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End user perspective on THz communication spectrum

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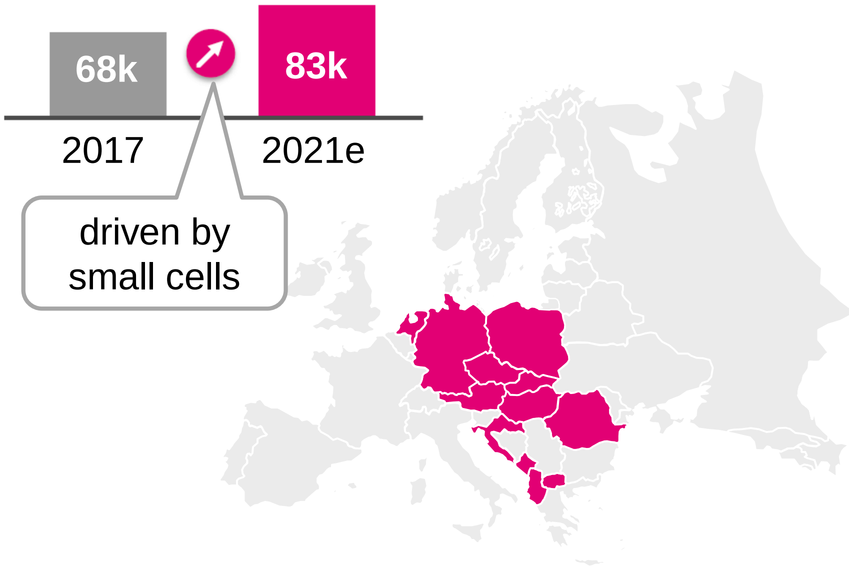
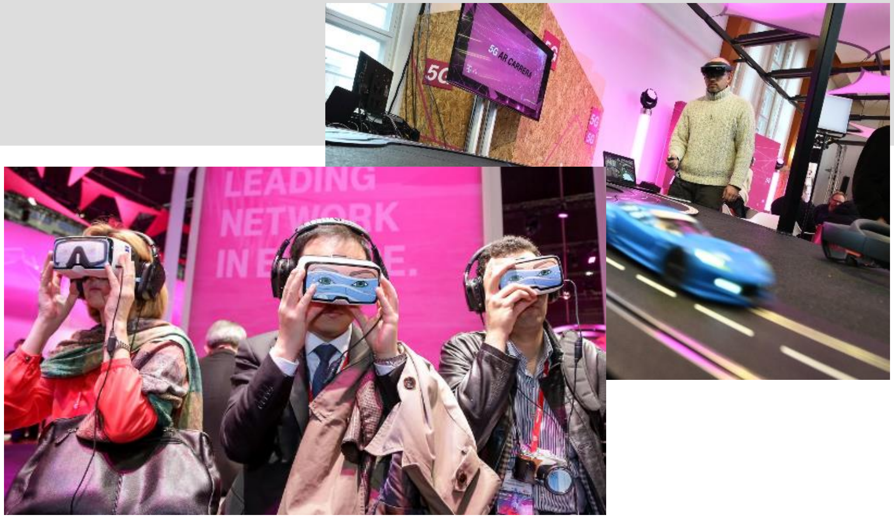
Introduction

Deutsche Telekom

mobile customers: 92 mil (43 mil in Germany)
broadband lines: 19 mil (13 mil in Germany)

Number of cell sites





Next generations network deployment:

