HF-ULE-Interworking V2.0.0 (2017-12-18)

ULE Alliance Standard

Digital Enhanced Cordless Telecommunications (DECT); Ultra Low Energy (ULE);

Home Area Network Functional (HAN-FUN) and Ultra Low Energy (ULE) Interworking

Reference

DF/ULE-HF-01

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Contents

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Foreword

This document has been produced by the ULE Alliance Technical Working Group.

The information in the present document is believed to be correct at the time of publication. However, Home Area Network Functional (HAN-FUN) and Ultra Low Energy (ULE) may rapidly evolve, and consequently, it is possible that some of the information contained in the present document may become incomplete.

The present document is part of a multi-part deliverable covering the HAN-FUN protocol as identified below:

HF-Overview [REF 1]: Overview

HF-Protocol [REF 2]: Protocol Specification

HF-Service [REF 3]: Core Services & Interfaces

HF-Interfaces [REF 4]: Interface Library

HF-Profile [REF 5]: Profiles

HF-ULE-Interworking [REF 6]: HF &ULE Interworking

1. Scope

The present document specifies the standard HAN-FUN (HF) and Ultra Low Energy (ULE) interworking with the former using the latter's transport service.

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.

Referenced documents:

[1] ETSI EN 300 175-1: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 1: Overview"

http://www.etsi.org/deliver/etsi_en/300100_300199/30017501/02.02.01_60/en_30017501v020201p.pdf

[2] ETSI TS 102 939-1: "Digital Enhanced Cordless Telecommunications (DECT); Ultra Low Energy (ULE); Machine to Machine Communications; Part 1: Home Automation Network (phase 1)"

http://www.etsi.org/deliver/etsi_ts/102900_102999/10293901/01.01.01_60/ts_10293901v010101p.pdf

[3] ETSI TS 102 939-2: "Digital Enhanced Cordless Telecommunications (DECT); Ultra Low Energy (ULE); Machine to Machine Communications; Part 2: Home Automation Network (phase 2)"

http://www.etsi.org/deliver/etsi_ts/102900_102999/10293902/01.01.01_60/ts_10293902v010101p.pdf

[4] ULE Alliance HF-Services-00.0 - "Digital Enhanced Cordless Telecommunications (DECT); Ultra Low Energy (ULE); Home Area Network Functional (HAN-FUN) Core Services and Interfaces"

[5] ETSI TS 102 527-5: "Digital Enhanced Cordless Telecommunications (DECT); New Generation (NG); Part 5: Extended wideband speech services"

http://www.etsi.org/deliver/etsi_ts/102500_102599/10252703/01.05.01_60/ts_10252703v010501p.pdf

[6] ETSI EN 300 444: "Digital Enhanced Cordless Telecommunications (DECT); General Access Profile (GAP)

http://www.etsi.org/deliver/etsi_en/300400_300499/300444/02.04.01_60/en_300444v020401p.pdf

[7] ETSI TS 102 527-4: "Digital Enhanced Cordless Telecommunications (DECT); New Generation (NG); Part 4: Light Data Services"

http://www.etsi.org/deliver/etsi_ts/102500_102599/10252704/01.02.01_60/ts_10252704v010201p.pdf

3. Definitions, Symbols and Abbreviations

3.1 Definitions

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

- *Italic* is used to indicate the name designation of attributes and commands.
- Device addresses are indicated as D'xxxx, where xxxx is a hexadecimal number up to four digits. This provides a compact notation for a HF device address. Usually appears as D'0 referring to the network main device, which has the address 0x0000.
- Group addresses are indicated as G'xxxx and have the same notation definitions as a device address.
- Unit IDs are indicated as U'xx, where xx is a hexadecimal number up to two digits. This provides a compact notation for a unit's ID. Usually appears as U'0 referring to the network management unit, with ID 0x00, that every HF device implements.
- Fully qualified HF network addresses are indicated as D'xxxx:U'xx. This compact notation is a combination of the previous two definitions.
- Permanent Virtual Circuit (PVC) is a Virtual Circuit that can be established and cleared only by configuration.
    - NOTE: A Permanent Virtual Circuit is the packet-mode equivalent of a circuit-mode leased line
- Subscription registration is the infrequent process whereby a subscriber obtains access rights to one or FPs
    - NOTE: Subscription registration is usually required before a setting any Virtual Call.
- Virtual Circuit (VC) is a packet-mode user connection able to transport the user packet data protocol. Each Virtual Circuit provides an independent and isolated context for each subscriber data session and is mapped to one DLC Link and to one MAC Logical connection.
    - NOTE: Virtual circuits could be of two types: Virtual Calls (VC) or Permanent Virtual Calls (PVC).
- ULE Service Call: call with only C-plane initiated by a DECT PT for entering of FT related service and adjustment procedures.

3.2 Symbols

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

M, (M)	Provision Mandatory
O, (O)	Provision Optional

The symbols here defined are applied to interfaces, attributes and commands and their fields in the present document if not explicitly otherwise stated. The interpretation of these status indications is as follows:

- Provision mandatory, means that the indicated interface, attributes, command or command field shall be implemented as described in the present document, and may be subject to testing.
- Provision optional, means that the indicated interface, attribute, command or command field may be implemented, and if implemented, the interface, attribute or command shall be implemented as described in the present document, and may be subject to testing.

3.3 Abbreviations

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

DECT	Digital Enhanced Cordless Telecommunications
DFS	DECT Forum Standard
FP	Fixed Part
HAN	Home Area Network
HAN-FUN (HF)	Home Area Network Functional
HF-IFL	HAN-FUN Interface Library
HF-UI	HAN-FUN ULE Interworking
HF-PRF	HAN-FUN Profiles
ID	Identifier
PP	Portable Part
PVC	Permanent Virtual Circuit
SUOTA	Software Update Over The Air
ULE	Ultra Low Energy
VC	Virtual Circuit

4. Introduction

The HAN-FUN ULE Interworking (HF-UI) document defines the requirements and usage of DECT ULE services to support HAN-FUN (HF) applications. It defines the necessary interactions between a PP and FP. In the scope of this document a PP is considered to implement a HF device and the FP to a HF concentrator.

5. ULE features used in HAN-FUN

HAN-FUN makes use of several DECT ULE features and services as defined by TS 102 939-2 as listed in the below sub-sections.

5.1 ULE Capability Bit

ULE has introduced a new capability bit to the Terminal Capability IE used in *{ACCESS-RIGHTS-REQUEST}* and *{LOCATE-REQUEST}* messages. The <*Profile indicator_9*> field in the IE shall be used as indicated in section 12.2.1 of TS 102 939-2 (replicated in Annex A - Information Elements coding for convenience).

5.2 ULE Extended Higher Layer Capabilities

A HF FP shall broadcast higher layer information as indicated in sections 12.2.2.1.3 of TS 102 102 939-2 [5] (ULE), having set bits <*a39-a41*> of the Extended Higher Layer Capabilities part 2 in order to indicate the supported ULE version; 100 indicates ULE Phase 1 (version v1.1.1); 110 indicates ULE Phase 1 (version v1.2.1 or later), 101indicates support of phase 2 and 111 is reserved for indicating support of Phase 3.

5.3 ULE Service Call

The ULE Standard introduced a new service call called "*ULE Service Call*". Its setup is defined in TS 102 939-1 section 12.2. Both PP and FP may initiate a service call.

In the case of the FP it can do so using on the PVC link release a release reason "*Switch to circuit mode*" (ULE Service Call).

The ULE Service Call is used to support the following functionalities:

- Resume/Suspend PVC including Key exchange for encryption of PVC
- Negotiation of ULE and Application protocol (FUN in this case) versions
- Assigning of Individual Paging Channel to a page-able device

The ULE Service Call is used during registration (refer to section 6.2) and after registration, e.g., Mid-life (Section 8).

5.4 Packet Mode PVC

Packet mode through PVC is the default mode for data exchange with HAN-FUN DECT ULE devices. The HAN-FUN client is the initiator of transactions. Transport of MTU/SDUs of up to 500 Bytes will be supported in both directions as well as their respective ACK messages. A given device may support a lower than 500 Bytes PDU/SDU and indicate this in the PVC negotiation as indicated in 6.3.

5.5 Paging

PPs and FPs shall support the paging services as defined in TS 102 939-1 section 6.5.1.

Paging may be done to a specific device/unit of devices/units with the intention to initiate a ULE-DECT link.

6. Subscription

This section covers the device subscription registration procedure required to associate HAN-FUN (or HF) devices in a network to a given HF concentrator when ULE is used as the transport layer. The procedure involves three phases, each described in the following sections. Failure to complete successfully any of the three phases will result in device subscription failure.

6.1 Phase 1 - DECT ULE Subscription Registration

The subscription of a PP to a FP shall be initiated by the PP checking for FP ULE support (see 5.2). This shall be followed by the Easy Pairing mechanism as specified in section 7.10.1 of TS 102 527-3 [4] (New Generation DECT).

The PP shall be able to send the <<*Terminal capability*>> information element and the FP shall be able to receive it at least in *{ACCESS-RIGHTS-REQUEST}* and when location registration is supported in *{LOCATE-REQUEST}*.

