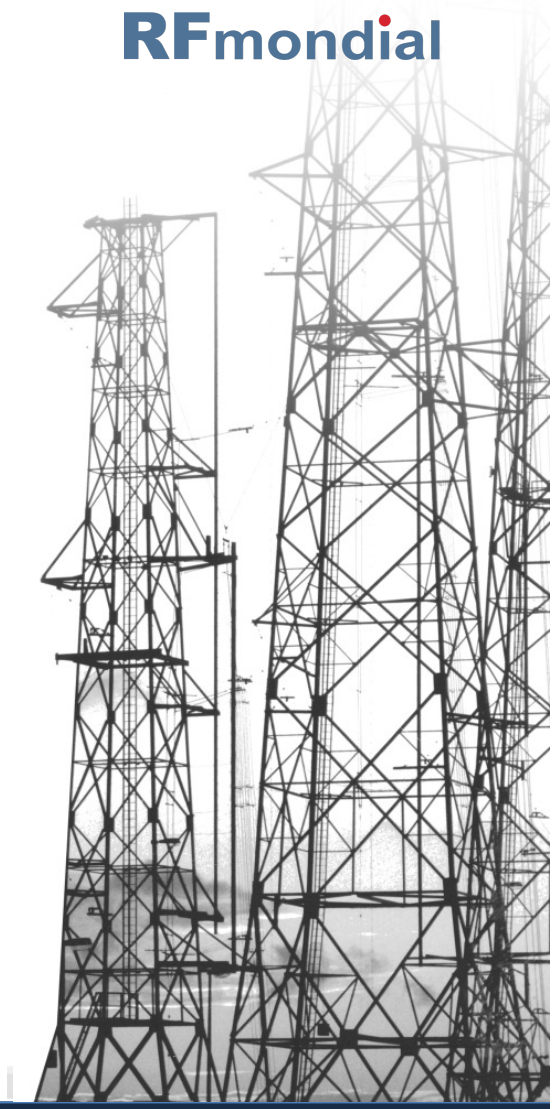
DECT NR+ Portfolio

Maxim Penner

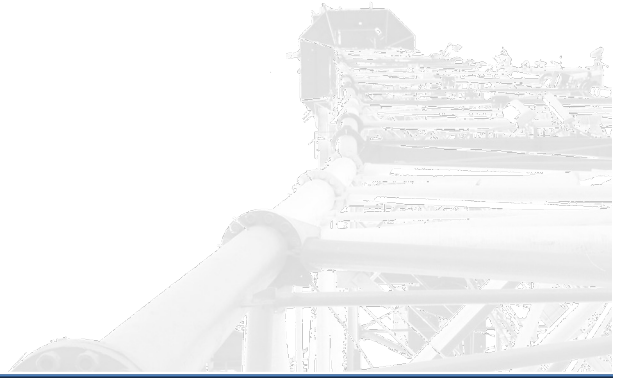
DECT World 2026



RFmondial

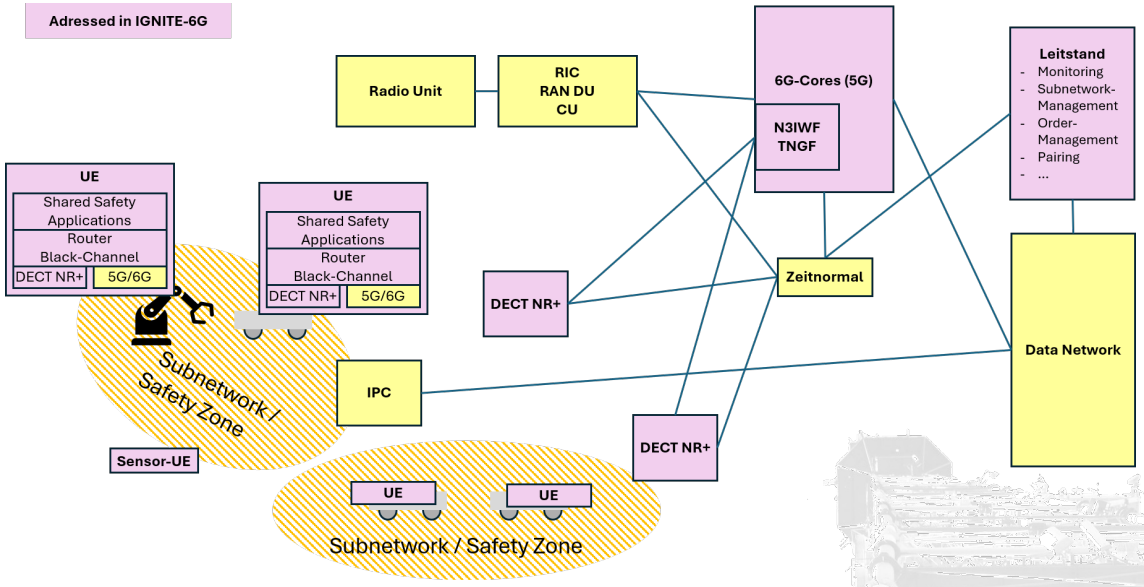
Who is RFmondial?