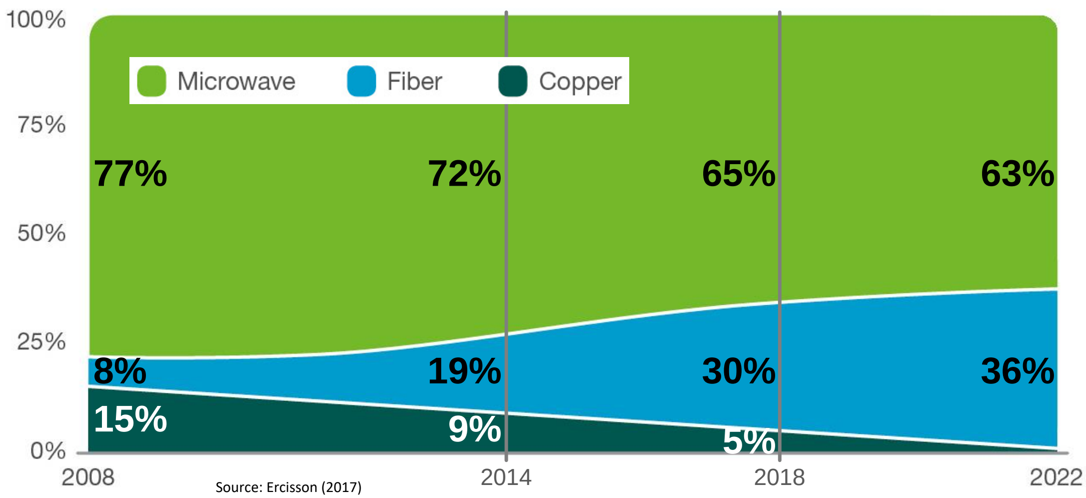
- Growing number of users
- Faster end-user data rates (> Gbps)
- Masive Internet Everywhere → more devices and connections
- Broader range of use cases and applications (AR/VR)
- Network densification

Data traffic, capacity and connectivity growth in access network must be also reflected in **transport networks**

Transport network – backhaul/fronthaul

Base stations are connected to the core network through **wire or wireless transport networks**

- **wireless systems** offer important advantages - fast deployment, flexibility and easy reconfiguration, lower deployment costs (CAPEX)



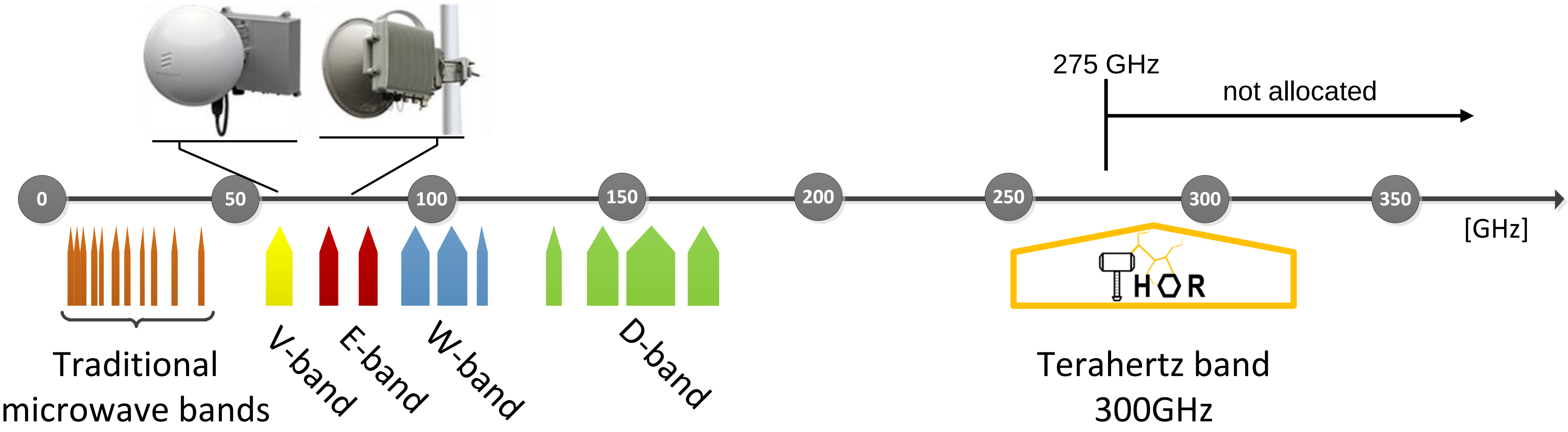
The share is operator and country dependent - integrated vs. pure mobile operator

Deutsche Telekom

- more than 455000 km fiber deployed in Germany; 240000 km in other EU countries
- In Germany (integrated operator): 74% of fiber, 26% of MW links

It is expected that **wireless links will still be important** and necessary in 5G and Beyond 5G (B5G) transport networks

