DECT NR+: License-free 5G networking

Christian Amsüss
chrysn@fsfe.org

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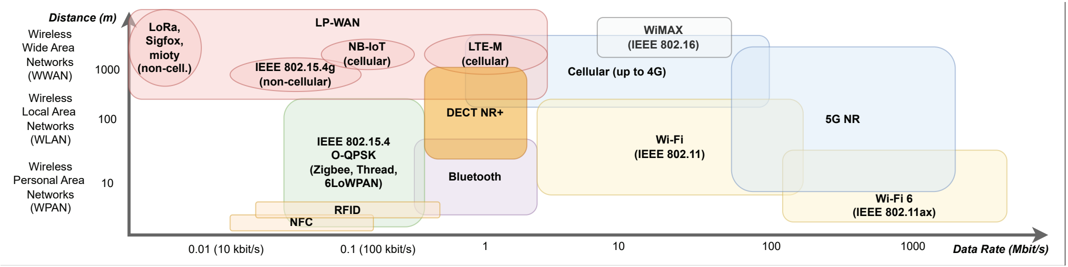
Plan for today

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?



[1] F. 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

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: Net^3 (early wireless LAN)
- various compatible evolution steps
- 2011: DECT ULE (RFC 8105: 6lo-over-dect)

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

[2] ETSI 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 / km^2 (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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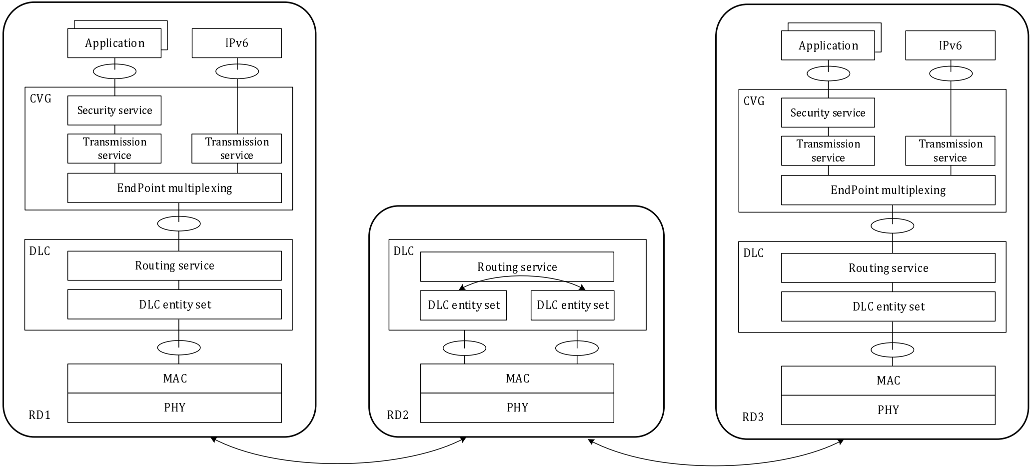
CEPT & co	1 880 – 1 900 MHz, exclusive
North America	1 920 – 1 930 MHz
Latin America	1 910 – 1 930 MHz
Japan	1 893 – 1 906 MHz
EU (from 2027)	3 800 – 4 200 MHz

Radio stack

271 pages in 1 picture



[3] Diagrams 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

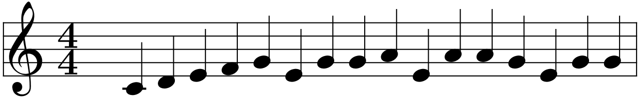
Making the most of the allocated bandwidth.

Making the most of the available SNR.