The PP shall set the <*Profile 9*> field in the <<*Terminal capability*>> information element, as defined in TS 102 102 939-1 [5] (ULE), in order to indicate DECT ULE Phase 1 support.

6.2 Phase 2 - ULE Support Service Setup

After successful registration of a HF PP with a FP, the registration second phase using service call mechanism follows. This phase involves:

- PP and FP exchange of ULE and FUN supported version information;
- PVC setup
- Provide paging channel to a Page-able device

A service call is required to be in place when this phase is initiated. If not available at this stage, its establishment shall be as indicated in 12.2.1 of TS 102 102 939-1 [5] (ULE).

The PP shall send a *{CC-SERVICE-CHANGE}* with <<*SERVICE-CHANGE-INFO*>> information element indicating "*Resume*" and additional <<*IWU-ATTRIBUTES*>> information element holding the ULE version and FUN version among other attributes specified in the ULE standard.

The FP should respond with a *{CC-SERVICE-ACCEPT}* message with the same information elements.

The FP shall then initiate an additional message exchange in order to reset the PVC sequences and set the security keys. It shall do so by sending a *{MM-AUTHNTICATION}* message to the registered PP that shall respond with a <<*MM-AUTHNTICATION-REPLY*>> message.

The registration process is at this stage complete and FUN messages may be exchanged over the PVC. The ULE and FUN versions are also known to both PP and FP.

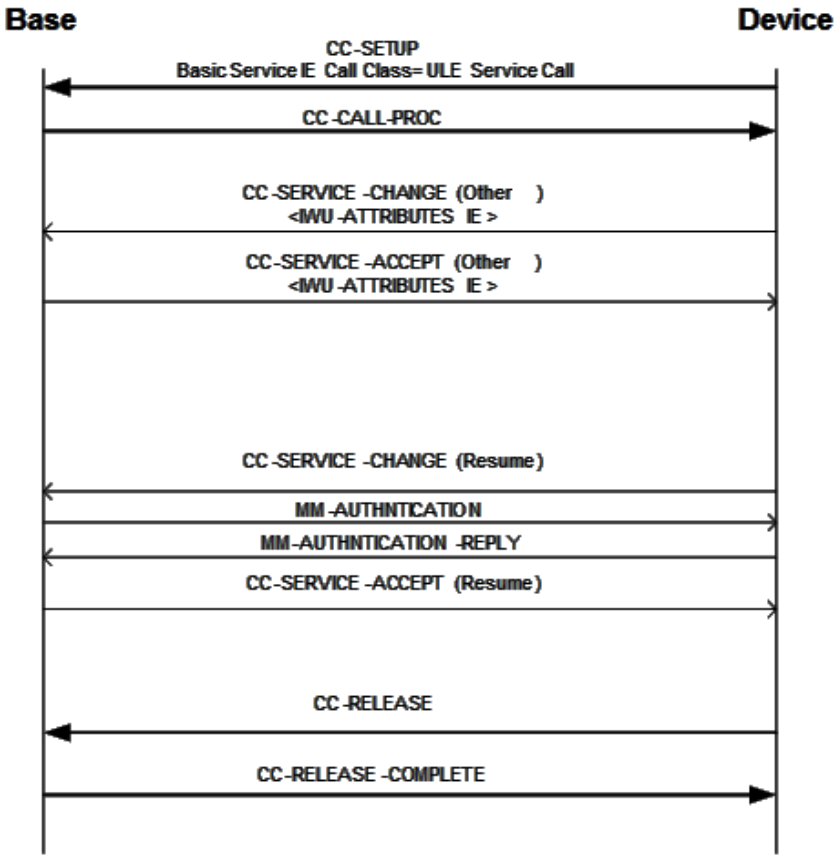

Figure 1 – Non Page-able device 2nd phase registration using service call

In case the PP is capable of paging, it shall indicate this to the FP by sending a *{IWU-INFO}* message with the *<<IWU-to-IWU>>* information element containing the ULE-FUN command defined for Paging Required Response Time. Upon receiving this message the FP shall allocate a Paging Channel to the PP.

The Required Response time value shall be used by the FP to in the assignment of the PP paging channel. The FP can assign an interval equal or greater to the required response time but cannot provide an interval less than that response time.

Typically, when the number of devices (PPs) is low, the FP will provide a paging channel with interval equal to the required response time to allow for best possible response time for this device. However, with a high number of devices (PPs) the FP can chose to give a paging channel with interval larger than response time, keeping the ability to assign more channels to more devices (PPs) with a non-optimal response time.

