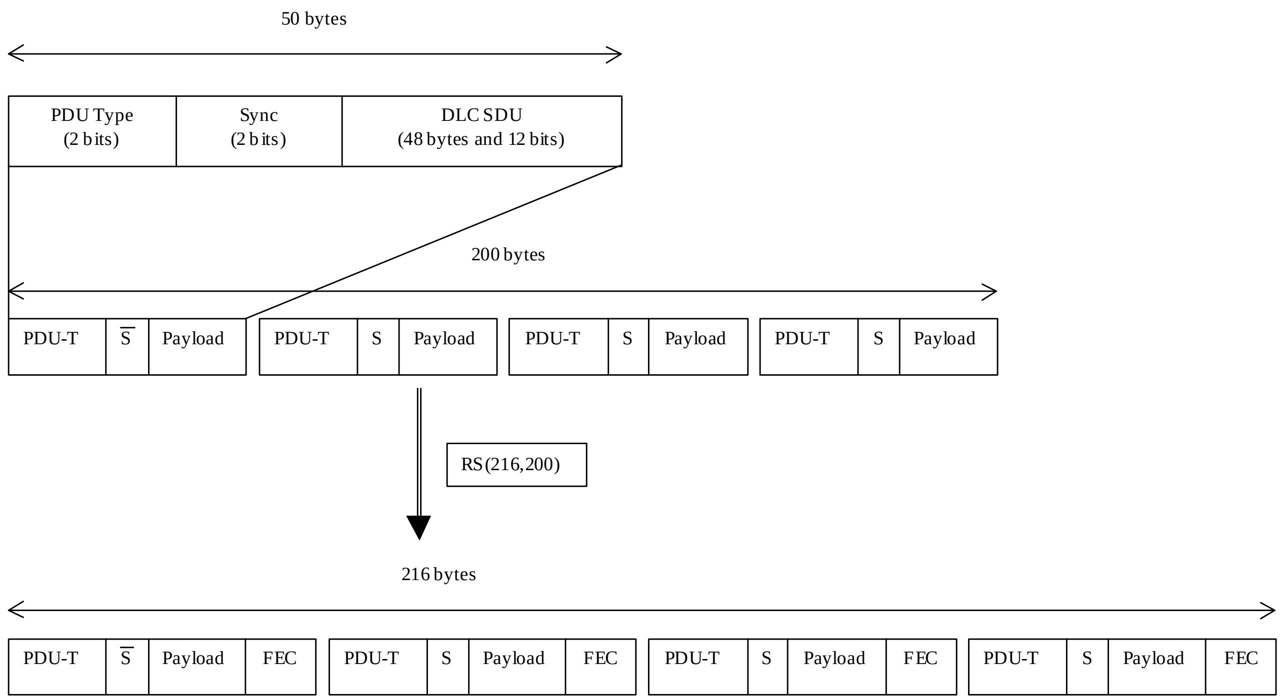

Figure 8: RS word generation

The 4 blocks of 50 bytes, are concatenated to form a 200-byte block, where each 50 byte block consists of the 2-bit PDU type, the 2-bit Sync field in front of the 49,5 byte DLC SDU each, 39 zero bytes shall be padded before these 200 bytes and the obtained 239 bytes are fed to the RS(255,239) Reed-Solomon code with the following properties:

- Code Generator Polynomial: $g(x) = (x+\mu^0)(x+\mu^1)\ldots(x+\mu^{15})$, where $\mu = 02_{HEX}$
- Field Generator Polynomial: $p(x) = x^8 + x^4 + x^3 + x^2 + 1$

The 39 zero bytes shall be discarded after computation of the RS code word and shall not be transmitted over the air interface.

The redundancy of 16 bytes per RS(255, 239) is split into 4 packets of 4 bytes each which are inserted at the end of each DLC PDU according to Table 5.

Table 5: Redundancy addressing within a RS word

Redundancy bytes	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	#16
PDU	#1	#1	#1	#1	#2	#2	#2	#2	#3	#3	#3	#3	#4	#4	#4	#4
Octet in the PDU	#51	#52	#53	#54	#51	#52	#53	#54	#51	#52	#53	#54	#51	#52	#53	#54

5.8.4.4 Dummy LCH PDU generation

In the basic TS 101 761-1 [1], the DLC can insert dummy PDUs by setting the PDU type value to 01. The content of the dummy payload is not specified.

However, in case the DLC FEC mode is used, the Sync field shall always be correctly set according to the rule given above, where every fourth Sync field is inverted from 00 to 11, see Table 4. The value of the other bits of the dummy PDUs is not specified.

At connection release, the sender shall ensure that always a multiple of four PDUs are transmitted over the air. If this is not achievable by the user PDUs alone, the sender shall generate up to 3 dummy PDUs to complete the transmission of a multiple of 4 PDUs over the air.

During the connection the sender may also generate as many dummy PDUs as necessary to fill multiple of 4 PDUs within one MAC frame.

5.8.4.5 Interleaver and deinterleaver

A Forney type convolutional interleaver with 3 branches is inserted after the RS output. The octets #1, #4,..., #52 of each LCH PDU shall be sent to branch #1, octets #2, #5,..., #53 to branch #2 and the other to branch #3. Explicitly, the rule for the interleaver DEMUX is that the octets #(3p+n), where $0 \le p \le 17$ and $1 \le n \le 3$, shall be sent to branch #n. When a byte is sent to branch #n, the output from the interleaver MUX shall be the byte coming from the branch #n FIFO. The FIFO lengths shall be 0, 72, and 144 bytes, respectively.

At the deinterleaver side, the FIFO lengths of branches #1, #2, #3 are 144, 72, and 0 bytes, respectively. The octets #1, #4,..., #52 of each received LCH PDU shall be sent to branch #1, octets #2, #5,..., #53 to branch #2 and the other to branch #3. Explicitly, the rule for the deinterleaver DEMUX is that the octets #(3p+n), where $0 \le p \le 17$ and $1 \le n \le 3$, shall be sent to branch #n.

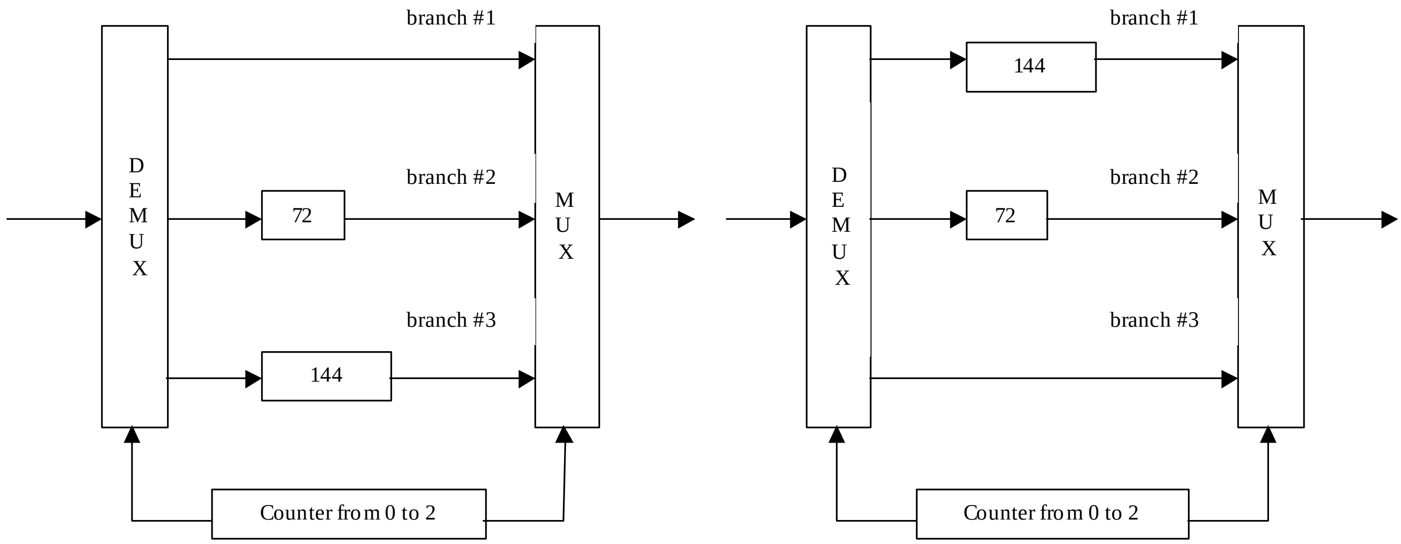

Figure 9: Interleaver and deinterleaver

5.8.4.6 Interleaver/deinterleaver memories initialization

When setting up a connection, the sender shall initialize the memories of the interleaver with relevant data, which once transmitted can be correctly decoded by the receiver. The sender shall generate one RS code word consisting of 4 dummy 54-byte PDUs (called a dummy RS word). The payload (49,5 bytes) shall be set to zero, the PDU type to 01, and the sync field correctly set as specified in clause 5.8.4.4. The remaining 4 bytes are used as FEC redundancy.

The payload of the dummy PDUs is set to zero, because they are generated locally in the transmitter and receiver, and shall have the same content.

The 216 bytes obtained shall be then fed twice consecutively to the interleaver according to the interleaver rules, until both FIFOs are full. By doing so, the contents of the FIFOs of the interleaver are as follows, where byte #1 is the first byte of the first dummy PDU of the dummy RS word:

- Branch #1: No FIFO
- Branch #2: 72 bytes: #215 #212 #209... #2
- Branch #3: 144 bytes: #216 #213 #210... #3 #216 #213 #210... #3

To save radio resources, no byte from the interleaver output shall be sent over the air during the FIFO initialization process, since the receiver deinterleaver can initialize its memory locally by using the same dummy RS words. With the same dummy RS word stored locally, the deinterleaver can achieve an equivalent initialization by taking into account the expected interleaver output and the deinterleaver rule. This results in the following FIFO contents in the deinterleaver branches after the equivalent initialization:

- Branch #1: 144 bytes: #214 #211 #208... #1 #214 #211 #208... #1
- Branch #2: 72 bytes: #215 #212 #209... #2
- Branch #3: No FIFO

Consequently, when a user PDU coming from the sender CL is input to the interleaver, the first outgoing byte at the deinterleaver output is byte #1 of the dummy RS word, and the n-th byte at the deinterleaver output is byte #n of the dummy RS word. Thus, the RS decoder works correctly.

5.8.4.7 Connection termination

In case a connection uses the DLC FEC mode, the end-to-end delay due to the interleaver-deinterleaver process equals 8 PDUs. Hence, if a receiver has to decode the last PDU of a connection before the connection release, the sender shall take 2 actions:

1) If a multiple of 4 PDUs is not achieved, add the missing number (1, 2 or 3) of dummy PDUs to complete a RS word.
2) Purge the whole memories by generating two dummy RS words before releasing the connection.

NOTE: The payload of the dummy PDUs used for completing the RS words and for purging can be of any values.

Doing so, it is ensured that the last useful PDU is always read out of the deinterleaver, while the purging dummy RS words remain in the memories of the interleaver and the deinterleaver.

5.9 Broadcast Transmission

The downlink broadcast channels BCCH, FCCH, RFCH, RBCH and UBCH shall only be used by the acting CC. The BCCH is transmitted in the BCH and is identified by the occurrence of the BCH. The FCCH is transmitted in the FCH and is identified by the occurrence of the FCH. The RFCH is transmitted in the ACH and is identified by the occurrence of the ACH. The downlink RBCH is announced in the FCCH and is identified by MAC ID = 0 and DLCC ID = 0 in the case of the downlink. The downlink UBCH for a particular convergence layer is identified by the unique MAC ID that shall be assigned dynamically by the RLC (see TS 101 761-2 [2]) in the CC, taken from the MAC ID range 1 to 223, and DLCC ID = 63.

The direct link broadcast channels RBCH and UBCH can be used by any H/2-HD to distribute control and user data, respectively, to all other H/2-HDs. The direct link RBCH is identified by the source MAC ID of the transmitting H/2-HD, destination MAC ID = 0, and DLCC ID = 0. The direct link UBCH for a particular convergence layer is identified by the unique destination MAC ID that shall be assigned dynamically by the RLC (see TS 101 761-2 [2]) in the CC, taken from the MAC ID range 1 to 223, the source MAC ID of the transmitting H/2-HD, and DLCC ID = 63.

In both the CM and DM, the transmit power shall be adapted to the decoding quality of the farthest receiver.

5.10 Encryption

H/2-HDs shall encrypt UDCH, UMCH, UBCH and DCCH messages carried by LCHs using the DES algorithm. The RBCH is not encrypted (see TS 101 761-1 [1]). Encryption of SCHs is not possible. The implementation and use of the Triple DES is optional (TS 101 761-1 [1]). In TS 101 761-1 [1] and TS 101 761-2 [2] a unicast encryption key is used by every WT for encrypted UL/DL communication on LCHs with the CC. In the HE most of the communication links are DiLs between two WTs. On these DiLs the unicast keys cannot be used. In a subnet, all DiL LCHs sent by an H/2-HD therefore shall use one single encryption key. This key is thus a common key; it is called DM Common Key. The only case, where H/2-HDs do not communicate over DiLs, is the sending/reception of RLC messages to/from the CC. The concerned channels are UL DCCH, DL DCCH and DL RBCH. In contrast to TS 101 761-1 [1], in the HE DL DCCH is also used for point-to-multipoint communication. This implies the use of the Common Key in the case of DL DCCH. For this reason and for the sake of simplicity, H/2-HDs shall use the same DM Common Key also for UL DCCH and DL DCCH. Furthermore, this solution has the advantage that no unicast encryption keys need to be transferred in case of a CC Responsibility Handover.

NOTE: DL RBCH remains un-encrypted in HE.

Since the DM Common Key shall be distributed to the WT in a secure way, it is nevertheless necessary that a unicast encryption key is generated by each WT during its association at the CC. For this purpose each H/2-HD shall implement the DES algorithm, whereas the implementation of the Triple DES is optional (TS 101 761-1 [1]). The choice of the encryption algorithm to be used for this purpose is negotiated between the CC and the WT during association (TS 101 761-2 [2]).

During association the usage of the DM Common Key Distribution procedure shall be announced in the RLC-LINK-CAPABILITY-ACK message by setting the parameter DM-USE-COMMON-KEY to the value use-common-key. DM-USE-COMMON-KEY = no-common-key is not allowed for any H/2-HD.

The CC shall generate a common key (see TS 101 761-2 [2]), define a Key Identifier for it, and call this key the DM Common Key. This key shall then be used for the encryption of all DiL as well as UL/DL DCCH LCHs of all H/2-HDs in the subnet. In case a low number of common keys is desirable, it is allowed to reuse the DM Common Key as DL Broadcast and DL Multicast Common Key.

The DM Common Key Distribution shall be always carried out after the downlink and uplink unicast Encryption Startup procedure (see TS 101 761-2 [2]), after the authentication following the unicast encryption startup (association with authentication). In the DM Common Key Distribution procedure the CC shall send a message RLC_DM_COMMON_KEY_DISTR to the associating WT. The WT shall reply with the message RLC_DM_COMMON_KEY_DISTR_ACK. Authentication is mandatory for all installed H/2-HDs, that have successfully completed the PIN and time-window protected authentication key exchange process in clause 6.9.

The message RLC_DM_COMMON_KEY_DISTR defines the encryption algorithm that is used and contains the Common Key Identifier and the DM Common Key. Since the message is encrypted with the downlink/uplink unicast key, the DM Common Key cannot be read by an eavesdropper.

The response message RLC_DM_COMMON_KEY_DISTR_ACK contains the descriptor of the encryption algorithm as a confirmation and a hash sum of the Common Key Identifier and the DM Common Key. The hash sum consists of the MD5 sum on the concatenation of the Common Key Identifier and the DM Common Key.

The unicast encryption key shall be used to encrypt all sent messages during the association procedure, but in the HE it shall be never used after the association procedure has ended. Once associated, an H/2-HD shall always use the Common Key for the encryption of (DiL and UL/DL DCCH) LCHs.

Once the DM Common Key is received by an H/2-HD, it shall use the encryption and decryption procedure in clause 6.7.4 of TS 101 761-1 [1] to encrypt and decrypt LCHs to and from other H/2-HDs. The seed sent periodically by the CC in downlink RBCH is used to support the generation of the Initialization Vector (IV) in each WT. All H/2-HDs have a seed generator, which cycles stepwise in the same way to produce non-repeating seeds (before it wraps) for each MAC frame. The seed generator of a WT shall be reset by the newly received seed from the CC, if its decoding was successful (TS 101 761-1 [1]). A new IV is used for each DiL LCH. The IV is a function of the locally generated seed and the 12 LSBs of the start pointer value in the FCCH IE for that particular connection. This ensures the synchronization of the encryption and decryption processes for each connection, although only a single DM Common Key is used for all encrypted LCHs and all H/2-HDs.

The DL Broadcast and DL Multicast Common Keys described in TS 101 761-2 [2] shall be distributed after the association. The distribution of these keys is protected against eavesdropping by encryption with the DM Common Key in case of an H/2-HD and by encryption with the unicast key in case of a Non HE-compliant Device. Only in case that one or multiple Non HE-compliant Devices participate in the network, there may also be DL Broadcast or DL Multicast groups in which an H/2-HD wants to participate, too. While the distribution mechanism of the DM Common Key differs from the distribution of DL Multicast and DL Broadcast Common Keys, the refresh mechanism is the same for all common keys.

As Non HE-compliant Devices shall be also supported by the CC of a HE subnet, the CC has the task to differentiate between H/2-HDs and Non HE-compliant Devices. The CC shall be aware that a Non HE-compliant Device will encrypt UL DCCH and UL UDCH with its unicast encryption key. The CC shall encrypt all messages directed to a Non HE-compliant Device and carried on a DL DCCH or DL UDCH with the unicast encryption key of that WT. DL UBCH and DL UMCH messages are encrypted with the DL Broadcast and DL Multicast Common Key, respectively. On the other hand, the CC shall be aware that an H/2-HD will encrypt all UL DCCH, DiL DCCH and DiL UDCH messages with the DM Common Key. Table 6 gives an overview over the use of the different encryption keys for the two different device types. A dash in a field indicates that the channel used by one device type is not used by the other device type.

Table 6: Encryption of logical channels for H/2-HDs and Non HE-compliant Devices

Sender	H/2-HD	Key used by H/2-HD	Non HE-compliant Device	Key used by Non HE-compliant Device
CC	DL DCCH	DM Common Key	DL DCCH	Unicast Key of WT
CC	-	-	DL UDCH	Unicast Key of WT
CC	DL RBCH	Not encrypted	DL RBCH	Not encrypted
CC	-	-	DL UBCH	DL Broadcast CK
CC	-	-	DL UMCH	DL Multicast CK
WT	UL DCCH	DM Common Key	UL DCCH	Unicast Key of WT
WT	-	-	UL UDCH	Unicast Key of WT
H/2-HD	DiL RBCH	DM Common Key	-	-
H/2-HD	DiL UBCH	DM Common Key	-	-
H/2-HD	DiL UMCH	DM Common Key	-	-
H/2-HD	DiL DCCH	DM Common Key	-	-
H/2-HD	DiL UDCH	DM Common Key	-	-

NOTE 1: H/2-HD includes both WT and CC.
NOTE 2: If an H/2-HD is to communicate with a Non HE-compliant Device, this H/2-HD shall operate in CM with respect to the connections to and from the Non HE-compliant Device.

6 Services supported by the Radio Link Control sublayer

6.1 General

The radio link control sublayer supports:

- Association Control Function (ACF) including Encryption, Authentication and Key Management. Additionally to these basic functions the Home Environment shall support Multiple Convergence Layers not only for the CC but also for each WT.
- Radio Resource Control (RRC): the "Dynamic Frequency Selection", the "MT Absence" and the "Power Saving functions" of the RRC are also required for Home Environment whereas the cellular "Handover" is an optional functionality for H/2 home devices. Additional functions in the home environment are the Dynamic CC Selection and the CC Responsibility Handover described in clauses 6.7 and 6.8. The Power Control and the Link Adaptation functions for the CM are described in TS 101 761-1 [1]. The corresponding functions for the DM are specified in the present document.
- DLC User Connection Control (DUCC): the DUCC contains functions for the establishment and the modification both of unicast and multicast connections. The DUCC basic functions in TS 101 761-2 [2] include DUCC for the direct link unicast and DiL multicast without QoS negotiation. The DiL multicast with QoS negotiation is specified in clause 6.6.2 of the present document.

6.1.1 Basic RLC Functions applied

The following concepts of the RLC basic functions TS 101 761-2 [2] have been adopted:

- Usage of DLC logical and transport channels for RLC messages;
- Transfer Syntax of RLC (except DiL and DL multicast DCCH);
- Sequencing of RLC messages;
- ASN.1 definition of the RLC PDUs;
- Timers and repetitions of RLC messages.

6.1.1.1 DLC User Connection Control

The DUCC contains functions for the establishment, modification and release of unicast, multicast and broadcast connections. Furthermore the DUCC for direct link unicast is described in TS 101 761-2 [2].

6.1.1.2 Radio Resource Control

Dynamic Frequency Selection

The Dynamic Frequency Selection (DFS) is applied in the HE in the way it is supported by the TS 101 761-2 [2]. The DFS shall avoid the interference of other devices using the same frequency band that may arise from neighbouring H/2 networks using the same frequency or Non HE-compliant Devices on the frequency band. The H/2 DFS scheme is centralized to CCs. Every CC collects measurement results and chooses the operating frequency independently of other CCs.

MT Absence

The MT Absence function is for WT maintenance purposes (scanning channels, etc.). The MT Absence in CM is defined in TS 101 761-2 [2]. The MT Absence in DM does not differ from the procedure in CM. In DM, the user packets to be transmitted to a WT in the absence state are queued in the transmitting WT, not in the CC.

6.1.2 Changed RLC Functions

6.1.2.1 Association Control Function

In HE, the CC is determined as a result of the CC Selection process. Its role is handed over to another CC-capable H/2-HD after a successful CC responsibility handover. A HE-compliant H/2-HD shall only try to associate with the CC whose NET-ID matches that stored in the H/2-HD, see clause 6.9. If more than one such CC is detectable, the H/2-HD shall first try to associate with the CC with the best receive quality. Since the NET-ID is just a random number, it is possible that the same NET-ID value is used by a nearby non HE-compliant CC. Therefore, the HE-compliant H/2-HD shall abort the association process with a CC, as soon as it detects that this CC is not HE-compliant. Re-association with this Non HE-compliant CC is optional, if the HE-compliant H/2-HD cannot find any other HE-compliant CC with the same NET-ID, and if it is unable or not willing to become the CC of the HE-compliant network.

NOTE 1: A manufacturer can implement on an H/2-HD different usage profiles. By selecting a Non HE-compliant usage profile, the user can configure an H/2-HD as a Non HE-compliant device to be preferably associated with a non HE-compliant CC.

NOTE 2: AN H/2-HD acting as CC may allow a Non HE-compliant Device to associate with the network. In this case, all H/2-HDs having communications with that Non HE-compliant Device shall operate in CM with respect to all connections to and from that Non HE-compliant Device.

Terminal Association for Multiple CLs

After the RBCH Association message transfer the list of CL-IDs is processed by the WT. The WT shall abort the association process if there are no corresponding CLs supported. If several CLs are supported both by the CC and the WT, the WT shall select CL IDs according to a set of rules that are defined in clause 6.2. The WT transmits the selected CL-ID-list to the CC in the RLC_LINK_CAPABILITY message which is sent after the MAC ID assignment.

6.1.2.2 Radio Resource Control

Handover

The "Radio Handover", "Network Handover" and "Forced Handover" as described in the TS 101 761-2 [2] are only optional for H/2-HDs, since no cellular infrastructure can be assumed for private homes.

Power Saving

The Power Saving functions are initiated by the WT with the purpose of entering or leaving low consumption modes and controlling the power of the transmitter. Direct link connections addressed to a WT that is in a power saving state shall not be scheduled by the CC. The CC shall wake up the sleeping WT, when detecting another WT having pending data for this sleeping WT.

6.1.3 Changed RLC Messages, Parameter Settings

6.1.3.1 Association Control Function

In the home environment no Network Operator ID shall be applied. Therefore the NOP-ID field shall not be used in the RBCH Association message.

The parameters exchanged during association and being relevant to H/2-HDs are described below:

direct-mode-cap: The value of the direct-mode-cap field shall be set to 1 ("dm-capabilities") for all H/2-HDs. (message: **RLC_LINK_CAPABILITY**).

cl-vid-list: H/2-HD may support more than one CLs. The IDs of these CLs shall be included in this CL-ID-List. (messages: **RLC_RBCH_ASSOCIATION, RLC_LINK_CAPABILITY**).

support-fsa: H/2-HDs supporting isochronous services shall support FSA, and set Support-FSA field to the value 1 ("support-fsa"). (message: **RLC_LINK_CAPABILITY, RLC_LINK_CAPABILITY_ACK**).

cc-ho-cap: A CC-capable H/2-HD supporting CC responsibility handover shall set this parameter field to cc-ho-supported. (message: **RLC_LINK_CAPABILITY**).

dm-use-common-key: This parameter field is used to indicate if the DM Common Key distribution procedure is performed. It shall be set to the value "use-common-key". (message: **RLC_LINK_CAPABILITY**).

dm-attributes: The parameter field dil-power-control shall be set to dil-dynamic-pc, the parameter fields rx-arq-win-size and tx-arq-win-size shall be set to the supported ARQ window size. (message: **RLC_LINK_CAPABILITY, RLC_LINK_CAPABILITY_ACK**).

6.1.3.2 DLC User Connection Control

The following parameters contained in the setup/modify messages for DiL UDCH and DiL UMCH shall be set as follows:

cl-id: This parameter shall be set to the ID of the CL instance that sets up or modifies a DiL UDCH or DiL UMCH.

NOTE: CL-ID is also used by the join and leave procedures for DiL UBCH or DiL UMCH.

allocation-type: The allocation-type parameter in duc-descr describes the type of connection: basic, fca, or fsa.

fec-used: The fec-used flag shall be set for each DiL UDCH or DiL UMCH that uses FEC mode.

fec: The fec field defines the coder type and the interleaver type of the applied FEC.

6.1.4 New RLC Functionality

CC Selection, CC Responsibility Handover

Because of the ad hoc network topology, additional functions like the CC selection procedure and the CC Responsibility Handover procedure are introduced in clauses 6.7 and 6.8. Support for CC Selection is mandatory for CC-capable H/2-HDs.

Direct Link related Functions

Support for DiL Link Adaptation, DiL Power Control, and Link Quality Calibration, are mandatory for H/2-HDs. The corresponding functions are specified in clauses 6.3, 6.4, and 6.5.

The DiL UMCH setup/modify/release is specified in clause 6.6.2, and the use of DiL UBCH is specified in clause 5.9. The support for DiL UMCH and DiL UBCH is mandatory for H/2-HDs.

Authentication Key Exchange

The Key Exchange with special reference to direct link requirements is specified in clause 6.9.

Fixed Slot Allocation

The *fsa-descr* field in the *duc-descr* parameter list of TS 101 761-2 [2] enables the establishment of an FSA connection, which is further elaborated in the present document. The support for Fixed Slot Allocation is mandatory for all CC-capable WTs, and optional for basic WTs. The FSA enables the reservation of slots at fixed positions in the MAC Frame which cannot be changed with normal RGs.

6.2 Terminal association for multiple convergence layers

In the HE multiple active CLs may make use of multiple CLs, since WTs may be connected to different types of fixed networks, for example IEEE 1394 and Ethernet. In this case, the terminal association is done in several steps. In the RBCH Association procedure the CC shall inform the WT about the CLs supported in parallel by the CC, using the cl-vid-list parameter. During the link capability procedure, the WT informs the CC about the CLs it wants to associate with, also using a cl-vid-list. The WT's cl-vid-list shall be a sub-set of the cl-vid-list sent by the CC. If none of the CL IDs sent in RBCH association message is supported by the WT, the WT shall not continue with the association.

In case of successful negotiation of CL-IDs, the info transfer procedure (see TS 101 761-2 [2]) shall be subsequently performed between the WT and the CC for each selected CL-ID. Per CL-ID one info transfer is performed. The format of the INFO_PDU is described in TS 101 761-2 [2]. After successful association of the CLs, the CL-specific C-SAP(s) and U-SAP(s) are created for the individual CL-IDs. During DiL UDCH or DiL UMCH setup the CL-ID contained in the messages identifies the C-SAP of the addressed CL. After the setup of a DIL UDCH or DiL UMCH, the DUC-ID implicitly identifies the U-SAP of the addressed CL.

6.3 Link Adaptation in Direct Link Phase

In unicast DiL communication only the receiver is allowed to recommend a new PHY mode based upon the packet decoding quality at any time. In this case the receiver shall set the PHY mode LCH and PHY mode SCH parameters in RR for DiL to the proposed new PHY mode, see clause 6.2.9.1 of TS 101 761-1 [1]. The parameters #SCH and #LCH shall be set to zero.

NOTE: In contrast to a RR for DiL used for unicast link adaptation (#LCH = #SCH = 0), which is issued by a receiver, the RR for DiL with #LCH > 0 and/or #SCH > 0 can only be sent by the transmitter of a DiL connection to request LCH(s) and/or SCH(s).

In multicast/broadcast DiL communication, link adaptation shall only be performed in conjunction with dynamic power control in clause 6.4.2. Here, a new PHY mode shall only be recommended by the sender of a multicast connection, which is defined uniquely by the sender MAC-ID and the multicast MAC-ID. The sender of a multicast connection may propose a more robust PHY mode, if the transmit power for this connection has reached the upper boundary, and at least one of its receivers is suggesting a higher transmit power. It can propose a less robust PHY mode, if the transmit power for this connection has reached the lower boundary, and all of its receivers are suggesting a lower transmit power. The sender of the multicast connection shall use a RR for DiL to recommend the new PHY mode for LCH and/or SCH. It shall set #LCH and/or #SCH to zero, if no real resources are requested by this RR.

For both direct link unicast and multicast, the CC shall not change the PHY mode of a DiL connection without recommendation from the involved WTs.

6.4 Power Control in Direct Link Phase

Dynamic power control, in direct link phase, enables the transmitting WT to always set its transmit power level appropriately, to provide acceptable reception quality at the receiving WT. This is determined according to the explicit recommendation from the receiver to the transmitter, to increase or decrease its power level by a certain value (dB). The criteria the receiver uses to determine this value is implementation specific.

NOTE: The receiving WT might use received signal strength (RSS) or the BER of received data as a criteria for reception quality.

Dynamic power control shall be supported by all H/2 home devices. Dynamic power control for unicast and multicast/broadcast connections in direct link is described below.

For the purpose of power control in unicast and multicast/broadcast, the message RLC_DM_POWER_CONTROL is used as described below: Since unicast and multicast/broadcast PDUs from the same sender are not necessarily received in one PDU train, dynamic power control is performed separately. A connection type field dm-duc-type in RLC_DM_POWER_CONTROL indicates whether the recommendation concerns unicast or multicast/broadcast PDUs originating from the same sender.

RLC_DM_POWER_CONTROL messages shall be always transmitted using the most robust PHY mode. The transmit power level may vary, and is specified below.

6.4.1 Direct Link unicast power control

Dynamic power control shall be performed for each unicast DUC in DiL, for both simplex and duplex connections. Two WTs that have several DUCs, using different PHY modes, would usually require different transmit power levels. However, since PDUs belonging to different DUCs which are sent from one WT to a peer WT in one MAC frame, are transmitted in a train, the same transmit power level shall be used for all PDUs in the train. The transmit power level is set to satisfy the connection with the worst reception quality (i.e. less robust PHY mode). This is provided by the receiver's explicit recommendation.

In unicast, the power control scheme in direct link phase is performed as follows:

1) Connectivity Check: performed during the first DiL DUC Setup between a WT pair;

2) Power Update: performed after each DiL DUC Setup involving the same WT pair, and during the lifetime of their unicast connections.

During the first DiL DUC Setup, the peer WTs exchange power control messages, in order to check if a direct radio link is possible. After the first connection setup is successfully completed, and during the lifetime of the connection, power update is dynamically performed, to inform the sender about appropriate transmit power level. Power update can also be performed after a further DiL DUC setup between the same WT pair, to take into account different power requirements for different PHY modes.

6.4.1.1 Connectivity Check

Connectivity check is performed only for the first DiL DUC between two WTs using RLC_DM_POWER_CONTROL messages. During the setup of the first unicast DiL DUC (see TS 101 761-2 [2]), the CC enables both WTs to perform connectivity check by granting each WT at least one DiL DCCH to transmit its power control message, using a SCH. The CC itself can be one of the WTs. The CC shall send the RGs to both WTs, after the second RLC_DM_CONNECT_ACK message (to WT2), and before the first RLC_DM_CONNECT_COMPLETE message (to WT1), have been sent. This is shown in the following MSCs for both CC and WT initiated DUC setup. The CC may grant resources for connectivity check several times during this period. All these granted DiL DCCH SCHs to this WT pair shall be used for connectivity checking. All RLC_DM_POWER_CONTROL messages sent for connectivity check shall be transmitted at maximum allowed power level.

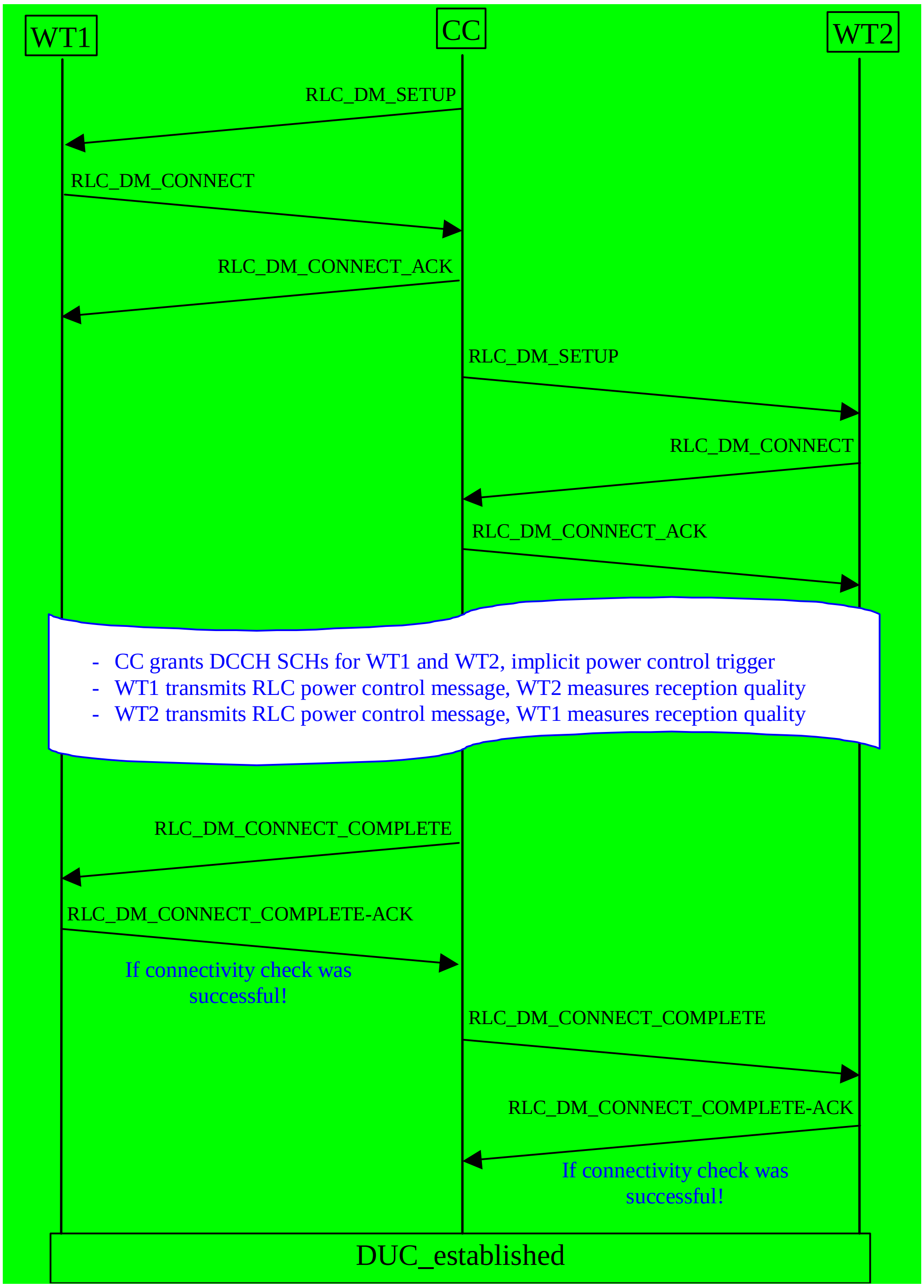

Figure 10: Direct Link Setup procedure - CC initiated

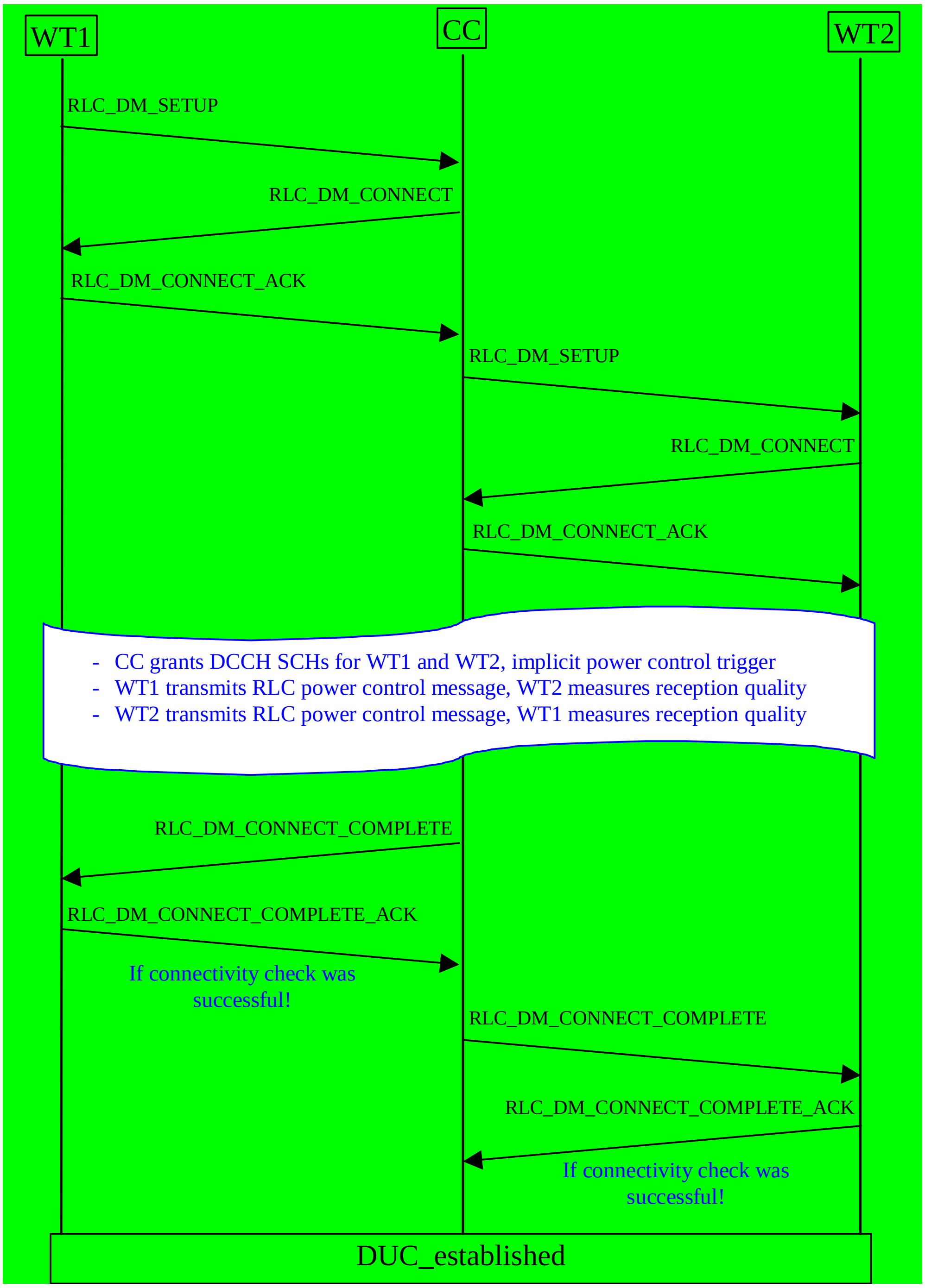

Figure 11: Direct Link Setup procedure - WT initiated

RLC-DM-POWER_CONTROL-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-SCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
dm-duc-type	DM-DUC-TYPE,
wt-tx-level	TX-LEVEL
adjust-tx	ADJUST-TX }

The RGs are considered as an implicit trigger for connectivity check. No RR shall be generated by the WTs. On reception of such an RG, each WT transmits RLC_DM_POWER_CONTROL message to the peer WT, using the maximum allowed transmit power level for the frequency band of operation. Each WT measures then the reception quality (e.g. using RSS, BER, etc…) of the RLC_DM_POWER_CONTROL message from the peer WT.