PHY: OFDM

… by acoustic intuition

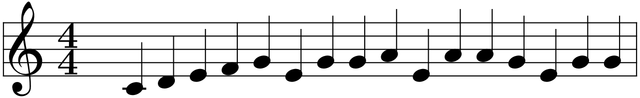
FSK



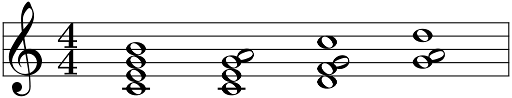
PHY: OFDM

… by acoustic intuition

FSK

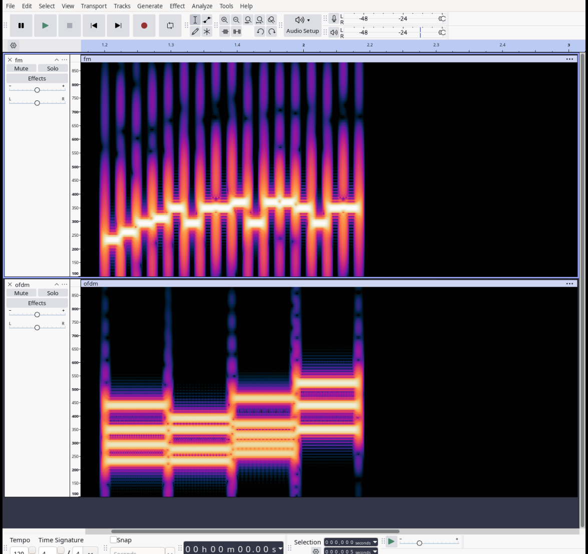


OFDM



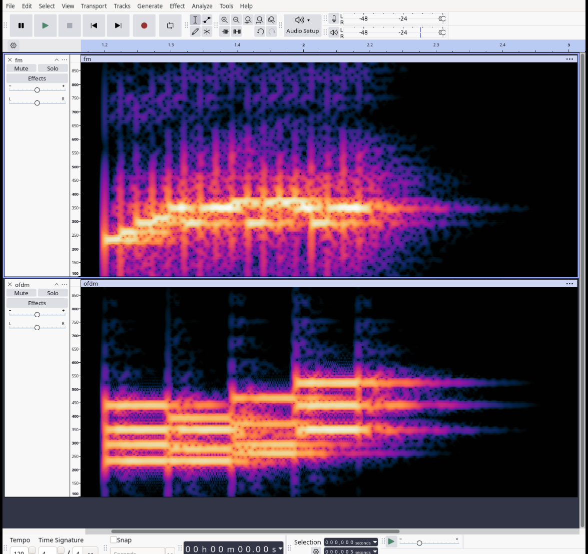
PHY: OFDM

as a spectrum

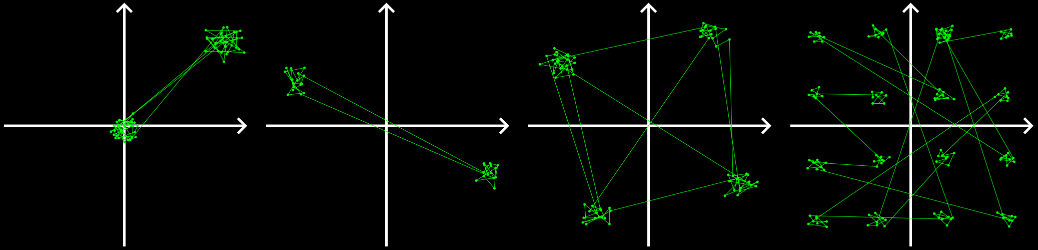


PHY: OFDM

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

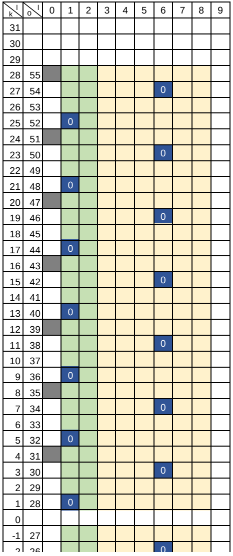
- Subcarrier spacing μ: More bandwidth per subcarrier, faster symbols.
- Fourier transform scaling factor β: Just more subcarriers.
- $\mu \times \beta$: Wider band transmissions, same SNR budget.

- "Frame": 10ms
- 24 "Slots" per frame

- $2 \times \mu$ "sub-slots" per slot
- 5 symbols per subslot

Minimal message: 1 subslot (200µs)

Longest message: $\sim$700 byte



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

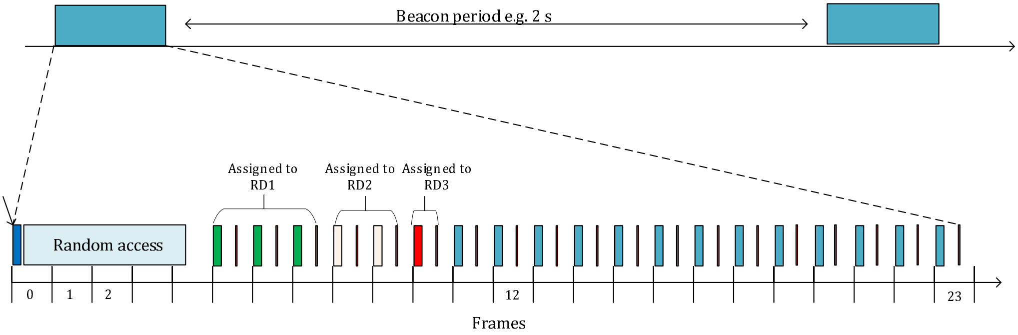
- Cluster: coordinated by "Fixed Termination points" (FT) associated with "Portable Termination points" (PT)
- Tree topology. Or just star. Or point-to-point.
- Root: "Sink"
- Network: 32-bit and 8-bit IDs
- Device: 32-bit and 16-bit IDs

