ETSI TS 103 636-4 V1.4.1 (2023-01)

DECT-2020 New Radio (NR);
Part 4: MAC layer;
Release 1

Reference
RTS/DECT-00378

Keywords
DECT, DECT-2020, IMT-2020, MAC, NR, radio

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Digital Enhanced Cordless Telecommunications (DECT).

The present document is part 4 of a multi-part deliverable covering the DECT-2020 New Radio (NR) technology. Full details of the entire series can be found in part 1 [1].

DECT-2020 NR is recognized in Recommendation ITU-R M.2150 [i.2] as a component RIT fulfilling the IMT-2020 requirements of the IMT-2020 use scenarios URLLC and mMTC. The Set of Radio Interface Technology (SRIT) called "DECT 5G SRIT" is involving 3GPP NR and DECT-2020 NR.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document is one of the parts of the specification of the DECT-2020 New Radio (NR).

The present document specifies the Medium Access Control (MAC) layer and interactions between the MAC layer and physical layer and higher layers.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 103 636-1: "DECT-2020 New Radio (NR); Part 1: Overview; Release 1".

[2] ETSI TS 103 636-2: "DECT-2020 New Radio (NR); Part 2: Radio reception and transmission requirements; Release 1".

[3] ETSI TS 103 636-3: "DECT-2020 New Radio (NR); Part 3: Physical layer; Release 1".

[4] FIPS PUB 197: "Advanced Encryption Standard (AES)".

[5] NIST Special Publication 800-38B: "Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication".

[6] ETSI TS 103 636-5: "DECT-2020 New Radio (NR); Part 5: DLC and Convergence layers; Release 1".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EN 300 175 (all parts): "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI)".

[i.2] Recommendation ITU-R M.2150: "Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

Fixed Termination point (FT): operational mode of an RD where the RD initiates, coordinates local radio resources, and provides information on how other RDs may connect and communicate with it

operating channel: single continuous part of the radio spectrum with a defined bandwidth where RDs transmit and/or receive as defined in ETSI TS 103 636-2 [2]

Portable Termination point (PT): operational mode of RD where RD selects another RD, which is in FT mode, for association

Radio Device (RD): device with radio transmission and reception capability which can operate in FT and/or PT mode

resource: variable length time unit defined in subslot(s) or slot(s) in the single operating channel that an RD is using for transmission or reception of a physical layer packet

NOTE: Resource can be contentious or contention free, i.e. scheduled.

slot: unit of a radio frame as defined in ETSI TS 103 636-3 [3], clause 4

subslot: unit of a radio frame as defined in ETSI TS 103 636-3 [3], clause 4

NOTE: Subslots in the frame are numbered in increasing order and the first subslot of the radio frame is number 0.

3.2 Symbols

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

0x Value in hexadecimals

β Fourier transform scaling factor

NOTE: As defined in ETSI TS 103 636-3 [3].

μ Subcarrier scaling factor

NOTE: As defined in ETSI TS 103 636-3 [3].

RSSI-1 RSSI-1 measurement

NOTE: As defined in ETSI TS 103 636-2 [2].

RSSI-2 RSSI-2 measurement

NOTE: As defined in ETSI TS 103 636-2 [2].

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 636-1 [1] and the following apply:

NOTE: An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in ETSI TS 103 636-1 [1].

ACK Acknowledgement
BCC Broadcast Control
BCCH Broadcast Control Channel
BLER Block Error Ratio
BS Buffer Size

BSC	Beacon Scanning Control
CCC	Connection Configuration Control
CCCH	Common Control Channel
CMAC	Cipher-based Message Authentication Code
CQI	Channel Quality Indicator
CTR	Counter mode
DCCH	Dedicated Control Channel
DCH	Dedicated Channel
DF	Data Field

NOTE: As defined in ETSI TS 103 636-3 [3].

DTCH	Dedicated Traffic Channel
FO	Frame Offset
FT	Fixed Termination point
GI	Guard Interval

NOTE: As defined in ETSI TS 103 636-3 [3].

HARQ	Hybrid Automatic Repeat reQuest
HPC	Hyper Packet Counter
HW	Hardware
ID	Identity
IE	Information Element
IV	Initialization Vector
LBT	Listen Before Talk
LRC	Local Radio Control
MCS	Modulation and Coding Scheme
MIC	Message Integrity Code

NOTE: Same as Message Authentication Code.

