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TECHNICAL SPECIFICATION

DECT-2020 New Radio (NR);
Part 1: Overview;
Release 1

Reference

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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 1 of a multi-part deliverable covering the overall description of DECT-2020 NR standards, as identified below:

Part 1: "Overview";

Part 2: "Radio reception and transmission requirements";

Part 3: "Physical layer";

Part 4: "MAC layer".

The present document introduces the system overview covering massive Machine Type Communication (mMTC) and Ultra-Reliable Low Latency Communication (URLLC) features.

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 provides an overview on DECT-2020 NR including layers, system and network architectures envisioned for this release. Further it provides an overview to ETSI TS 103 636-2 [1], ETSI TS 103 636-3 [2], ETSI TS 103 636-4 [3] and their interrelation.

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

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

[3] ETSI TS 103 636-4: "DECT-2020 New Radio (NR); Part 4: MAC layer; 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.

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

[i.1] ETSI TS 123 501: "5G; System architecture for the 5G System (5GS) (3GPP TS 23.501 Release 16)".

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 RD where RD initiates coordinates local radio resources, provides information how other RDs may connect and communicate with it

operating channel: single continuous part of radio spectrum with a defined bandwidth where RDs transmits and/or receives

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 single operating channel that RD is using for transmission or reception of physical layer packet

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

3.2 Symbols

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

$\mathbf{RD_{FT}}$	RD operating in FT mode
$\mathbf{RD_{FT,PT}}$	RD operating in both FT and PT mode
$\mathbf{RD_{PT}}$	RD operating in PT mode

3.3 Abbreviations

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

ARQ	Automatic Repeat reQuest
BCC	Broadcast Control
BCCH	Broadcast Control Channel
BLER	Block Error Ratio
BPSK	Binary Phase Shift Keying
BSC	Beacon Scanning Control
CCC	Connection Configuration Control
CCCH	Common Control CHannel
CP-OFDM	Cyclic Prefix Orthogonal Frequency Division Multiplexing
CRC	Cyclic Redundancy Check
DCCH	Dedicated Control CHannel
DCH	Dedicated CHannel
DECT	Digital Enhanced Cordless Telecommunications
DL	Downlink
DTCH	Dedicated Traffic CHannel
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FP	Fixed Part
FT	Fixed Termination point
GI	Guard Interval
HARQ	Hybrid Automatic Repeat Request
ID	IDentity
IMT	International Mobile Telecommunications
IoT	Internet of Things
ITU-R	International Telecommunication Union-Radiocommunication sector
LRC	Local Radio Control
LSB	Least Significant Bit
MAC	Medium Access Control
MCS	Modulation and Coding Scheme
MIMO	Multiple Input Multiple Output
mMTC	massive Machine Type Communication
MSB	Most Significant Bit
MTCH	Multicast (Broadcast) Traffic Channel
N3IWF	Non-3GPP Inter-Working-Function
NR	New Radio
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
PHY	Physical Layer
PLMN	Public Land Mobile Network
PT	Portable Termination point
PTC	Paging Transmission Control
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RAC	Random Access Control
RACH	Random Access CHannel
RD	Radio Device
RF	Radio Frequency
RIT	Radio Interface Technology
RSSI	Received Signal Strength Indicator
RX	Receiver
RX-TX	Receive-Transmit
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TNGF	Trusted Non-3GPP Gateway Function
TX	Transmitter
UE	User Equipment
UL	Uplink
ULE	Ultra Low Energy
URLLC	Ultra-Reliable Low Latency Communication
WAN	Wide Area Networks

4 General

4.1 Introduction

DECT-2020 NR is a Radio Interface Technology (RIT) designed to provide a slim but powerful technology foundation for wireless applications deployed in various use cases and markets.

This radio technology includes, but is not limited to Cordless Telephony, Audio Streaming Applications, Professional Audio Applications, consumer and industrial applications of Internet of Things (IoT) such as industry and building automation and monitoring, and in general solutions for local area deployments for Ultra-Reliable Low Latency Communication (URLLC) and massive Machine Type Communication (mMTC) as envisioned by ITU-R for IMT-2020.