Wireless transport - Overview of available frequency spectrum

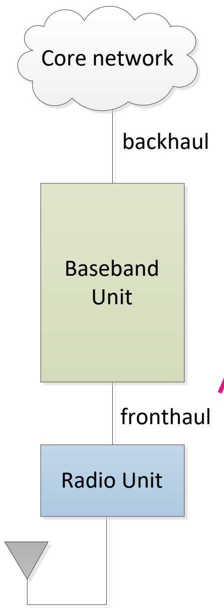


- Next generations of mobile access networks are expected to enlarge the usage of the frequency spectrum to the lower millimeter wave range below 100 MHz
- Consequently a need for new frequencies for wireless transport links beyond 100GHz

Allocation of higher frequency bands beyond 100 GHz is expected to be necessary for the next generation(s) of wireless transport networks

Distributed/centralized network architecture

Distributed or centralized architecture



3G – 4G/LTE networks

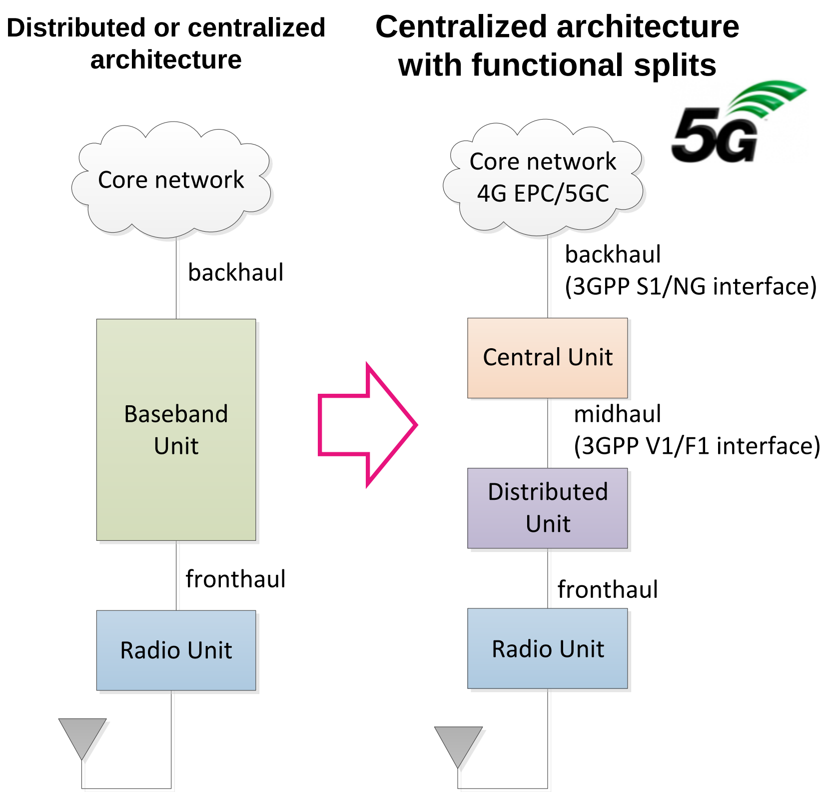
Peak data rate of baseband signals via fronthaul link [Gbps]

Number of ports at base station's antenna (single sector)	Aggregated channel bandwidth at access network (base station) [Gbps]				
	20MHz	40MHz	100MHz	200MHz	400MHz
2 (2T2R)	2	3.9	9.8	19.7	39.3
4 (4T4R)	3.9	7.9	19.7	39.3	78.6
8 (8T8R)	7.9	15.7	39.3	78.6	157.3
16 (16T16R)	15.7	31.5	78.6	157.3	314.6
32 (32T32R)	31.5	62.9	157.3	314.6	629.2
64 (64T64R)	62.9	128.8	314.6	629.2	1258.3
128 (128T128R)	125.8	251.7	629.2	1258.3	2516.6
256 (256T256R)	251.7	503.3	1258.3	2516.6	5033.2

Traditional network architecture using wireless transport links simply cannot support the 5G/B5G requirements, and so new approaches and solutions have to be considered.