MIMO	Multiple Input Multiple Output
MSB	Most Significant Bit
MTCH	Multicast (Broadcast) Traffic Channel
MUX	Multiplexing
NA	Not Applicable
NACK	Negative Acknowledgement
NSS	Number of Spatial Streams
OFDM	Orthogonal Frequency Division Multiplexing
PCC	Physical Control Channel
PCCH	Paging Common Channel
PCH/BCH	Paging and Broadcast Channel
PDC	Physical Data Channel
PDU	Protocol Data Unit
PSN	Packet Sequence Number
PT	Portable Termination point
PTC	Paging Transmission Control
RAC	Random Access Control
RACH	Random Access Channel
RD	Radio Device
RSSI	Received Signal Strength Indicator
SDU	Service Data Unit
SFN	System Frame Number
SNR	Signal to Noise Ratio
STF	Synchronization Training Field

NOTE: As defined in ETSI TS 103 636-3 [3].

4 General

4.1 Introduction

The objective of this clause is to describe the MAC protocol layer architecture, used identities, used transport channels and mapping MAC PDU into physical layer packet.

4.2 MAC Architecture

4.2.1 General

This clause describes a model of the MAC i.e. it does not specify or restrict implementations.

4.2.2 MAC Structure

The overall MAC structure is depicted in Figure 4.2.2-1. MAC provides DTCH and MTCH logical channels for transferring higher layer data. The flow of the higher layer data and MAC internal messages to physical channels is depicted with black solid lines. The grey dashed line corresponds to MAC internal control interfaces between MAC functions and the MAC control entity.