Either WT shall abort the DiL DUC connection setup in the following cases:

- It is not granted at least one DiL DCCH SCH, or cannot successfully decode at least one corresponding RG, before receiving the RLC_DM_CONNECT_COMPLETE message from the CC.
- It could not receive the RLC_DM_POWER_CONTROL message, or the reception quality was not acceptable.

In order to reject the DiL DUC Setup the WT shall send RLC_DM_RELEASE message and continue with the DiL Release procedure.

Either WT shall only acknowledge the RLC_DM_CONNECT_COMPLETE message from the CC with RLC_DM_CONNECT_COMPLETE_ACK, after it has successfully decoded at least one RLC_DM_POWER_CONTROL message from the peer WT, and it has sent at least one RLC_DM_POWER_CONTROL message to the peer WT.

In case both WTs successfully acknowledged the RLC_DM_CONNECT_COMPLETE from the CC, the connectivity check is considered successful, and the connection setup is successfully completed.

6.4.1.2 Power Update

As long as there is at least one unicast connection between a WT pair, power update is performed whenever it is necessary. After each further unicast connection setup or release, either WT should consider performing power update, to ensure always satisfying the connection with worst reception quality.

Each WT continuously monitors the received signal quality of all its unicast connections with the peer WT. If a WT detects a worsening or an improvement of the received signal strength or another reception quality criterion (implementation specific) above an acceptable threshold, it should request a DiL DCCH SCH to transmit a RLC_DM_POWER_CONTROL message. The message contains an explicit recommendation to the peer WT to adjust its transmit power level for unicast traffic appropriately. For the RLC_DM_POWER_CONTROL message transfer the WT shall use the most robust PHY mode. If this message is transmitted together with other PDUs, the regulated Power level, otherwise the maximum transmit power level, shall be used for the unicast transmission.

Even though the radio channel can be considered symmetric in most of the cases, it is recommended that a transmitting WT1 only adapts its power level based on explicit recommendation from the receiving WT2. WT1 should not change its transmit power level based on the change of its own reception quality for WT2.

Latest, two frames after either WT has successfully decoded the received RLC_DM_POWER_CONTROL message with explicit recommendation, it shall start to transmit all its direct link unicast traffic to the peer WT, using the adjusted power level.

The power control scheme in direct mode should not react on burst changes of the radio channel, rather on persistent changes. The exact algorithm is implementation specific.

In case the PHY mode is changed during a connection, the WTs might also readjust the transmit power levels accordingly.

In addition to the dm-duc-type field and recommendation for power control, the RLC_DM_POWER_CONTROL message also contains the current transmit power level of the sender of this message, for all its unicast connections with the receiving WT. Thus, the receiving WT recognizes whether the transmitter has reached the lower or upper transmit power limit in the frequency band of operation. In this case, the peer WTs might initiate a change of PHY mode for link adaptation, see clause 6.3.

If a WT does not react to a recommendation from its peer WT after two frames, the originator of the recommendation shall retransmit its RLC_DM_POWER_CONTROL message.

In case the receiving WT can no more successfully decode the received user data, it shall transmit its RLC_DM_POWER_CONTROL message at the maximum transmit power level, informing the sender to increase its transmit power level to the recommended value. If the receiver is still not able to successfully decode received data, it might trigger a PHY mode change for link adaptation, before it releases the connection.

RLC_DM_POWER_CONTROL messages can be exchanged anytime by just requesting SCH for DiL DCCH, as long as there is at least one connection between the WT pair.

6.4.2 Direct Link Multicast/Broadcast Power Control

In the case of multicast and broadcast connections, a quasi static transmit power control scheme shall be applied. The sender shall start transmission of the first multicast/broadcast connection, at 3 dB below the maximum allowed transmit power level for the centre frequency where it is operating. No connectivity check is performed in DiL broadcast or multicast connections (both with and without connection setup).

After multicast/broadcast connection has started (corresponding RGs in FCH), each receiving WT shall send its RLC_DM_POWER_CONTROL message to the multicast/broadcast sender, latest within a timer T_mc_dm_power_control. A receiving WT that could successfully decode the corresponding user data informs the multicast/broadcast sender to decrease its transmit power level by a certain value. A receiving WT that could not successfully decode the user data requests the multicast/broadcast sender to increase its transmit power level appropriately. The multicast/broadcast sender shall adjust its transmit power level, in order to satisfy the receiver with the worst reception quality, i.e. which recommended highest increase or lowest decrease of power level. The sender shall always ensure that it is compliant with the maximum allowed transmitted power level for the centre frequency where it is operating.

Similar to unicast, the sender shall always use the same transmit power level for all its active multicast and broadcast connections, even if different multicast groups are target. The receiving WTs should therefore determine the required transmit power adjustment for a certain multicast/broadcast sender, based on the multicast or broadcast connection with the worst reception quality.

During the lifetime of all multicast/broadcast connections from the same sender, each receiving WT shall send its RLC_DM_POWER_CONTROL message to the sender whenever necessary, but not less than once every T_mc_dm_power_control. The sender should adjust its transmit power level, if it notices that all receiving devices have a persistently acceptable reception quality according to their RLC_DM_POWER_CONTROL messages. Recommendations from multicast/broadcast receivers to increase the transmit power level shall be applied latest two frames after reception of the corresponding RLC_DM_POWER_CONTROL message. The multicast/broadcast sender shall however not reduce its transmit power level by more than 3 dB within T_mc_dm_power_control. This shall ensure that the sender does not react to burst characteristics of the radio channel.

Since a new multicast/broadcast connection might require higher transmit power level than already active ones (if it uses different PHY mode, or it targets different multicast receivers), each new multicast/broadcast connection shall be started at 3 dB below the maximum allowed transmit power level, or the currently used multicast/broadcast power level if it is higher. Consequently, latest when a new multicast/broadcast connection is started, the sender shall have increased the power level of all its active multicast/broadcast connections, if it was originally less then 3 dB below the maximum power. If the power level of active connections already exceeds this level, the same level shall be used for the new connection as well. After the new multicast/broadcast connection is started, the appropriate transmit power level is determined based on the receiver's recommendations.

NOTE: The sender may steadily perform the increase of power level for example during multicast connection setup.

RLC_DM_POWER_CONTROL messages for direct link multicast/broadcast power control may be transmitted together with unicast traffic to the multicast sender. In this case, this message may be transmitted at regulated transmit power level for unicast traffic. Otherwise, the RLC_DM_POWER_CONTROL message shall be transmitted using the maximum transmit power level. Thus it can be assumed that the sender can successfully decode the messages from those receivers, where direct link connection is possible. The sender may initiate link adaptation (see clause 6.3), if the transmit power for its multicast/broadcast connections has reached the upper (lower) boundary, and at least one (all) of its receivers is suggesting a higher (lower) transmit power.

A multicast/broadcast receiver may retransmit its RLC_DM_POWER_CONTROL message several times to request the sender increase its power level, if the sender does not satisfy this request within two frames. The receiver may leave the multicast/broadcast group if the reception quality is still not acceptable.

A new WT that joins a multicast/broadcast group, first checks if a connection is active (corresponding RGs in FCH). Depending on the reception quality of all active multicast/broadcast connections from the same sender, the new WT shall send its RLC_DM_POWER_CONTROL message with appropriate recommendation, latest within T_mc_dm_power_control.

6.5 Link Quality Calibration for DM operation

The link quality calibration aims at creating a map of the network, which describes the quality of the radio link between each WT pair, including the CC. The link quality map is required by H/2-HDs for several reasons, for example CC responsibility handover, future support of hidden nodes, loop detection in 1394 networks, etc.

6.5.1 Principles of Calibration

The calibration procedure consists of two phases: measurement phase and reporting phase. It is always triggered by the CC, and it is started in two cases:

- *High Priority Calibration*

  When a new WT joins the network, the CC shall trigger a calibration procedure with high priority. The CC allocates resources for the measurement and reporting phases as described in the following clauses.

- *Low Priority Calibration*

  To keep the link quality map of the network up to date, the CC shall trigger low priority calibrations, if spare resources are available. It is up to the CC to determine the frequency of low priority calibrations. Depending on the mobility of the WTs, the update interval might vary from 100 milliseconds to a few minutes. The algorithm to determine the frequency of calibration is an implementation specific issue.

NOTE 1: If the CC is to take a decision based on the link quality map, such as to select the best CC-candidate, it should be aware that an RSS2 value in the link quality map could be outdated.

The triggers for both measurement and reporting phases have a lifetime of T_trigger_lifetime each. Within the lifetime of a measurement or report trigger the CC shall send out neither a new measurement trigger, nor a new report trigger. The lifetime of a measurement or report trigger begins with the start of the next MAC frame following the MAC-frame that contains that trigger PDU.

Since link quality calibration is always triggered by the CC, only Resource Grant messages are required (no RR for calibration). Resource grants for measurement and report PDUs are announced in FCCH, using the RG IE for DiL RBCH. The CC shall act as a WT to use the measurement PDUs during the measurement phase.

All measurement, report and trigger messages shall be transmitted using the most robust PHY mode, and the maximum transmit power level. Further, it is suggested that the entire link quality calibration is always performed using omni-directional antennas, at both transmitter and receiver sides, without support of antenna diversity. This enables a fast calibration of the network. A more accurate calibration of the network, using sectorized antennas, requires very extensive measurements.

NOTE 2: The omni-directional antenna can be implemented using existing sectorized antennas.

The CC may wake up a sleeping WT (TS 101 761-2 [2]) to perform measurement or report.

The granted calibration measurement and report DiL RBCH resources may become ambiguous for a WT, if it had not received the corresponding trigger within the last T_trigger_lifetime and it had not sent a RR for the same DiL RBCH resources before the grant. If a WT cannot unambiguously identify the purpose of a granted DiL RBCH SCH or DiL RBCH LCH, it shall send a dummy DiL RBCH SCH or LCH PDU with all payload bits set to zero.

NOTE 3: A WT may use granted DiL RBCH resources for purposes other than calibration, if it had not received the corresponding calibration trigger within the last T_trigger_lifetime and it had sent a RR for the same DiL RBCH resources before the grant.

The CC maintains the resulting link quality map of the network, and may be requested by any WT to broadcast its contents as described in clause 6.5.4.

6.5.2 Measurement Phase

The measurement phase is started by the calibration-measurement trigger broadcast by the CC. The lifetime of the measurement trigger is T_trigger_lifetime, within which a triggered WT1 is granted a SCH for DiL RBCH to be sent as measurement PDU. This PDU shall be received by other WTs to determine the quality of their links to WT1. The measurement phase for WT1 is completed after the trigger has expired.

6.5.2.1 Calibration-Measurement Trigger

The CC shall trigger the start of the measurement phase by broadcasting the RLC_CALIBRATION_MEASUREMENT_TRIGGER message using a downlink RBCH SCH. Selective triggering shall be enabled for simultaneous calibration measurements and calibration reporting from different WTs (Figure 12). The trigger type indicates whether all WTs will be requested to perform calibration measurement, or only a set of selected WTs. In case only a set of WTs (up to three) is triggered, the corresponding MAC-ID list shall be included in the trigger message.

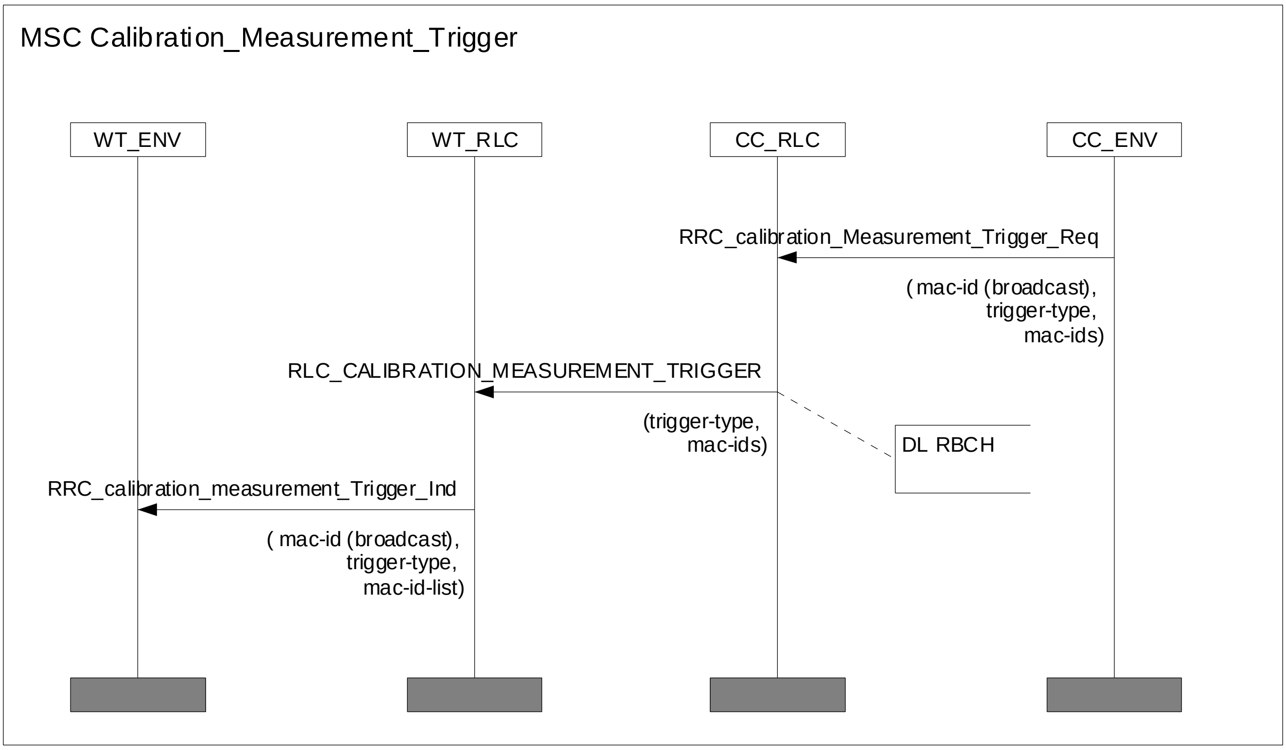

Figure 12: MSC for RLC_CALIBRATION_MEASUREMENT_TRIGGER

The RLC_CALIBRATION_MEASUREMENT_TRIGGER message shall be transmitted using the most robust PHY mode.

After calibration measurement trigger, the CC shall grant DiL RBCH resources to all, or a set of WTs to transmit calibration measurement PDUs in direct link. Only DiL RBCH SCHs granted within the lifetime of the measurement trigger shall be regarded as measurement PDUs.

Table 7: RLC-CALIBRATION-MEASUREMENT-TRIGGER

RLC-CALIBRATION-MEASUREMENT-TRIGGER -ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-SCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
trigger-type	TRIGGER-TYPE,
mac-ids	MAC-IDS }

6.5.2.2 Calibration Measurement

After reception of a (network-wide or selective) calibration-measurement trigger message from the CC, a WT that is granted a SCH in DiL RBCH as transmitter shall broadcast a RLC_CALIBRATION_MEASUREMENT message during direct link phase (Figure 13). It shall set the source MAC-ID of this DiL RBCH to its own MAC-ID.

A WT, which is granted a DiL RBCH SCH without having received a measurement trigger message from the CC during the last T_trigger_lifetime (the measurement trigger lifetime) shall not use this DiL RBCH SCH for calibration measurement. It may use this DiL RBCH SCH for purposes other than calibration, if it has sent a RR for DiL RBCH SCH before.

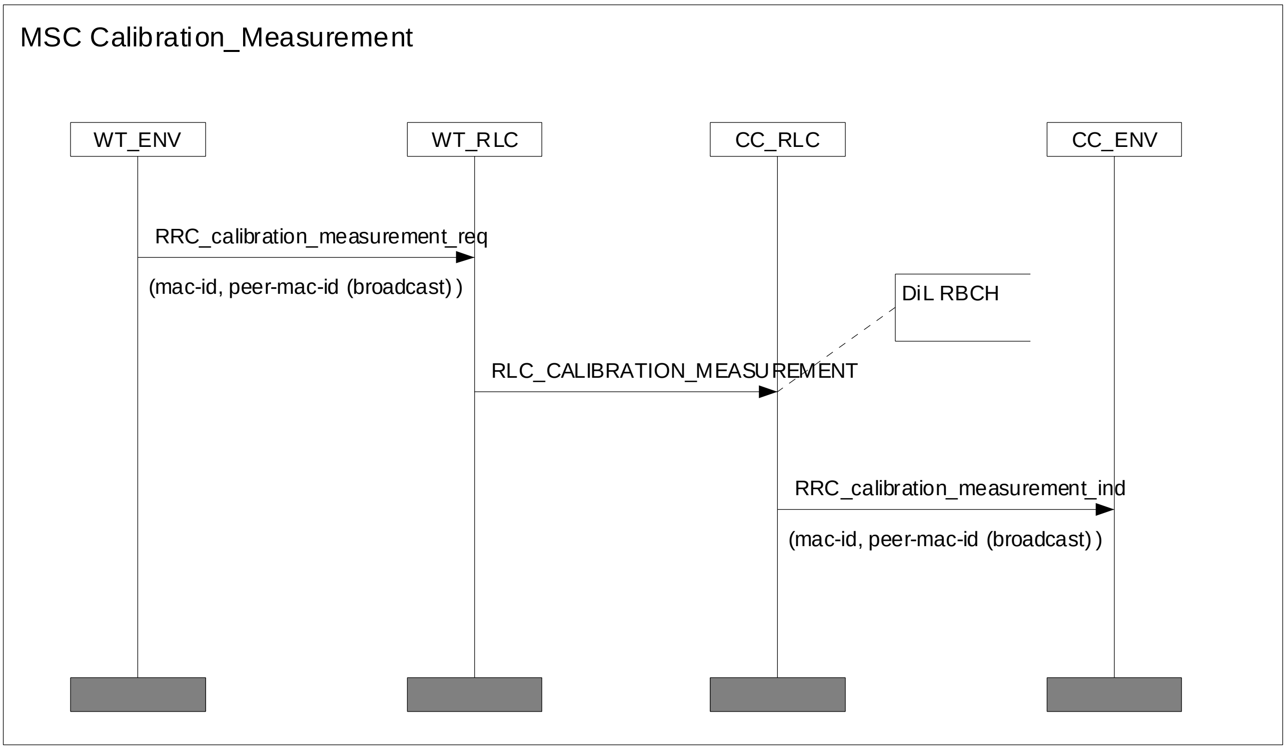

Figure 13: MSC for RLC_CALIBRATION_MEASUREMENT

The RLC_CALIBRATION_MEASUREMENT message shall be transmitted using the most robust PHY mode and maximum allowed transmit power level in the frequency band of operation.

The RLC_CALIBRATION_MEASUREMENT message will be received by all other WTs (including the CC), which can listen to the sender of this message. Upon reception of this message, each WT (including the CC) shall perform physical layer measurement of received signal strength (referred to as RSS2 for Direct Link (TS 101 475 [3])), and shall compare it to the previously measured value, if available. In case that the RSS2 value difference exceeds a threshold of ±6 dB, the corresponding value in the local link quality map shall be updated. This value is reported during the report phase as described below.

6.5.3 Reporting Phase

The reporting phase is started by the calibration-report trigger, broadcast by the CC. The lifetime of the report trigger is T_trigger_lifetime, within which a triggered WT1 is granted a SCH for DiL RBCH to be sent as report PDU. This PDU shall be received by the CC to update the global link quality map. It shall also be received by other WTs to update their locally stored (partial) link quality maps, if any. The reporting phase for WT1 is completed after the trigger has expired.

6.5.3.1 Calibration-Report Trigger:

The CC shall trigger the start of the reporting phase by broadcasting the RLC_CALIBRATION_REPORT_TRIGGER message using a downlink RBCH SCH (Figure 14). The report trigger shall indicate whether all WTs, or a set of selected WTs shall report their calibration measurement results. In case that a set of WTs (up to three) is triggered, the corresponding MAC-ID list shall be included in the trigger message.

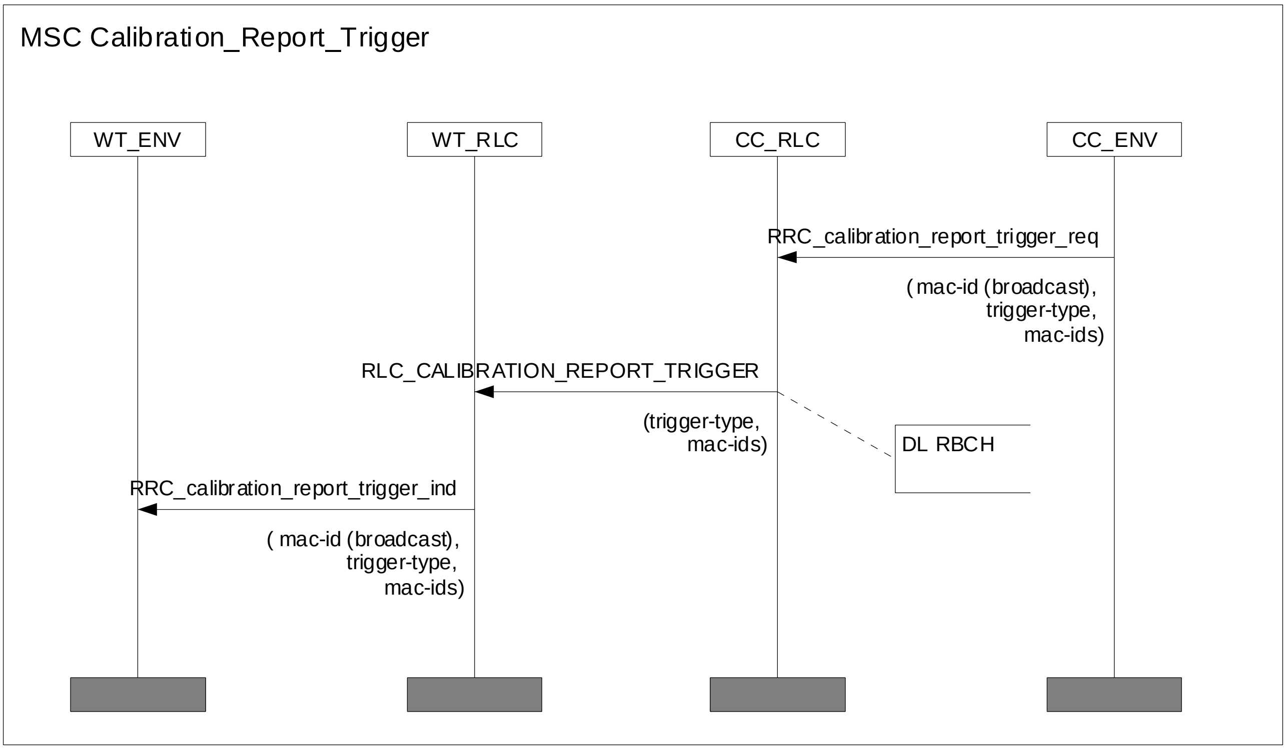

Figure 14: MSC for RLC_CALIBRATION_REPORT_TRIGGER

The RLC_CALIBRATION_REPROT_TRIGGER message shall be transmitted using the most robust PHY mode.

After calibration report trigger, the CC shall grant DiL RBCH resources to all, or a set of WTs to transmit calibration report PDUs in direct link. Only DiL RBCH SCHs granted within the lifetime of the report trigger of T_trigger_lifetime shall be regarded as calibration report PDUs.

Table 8: RLC-CALIBRATION-REPORT-TRIGGER

RLC-CALIBRATION-REPORT-TRIGGER -ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-SCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
trigger-type	TRIGGER-TYPE,
mac-ids	MAC-IDS }

6.5.3.2 Calibration Report:

Depending on the number of calibration measurements performed, the CC may grant SCHs or LCHs to a triggered WT to send its reports. After reception of a (network-wide or selective) calibration-report trigger message from the CC, a WT that is granted a SCH or LCH in DiL RBCH as transmitter, shall broadcast a RLC_SHORT_CALIBRATION_REPORT or RLC_CALIBRATION_REPORT message during direct link phase (Figure 15). It shall set the source MAC-ID of this DiL RBCH to its own MAC-ID. In the case of SCH, RLC_SHORT_CALIBRATION_REPORT contains up to two reports. In the case of LCH, RLC_CALIBRATION_REPORT may contain up to 22 reports. The field number-of-reports describes the number of actual reports contained in the current LCH PDU.

A WT, which is granted a DiL RBCH SCH or LCH without having received a report trigger message from the CC during the last T_trigger_lifetime (the report trigger lifetime) shall not use this DiL RBCH SCH or LCH for calibration reporting. It may use this DiL RBCH SCH or LCH for purposes other than calibration, if it has sent a RR for DiL RBCH SCH, or LCH, respectively, before.

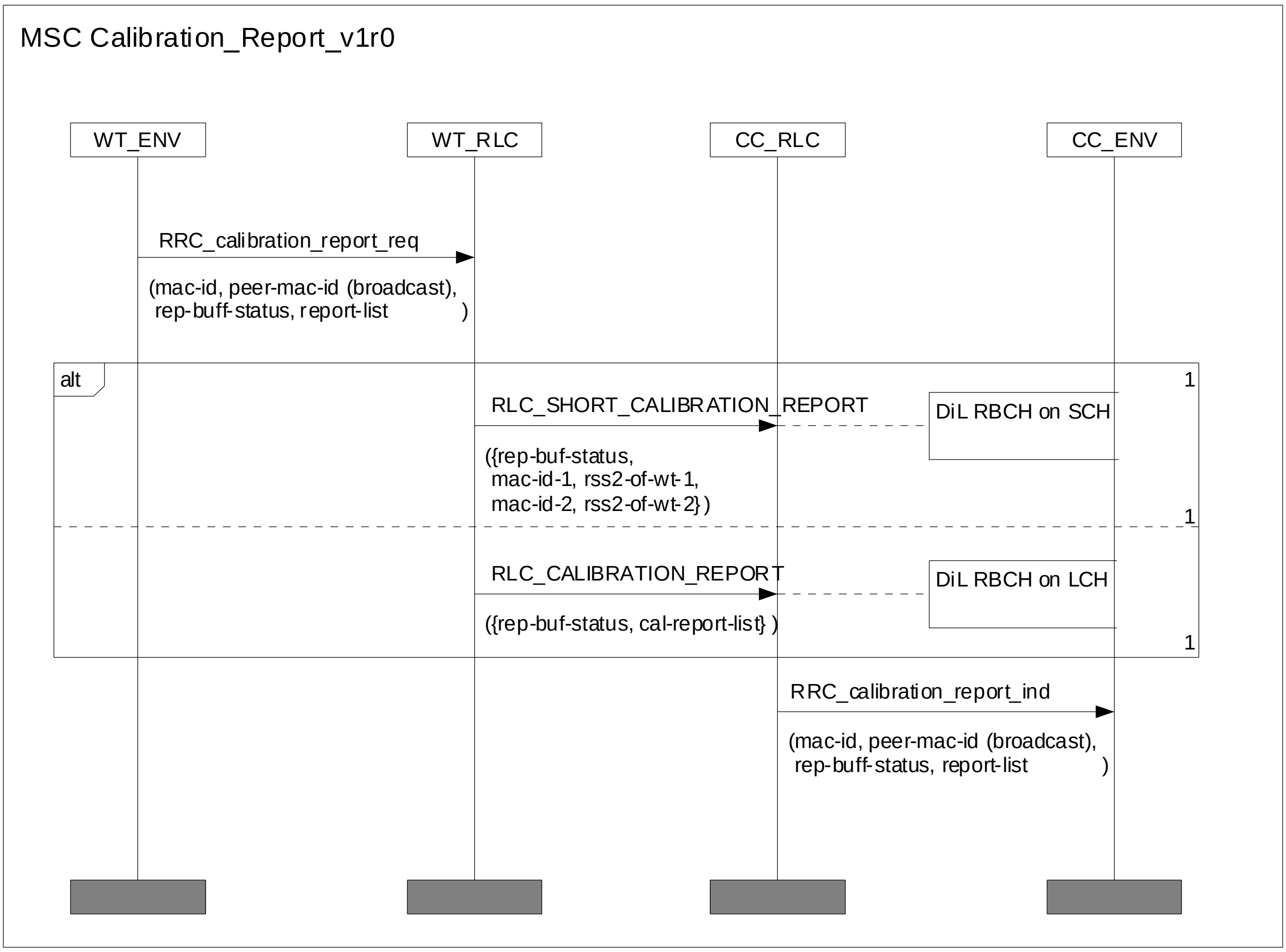

Figure 15: MSC for RLC_CALIBRATION_REPORT

The RLC_SHORT_CALIBRATION_REPROT and RLC_CALIBRATION_REPROT messages shall be transmitted using the most robust PHY mode, and the maximum allowed transmit power level in the frequency band of operation.

Table 9: RLC-SHORT-CALIBRATION-REPORT

RLC-SHORT-CALIBRATION-REPORT-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-SCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
rep-buf-status	REP-BUF-STATUS,
mac-id-1	MAC-ID,
rss2-of-wt1	RSS2-VALUE,
mac-id-2	MAC-ID,
rss2-of-wt2	RSS2-VALUE}

Table 10: RLC-CALIBRATION-REPORT

RLC-CALIBRATION-REPORT-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
rep-buf-status	REP-BUF-STATUS,
cal-report-list	CAL-REPORT-LIST }

Each WT shall arrange the measured RSS2 values according to their relative change since the last calibration measurement. Those RSS2 values with the highest change shall be reported first. Depending on the granted resources, the WT transmits all or part of its reports. In case the WT could not report all RSS2 measurement values that have changed by more than ±6 dB, it may indicate in the report PDU by setting the rep-buf-status bit that more resources are required.

From time to time, the CC may want to receive all RSS2 values from a WT. In this case the CC shall grant sufficient SCHs or LCHs for DiL RBCH to this WT, so that even those RSS2 values whose changes are below ±6 dB, can be included in the calibration report PDU.

The report list includes the MAC-ID of the measured WT and the corresponding RSS2 value.

NOTE: The received signal strength of the reports can also be used to check the local topology map.

6.5.4 Link Quality Map of the Network

Once all WTs have reported their measurement results, the CC creates and stores the link quality map of the network, which indicates the quality of connectivity between each WT pairs. The link quality map of a network with n associated WTs (including the CC), can be represented by a matrix:

Table 11: Link quality map of the network

	MAC-ID1	**MAC-ID2**	**MAC-IDi**	**…**	**MAC-IDn**
MAC-ID1		RSS2 1 ← 2	RSS2 1 ← i	…	RSS2 1 ← n
MAC-ID2	RSS2 2 ← 1		RSS2 2 ← i	…	RSS2 2 ← n
MAC-IDx	RSS2 x ← 1	RSS2 x ← 2		…	RSS2 x ← n
…	…	…	…	…	…
MAC-IDn	RSS2 n ← 1	RSS2 n ← 2	RSS2 n ← i	…	

NOTE 1: RSS2 n ← m represents the DiL received signal strength measured at WT n, when transmitted by WT m.

A row corresponds to how a given WT receives all other WTs. RSS2 information contained in a row is gathered as it is measured by the WT.

A column corresponds to how a WT is received by all other WTs. RSS2 information contained in a column is gathered as it is broadcast to other WTs.

Each WT stores locally the relevant part of the map, i.e. the corresponding row and column. The CC shall store the complete link quality map of the network. The CC may assign a timer to each RSS2 value in the link quality map so as to handle partial reporting or some reports received in error. Timers are initialized by the CC when measurements are performed.

The CC may distribute the link quality map of the network to a single or to all WTs in the network. A specific RLC PDU is defined for this purpose, called RLC_CALIBRATION_LINKQUALITYMAP. The RLC_CALIBRATION_LINKQUALITYMAP may be send upon request of a WT (RLC_CALIBRATION_LINKQUALITYMAP_REQUEST) or without an explicit request from a WT.

NOTE 2: In the latter case the point in time or the period of the link quality map broadcast is out of the scope of the present document.

Figure 16 gives an overview of the distribution of the link quality map. Without an explicit request from a WT only the lower part of the figure is carried out.

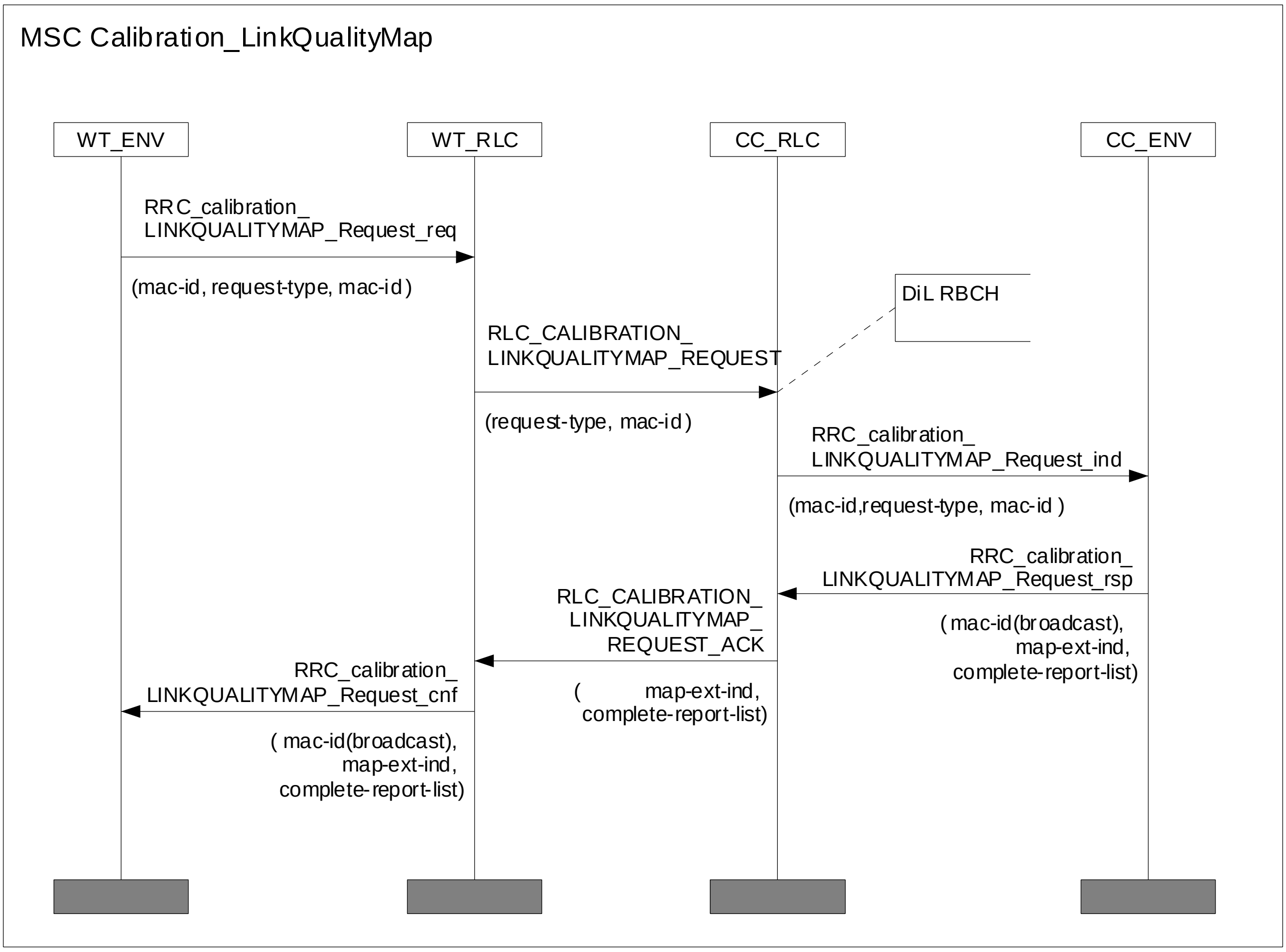

Figure 16: MSC for RLC_CALIBRATION_LINKQUALITYMAP_REQUEST and RLC_CALIBRATION_LINKQUALITYMAP

The RLC_CALIBRATION_LINKQUALITYMAP_REQUEST and RLC_CALIBRATION_LINKQUALITYMAP messages shall be transmitted using the most robust PHY mode.

Table 12: RLC-CALIBRATION-LINKQUALITYMAP-REQUEST

RLC-CALIBRATION-LINKQUALITYMAP-REQUEST-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-SCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
mac-id	MAC-ID,
request-type	REQUEST-TYPE }

Table 13: RLC-CALIBRATION-LINKQUALITYMAP

RLC-CALIBRATION-LINKQUALITYMAP -ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
map-ext-ind	MAP-EXT-IND,
complete-report-list	COMPLETE-REPORT-LIST }

Within the RLC_CALIBRATION_LINKQUALITYMAP_REQUEST a parameter called *request-type* indicates whether the whole map is requested or only a partial map. A partial map corresponds to a column in Table 11, which includes the RSS2 values with which all other WTs have received the RLC_CALIBRATION_MEASUREMENT PDU from the WT with *mac-id*.

To unify complete and partial quality map encoding, the link quality map shall be encoded by columns. This means that each (partial) report consists of the MAC-ID of the WT that has sent RLC_CALIBRATION_MEASUREMENT, and N times the MAC-ID, RSS2 value and the age of the measurement for each of the N receiving WTs. A complete report list is composed of several partial reports (for all sending WTs). An age of measurement field has been included to indicate when the RSS2 value has been updated for each of the receiving WTs. The field map-ext-ind (map-end, map-continue) indicates whether more RLC_CALIBRATION_LINKQUALITYMAP PDUs will follow, and can be used in the case that the link quality map cannot be transmitted in a single LCH PDU.

The encoding of RLC_CALIBRATION_LINKQUALITYMAP is the same for partial and complete link quality maps, but partial RLC_CALIBRATION_LINKQUALITYMAP shall be transmitted on DL DCCH to the sender-WT of the report whereas complete RLC_CALIBRATION_LINKQUALITYMAP shall be broadcast on DL RBCH.

6.6 DLC User Connection Control

6.6.1 Fixed slot allocation for DM

Fixed Slot Allocation is a mode of capacity allocation negotiated during DUC Setup. With FSA a fixed amount of LCHs at a fixed position in the MAC Frame is allocated. This allocation is valid until a DUC Modify or DUC Release procedure is used. No RR or RG shall be used for the LCHs of DUCs in FSA mode. Support for Fixed Slot Allocation is mandatory for all CC-capable WTs, and optional for basic WTs.

MAC Frame	FSA		MAC Frame	FSA	

Figure 17: Example for a fixed slot allocation

Figure 17 shows an example for a fixed slot allocation in the middle of the MAC Frame. The position in the MAC Frame is fixed and cannot be changed with normal RGs. To change the position, the number of LCHs, or the PHY mode of an FSA, a DUC modify shall be performed.

A typical usage of FSA would be in combination with unacknowledged (error) mode and with FEC. Nevertheless the use of any other combination of error control is possible. In case the acknowledged or ARQ mode is used, a WT shall decode the FCCH to look for SCH RGs. These SCHs may be used for ARQ discard and acknowledge messages. In unacknowledged mode a WT may not decode the FCCH, because no need for SCHs exists.

