

DECT NR+: License-free 5G networking

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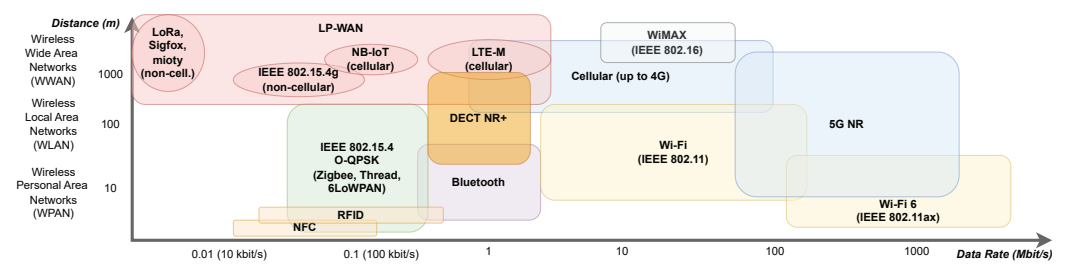
RIOT summit, Grenoble

Plan for today

1. What is DECT NR+?
2. Layers and functionality
3. Implementations
4. Suitable for embedded devices?

What is DECT NR+...

...in the context to radio technologies you know?



¹F. Graf, T. Watteyne and M. Villnow, "What to Expect When Using DECT NR+", in IEEE Communications Magazine, vol. 64, no. 2, pp. 16-22, February 2026, doi: [10.1109/MCOM.001.2500286](https://doi.org/10.1109/MCOM.001.2500286)

Where does DECT NR+ come from?

Digital Enhanced Cordless Telecommunication

- ▶ 1987: Digital European Cordless Telephone launched at CEPT
- ▶ 1988: ETSI founded, DECT specified there
- ▶ 1992: cordless phones
- ▶ 1993: Net³ (early wireless LAN)
- ▶ various compatible evolution steps
- ▶ 2011: DECT ULE ([RFC 8105](#): 6lo-over-dect)

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- ▶ various compatible evolution steps
- ▶ 2011: DECT ULE ([RFC 8105](#): 6lo-over-dect)
- ▶ 2020: DECT NR+² (an IMT-2020 / 5G technology)
breaking compatibility with earlier standards

²ETSI TS 103 636-[1-5] “DECT-2020 New Radio (NR)”

How is DECT NR+ “5G”?

3G / 4G / 5G $\neq$ 3GPP / cellular operators

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IMT-2000 / IMT-Advanced / **IMT-2020**

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IMT-2000 / IMT-Advanced / **IMT-2020**

- ▶ ~~100Mbit/s download speed (eMBB)~~
- ▶ 1ms latency (URLLC)
- ▶ 1 million devices / km² (mMTC)

Spectrum and allocation

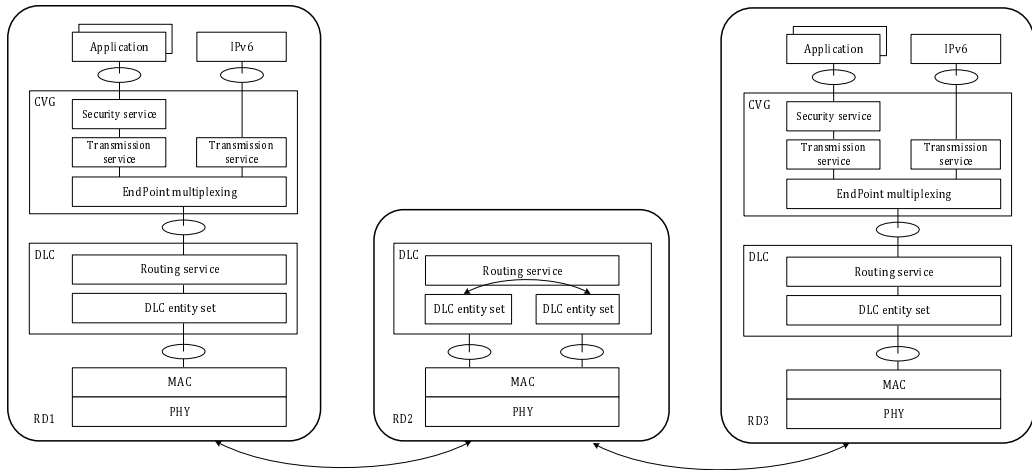
- ▶ CEPT & co 1 880 – 1 900 MHz, exclusive
- ▶ North America 1 920 – 1 930 MHz
- ▶ Latin America 1 910 – 1 930 MHz
- ▶ Japan 1 893 – 1 906 MHz

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- ▶ EU (from 2027) 3 800 – 4 200 MHz

Radio stack

271 pages in 1 picture



³Diagrams from ETSI TS 103 636-[1-5] v2.1.1 unless noted otherwise.