- Finished project MERCI
- First audio transmission via DECT NR+
  - analog-to-analog latency of 8ms on Linux platform
- First video transmission via DECT NR+
  - 1080p with 1.5MBit/s
  - Below 50ms latency (considered low-latency in video industry)



Who is RFmondial?

- Upcoming project IGNITE-6G
- Partners: LMS, Pilz, REHAU, Fraunhofer, DFKI etc.
- DECT NR+ for industrial safety zones
  - Low-latency, reliable and dynamic zones for robots
  - Attached to 6G-Core



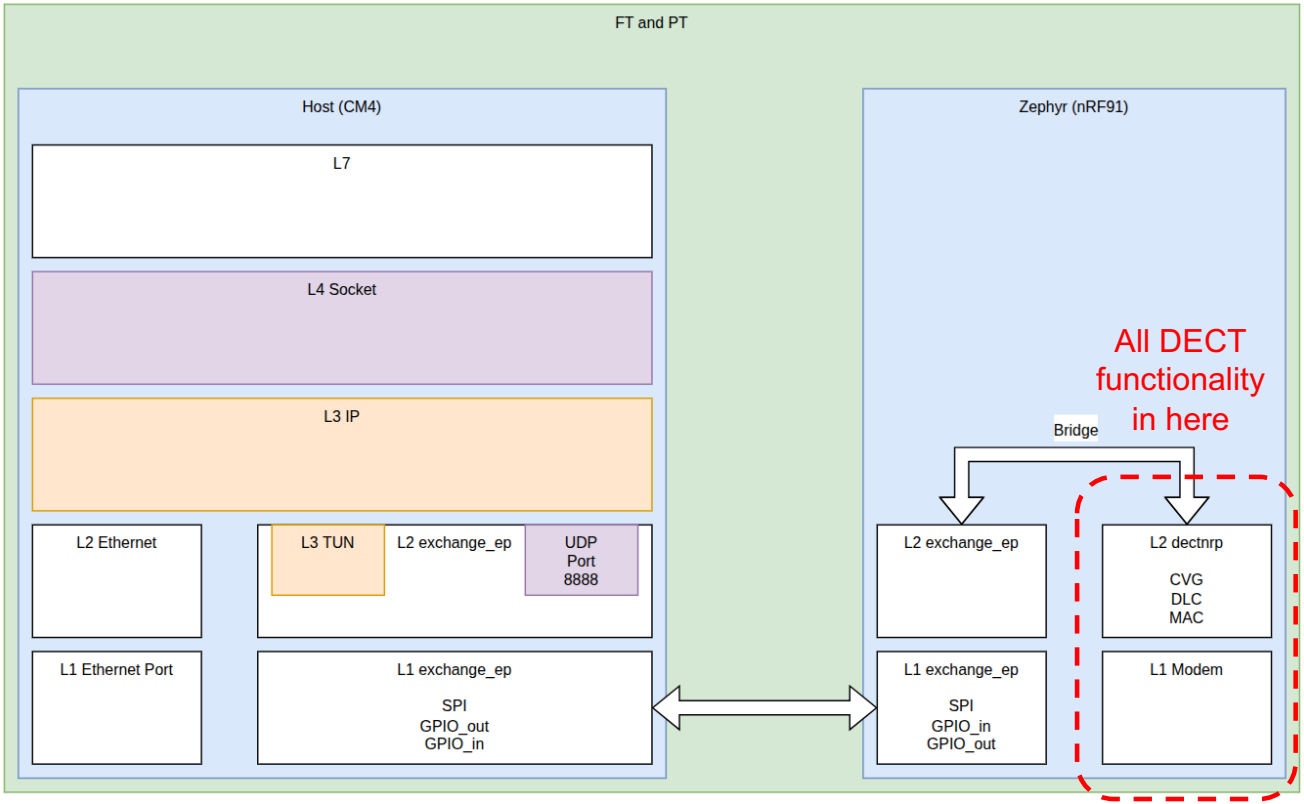
DECT NR+ portfolio: integrated solution

- nRF9151 with CM4
  - Embedded Linux, 1GBit/s, Audio, USB
- shop window demo
  - DECT NR+ as simple as Wi-Fi
  - Linux acts as a IPv4/v6-Router
  - Calls over Teams, WhatsApp, YouTube, web browsing …
  - Technically: scheduled access, random access for association procedure, interference management etc.