*Data rate = Number of ant. ports * Sampling frequency (30.72 MSamples for each 20 MHz (2048 FFT)) * bits per sample (2*16 bits per I a Q samples).*

Network architecture

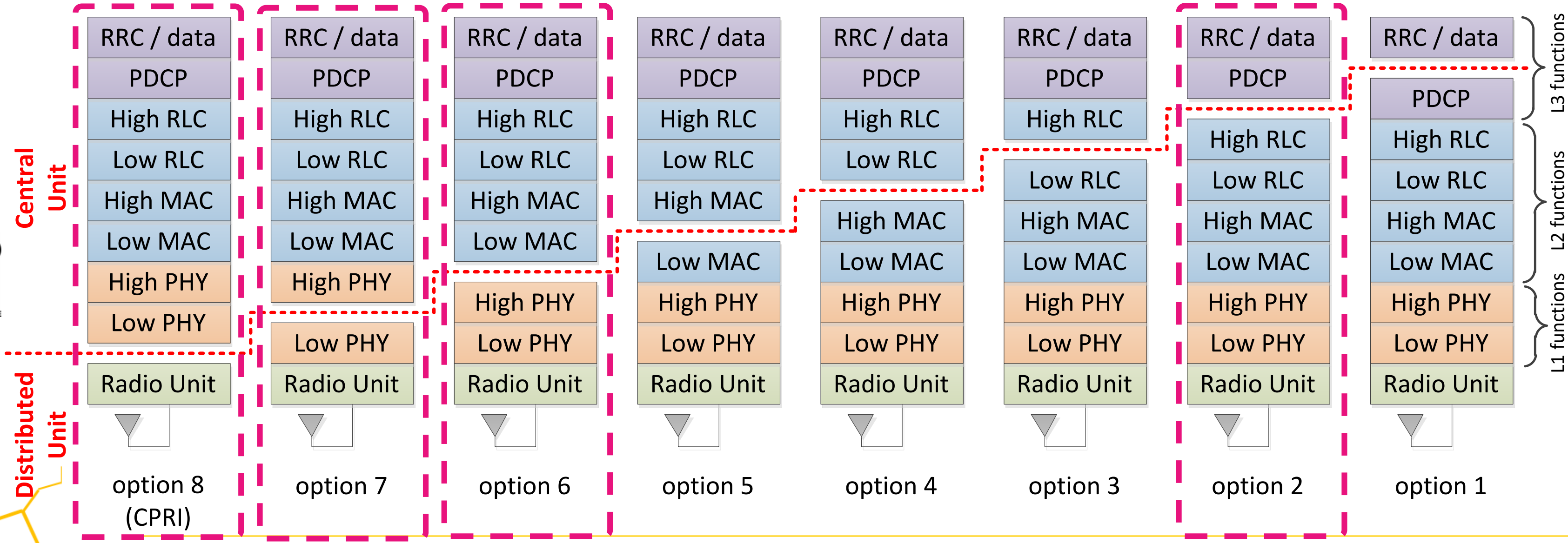


Centralized architecture with functional splits

- Reduce the demands on data rates and latencies, and consequently the deployment costs in transport networks.
- The functions (protocol stack) of the mobile base station are split between Central Unit (CU) and Distributed Unit (DU), which may be may be placed at different physical locations according to performance requirements and limitations.
- By centralizing resource and signal processing, this architecture can take advantage of cloud computing, flexible network configuration, virtualization and softwarization of network functions

Functional splits

- Several standards organizations (such as 3GPP, eCPRI, Small Cell Forum, ORAN, IEEE 1914) are working on the identification and specification of different split points
- 3GPP
  - As a part of study item for 5G New Radio interface (5G NR – 3GPP Release 15), 3GPP started studying different functional splits between CU and DU.
  - Eight main split options - lower layer splits requiring much larger transport data rates and shorter latency than higher layer splits. On the other hand, fewer functions can be centralized with higher layer splits.



Performance requirements for the transport network

The choice of functional split point and consequently placement of RU, DU and CU determines the performance requirements of the transport network.