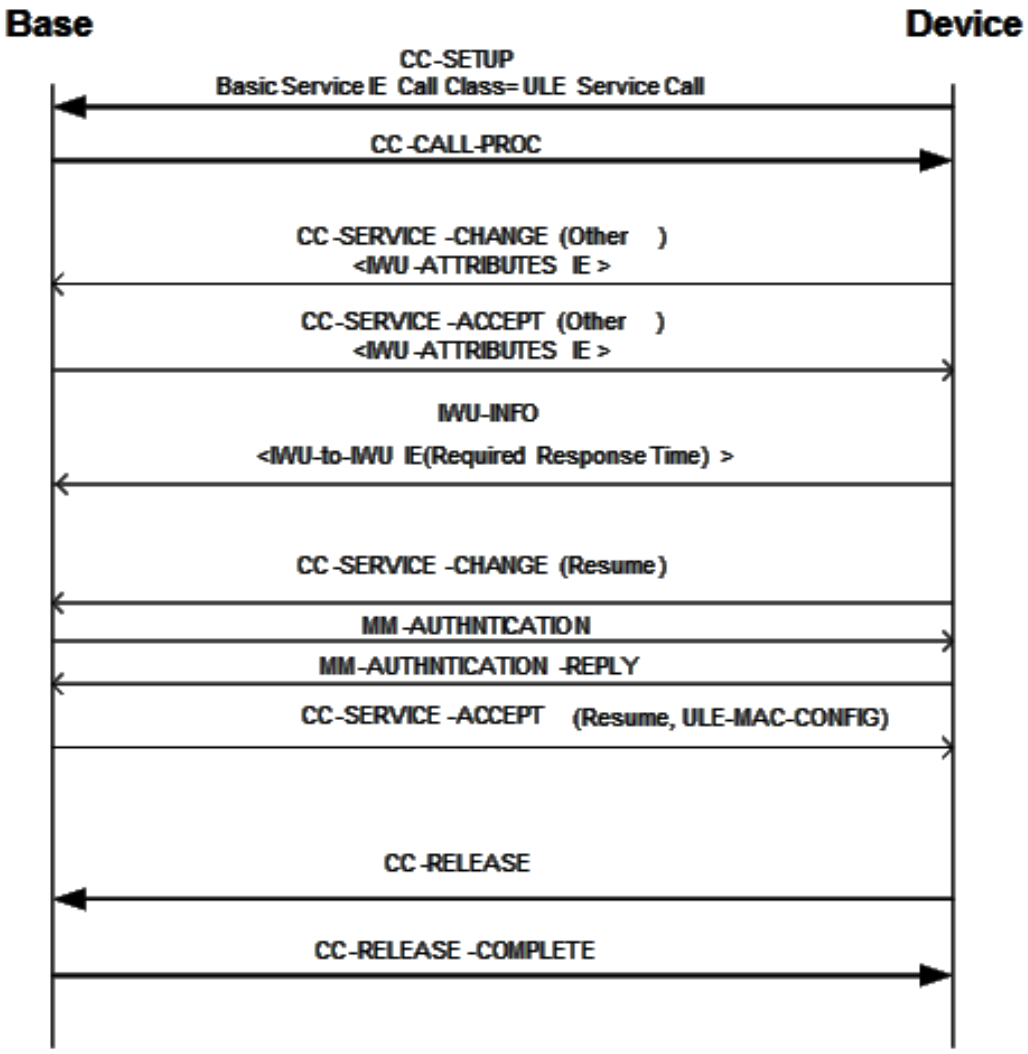

Figure 2 – Page-able device 2nd phase registration using service call

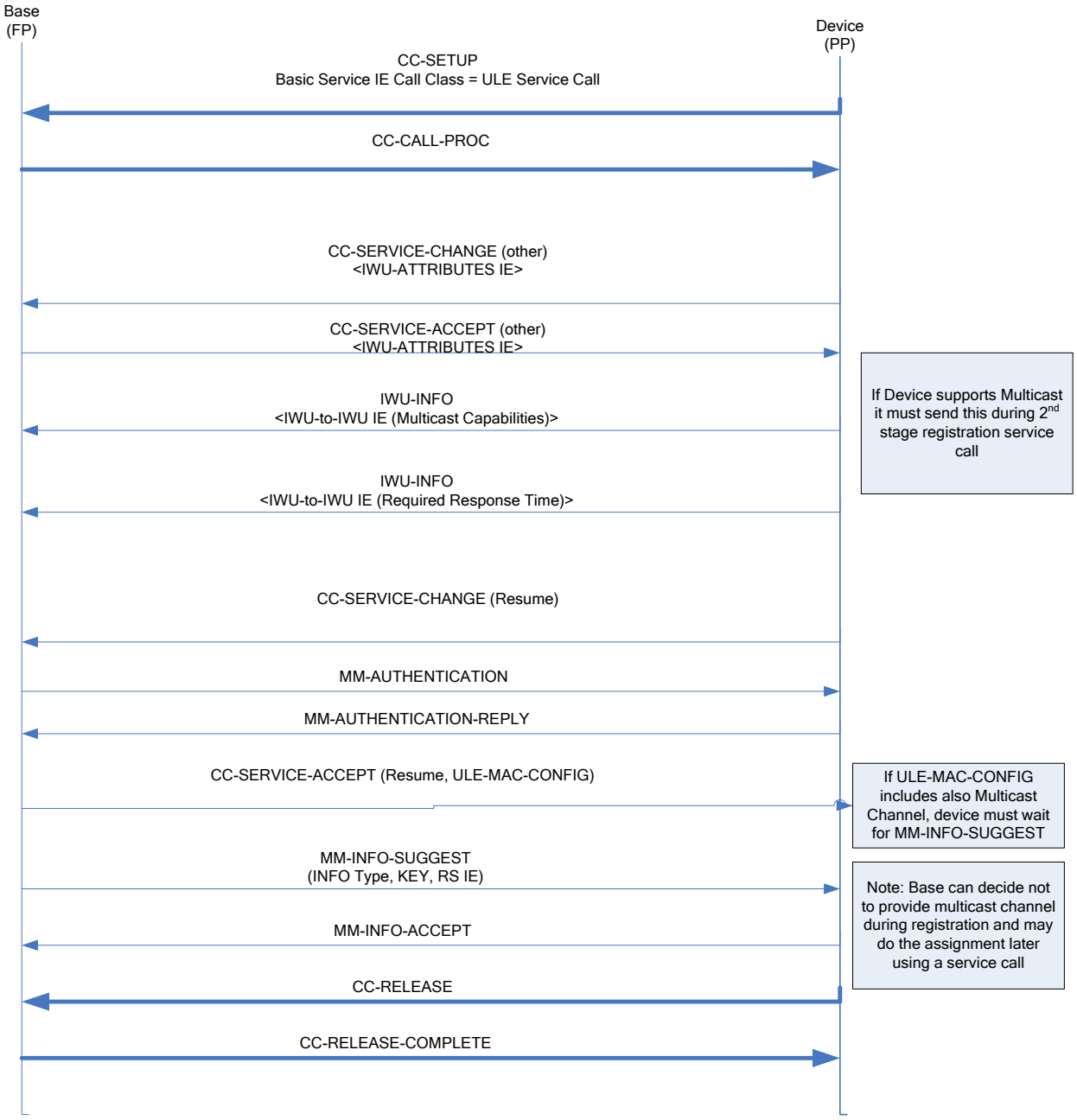

Figure 3 – Multicast capabilities exchange during 2nd phase registration using service call

6.3 Phase 3 - HF Device Registration

The HF Device Management Service shall support the device registration as described in [3].

7. Un-subscription

A PP device will become un-subscribed from a FP, and the associated information cleared from non-volatile memory, in one of the following cases.

7.1 Expected

After the PP responds positively to a "De-register command" as specified in HAN-FUN Service (section 6.1.5.2) the FP will terminate access rights as specified in 5.1.4 in TS 102 102 939-1 [5] (ULE). If any of mentioned steps fail, the un-subscription will fail.

7.2 Unexpected

In the case a PP is no longer registered (or has never been registered) the FP upon detecting that the PP tried to use a Packet Mode link, sends back a release with reason "unacceptable PMID / Unregistered PMID" - see 10.10.2.3 in TS 102 102 939-1 [5] (ULE).

Upon receiving the release with reason "*Unacceptable PMID / Unregistered PMID*", the PP must initiate a LOCATE procedure, allowing the FP to explicitly inform the PP that is not registered.

To support the above, the FP should implement the "Network termination" procedure:

- When the PP is deleted locally, the FP will not delete the associated keys but will only mark the PP for un-subscription;
- When a PP, that is marked for un-subscription, starts a LOCATE procedure it should be authenticated by the FP and then be informed that is no longer subscribed to the FP.

In the case the LOCATE procedure fails for whatever reason then is up to the PP implementation to move to an un-subscribed state or not.

8. ULE Service Call after Subscription

The service call shall comply with the provisions as set forth in TS 102 939-1.

A service call may be necessary outside of the subscription handling and may be used in one of the following cases:

- PVC Reset: the PVC becomes non-operational and needs to be reset;
- Update Paging Channel: the FP re-assigns the PP associated paging channel;
- Multicast Channel assignment : the FP assigns to PP multicast channel and encryption parameters (in case it was not assigned during 2nd stage registration);
- Multicast Channel Update: the FP updates a previously assigned Multicast channel;
- Multicast Channel Encryption parameters reassigned – FP initiated;
- Multicast Channel Encryption parameters retrieval – PP initiated;
- After SUOTA – service call flows;

8.1 PVC Reset - PP Initiated

In case the PP detects that need to reset the PVC (e.g. because PVC is not operational), it shall initiate a service call and send a *{CC-SERVICE-CAHNGE}* requesting *Suspend*. The FP shall answer with a *{CC-SERVICE-ACCEPT}*.

Upon receiving the *{CC-SERVICE-ACCEPT}* message the PP will send back a *{CC-SERVICE-CHANGE}* message with *Resume*.

The FP shall answer to it with *{MM-AUTHENTICATION}* to negotiate the security of the PVC and the PP will reply with a *{MM-AUTHENTICATION-REPLY}* message to complete the transaction to which the FP should respond with a *{CC-SERVICE-ACCEPT}*, resume the PVC and release the service call.

Note: this is similar to PVC resume in registration phase with the exception that <<*IWU-ATTIRBUTES*>> is not used.

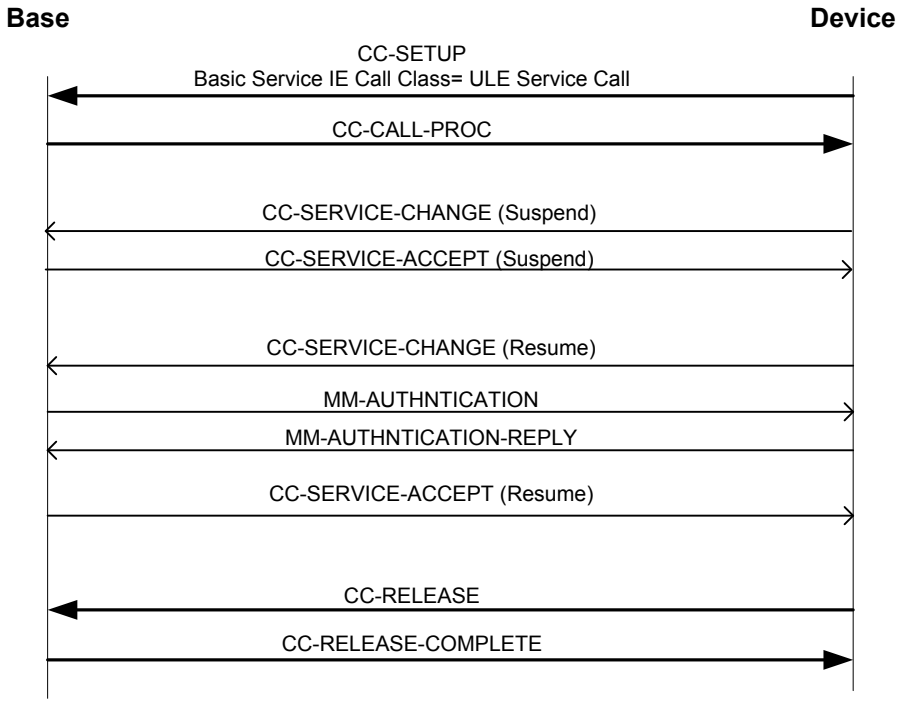

Figure 4 – PP (Device) **initiated PVC Reset**

8.2 PVC Reset - FP Initiated

In case the FP detects that the PVC is not operational, when the PP tries to raise a PVC link to the FP and the FP detects a problem (e.g. PDUs out of sequence or unable to decrypt the payload) it will release the link by sending an expedited release message with Release Reason "*Switch to circuit mode*" and requested action "*Start ULE service call*" - see 10.10.5.4 in TS 102 102 939-1 [5] (ULE).

The PP will receive this Release Reason from the PVC link and will initiate a ULE Service Call.

The FP will then send a *{CC-SERVICE-CHANGE}* message with Suspend. In essence the PVC Resets now starts from the FP. See **Figure 5** for reference.

A new cipher keys is obtained from the authentication procedure and the PVC is resumed.

Finally, the FP releases the service call.