DECT NR+ portfolio: integrated solution

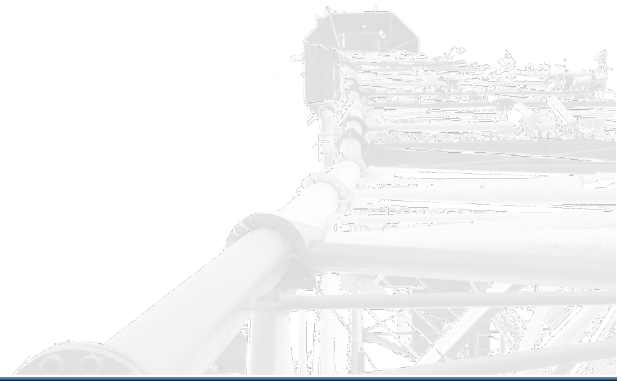
- All our demos use the same
  - Hardware
  - Firmware
  - Stack architecture



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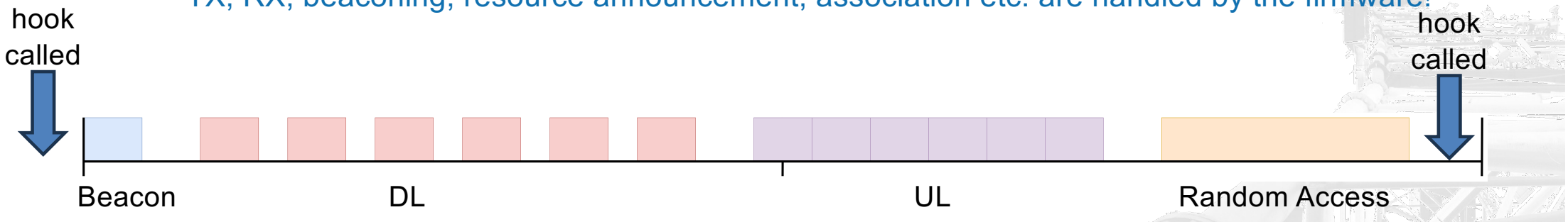
DECT NR+ portfolio: integrated solution

- Goal
  - general purpose stack usable for a wide range of applications
- Approach
  - L1 and L2 Zephyr driver with generic commands (scan, start, join)
  - Inject custom hook-functions into the L2 driver



DECT NR+ portfolio: integrated solution

- Simplest example with a single hook-function:
  - When is the hooked called?
    - Immediately before the start of every frame
  - What do you do in the hook?
    - Assign random access resources
    - Assign scheduled resources to associated devices
  - What are the assignable resources?
    - 20ms frame length: Beacon + 6 DL + 6 UL + Random Access
  - TX, RX, beaconing, resource announcement, association etc. are handled by the firmware!



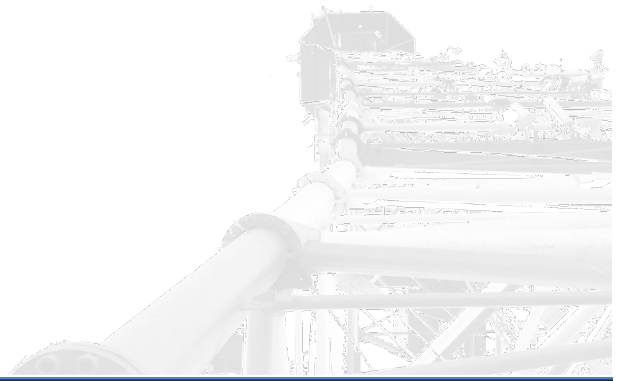
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DECT NR+ portfolio: integrated solution

- Advanced example: hooks to customize beacon
  - pchbch_pull_cluster_beacon()
    - bcch_pull_cluster_mm()
    - dcch_pull_resource_ie_random_access()
    - dcch_pull_resource_ie_of_all_contacts()
- Firmware allows multiple roles
  - FT + FT (network slicing)
  - FT + PT (branch node)
  - PT + PT (make-before-break)

Table 4.5.1-3: Channel mapping

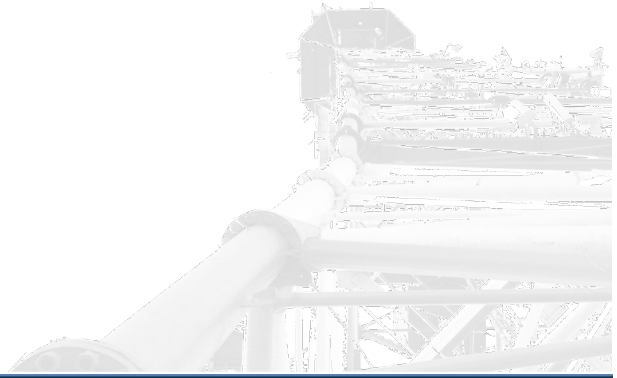
Logical channel \ Transport channel	PCH/BCH	DCH	RACH
BCCH	X		
PCCH	X		
CCCH			X
DCCH	X	X	X
DTCH		X	X
MTCH	X		X