In general, DECT-2020 NR as a technology foundation is targeted for local area wireless applications, which can be deployed anywhere by anyone at any time. The technology supports autonomous and automatic operation with minimal maintenance effort. Where applicable, interworking functions to Wide Area Networks (WAN). e.g. PLMN, satellite, fibre, and internet protocols foster the vision of a network of networks.

DECT-2020 NR can be used as a foundation for:

- Very reliable Point-to-Point and Point-to-Multipoint Wireless Links provisioning (e.g. cable replacement solutions);
- Local Area Wireless Access Networks following a star topology as in classical DECT deployment supporting URLLC use cases; and
- Self-Organizing Local Area Wireless Access Networks following a mesh network topology, which enables to support mMTC use cases.

DECT-2020 NR applies similar design principles as in legacy DECT and DECT ULE. Especially the inherent feature of automatic interference management allows deployments without extensive frequency planning. The Mesh networking capability of DECT-2020 NR enables application-driven network topologies and deployments in e.g. IoT and mMTC use scenarios such that the link budget of classical cellular base-station to user equipment constellations is no longer a limiting factor.

The DECT-2020 NR physical layer is in principle is suited to addressing frequency bands below 6 GHz. The physical layer employs Cyclic Prefix Orthogonal Frequency Division Multiplexing (CP-OFDM) combined with Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) in a Time Division Duplex (TDD) communication manner. The physical layer employs multiple numerologies, with different subcarrier spacings and corresponding Cyclic Prefix lengths and FFT sizes, allowing operation with different channel bandwidths, and optimize operations in different frequency bands and propagation environments. The physical layer supports advanced channel coding (Turbo coding) for both control and physical channels and Hybrid ARQ with incremental redundancy, which enables fast re-transmission. Advanced channel coding together with Hybrid ARQ ensures very reliable communication.

Additionally, the physical layer supports, fast link adaptation, transmit and receiver diversity, as well as MIMO operations up to 8 streams.

DECT-2020 NR (i.e. PHY layer numerology and MAC algorithms) is designed to enable coexistence with legacy DECT and DECT evolution in current frequency bands allocated to DECT.

4.2 Overview of the parts of DECT-2020 Technical Specifications

Release 1 of the DECT-2020 NR technical specifications defines the Radio Interface Technology (RIT) by the following parts:

- ETSI TS 103 636-1 (the present document): "DECT-2020 New Radio (NR); Part 1: Overview".
- ETSI TS 103 636-2: "DECT-2020 New Radio (NR); Part 2: Radio Reception and Transmission requirements" [1].
- ETSI TS 103 636-3: "DECT-2020 New Radio (NR); Part 3: Physical layer" [2].
- ETSI TS 103 636-4: "DECT-2020 New Radio (NR); Part 4: Medium Access Control layer" [3].

ETSI TS 103 636 series will be accompanied by a feature and/or application-driven technical specification set, which is organized as a multi-part deliverable, delivering profiles and application specific solutions for various industries.

ETSI TS 103 636-1 is the present document.

ETSI TS 103 636-2 [1] establishes the minimum RF requirements for DECT-2020 New Radio (NR) Radio Devices (RDs). These requirements cover both Fixed Termination point (FT) as well as Portable Termination point (PT). This document also provides a list of supported frequency bands.

ETSI TS 103 636-3 [2] specifies the physical layer (PHY) and interaction between PHY and MAC layer.

ETSI TS 103 636-4 [3] specifies MAC layer and interaction between MAC layer and physical layer and higher layers.

5 System and Network Architectures

5.1 Wireless Point-to-Point and Point-to-Multipoint Links

Wireless Point-to-Point links involve two radio devices communicating with each other. A typical application is the cable replacement by a wireless link established between two radio devices requiring communicating with each other.

Compared to wireline systems, wireless comes with the benefit that point to multipoint communication is an inherent feature of radio propagation, so that the support of broadcast and multicast messages from one point to multiple points is just a matter of protocol.

The radio connection between two or more radio devices is enabled by one RD selecting to operate in FT mode (RD_{FT}) and initiate radio resource coordination and beacon transmissions. Other RD(s) perform association procedure in PT mode (RD_{PT}) with the RD_{FT}.