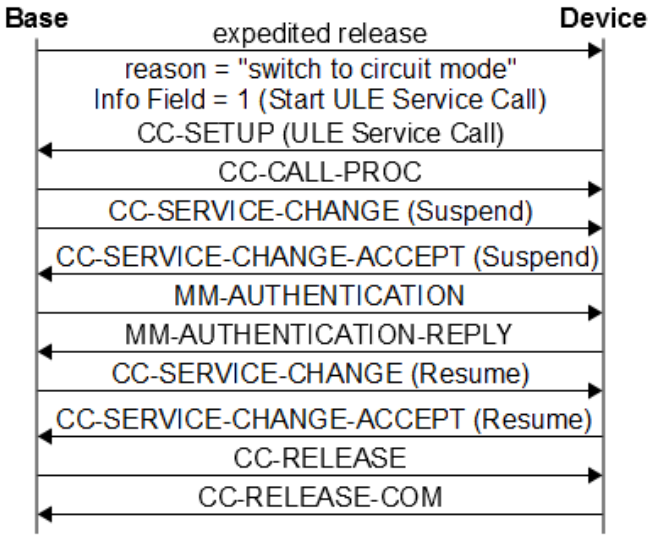

Figure 5 – FP (Base) initiated PVC Reset

8.3 PVC Reset - Collision

In case both the PP and the FP detects problems on the PVC and reset it simultaneously a collision of the above procedures may occur. In such an event the FP initiated procedure shall take precedence as defined in TS 102 102 939-1 [5] (ULE).

The image below depicts the situation of a Service Change collision as describe in TS 102 102 939-1 [5] (ULE) paragraph 12.1.3.6.1. At the end, the FP releases the service call as it won in the collision.

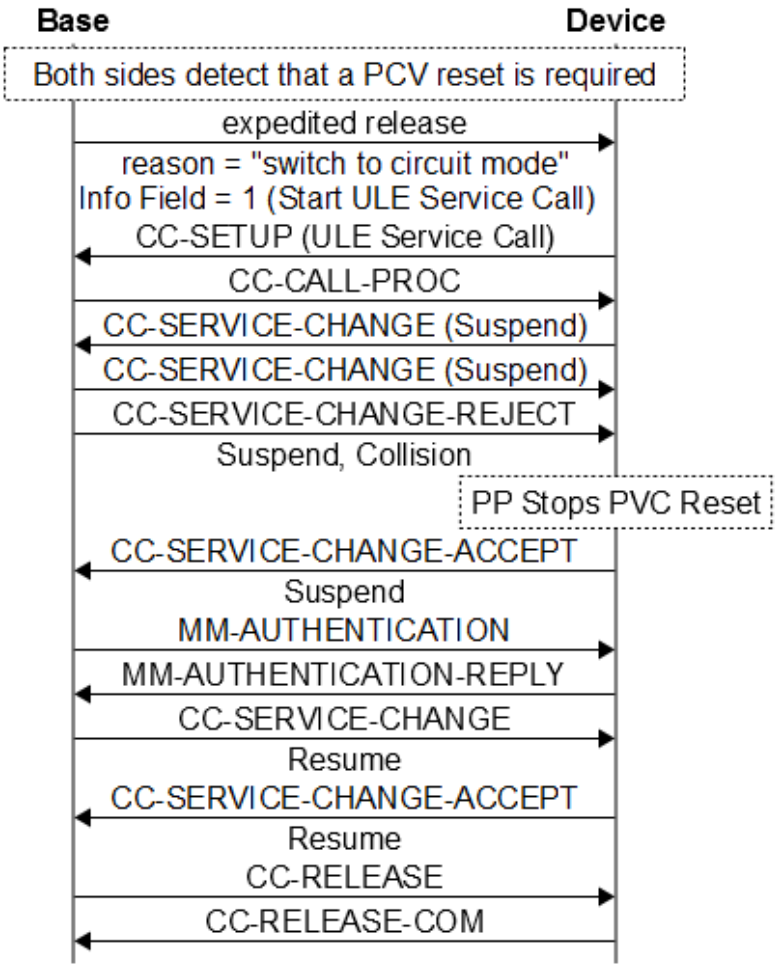

Figure 6 - Service change collision in PVC reset

8.4 Update Paging Channel

The FP manages the attributed paging channel to a given PP.

In case a paging channel modification is required the FP will wait until the PP will start a PVC transaction and will then release the PVC link with release reason "*Switch to circuit mode*" and requested action "*Start ULE service call*", see 10.10.5.4 in TS 102 102 939-1 [5] (ULE).

The PP will then establish a ULE Service Call and the FP will send a *{CC-SERVICE-CHANGE}* (Other – Not Resume or Suspend) with the *<<ULE-MAC-CONFIGURATOIN-INFO>>* information element.

In the *<<ULE-MAC-CONFIGURATION-INFO>>* information element there is a field that indicate to use this new channel and stop using previous channel (replace instead of add a channel).

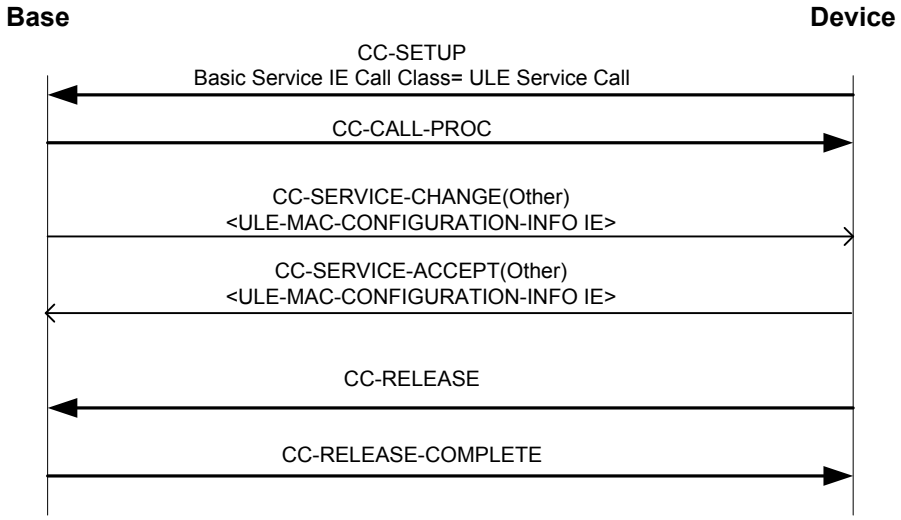

Figure 7 - Paging channel update

8.5 Multicast Channel Assignment /Re-assignment

In case Multicast channel was not assigned during 2nd stage registration, the FP may assign it in a later stage using the following procedure.

The FP may page the device if it is page-able and wait until PP starts a PM transaction and will then release the PM link with release reason "*Switch to circuit mode*" and requested action "*Start ULE service call*", see 10.10.5.4 in TS 102 102 939-1 [5] (ULE).

The PP will then establish a ULE Service Call and the FP will send a *{CC-SERVICE-CHANGE}* (Other – Not Resume or Suspend) with the *<<ULE-MAC-CONFIGURATOIN-INFO>>* information element.

In the *<<ULE-MAC-CONFIGURATION-INFO>>* information element there is a field holding the Multicast channel. The PP should accept and wait for a *{MM-INFO-SUGGEST}* in which it will receive the encryption parameters for this multicast channel. The PP should then send a *{MM-INFO-ACCEPT}* and the FP will release the service call.