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DECT NR+ portfolio: integrated solution

- CM4 is a great development platform, but …
  - Too many peripherals for most applications (ETH *and* USB *and* audio)
- Solution: split capabilities into more hardware platforms
  - nRF9151 and ETH module
    - Applications are IP-over-DECT and ETH-over-DECT
  - nRF9151 and ESP32 Audio
    - Low-latency audio



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DECT NR+ portfolio: Software-Defined Radio

- FOSS (GPL)
- C++ Software
- GPP with Linux
- Advanced features
  - All μ and β
  - All N_{TX} and MIMO
  - AGC
  - Customizable API

DECT NR+ SDR



www.github.com/maximpenner/DECT-NR-Plus-SDR

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DECT NR+ portfolio: Software-Defined Radio

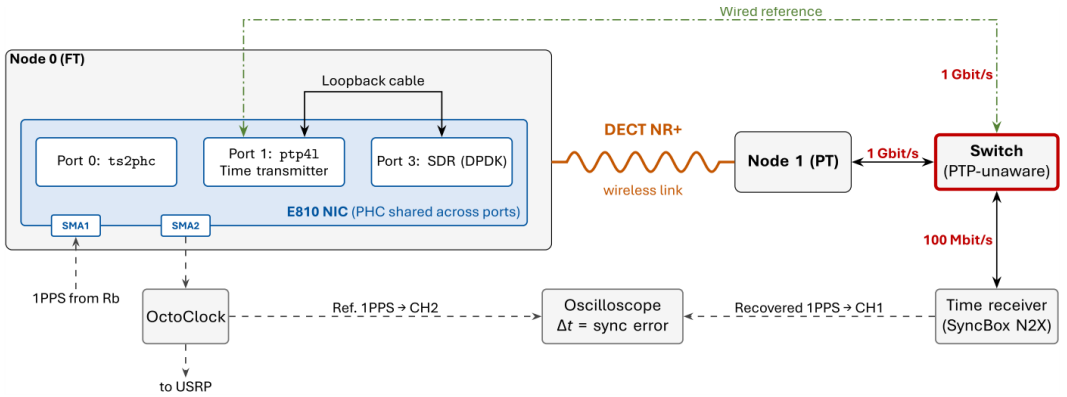
- Sensitivity close to theoretical limits at -100.6dBm
- One-Way latency 175µs
- 140Mbit/s combined UL+DL with a single spatial stream
- 200Mbit/s combined UL+DL with two spatial streams

Table II: Data Rate Measurements

Configuration	A	B	C	D
μ	1	1	1	2
β	16	16	16	2
B (MHz)	27.648	27.648	27.648	55.296
QAM Set Size	16	64	256	256
Code Rate	3/4	5/6	5/6	5/6
Packet Length (slots)	2	2	2	1
Packet Size (B)	5645	9414	12 554	11 813
DL/UL per 10 ms	4	4	4	8
Rate Limit (Mbit s^{-1})	18.06	30.12	40.17	75.6
Result	**Data Rate**			
DL Rate (Mbit s^{-1})	17.3	29.1	35.9	71.6[1]
UL Rate (Mbit s^{-1})	17.3	27.5	32.2	70.0[1]

DECT NR+ portfolio: Software-Defined Radio

- Over-the-Air Synchronization
  - PPS derived from beacons
- nRF91
  - PPS imported at FT from CM4
  - PPS exported at PT to CM4
  - < 5µs
- SDR
  - < 100ns



1PPS synchronization error in nanoseconds

Condition	Mean	Std. dev.	Min.	Max.
Wired	3025.8	12.1	2995.6	3061.6
Wireless	2910.4	3.4	2884.4	2917.6
Wireless (offset-compensated)	25.5	5.4	10.4	54.8

A. Poets · Synchronizing AES67 over Non-Cellular 5G · IEEE IS2 2026

RFmondial

DECT NR+ portfolio: Software-Defined Radio

- Upsides of SDRs
  - Fast development in C++
  - Advanced features: MIMO diversity, larger bandwidths against fading etc.
- Downsides of SDRs
  - Power consumption and cost
  - No fast AGC (i.e. gain settling time shorter than an STF)*
  - No Listen-Before-Talk*

*close to being solved