5.2 Local Area Wireless Access Networks in Cellular Network Topology

A single-cell network topology involves in principle two types of Radio Devices (RDs): an RD operates in FT mode (RD_{FT}) as a base station, which is a component of the fixed network infrastructure, other RDs operate PT mode (RD_{PT}).

RD_{FT} is coordinating radio resources, and serves a communication cell by being the central communication point for, RD_{PT}, which can be portable device.

A multi-cell topology is a deployment of multiple RD_{FT} as base stations in a fixed network infrastructure, where each base station is serving its own dedicated cell area and RD_{PT} can move from one cell area to the other.

5.3 Mesh network topology

5.3.1 Introduction

In DECT-2020 mesh network devices can communicate directly to each other extending the range of network and increasing the reliability of communication. The mode of the involved radio devices may change autonomously depending the context of the communication. Each radio device can act as a node transmitting a message, as a node forwarding any message from another radio device or as a node being the destination of a message. Each radio device can communicate directly (device to device) or, if not in range, indirectly - via other radio devices establishing a communication route - with each other which minimizes the probability of outage.

Mesh topology can support high device densities and the autonomous routing provides the ability to adapt dynamically mobile users and interference.

Mesh operation supports autonomous routing. In order to achieve efficient mMTC operation the mesh system is scalable to a very high number of devices in a network, the routing is based on cost value, without the need to maintain routing tables in each device.

The key requirements of how the scalability can be achieved are:

- All radio devices can route data. Whether RD is routing data is based on an autonomous decision of the RD. In addition, an RD may be configured to operate in PT mode only, e.g. due to low battery resources.
- Radio devices take local decisions of the radio recourses, e.g. how radio devices use Hybrid ARQ, selects modulation and coding and so forth in each radio link.
- Radio devices may change their operating mode between FT mode (RD_{FT}), PT mode (RD_{PT}), or both FT and PT modes ($RD_{FT,PT}$), autonomously based on local decisions.
- No central coordinator(s), enabling the massive scale of the network.
- Radio device operating in RD_{FT} or $RD_{FT,\ PT}$ mode coordinates local radio resouces.
- Support of multiple backend connected Radio devices that operate in FT mode (RD_{FT}).
- RDs can operate with multiple radio channels.

5.3.2 Mesh system operation

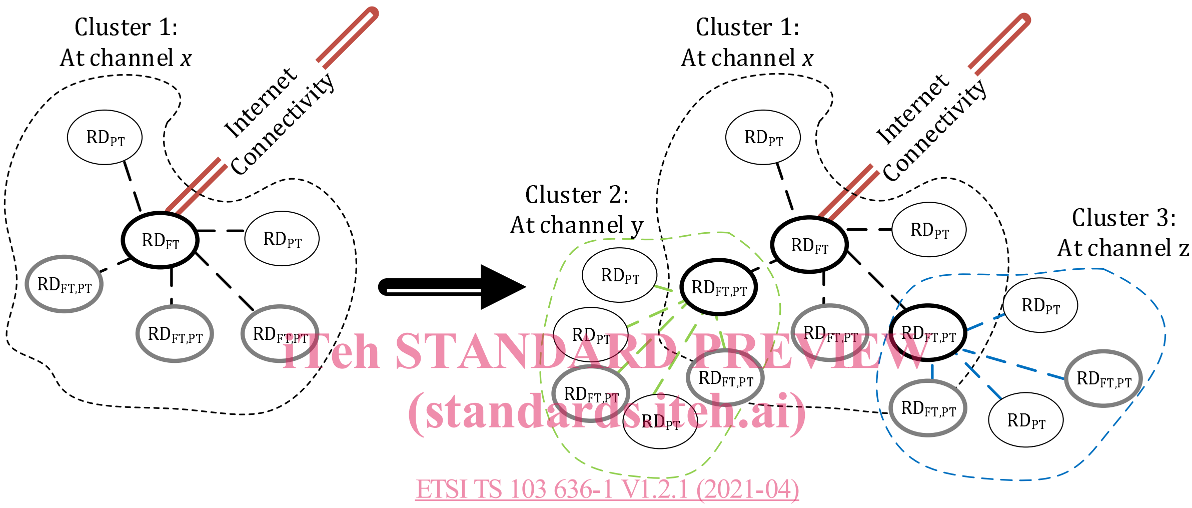
The mesh system operation is based on a clustered tree topology where each RD decides the next hop individually based available routes towards the RD providing the connection to the external internet in FT mode (RD_{FT}). Each radio device has knowledge of the next uplink and downlink hop in the clustered tree and RD_{FT}, or $RD_{FT,PT}$ mode in each cluster controls radio resources and transmissions independently.