MAC: Cluster Beacons

Control when to Access the Medium

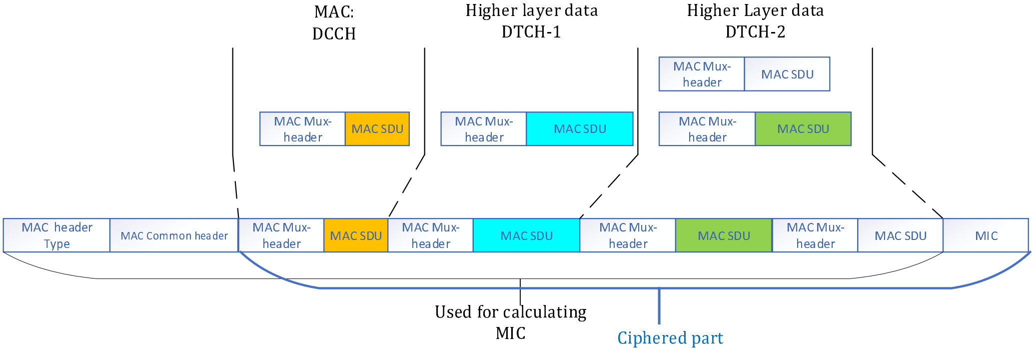
- Every 10ms – 32s
- Metrics
- Access: When
- Access: Who may, who should

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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- Routing
  - “Mesh-under”
  - towards the sink
  - source routing (downlink)
  - hop-limited flooding (device-to-device)

CVG (Convergence)

- Multiplex into applications
- Optional E2EE

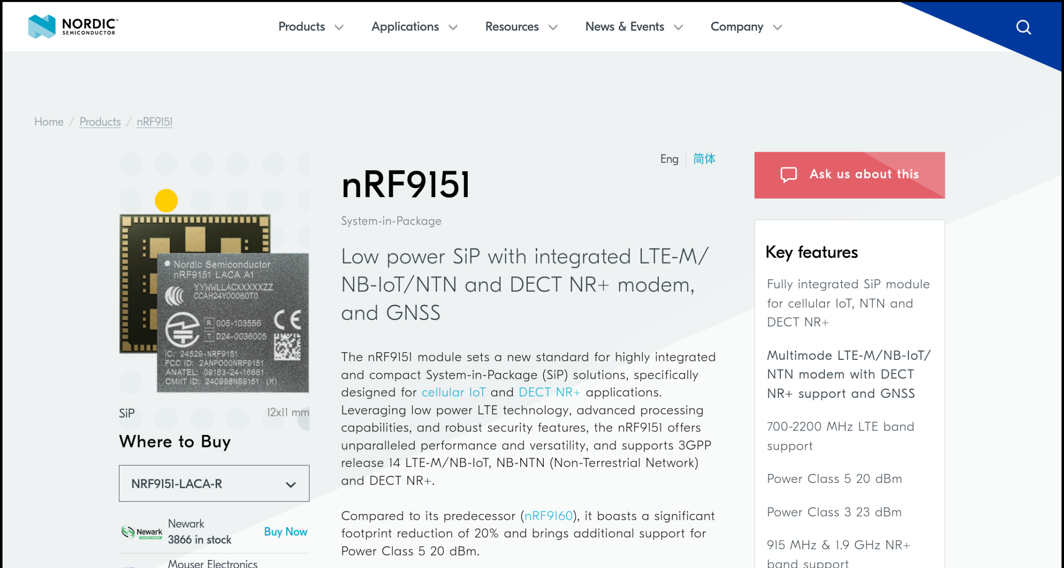
IP over DECT NR+

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

Hardware

Hardware

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



Hardware

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

Software

Opener Initiative

OPENER

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

hophop

- 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.