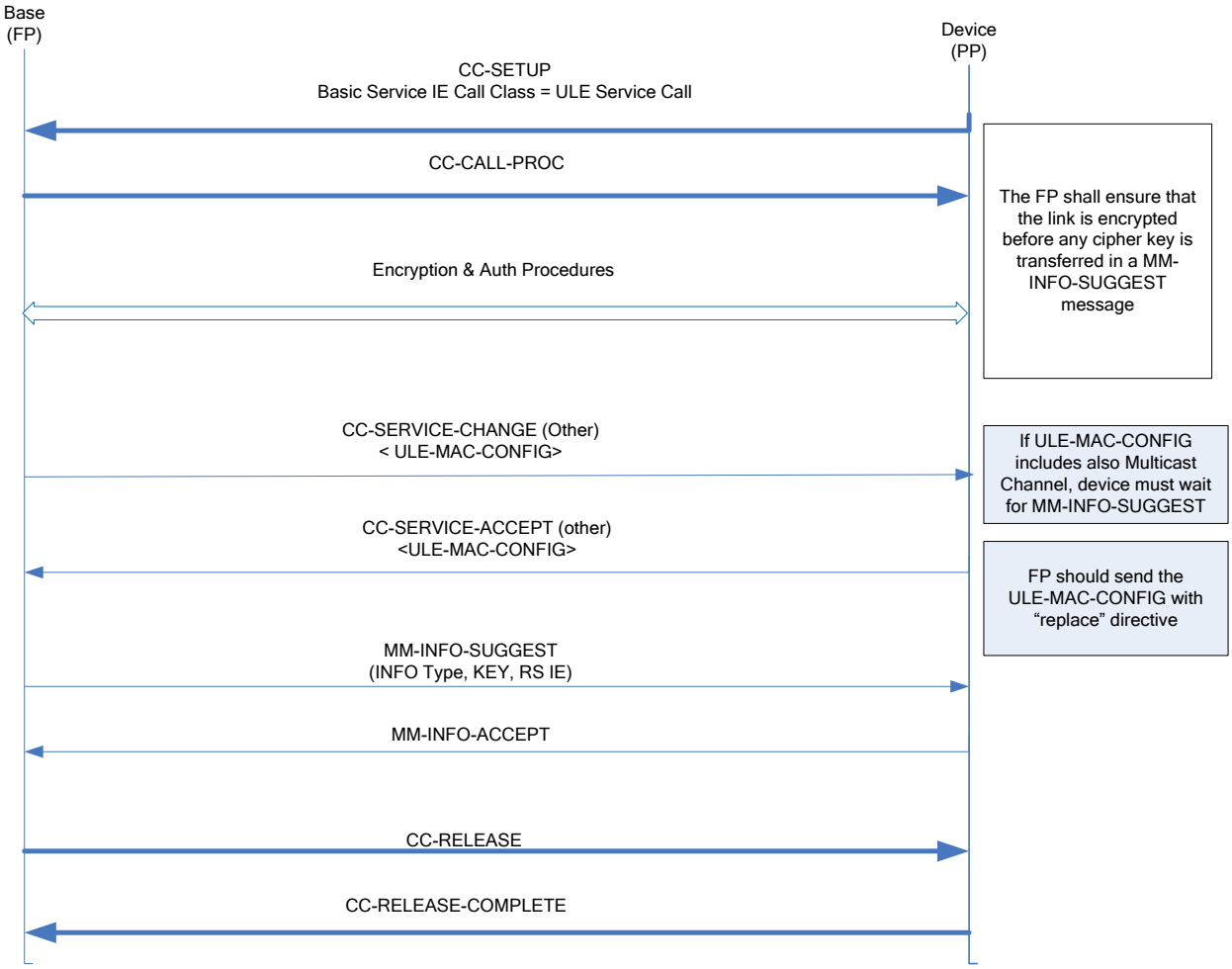

Figure 8 - Multicast channel assignment

8.6 Multicast Channel Encryption parameters reassigned

In case of any other reason if FP would like to transfer encryption parameters the following procedure should be used.

The FP will request the PP to set up a service call by releasing the expedited connection with release reason "Start ULE service call" (Refer 10.10.5.4 in TS 102 102 939-1 [5] (ULE)).

The PP will then establish a ULE Service Call and the FP will send a *{MM-INFO-SUGGEST}* with the updated encryption parameters. The PP will then send a *{MM-INFO-ACCEPT}* and the FP will release the service call.

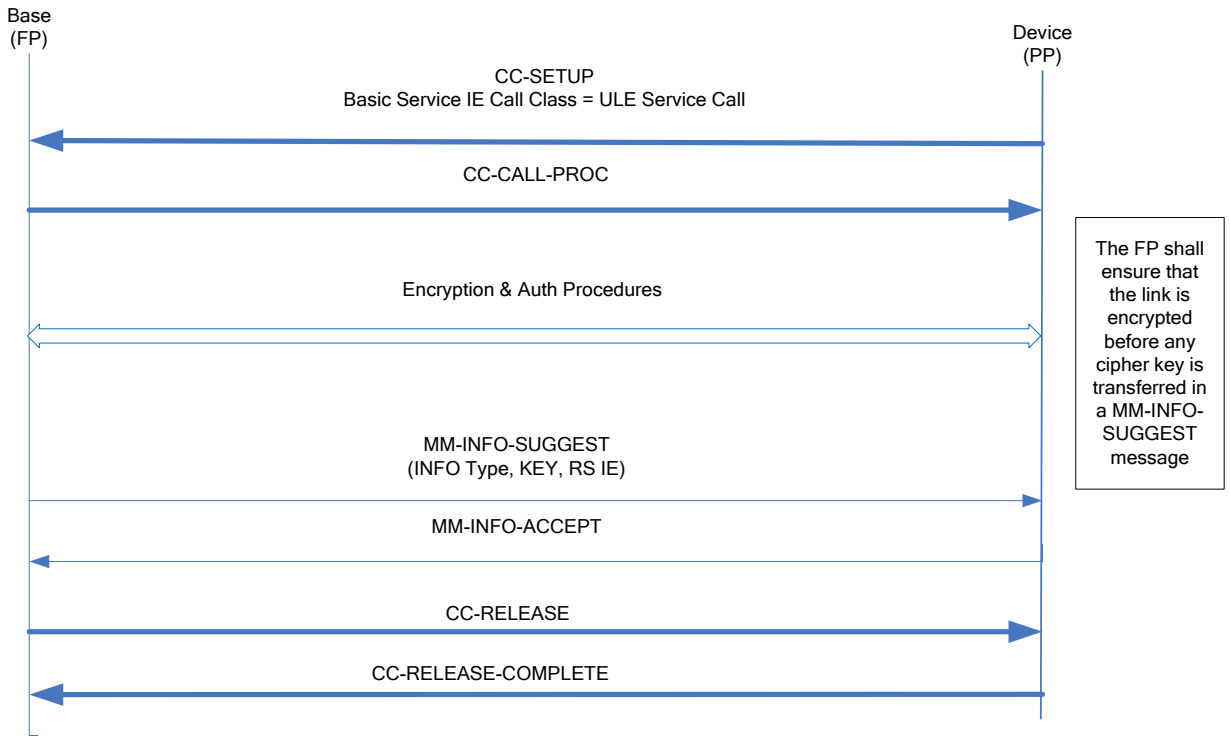

Figure 9 - Multicast channel encryption parameters reassigned by FP

8.7 Multicast Channel Encryption parameters retrieval

In case PP cannot decrypt the multicast SDU, it can retrieve the encryption parameters using the following procedure.

The PP establishes a ULE Service Call and sends to the FP a *{MM-INFO-REQUEST}*.

The FP will then send a *{MM-INFO-SUGGEST}* with the updated encryption parameters.

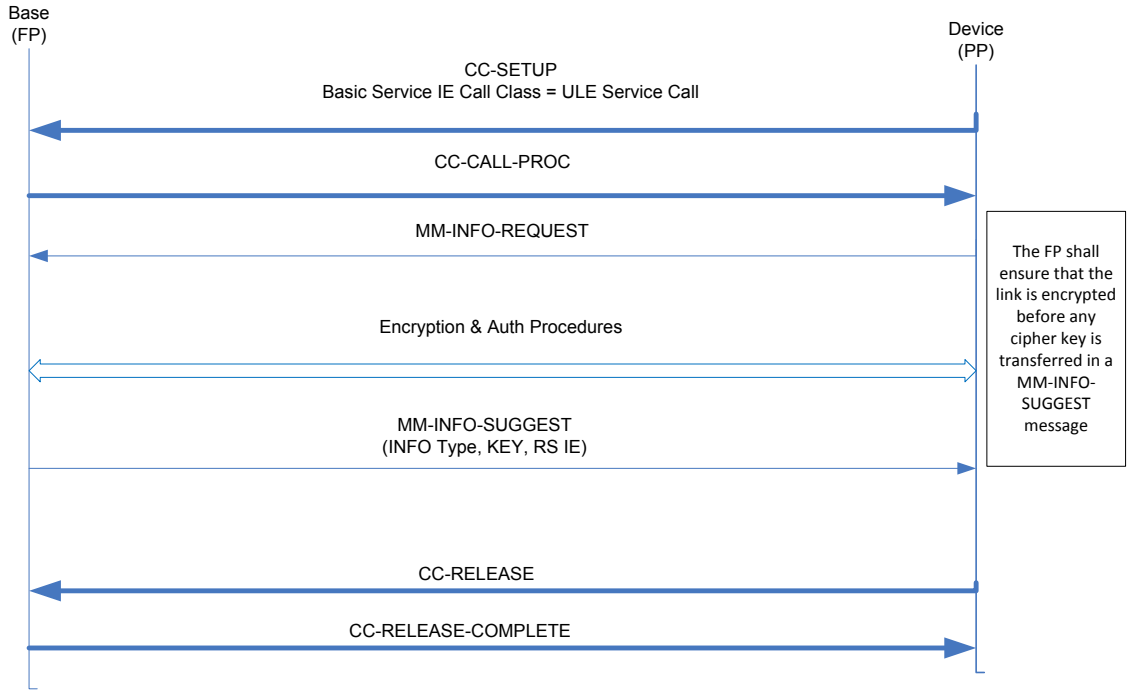

Figure 10 - Multicast channel encryption parameters retrieval by PP

9. Software Update Over The Air (SUOTA)

The procedure used by ULE to perform a SUOTA is as defined in TS 102 527-4 [8], specifically the "Binary content download" section.

Whenever either the FP or the PP are updated with new software it shall be indicated to peer end so that re-registration of the PP can happen so that required and new capabilities can be negotiated and known to each other.

In general, if after SUOTA, any of the following has changed due to upgraded software then the device should do re-registration of stage 2 and stage 3:

- Version in IWU-ATTRIBUTE;
- Device's page-ability feature (non-page-able device become page-able or vice versa);
- Device's multicast ability feature (non-multicast device becomes multicast-able or vice versa);

Change in Device's units or interface support;

After SUOTA the PP will setup a service call with the FP to indicate the update in Software through <<*IWU-ATTIRBUTES*>> using *{CC-SERVICE-CHANGE}* (other) message and if the PP gets back a positive response from the FP, with a *{CC-SERVICE-ACCEPT}* (other) then PP continues to do the re-registration procedure (stage 2 and stage 3) in the same service call.