The formation of clustered tree topology has following steps:

- An RD which has internet connectivity, RD_{FT}, in FT mode i.e. *Sink* selects operating frequency (or frequencies) and initiates a beacon transmission indicating that it has a route to the external world. This enables other RDs to detect it and associate with it. Beacons indicate all necessary parameters how to perform association, such as frame timing and how radio resources are used and the set of routing parameters. This association procedure does not differentiate from the association process in other system architectures described in clauses 5.1 and 5.2.

- RD detecting a beacon from another RD evaluates the connection based on the information included in the received beacon. Based on the information and signal quality the RD does an independent decision to which RD_{FT} or $RD_{FT,PT}$ to associate. RD monitors its neighbourhood and may autonomously initiate an association process towards another RD based on routing cost.

- Process continues to next hops and so on and it is illustrated in Figure 5.3.2-1.



a) Formation of first hop b) Formation of second hop

NOTE 1: At the formation of the first hop a) one or more RD_{PT} or $RD_{FT,PT}$ associates with an RD_{FT}.
NOTE 2: The second hop b) is formed by RD_{PT} or $RD_{FT,PT}$ that associate with the first hop $RD_{FT.PT}$.
NOTE 3: Black thick circle: RD with associated members, grey thick circle: RD that is available routing, but yet has no associated members, black thin circle: RD in PT only mode.

Figure 5.3.2-1: Formation of the clustered tree mesh network topology

Once the RD has connectivity to the next hop, it can start sending data towards the RD in FT-mode. It can simply use a specific address value to indicate that the data is addressed to a backend. A backend system or other RDs can send DL data to the associated RD.

The basic beaconing and association procedures between RDs in mesh topology and in star topology are same. To enable battery powered RDs which are capable for routing data, the beacon transmission interval can be set longer.

Beaconing intervals extend to several seconds depending on the actual use case enabling low power RDs and routing RDs operations. On the other hand, when RD is mains powered, the beaconing period could be more frequent.

The system operation with multiple RDs in FT mode (*sinks*) is illustrates in Figure 5.3.2-2. The process of forming clusters is identical and a RD may choose to change its association to the next hop RD regardless if the next hop RD will provide connectivity to a different RD_{FT} having the backend connection. Figure 5.3.2-2 also illustrates the case when there is $RD_{FT,PT}$ that does not yet have any associated RD_{PT}.