The FSA specific information in the set-up, release or modify messages is contained in an fsa-descr field inside the duc-direction-descr (see TS 101 761-2 [2]). A proposed FSA parameter setting (by a WT) is called FSA Resource Request (FSA-RR). The definite FSA parameter setting (by the CC) is called FSA Resource Grant (FSA-RG). The setting of the parameters in the fsa-descr in case of an FSA-RR and an FSA-RG is treated in clause 7.6.1.

Depending on the RLC procedure FSA-RR and FSA-RG are contained in the following messages:

- In the WT initiated Unicast FSA DUC Setup the sender includes the FSA-RR in the RLC_DM_SETUP message that is sent to the CC. The FSA-RG is sent back to the initiating WT (sender) within the RLC_DM_CONNECT message. The receiver is informed about the FSA-RG in the RLC_DM_SETUP message sent to him by the CC.
- In the CC initiated Unicast FSA DUC Setup no FSA-RR is necessary. The FSA-RG is sent to the respective WT in the RLC_DM_SETUP PDU, generated by the CC at the beginning of the procedure.
- In the WT initiated Multicast FSA DUC Setup the sender includes the FSA-RR in the RLC_DM_MC_SETUP message that is sent to the CC. The FSA-RG is sent back to the initiating WT (sender) within the RLC_DM_MC_CONNECT message. Every receiver is informed about the FSA-RG in its respective RLC_DM_MC_SETUP message sent to him by the CC.
- In the CC initiated Multicast FSA DUC Setup no FSA-RR is necessary. The FSA-RG is sent to every WT in the Multicast group by the RLC_DM_MC_SETUP PDU, generated by the CC at the beginning of the procedure.
- In the WT initiated DM-MODIFY procedure (Unicast or Multicast) the new FSA-RR is included by the initiating WT in the RLC_DM_MODIFY_REQ PDU. The new FSA-RG is sent by the CC to every receiver in a RLC_DM_MODIFY PDU.

- In the CC initiated DM-MODIFY procedure (Unicast or Multicast) no FSA-RR is necessary. The new FSA-RG is sent to the sender as well as every receiver in the RLC_DM_MODIFY_REQ PDU.

Note, that depending on who has initiated the DUC Setup, the RLC_DM_SETUP message either contains the FSA-RR or the FSA-RG. Regarding the starting MAC frame that is signalled to the sender and all receivers within the FSA-RG some timing constraints have to be considered, what is dealt with in clause 6.6.1.2.

If Fixed Slot Allocation has been accepted for a DUC, CC and WT perform the following operations in addition.

6.6.1.1 CC Operation

The CC operation is the following:

- The CC shall not schedule LCHs (using RGs in the FCCH), or RCHs (in the BCCH) for the part of the MAC Frame where Fixed Slot Allocation is used. SCHs shall only be scheduled when acknowledged mode (ARQ) is used.
- No RGs shall be generated for an FSA connection in unacknowledged mode. For an FSA connection in acknowledged mode, SCH RGs shall be generated for WT discards and acknowledgements.
- The CC may change the Fixed Slot Allocation by using the DUC_MODIFY or DUC_RELEASE procedure.

6.6.1.2 WT Operation

The WT operation is the following:

- After DUC setup the transmitting WT shall start transmission in the specified *start-mac-frame*.
- After DUC setup the receiving WT shall start receiving in the specified *start-mac-frame*.
- No RR shall be generated for an FSA connection in unacknowledged mode. In acknowledged mode only RRs for SCHs may be generated (in case the number of SCHs granted by the CC are not sufficient for ARQ operation).
- In order to change the PHY Mode (Link Adaptation) the WT shall use the DUC_MODIFY procedure.

6.6.1.3 Timing of FSA

The beginning and modification of FSA is valid from a signalled MAC Frame on. The value *start-mac-frame* in the FSA-RG gives the exact MAC Frame to start FSA. *start-mac-frame* is the absolute MAC Frame number as determined by the MAC Frame Counter in the BCCH. To overcome the 4 bit limitation of the MAC Frame Counter parameter in BCCH, Start MAC Frame is furthermore offset by a *repetition-counter* parameter, which gives the number the *frame-count* value repeats in BCCH after the reception of the FSA-RG (1 repetition corresponds to 16 MAC frames). The reference for the offset is the MAC frame the FSA-RG is received by the respective WT. That means that the RLC instance shall know in which MAC frame it received the FSA-RG in order to determine the right MAC frame to start FSA. *start-mac-frame* of every receiver as well as *start-mac-frame* of the sender shall always be set such that it is guaranteed that the time until the receiver starts reception of FSA is shorter or equal to the time until the sender starts sending with FSA. As an example this implies that the *start-mac-frame* values of every receiver are shorter than the *start-mac-frame* value of the sender, if all FSA DUC descriptors are transmitted in the same frame. The sender shall never start sending data before the starting MAC frame of FSA, but may start in a later frame than its *start-mac-frame*. It is therefore not necessary (but still possible) that the CC reserves capacity for the sender in a frame before the starting MAC frame of FSA. The CC shall reserve the negotiated capacity for FSA at the latest from the starting MAC frame on.

start-mac-frame is 16 bits long. Its 4 MSB are used to encode the MAC Frame Counter value called *frame-count*, and its 12 LSB are used to encode the *repetition-counter* value. Either coding is binary. With this length of the *start-mac-frame* parameter the maximum time between the FSA-RG and the start of the FSA is 131 seconds.

EXAMPLE: start-mac-frame = 000000000001 0010
The MAC frame to start with FSA is the second time (because of offset = 000000000001) the MAC Frame Counter in the BCCH shows the value 0010 after the reception of the FSA-RG.

Each WT supporting FSA shall be able to start FSA two MAC frames after the MAC frame the FSA-RG is received. For example, if FSA-RG is received in MAC frame #2, the WT shall be able to start FSA in any DiL position of MAC frame #4. The CC shall set the Start MAC Frame value such that it is possible to complete the DUC setup/modify procedure before the Start MAC Frame is reached with a high probability.

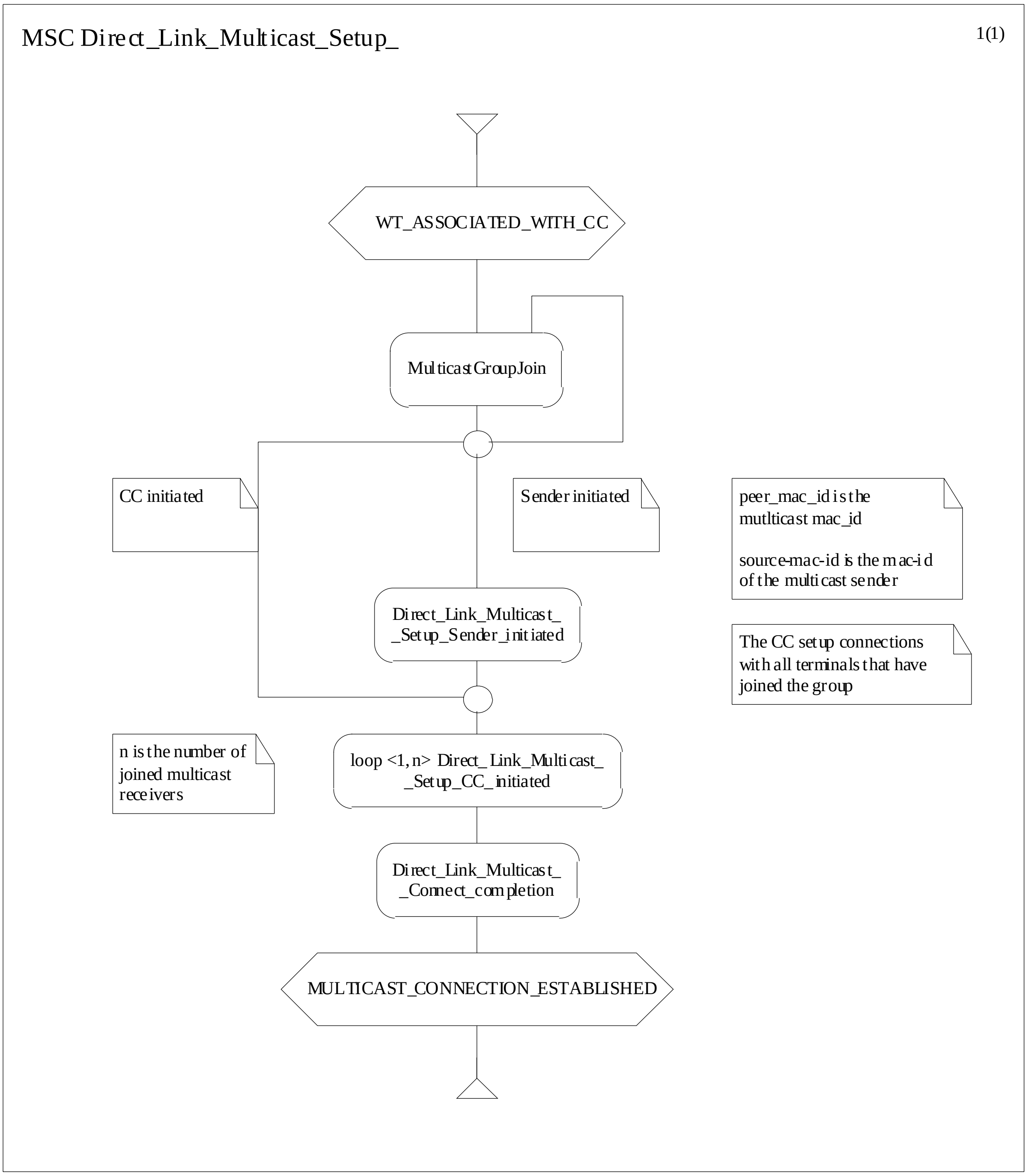

Figure 18: Overview of DiL Multicast Setup

6.6.2 Multicast in DiL phase

6.6.2.1 General

The Direct Link can also be used for multicast connections. DiL multicast without QoS negotiation is already supported by documents TS 101 761-1 [1], TS 101 761-2 [2].

A multicast connection is identified by three numbers:

- *Destination MAC_ID*, numbers from 224 to 254 shall be used;
- *Source MAC_ID*, mac_id of the WT that is the sender of this group;
- *DLCC_ID* = 63 shall be used.

As is shown in Figure 18, the first action for a WT is to join the muticast group by using the RLC_GROUP_JOIN message. Then the CC replies with a dynamically selected multicast MAC ID within the range {224, 254}. This MAC ID, in conjunction with DLCC ID = 63, will be used as a unique identifier for the multicast group.

A multicast group that does not require QoS parameter negotiation shall start multicast immediately without performing the DiL multicast setup procedure specified in the following clauses. In this case, each WT of a multicast group can become the sender of this multicast group at any time. It just needs to send out a RR for DiL UMCH, in which it sets the destination MAC ID to the assigned multicast MAC ID, the source MAC ID to its own MAC ID, and DLCC ID to 63.

Before a WT1 can become a sender of a multicast group which requires QoS parameter negotiation, it shall first run a sender-initiated DM_Multicast_Setup procedure with the CC. Before the DM_Multicast_Setup procedure is successfully completed, the WT1 shall not begin to transmit data. After the multicast setup initiation by WT1, the CC shall forward the multicast setup request message to each multicast receiver WTx that has joined the multicast group.

The CC can also initiate a DM_Multicast_Setup even if it is not the sender, in that case it has also to send a multicast setup request to the sender WT1. Then, the CC shall perform a multicast setup forwarding procedure for each receiver WTx of the multicast group. The setup request to the sender WT1 and the setup forwarding to each receiver WTx uses a common procedure, which is the same as the setup forwarding procedure used in the sender-initiated case.

In both sender-initiated and CC-initiated cases, the CC shall send a RLC_DM_MC_CONNECT_COMPLETE message to the sender WT1 after it has forwarded all setup request messages to all other WTs of the group. The RLC_DM_MC_CONNECT_COMPLETE message shall be sent only when at least min-req-receivers receivers have positively acknowledged the multicast setup request. min-required-receivers is a parameter in the RLC_DM_MC_SETUP message, which will be set by the initiating WT, or the CC.

Another parameter set by the initiating WT is the max_setup_time. This parameter is coded exponentially:

$$T\_dm\_setup\_wt = 4^{\max\_setup\_time} [MacFrames]$$

After transmitting the first RLC_DM_MC_SETUP message to a receiver WTx, the CC starts the timer T_dm_setup_wt. If more than or equal to min_required_receivers WTs have completed the setup procedure until the timer T_dm_setup_wt expires, the multicast connection is established. That confirmation is given by the CC to the sender WT1 by sending it a RLC_DM_MC_CONNECT_COMPLETE message. Then, the sender WT1 is allowed to send data in the specified multicast DUC.

If a terminal responds to the CC after the connection setup has finished it is allowed to receive the multicast DUC, although the earlier data might be lost for this WT. If a terminal joins the group after the setup procedure is completed, it shall wait until the CC informs it of the ongoing multicast connection. The CC shall inform later joining WTx of the connection parameters by performing the setup forwarding procedure for the joining receiver WTx.

The parameters of an established multicast connection can be modified by a DM_Multicast_Modify procedure. The DM_Multicast_Release procedure is used to release an established multicast connection.

DiL multicast setup is mandatory for multicast groups which make use of Fixed Capacity Assignment specified in TS 101 761-1 [1] or Fixed Slot Allocation as specified in clause 6.6.1 of the present document.

Referring to the following MSCs the CC can act as the multicast sender WT1, or as one of the multicast receivers WTx. In this case all multicast related RLC messages between this WT1 and the CC, or between this multicast receiver WTx and the CC, shall be exchanged internally in the CC device.

All multicast setup, modify and release procedures specified in the following shall use unicast DL DCCH and UL DCCH for message exchange between the CC and multicast sender WT1, and between the CC and a particular multicast receiver WTx, respectively. As defined for CM, the MAC ID of the uplink and downlink unicast DCCH shall be always set to the MAC ID of the WT, which sends or receives this DL or UL DCCH.

6.6.2.2 DiL MULTICAST SETUP, WT-initiated

When a WT1 of a DiL multicast group wants to become a sender of this multicast group, it shall initiate this procedure if the connection requires QoS parameter negotiation. The CC and WT1 may negotiate e.g. FSA or FCA parameters. Referring to the following MSC (Figure 19), the source MAC ID is the MAC ID of WT1. This MAC ID is needed for the CC to identify the sender WT1.

For exchanging the link parameters the initiating WT1 transmits a RLC_DM_MC_SETUP message to the CC. The CC shall respond by sending the RLC_DM_MC_CONNECT message, which is acknowledged by the initiating WT1. In this message the CC can modify the QoS parameters proposed by the initiating WT1.

The direction parameter of the multicast duc-descriptor shall be set to simplex-forward for the multicast sender WT1, and set to simplex-backward for all multicast receivers WTx.

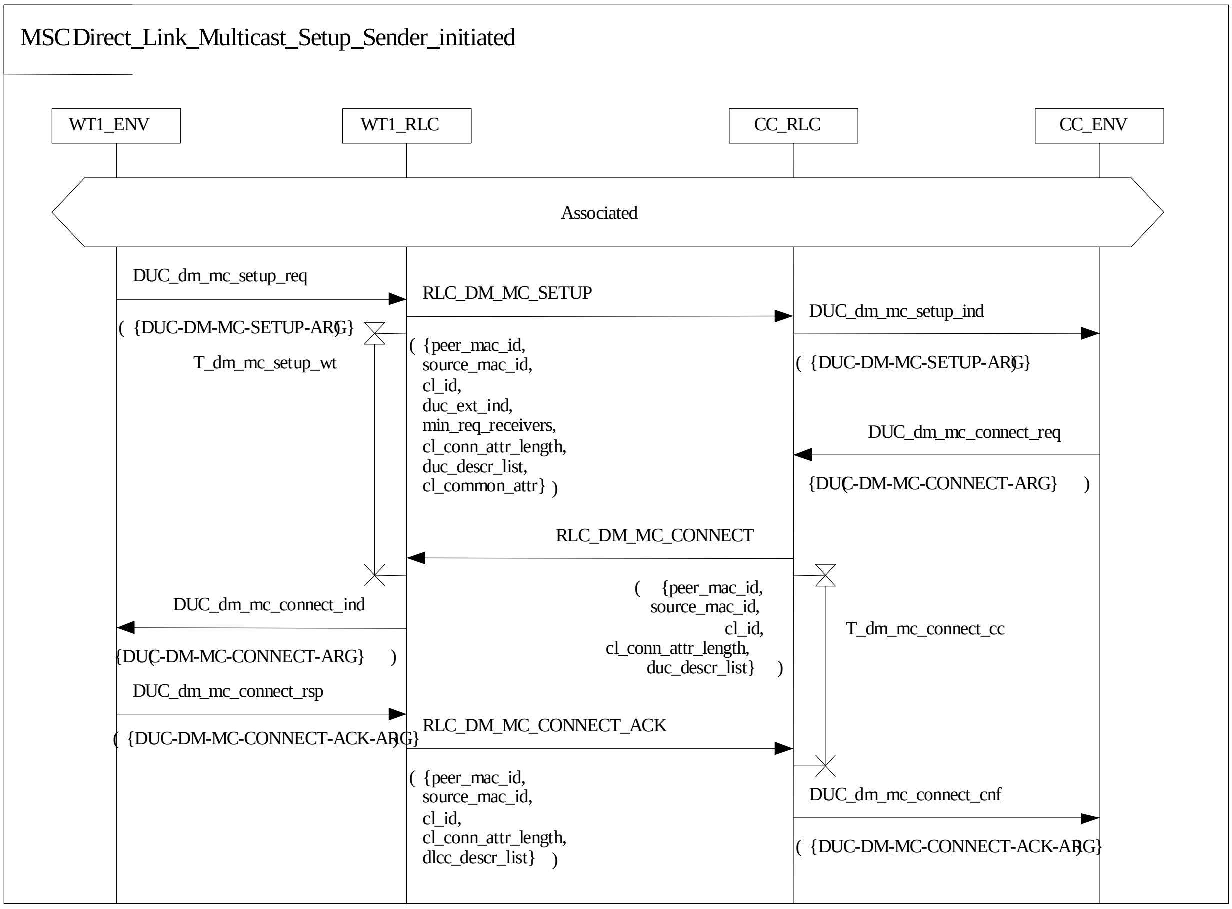

Figure 19: MSC Direct_Link_Multicast_Setup_WT_CC

Table 14: RLC-DM-MC-SETUP

RLC-DM-MC-SETUP-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID,
cl-id	CL-ID,
duc-ext-ind	BOOLEAN,
min-req-receivers	INTEGER(0..255),
cl-conn-attr-length	INTEGER(0..31),
duc-descr-list	DUC-DESCR-LIST,
cl-common-attr	CL-COMMON-ATTR }

The parameter source-mac-id is used to identify the sender WT1 in the case of a sender-initiated connection setup. In the case of a CC-initiated connection setup this parameter is used to inform a WT1 that it is to become the sender.

Table 15: RLC-DM-MC-CONNECT

RLC-DM-MC-CONNECT-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID,
cl-id	CL-ID,
cl-conn-attr-length	INTEGER(0..31),
duc-descr-list	DUC-DESCR-LIST}

Table 16: RLC-DM-MC-CONNECT-ACK

RLC-DM-MC-CONNECT-ACK-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID,
cl-id	CL-ID,
cl-conn-attr-length	INTEGER(0..31),
dlcc-descr-list	DUC-DESCR-LIST}

The sender-initiated setup procedure in Figure 19 shall be followed by a setup forwarding procedure for each multicast receiver, as is shown in Figure 20. The CC forwards the RLC_DM_MC_SETUP message to each multicast receiver WTx. The peer MAC ID in the setup procedure's messages shall be set to the MAC ID of the multicast group, and source MAC ID set to the MAC ID of WT1.

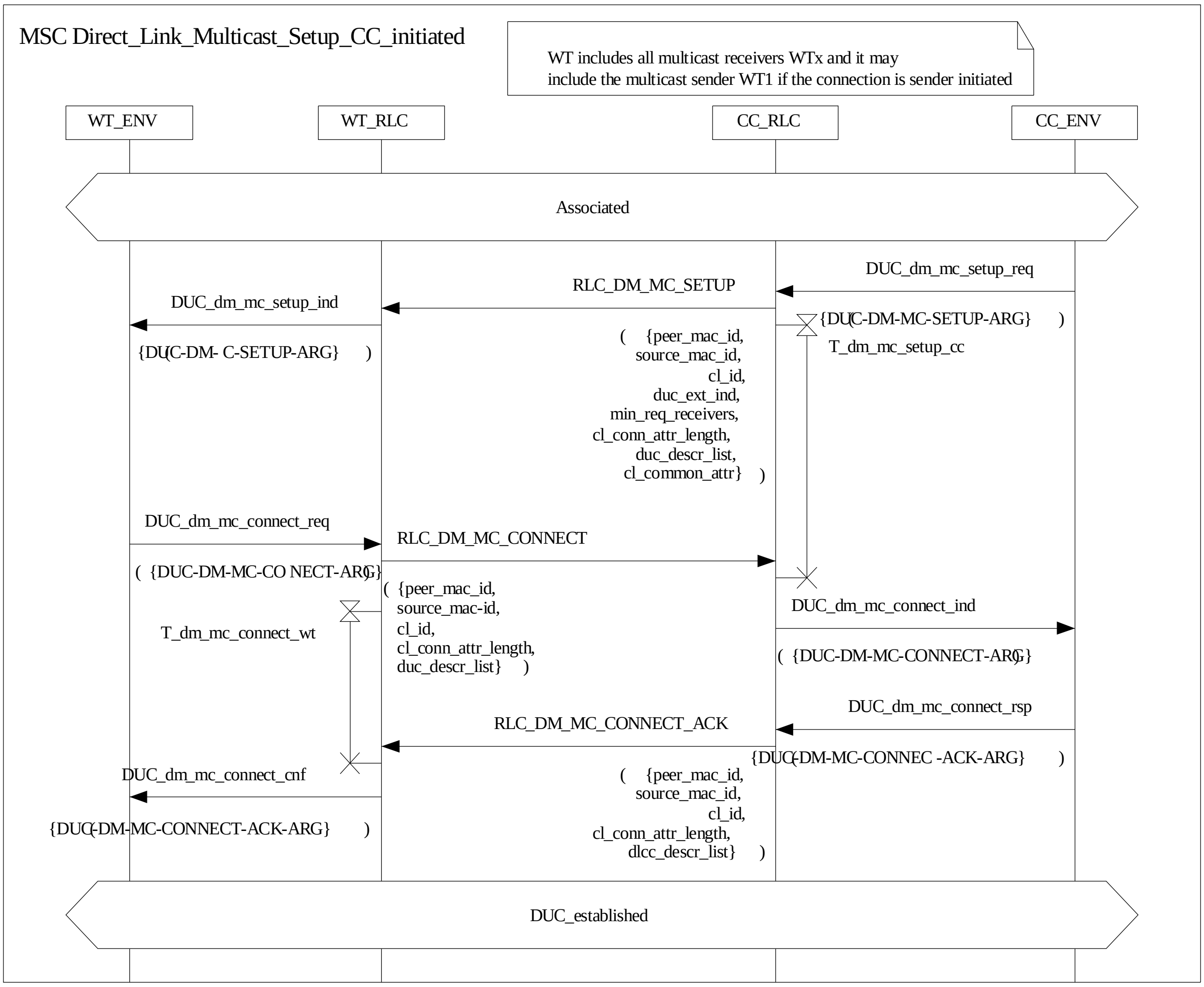

Figure 20: MSC Direct_Link_Multicast_Setup_forwarding

The CC then waits for the multicast receivers to respond. If one or more multicast receivers do not respond within max_setup_time, the CC may retransmit the RLC_DM_MC_SETUP message to each of those multicast receivers. Further repetitions are also possible.

After min-req-receivers receivers have accepted the multicast setup within max-setup-time, the CC shall respond to WTx by sending RLC_DM_MC_CONNECT_ACK messages. Otherwise, it shall abort the multicast connection setup by performing a CC-initiated multicast release for each receiver WTx that is already involved in the setup procedure, and the sender WT1.

If at least min_required_receivers WTx respond positively within max-setup-time, which has been exchanged between initiating WT1 and CC, the multicast connection is accepted by the CC. The CC transmits a RLC_DM_MC_CONNECT_COMPLETE message to the initiating WT1. The initiating WT1 shall respond with a RLC_DM_MC_CONNECT_COMPLETE_ACK message (Figure 21).

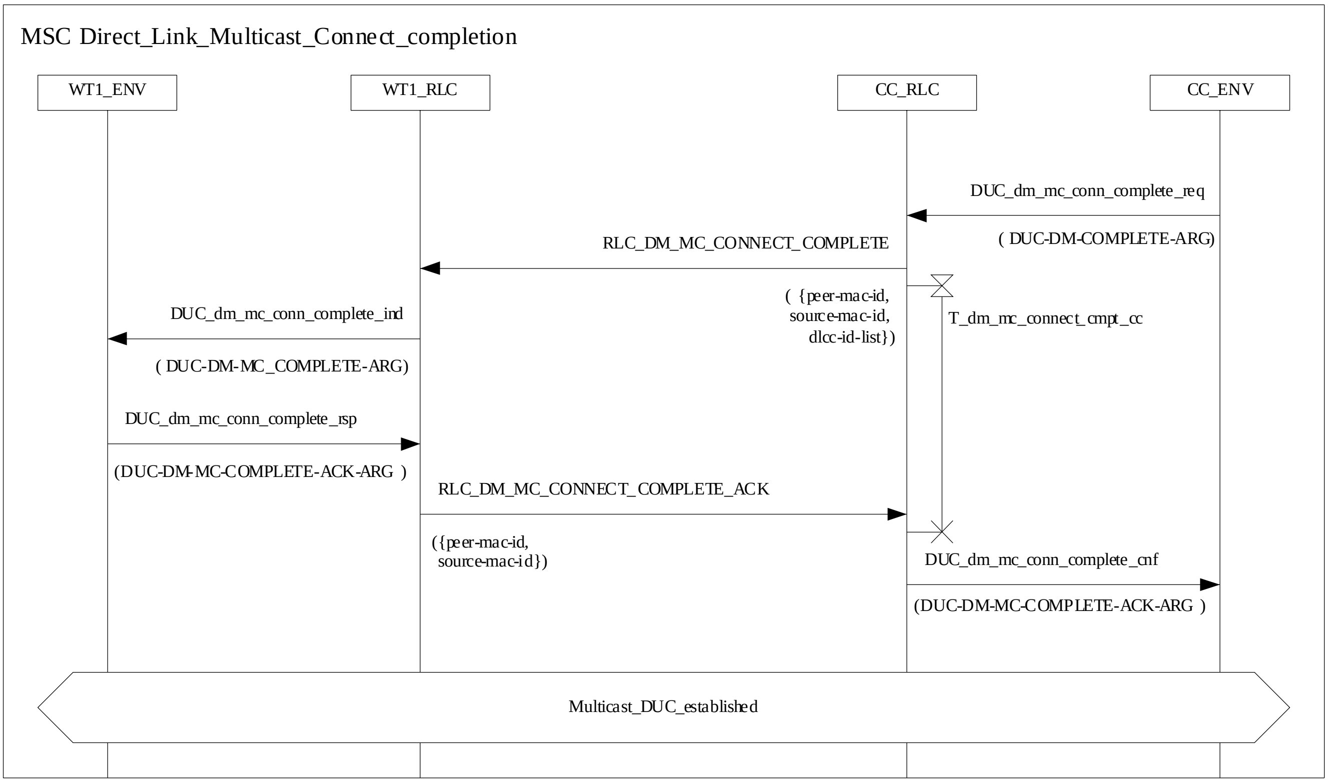

Figure 21: MSC Direct_Link_Multicast_Setup_Completion

Table 17: RLC-DM-MC-CONNECT-COMPLETE

RLC-DM-MC-CONNECT-COMPLETE-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID,
dlcc-id-list	DLCC-ID-LIST}

Table 18: RLC-DM-MC-CONNECT-COMPLETE-ACK

RLC-DM-MC-CONNECT-COMPLETE-ACK-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID}

Fixed Slot Allocation

The FSA-RR is sent in the RLC_DM_MC_SETUP message from the initiating WT1 to the CC.

The FSA-RG is transmitted from the CC to each receiver WTx in the RLC_DM_MC_SETUP message.

The FSA-RG to the initiating WT1 is sent within the RLC_DM_MC_CONNECT message.

6.6.2.3 DiL MULTICAST SETUP for a new joining WT

This clause describes the cases that a new WT has joined the group and is informed by the CC of the multicast connection parameters.

The CC shall re-use the setup forwarding procedure depicted in Figure 20 after a new WT has joined the multicast group using the JOIN procedure to let the new WT know the MAC ID of the multicast sender and other connection parameters. After this multicast setup procedure is completed, this new WT might not be able to receive the multicast data. In this case, it may perform the DiL Power Control procedure for multicast/broadcast to request the multicast sender to increase the transmit power. No further action is specified, if the new WT still cannot decode the multicast data correctly.

The multicast setup forwarding procedure for a new joining multicast receiver is transparent to the multicast sender.

6.6.2.4 DiL MULTICAST SETUP, CC initiated

This clause describes the case that a new multicast connection from a sender WT1 (also the CC may be the sender) to the multicast group (also the CC may be member of this group) is to be established by the CC.

The CC-initiated multicast uses the procedure in Figure 20 for the multicast sender and all receivers. The CC shall first transmit a RLC_DM_MC_SETUP to the sender WT1, at this stage the sender can negotiate parameters of the connection with the CC. The peer_MAC_ID parameter in the RLC_DM_MC_SETUP message shall be set to the MAC-ID of the multicast group. The sender WT1 is informed that it is to become the sender by looking at the source_mac_id field in the RLC_DM_MC_SETUP message, which is set to the MAC ID of WT1.

The sender WT1 shall respond with a RLC_DM_MC_CONNECT and the CC shall send the acknowledgement to confirm parameters. Then the CC shall repeat the setup forwarding procedure in Figure 20 for each joined multicast receiver WTx.

The CC then waits for WTs to respond. If one or more multicast receiver WTs does not respond within max_setup_time, the CC may retransmit the RLC_DM_MC_SETUP message using a downlink unicast DCCH. Further repetitions are also possible. The multicast sender WT1 shall respond positively within max_setup_time. Otherwise, the CC-initiated DiL_Multicast_Setup procedure fails.

If at least min_required_receivers WTs (the sender excluded) of the multicast group respond within max_setup_time to the RLC_DM_MC_SETUP message, the multicast connection is accepted by the CC. A negotiation of max_setup_time is not needed, if the CC is the sender of the multicast connection. If for any reason the multicast setup fails, the CC shall abort the multicast setup procedure by performing a CC-initiated multicast release for the multicast sender and each multicast receiver already involved in the setup procedure.

If the sender and min_req_receivers receivers have accepted the multicast setup, the Multicast Setup Completion procedure in Figure 21 shall be finally performed. The CC shall transmit a RLC_DM_MC_CONNECT_COMPLETE message to the sender WT1 or to itself (if CC is sender), which shall be responded by a RLC_DM_MC_CONNECT_COMPLETE_ACK message.

Fixed Slot Allocation

No FSA-RR is needed because a recommendation to the CC itself does not make sense.

The FSA-RG is sent in the RLC_DM_MC_SETUP message from the CC to the initiating WT and the receiving WTs.

6.6.2.5 MODIFY MULTICAST

The modification of the multicast connection characteristics can be sender-initiated or CC-initiated. If it is sender-initiated, the multicast sender WT1 shall send a RLC_DM_MC_MODIFY_REQ to the CC. This triggers the CC to perform multicast modify by sending RLC_DM_MC_MODIFY to the multicast sender WT1 (Figure 22) and to each of the multicast receivers WTx (Figure 23). The RLC_DM_MC_MODIFY contains a parameter field start-mac-frame, which tells all WTs when the modified multicast shall start. If it is CC-initiated, the CC shall perform the multicast modify procedure without the request from the multicast sender. In this case, the procedure in Figure 23 shall also perform for the multicast sender.

A timer T_rsp is set similar to the multicast setup procedure. If not all WTs have responded by sending a RLC_DM_MC_MODIFY_ACK until the timer expires the CC shall retransmit the RLC_DM_MC_MODIFY message on DL DCCH to each of the concerned WTs.

The Multicast Setup Completion procedure shall not be used in case of modifying a multicast DUC.

The connection parameters are changed after all WTs of the multicast group have responded or all repetitions to the not responding WTs have finished.

If the sender does not accept the RLC_DM_MC_MODIFY message from the CC, the CC shall release the multicast connection for all involved WTs. If one or more multicast receiver does not accept the RLC_DM_MC_MODIFY message from the CC, the CC shall release the connection for these receivers. In the latter case it shall only release the multicast connection for all other WTs (including the sender), if the number of the remaining receivers is less than min_required_receivers.

The exact start point to change the multicast connection is given by the start-mac-frame parameter, which is sent from the CC to all multicast WTs. start-mac-frame is the absolute MAC Frame number as determined by the MAC Frame Counter in the BCCH. To overcome the 4 bit limitation of the MAC Frame Counter parameter in BCCH, start-mac-frame is furthermore offset by a MAC Frame Cycle parameter, which gives the number, the MAC Frame Counter value repeats in BCCH after the reception of the RLC_DM_MC_MODIFY message (1 repetition corresponds to 16 MAC frames). The reference for the offset is the MAC frame the RLC_DM_MC_MODIFY PDU is received. That means that the RLC instance shall know in which MAC frame it received the RLC_DM_MC_MODIFY message in order to determine the right MAC frame to change the multicast connection. The CC should set start_mac_frame sufficiently late to allow all WTs to be prepared for this change.

start_mac_frame is 16 bits long. Its 4 MSB are used to encode the MAC Frame Counter value, and its 12 LSB are used to encode the MAC Frame Cycle value. Either coding is in binary. With this length of the start_mac_frame parameter the maximum time between the RLC_DM_MC_MODIFY PDU and the multicast connection change is 131 seconds.

EXAMPLE: start_mac_frame = 0010 000000000001
The MAC frame to change the multicast connection is the second time (because of offset = 000000000001) the MAC Frame Counter in the BCCH shows the value 0010 after the reception of the RLC_DM_MC_MODIFY PDU.

If a multicast connection is used for FSA, the start_mac_frame value in the RLC_DM_MC_MODIFY message shall be equal to the start-mac-frame value in the FSA-RG parameter, which is also included in RLC_DM_MC_MODIFY.

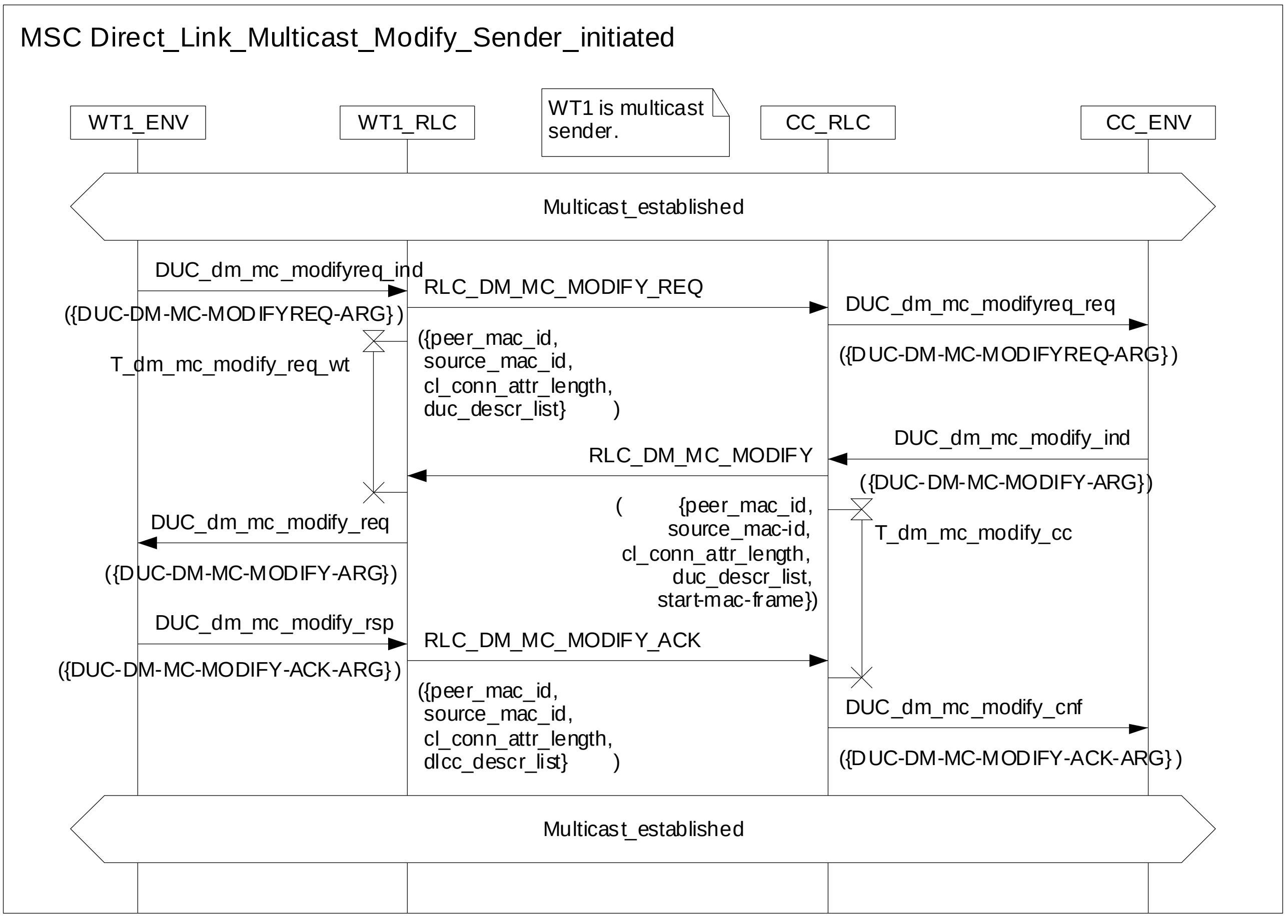

Figure 22: MSC Direct_Link_Multicast_Modify_WT_CC

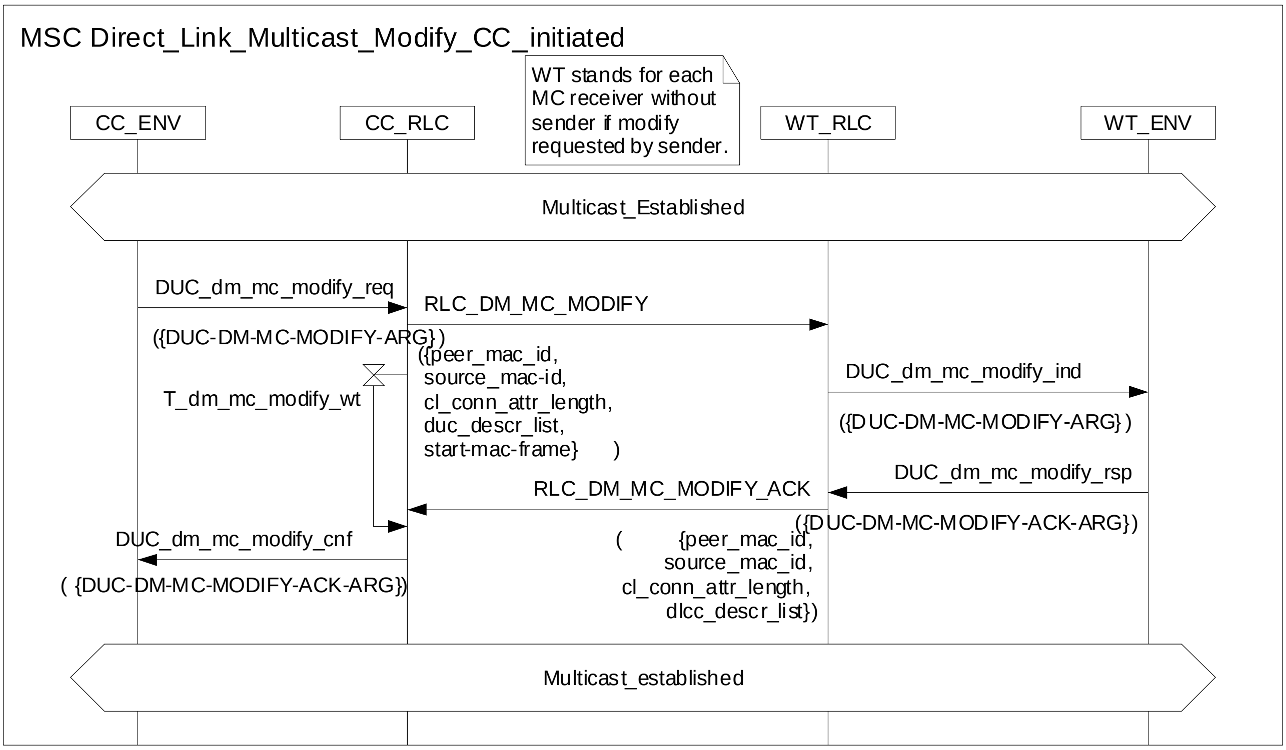

Figure 23: MSC Direct_Link_Multicast_Modify_CC_WT

Table 19: RLC-DM-MC-MODIFY-REQ

RLC-DM-MC-MODIFY-REQ-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID,
cl-conn-attr-length	INTEGER(0..31),
duc-descr-list	DUC-DESCR-LIST}

Table 20: RLC-DM-MC-MODIFY

RLC-DM-MC-MODIFY-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID,
start-mac-frame	START-MAC-FRAME,
cl-conn-attr-length	INTEGER(0..31),
duc-descr-list	DUC-DESCR-LIST}

Table 21: RLC-DM-MODIFY-ACK

RLC-DM-MC_MODIFY-ACK-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID,
start-mac-frame	START-MAC-FRAME,
cl-conn-attr-length	INTEGER(0..31),
dlcc-descr-list	DUC-DESCR-LIST}

6.6.2.6 RELEASE MULTICAST

The release can be CC-initiated or WT-initiated, where WT can be the multicast sender or one of the receivers. In case of a CC-initiated release the CC shall transmit a RLC_DM_MC_RELEASE to the WT, which it wants to disconnect from the multicast. The WT shall reply with RLC_DM_MC_RELEASE_ACK. If the sender has been released, the CC-initiated multicast release as shown in Figure 24 shall be repeated for each multicast receiver to stop its receive operation.