However, it is still recommended to cross check the version of the peer end and be compatible with each other, i.e. higher version of software will always honor the capabilities of lower version software.

Regarding the stage 2 re-registration the PP should use one of the three call flows depending on the ability to page and multicast support, as indicated in 9.1, 9.2 and 9.3.

Note: Since devices are already in PVC RESUME state, the devices shall first SUSPEND the PVC state and should continue rest of the Stage 2.

9.1 Non page-able non multicast-able device

After SUOTA and in case the PP is not page-able and not multicast-able, it should initiate a ULE Service Call similar to the procedure described in Figure 11.

Note: the PP shall do the service change SUSPEND after the *{CC-SERVICE-CHANGE}* (other) <<IWU-ATTIRBUTES>> (version 2 or higher) is received from the FP and continue with the rest of the procedure.

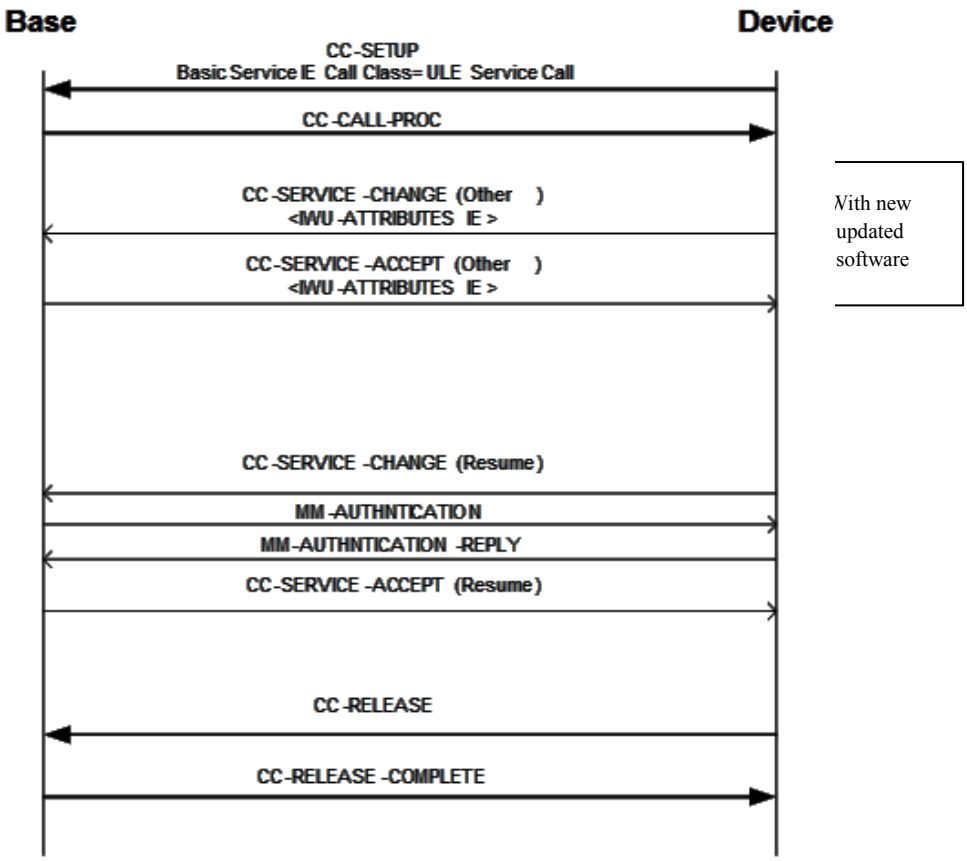

Figure 11 - Procedure after SUOTA for Non Page-able and non-multicast-able device

9.2 Device becomes page-able

After SUOTA and device becomes page-able and not multicast-able, then the PP should initiate a ULE Service Call similar to the procedure described inFigure 12.

Note: the PP shall do *{CC-SERVICE-CHANGE}* SUSPEND after the *{CC-SERVICE-CHANGE}* (other) <<IWU-ATTIRBUTES>> (with version 2 or higher) is received from the FP. The PP should then continue with the rest of the registration procedure.

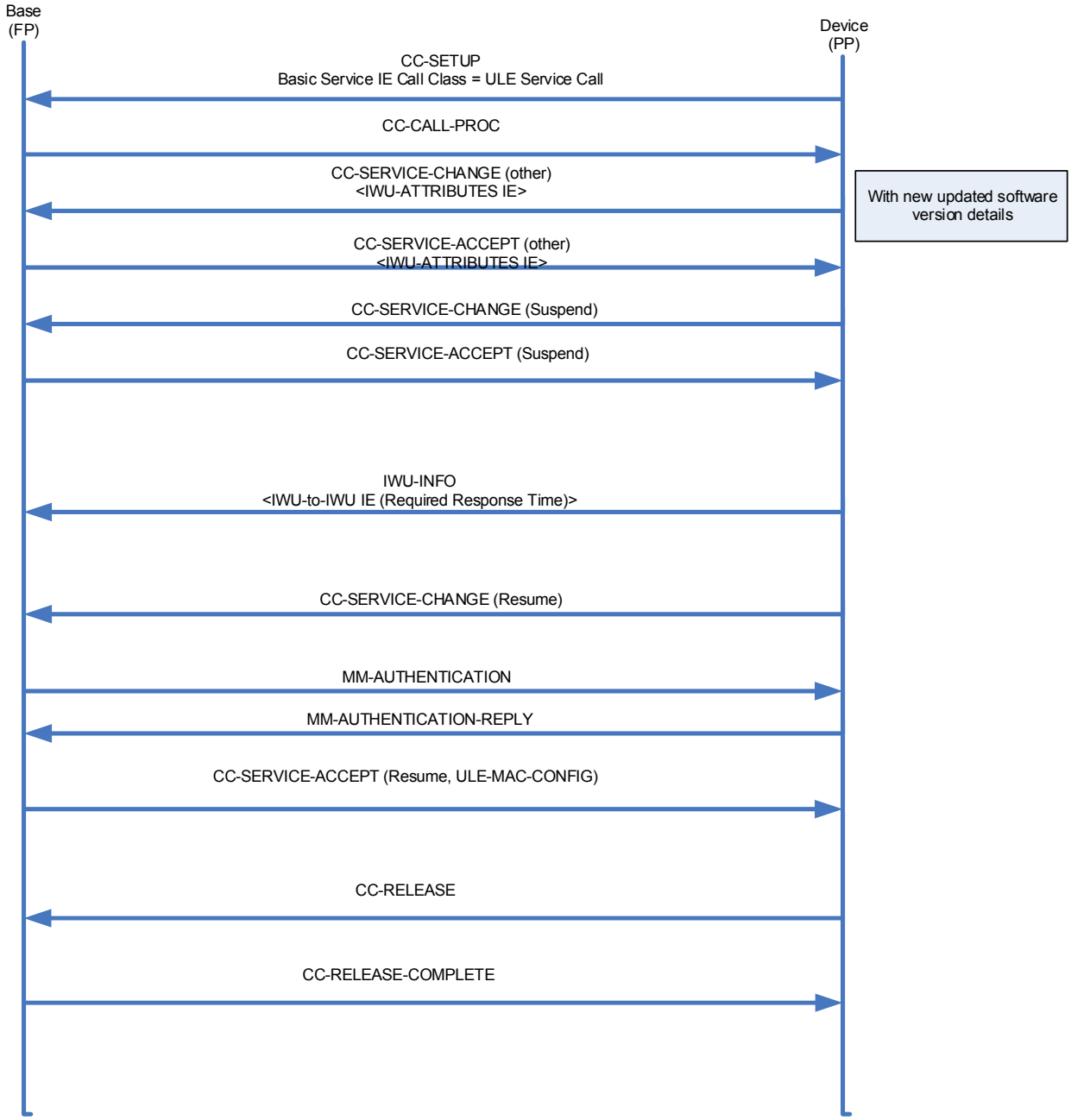

Figure 12 - Procedure after SUOTA for Page-able device

9.3 Device becomes page-able and multicast-able

After SUOTA and device becomes page-able and multicast-able, then the PP should initiate a ULE Service Call similar to the procedure described in Figure 13.

Note: the PP shall do *{CC-SERVICE-CHANGE}* SUSPEND after the *{CC-SERVICE-CHANGE}* (other) <<IWU-ATTIRBUTES>> (with version 2 or higher) is received from the FP. The PP should then continue with the rest of the registration procedure.