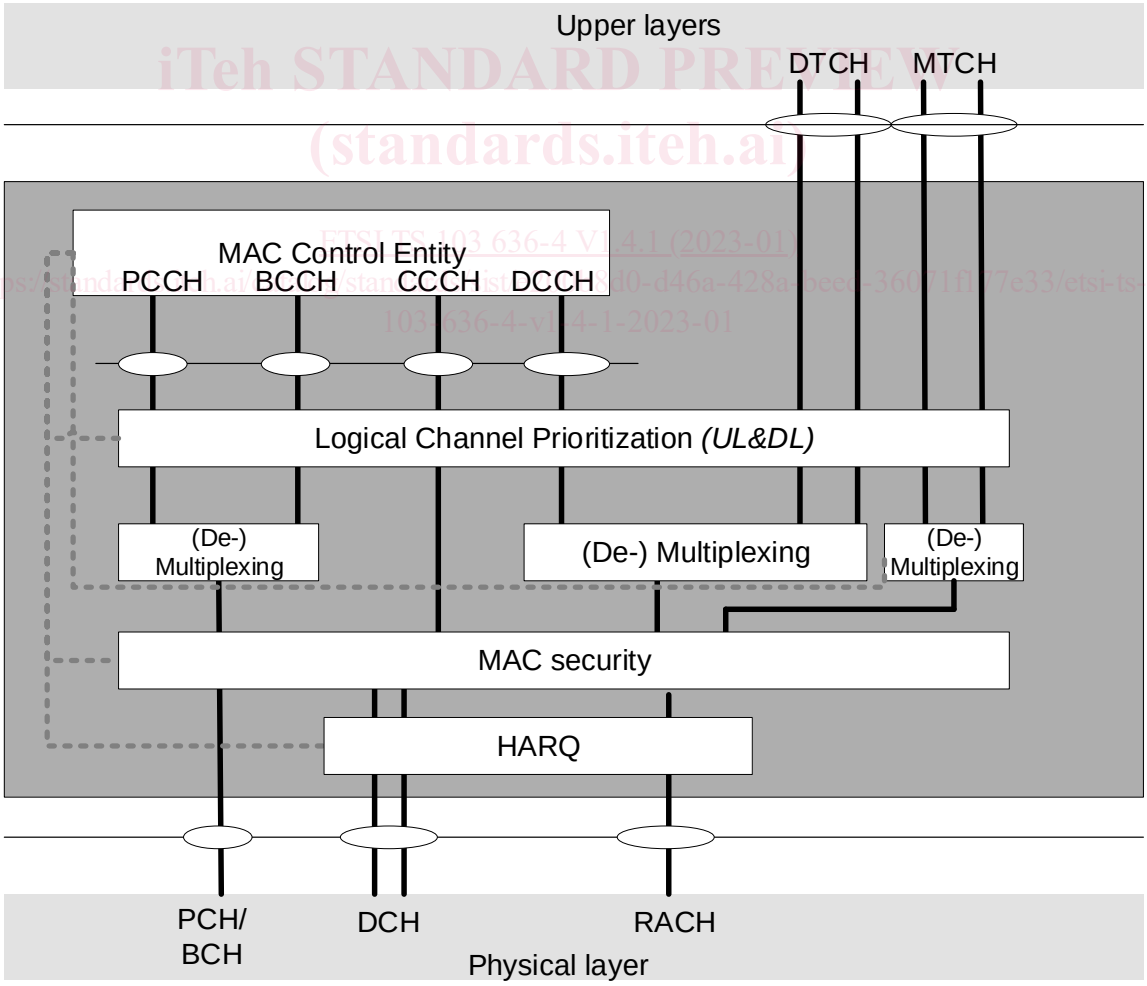

Figure 4.2.2-1: MAC structure overview

The MAC layer of the Radio Device (RD) handles the transmission and reception of the following transport channels:

- Paging and Broadcast Channel (PCH/BCH);

- Dedicated Channel (DCH);
- Random Access Channel (RACH).

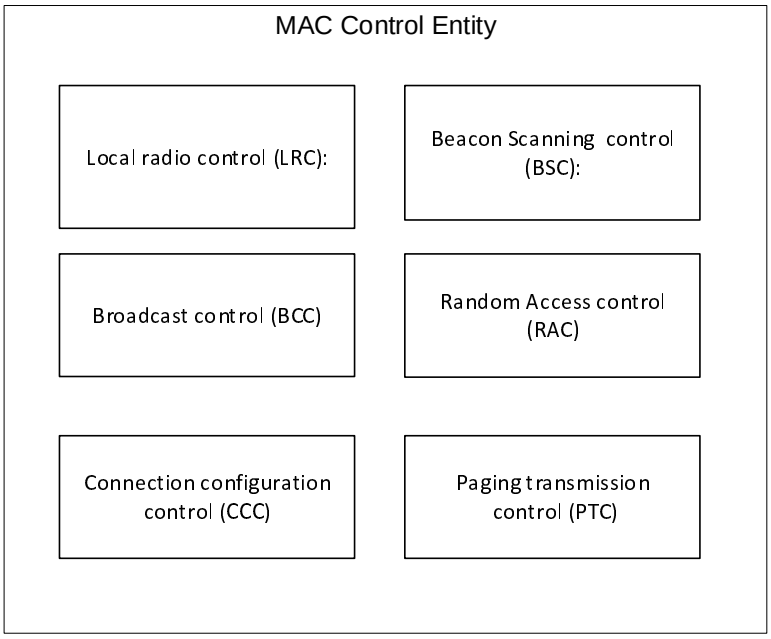

Figure 4.2.2-2: MAC control Entity

The MAC control entity is depicted in Figure 4.2.2-2 and described in clause 4.4.

4.2.3 Identities

4.2.3.1 Network ID

The Network ID has a length of 32 bits, and the first 24 MSB bits are used to identify a DECT-2020 network uniquely from other DECT-2020 networks. The 8 LSB bits of the network are selected locally to minimize collision with other networks.

The network ID is transmitted periodically in beacon messages as plain text enabling other RDs to detect which network the transmitted beacon belongs to.

The last 8 LSB bits of the network ID are transmitted in the PHY control field of the packet as defined in clause 6.2.

The 24 MSB bits of the network ID are provided to the PHY layer to initialize the PDC scrambling sequence in clause 7.6.6 of ETSI TS 103 636-3 [3].

The network ID can be set to any other value than 0x00000000.

NOTE: The Network ID should be set in such a manner that the maximum likelihood for a unique identity for a network is obtained due to randomness of 2 to the power of 32.

4.2.3.2 Long Radio Device ID (Long RD ID)

The Long radio device ID has a length of 32 bits, and it identifies a radio device uniquely in a single DECT-2020 network. The coding of the Long RD ID is defined in Table 4.2.3.2-1. An RD obtains the Long RD ID as part of the authentication process over the DECT-2020 NR system or via manual provision or by using other communication channels.

The Long RD ID is used in:

- an association procedure to recognize associating RDs uniquely;
- MAC layer security procedures;

- packet routing in mesh system operation to identify the original source and the final target receiver of the routed data packet as defined in ETSI TS 103 636-5 [6].