In case of a sender-initiated release, the sender of the multicast group shall send a RLC_DM_MC_RELEASE to the CC. The CC shall send back a RLC_DM_MC_RELEASE_ACK message to the sender (Figure 25). The CC shall then start the CC-initiated multicast release in Figure 24 for each multicast receiver to stop its receive operation. If a multicast receiver initiates the WT-initiated release in Figure 25, the CC shall acknowledge by replying with RLC_DM_MC_RELEASE_ACK. In this case, the CC shall only release the multicast connection for all other WTs (including the sender), if the number of the remaining receivers is less than min_required_receivers.

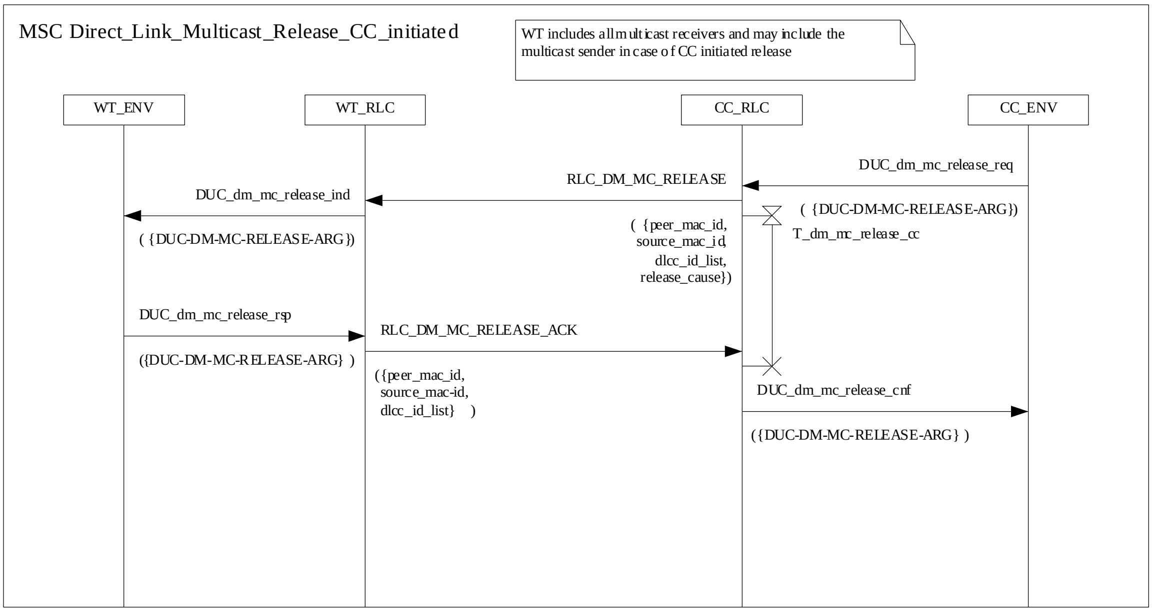

Figure 24: MSC Direct_Link_Multicast_Release_CC_WT

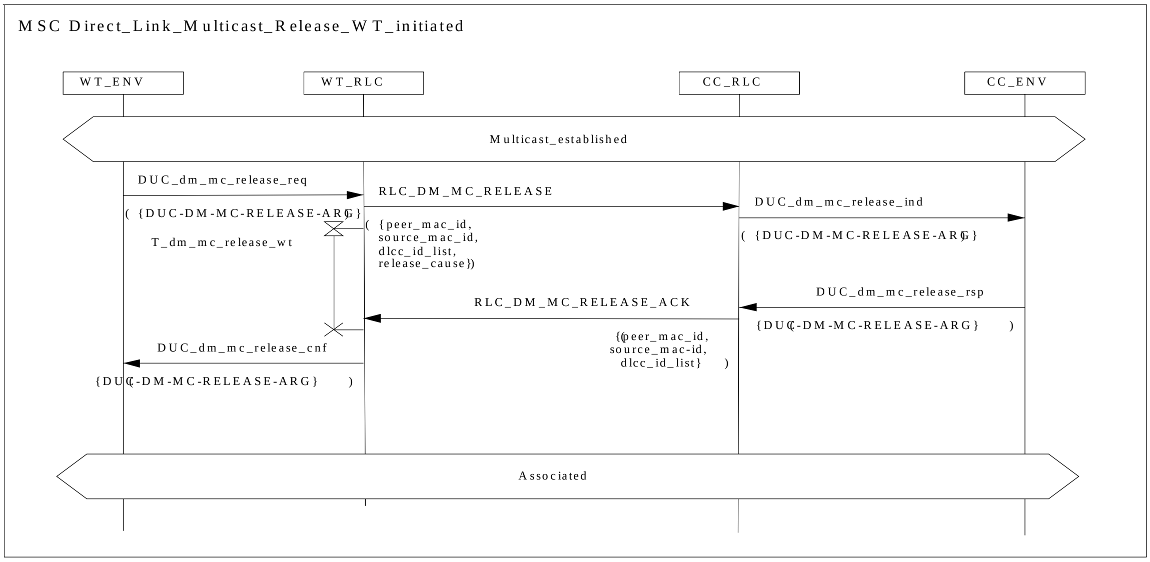

Figure 25: MSC Direct_Link_Multicast_Release_WT_CC

Table 22: RLC-DM-MC-RELEASE

RLC-DM-MC-RELEASE-ARG::= SEQUENCE {
rlc-pdu-type RLC-HE-LCH-PDU-TYPE, extension-type EXTENSION-TYPE, peer-mac-id MAC-ID, source-mac-id MAC-ID, dlcc-id-list DLCC-ID-LIST, release-causeRELEASE-CAUSE}

Table 23: RLC- DM-MC- RELEASE-ACK

RLC-DM-MC-RELEASE-ACK-ARG::= SEQUENCE {	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
peer-mac-id	MAC-ID,
source-mac-id	MAC-ID,
dlcc-id-list	DLCC-ID-LIST}

6.7 Dynamic CC Selection

The dynamic CC Selection ensures that within one radio cell or subnet only one CC is established. It is performed in a decentralized and autonomous way by each CC-capable device. The selection does not take into account the best position or the best capabilities of a CC-capable device because the necessary measurements are not available at this stage. The CC is selected at random based on a contention process. However, the user can prevent an unfavourably located CC-capable device from being the CC by disabling this CC-capable device to participate in the CC selection process. All CC-capable H/2–HDs shall support dynamic CC selection. Besides, all CC-capable H/2-HDs shall indicate to the user by an implementation specific means whether they are in the CC selection phase, or acting as the CC.

6.7.1 Principle

Each CC-capable device first tries to become a WT. The first step is to scan all available frequencies for already running CCs (initial scanning process, see clause 6.7.2). If no CC has been found or association to the CCs is not possible (e.g. it is the CC of the neighbour or a CC/AP without HE capability) each CC-capable device shall try to become a CC by performing the CC Selection protocol. Each CC-capable shall also have a user interface, which enables the user to disable the CC Selection function, if the corresponding CC-capable device is to be excluded from the CC selection process. A CC-capable device with disabled CC Selection function shall only be able to act as a basic WT.

In order to prevent multiple CC-capable devices from becoming CC, a CC collision resolution, i.e. the CC Selection protocol, is performed. The basic idea is that each CC-capable device transmits a "Probing Beacon" from time to time and senses the channel in between. The Probing Process, i.e. transmitting of Probing Beacons and sensing the Probing Channel to detect beacons from other devices, is interrupted for frequency scanning phases in which all other available frequencies are scanned for another CC-capable device. Each CC-capable device which senses a "Probing Beacon" withdraws from the CC Selection, performs a back-off and starts with the initial scanning process again. This may result in a new CC Selection process.

After a predefined time the CC-capable device which has not sensed anything survives and becomes CC. Of course it is not possible to resolve all collisions with this protocol. There is still a residual collision probability.

6.7.2 Initial Scanning Process

The scanning of frequency channels is not defined in the present document. For detection and selection of a CC it is necessary to define some minimum requirements on the scanning process.

In order to find a CC the initial frequency scanning is performed first, e.g. if an H/2-HD is powered on. The CC selection process is started only in the case no CC has been found.

A CC-capable device in the initial scanning phase shall:

- Scan all available frequencies for other CC.
- Scan each frequency for at least two MAC Frames = 4 ms.
- Measure and store the interference level on all available frequencies.
- Store all successfully received BCCH.
- Decode the downlink RBCH, if a BCCH has been received successfully.
- Try association with all detected CCs. If a detected CC does not support the HE, the association with this CC shall be aborted.

If Association has been successful with any CC the CC Selection for this CC-capable device is done. This device becomes a WT.

If no BCCH has been detected, or no Association has been successful the CC-capable device starts the CC Collision Resolution procedure, see clause 6.7.4.

NOTE: An aborted association with a non HE-compliant CC is an unsuccessful association. The frequency used by this CC shall be excluded from the following CC Collision Resolution process. A re-association to this CC after the completion of CC Collision Resolution is optional, if no other CC with HE capability can be found, and the scanning CC-capable device decides not to become a CC.

A manufacturer can implement on an H/2-HD different usage profiles. By selecting a non HE-compliant usage profile, the user can configure an H/2-HD as a non HE-compliant device to be preferably associated with a non HE-compliant CC.

6.7.3 Definitions

6.7.3.1 Probing Phase

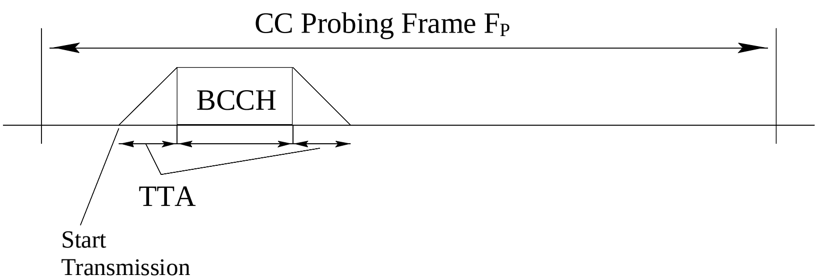

Figure 26: CC Probing Frame

Figure 26 shows a CC Probing Frame F_P. Within each CC Probing Frame a CC-capable device transmits one CC Probing BCCH (for the contents of the Probing BCCH see clause 7.6). Inside F_P the beginning of the transmission is defined by the Start_Transmission time. Thus a CC Probing BCCH can overlap into the next CC Probing Frame. This is shown in Figure 27.

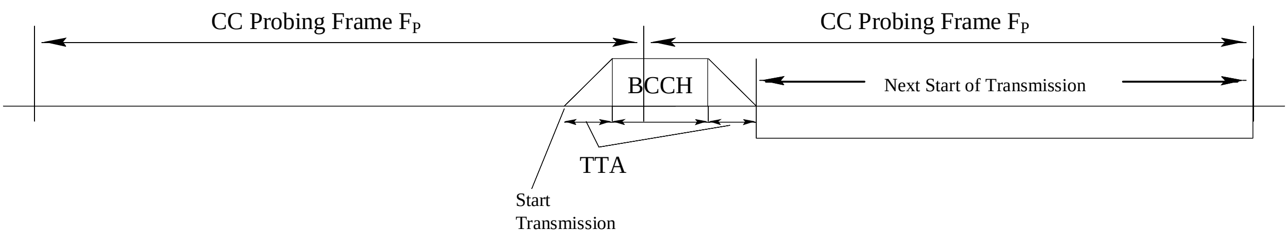

Figure 27: Start Transmission of CC Probing BCCH

If the CC Probing BCCH overlaps into the next CC Probing Frame, the next start of transmission is limited to the range from the end of transmission to the end of F_P. In Figure 27 this is called "Next Start of Transmission".

6.7.3.2 Frequency Scan Phase

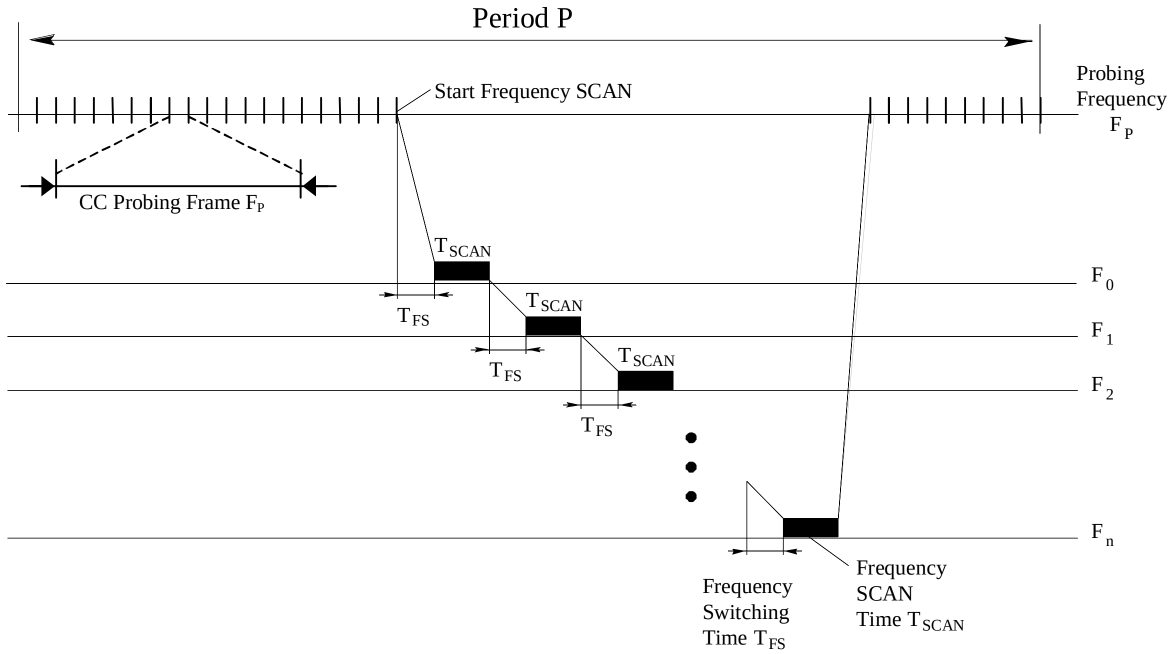

Figure 28: Probing Period consisting of Probing Phase and Frequency Scan Phase

Figure 28 shows the definition of a Probing Period P. Each Probing Period consists of several CC Probing Frames (Probing Phase) and a Frequency Scan Phase. During the Frequency Scan Phase the CC Probing is stopped for the CC-capable device which performs the Frequency Scan.

Within one Probing Period a CC-capable device shall scan all other frequencies for CC Probing BCCH. The Frequency Switching Time T_{FS} is the maximum time it takes to switch to another frequency channel. This time is defined in the TS 101 475 [3]. The Frequency Scan Time TS_{CAN} determines the time a CC-capable device in the CC Selection process shall scan a frequency channel for a CC Probing BCCH. The CC-capable device shall switch to a new frequency immediately after scanning the previous one.

After a CC-capable device returns from a Frequency Scan Phase it continues with CC Probing Frames, if no BCCH has been detected during the Frequency Scan Phase. The definition and random calculation of the start time of the Frequency Scan Phase (timer Start_ Frequency_SCAN) per Probing Period is similar to the start time of the Beacon transmission (timer Start_Transmission) per CC Probing Frame.

6.7.3.3 Parameter, Timer

Table 24: CC Selection Parameters

Parameter	Value
CC Probing Frame F_P	500 µs
Frequency SCAN Time TS_{CAN}	2 * F_P = 1 ms
CC Probing Period P	100 ms
Number of Periods	10
Total Time for CC Collision Resolution	1 s
Collision Probability	$5*10^{-5}$ = 0?005 % = 1/20 000

The Timer for *Start Transmission* and *Start Frequency SCAN* are set as follows:

Start Transmission:

- Start_Transmission is randomly chosen with a uniform distribution within [min_Start_Transmission, CC_Probing_Frame F_P);
- min_Start_Transmission = max (0, previous_Start_time+BCCH_Transmission_duration - F_P);
- previous_Start_time = 0 for the first transmission in the first Probing Period and after each Frequency Scan Phase;
- previous_Start_time = Start_Transmission, after the selection of Start_Transmission;
- BCCH_Transmission_duration = 48 µs (including preamble and two transceiver turnaround times).

Start Frequency SCAN:

- Start_Frequency_SCAN is randomly chosen with a uniform distribution within [min_Start_Frequency_SCAN, Period P);
- min_Start_Frequency_SCAN = max (0, previous_Start_Frequency_SCAN_time+Frequency_SCAN_duration - P);
- previous_Start_Frequency_SCAN_time = 0 for the first frequency Scanning Phase;
- previous_Start_Frequency_SCAN_time = Start_Frequency_SCAN, after the selection of Start_Frequency_SCAN;
- Frequency_SCAN_duration = 37 ms (for a total number of 18 available frequency channels – the Probing Channel is excluded - and a frequency switching time of 1 ms TS 101 475 [3].

6.7.4 Protocol

If no Association has been successful the CC-capable device shall choose one appropriate frequency channel. This frequency channel is called CC Probing frequency.

The CC-capable device shall:

- Maintain a CC Probing Frame timer.
- Maintain a Start_Transmission timer.
- Maintain a CC Probing Period timer.
- Maintain a Start_Frequency_SCAN timer.
- Maintain a Period counter.
- Select a CC Probing BCCH transmission start time (Start_Transmission) each time the CC Probing Frame timer expires, or after the completion of the Frequency Scan Phase, if no BCCH has been detected; Set the CC Probing Frame Timer to F_P.
- Select a frequency scanning start time (Start_Frequency_SCAN) each time the CC Probing Period timer expires, set the CC Probing Period Timer to P and increase the Period_Counter by one.
- Transmit a CC Probing BCCH, if the CC Probing BCCH transmission start time is reached.
- Stop CC Probing and Start the frequency scanning procedure, if the frequency scanning start time is reached.
- Sense each frequency channel excluding the last Probing Frequency for other Probing BCCH.

- Stop the CC Selection Procedure and start a back-off of (1 s), if a Probing BCCH or a regular BCCH is received successfully. All timers are stopped. After the back-off has expired the CC-capable device starts again with the initial scanning process trying to find a CC in operation and to associate to it, see clause 6.7.2. If no association is possible the CC Selection Protocol is performed again.

- Start CC operation, if Period_Counter = Number of Periods.

6.7.4.1 Frequency scanning

During the frequency scanning each frequency channel except the CC Probing frequency channel is scanned for CC Probing BCCH. The order of the frequency channels is randomly chosen. The selection procedure has to ensure that each frequency is scanned once per Frequency SCAN.

Each frequency is scanned for 1 ms. If no BCCH has been detected after 1 ms the CC-capable device switches to the next frequency. If no more frequencies have to be scanned in the current Period, the CC-capable device continues with CC Probing Frames.

6.8 CC Responsibility Handover

The CC Responsibility Handover is necessary in case that the current CC is no longer able or intended to carry the CC responsibility for the subnet. Reasons for a CC Responsibility Handover, that are out of the scope of the present document, can be e.g. switch off of the WT currently carrying the CC responsibility, a bad connectivity of the current CC, power constraints of the CC, etc. Only old CC-initiated CC Handover is considered in the present document.

The CC Responsibility Handover protocol guarantees a soft handover, in which case all DiL connections are maintained during and after the handover process. The handover is transparent to the network and to the other WTs as far as DiL connections are concerned. The same applies to the user plane of the two terminals involved in the CC Responsibility Handover. The old CC becomes a WT and keeps its own DiL connections. All connections in CM are nevertheless released during CC Responsibility Handover. The CC Responsibility Handover concerns mainly MAC control and RLC instances of the control plane of the current CC.

To seamlessly maintain all running DiL connections, the RLC instances of the current CC have to be transferred to the CC-capable WT that is going to take over the CC responsibility. This CC-capable WT is called CC-candidate. All relevant RLC information is directly transmitted from the current CC to the CC-candidate. This is done during ongoing operation on the current frequency. No MAC control information is transferred during or after the CC Handover process. The new CC may build its own MAC database by either listening to RRs of the WTs and decoding RGs in the frames before CC Handover or by polling the WTs for RRs in the frame(s) after CC Handover. After successful preparation of the CC Handover between the old and the new CC, the new CC takes over BCCH transmission seamlessly.

Support of CC Responsibility Handover is optional for CC-capable H/2-HDs.

6.8.1 Basic Procedure

The basic procedure of CC Responsibility Handover can be depicted from Figure 29.

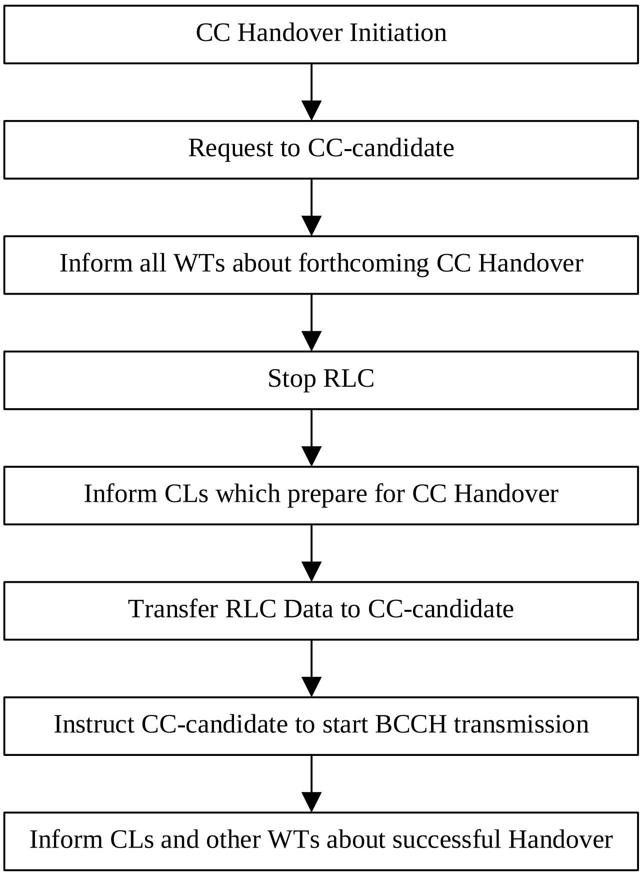

Figure 29: Basic Procedure of CC Handover

In case of a CC initiated CC Responsibility Handover the handover procedure is triggered by an internal request.

- As the CC Handover should be as much as possible transparent to the higher layers the CC Handover is triggered by an implementation specific algorithm inside the RLC layer. This is indicated by the CCH_cc_ho_request_req primitive which is generated under control of the RLC (see Figure 30).

After reception of the CC Handover Request the current CC has to select a CC-candidate from the list of CC-capable WTs. As an example, this selection can be done based upon the global connectivity map, see clause 6.5.4.

The selected CC-candidate HL2/HD is informed, that it has been chosen to take over the CC functionality. This implies the following message exchanges:

- A Handover Request message is sent out to the selected CC-Candidate. The selected CC-candidate is requested to prepare itself for the CC Handover. RLC_CC_HO_REQUEST is transmitted on DL DCCH.
- The CC-candidate informs its RLC environment about the CC Handover Request by a CC Handover Indication.
- The RLC environment of the CC-candidate answers with a CC Handover Response.
- Then the selected CC-candidate WT acknowledges that it is prepared for the CC Handover. This RLC_CC_HO_ACK PDU is transmitted on UL DCCH.

The next step consists in informing all WTs about the forthcoming CC Handover. Sleeping WTs are not woken up. Instead, the sleeping intervals of these WTs are transferred together with the other RLC data to the CC-candidate in a later stage of the procedure (see below).

- The CC sends out a broadcast message on DL RBCH to inform all WTs about the forthcoming CC Responsibility Handover (RLC_CC_HO_NOTIFY). Even CC Handover is optional for CC-capable devices, the RLC_CC_HO_NOTIFY shall be supported by all H/2-HDs.

In response, the RLC entities of all WTs in the subnet are stopped. This means that no new Association, DUC Set-up/modify/release, power saving and DFS requests are started. The RLC entities of the WTs are set into a special state RLC_Stopped_WT which only occurs during CC Handover.

- At the same time all ongoing Association, DUC Set-up/modify/release and power saving requests are aborted by the current CC.

The RLC entities within the CC are set into the RLC_Stopped state. New requests are not processed by the CC any more. During CC Handover no Association, DUC Set-up/Modify, Sleep or DFS request is possible to ease the operation. However RLC_INFO requests (either MT or CC initiated) shall be possible during a CC Handover operation.

The fifth step in Figure 29 concerns the influence of the CC Handover on the higher layers, which may have to prepare for the CC Handover.

- After the positive acknowledgement of the CC-candidate the current CC sends out a CCH_start_cl_ho_ind primitive to the environment. This primitive may be used by the CLs as information of the forthcoming CC Handover.

After reception of the CCH_start_cl_ho_ind the CLs may prepare themselves for the CC Responsibility Handover, if this is necessary. They may e.g. perform a CL handover, if the current CC also contains a centralized decision making entity and database in the respective CL. It is up to the CLs of the old CC to inform the other WTs (including the CC-candidate) on CL level about the ongoing CC Handover on RLC level, if necessary. The main part of the CC Handover procedure on RLC level, the transmission of the RLC data to the CC-candidate, may not be started unless the CL procedures are finished.

- After a CCH_start_cl_ho_rsp primitive is received from the environment, all connections in CM are released by the CC.

DiL connections relayed by the current CC are kept. They are only released in case that the CC is leaving the network (e.g. switch-off).

- Then the transfer of data, states and timers of the RLC to the CC-candidate is started by a CCH_start_cc_req primitive from the RLC environment. For this purpose DL DCCH is used between the CC and the CC-candidate (ordinary RLC operation). The RLC instances in the new CC are set to the same state as in the old CC. For a detailed description of the data transfer see clauses 6.8.3 and 7.8.

- The CC data PDUs are transmitted by means of a "Go-back-n" ARQ mechanism. A certain number of RLC_TRANS_CC_DATA PDUs are acknowledged by the CC-candidate with a RLC_TRANS_CC_DATA_ACK PDU on UL DCCH.

The CC-candidate is now ready to take over the CC functionality. To enable a smooth handover, the old CC informs the new CC when to start with a BCCH transmission. This is done by a handshake message:

- The current CC sends a RLC_START_CC message to the CC-candidate using DL DCCH and including an indication when to start with BCCH transmission (start-mac-frame). The parameter start-mac-frame gives the exact MAC Frame the new CC shall start CC operation. start-mac-frame is the absolute MAC Frame number as determined by the MAC Frame Counter in the BCCH. To overcome the 4 bit limitation of the MAC Frame Counter parameter in BCCH, Start MAC Frame is furthermore offset by a MAC Frame Cycle parameter, which gives the number, the MAC Frame Counter value repeats in BCCH after the reception of the Start CC message (1 repetition corresponds to 16 MAC frames). The reference for the offset is the MAC frame the RLC_Start_CC PDU is received. That means that the RLC instance shall know in which MAC frame it received the RLC_Start_CC in order to determine the right MAC frame to start CC operation. The CC-candidate shall be able to start the CC operation at latest 2 MAC frames after the arrival of the RLC_Start_CC message.

Start-mac-frame is 16 bits long. Its 4 MSB are used to encode the MAC Frame Counter value, and its 12 LSB are used to encode the MAC Frame Cycle value. Either coding is in binary. With this length of the start-mac-frame parameter the maximum time between the RLC_START_CC PDU and the CC Handover is 131 seconds.

EXAMPLE: start-mac-frame = 0010 000000000001
The MAC frame to start CC operation is the second time (because of offset = 000000000001) the MAC Frame Counter in the BCCH shows the value 0010 after the reception of the RLC_Start_CC PDU.

- The CC-candidate sends a CCH_start_cc_ind primitive to the environment. This primitive may be used to inform the CLs present in the CC-candidate about the completion of the CC Handover.

- Upon reception of a CCH_start_cc_rsp the CC-candidate sends a RLC_START_CC_ACK message to the old CC using UL DCCH.

The new CC starts at the time a BCCH is expected. Thus the synchronization is nearly maintained (apart from some jitter due to the ±20 ppm BRAN clock drift in old and new CC). The new CC shall use maximum transmit power in the first frames after take over of the CC responsibility. When the new CC is ready to take new RLC requests, it enables the RLC instances again.

- The new CC informs the WTs about the successful CC Responsibility Handover by sending out a RLC_CC_START_OPERATION Broadcast message on DL RBCH. On reception of RLC_CC_START_OPERATION the WTs are allowed to start again with new RLC requests. Even CC Handover is optional for CC-capable devices, the RLC_CC_START_OPERATION shall be supported by all H/2-HDs. Both CC and WTs may apply an increased power level after reception of the RLC_CC_START_OPERATION (because the distance to the CC has changed).

- At the same time the old CC, which knows the start time of the new CC, informs its RLC environment about the take over of the CC responsibility by the new CC using a CCH_start_cc_cnf.

NOTE: Like for all other procedures, the primitives (between RLC environment and RLC as well as between CLs and RLC) defined in this clause are only of informative nature.

The RRs, or the state of the scheduler are not transmitted to the new CC. Thus the new CC has to take action to get RRs from the WTs. The new CC can either listen to RRs and decode RGs in the frames after the first Handover Request message and already before sending out the BCCH for the first time or it can poll WTs in the frame(s) after take over of the CC responsibility.

During the whole CC handover process, the ordinary user data transmission including RR, RG, scheduling, Random Access, and Random Access Feedback go on as usually for all DiL connections.

A high level Message Sequence Chart (MSC) of the CC Handover Procedure can be found in Figure 30.

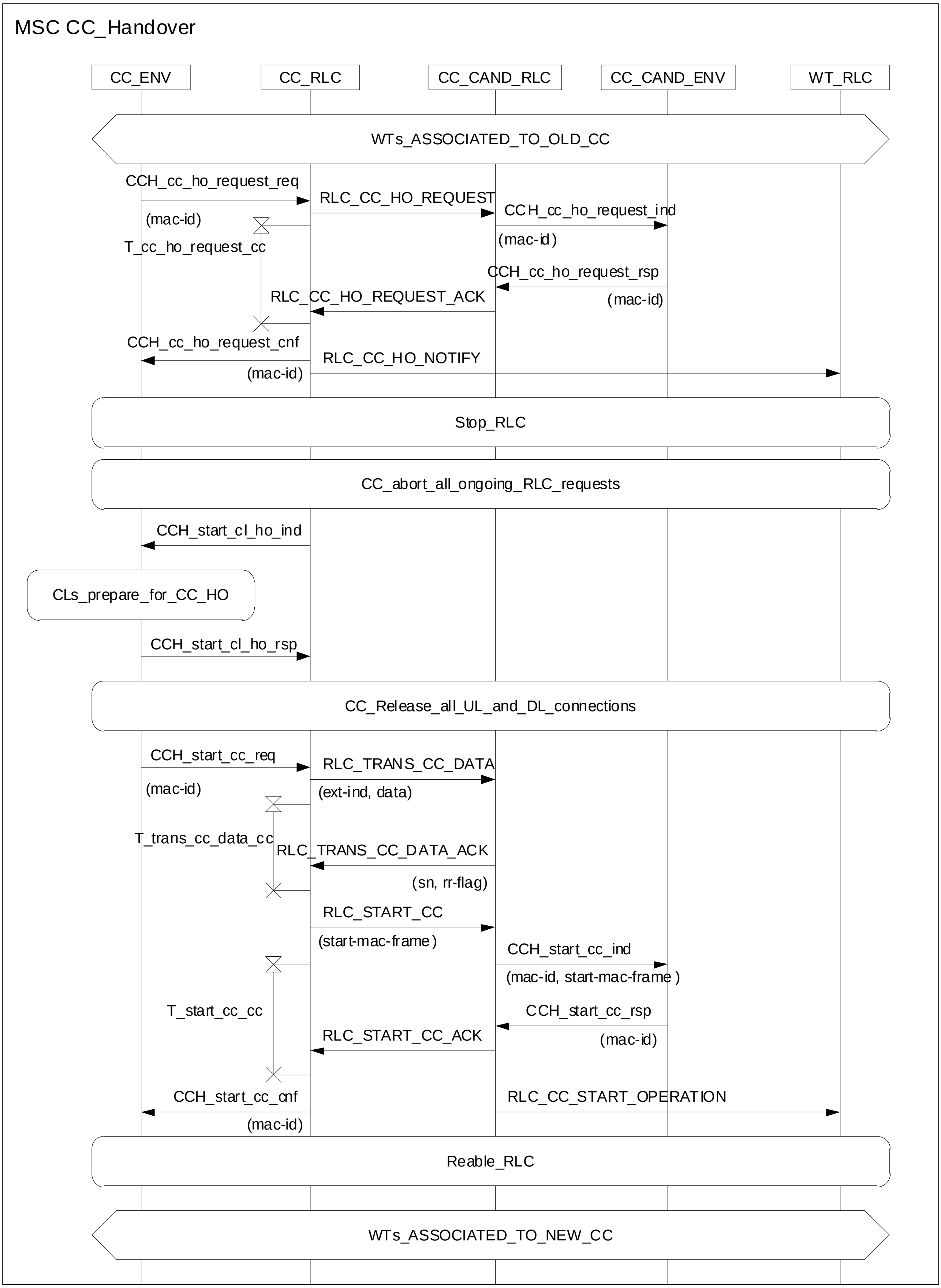

Figure 30: MSC of the CC Responsibility Handover Procedure

Table 25: RLC_TRANS_CC_DATA

RLC-TRANS-CC-DATA-ARG::= SEQUENCE{	
rlc-pdu-type	RLC-HE-SCH-PDU-TYPE
extension-type	EXTENSION-TYPE,
ext-ind	EXT-IND,
data	DATA}

Table 26: RLC_TRANS_CC_DATA_ACK

RLC-TRANS-CC-DATA-ACK-ARG::= SEQUENCE{	
rlc-pdu-type	RLC-HE-SCH-PDU-TYPE
extension-type	EXTENSION-TYPE,
sn	SEQUENCE-NUMBER
rr-flag	RR-FLAG
}	

Table 27: RLC_START_CC

RLC-START-CC-ARG::= SEQUENCE{	
rlc-pdu-type	RLC-HE-SCH-PDU-TYPE
extension-type	EXTENSION-TYPE,
start-mac-frame	START-MAC-FRAME
}	

6.8.2 RLC Data Transmitted During CC Responsibility Handover

The data to be transmitted from the current CC to the CC candidate falls into two categories:

- parameters related to all associated H/2-HDs;
- parameters related to all maintained DiL connections (unicast and multicast).

No information related to connections in CM shall be transmitted, because these connections are not maintained during CC Handover.

No broadcast specific parameters shall be transmitted, because the CC-candidate has necessarily been member of the broadcast group.

No CC specific parameters shall be transmitted during CC Handover. This is due to the fact that relevant parameters like NET ID or AP ID of the old CC are always announced in the BCCH and therefore known to the CC-candidate. The new CC takes over the AP ID of the old CC, but all MAC IDs remain unchanged.

No RR specific parameters shall be transmitted during CC Handover. The reason for this is that all RR specific information is related to the same frame, in which this information is transmitted from the old to the new CC. In other words, this information is already quite old if the new CC receives it. Another reason for not transmitting the RRs from the old to the new CC is, that the probability of error in this transmission is as high as the probability that the CC-candidate does not correctly understand a RR, if the CC-candidate is listening to the RRs in the frame(s) before the handover.

If the CC-candidate was not able to listen to the RRs in the frames before handover, there is an interruption from the user point of view in the 'loss' of RRs. If the new CC polls all WTs in the first MAC Frame for RRs by granting one LCCH to each WT and connection, the interruption is limited to one MAC Frame.

6.8.2.1 Parameters related to all associated H/2-HDs

For every WT as well as for the old CC (which becomes a WT) the following set of parameters (Table 28) should be transmitted:

Table 28: Parameters related to all associated H/2-HDs

Parameter	O/M	Description
auth-id-pr	M	One bit that equals 1 if mt-auth-id is transmitted (resp. present).
mt-auth-id-type	O	The mt-auth-id (4 bits) is of one of the following types: ieee, ext-ieee, net-acc-id or dist-name, compressed or generic.
mt-auth-id	O	This is the concrete authentication identifier of the H/2-HD in one of the formats mentioned above. It is either 6 octets long in case of an ieee address, 8 octets long in case of ext-ieee, 46 octets long in case of net-acc-id or dist-name, 16 octets long in case of "compressed" and 92 octets in case of "generic".
mac-id	M	This is an 8 bits long unique identifier of the H/2-HD inside one subnet.
dlc-version-selected	M	Version of the DLC protocol (8 bits long).
rlc-version-selected	M	Version of the RLC protocol (8 bits long).
nr-cl-vid	M	Indicates the number N of CLs present within the H/2-HD and at the same time the number of cl-vid that follow. The nr-cl-vid field is 3 bits long.
cl-vid	M	This parameter consists of a cl-id field (8 bits) and a cl-version field (8 bits), which define the id and version of one of the multiple CLs. For every CL present within the H/2-HD the cl-vid parameter is transmitted.
support64qam	M	One bit that equals 1 if WT supports 64 QAM.
freq-band	M	Identifies which frequency band can be used by the WT. Low band: 5 180 - 5 320 MHz. High band: 5 500 - 5 700 MHz. (2 bits).
direct-mode-cap	M	One bit that equals 1 if WT supports DM.
support-fca	M	One bit that equals 1 if WT supports polling.
support-fsa	M	One bit that equals 1 if WT supports FSA.
ho-cap	M	1 bit that indicates if WT is handover capable.
cc-ho-cap	M	1 bit that indicates if WT is CC Handover capable.
duty-cycle	M	percent of the MAC frame that the WT can use for uplink transmission (3 bits).
cyclic-prefix	M	1 bit to indicate the type of the preamble used by this H/2-HD.
time-gap-ach-uplink	M	Indicates time the respective H/2-HD needs after FCCH reception until it can receive again (3 bits).
arq-delay-rx	M	ARQ delay of the receiver inside the respective H/2-HD (2 bits).
arq-delay-tx	M	ARQ delay of the transmitter inside the respective H/2-HD (2 bits).
auth-encr-selected	M	This parameter consists of an auth-info field and an encr-info field, which are 4 bits long each and define the type of auth. and encr. selected.
dil-power-control	M	2 bits to indicate the type of DiL power control.
tx-arq-win-size	M	3 bits for window size.
rx-arq-win-size	M	3 bits for window size.
length-of-measurement	M	Indicates how many MAC frames the WT will still be absent for DFS. Reference frame is the frame in which this parameter is transmitted during CC Handover. A start-of-measurement parameter is not necessary, since the length-of-measurement field should be filled (in case of CC Handover) with the remaining absence time of the WT and since a start-of-measurement value in the future would not be possible, because the RLC is stopped during CC Handover. Afterwards, the new CC is responsible for polling the WT that is not aware of the CC Responsibility Handover due to its absence for DFS. The field is 6 bits long. length-of-measurement is set to 0 if the WT is not absent for DFS.
sleep-interval	M	Indicates how many MAC frames the WT will still be sleeping. Reference frame is the frame in which this parameter is transmitted during CC Handover. A fc-start-pointer parameter is not necessary, since the sleep-interval field should be filled (in case of CC Handover) with the remaining sleeping time of the WT and since a fc-start-pointer value in the future would not be possible, because the RLC is stopped during CC Handover. Afterwards, the new CC is responsible for polling the WT that is not aware of the CC Responsibility Handover, because it has been in sleeping mode during the procedure. Sleep time is 2^2^sleep-interval (8 bits). sleeping-interval is set to 0 if the WT is not in sleeping mode.
cl-common-attr-length	M	5 bits to indicate the length of the cl-common-attr container.
cl-common-attr	M	This field represents a container in which CL related information is transferred that is common to all DUCs of the respective H/2-HD. The length M of the container can vary between 0 and 31 octets in multiples of one octet.