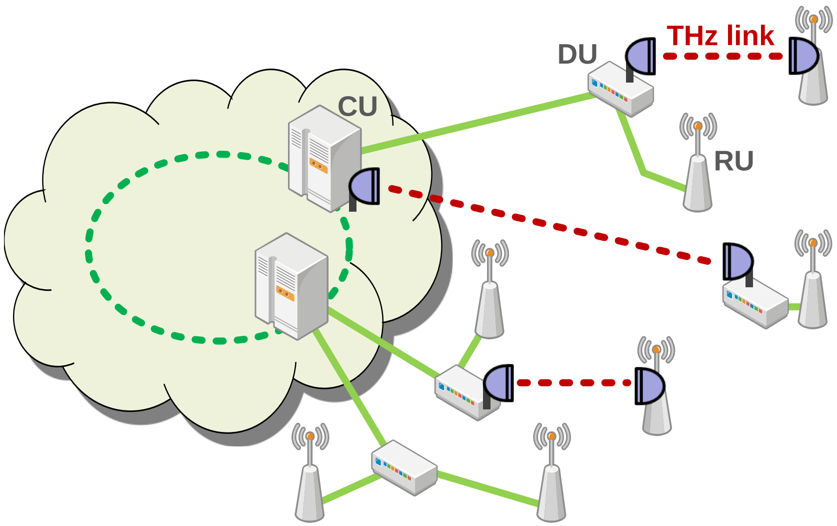
3GPP split option			2	6	7-3	7-2	8 CPRI
Max one way latency between CU and DU (midhaul)			1.5 – 10ms	250 µs	250 µs	250 µs	250 µs
Throughput requirement between CU and DU (midhaul)	Configuration 1 20MHz, 4T4R, 4 MIMO layers	per sector/cell (micro BS)	0.42Gbps 11%	0.43Gbps 11%	0.54Gbps 14%	1.3Gbps 34%	3.9Gbps 100%
		per macro BS	1.26Gbps	1.3Gbps	1.6Gbps	4Gbps	11.8Gbps
	Configuration 2 40MHz, 32T32R, 8 MIMO layers	per sector/cell (micro BS)	1.84Gbps 3%	1.9Gbps 3%	2.3Gbps 4%	5.8Gbps 9%	62.9Gbps 100%
		per macro BS	5.4Gbps	5.6Gbps	7Gbps	17.4Gbps	189Gbps
	Configuration 3 100MHz, 64T64R, 8 MIMO layers	per sector/cell (micro BS)	4.37Gbps 2%	4.5Gbps 2%	5.7Gbps 3%	14.2Gbps 6%	252Gbps 100%
		per macro BS	13.2Gbps	13.6Gbps	17Gbps	42.6Gbps	755Gbps
	Configuration 4 200MHz, 64T64R, 8 MIMO layers	per sector/cell (micro BS)	8.7Gbps 2%	9Gbps 2%	11.4Gbps 3%	28.4Gbps 6%	503Gbps 100%
		per macro BS	26.4Gbps	27.2Gbps	34.1Gbps	85.1Gbps	1510Gbps
	Configuration 5 400MHz, 128T128R, 8 MIMO layers	per sector/cell (micro BS)	17.5Gbps 0.9%	18Gbps 0.9%	22.8Gbps 1.1%	56.8Gbps 2.8%	2014Gbps 100%
		per macro BS	52.45Gbps	54Gbps	68.4Gbps	170Gbps	6042Gbps

*Modulation: 256QAM (i.e. spectral efficiency 7.4063 bits/s/Hz); Sub-carrier spacing: 15 kHz/60 kHz; Number of bits per I/Q sample: 32 bits (2*16 bits); Max FFT size: 4096 (scales with bandwidth); Min/Max number of Physical Resource Blocks: 20/275 PRBs*

Deployment scenarios

The evolved **centralized architecture with functional split** is promising and preferred solution for incoming 5G network deployments to meet the different service requirements of a wide range of use cases

Deployment scenario



Conclusions

Data traffic, capacity and connectivity growth in access network must be also reflected in **transport networks**

It is expected that **wireless links will still be important** and necessary in next generations (s) transport networks

Allocation of **higher frequency bands beyond 100 GHz** is expected to be necessary for the next generation(s) of wireless transport networks

Traditional network architecture using wireless transport links simply cannot support the 5G/B5G requirements, and so new approaches and solutions have to be considered → the **architecture based on functional splits** and utilization of frequency spectrum beyond 100 GHz

Thank you for your attention!

ご清聴ありがとうございました

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