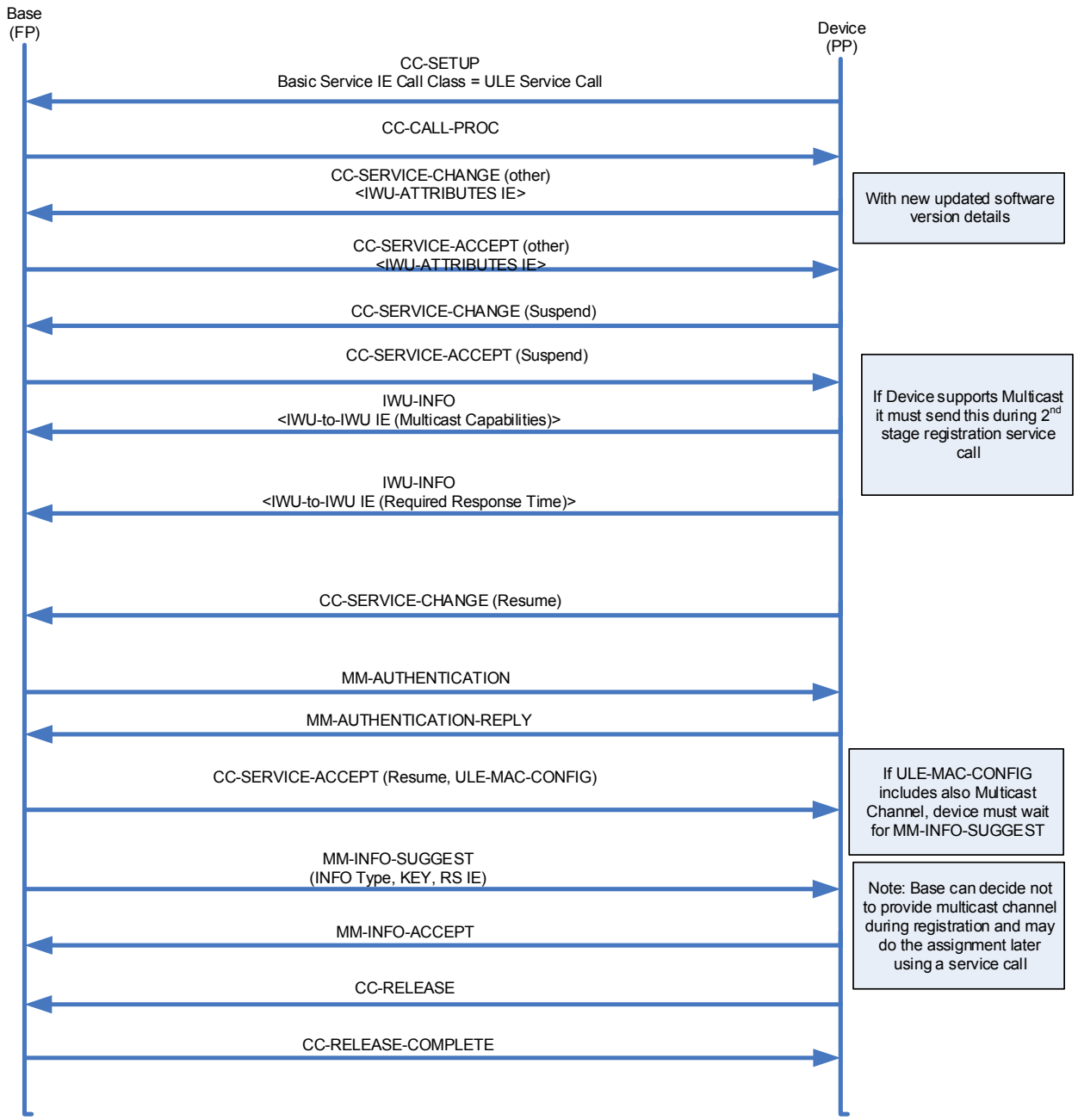

Figure 13 - Procedure after SUOTA for Page-able and multicast-able device

9.4 Base upgrade

When either the FP or PP, are updated with new software it shall be indicated to peer end so that re-registration of the PP can happen, so the new capabilities can be negotiated and known to each peer.

The intention of the below procedure is to be able to reconfigure the network so that existing PPs can take advantage of the new features present in the FP, e.g. when a service provider upgrades the firmware of a FP.

After a software upgrade of the FP, it shall request the PP to do service call by releasing the expedited link with release reason as “Start ULE service call”.

When device establishes the service call the FP use this service call to indicate the update in Software *<<IWU-ATTIRBUTES>>* using *{CC-SERVICE-CHANGE}* (other) message as shown in Figure 14.

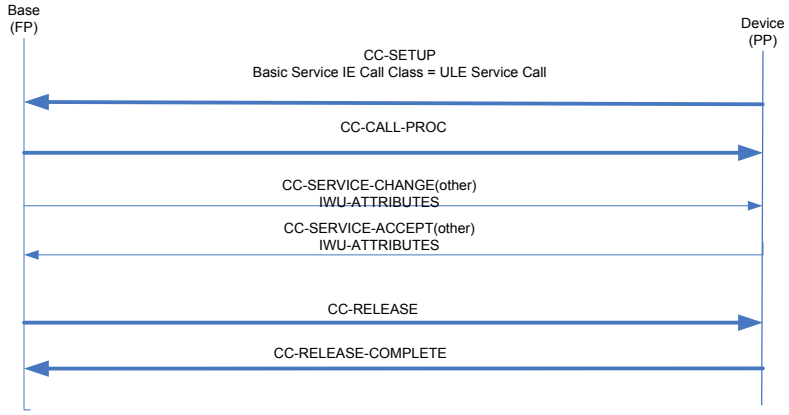

Figure 14 - Procedure after FP software update

Since initiating this *{CC-SERVICE-CHANGE}* (other) from the FP is a new procedure (starting from version 2) the PP may behave in any of the following manners depending upon its software version:

- Ignore this message
- Send *{CC-SERVICE-REJECT}* (other)
- *{CC-SERVICE-ACCEPT}* (other)

The first 2 cases may happen in the case the PP has software supporting only version 1, where this new feature is not present. In these cases no re-registration from PP is required until the PP is updated to a newer version. The FP shall release the service call and the FP shall behave as version 1 FP for that PP despite being updated to newer version, so that backward compatibility is ensured.

If the PP responds with *{CC-SERVICE-ACCEPT}* (other) indicating that it supports this new feature, can then decide to do the re-registration procedure (phase 2 & 3) if required (for e.g. device is v2 and now base sends its version as v2) as explained in sections 9.1, 9.2 and 9.3.

In general, the PP shall do the re-registration procedure when the PP follows the above procedure to indicate its version and the new version of the FP is greater than the version the PP has in its database, from the previous registrations, for that FP.

9.5 Handling negative response from FP for the software update notification from the PP

If the FP is not responding to CC-SERVICE-CHANGE (other) message from the PP or responds back with CC-SERVICE-REJECT (other), it shall be interpreted as the FP is of older version (version 1) and the PP shall release the service call.

In this case the PP shall still behave as a version 1 device to be backward compatible with the FP despite being updated to a newer version.

Annex A - Information Elements coding

<<IWU-ATTRIBUTES>>

The base standard EN 300 175-5 defines the basic structure of the IE, and the present document describes the profile-specific structure.

Bit								Octet
8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
0	<< IWU-ATTRIBUTES >>							**1**
Length of Contents (L)								**2**
1	0	1	Profile					**3**
1	Negotiation indicator		Profile subtype					**4**
1	IWU function at FP							**5**
0	Maximum MTU/SDU size PT => FT (most significant 7 bits)							**6**
0/1	Maximum MTU/SDU size PT => FT (least significant 7 bits)							**6a**
0	Maximum MTU/SDU size FT => PT (most significant 7 bits)							**6b**
1	Maximum MTU/SDU size FT => PT (least significant 7 bits)							**6c**
0	ULE Application Protocol Identifier							**7**
0/1	ULE Application Protocol Version							**7a**
0	EMC or extended Application Protocol Identifier							**7b**
0	EMC or extended Application Protocol Identifier (continued)							**7c**
1	EMC or extended Application Protocol Identifier (continued)							**7d**
	. . .							
0	ULE Application Protocol Identifier							**k**
0/1	ULE Application Protocol Version							**ka**
0	EMC or extended Application Protocol Identifier							**kb**
0	EMC or extended Application Protocol Identifier (continued)							**kc**
1	EMC or extended Application Protocol Identifier (continued)							**kd**

Figure A.2: ULE specific <<IWU-ATTRIBUTES>> information element coding

Coding Standard (octet 3):

Bit							Meaning
7	**6**	**5**	**4**	**3**	**2**	**1**	
0	1	x	x	x	x	x	Profile Defined Coding

Profile (octet 3):

Bit							Meaning
7	**6**	**5**	**4**	**3**	**2**	**1**	
x	x	1	0	0	0	0	ULE Profile

Negotiation indicator (octet 4):

Bit							Meaning
7	6	5	4	3	2	1	
0	0	0	x	x	x	x	Negotiation not possible
1	0	0	x	x	x	x	Exchanged parameter negotiation
0	1	0	x	x	x	x	Peer attribute negotiation
1	1	0	x	x	x	x	Exchanged parameter negotiation and Peer attribute negotiation
x	x	x	x	x	x	x	All other values reserved

Profile subtype (octet 4):

Bit							Meaning
7	6	5	4	3	2	1	
x	x	x	0	0	0	0	ULE Part 1 transparent Interworking
x	x	x	x	x	x	x	All other values reserved

IWU functionality at FP (octet 5):

Bit							Meaning
7	6	5	4	3	2	1	
x	0	0	0	0	0	0	Undefined
x	0	0	0	0	0	1	Transparent routing
x	x	x	x	x	x	x	All other values reserved

Maximum MTU/SDU size PT => FT (or bidirectional) (octets 6 and 6a):

This 14-bit word represents the natural binary coding of the maximum MTU/SDU length, in units of four bytes (32 bits) to be used in PT => FT direction. The sending side shall not send MTU/SDU bigger than this value. The least significant bit shall be in position 1 of octet 6.