PHY layer

One PHY for all bands

... but you don't want to bit-bang it.

- ▶ OFDM and modulation
- ▶ Parametrization: bandwidth
- ▶ Data
- ▶ Error correction

PHY: OFDM and modulation

Orthogonal Frequency-Division Multiplexing

Making the most of the allocated bandwidth.

Making the most of the available SNR.

PHY: OFDM

... by acoustic intuition



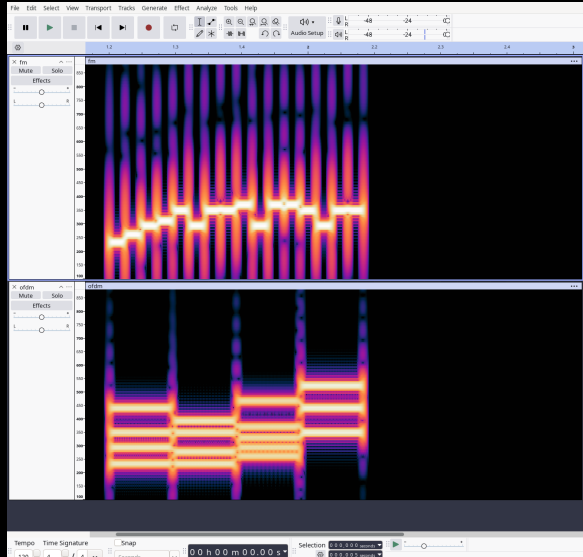
PHY: OFDM

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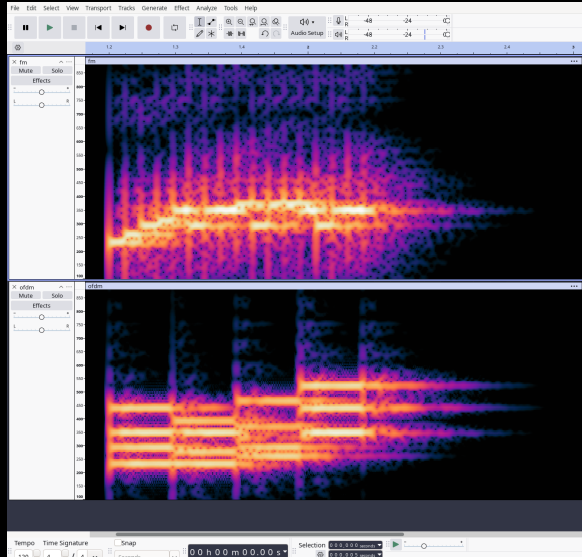
PHY: OFDM

as a spectrum

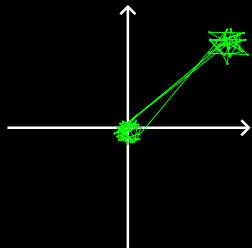


PHY: OFDM

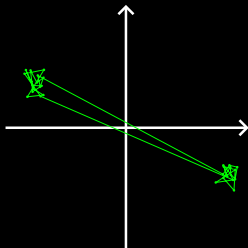
as a spectrum under ... conditions



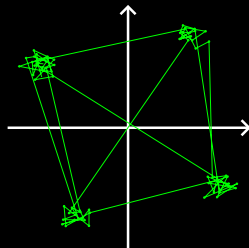
PHY: After the OFDM



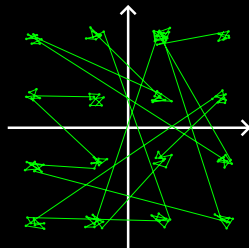
OOK
(audio example)



BPSK
(MCS=0)



QPSK
(MCS=1-2)



QAM16
(MCS=3-4)

PHY: Sending more data

Parametrization of transmissions: How wide we send

- ▶ Subcarrier spacing μ : More bandwidth per subcarrier, faster symbols.
- ▶ Fourier transform scaling factor β : Just more subcarriers.
- ▶ $\mu \times \beta$: Wider band transmissions, same SNR budget.