Parameter	O/M	Description
nr-mc-groups	M	Indicates the number L of DM multicast groups the H/2-HD is participating in and at the same time the number of group-mac-id fields that follow. The nr-mc-groups field is 5 bits long.
first-group-mac-id	M	Multicast Group MAC ID of the first group the H/2-HD is member of. (8 bits).
second-group-mac-id	M	Multicast Group MAC ID of the second group the H/2-HD is member of. (8 bits).
..... (until L^{th}-group-mac-id)	M	....

For operation in a single HEE subnet MT-AUTH-ID is not absolutely necessary. Inside the subnet the MAC ID is already a unique identifier of the H/2-HD. This is why the transfer of the parameters mt-auth-id-type and mt-auth-id is only optional. The flag auth-id-pr, which indicates the presence of the MT AUTH ID during transmission, is nevertheless mandatory.

NOTE: The information regarding DiL multicast groups is implicitly contained in this set of H/2-HD-specific parameters.

The ASN.1 tables of the parameters can be found in TS 101 761-2 [2], except for mit-id-pr, auth-id-pr, nr-cl-vid, cl-common-attr-length, nr-mc-groups, first-group-mac-id and second-group-mac-id, etc. The mt-id-pr, auth-id-pr, nr-cl-vid and the nr-mc-groups parameters are new and have the length and purpose described above. The group-mac-id fields are parameters, only transmitted during CC Handover, but are of the same type as mac-id. The cl-common-attr-length is also a new field which has the same type as the cl-conn-attr-length in TS 101 761-2 [2].

Beside the H/2-HD specific data, the data regarding the DiL connections of each H/2-HD has to be transmitted in addition. These parameters are treated in the following clause.

6.8.2.2 Parameters related to all maintained DiL connections

Parameters related to DiL unicast connections on the one hand side and parameters related to DiL multicast connections on the other hand can be treated in a very similar way. Table 29 shows the parameters that shall be transmitted for each DiL unicast or multicast connection.

Table 29: Parameters related to all maintained DM connections

Parameter	O/M	Description
first-mac-id	M	In case of a DiL unicast connection first-mac-id (8 bits) is filled with the mac-id of one of the two H/2-HDs involved in the connection. In case of a DiL multicast connection the first-mac-id field is filled with the mac-id of the sending H/2-HD.
second-mac-id	M	In case of a DiL unicast connection second-mac-id (8 bits) is filled with the mac-id of the other of the two H/2-HDs involved in the connection. In case of a DiL multicast connection the second-mac-id field is filled with the mac-id of the multicast group for which the connection is maintained.
cl-vid	M	This parameter consists of a cl-id field (8 bits) and a cl-version field (8 bits), which define the id and version of one of the multiple CLs. For every CL present within the H/2-HD the cl-vid parameter is transmitted.
dlcc-id	M	Connection Identifier (6 bits). In case of a multicast connection the dlcc-id is always set to the value 63.
direction	M	2 bits to indicate in case of a unicast connection one of the following four possibilities: simplex-forward, simplex-backward, duplex, duplex-symmetric. In case of multicast the connection is always of type simplex-forward.
cl-conn-attr-length	M	Length of the cl-conn-attr(ibutes). Not all cl-attributes containers of all connections have the same length. Field is 5 bits long.
cl-conn-attr	M	Container for CL specific information of the respective connection. The length of the container can vary between 0 and 31 octets in multiples of one octet.
forward-descr	M	Forward descriptor of the connection (56 bits in total). It comprises the following fields: allocation-type, cyclic prefix, ec-mode, arq-used, fec-used, arq-data, fec and fca-descr.
backward-descr	M	Backward descriptor of the connection (56 bits in total). It comprises the same fields as the forward-descr (see above). In case of a multicast connection no backward-descr is present, which is indicated by the direction field being set to "simplex-forward".

The ASN.1 tables of the parameters can be found in TS 101 761-2 [2]. First-mac-id and second-mac-id are of the same type as peer-mac-id in TS 101 761-2 [2].

6.8.3 Data Transfer Procedure

The parameters related to all associated H/2-HDs and the parameters related to all DiL connections are transmitted as byte string from the CC to the CC-candidate. The structure of this byte string and the coding of the parameters inside the byte string are defined in clause 7.8. The byte string is transmitted as payload of one or several DiL DCCH LCHs called RLC_TRANS_CC_DATA PDUs. The coding of a RLC_TRANS_CC_DATA PDU is also defined in clause 7.8.

If the byte string has to be transmitted on several RLC_TRANS_CC_DATA PDUs, it has to be segmented. The complete byte string shall be reassembled in the receiver. To reassemble the payload of the RLC_TRANS_CC_DATA PDUs in the correct order, each PDU shall have a Sequence Number (SN). For this purpose the SN-field defined in TS 101 761-1 [1] shall be used. This is possible because the field is in general not used in case of a DiL DCCH.

To ensure the integrity of the transmitted data, a "Go-back-n" ARQ mechanism shall be applied on the RLC_TRANS_CC_DATA PDUs using RLC_TRANS_CC_DATA_ACK PDUs. The sender window is implicitly defined by the size of the SN-field (1 024 PDUs).

NOTE 1: It is implementation specific and e.g. load dependent, how many RLC_TRANS_CC_DATA_PDUs are transmitted before the sender (CC) waits for a RLC_TRANS_CC_DATA_ACK sent by the receiver (CC-candidate).

With a RLC_TRANS_CC_DATA_ACK PDU the receiver acknowledges all PDUs up to an indicated SN-1. A *ReceiveReady-flag (RR-flag)* inside the RLC_TRANS_CC_DATA_ACK indicates whether further PDUs (starting with SN) have not been correctly received (RR - flag = 0) or whether all PDUs up to (and including) SN have been correctly received (RR - flag = 1). In the first case the sender (CC) shall re-send all PDUs beginning with the indicated SN.

NOTE 2: In the second case the acknowledged SN may be lower than the SN of the last sent PDU. This may occur if the receiver (CC-candidate) has not yet processed the remaining PDUs. Nevertheless, the sender (CC) shall continue transmission of RLC_TRANS_CC_DATA PDUs beginning with SN where he had previously stopped transmission.

If the sender (CC) has not received a RLC_TRANS_CC_DATA_ACK PDU within time *T_trans_cc_data_cc*, it shall re-send all RLC_TRANS_CC_DATA PDUs from the last acknowledged SN on. The receiver (CC-candidate) shall send at least one RLC_TRANS_CC_DATA_ACK PDU per frame (if there are RLC_TRANS_CC_DATA PDUs that have not yet been acknowledged).

The timer T_trans_cc_data_cc shall be set to 6 ms.

6.9 Authentication Key Management

During association, the authentication phase is performed by a challenge/response technique in which each end-entity (CC and WT) uses a common secret authentication key auth-key to respond to the challenge sent by the other entity. Therefore, auth-key shall be downloaded into each H2-HD. Support for Authentication Key Distribution is mandatory for all H/2-HDs.

Before an H/2-HD can take part in normal operation, meaning to start the CC selection process as a CC-capable device, or to start the association process as a basic WT, it shall first be initialized with the common secret authentication key and the owner identifier NET-ID of the home network. auth-key and NET-ID shall only be generated by the first CC-capable device to be installed in the home network and shall then be distributed to each new device to be installed. The NET-ID is broadcast by the CC in the BCCH and therefore known to every WT to be installed. The new WT shall store the NET-ID locally. The authentication key auth-key is distributed in a secure way to avoid:

- The key to be discovered by an eavesdropper;
- The registration of an attacker's devices on a network.

To avoid the registration of attacker's devices on a home network, each network shall be protected by an up to 23 octets PIN (Personal Identification Number). This PIN shall be stored in the CC (or each CC-capable device). When installing a new device, the user shall be asked via an implementation specific user interface whether:

1) The device is the first device to be installed in the network;
2) The device is a new additional device in the network (in that case, another device shall already have been installed in the network).

In the first case, the CC capable device to be installed shall act as a CC without performing CC Selection, and shall generate the secret auth-key and the owner identifier NET-ID. In the second case, the new device to be installed shall act as a WT without performing CC Selection; the existing CC broadcasts NET-ID and shall send auth-key to this new device.

The PIN is CC-defined and a way of recovery may exist in case the PIN is lost. This way may be different for each manufacturer and is out of the scope of the present document. Moreover, a user may have the ability to change his PIN.

6.9.1 Installation of the First Device in the Network

Using an implementation specific interface, the user shall be asked if the device to be installed shall be the first operational device of a network. The first device of a network shall be CC-capable. To avoid wrong setting by the user, the device may indicate to the user if it has detected other CCs with or without displaying the associated NET-IDs. If the user set the device as the first device in the network, the device shall act as the CC on a free frequency and shall generate the secret key auth-key and the owner identifier NET-ID. Before generating them, the CC inquire the network's PIN from the user. If the PIN is validated by the CC, the CC generates auth-key and NET-ID.

auth-key shall be the output of a random generator, or the result of a function *f* that depends on several parameters such as the device identifier, the network PIN and so on:

auth-key = f(device_id, PIN,…).

The function *f* shall ensure the approximate uniqueness of auth-key. This means that given two different possible inputs of *f*, the probability of obtaining the same key auth-key shall be less than 2^{-40}. However, *f* may be different for each manufacturer and its definition is out of the scope of the present document.

NET-ID shall be a random number between 0 and 959. During the installation and normal operation, the NET-ID shall be sent on BCCH by the acting CC.

The user shall be able to undo or renew this first device installation process whenever he/she wants.

NOTE: The manufacturer should make clear in the user manual that the user should not configure a new CC-capable device as the first one, if there is already one installed.

If multiple CC-capable devices are configured by the user as the first devices of a network. It is very likely that they generate independent networks with different owner identifiers and authentication keys.

By looking at an implementation specific indicator on each CC-capable device, the user should be able to detect if more than one CC is active at a time. If the user wants to have one single network, he/she should undo the installation process of all CCs, except the one that he/she wants to keep.

6.9.2 Installation of a New Device in the Network

The generated authentication key auth-key shall be downloaded into each new device before it can use the network. This download phase involves the participation of the CC and the new H2-HD, and is composed of the following steps:

1) Via an implementation specific user interface, the user shall activate the installation phase on the CC to install a new device;

2) The CC shall inquire the network PIN from the user. If the entered PIN is validated by the CC, the download process is started and remains valid during a time window; The user may determine the duration of the time window;

3) The user shall activate the installation phase on the new H2-HD to be installed. This device shall associate with the CC, requesting unicast encryption but no authentication. At the end of this association phase, the H2-HD and the CC agree on an encryption algorithm *A* (*A* may be DES or 3DES) and execute a Diffie-Hellman key exchange. The result of this step is a secret session key SSK shared by the new device and the CC. This session key shall be used by the algorithm *A* negotiated in the previous step. Figure 31 gives an overview which parts of the association procedure are carried out for the installation purpose.

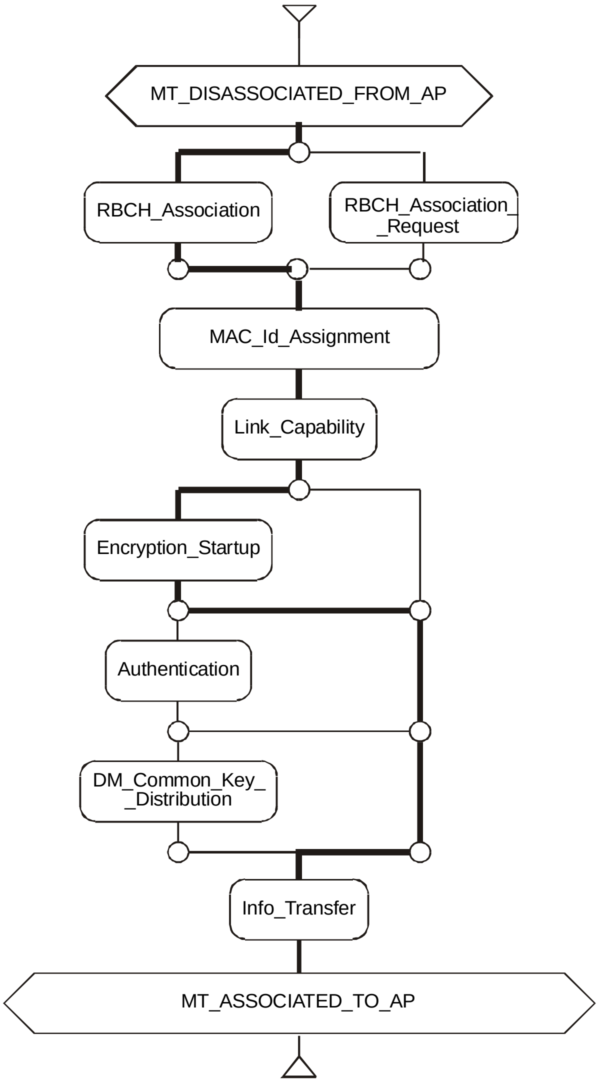

Figure 31: Association procedure for installation purposes

1) After association, the new device shall give its identification number mt-id-number to the CC. The length of identification number is limited to 47 octets. The definition of the identification number is out of scope of the present document;

2) The CC shall display the information of the new device (identification number) to the user and ask for validation;

3) If the user validates, auth-key and the network's PIN are sent to the new device, encrypted by the algorithm A using the key SSK. As the length of auth-key and the PIN are not prescribed, two length-fields are also included in the PDU. From the length of the length-fields follows that auth-key and the PIN can be up to 46 bytes long in total. At receipt, the device stores K, together with the NET-ID received on BCCH, in a non-volatile memory and sends the acknowledgement SSK(MD5(K)) to the CC;

4) The new device disassociates and starts a normal association requesting encryption and authentication.

NOTE: In order that the user can validate the identification number mt-id-number, it is to be displayed on the new device and the CC in the same format to be agreed upon by manufacturers.

These steps are illustrated in Figure 32.

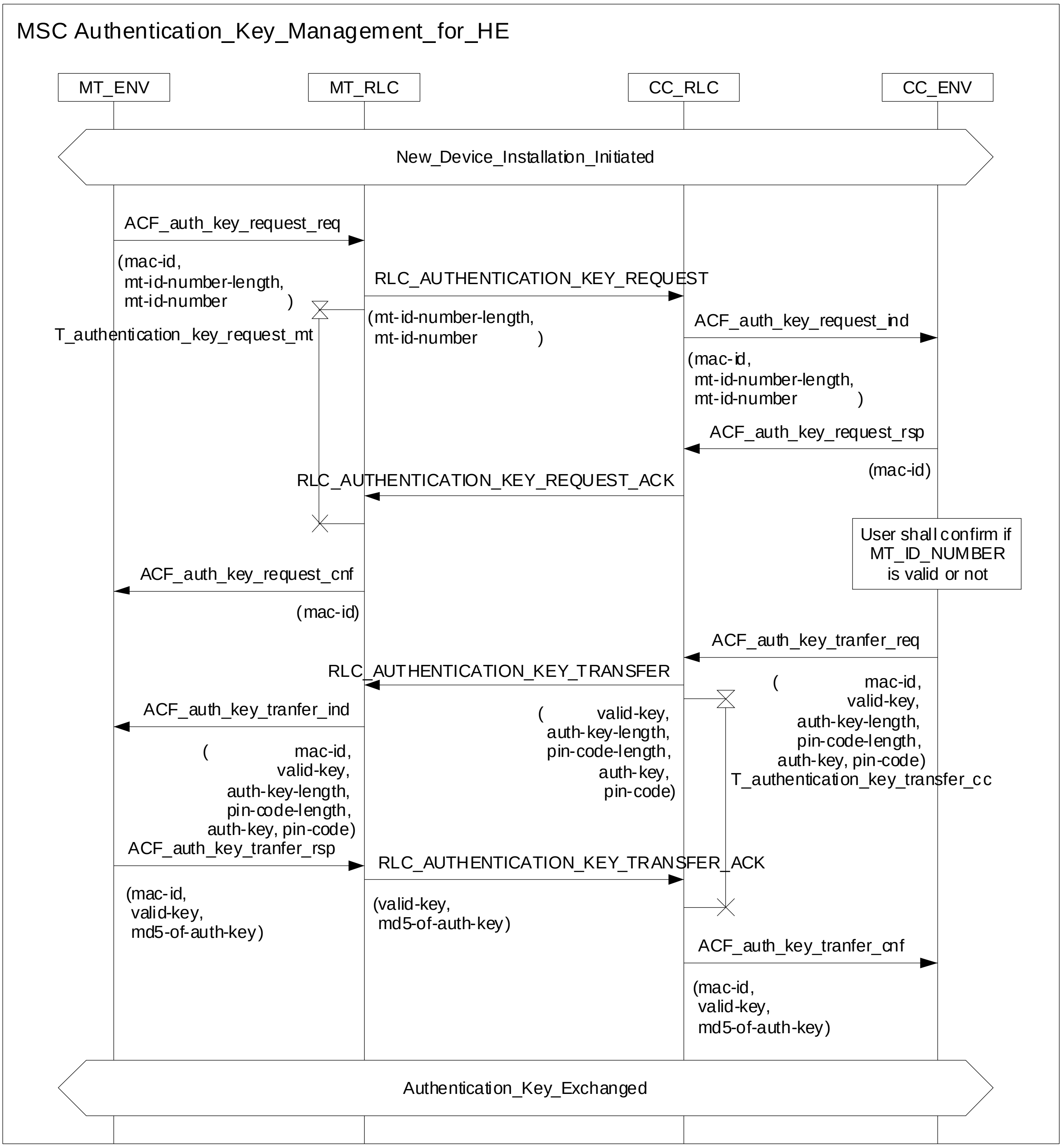

Figure 32: Messages exchanged during the installation of a new device

Table 30: RLC-AUTHENTICATION-KEY-REQUEST

RLC-AUTHENTICATION-KEY-REQUEST-ARG::= SEQUENCE{	
rlc-pdu-type	RLC-HE-LCH-PDU-TYPE,
extension-type	EXTENSION-TYPE,
mt-id-number-length	MT-ID-NUMBER-LENGTH,
mt-id-number	MT-ID-NUMBER }

Table 31: RLC-AUTHENTICATION-KEY-REQUEST-ACK

```
RLC-AUTHENTICATION-KEY-REQUEST-ACK-ARG::= SEQUENCE{
    rlc-pdu-type   RLC-HE-SCH-PDU-TYPE
    extension-type         EXTENSION-TYPE,
    }
```

Table 32: RLC-AUTHENTICATION-KEY-TRANSFER

```
RLC-AUTHENTICATION-KEY-TRANSFER-ARG::= SEQUENCE{
    rlc-pdu-type           RLC-HE-LCH-PDU-TYPE,
    extension-type         EXTENSION-TYPE,
    valid-key              VALID-KEY,
                   -- indicated whether the exchanged
                   -- key is valid or not
    auth-key-length        AUTH-KEY-LENGTH,
    pin-code-length        PIN-CODE-LENGTH,
    auth-key               AUTH-KEY,
    pin-code               PIN-CODE}
```

Table 33: RLC-AUTHENTICATION-KEY-TRANSFER-ACK

```
RLC-AUTHENTICATION-KEY-TRANSFER-ACK-ARG::= SEQUENCE{
    rlc-pdu-type           RLC-HE-SCH-PDU-TYPE,
    extension-type         EXTENSION-TYPE,
    valid-key              VALID-KEY,
                           -- indicated whether the exchanged
                           -- key is valid or not
    md5-of-auth-key        MD5-ON-KEY}
```

To download the common authentication key and the owner identifier from the CC, the new device shall first run an association phase without the authentication procedure. It shall abort this association, as soon as it detects that the CC to be associated with is a Non HE-compliant Device. If more than one active HE-compliant CCs are detected, the new device to be installed shall try out the CC, whose download process has been started by the user. When the authentication key has been exchanged, the WT shall disassociate and run the association procedure with the authentication phase.

NOTE: The installation phase activation mentioned in steps (1) and (3) depends on the manufacturers and is out the scope of the present document. Moreover, the choice of algorithm *A* in step (3) depends on the required security level. The standard does not impose any algorithm but recommend to use 3DES to reach a high level of security.

Three new RLC messages are introduced, namely RLC_AUTHENTICATION_KEY_REQUEST, RLC_AUTHENTICATION_KEY_TRANSFER, RLC_AUTHENTICATION_KEY_TRANSFER_ACK. The encoding of these RLC PDUs is defined in clause 7.9.

Once a H2-HD is installed, it can be reinstalled in any new network by repeating the eight operations mentioned above on the new network. In that case, the old authentication key may be deleted and replaced by the new one, if the manufacturer only supports one usage profile. Using an implementation specific user interface, the user may be enabled to select different usage profiles. Different usage profiles may correspond to different independent networks in the same or different places. In this case, for each usage profile a specific authentication key and owner identifier can be downloaded and stored in the H/2-HD.

7 RLC Protocol Data Units

7.1 General

The general concept of the transfer syntax of RLC is described in TS 101 761-1 [1] and TS 101 761-2 [2]. The specific transfer syntax formats for DiL RLC messages using SCH or LCH are defined below:

Table 34: Transfer syntax format of the RLC SCH in Direct Link

	8	7	6	5	4	3	2	1
Octet 1	Defined in DLC TS				Future Use			
Octet 2	MSB RLC SCH PDU type							
Octet 3	MSB EXTENSION-TYPE			MSB RLC DATA				
Octet 4	MSB RLC DATA							
…								
Octet 7								

Table 35: Transfer syntax format of the RLC LCH in Direct Link

	8	7	6	5	4	3	2	1
Octet 1	Defined in DLC TS		MSB Sequence number					
Octet 2	Sequence number				MSB EXTENSION-TYPE			Future use
Octet 3	MSB RLC LCH PDU type							
Octet 4	MSB RLC DATA							
…								
Octet 51								

The definition of MSB for coding of RLC messages and its usage rules are given in TS 101 761-2 [2] (clause 4.4).

Table 36 lists all RLC messages defined in TS 101 761-2 [2] with changed requirement for support, i.e. the implementation changes from optional to mandatory.

Table 36: RLC messages with changed requirement for support

RLC MESSAGE	CC-capable WT O/M	basic WT O/M
RLC_DM_COMMON_KEY_DISTR_(/ACK)	M	M
RLC_INFO_(-/ACK)	M	M
RLC_GROUP_JOIN_(/ACK/NACK)	M	O
RLC_GROUP_LEAVE_(/ACK/NACK)	M	O
RLC_DM_SETUP	M	M
RLC_DM_CONNECT_(-/ACK/COMPLETE)	M	M
RLC_DM_RELEASE_(-/ACK)	M	M
RLC_DM_RESET_(-/ACK)	M	M

Table 37 lists all parameters added or changed indicating whether the support is mandatory or optional.

Table 37: Parameters added/changed

Parameter	O/M	Description
dm-attributes	M	Additional parameters needed for the DM are transferred as DM-Attributes. This parameter is for future use.

7.2 Terminal association for multiple convergence layers

The terminal association consists of the MAC_Id assignment, the link capability, the encryption startup, the authentication and the information transfer procedure. Only the RLC PDUs for link capability exchange and the information transfer carry information, which is needed for the multiple convergence layers association. For the corresponding message formats, parameters and their values please refer to clause 6.2.

For each convergence layer negotiated by WT and CC an RLC information transfer takes place. During this information transfer a parameter cl_data is exchanged between the corresponding CLs which is transparent to the RLC. The cl_data contains specific information needed for the coordination of the CLs.

7.3 Link Adaptation in Direct Link Phase

No new HE PDUs are defined for link adaptation in DiL.

7.4 Power Control in Direct Link Phase

RLC_DM_POWER_CONTROL

The transfer syntax table of RLC_DM_POWER_CONTROL message is shown below:

Table 38: Transfer Syntax of RLC_DM_POWER_CONTROL

	8	7	6	5	4	3	2	1
Octet 3				dm-duc-type	adjust-tx			
Octet 4	wt-tx-level				future use			
Octet 5								
Octet 6	not used							
Octet 7	not used							

Semantics:

Parameter	O/M	Description
dm-duc-type	M	Indicates whether DiL PC message concerns: 0: unicast traffic from peer WT 1: multicast/broadcast traffic from peer WT
adjust-tx	M	Recommended adjustment of transmit power level at peer WT
wt-tx-level	M	Actual transmit power level of Sender

dm-duc-type field indicates whether the RLC_DM_POWER_CONTROL message concerns unicast or multicast/broadcast traffic from the peer WT.

During connectivity check, the field adjust_tx in RLC_DM_POWER_CONTROL message is set to 0000, which indicates that the WT was not able to make a recommendation for the transmit power level, since it has not been able to perform any measurements of reception quality.

The mapping of the field adjust-tx, using 4 bits and a step size of 3dB, is shown in Table 40.

The mapping of wt_tx_level, using 4 bits and a step size of 3dB, is shown in Table 39. This is the same mapping and accuracy as for the CC transmission power AP_Tx_Level [3].

Table 39 shows the mapping of the field adjust-tx, using 4 bits and a step size of 3dB.

Table 39: Mapping of adjust-tx field

adjust-tx	Adjust power level by:
0000	No change / Not enough measurements
0001	–3 dB
0010	–6 dB
…	…
0111	–21 dB
1000	Not used
1001	+3 dB
1010	+6 dB
…	…
1111	+21 dB

Table 40 shows the mapping of wt-tx-level, using 4 bits and a step size of 3dB.

Table 40: Mapping of wt-tx-level field

wt-tx-level	Mean EIRP [dBm]	Accuracy [dB]
1111	30	+/- 4
1110	27	+/- 4
1101	24	+/- 4
1100	21	+/- 4
1011	18	+/- 4
1010	15	+/- 5
1001	12	+/- 5
1000	9	+/- 5
0111	6	+/- 6
0110	3	+/- 6
0101	0	+/- 6
0100	-3	+/- 6
0011	-6	+/- 6
0010	-9	+/- 6
0001	-12	+/- 8
0000	-15	+/- 8

7.5 Link Quality Calibration for DM operation

RLC_CALIBRATION_MEASUREMENT_TRIGGER

The transfer syntax table of RLC_CALIBRATION_MEASUREMENT_TRIGGER message is shown below:

Table 41: Transfer Syntax of RLC_CALIBRATION_MEASUREMENT_TRIGGER

<table>
<tr><th></th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th></tr>
<tr><td>Octet 3</td><td colspan="3"></td><td colspan="2">trigger-type</td><td colspan="3">future use</td></tr>
<tr><td>Octet 4</td><td colspan="8">mac-id-1 (presence depending on trigger-type)</td></tr>
<tr><td>Octet 5</td><td colspan="8">mac-id-2 (presence depending on trigger-type)</td></tr>
<tr><td>Octet 6</td><td colspan="8">mac-id-3 (presence depending on trigger-type)</td></tr>
<tr><td>Octet 7</td><td colspan="8">not used</td></tr>
</table>

Semantics:

Parameter	O/M	Description
trigger-type	M	2 bits that indicate if one, two, three or all WTs are triggered: 00 → All WTs are triggered (no MAC-ID included) 01 → One WT is triggered 10 → Two WTs are triggered 11 → Three WTs are triggered
mac-ids	M	MAC-ID of triggered WTs (up to 3), in case of selective calibrations.

RLC_CALIBRATION _ MEASUREMENT

The transfer syntax table of RLC_CALIBRATION_MEASUREMENT message is shown below (no parameters are contained):

Table 42: Transfer Syntax of RLC_CALIBRATION_MEASUREMENT

	8	7	6	5	4	3	2	1
Octet 3				Not used				
Octet 4	Not used							
Octet 5								
Octet 6								
Octet 7								

Semantics:

Parameter	O/M	Description
		No parameters included

RLC_CALIBRATION _REPORT_TRIGGER

The transfer syntax table of RLC_CALIBRATION_REPORT_TRIGGER message is shown below:

Table 43: Transfer Syntax of RLC_CALIBRATION_REPORT_TRIGGER

	8	7	6	5	4	3	2	1
Octet 3				trigger-type		future use		
Octet 4	mac-id-1 (presence depending on trigger-type)							
Octet 5	mac-id-2 (presence depending on trigger-type)							
Octet 6	mac-id-3 (presence depending on trigger-type)							
Octet 7	not used							

Semantics:

Parameter	O/M	Description
trigger-type	M	2 bits that indicate if one, two, three or all WTs are triggered to report: 00 → Report from all WTs 01 → Report from one WT 10 → Report from two WTs 11 → Report from three WTs
mac-ids	M	MAC-IDs of up to 3 WTs (8 bits each), in case of selective reports

RLC_SHORT_CALIBRATION _REPORT

The transfer syntax table of RLC_CALIBRATION_REPORT message in SCH:

Table 44: Transfer Syntax of RLC_SHORT_CALIBRATION_REPORT

	8	7	6	5	4	3	2	1
Octet 3				rep-buf-status	future use			
Octet 4	mac-id-1							
Octet 5	rss2-of-wt-1						future use Future use	
Octet 6	mac-id-2							
Octet 7	rss2-of-wt-2						future use	

RLC_CALIBRATION _REPORT

The transfer syntax table of RLC_CALIBRATION_REPORT message in LCH:

Table 45: Transfer Syntax of RLC_CALIBRATION_REPORT

	8	7	6	5	4	3	2	1
Octet 4	number-of-reports					rep-buf-status	future use	
Octet 5	mac-id-1							
Octet 6	rss2-of-wt-1						future use	
Octet 7	mac-id-2							
Octet 8	rss2-of-wt-2						future use	
Octet 9	mac-id-3							
Octet 10	rss2-of-wt-3						future use	
Octet 11	mac-id-4							
Octet 12	rss2-of-wt-4						future use	
Octet...	etc for other wts							
Octet …	not used							
Octet …								
Octet 51								

Semantics:

Parameter	O/M	Description
rep-buf-status	M	Indicates whether reports still need to be broadcast. 0 All reports have been transmitted 1 Still reports in buffer
cap-report-list	M	Each report contains a MAC-ID (8 bits) and the corresponding RSS2 value (6 bits) of the WT.

RLC_CALIBRATION_LINKQUALITYMAP_REQUEST

The transfer syntax table of RLC_CALIBRATION_LINKQUALITYMAP_REQUEST message:

Table 46: Transfer Syntax of RLC_CALIBRATION_LINKQUALITYMAP_REQUEST

	8	7	6	5	4	3	2	1
Octet 3				request-type	future use			
Octet 4	mac-id							
Octet 5	not used							
Octet 6								
Octet 7								

Semantics:

Parameter	O/M	Description
request-type	M	Indicates whether the whole map is requested or only information related to one WT with mac-id. 0 Whole Map request 1 Only RSS2 information related to the MAC-ID given below
mac-id	M	mac-id of the specific WT in case of request-type=1. With request-type=0 the field is not present.

RLC_CALIBRATION_LINKQUALITYMAP

The transfer syntax table of RLC_CALIBRATION_LINKQUALITYMAP message:

Table 47: Transfer Syntax of RLC_CALIBRATION_LINKQUALITYMAP

	8	7	6	5	4	3	2	1
Octet 4	number-of-mac-ids				map-ext-ind	future use		
Octet 5	mac-id-of-sender-wt-i							
Octet 6	no-of-reports-wt-i							
Octet 7	mac-id-receiver-wt-ix							
Octet 8	age-of-rss2		rss2-for-wt-ix					
Octet 9	mac-id-receiver-wt-iy							
...	age-of-rss2		rss2-for-wt-iy					
Octet 6+(2*N)	…							
Octet 7+(2*N)	mac-id-of-sender-wt-j							
Octet 8+(2*N)	no-of-reports-wt-j							
Octet 9+(2*N)	mac-id-wt-jx							
Octet 10+(2*N)	age-of-rss2		rss2-for-wt-jx					
Octet 11+(2*N)	mac-id-wt-jy							
Octet 12+(2*N)	age-of-rss2		rss2 –for-wt-jy					
...	…							
8+(2*N)+(2*K)	...							
9+(2*N)+(2*K)								
...								
Octet 51								

Semantics:

Parameter	O/M	Description
number-of-mac-ids	M	Number of the MAC-IDs of the WT_xi, whose transmitted RSS2 values are being reported by WT_i.
map-ext-ind	M	extension indication bit whether more RLC_CALIBRATION_LINKQUALITYMAP PDUs follow
complete-report-list	M	Contains following Reports from each WT_i, whose RSS2 values have been measured by other WT_ix: MAC-ID of WT_i (8 Bits) Number of reports for measurement PDU from WT_i (8 Bits) Report list (N * 16 Bits): MAC-ID of WT_ix (8 Bits) RSS2 measured by WT_ix when signal transmitted by WT_i (6 Bits) Age (2 bits) indicates the time since the measurement was performed: 00: within last 100 msec 01: within last 250 msec 10: within last 500 msec 11: older than 1 sec In case of a partial quality map only the reports concerning one reporting WT_i are included in the PDU.

If RLC_CALIBRATION_LINKQUALITYMAP contains a partial map, dedicated to one WT_i only, it is transmitted on DL DCCH, if it contains a complete quality map or a part of the complete quality map it is transmitted on DL RBCH.

NOTE: The complete quality map may not fit into one LCH, in which case several RLC_CALIBRATION_LINKQUALITYMAP PDUs will be broadcast by the CC. number-of-mac-ids only indicates the number of WT_i in the current PDU, whose RSS2 values have been measured by other WT_ix.

7.6 DLC User Connection Control

7.6.1 Fixed slot allocation for DM

An FSA connection set-up, release, modify, etc. is identified by the *allocation-type* field in the *duc-direction-descr* being set to the value "fsa" (see TS 101 761-2 [2]). The FSA specific parameters of the connection are contained in the *fsa-descr,* which is also part of the *duc-direction-descr*. The *fsa-descr* is only present inside the *duc-direction-descr* when *allocation-type* is set to "fsa".

The *fsa-descr* is defined in TS 101 761-2 [2]. It contains the parameters: *phy-mode-lch, nb-of-lch, min-nb-of-lch, start-pointer* and *start-mac-frame*. In case of an FSA-RR only the parameters *phy-mode-lch*, *nb-of-lch, min-nb-of-lch* and *start-mac-frame* are used. For an FSA-RR the *start-pointer* shall be filled with 0 bits. In case of an FSA-RG only the parameters *phy-mode-lch*, *nb-of-lch, start-pointer* and *start-mac-frame* are used. For an FSA-RG *min-nb-of-lch* shall be set to the value of *nb-of-lch.* The meaning and use of the parameters in case of FSA-RR and FSA-RG is summarized in Table 48.

Table 48: Parameters of the *fsa-descr* in case of FSA-RR and FSA-RG

Parameter	O/M	Description
phy-mode-lch	M	Phy-mode of the LCHs (4 bits)
nb-of-lch	M	Number of requested (in case of FSA-RR) or granted (in case of FSA-RG) LCHs. (8 bits)
min-nb-of-lch	M	Minimum number of requested LCHs in case of an FSA-RR. In case of an FSA-RG the min-nb-of-lch shall be set to the same value as the granted nb-of-lch. (8 bits)
start-pointer	M	Pointer to the position of the *Fixed Slot Allocation* in the MAC Frame (used in case of an FSA-RG). Same meaning and coding as for *Resource Grants.* Shall be set to 0 in case of an FSA-RR. (13 bits)
start-mac-frame	M	In case of an FSA-RG, start-mac-frame gives the exact MAC Frame to start FSA. In case of an FSA-RR start-mac-frame may contain an indicative value, when the WT wants its connection to be started. (16 bits)

The Transfer Syntax Tables of the concerned RLC PDUs are contained in TS 101 761-2 [2].

7.6.2 Multicast in DiL phase

The transfer syntax tables below display the structures of all messages used for Direct Link Multicast Connection Setup, Modify and Release.

7.6.2.1 RLC-DM-MC-SETUP encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	CL-ID							
Octet 7	EXT-	CL-ATTRIBUTE-LENGTH(L)					# of DUC:s	
Octet 8	# of DUC:s(N)		Future use					
Octet 9	DUC1-		DLCC-ID					
Octet 10	MIN-REQ-RECEIVERS							
	CL-CONN ATTR							
Octet Y	DUC1-FW-TYPE-OF-ALLOCATION			Future use	cyclic-prefix	FEC-USED	EC-MODE	
Octet...	DUC1-FW-NUM-OF-				Future	DUC1-FW-ARQ-WIN-SIZE		
	FEC-FW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINIMUM-NUM-OF-LCH							
Octet ...	Future use				PHY-MODE-LCH			
Octet ...	NB-OF-LCH							
Octet ...	MIN-NB-OF-LCH							
Octet ...	start-pointer							
Octet ...	start-pointer					Future use		
Octet ...	repetition-counter							
Octet ...	repetition-counter				frame-count			
Octet X	DUC1-BW-TYPE-OF-ALLOCATION			Future use	Cyclic-prefix	FEC-USED	EC-MODE	
Octet...	DUC1-BW-NUM-OF-				Future	DUC1-BW-ARQ-WIN-SIZE		
	FEC-BW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINIMUM-NUM-OF-LCH							
Octet ...	Future use				PHY-MODE-LCH			
Octet ...	NB-OF-LCH							
Octet ...	MIN-NB-OF-LCH							
Octet ...	start-pointer							
Octet ...	start-pointer					Future use		
Octet ...	repetition-counter							
Octet ...	repetition-counter				frame-count			
Octet ...	CL-COMMON-ATTR-LENGTH							
Octet ...	CL-COMMON-ATTR							
Octet ...								
Octet ...								
Octet ...	Not used							
Octet ...								
Octet 51								

Y = 10 + L

X = 10 + L + 6 if asymmetric duplex with FCA and ARQ or FEC.

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	identifies the multicast sender
min-req-receivers	M	number of receivers required to establish the multicast connection
cl-common-attr	M	common attributes concerning CL
cl-common-attr-length	M	giving the length of the cl-common-attr field, can be set to zero.