Maximum MTU/SDU size FT => PT (octets 6b and 6c, optional):

This 14-bit word represents the natural binary coding of the maximum MTU/SDU length, in units of four bytes (32 bits) to be used in FT => PT direction. The sending side shall not send MTU/SDU bigger than this value. The least significant bit shall be in position 1 of octet 6b.

If octets 6b and 6c are not present, the MTU/SDU size value defined for PT => FT direction shall be also used if FT => PT direction.

NOTE 1: In the Interworking type "transparent interworking" the size of the SDU is equal to the size of the external MTU.

ULE Application Protocol Identifier (octet 7, k):

Bit							Meaning
7	**6**	**5**	**4**	**3**	**2**	**1**	
0	0	0	0	0	0	0	Undefined
0	**0**	**0**	**0**	**0**	**0**	**1**	**ULE HAN-FUN Protocol Version 1**
0	**0**	**0**	**0**	**0**	**1**	**0**	**ULE HAN-FUN Protocol Version 2**
1	x	x	x	x	x	x	Proprietary ULE Protocols
x	x	x	x	x	x	x	All other values reserved

NOTE 2: When the coding for Proprietary ULE protocols is used, the bits 1 to 6 may be freely coded by the vendor to specify different proprietary protocols or any other use. The FP and PP may also use proprietary messaging to negotiate the protocol used.

ULE Application Protocol Version (octet 7a, ka):

Bits 1-7 form a version number which may be used to further identify the ULE Application Protocol. A value of 0 shall be used when there is no specific requirement to specify the version.

Note: This should be set to 1 for FUN version 1.0.

Note: This should be set to 2 for FUN version 1.4.

EMC or extended Application Protocol Identifier (octet 7b-7d, kb-kd, optional):

If bit 7 of the Application Protocol Identifier is set to '1' (proprietary application protocol) these three octets are used to code the EMC field that may be used to discriminate between different proprietary protocols. The EMC is a 16 bit number, which is inserted into the 'EMC field' as follows:

Octet 7b, kb : 7 most significant bits of EMC (LSB inserted into bit 1 of 7b,kb)

Octet 7c, kc : next 7 most significant bits of EMC (LSB inserted into bit 1 of 7c,kc)

Octet 7d, kd : least significant 2 bits (LSB inserted into bit 1 of 7d,kd)

NOTE 3: The use of standard IE coding rules allow the octet group 7, k to be ended at the end of 7a, ka. This means that the addition of the EMC is optional in the IE, and may be omitted, if not required by the specified ULE Application Protocol.

If bit 7 of the Application Protocol Identifier is set to '0' the three octets 7b, 7c and 7d (or kb, kc, kd) are used to extend the Application Protocol Identifier, that has now 4 octets with a total of 4 x 7 bits. Most significant 7 bits are coded in octet 7 (or k) and LSB in octet 7d (or kd).

NOTE 4: A total of 20 bits are usable since bit 1 of octet 7 (or k) has to be set to '0'.

<<IWU-to-IWU>>

The <<*IWU-to-IWU*>> Information Element may be used to transport data between ULE applications peer-to-peer (i.e., FP to PP) in both directions.

The base standard EN 300 175-5 [5] defines the basic structure of the IE. The actual payload data for the **<<IWU-to-IWU INFORMATION>>** is ULE Application Protocol specific, and is not defined in the present document.

Bit								**Octet**
8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
0	<<IWU-to-IWU>>							**1**
Length of Contents (L)								**2**
1	S/R	Protocol Discriminator						**3**
								4
IWU-TO-IWU INFORMATION								
								L+2

Discriminator type (octet 3, Bits 6 to 1):

For ULE Configuration and Control the value should be set to '05'H
When this value is set the IWU-TO-IWU INFORMATION is defined as below.

IWU-TO-IWU-INFORMATION

Bit								**Octet**
8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
1	Protocol Discriminator							**4**
								5
Discriminator Specific Content								
								L+2

Discriminator type (octet 4):

Bit							Meaning
7	**6**	**5**	**4**	**3**	**2**	**1**	
0	0	0	0	0	0	0	ULE Common Control Protocol
0	**0**	**0**	**0**	**0**	**0**	**1**	**ULE HAN-FUN Application Protocol Version 1**
0	**0**	**0**	**0**	**0**	**1**	**0**	**ULE HAN-FUN Application Protocol Version 2**
1	x	x	x	x	x	x	Proprietary ULE Protocols
x	x	x	x	x	x	x	All other values are reserved.

Discriminator Content for ULE Functional Application Protocol (FUN)

Bit								Octet
8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
FUN Commands Class								**5**
FUN Command								**6**
								7
FUN Command Content								
								L+2

FUN Class of Commands (octet 5):

The FUN Class of Commands

FUN Command (octet 6):

The FUN Command

FUN Command Content (octet 7 to L+2):

The FUN Command Content

List of FUN Classes of Commands

Command Class Name	Command Class Value	Description
Registration Class	0x01	Commands related to registration
Reserved	All other values	Reserved for future class of commands

List of FUN Commands

List of Command of Class 'Registration'

Command	Command Class Value	Description
Paging Required	0x01	Indicates to FP that PP is capable of Paging and also pass the Required Response Time
Multicast Capabilities	0x02	Indicates to Base that Device is capable of Multicast and also pass the type of multicast supported
Reserved	All other values	Reserved for future class of commands

Commands Content Description

'Paging Required' Command Content description

Data in FUN Command Content

Field Name	Field Description	Type	Value	M/O
Required Paging Response Time	Required Paging Response time in 10^{th} of Milliseconds	U16	0x0000 - 0xFFFF	M

'Multicast Capabilities' Command Content description

Data in FUN Command Content

Field Name	Field Description	Type	Value	M/O
Multicast capabilities	What type of multicast is supported	U8	0x01 – Dummy Only, SDU consist of 1 PDU, retransmission	M

Annex B - Using ULE Dummy bearer for Multicast

ETSI TS 102 939-2 V1.1.1 describes the Multicast over ULE dummy and just for the sake of completeness and better understanding this appendix covers some important aspects of Multicast over ULE dummy and extends for repetition of Multicast. When this document is updated there are already following CRs are available for Multicast repetition:

- DECT(17)000090_ULE_C_L_Downlink_Repeat_Mechanism.doc
- DECT(17)000091_CR_for_ULE_C_L_Downlink_Repeat_Mechanism.doc

The ULE Multicast is a feature of ULE Phase-2. This Interworking document mandates that if any FP or PP implements ULE Phase 2 then this Multicast feature is mandatory and the working shall be as below:

1. Adding a device to Multicast happens only after Registration and when FP has the unicast paging details of that particular device. For eg. After Phase 3 of HANFUN registration.
2. Only down-link multicast has to be implemented; no up-link.
3. No response shall be sent for received multicast messages by setting up a new bearer as it might flood the ULE traffic.
4. ETSI TS 102 939-2 V1.1.1 (ULE phase 2) mentions the following about multicast:
    - sending multicast over dummy is mandatory and setting up new C/L channel is optional;
    - only a single burst multicast message is possible

    So considering above points this Interworking document mandates for ULE Phase 2 devices to use dummy for multicast and the message is of single frame.

5. The data over ULE dummy shall be sent over any of the frames 1, 5,9,13 with announcement in any of the previous frames w.r.t to data frames.
6. If the Multicast service requires re-transmissions then the data shall be repeated a minimum of N times (i.e. transmitted N+1 times in total) with announcement for each multi-frame. Since it is the repetition of same packet with same sequence number the device shall ignore if it is already received before.
7. Since data can be sent over 1, 5,9,13 there is a possibility to optimize by sending multicast messages to four different multicast groups if required within one multi-frame (this needs more analysis though to understand the side effects). In this case one has to be careful that announcement to a particular multicast group shall happen before the data packet.
   For example:
    - Group 1 can send data in frame 1 then announcement shall happen in frame 0;
    - Group 2 can send data in frame 5 then announcement shall happen in frame 2 or 3 or 4;
    - Group 3 can send data in frame 9 then announcement shall happen in frame 6 or 7 or 8;
    - Group 4 can send data in frame 13 then announcement shall happen in frame 10 or 11 or 12;
8. Announcement and sending data for a particular multicast group can be in two different multi-frames provided the announcement happens before data is sent out.
   For example:
    - Announcement is made on frame 14 and the data is sent on frame 1 of the following multi-frame;

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