PHY: Sending more data

Parametrization of transmissions: How long we send

- ▶ “Frame”: 10ms
- ▶ 24 “Slots” per frame
- ▶ $2 \times \mu$ “sub-slots” per slot
- ▶ 5 symbols per subslot

Minimal message: 1 subslot ($200\mu\text{s}$)

Longest message: ~ 700 byte

		0	1	2	3	4	5	6	7	8	9
31											
30											
29											
28	55										
27	54							0			
26	53										
25	52	0									
24	51										
23	50							0			
22	49										
21	48	0									
20	47										
19	46							0			
18	45										
17	44	0									
16	43										
15	42							0			
14	41										
13	40	0									
12	39										
11	38							0			
10	37										
9	36	0									
8	35										
7	34							0			
6	33										
5	32	0									
4	31										
3	30							0			
2	29										
1	28	0									
0											
-1	27										
-2	26							0			

PHY: Dealing with errors

- ▶ FEC: Turbo code
- ▶ Retransmissions: HARQ
- ▶ Final decision: CRC

MAC layer

MAC: Roles & topology

- ▶ Cluster: coordinated by “Fixed Termination points” (FT) associated with “Portable Termination points” (PT)
- ▶ Tree topology. Or just star. Or point-to-point.
- ▶ Root: “Sink”

MAC: Roles & topology

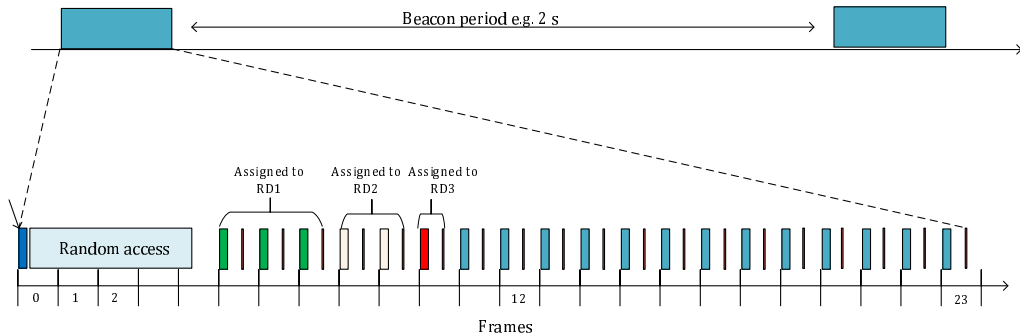
- ▶ Cluster: coordinated by “Fixed Termination points” (FT) associated with “Portable Termination points” (PT)
- ▶ Tree topology. Or just star. Or point-to-point.
- ▶ Root: “Sink”
- ▶ Network: 32-bit and 8-bit IDs
- ▶ Device: 32-bit and 16-bit IDs

MAC: Cluster Beacons

Control when to Access the Medium

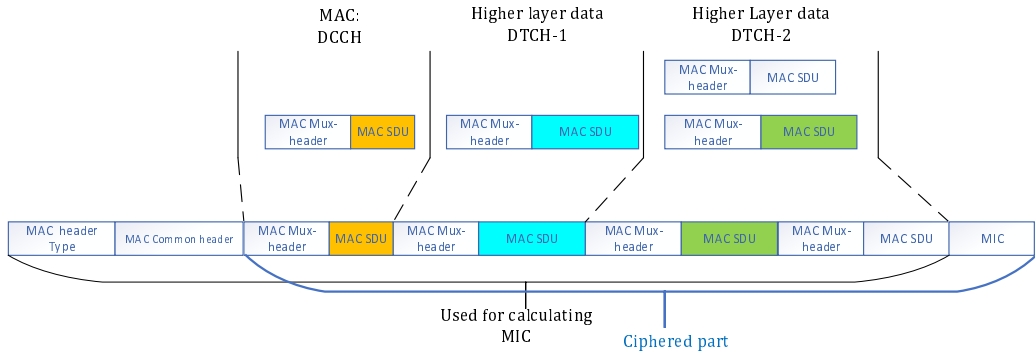
- ▶ Every 10ms – 32s
- ▶ Metrics
- ▶ Access: When
- ▶ Access: Who may, who should

MAC: Cluster Beacons



MAC: Data

Data in PDC (PHY data channel)