7.6.2.2 RLC-DM-MC-CONNECT encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	CL-ID							
Octet 7	Future use	CL-ATTRIBUTE-LENGTH(L)					# of DUC:s	
Octet 8	# of DUC:s(N)		Future use					
Octet 9	DUC1- DIRECTION		DLCC-ID					
	CL-CONN ATTR							
Octet Y	DUC1-FW-TYPE-OF-ALLOCATION			Future use	Cyclic-prefix	FEC-USED	EC-MODE	
Octet...	DUC1-FW-NUM-OF-RETRANSMISSIONS				Future use	DUC1-FW-ARQ-WIN-SIZE		
	FEC-FW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ SCH	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINUMUM-NUM-OF-LCH							
Octet ...	Future use				PHY-MODE-LCH			
Octet ...	NB-OF-LCH							
Octet ...	MIN-NB-OF-LCH							
Octet ...	start-pointer							
Octet ...	start-pointer					Future use		
Octet ...	repetition-counter							
Octet ...	repetition-counter				frame-count			
Octet X	DUC1-BW-TYPE-OF-ALLOCATION			Future use	cyclic-prefix	FEC-USED	EC-MODE	
Octet...	DUC1-BW-NUM-OF-RETRANSMISSIONS				Future use	DUC1-BW-ARQ-WIN-SIZE		
	FEC-BW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ SCH	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINUMUM-NUM-OF-LCH							
Octet ...	Future use				PHY-MODE-LCH			
Octet ...	NB-OF-LCH							
Octet ...	MIN-NB-OF-LCH							
Octet ...	start-pointer							
Octet ...	start-pointer					Future use		
Octet ...	repetition-counter							
Octet ...	repetition-counter				frame-count			
Octet...	Not used							
Octet...								
Octet 51								

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	identifies the multicast sender

7.6.2.3 RLC-DM-MC-CONNECT-ACK encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	CL-ID							
Octet 7	Future use	CL-CONN-ATTR-LENGTH (L)					# of DLCC:s+CL-ATTR	
Octet 8	# of DLCCs (N)		Future use					
Octet 9	Future use		DLCC-ID-1					
Octet …	CL-CONN-ATTR-1							
Octet …	Future use		DLCC-ID-N					
Octet …	CL-CONN-ATTR -N							
Octet 8+L*N								
Octet …	Not used							
Octet …								
Octet 51								

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	identifies the multicast sender

7.6.2.4 RLC-DM-MC-CONNECT-COMPLETE encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	Future use				# of DLCC:s (N)			
Octet 7	Future use		DLCC-ID -1					
Octet …	Future use		...					
Octet 5+N	Future use		DLCC-ID -N					
Octet 6+N	Not used							
Octet …								
Octet 51								

Semantics of parameters specifically used for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	identifies the multicast sender

7.6.2.5 RLC-DM-MC-CONNECT-COMPLETE-ACK encoding

	8	7	6	5	4	3	2	1
Octet 3				Future use				
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	Future use							
Octet 7								

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	identifies the multicast sender

7.6.2.6 RLC-DM-MC-MODIFY-REQ encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	Future use	CL-ATTRIBUTE-LENGTH(L)					# of DUC:s	
Octet 7	# of DUC:s(N)		Future use					
Octet 8	DUC1-DIRECTION		DLCC-ID					
	CL-CONN ATTR							
Octet Y	DUC1-FW-TYPE-OF-ALLOCATION			Future use	cyclic-prefix	FEC-USED	EC-MODE	
Octet...	DUC1-FW-NUM-OF-RETRANSMISSIONS				Future use	DUC1-FW-ARQ-WIN-SIZE		
	FEC-FW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ SCH	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINUMUM-NUM-OF-LCH							
Octet ...	Future use				PHY-MODE-LCH			
Octet ...	NB-OF-LCH							
Octet ...	MIN-NB-OF-LCH							
Octet ...	start-pointer							
Octet ...	start-pointer					Future use		
Octet ...	repetition-counter							
Octet ...	repetition-counter				frame-count			
Octet X	DUC1-BW-TYPE-OF-ALLOCATION			Future use	cyclic-prefix	FEC-USED	EC-MODE	
Octet...	DUC1-BW-NUM-OF-RETRANSMISSIONS				Future use	DUC1-BW-ARQ-WIN-SIZE		
	FEC-BW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ SCH	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINUMUM-NUM-OF-LCH							
Octet ...	Future use				PHY-MODE-LCH			
Octet ...	NB-OF-LCH							
Octet ...	MIN-NB-OF-LCH							
Octet ...	start-pointer							
Octet ...	start-pointer					Future use		
Octet ...	repetition-counter							
Octet ...	repetition-counter				frame-count			
Octet...	Not used							
Octet...								
Octet 51								

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	identifies the multicast sender

7.6.2.7 RLC-DM-MC-MODIFY encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	Future use	CL-ATTRIBUTE-LENGTH(L)					# of DUC:s	
Octet 7	# of DUC:s(N)		Future use					
Octet 8	DUC1-DIRECTION		DLCC-ID					
Octet 9	repetition-counter							
Octet 10	repetition-counter				frame-count			
	CL-CONN ATTR							
Octet Y	DUC1-FW-TYPE-OF-ALLOCATION			Future use	cyclic-prefix	FEC-USED	EC-MODE	
Octet...	DUC1-FW-NUM-OF-RETRANSMISSIONS				Future use	DUC1-FW-ARQ-WIN-SIZE		
	FEC-FW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ SCH	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINUMUM-NUM-OF-LCH							
Octet ...	Future use				PHY-MODE-LCH			
Octet ...	NB-OF-LCH							
Octet ...	MIN-NB-OF-LCH							
Octet ...	start-pointer							
Octet ...	start-pointer					Future use		
Octet ...	repetition-counter							
Octet ...	repetition-counter				frame-count			
Octet X	DUC1-BW-TYPE-OF-ALLOCATION			Future use	cyclic-prefix	FEC-USED	EC-MODE	
Octet...	DUC1-BW-NUM-OF-RETRANSMISSIONS				Future use	DUC1-BW-ARQ-WIN-SIZE		
	FEC-BW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ SCH	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINUMUM-NUM-OF-LCH							
Octet ...	Future use				PHY-MODE-LCH			
Octet ...	NB-OF-LCH							
Octet ...	MIN-NB-OF-LCH							
Octet ...	start-pointer							
Octet ...	start-pointer					Future use		
Octet ...	repetition-counter							
Octet ...	repetition-counter				frame-count			
Octet...	Not used							
Octet...								
Octet 51								

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	Identifies the multicast sender
repetition-counter	M	repetition of the value frame-count in BCCH
frame-count	M	The MAC frame number appearing in BCCH

7.6.2.8 RLC-DM-MC-MODIFY-ACK encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	CL-CONN-ATTR-LENGTH					# of DLCC:s+CL-CONN-ATTR		
Octet 7	# of DLCCs	Future use						
Octet 8	Future use		DLCC-ID-1					
Octet …	CL-CONN-ATTR-1							
…	Future use		DLCC-ID …					
…	CL-CONN-ATTR …							
…	Not used							
…								
Octet 51								

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	Identifies the multicast sender

7.6.2.9 RLC-DM-MC-RELEASE encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCE-MAC-ID							
Octet 6	CAUSE				# of DLCC:s			
Octet 7	Future use		DLCC-ID -1					
Octet 8	Future use		…					
Octet …	Future use		DLCC-ID N					
Octet …	Not used							
Octet…								
Octet 51								

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	identifies the multicast sender

7.6.2.10 RLC-DM-MC-RELEASE-ACK encoding

	8	7	6	5	4	3	2	1
Octet 4	PEER-MAC-ID							
Octet 5	SOURCEMAC-ID							
Octet 6	Future use				# of DLCC:s			
Octet 7	Future use		DLCC-ID-1					
Octet 8	Future use		…					
Octet …	Future use		DLCC-ID-N					
Octet …	Not used							
Octet…								
Octet 51								

Semantics of parameters specifically introduced for the DiL multicast case:

Parameter	O/M	Description
source-mac-id	M	identifies the multicast sender

7.7 Dynamic CC Selection

In each CC Probing Frame a CC-capable device in the CC Selection Process transmits a Probing Beacon with the structure of the usual BCCH and the following content:

Table 49: Contents of the CC Probing BCCH

Name	Length (bits)	Setting
Frame counter (scrambler seed)	4	as defined in basic DLC TS
NET-ID	10	0000000000
AP-ID	10	0000000000
Antenna ID	3	000
AP TX level	4	1111
AP RX UL level	3	000
Pointer to FCH	12	000000000000
Length FCH	4	0000
PHY Mode of FCH	2	00
Pointer to RCH	13	0000000000000
Length of RCH	5	00000
Guard space between RCH	2	00
DL RBCH indicator	1	0
DST (Data to sleeping terminals)	1	0
Uplink preamble	1	0
Version indicator	3	000
AP traffic load indicator	3	000
Maximum power indicator	1	1
# of antenna elements	3	000
Future use	14	any
CRC	24	as defined in 0
Total length	**120**	

The CC Probing BCCH is identified uniquely by 'Length of RCH' = 00000, which is not allowed in normal operation. All other fields shall be ignored on reception of a CC Probing BCCH.

7.8 CC Responsibility Handover

7.8.1 Encoding of CC Database Parameters for CC Handover

The H/2-HD specific parameters shall be encoded as in Table 50.

Table 50: Transfer Syntax Table of H/2-HD Specific Parameters (Content-field of an H/2-HD-DATA-BLOCK)

<table>
<tr><th></th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th></tr>
<tr><td>Octet 1</td><td colspan="8">mac-id</td></tr>
<tr><td>Octet 2</td><td colspan="8">dlc-version-selected</td></tr>
<tr><td>Octet 3</td><td colspan="8">rlc-version-selected</td></tr>
<tr><td>Octet 4</td><td>64-qam?</td><td>freq-band</td><td>dm-cap</td><td>support-fca</td><td>support-fsa</td><td colspan="3">nr-cl-vid (N)</td></tr>
<tr><td>Octet 5</td><td colspan="8">cl-id-1</td></tr>
<tr><td>Octet 6</td><td colspan="8">cl-version-1</td></tr>
<tr><td>...</td><td colspan="8">Other CL-ID and CL-Version</td></tr>
<tr><td>Octet 5+(2*N)</td><td>ho-cap</td><td>cc-ho-cap</td><td colspan="3">duty-cycle</td><td colspan="3">time-gap-ach-ul</td></tr>
<tr><td>Octet 6+(2*N)</td><td colspan="2">arq-delay-rx</td><td colspan="2">arq-delay-tx</td><td colspan="4">auth-selected</td></tr>
<tr><td>Octet 7+(2*N)</td><td colspan="4">encr-selected</td><td>cyclic prefix</td><td colspan="3">Future use</td></tr>
<tr><td>Octet 8+(2*N)</td><td colspan="2">dil-power-control</td><td colspan="3">rx-arq-win-size</td><td colspan="3">tx-arq-win-size</td></tr>
<tr><td>Octet 9+(2*N)</td><td colspan="6">length-of-measurement-DFS</td><td colspan="2">Future use</td></tr>
<tr><td>Octet 10+(2*N)</td><td colspan="8">sleep-interval</td></tr>
<tr><td>Octet 11+(2*N)</td><td colspan="5">cl-common-attr-length (M octets)</td><td colspan="3">Future use</td></tr>
<tr><td>...</td><td colspan="8" rowspan="2">cl-common-attr</td></tr>
<tr><td>Octet 11+(2*N)+M</td></tr>
<tr><td>Oct.12+(2*N)+M</td><td colspan="5">nr-mc-groups (L)</td><td colspan="3">Future use</td></tr>
<tr><td>...</td><td colspan="8">mac-id-1</td></tr>
<tr><td>Octet 12+(2*N)+M+L</td><td colspan="8">other-mac-ids</td></tr>
<tr><td>13+(2*N)+M+L</td><td>auth-id-pr?</td><td colspan="2">mt-auth-id-type</td><td colspan="5">Future use</td></tr>
<tr><td>...</td><td colspan="8" rowspan="2">mt-auth-id</td></tr>
<tr><td>Octet 19+(2*N)+M`+L or 21+(2*N)+M+L or 59+(2*N)+M+L or 105+(2*N)+M+L</td></tr>
<tr><td>Octet 1</td><td colspan="8">mac-id</td></tr>
<tr><td>Octet 2</td><td colspan="8">dlc-version</td></tr>
<tr><td>Octet 3</td><td colspan="8">rlc-version</td></tr>
<tr><td>Octet 4</td><td colspan="5">Future use</td><td colspan="3">nr-cl-vid (N)</td></tr>
<tr><td>Octet 5</td><td colspan="8">cl-id-1</td></tr>
<tr><td>Octet 6</td><td colspan="8">cl-version-1</td></tr>
<tr><td>...</td><td colspan="8">Other CL-ID and CL-Version</td></tr>
<tr><td>Octet 5+(2*N)</td><td>64-qam?</td><td>dm-cap</td><td>dm-use-key</td><td>polling?</td><td>fsa?</td><td colspan="3">time-gap-ach-ul</td></tr>
<tr><td>Octet 6+(2*N)</td><td colspan="2">arq-delay-rx</td><td colspan="2">arq-delay-tx</td><td colspan="4">auth-selected</td></tr>
<tr><td>Octet 7+(2*N)</td><td colspan="4">encr-selected</td><td colspan="4">Future use</td></tr>
<tr><td>Octet 8+(2*N)</td><td colspan="2">dil-power-control</td><td colspan="3">rx-arq-win-size</td><td colspan="3">tx-arq-win-size</td></tr>
<tr><td>Octet 9+(2*N)</td><td colspan="6">length-of-measurement-DFS</td><td colspan="2">Future use</td></tr>
<tr><td>Octet 10+(2*N)</td><td colspan="8">sleep-interval</td></tr>
<tr><td>Octet 11+(2*N)</td><td colspan="5">cl-common-attr-length (M octets)</td><td colspan="3">Future use</td></tr>
</table>

	8	7	6	5	4	3	2	1
...	cl-common-attr							
Octet 11+(2*N)+M								
Oct.12+(2*N)+M	nr-mc-groups (L)					Future use		
...	mac-id-1							
Octet 12+(2*N)+M+L	other-mac-ids							
13+(2*N)+M+L	mt-id-pr?	auth-id-pr?	mt-auth-id-type		Future use			
...	mt-id							
Octet 45+(2*N)+M								
...	mt-auth-id							
Octet 51+(2*N)+M or 53+(2*N)+M or 92+(2*N)+M								

The optional parameter mt-auth-id is transmitted at the end of the H/2-HD specific field. A flag auth-id-pr indicates whether MT-AUTH-ID is present or not.

The total length of the H/2-HD specific field depends on the number N of CLs present within the H/2-HD (**nr-cl-vid**), the length M of the **cl-common-attr** field, the number of multicast groups L the H/2-HD is participating in (**nr-mc-groups**) as well as the presence and the type of the MT-AUTH-ID (**auth-id-pr** and **mt-auth-id-type**). The H/2-HD specific field may not fit into one PDU (always a maximum of 48 octets available).

For this reason the transmission as byte string has been foreseen for the parameter transfer (see clause 6.8.2). The transmitted byte string consists of data blocks. Two types of data blocks are distinguished: **H/2-HD-DATA-BLOCK** and **CONN-DATA-BLOCK**. A data block consists of a **type-field**, a **length-field** and a **content-field**. An H/2-HD-DATA-BLOCK contains the information relevant to one H/2-HD. The content-field follows the structure in Table 50 in case of an H/2-HD-DATA-BLOCK. The length-field is to indicate the variable length of the content-field, which varies from 13 to 170 octets in case of an H/2-HD-DATA-BLOCK. The length-field is to indicate the variable length of the content-field in number of octets. The length-field has itself a length of 8 bits. The type-field is also 8 bits long. Only the last bit is to distinguish between the two types of data blocks (0 for H/2-HD-DATA-BLOCK, 1 for CONN-DATA-BLOCK), the other bits are for future use. Table 51 illustrates the structure of a data block.

Table 51: General Structure of a Data Block

	8	7	6	5	4	3	2	1
Octet 1	type-field							
Octet 2	length-field							
Octet 3	content-field							
...								

The content-field of a CONN-DATA-BLOCK, which contains the parameters of one unicast or multicast DM connection, shall be encoded like shown in Table 52.

Table 52: Transfer Syntax Table of DiL Connection Specific Parameters (Content-field of a CONN-DATA-BLOCK)

	8	7	6	5	4	3	2	1
Octet 1	first-mac-id							
Octet 2	second-mac-id							
Octet 3	cl-id							
Octet 4	dlcc-id						direction DIRECTION	
Octet 5	cl-conn-attr-length					Future use		
Octet 5+M	cl-conn-attr							
Octet Y	DUC-FW-TYPE-OF-ALLOCATION			Future use	cyclic-prefix	FEC-USED	ec-mode	
Octet...	DUC-FW-NUM-OF-RETRANSMISSIONS				Future use	DUC-FW-ARQ-WIN-SIZE		
	FEC-FW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ SCH	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINUMUM-NUM-OF-LCH							
Octet X	DUC-BW-TYPE-OF-ALLOCATION			Future use	cyclic-prefix	FEC-USED	ec-mode	
Octet...	DUC-BW-NUM-OF-RETRANSMISSIONS				Future use	DUC-BW-ARQ-WIN-SIZE		
	FEC-BW				Future Use			
Octet...	PER-#-MAC-FRAME(SCH)				PER-#-MAC-FRAME(LCH)			
Octet...	REQ SCH	PHY-MODE-SCH			PHY-MODE-LCH			
Octet...	REQUESTED-NUM-OF-LCH							
Octet...	MINUMUM-NUM-OF-LCH							

The total length of the DiL connection specific field depends on many parameters like the length of the **cl-common-attr** field, the presence of the **forward-descriptor** respectively **backward-descriptor**, the **fec-used** bit (green octet may not be present) and the **ec-mode** (blue octets may not be present). The maximum length of the content-field can be 50 octets. The CONN-DATA-BLOCK follows the general structure of a data block in Table 51.

H/2-HD-DATA-BLOCKS and CONN-DATA-BLOCKS are concatenated to form the byte string that is transmitted as payload of the RLC_TRANS_CC_DATA PDUs. First the H/2-HD-DATA-BLOCKS of all HDs shall be transmitted followed by the CONN-DATA-BLOCKS of all DM connections.

NOTE: A data block is segmented if its length exceeds the length of the payload field of an RLC LCH PDU (48 octets). By concatenating all received payload fields within (the memory of) the receiver, automatic reassembling can be performed.

7.8.2 Transfer Syntax Tables of CC Handover PDUs

As shown in Table 53 no parameters are included in the RLC_CC_HO_REQUEST, RLC_CC_HO_REQUEST_ACK, RLC_CC_HO_NOTIFY, RLC_START_CC_ACK and RLC_CC_START_OPERATION.

Table 53: RLC_CC_HO_REQUEST, RLC_CC_HO_REQUEST_ACK, RLC_CC_HO_NOTIFY, RLC_START_CC_ACK and RLC_CC_START_OPERATION encoding

	8	7	6	5	4	3	2	1
Octet 3				Not used				
Octet 4	Not used							
Octet 5								
Octet 6								
Octet 7								

The RLC_TRANS_CC_DATA PDU is encoded like illustrated in Table 54. In the transfer syntax table the whole PDU is shown including parts defined in TS 101 761-1 [1] and TS 101 761-2 [2]. The reason is that the Sequence Number field defined in TS 101 761-1 [1] is used for the Go-Back-n ARQ mechanism (see clause 6.8.3). During one CC Handover, the Sequence Number is incremented by 1 (modulo 1024) with each transmitted RLC_TRANS_CC_DATA PDU (and starting with 0). The purpose of the EXT-IND field is to indicate if the PDU is the last RLC_TRANS_CC_DATA PDU transmitted in this CC Handover. For all previous PDUs the field is set to 0. The byte string contains the H/2-HD-DATA-BLOCKs and CONN-DATA-BLOCKs the purpose and encoding of which has been explained in clause 7.7.1.

Table 54: RLC_TRANS_CC_DATA encoding

	8	7	6	5	4	3	2	1
Octet 1	lch-pdu-type		sequence-number					
Octet 2	sequence-number				Future use			
Octet 3	rlc-pdu-type							
Octet 4	ext-ind	Future use						
Octet 5	Byte-String (containing **H/2-HD-DATA-BLOCKs** and **CONN-DATA-BLOCKs)**							
Octet 6								
Octet...								
Octet...								
Octet...								
Octet …								
Octet …								
Octet 51								
Octet 52	CRC-24							
Octet 53								
Octet 54								

A certain number of RLC_TRANS_CC_DATA PDUs is acknowledged by one RLC_TRANS_CC_DATA_ACK PDU by the receiver. The receiver shall send at least one RLC_TRANS_CC_DATA_ACK PDU per frame (if there are RLC_TRANS_CC_DATA PDUs that have not yet been acknowledged). The RLC_TRANS_CC_DATA_ACK PDU contains the Sequence number of the RLC_TRANS_CC_DATA PDU that is expected next (see Table 55). The *error* bit indicates whether the sender (CC) shall re-send RLC_TRANS_CC_DATA PDUs from the contained Sequence number on. In case the *error* bit has the value 0, the sender shall take no action.

Table 55: RLC_TRANS_CC_DATA_ACK encoding

	8	7	6	5	4	3	2	1
Octet 3				sequence-number BROADCAST ?				
Octet 4	sequence-number					rr-flag	Future use	
Octet 5	not used							
Octet 6								
Octet 7								

The RLC_START_CC PDU contains the start-mac-frame parameter, which determines the start time for the new CC to take over CC responsibility (Table 56).

Table 56: RLC_START_CC encoding

	8	7	6	5	4	3	2	1
Octet 3				Future use				
Octet 4	Repetition-counter							
Octet 5	Repetition-counter				Frame-count			
Octet 6	Not used							
Octet 7								

7.9 Authentication Key Management

The transfer syntax table of the RLC_AUTHENTICATION_KEY_REQUEST is defined in Table 57.

Table 57: RLC_AUTHENTICATION_KEY_REQUEST encoding

	8	7	6	5	4	3	2	1
Octet 4	mt-id-number-length						Future use	
Octet 5	mt-id-number							
Octet 6								
Octet...								
Octet...								
Octet...								
Octet …	Not used							
Octet …								
Octet 51								

Semantics:

Parameter	O/M	Description
MT-ID-NUMBER-LENGTH	M	6 bits to indicate the length of the MT-ID-NUMBER in number of octets.
MT-ID-NUMBER	M	Some Identifier of the WT.

No parameters are included in the RLC_AUTHENTICATION_KEY_REQUEST_ACK PDU (see Table 58).

Table 58: RLC_AUTHENTICATION_KEY_REQUEST_ACK encoding

	8	7	6	5	4	3	2	1
Octet 3				Not used				
Octet 4								
Octet 5								
Octet 6								
Octet 7								

Table 57 shows the encoding of the RLC_AUTHENTICATION_KEY_TRANSFER PDU.

Table 59: RLC_AUTHENTICATION_KEY_TRANSFER encoding

	8	7	6	5	4	3	2	1
Octet 4	Valid-key	Auth-key-length						Future Use
Octet 5	Pin-code-length						Future use Future use	
Octet 6	Auth-key							
Octet...								
Octet...	Pin-code							
Octet...								
Octet …	Not used							
Octet …								
Octet 51								

Semantics:

Parameter	O/M	Description
VALID-KEY	M	1 bits that equals 1 if the key is valid.
AUTH-KEY-LENGTH	M	Length of the AUTHENTICATION KEY in number of octets (6 bits).
PIN-CODE-LENGTH	M	Length of the PIN code of the subnet in number of octets (6 bits).
AUTH-KEY	M	Common AUTHENTICATION-KEY of the subnet. The length of the field can vary from 0 to 46 octets.
PIN-CODE	M	PIN code of the network in binary format, encoded with the Secret Session Key (SSK). The length of the field can vary from 0 to 23 octets.

RLC_AUTHENTICATION_KEY_TRANFER_ACK is defined in Table 60.

Table 60: RLC_AUTHENTICATION_KEY_TRANSFER_ACK encoding

	8	7	6	5	4	3	2	1
	Valid-key	Future use						
Octet 4	md5-of-auth-key							
Octet 5								
Octet 6								
Octet...								
Octet 19								
Octet 20	Not used							
Octet …								
Octet …								
Octet 51								

Semantics:

Parameter	O/M	Description
VALID-KEY	M	1 bits that equals 1 if the key is valid.
MD5-OF-AUTH-KEY	M	Hash value of the AUTH-KEY, generated with the MD5 algorithm

8 Service Primitives

The following clauses define the service primitives exchanged between the RLC and CL layers within an H/2-HD. The additions to the RLC basic specification (TS 101 761-2 [2]) which are needed to meet the home environment requirements are documented.

8.1 Primitive types

Four primitive types may be used:

- req (request), for a higher layer to request service from a lower layer;
- cnf (confirm), for the layer providing the service to confirm that the activity has been completed;
- ind (indication), for a layer providing a service to notify the next higher layer of any specific service related activity;
- rsp (response), for a layer to acknowledge receipt of an indication primitive from the next lower layer.

The defined types for each category of primitive are shown as a list in curly brackets.

NOTE: These primitives are defined only for the purpose of describing layer-to-layer interactions. The primitives are defined as an abstract list of parameters, and their concrete realization may vary between implementations. No formal testing of primitives is intended. The following primitive definitions have no normative significance.

8.2 Common DLC C-SAP Primitives to Convergence Layer

This clause summarizes the common primitives between the convergence layer and the RLC layer whose realization is required for any supported CL.

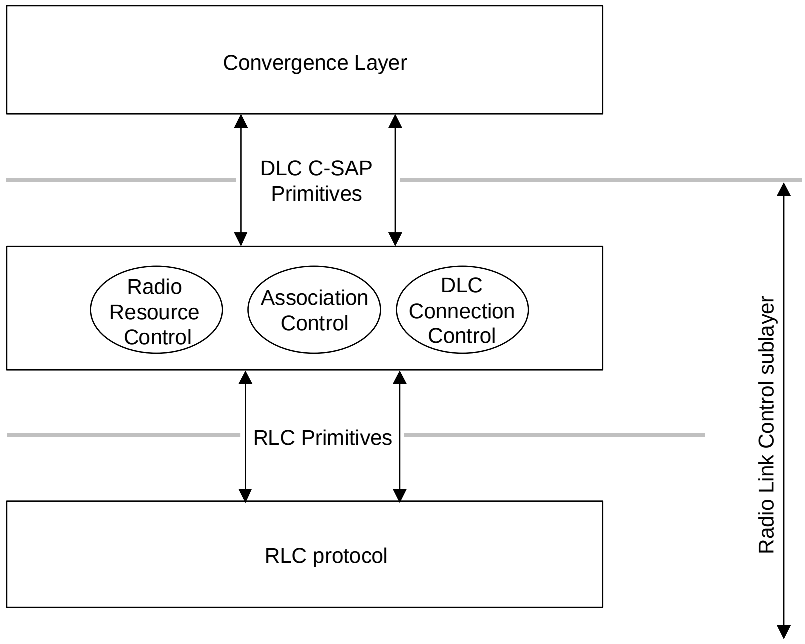

Figure 33: Reference Model of protocol primitives

The common primitives at the DLC C-SAP have a correspondence to a subset of the RLC primitives defined in TS 101 761-2 [2] and in the present document. The parameters used in the common primitives at the DLC C-SAP are equal to or a subset of the RLC parameters defined there.

One DLC C-SAP common primitive may correspond to one of possibly several RLC primitives. It is the task of the RLC functions to control the relation between DLC C-SAP primitives and the RLC primitives. The RLC functions invoke the RLC primitives with appropriate parameters. (E.g. a request from the CL to set up 8 connections may result in 2 subsequent connection setup sequences at the RLC level, each setting up 4 connections).

At the CC the MAC ID is used to distinguish between different RLC instances. Each CC-capable WT therefore has to support different RLC instances. A basic WT, however, only needs one RLC.

Realization of the following common DLC C-SAP primitives with their corresponding RLC primitives is necessary for all H/2-HDs.

Table 61: DLC and corresponding RLC primitives

DLC C-SAP primitive	RLC primitive
DLC_Setup - { req, ind };	DUC_SETUP - { req, ind }; DM_SETUP - { req, ind };
DLC_CONNECT - { req, cnf, ind, rsp };	DUC_CONN - { req, cnf, ind, rsp }; DM_CONN - { req, cnf, ind, rsp };
DLC_RELEASE - { req, cnf, ind, rsp };	DUC_RELEASE - { req, cnf, ind, rsp }; DM_RELEASE - { req, cnf, ind, rsp };
DLC_MODIFY - { req, cnf, ind, rsp };	DUC_MODIFY - { req, cnf, ind, rsp }; DM_MODIFY - { req, cnf, ind, rsp };
DLC_MULTICAST_JOIN - { req, cnf, ind, rsp };	ACF_GROUP_JOIN - { req, cnf, ind, rsp };
DLC_MULTICAST_LEAVE - { req, ind };	ACF_GROUP_LEAVE - { req, cnf, ind, rsp };
DLC_MULTICAST_CONNECT - { req, cnf, ind, rsp };	DM_Multicast CONN - { req, cnf, ind, rsp };
DLC_MULTICAST_RELEASE - { req, cnf, ind, rsp };	DM_Multicast RELEASE - { req, cnf, ind, rsp };
DLC_MULTICAST_MODIFY - { req, cnf, ind, rsp };	DM_Multicast MODIFY - { req, cnf, ind, rsp };
DLC_CL_BROADCAST_JOIN - { req, cnf, ind, rsp };	ACF_CL_BROADCAST_JOIN - {req, cnf, ind, rsp};
DLC_INFO_TRANSFER - { req, cnf, ind, rsp };	ACF_INFO - { req, cnf, ind, rsp };
CCH_start_cl_ho – { ind, rsp };	CCH_start_cl_ho – { ind, rsp };
CCH_start_cc – {ind, rsp};	CCH_start_cc – {ind, rsp};
NOTE: One DLC C-SAP primitive may correspond to one of possibly several RLC primitives. It is the task of the RLC functions (ACF and DCC) to control the relation between DLC C-SAP primitives and the RLC primitives. The RLC functions invoke the RLC primitives with appropriate parameters.	

8.3 Special DLC-C SAP Primitives to 1394 Convergence Layer

If the 1394 CL is to be supported by the H/2 DLC home extension, the following 1394 CL specific DLC C-SAP primitives shall be realized in the concerned H/2-HDs. These two 1394-specific primitives are defined to imply that some special H/2 DLC services shall be provided to the 1394 CL locally in an H/2-HD. There is no peer-to-peer RLC message associated with them.

1394 CL-specific DLC C-SAP primitive
DLC_MAC_FRAME_START - { ind};
DLC_MAC_FRAME_NUMBER { ind};

The realization of DLC_MAC_FRAME_START is necessary to enable 1394 Cycle Clock propagation from a WCM (Wireless Cycle Master) to all other H/2-HDs, where the WCM can be any H/2-HD in the subnet.

DLC_MAC_FRAME_START shall realize a time reference event, which shall be generated as a hardware impulse at the end of the 16 µs broadcast burst preamble TS 101 475 [3]. The processing delay between the assertion of this impulse to the 1394 CL and the end of the broadcast burst preamble shall be a constant, which is known to the 1394 CL. After a calibration of the processing delay, DLC_MAC_FRAME_START is used as a reference event to trigger all H/2-HDs supporting 1394 CL to read and store the local 1394 CTR (Cycle Time Register) value at the same time. The stored 1394 CTR value will be compared to that of the WCM, which is multicast in a LCH by the WCM to all other H/2 based 1394 devices in each MAC frame, in order to correct the deviation to the WCM CTR (TS 101 493-3 and TS 101 493-4 see Bibliography)).

NOTE: DLC_MAC_FRAME_START could be directly realized by a HW signal from the PHY layer.

DLC_MAC_FRAME_NUMBER primitive contains the current MAC frame counter value obtained from the BCCH. It shall be sent to the IEEE 1394 CL in a way, that the current MAC frame counter value is available in the IEEE 1394 CL not later than the end of the FCCH phase. The current MAC frame counter value will be included into the CTR adjustment protocol PDU in TS 101 493-3 and TS 101 493-4 (see Bibliography).

Annex A (normative): PDU Types

The basic WT and CC-capable columns indicate, whether the PDU is Mandatory or Optional to implement in basic WTs or CC-capable H/2-HDs. The PDU can be mandatory for both the sender and the receiver or the other peer only. If a PDU is mandatory for the sender, the sender shall be able to encode the PDU and send it at the correct time according to the present document. If the PDU is mandatory for the receiver, it shall be able to decode the PDU and perform the requested actions according to the present document. If the PDU is optional, the sender may not be able to encode or use it. If the PDU is optional the receiver may not be able to decode the PDU, but the receiver shall be able to send the corresponding RLC_NO_SUPPORT message TS 101 761-2 [2].

Table A.1: HE LCH PDU messages

LCH PDU type	RLC message name	Basic WT	CC-capable
(0000 0001) 1	RLC_CALIBRATION_REPORT	M	M
2	RLC_DM_MC_SETUP	O	M
3	RLC_DM_MC_CONNECT	O	M
4	RLC_DM_MC_CONNECT_ACK	O	M
5	RLC_DM_MC_CONNECT_COMPLETE	O	M
6	RLC_ DM_MC_CONNECT_COMPLETE_ACK	O	M
7	RLC_DM_MC_RELEASE	O	M
8	RLC_ DM_MC_RELEASE_ACK	O	M
9	RLC_DM_MC_MODIFY	O	M
10	RLC_DM_MC_MODIFY_ACK	O	M
11	RLC_TRANS_CC_DATA	-	O
12	RLC_AUTHENTICATION_KEY_REQUEST	M	M
13	RLC_AUTHENTICATION_KEY_TRANSFER	M	M

Table A.2: HE SCH PDU messages

SCH PDU type	RLC message name	Basic WT	CC-capable
(0000 0001) 1	RLC_DM_POWER_CONTROL	M	M
2	RLC_CALIBRATION_MEASUREMENT_TRIGGER	M	M
3	RLC_ CALIBRATION_MEASUREMENT	M	M
4	RLC_CALIBRATION_REPORT_TRIGGER	M	M
5	RLC_SHORT_CALIBRATION_REPORT	M	M
6	RLC_CALIBRATION_LINKQUALITYMAP_REQUEST	M	M
7	RLC_ CALIBRATION_LINKQUALITYMAP	M	M
8	RLC_CC_HO_REQUEST	-	O
9	RLC_CC_HO_REQUEST_ACK	-	O
10	RLC_CC_HO_NOTIFY	M	M
11	RLC_TRANS_CC_DATA_ACK	-	O
12	RLC_START_CC	-	O
13	RLC_START_CC_ACK	-	O
14	RLC_CC_START_OPERATION	M	M
15	RLC_AUTHENTICATION_KEY_REQUEST_ACK	M	M
16	RLC_AUTHENTICATION_KEY_TRANSFER_ACK	M	M

Annex B (normative): Parameter Types

Table B.1: Parameter Types

WT-TX-LEVEL::= TX-LEVEL	
ADJUST-TX::= ENUMERATED{ no-adjust (0), m3dbm (1), m6dbm (2), m9dbm (3), m12dbm (4), m15dbm (5), m18dbm (6), m21dbm (7), p3dbm (9), p6db (10), p9dbm (11), p12dbm (12), p15dbm (13), p18dbm (14), p21dbm (15) }	
AGE-OF-RSS::= ENUMERATED { last100ms (0), last250ms (1), last500ms (2), last1000ms (3) }	
AUTH-KEY::= OCTET STRING(SIZE(0..46))	
AUTH-KEY-LENGTH::= INTEGER(0..46)	
CAL-REPORT::= SEQUENCE { mac-id MAC-ID, rss2-value RSS2-VALUE }	
CAL-REPORT-LIST::= SEQUENCE (SIZE(0..23)) OF CAL-REPORT	
COMPLETE-REPORT::= SEQUENCE { mac-id MAC-ID, rss-report-list RSS-REPORT-LIST }	
COMPLETE-REPORT-LIST::= SEQUENCE OF COMPLETE-REPORT	
DATA::= OCTET STRING (SIZE(0..47))	
DM-DUC-TYPE::= ENUMERATED { unicast (0), mutli-broadcast (1) }	description
EXT-IND::= ENUMERATED{ data-end (0), data-continue (1)}	
MAC-IDS::= SEQUENCE (SIZE(0..3)) OF MAC-ID	
MAP-EXT-IND::= ENUMERATED{ map-end (0), map-continue (1)}	
MT-ID-NUMBER-LENGTH::=INTEGER(1..32)	
PIN-CODE::= OCTET STRING(SIZE(0..23))	
PIN-CODE-LENGTH::= INTEGER(0..23)	
REP-BUF-STATUS::= ENUMERATED { reports-transmitted (0), reports-in-buffer (1) }	description

WT-TX-LEVEL::= TX-LEVEL	
REQUEST-TYPE::= ENUMERATED { whole-map (0), mac-id-map (1) }	
RR-FLAG::= ENUMERATED { receive-not-ready (0), receive-ready (1) }	
RSS2-VALUE ::= INTEGER(0..63)	
RSS-REPORT::= SEQUENCE { mac-id MAC-ID, age-of-rss AGE-OF-RSS, rss2-value RSS2-VALUE }	
RSS-REPORT-LIST::= SEQUENCE OF RSS-REPORT	
SEQUENCE-NUMBER::= INTEGER(0..1024)	
TRIGGER-TYPE::= ENUMERATED { all-wts (0), one-wt (1), one-wt (2), one-wt (3) }	2 bits that indicate if one, two, three or all WTs are triggered: 00 → All WTs are triggered (no MAC-ID included) 01 → One WT is triggered 10 → Two WTs are triggered 11 → Three WTs are triggered
VALID-KEY::= ENUMERATED{ key-not-valid (0), key-valid (1)}	

Annex C (normative): RLC TIMERS

Management of RLC timers is described in TS 101 761-2 [2]. There are three different timers:

- T_short;
- T_medium;
- T_long.

The following new timers are defined in the present document:

Table C.1: H/2-HD Timers

H/2-HD	Value
T_dm_mc_setup_wt	T_short
T_dm_mc_connect_wt	T_short
T_dm_mc_modify_req_wt	T_short
T_dm_mc_release_wt	T_short
T_dm_mc_power_control	T_long
T_dm_mc_setup_cc	T_short
T_dm_mc_connect_cc	T_short
T_dm_mc_connect_cmpt_cc	T_short
T_dm_mc_modify_cc	T_short
T_dm_mc_release_cc	T_short
T_cc_ho_request_cc	T_short
T_trans_cc_data_cc	6 msec
T_start_cc_cc	T_short
T_dm_mc_connect_ack_wt	$4^{max\_setup\_time}$ frames
T_trigger_lifetime	50 msec

Annex D (informative): Informative SDL FSMs concerning Power Control

NOTE: The assumption in the model below is that the connection setup procedure between two WTs is split into connection setup between the CC and the first WT (WT1), and connection setup between the CC and the second WT (WT2). Only the connection setup with the second WT is represented since it does not depend on whether the connection was CC_initiated or WT_initated.