Table 4.2.3.2-1: Use of Long RD ID address space

Address type	Address field	Comment
Reserved address	0x00000000	Shall not be used as it is considered as not defined.
Backend address	0xFFFFFFFE	Indicates that a packet is to be delivered out from the DECT-2020 system, i.e. to a backend system.
Broadcast address	0xFFFFFFFF	This address can be used to indicate that a packet needs to be received by all RDs in the system when performing packet routing.
Long RD ID	0x00000001-0xFFFFFFFD	This address space is used to identify a radio device uniquely in a DECT-2020 system.
Multicast address	0x00000001-0xFFFFFFFD	The system configuration defines a range of addresses that are used as multicast addresses in the given system. A multicast group can use any of those addresses. When the receiver address of the packet is a multicast group the packet is intended for all members of that group. An RD can be part of one or multiple multicast groups.

The Long RD ID is transmitted in a MAC PDU to:

- identify the receiver and the transmitter of the packet in the association procedure for exchanging Short RD IDs; or
- when the transmitter of the MAC PDU considers that there is a potential confusion on Short RD IDs.

When an RD is initiating authentication over a DECT-2020 NR network the RD can use a random value or application defined value as a Long RD ID from the Long RD ID space defined in Table 4.2.3.2-1, if no valid Long RD ID value is available from the previous authentication procedures.

4.2.3.3 Short Radio Device ID (Short RD ID)

The Short radio device ID has a length of 16 bits, and it identifies a radio device locally in a DECT-2020 NR network. The coding of the Short RD ID is defined in Table 4.2.3.3-1.

The Short RD ID is used in the PHY control field as in transmitter or receiver fields to identify the transmitter and the receiver of the packet.

The Short RD ID is exchanged during the association procedure between RDs performing association so that linkage between Short RD ID and Long RD ID is obtained by both associating RD. Each radio device randomly selects a Short RD ID value that it uses in the association.

Table 4.2.3.3-1: Use of Short RD ID address space

Address type	Address field	Comment
Reserved address	0x0000	Shall not be used as it is considered as not defined
Short RD ID	0x0001-0xFFFE	This address space is used to identify RD in the PHY control field
Broadcast address	0xFFFF	This address can be used to indicate that transmission is a broadcast MAC PDU

4.3 Service

4.3.1 Services provided to upper layers

The MAC layer provides the following services to upper layers:

- data transfer;
- radio resource allocation.

4.3.2 Services expected from physical layer

The MAC layer expects the following services from the physical layer:

- data transfer services in physical layer packets;
- measurements.

4.4 Functions

The MAC layer supports the following control functions in the MAC control entity:

- Local Radio Control (LRC): This function is overall in charge of the radio resource in the local coordination area, when the RD coordinates local radio resources, i.e. operates as an FT.
- Paging Transmission Control (PTC): This function controls paging message transmission when the RD coordinates local radio resources, i.e. operates as FT.
- Broadcast Control (BCC): This functionality controls Beacons and other broadcast/multicast transmissions.
- Random Access Control (RAC): This functionality is in charge of random access transmissions.
- Beacon Scanning Control (BSC): This function controls scanning operations.
- Connection Configuration Control (CCC): This functionality controls multiplexing, mapping data to transport channels, MCS, HARQ configuration, MAC security and handovers with LRC.

The MAC layer supports the following transmission functions:

- paging and broadcast signalling;
- control signalling;
- radio resource management by channel selection and channel access procedures;
- logical channel prioritization;
- mapping between logical channels and transport channels;
- multiplexing of MAC SDUs from one or different logical channels onto the MAC PDU to be delivered to the physical layer via transport channels;
- demultiplexing of MAC SDUs to one or different logical channels from transport blocks MAC PDU delivered from the physical layer via transport channels;
- error correction through HARQ;
- MAC layer security by providing integrity protection and ciphering.

4.5 Channel Structure

4.5.1 Logical and Transport Channels

The MAC layer provides data transfer services on logical channels. To accommodate different kinds of data transfer services, multiple types of logical channels are defined i.e. each supporting transfer of a particular type of information.

Each logical channel type is defined by what type of information is transferred. The MAC has a set of internal logical channels and logical channels to higher layers.

The MAC layer has the control and traffic channels listed in Table 4.5.1-1.

Table 4.5.1-1: Logical channels provided by MAC

Logical channel name	Acronym	Available for higher layers	Control channel	Traffic channel
Broadcast Control Channel	BCCH		X	
Paging Control Channel	PCCH		X	
Common Control Channel	CCCH		X	
Dedicated Control Channel	DCCH		X	
Dedicated Traffic Channel	DTCH	X		X
Multicast Traffic Channel	MTCH	X		X

The MAC sublayer uses the transport channels listed in Table 4.5.1-2.