MAC: Data

Data in PDC (PHY data channel)

- ▶ *not* short addresses: Already in PHY header (PCC)
- ▶ Security bits, next-header
- ▶ Header types: beacon, broadcast, unicast, data
- ▶ TLV data

MAC: Data

Typical elements found

- ▶ Beacon details
- ▶ Association management
- ▶ “security starts here”
- ▶ Data item(s!)
- ▶ Padding

MAC: Security

- ▶ AES; “pre”-AEAD but looks OK
- ▶ Keys “not our department” (CoJP/LAKE to the rescue?)
- ▶ Extension proposed

DLC (Data Link Control)

- ▶ Turn QoS parameters into MAC methods ... Controlling the Data Link
- ▶ Routing

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- ▶ Turn QoS parameters into MAC methods ... Controlling the Data Link
- ▶ Routing
 - ▶ “Mesh-under”
 - ▶ towards the sink
 - ▶ source routing (downlink)
 - ▶ hop-limited flooding (device-to-device)

CVG (Convergence)

- ▶ Multiplex into applications
- ▶ Optional E2EE

IP over DECT NR+

- ▶ Full IPv6 packet or 6lo header compression
- ▶ Routed based on local part constructed from DECT addresses

Hardware

Hardware

<https://www.nordicsemi.com/Products/nRF9151>



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SiP 12x11 mm

Where to Buy

NRF9151-LACA-R ▾

Newark
3866 in stock
Buy Now

Mouser Electronics

nRF9151

System-in-Package

Low power SiP with integrated LTE-M/
NB-IoT/NTN and DECT NR+ modem,
and GNSS

The nRF9151 module sets a new standard for highly integrated and compact System-in-Package (SiP) solutions, specifically designed for [cellular IoT](#) and [DECT NR+](#) applications. Leveraging low power LTE technology, advanced processing capabilities, and robust security features, the nRF9151 offers unparalleled performance and versatility, and supports 3GPP release 14 LTE-M/NB-IoT, NB-NTN (Non-Terrestrial Network) and DECT NR+.

Compared to its predecessor ([nRF9160](#)), it boasts a significant footprint reduction of 20% and brings additional support for Power Class 5 20 dBm.

Key features

- Fully integrated SiP module for cellular IoT, NTN and DECT NR+
- Multimode LTE-M/NB-IoT/NTN modem with DECT NR+ support and GNSS
- 700-2200 MHz LTE band support
- Power Class 5 20 dBm
- Power Class 3 23 dBm
- 915 MHz & 1.9 GHz NR+ band support

Hardware

<https://www.lm-semi.com/lm10xx-series-system-on-chip/>



The image shows a 3D rendering of a square, dark-colored system-on-chip (SoC) component. On its top surface, the text "LM10xx" is printed in a yellow, sans-serif font. Below this, there is a white logo consisting of a stylized "n" followed by a plus sign inside a circle. A small circular hole is visible on the top edge of the chip.



The logo for LM Semi, featuring the letters "lms" in a stylized, lowercase, sans-serif font. Below the letters, the text "last mile semiconductor" is written in a smaller, lowercase, sans-serif font.

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LM10xx Series

Designed for next-generation IoT Connectivity.

+

 Ultra-Secure

+

 Highly reliable

+

 Low-cost

+

 Simple to implement

Our LM10xx Series System-on-Chip is based on the globally free, non-cellular 5G standard NR+, provides a low-cost, secure and reliable

Software

Opener Initiative



- ▶ goal: full implementation
- ▶ bottom-up: drivers, MAC
- ▶ developed on Zephyr,
written in C



- ▶ focus: on high-level / IPv6
- ▶ contributing to Opener
- ▶ developed on Ariel OS, written in Rust

In the context of RIOT style IoT systems,
does DECT NR+ make right choices for IoT in general?

Suitable for IoT?

Progress since ATMega, therefore...

- ▶ build smaller chips (STM32C0)
- ▶ add more compute (ESP32)

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Can this provide Internet of *our* Things?

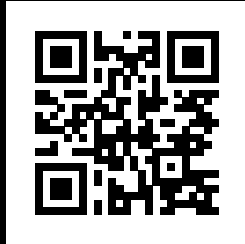
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Can this provide Internet of *our* Things?

Too early to say – clearly useful for *several* things.

Until then: Let's contribute experience to make it better,
and play to a cool radio standard.



Sponsored by Silano.