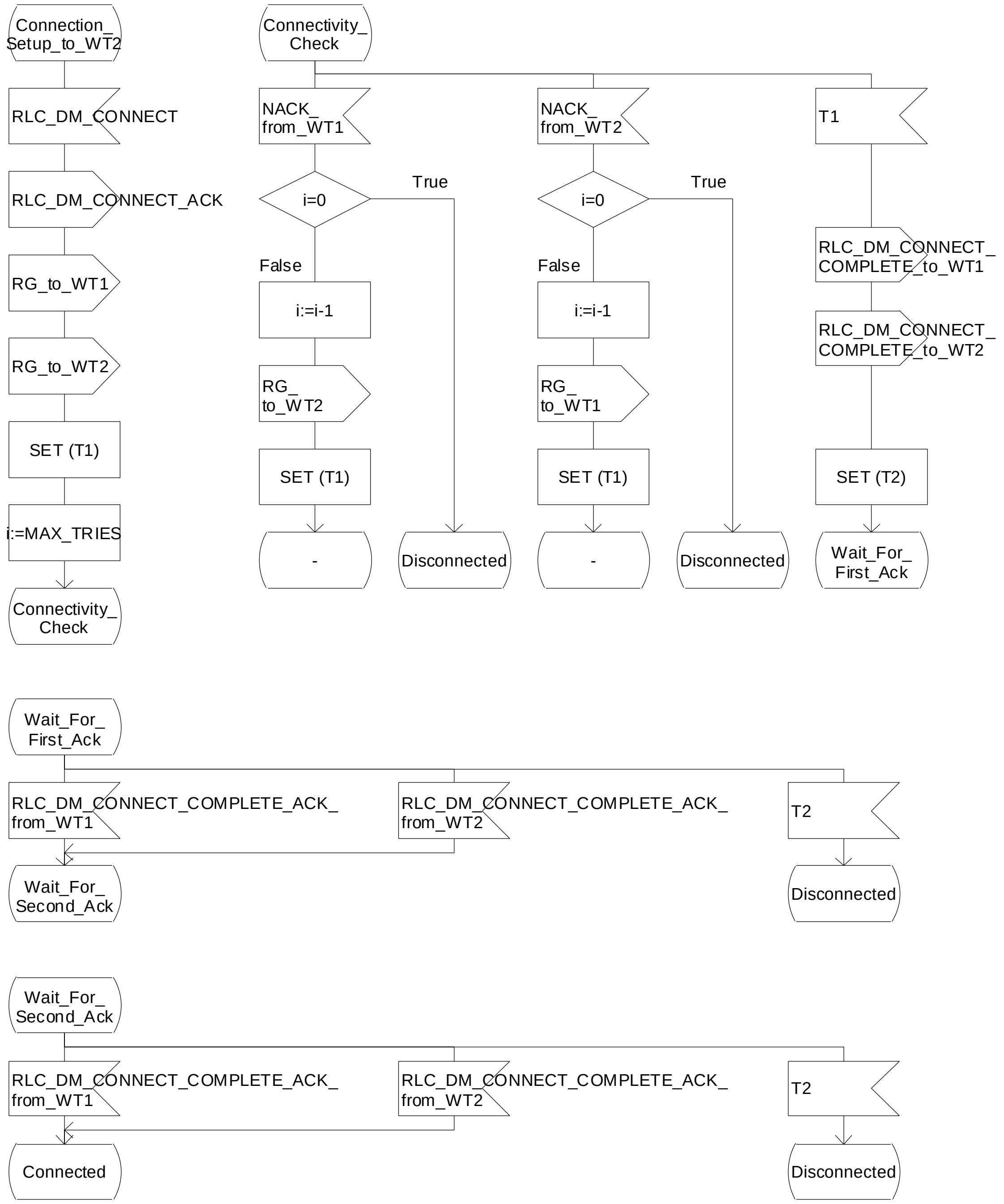

Figure D.1: Power Control – Connectivity Check – CC side

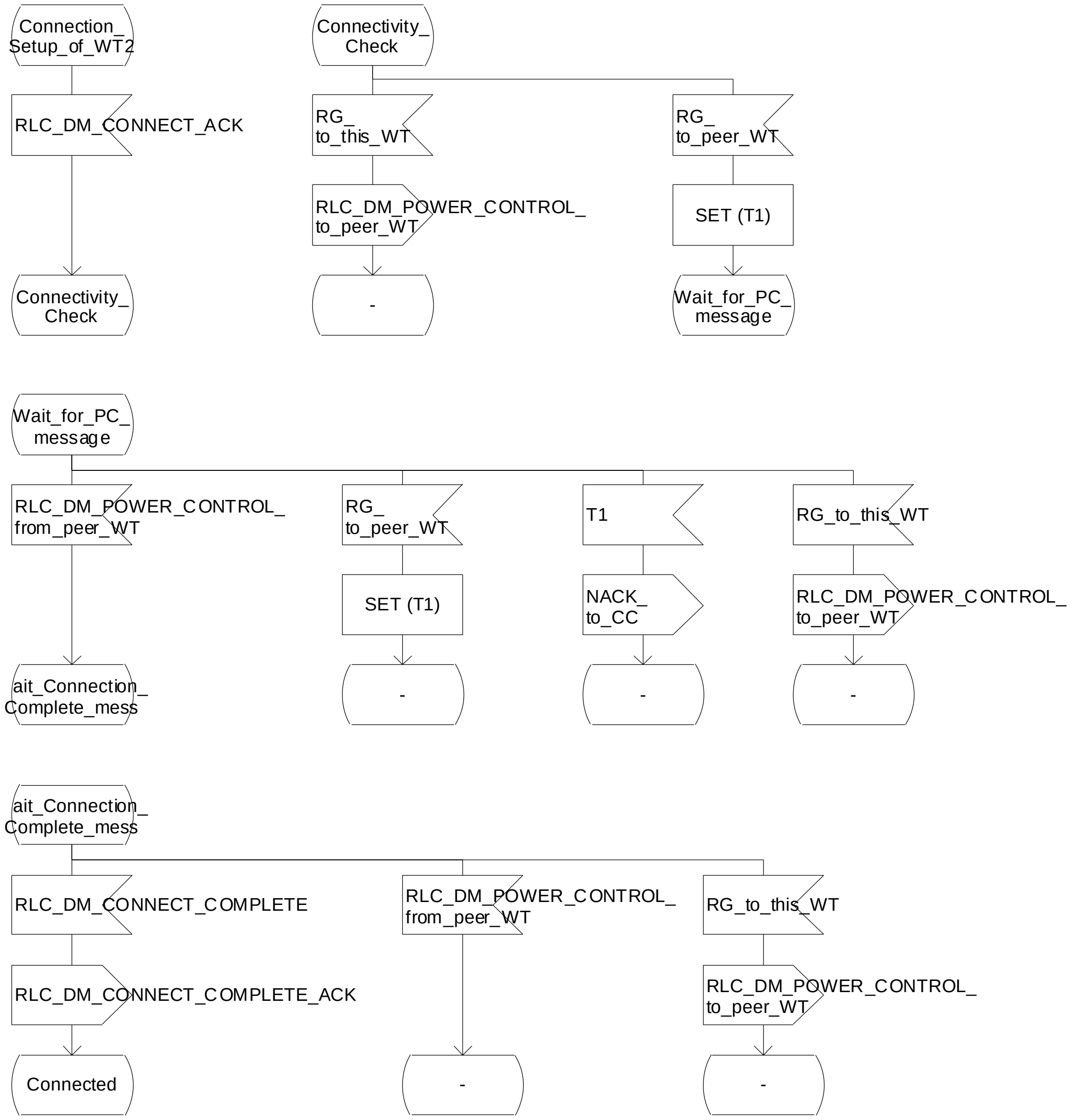

Figure D.2: Power Control – Connectivity Check – WT side

Annex E (informative): SDL FSMs concerning Calibration

NOTE: The following FSMs are only informative. Their aim is to explain the basic idea of how calibration and power control work, rather than to give algorithms ready to be implemented.

Calibration – CC side

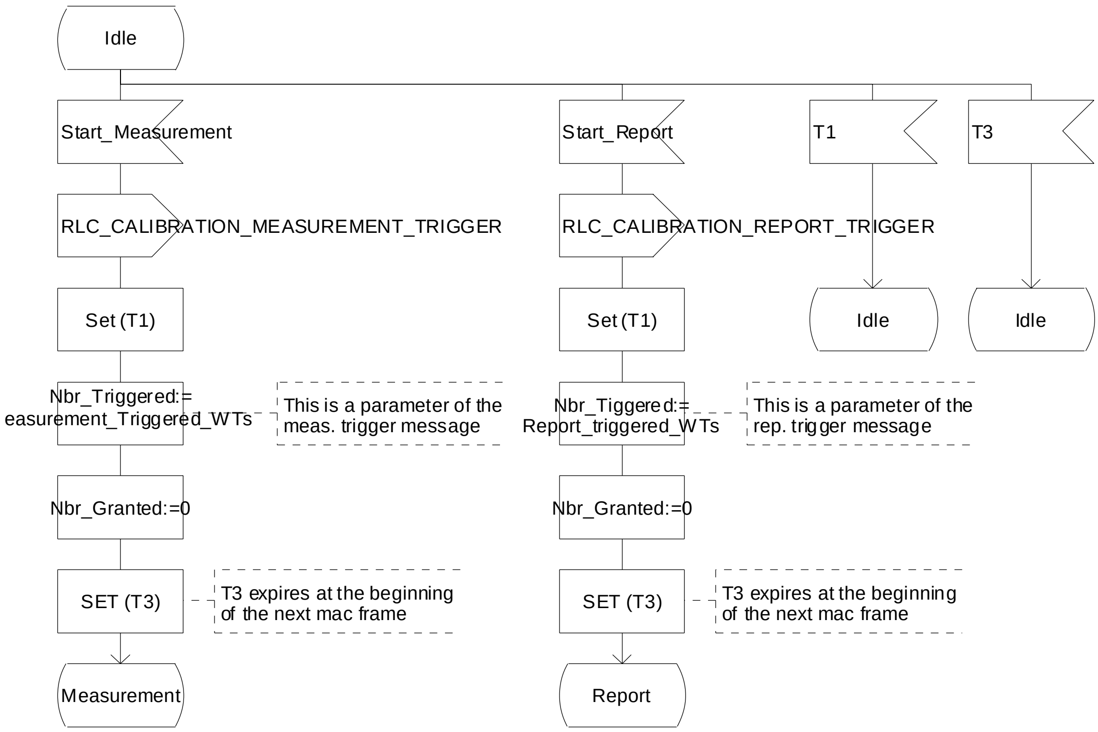

Figure E.1: Calibration CC side – page 1

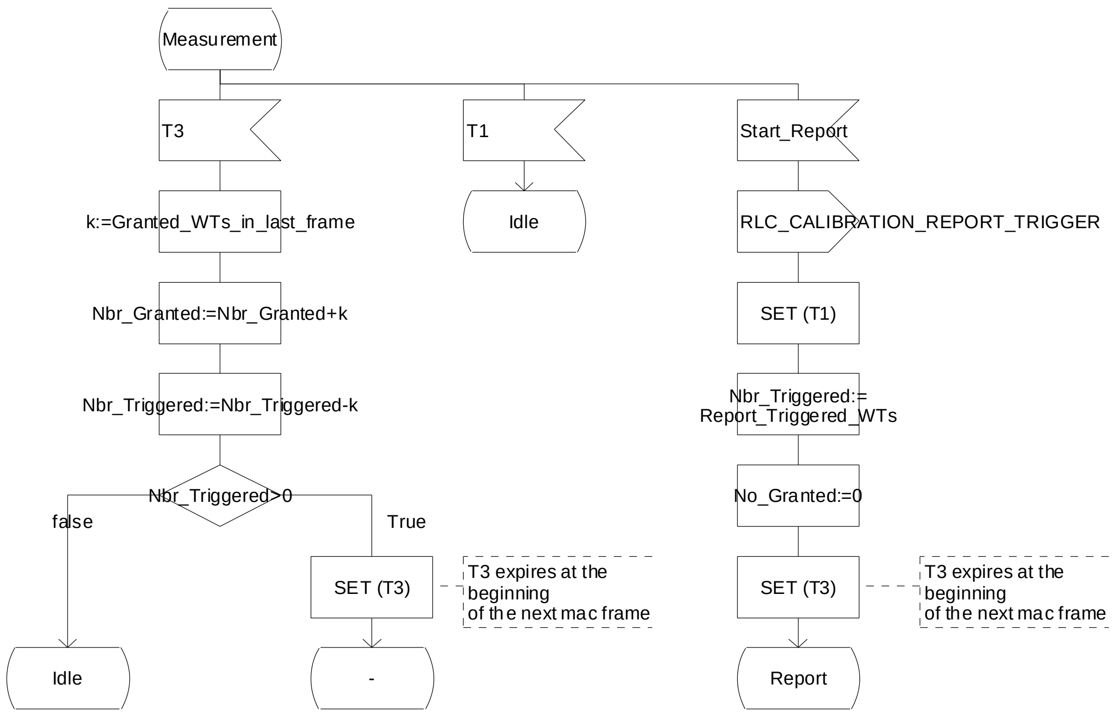

Figure E.2: Calibration CC side – page 2

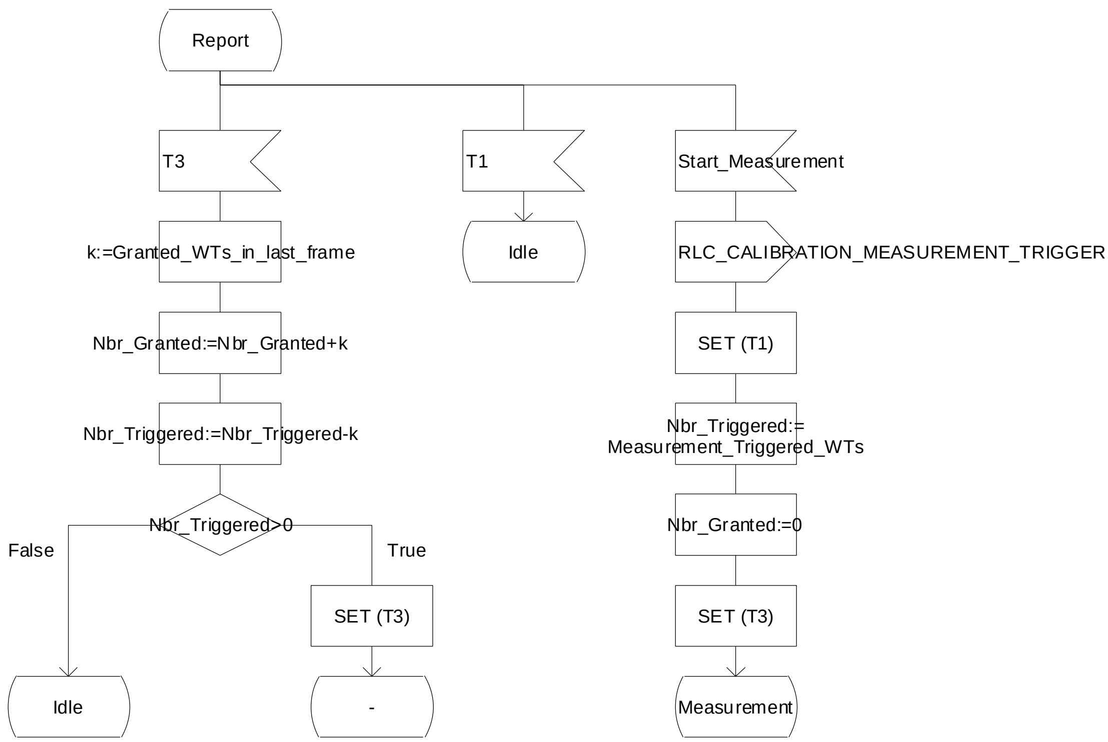

Figure E.3: Calibration CC side – page 3

Calibration – WT side

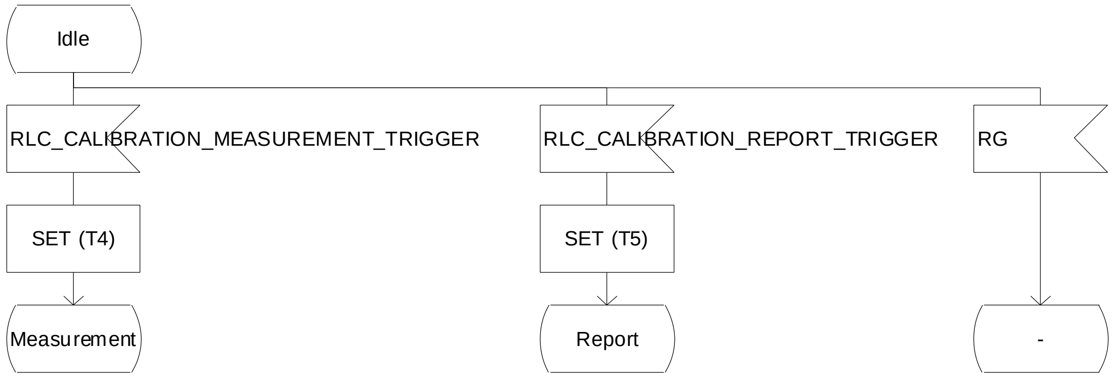

Figure E.4: Calibration WT side – page 1

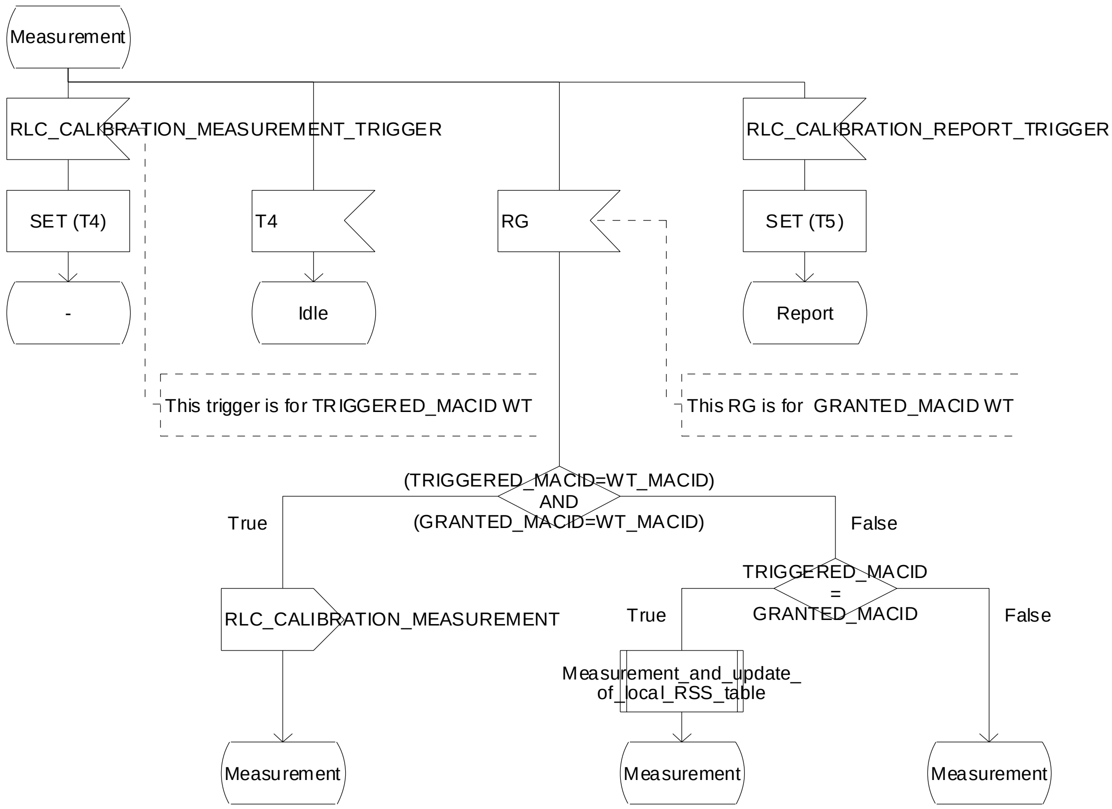

Figure E.5: Calibration WT side – page 2

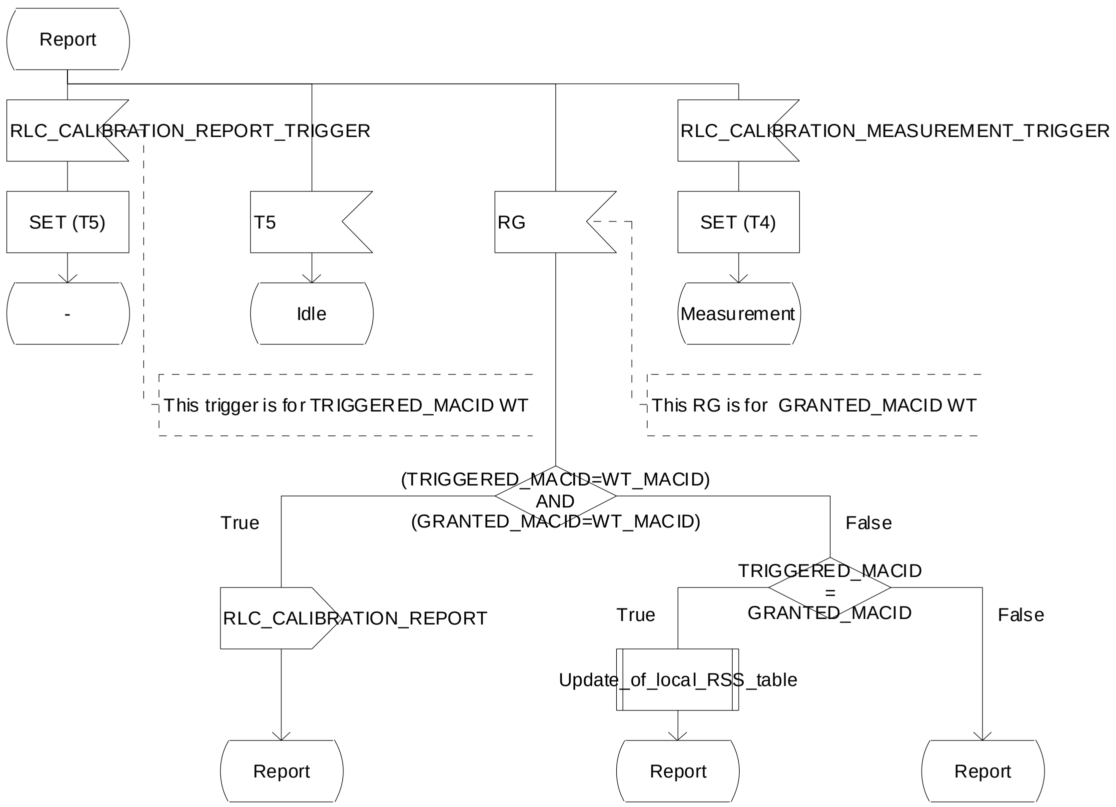

Figure E.6: Calibration WT side – page 3

Annex F (informative): Specification of the CC Probing Process in SDL

The dynamic CC Selection has to prevent different CC-capable devices from becoming CC at the same time. The collision resolution mechanism is realized by the CC Probing and Frequency Scan processes that are defined in clause 6.7. Both processes are described by a SDL specification, which is depicted in Figure F.1 to Figure F.4 and documented within this annex.

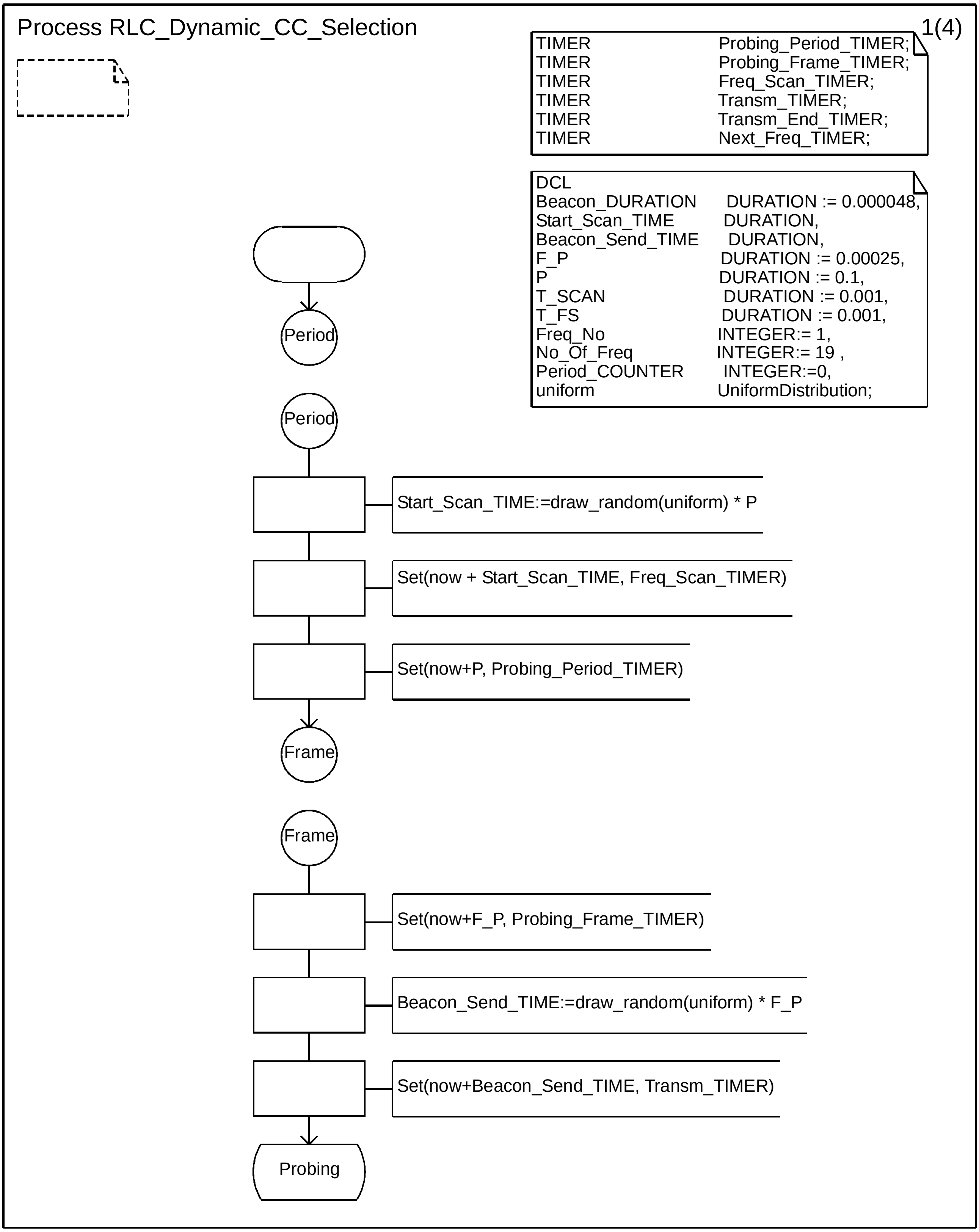

Figure F.1: CC Selection – Initialization

For the CC Probing and Frequency Scan procedures several timers are needed. Figure F.1 contains the declaration of these timers which are the timers for probing period and probing frame, a timer announcing the transmission of a beacon (*Transm_TIMER*), a timer indicating the beacon fully has been transferred (Transm_End_Timer), a timer announcing the start of the scan process (*Freq_Scan_TIMER*) and a timer indicating the change of the scan frequency (*Next_Freq_TIMER*).

Within the declaration the CC selection parameters are also defined and initialized according to the reference values introduced in clause 6.7.3.1. The first phase of the CC Probing process is the initialization of the probing period introduced by the ***Period*** connector. The second phase of the CC Probing is the initialization of the probing frame introduced by the ***Frame*** connector.

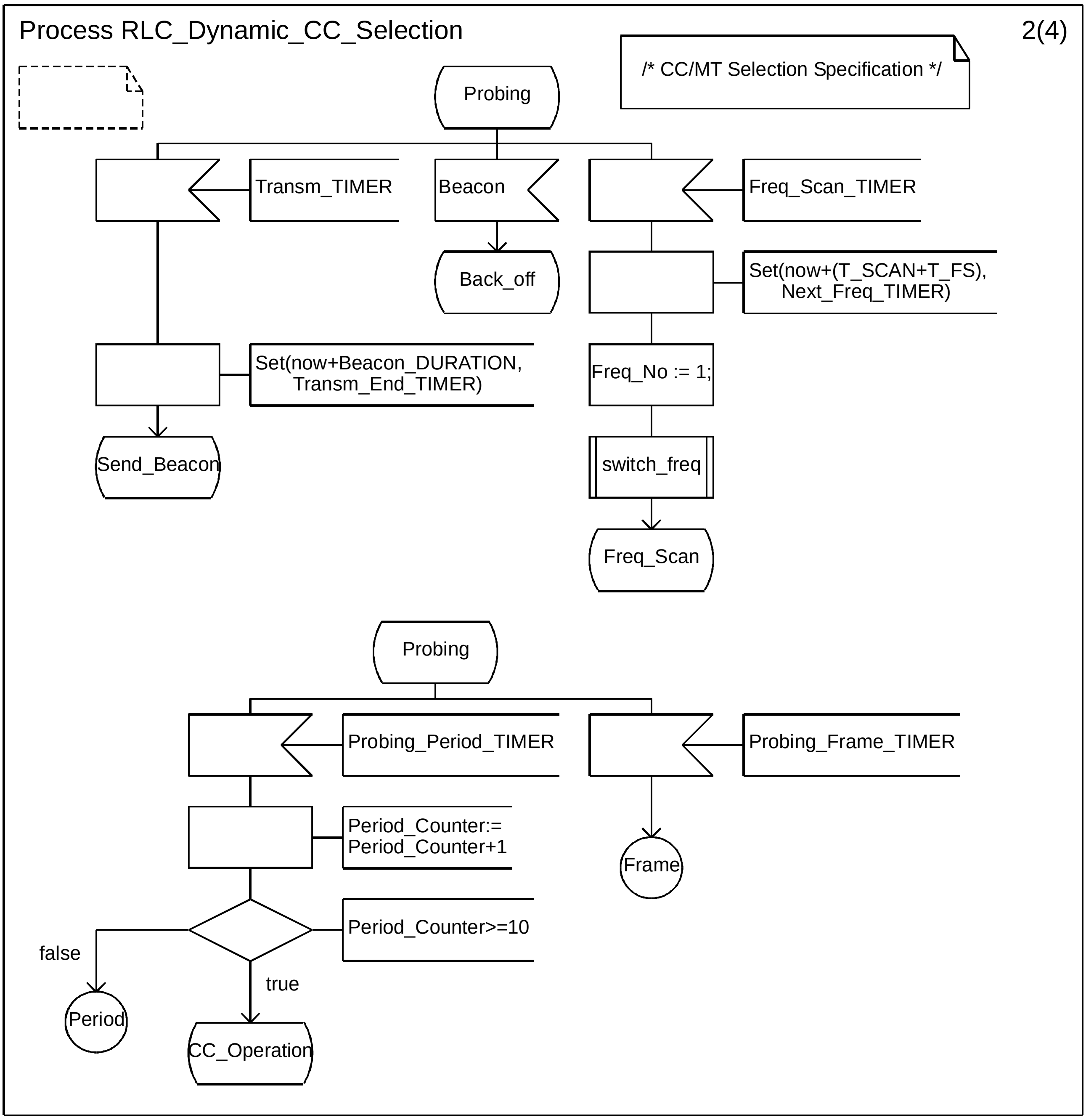

Figure F.2: CC Selection – ***Probing*** **state**

In the state ***Probing*** several signals can be expected, see Figure F.2. A "Probing_Period_Timer" signal indicates the beginning of a new probing period, a *Probing_Frame_TIMER* signal indicates the beginning of a new probing frame (virtual frame, not identically to the MAC frame). The reception of a beacon signal from another CC-capable terminal induces the terminal to leave the probing process and to accept the other terminal as CC candidate. The *Transm_TIMER* signal is received if the next beacon has to be sent. In this case the timer *Transm_End_TIMER* is started. Another signal, which can occur, is the *Freq_Scan_TIMER* indicating the beginning of a new frequency scan period. The probing process is finished if the *Period_COUNTER* expires. In this case the terminal becomes a CC.

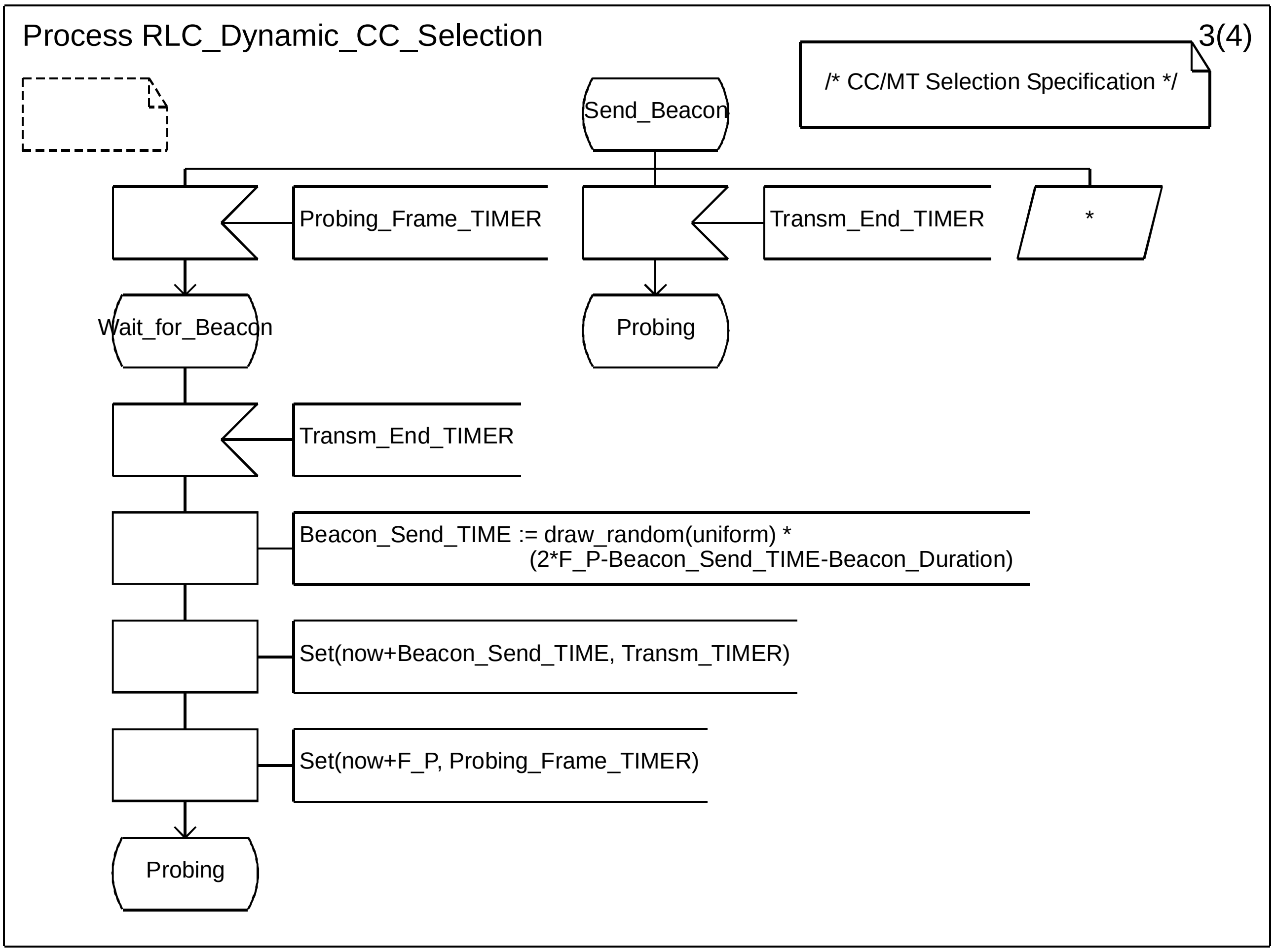

Figure F.3: CC Probing Process – Sending of a Beacon

The probing process resides in the state ***Send_Beacon*** (Figure F.3) after the transmission of the beacon has been initiated by sending the beacon signal. If the beacon (CC Probing BCCH) overlaps into the next CC Probing Frame the *Probing_Frame_TIMER* signal is received and the process changes to a state ***Wait_for_Beacon*** in which the *Transm_End_TIMER* signal is expected. After the beacon has fully been sent (*Transm_End_TIMER* occurs) the sending time of the next beacon is calculated due to the overlap.

The process changes back to the ***Probing*** state after the CC Probing BCCH has been fully sent.

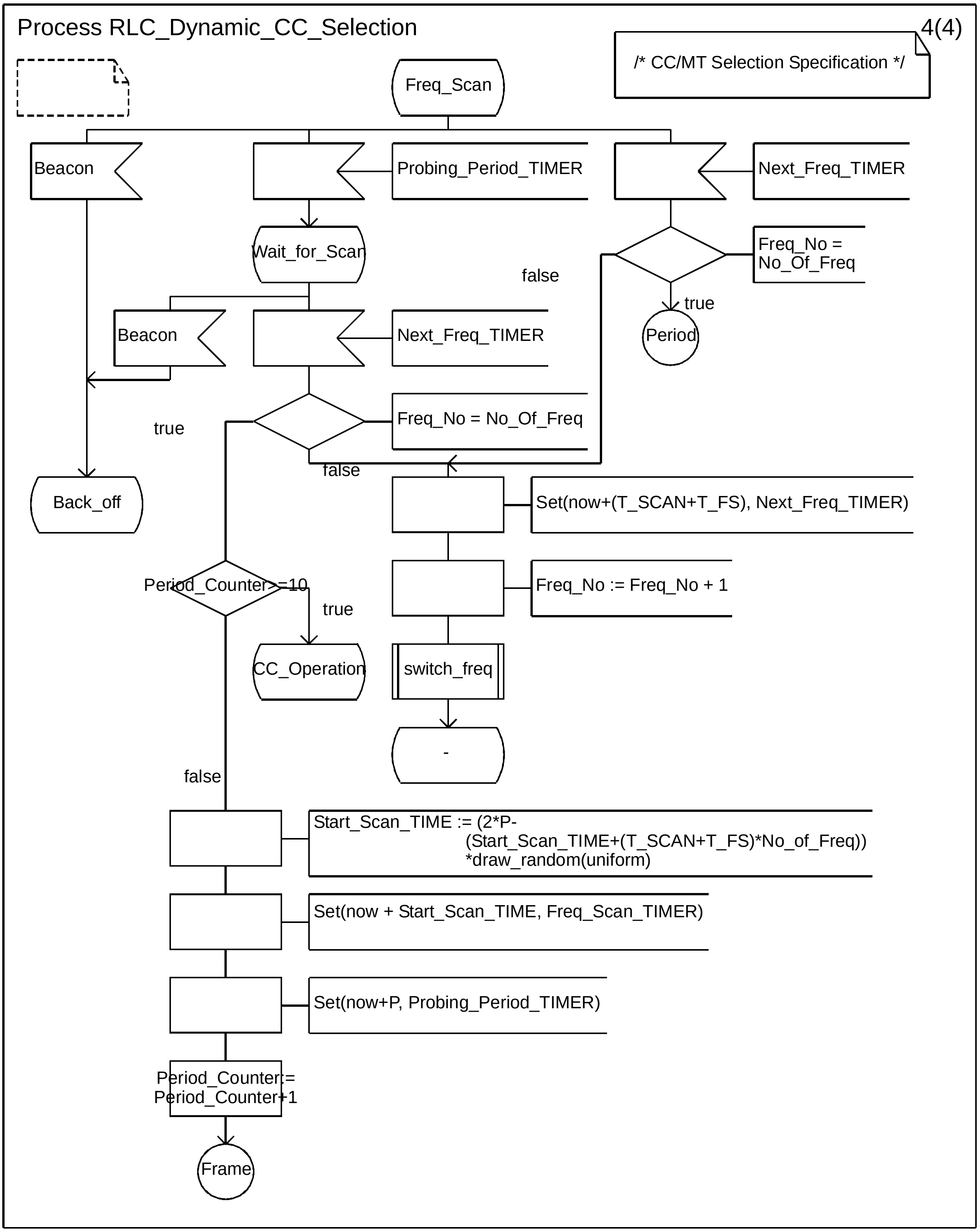

Figure F.4: CC Probing Process – Frequency Scan

The frequency scan (Figure F.4) is started periodically whereby the start time is determined by random. The start time of the last frequency scan has been stored in the variable *Start_Scan_TIME*. To generate the start time of the next scanning period it has to be evaluated if the scanning period overlaps into the following probing period. In this case the *Probing_Period_TIMER* is received during the scanning period. The process changes to the ***Wait_for_Scan*** state. The scan procedure finishes equally with a non-overlapping scan process. Afterwards the starting time of the next frequency scanning is calculated. The process is then continued at the probing frame initialization, which is symbolized by the "Frame" connector. If a beacon signal is received the terminal leaves the probing process and accepts the other terminal as CC candidate. The receipt of a *Next_Freq_TIMER* signal within the scan procedure (state ***Freq_Scan*** or ***Wait_for_Scan***) induces the process to change the operating frequency after the scanning duration *T_SCAN*. After all 19 frequencies have been scanned the frequency scan is finished. It is not allowed to scan the frequency channels in order. The index Freq_No shall be mapped randomly onto the different usable frequency channels. The receipt of a *Transm_TIMER* indicating the start of beacon transmission is ignored during the scan procedure.