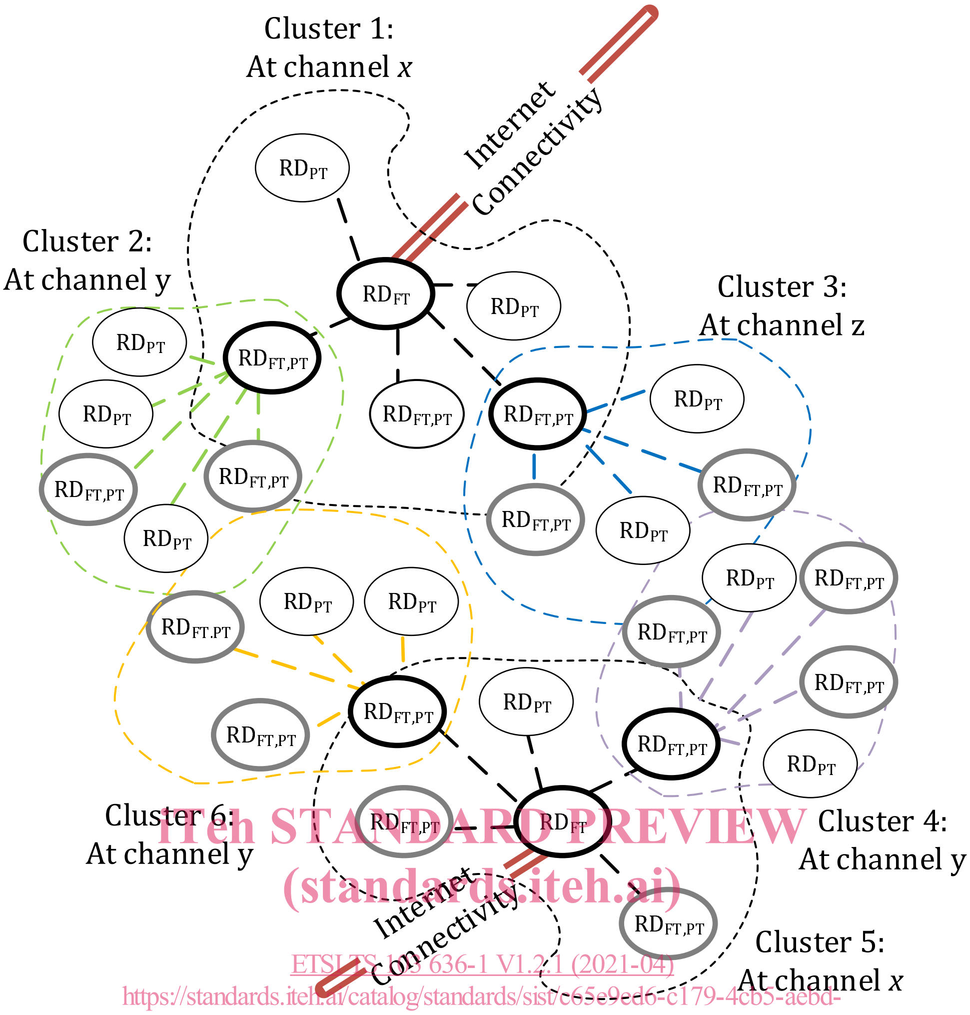


Figure 5.3.2-2: Example formation of the clusters in multiple RD_{FT} scenario

5.3.3 Mesh Routing

RD associates to the next hop RD based on received beacons quality attributes such as Received Signal Strength Indicator (RSSI) measurement from a beacon signal which assist it to determine the pathloss. If both DL pathloss and UL pathloss are such that connection can be established, the RD transmitting this beacon is considered as *potential next hop*. If RD detects multiple beacons from multiple RDs that meet the criteria of reliable connection, the RD considers the *route cost.* The *route cost* expresses the cost of the route to deliver data to the *sink*, i.e. to the RD_{FT} that has a backend connection to the internet. RD may select the RD_{FT} or $RD_{FT,PT}$ for association which indicates the smallest *cost*.

How the RD calculates the value for the *route cost* is left to implementation, as detailed the calculation can be dependent on multiple factors, such as RD capabilities, data rate, interference and BLER, own load i.e. data amount to be delivered, available battery energy, etc. Route cost value will increase at least 1 in every hop. The maximum route cost value is 254, which is not seen as a limiting factor in real deployments.

Routing has also a *sink address*, which is the long RD ID (32 bits) of the RD_{FT} having the backend connection. When a system supports multiple RD_{FT}s, (the actual number of RD_{FT}s can be significantly large), the RD may send short packet to the backend so that that backend can update its knowledge of where different RDs are located in the mesh network and send DL traffic only to the correct RD_{FT}.

The third routing parameter, *application sequence number*, provides identification for network level application data that needs to be distributed in the DL direction to all members of the network. The application sequence number is used by the RD associated to the next hop to identify whether the application data has changed compared to the current application data. If the sequence number is increased the RD requests the application data from its next hop.

The actual application data is outside of the scope of DECT-2020 NR but it can contain e.g. configuration data of the RD application such as measurement quantities and corresponding reporting frequencies, etc.