Table 4.5.1-2: Transport channels used by MAC

Transport channel name	Acronym	Downlink	Uplink
Paging and Broadcast Channel	PCH/BCH	X	
Dedicated Channel	DCH	X	X
Random Access Channel	RACH	X	X

Logical channels can be mapped as described in Table 4.5.1-3.

Table 4.5.1-3: Channel mapping

Transport channel / Logical channel	PCH/BCH	DCH	RACH
BCCH	X		
PCCH	X		
CCCH			X
DCCH	X	X	X
DTCH		X	X
MTCH	X		X

4.5.2 Mapping Physical layer packet

In packet transmissions transport channels are mapped to Physical Data Channels (PDC) carried in a physical layer packet. Additionally, the MAC provides the number of used spatial streams, and the content of the Physical Layer Control Field to the physical layer. The Physical Layer Control Field is mapped to a Physical Control Channel (PCC) of the physical layer packet.

4.6 Order of transmission and figure numbering conventions

The transmission order is Big endian and left to right:

- A list of octets is transmitted 1st octet first.
- For each octet, bits are numbered 0 to 7 according to the transmission order. Bit 0 is transmitted first (ascending transmission order).
- When bits are numbered in any other MAC structure, they are also numbered according to transmission order.

Whenever an octet or other container represents a numeric quantity the left most bit in the diagram and thus, the first to be transmitted, is the high order or most significant bit.

For octets, the bit labelled 0 is the most significant bit and bit 7 is the least significant bit.

When referring to the bits of a numerical value, ordinal numbers starting by 1st can be used to refer to the bits. 1st bit means the most significant bit, 2nd bit means the second MSB (note that if the value is placed in an octet the first bit is transmitted in bit 0). Last bit, 2nd last, 3rd last, etc. can be used to refer to the 3 least significant bits of the number.

NOTE: The transmission order (endianness and bit transmission order) is identical to DECT (ETSI EN 300 175 [i.1], parts 1 to 8). However the numbering convention in figures (bit numbering in octets carrying numeric values) has been reversed to follow generally accepted conventions.

5 MAC Layer Procedures

5.1 Spectrum Management Procedures

5.1.1 General

An RD shall support the set of cognitive radio spectrum management features, defined in clause 5.1.

In each connection between two RDs, one RD is in FT mode and the other RD is in PT mode. The RD in FT mode coordinates local radio resources and provides information on how other RDs may connect and communicate with it, whereas the RD in PT mode performs functions based on information provided by the RD in FT mode.

The radio resource coordination in an FT mode RD is performed with the following functions:

- Operating carrier(s) and subslot(s) selection by using a background scan as defined in clause 5.1.2.
- Transmitting beacon(s) to enable other RDs to identify, measure and initiate association with the RD, as defined in clause 5.1.5.
- Providing and configuring radio communication parameters of the connections with associated RDs.
- Selecting the optimum power level as defined in clause 5.1.6.

An RD in PT mode operates based on information provided by RDs in FT mode and performs the following functions:

- Selecting RD for the association as defined in clause 5.1.4.
- Performing configured measurements before initiating transmissions to an RD in FT mode as defined in clause 5.1.4 or clause 5.7.
- Selecting the optimum power level as defined in clause 5.1.6.

A single RD can operate both in FT and PT modes simultaneously, i.e. in FT mode it coordinates radio resources for other RDs connecting to it as well as in PT mode it is connected to another RD, which operates in FT mode.

5.1.2 Operating Channel(s) and Subslot(s) selection

When an RD initiates FT mode operation, the RD shall initiate the background scan process for finding the operating channels and subslots, which are fulfilling the operating conditions.

The background scan may be done in any order on the supported band(s) and channel(s). For each channel, the RD shall measure at least the duration of the variable *SCAN_MEAS_DURATION* and obtain the RSSI-1 value for each measured subslot.

For each measured subslot on the channel, the RD shall consider whether the subslot is "free", "possible" or "busy". The subslot status is considered as:

- "free" if max(RSSI-1) ≤ *RSSI_THRESHOLD_MIN*;
- "possible" if *RSSI_THRESHOLD_MIN* <max(RSSI-1) ≤ *RSSI_THRESHOLD_MAX;*
- "busy" if max(RSSI-1) > *RSSI_THRESHOLD_MAX*.

within the duration of the measured subslot.