Annex G (informative): Specification of the CC Responsibility Handover Process in SDL

In this annex the SDL specification for the CC Responsibility Handover is presented. The primitive initiating the CC Handover called CCH_cc_ho_request_req is received in the Associated state within the current CC (Figure G.1). Upon reception of the primitive the RLC_CC_HO_REQUEST PDU is sent to all WTs in the subnet and the CC changes to the state Central_Controller_Handover_Requested. In this state the RLC_CC_HO_REQUEST_ACK PDU is expected. If this PDU comes in, the CCH_cc_ho_request_cnf primitive is sent to the RLC environment. Afterwards a RLC_CC_HO_NOTIFY PDU is sent to all WTs. This is represented in the SDL diagram by a loop from MaxMacId to 0. If the signal has been sent to all WT MAC Ids the CCH_start_cl_ho_ind primitive is sent to all CLs and the CC goes into the state RLC_Stopped.

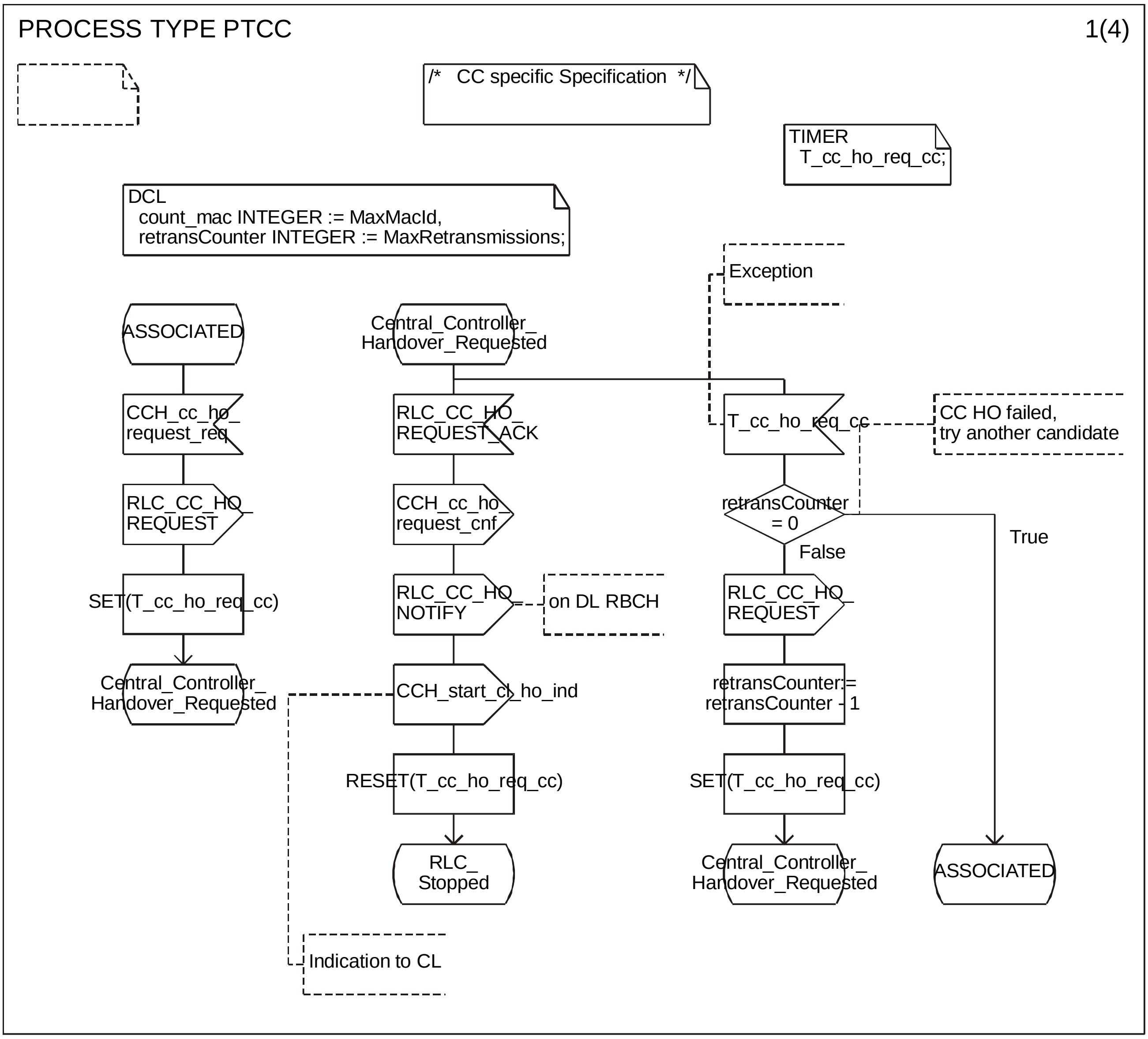

Figure G.1: CC Responsibility Handover – SDL specification of CC, page 1

In the state RLC_stopped only the CC Handover procedure goes on at RLC level. The CC waits to receive the primitive CCH_start_cl_ho_rsp from the environment. After reception of this primitive the CC first starts to release all connections in CM of all WTs (see Figure G.2). If all connections in CM are released, the CC goes into the state Wait_for_ho_start.

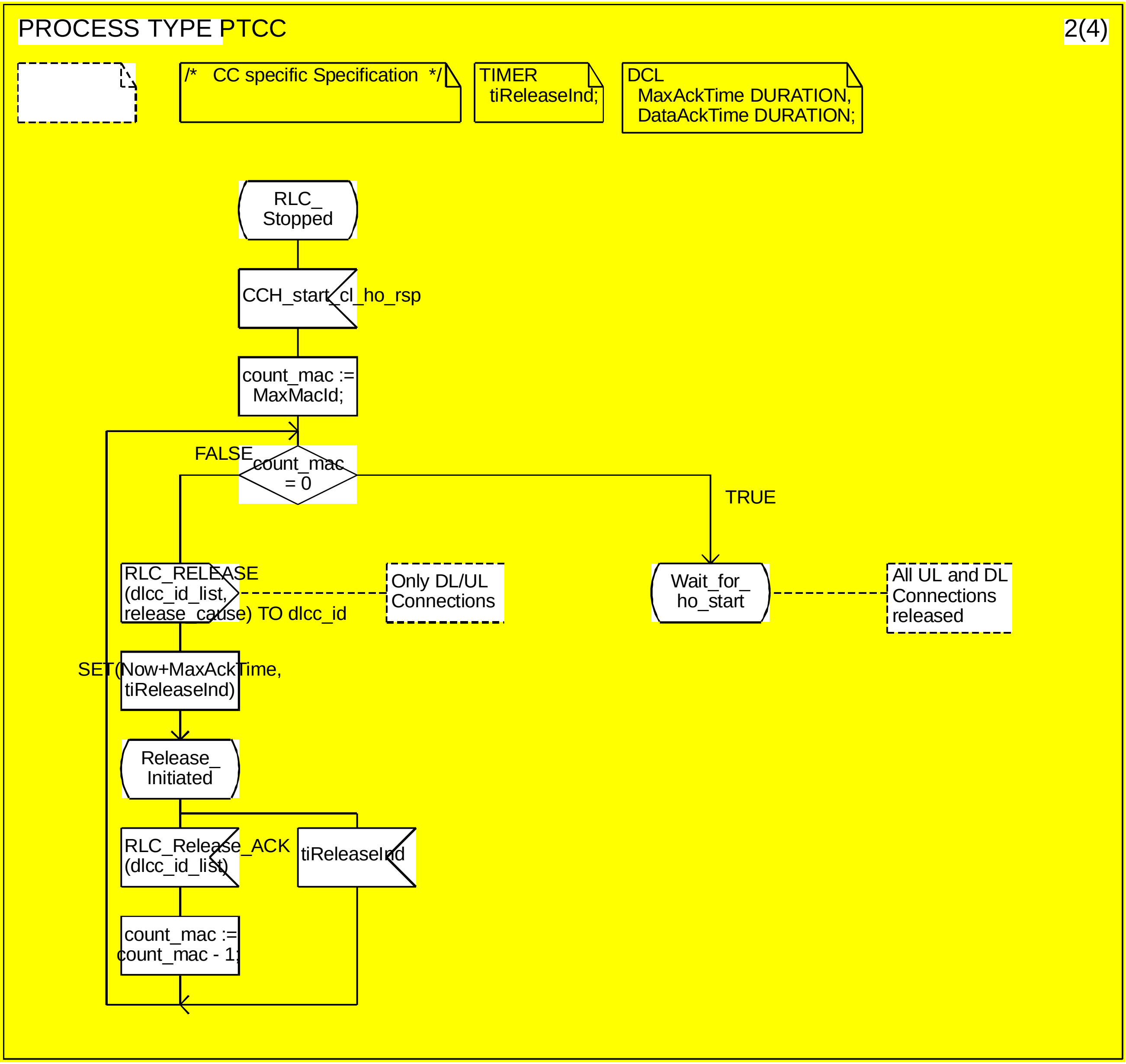

Figure G.2: CC Responsibility Handover – SDL specification of CC, page 2

In the state Wait_for_ho_start, the CCH_start_cc_req primitive is expected. If it comes in, the data transfer procedure is started (Figure G.3). For the data transfer a Go-Back-N ARQ protocol is applied. The CC knows how many RLC_CC_TRANS_CC_DATA PDUs are necessary to transmit all data to the CC-candidate. This number of PDUs is stored in the parameter pduToSend. The variable count_pduToSend in Figure 3 gives the number of PDUs that still have to be sent in the course of the procedure. At the beginning of the data transfer count_pduToSend is set to the value pduToSend. In each frame a certain number of RLC_TRANS_CC_DATA PDUs is transmitted in one packet train. How many PDUs are transmitted in a row is out of the scope of the present document. This is why the implementation of the function calcOptPduInARow is left open in Figure 3. Depending on how many PDUs still have to be send and probably also on the current traffic load the function calcOptPduInARow determines the value of the variable optPduInARow. Then the optPduInARow number of PDUs is transmitted by the loop that is controlled by the variable count_pduInRow. With each transmitted PDU the sequence number sn is incremented by 1. If the PDU is the last PDU of the whole data transfer (count_pduInRow = 1 and count_pduToSend = optPduInARow), then the ext_ind field is set to 0 (false).

If all PDUs of the packet train have been transmitted, the CC sets a timer for the acknowledgement and goes to the state Data_Send. In this state either the RLC_TRANS_CC_DATA_ACK arrives or the timer runs out. In case the RLC_TRANS_CC_DATA_ACK has arrived, the CC checks whether the RR_flag included in the PDU is true or false. If the RR_flag is false, the CC retransmits from the signalled snAck number on (this is done by setting sn = snAck). If the RR_flag is true, this means that all PDUs up to snAck have been correctly received. In this case the CC just sets the count_pduToSend parameter to the new value. It does not retransmit PDUs from snAck+1 on, but continues with transmission of PDU sn (sn is unchanged). A special case occurs if snAck is equal to 0. This indicates that the last RLC_TRANS_CC_DATA PDU of the whole procedure has been correctly received by the CC-candidate and that the CC can change to the state CC_Start_Initiated.

In case the timer for the acknowledgement (T_trans_cc_data_cc) runs out, the CC retransmits the last optPduInARow PDUs (this is done by setting sn = sn - optPduInARow).

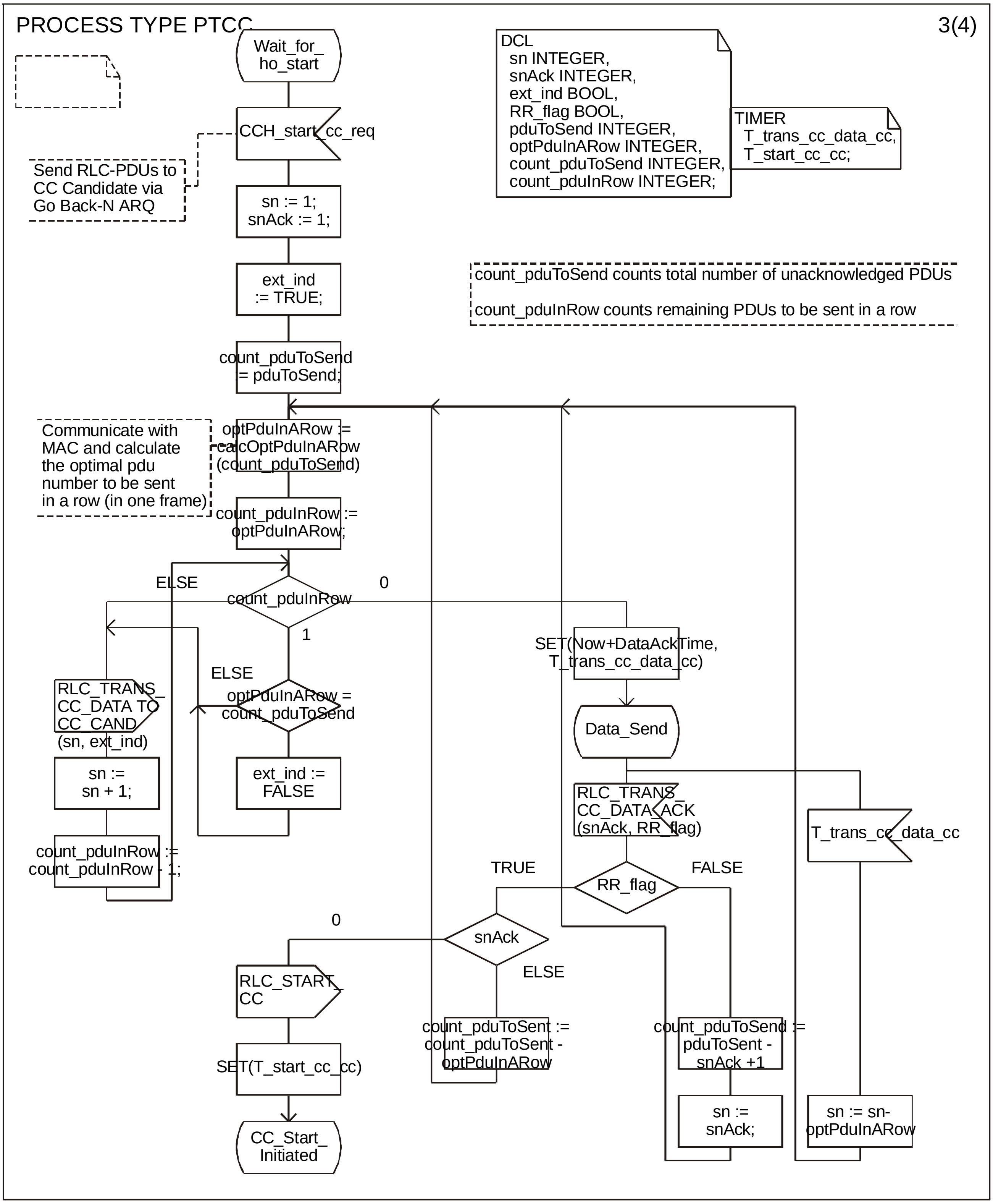

Figure G.3: CC Responsibility Handover – SDL specification of CC, page 3

In the state CC_Start_Initiated the RLC_START_CC_ACK PDU is expected from the CC-candidate (Figure G.4). If this PDU arrives, the CC sends the CCH_start_cc_cnf primitive to the RLC environment, reables its RLC and becomes a normal WT.

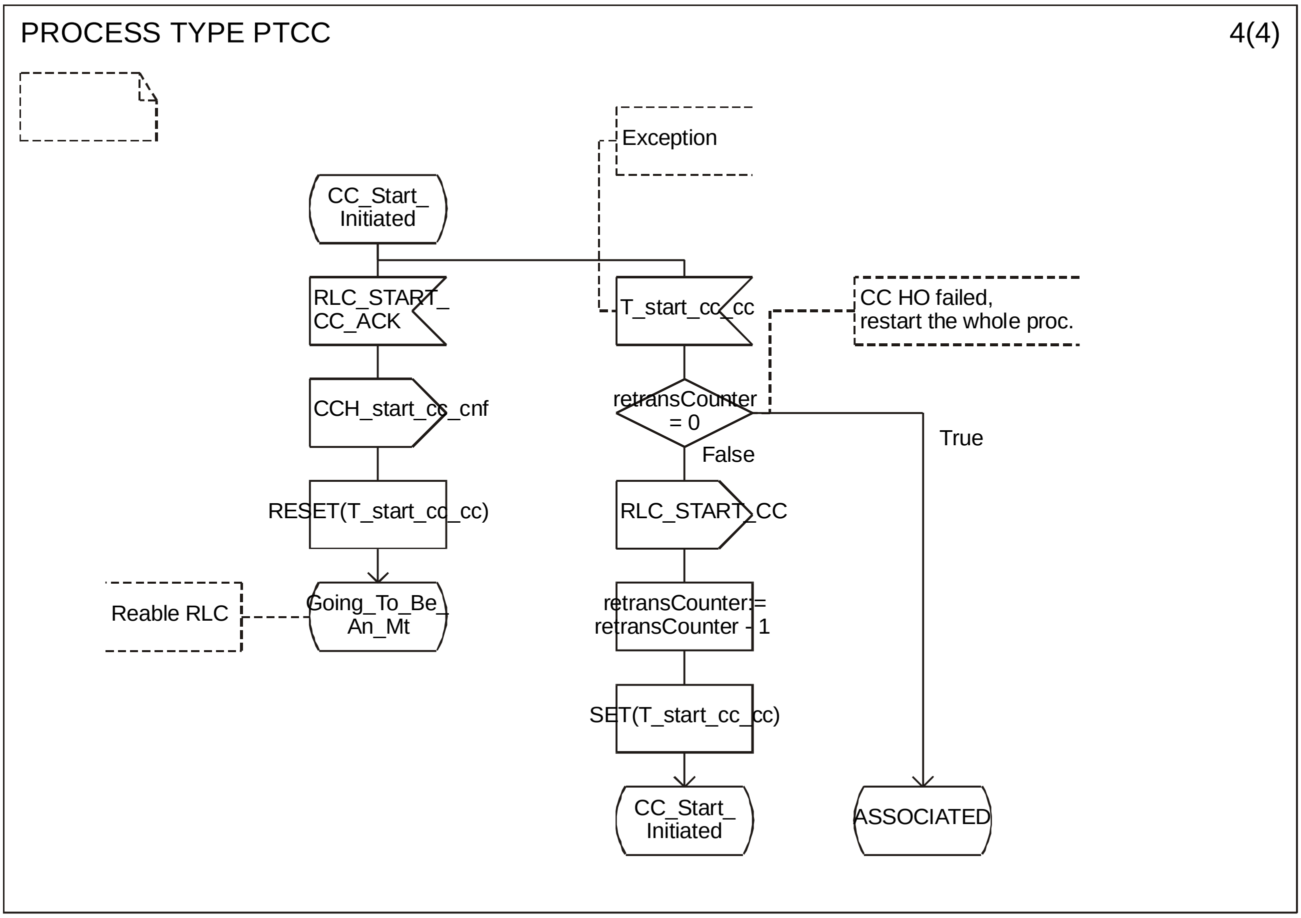

Figure G.4: CC Responsibility Handover – SDL specification of CC, page 4

The SDL specification of CC Handover on the WT side of an H/2-HD (resp. on MT side in the basic SDL model) is divided in two parts. The first part in Figure G.5, Figure G.6 and Figure G.7concerns a WT that is selected as CC-candidate. The second part in Figure G.8 refers to all other WTs in the subnet.

In Figure G.5 the CC-candidate receives the RLC_CC_HO_REQUEST PDU in the Associated state. Upon reception the candidate generates a CCH_cc_ho_request_ind primitive that is sent to the RLC environment and the candidate changes to the CC_Handover_Indicated state. In this state the CC-candidate waits for the response primitive of the RLC environment to send an RLC_CC_HO_REQUEST_ACK to the CC.

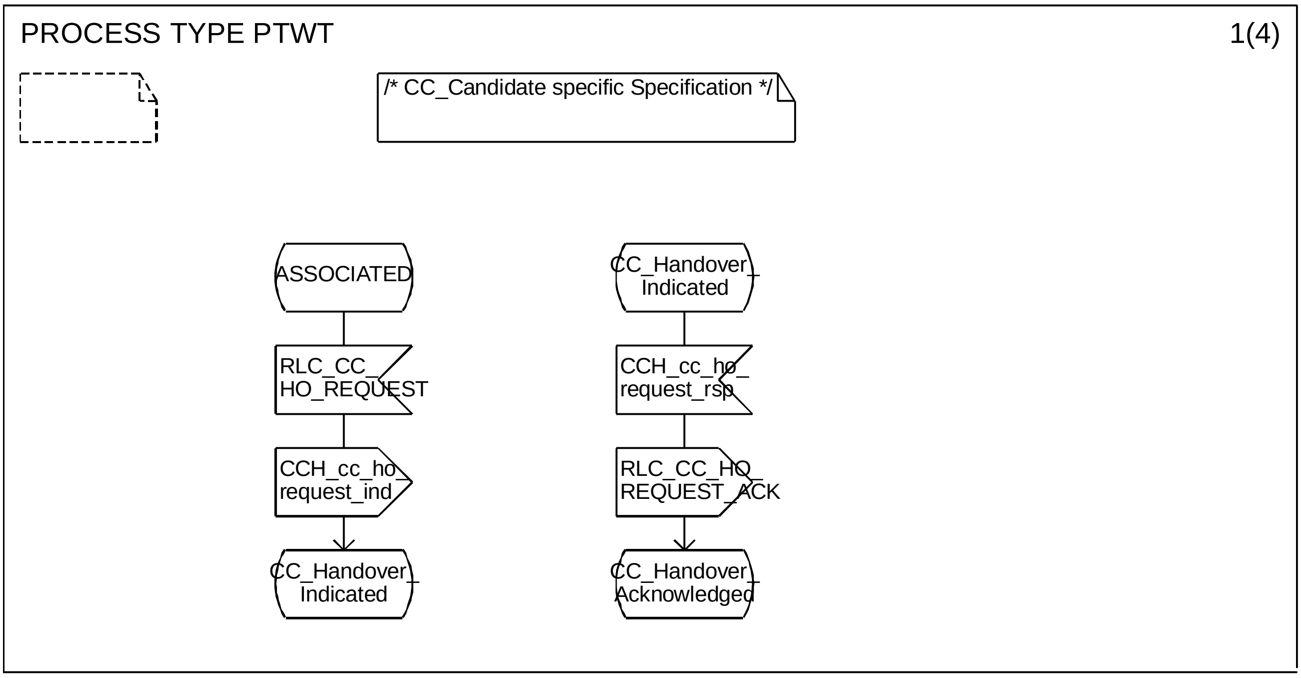

Figure G.5: CC Responsibility Handover – SDL specification of CC-candidate WT, page 1

The CC-candidate is now in the state CC_Handover_Acknowledged. In this state the RLC_RELEASE PDUs sent by the CC are received (see Figure G.6 left corner). They are indicated to the CL with an appropriate primitive and in the state Release_Indicated_Cand the CC-candidate waits for a response primitive of the CL. If the response is received, the candidate changes to the state Wait_For_CC_Data.

NOTE: The CC-candidate is a regular WT and may therefore also have ongoing CM connections that have to be released.

In the state Wait_For_CC_Data either a RLC_TRANS_CC_DATA PDU sent by the CC is received, or the acknowledgement timer tiAckInd runs out. This timer is not specified but it shall have a value less than 2 ms, to guarantee that at least one acknowledgement is sent per frame. All PDUs received within one frame are certainly contained in the same packet train. Therefore the inter-arrival time in between RLC_TRANS_CC_DATA PDUs of the same frame is very short. Due to this fact, the tiAckInd timer could even have a much shorter value than 2 ms. If in a short time after a PDU arrival, no further PDU is recognized, this probably means that the PDU has been the last RLC_TRANS_CC_DATA PDU in the frame and an acknowledgement should be generated.

If a RLC_TRANS_CC_DATA PDU arrives, first of all the tiAckInd timer of the previous PDU is stopped. In case the received PDU is the expected one (snAck = sn - 1) and not the last one (ext_ind = TRUE), a new tiAckInd timer is started. In all other cases the acknowledgement is directly sent and therefore no timer is needed. One of these other cases is that the received PDU is not the expected one (snAck ≠ sn - 1). If this occurs a negative acknowledgement is generated (RR_flag = FALSE). A last case consists of the received PDU being the last RLC_TRANS_CC_DATA PDU of the whole CC Handover procedure (ext_ind = 0). In this case a positive acknowledgement is sent to the CC with the snAck value set to 0. A snAck value of 0 indicates to the CC that the data transfer has been successfully completed.

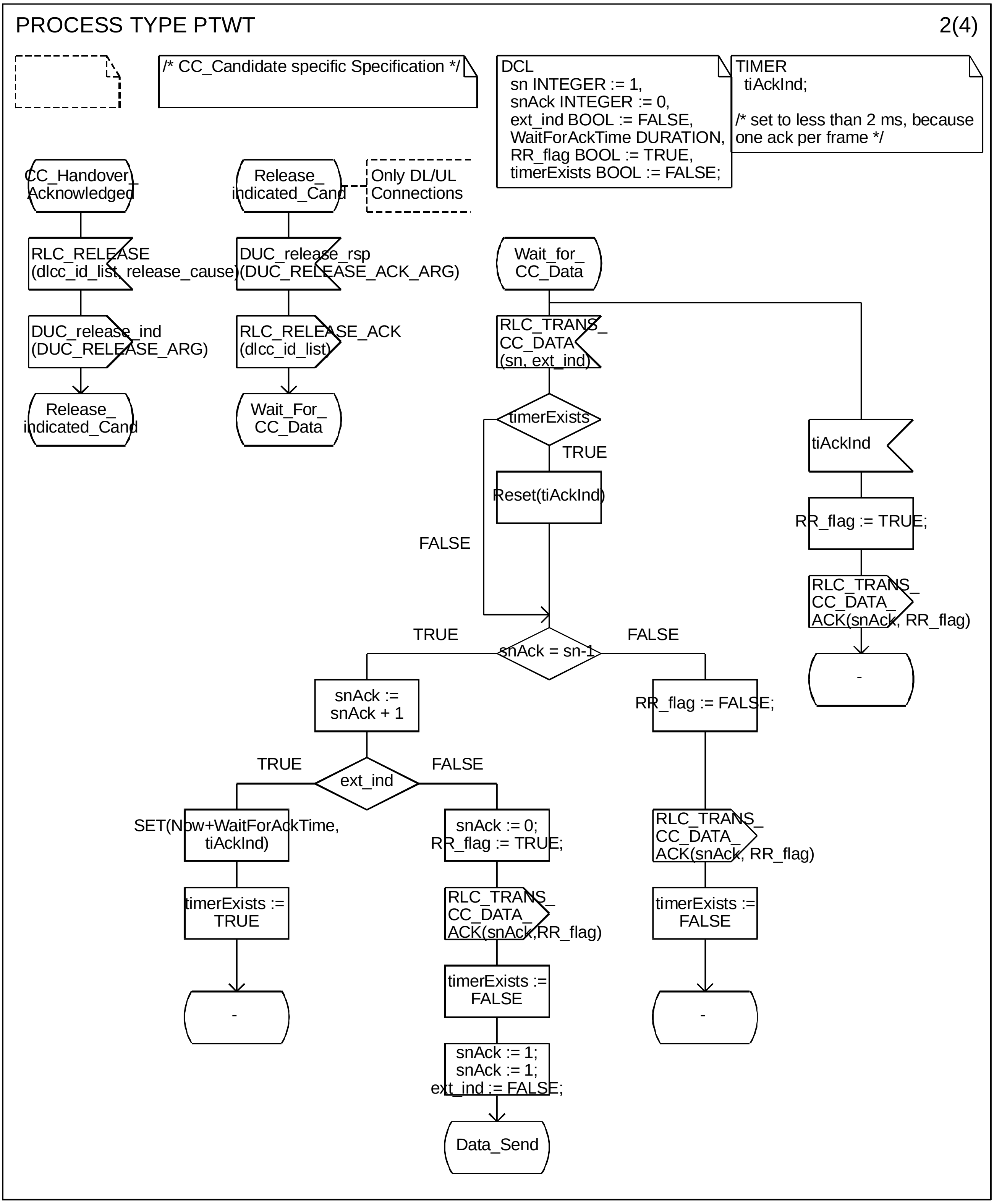

Figure G.6: CC Responsibility Handover – SDL specification of CC-candidate WT, page 2

In the state Data_Send the CC-candidate waits for the RLC_START_CC PDU from the CC (Figure G.7). Upon reception of the PDU a CCH_start_cc_ind is sent to the environment. The environment responds with a CCH_start_cc_rsp while the CC-candidate RLC layer is in the state CC_Start_indicated. If the RLC receives the response of the environment it sends a RLC_START_CC_ACK PDU to the old CC and starts CC operation at the requested time. Furthermore a RLC_CC_START_OPERATION is sent out in broadcast mode to inform all WTs about the take over of CC functionality.

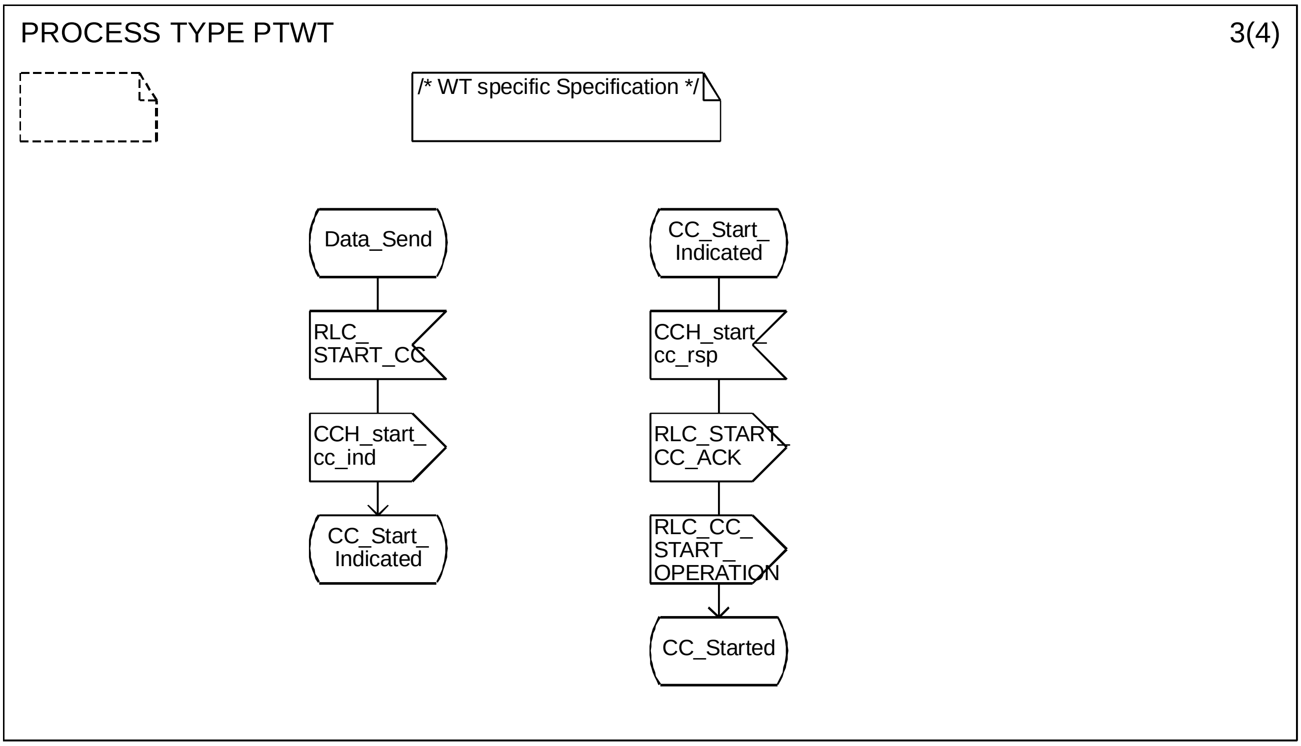

Figure G.7: CC Responsibility Handover – SDL specification of CC-candidate WT, page 3

Figure G.8 finally gives an overview over the CC Handover specific processes inside a WT that is not a CC-candidate. After the reception of the RLC_CC_HO_NOTIFY PDU the WT goes into the state RLC_Stopped_MT. In this state the WT waits for the RLC_RELEASE requests for its CM connections. After indication and response to/from the CL, the WT changes to the state Connections_Released_MT. If no RLC_RELEASE requests are received, e.g. in the case where the WT only maintains DM connections, the WT directly changes to the state Connections_Released_MT after the timer tiNoReleases has run out. In the state Connections_Released_MT the WT receives the RLC_CC_START_OPERATION message and goes back to its basic state Associated.

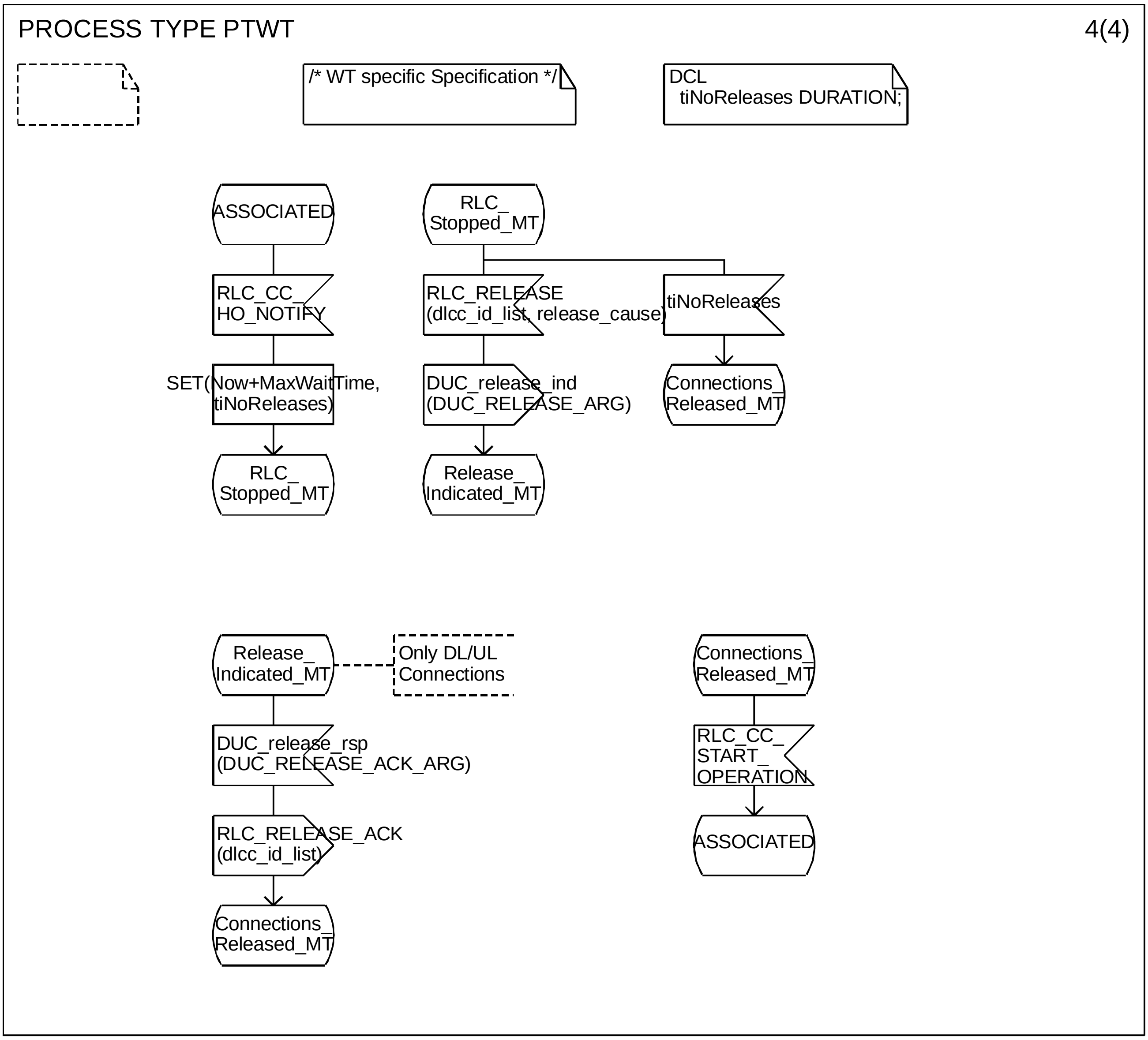

Figure G.8: CC Responsibility Handover – SDL specification of WT

Annex H (informative): Example of valid Reed-Solomon word

The following RS word is built from 4 consecutive PDUs. These PDUs are normal LCH, hence the PDU-type is set to 00. The sync field is inverted for the first PDU. The other bits of the first octet are set to zero. The contents of the other octets of the PDUs are explained in table H.1.

Table H.1

	PDU#1	**PDU#2**	**PDU#3**	**PDU#4**
PDU type	00	00	00	00
Sync field	11	00	00	00
Octet #i value (from i = 2 to 50)	I	50+i	100+i	150+i

The following RS word has been obtained from these 4 PDUs payload with padding 39 0-bytes in front of the 200 payload bytes and applying the RS(239,255). The redundancy is in bold.

Table H.2

	PDU#1	PDU#2	PDU#3	PDU#4
Octet #1	48	0	0	0
Octet #2	2	52	102	152
Octet #3	3	53	103	153
Octet #4	4	54	104	154
Octet #5	5	55	105	155
Octet #6	6	56	106	156
Octet #7	7	57	107	157
Octet #8	8	58	108	158
Octet #9	9	59	109	159
Octet #10	10	60	110	160
Octet #11	11	61	111	161
Octet #12	12	62	112	162
Octet #13	13	63	113	163
Octet #14	14	64	114	164
Octet #15	15	65	115	165
Octet #16	16	66	116	166
Octet #17	17	67	117	167
Octet #18	18	68	118	168
Octet #19	19	69	119	169
Octet #20	20	70	120	170
Octet #21	21	71	121	171
Octet #22	22	72	122	172
Octet #23	23	73	123	173
Octet #24	24	74	124	174
Octet #25	25	75	125	175
Octet #26	26	76	126	176
Octet #27	27	77	127	177
Octet #28	28	78	128	178
Octet #29	29	79	129	179
Octet #30	30	80	130	180
Octet #31	31	81	131	181
Octet #32	32	82	132	182
Octet #33	33	83	133	183
Octet #34	34	84	134	184
Octet #35	35	85	135	185
Octet #36	36	86	136	186
Octet #37	37	87	137	187
Octet #38	38	88	138	188
Octet #39	39	89	139	189
Octet #40	40	90	140	190
Octet #41	41	91	141	191
Octet #42	42	92	142	192
Octet #43	43	93	143	193
Octet #44	44	94	144	194
Octet #45	45	95	145	195
Octet #46	46	96	146	196
Octet #47	47	97	147	197
Octet #48	48	98	148	198
Octet #49	49	99	149	199
Octet #50	50	100	150	200
Octet #51	**6**	**76**	**209**	**27**
Octet #52	**125**	**158**	**101**	**163**
Octet #53	**87**	**1**	**115**	**101**
Octet #54	**179**	**92**	**15**	**61**

Annex I (informative): Bibliography

The following material, though not specifically referenced in the body of the present document (or not publicly available), gives supporting information.

ETSI TS 101 493-1: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Packet based Convergence Layer; Part 1: Common Part".

ETSI TS 101 493-2: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Packet based Convergence Layer; Part 2: Ethernet Service Specific Convergence Sublayer (SSCS)".

ETSI TS 101 493-3: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Packet based Convergence Layer; Part 3: IEEE 1394 Service Specific Convergence Sublayer (SSCS)".

ETSI TS 101 493-4: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Packet based Convergence Layer; Part 4: IEEE 1394 bridge layer".

ETSI TS 101 763-1: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Cell based Convergence Layer; Part 1: Common Part".

ETSI TS 101 763-2: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Cell based Convergence Layer; Part 2: UNI Service Specific Convergence Sublayer (SSCS)".

ETSI TR 101 683 (V1.1): "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; System overview".

ETSI TR 101 031: "Broadband Radio Access Networks (BRAN); HIgh PErformance Radio Local Area Network (HIPERLAN) Type 2; Requirements and architectures for wireless broadband access".

ETSI TS 101 762: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Network Management".

ETSI TS 101 761-3: "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Data Link Control (DLC) Layer; Part 3: Profile for Business Environment".

History

Document history		
V1.1.1	June 2000	Publication
V1.2.1	December 2000	Publication