Wireless Access Evolution

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High-level 5G vision still valid

Non-limiting access to information and sharing of data …

… anywhere and anytime …



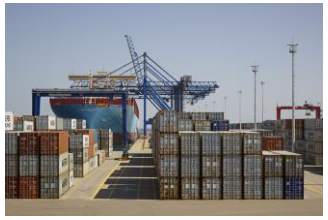



• • •

… for anyone and anything





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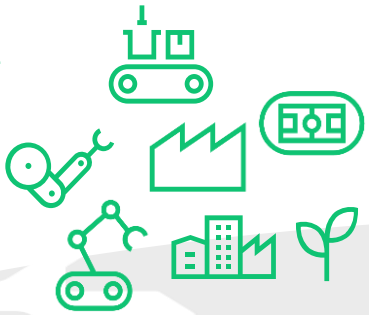
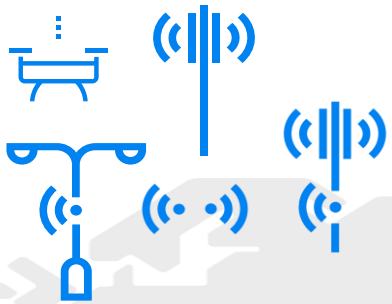
Evolved 5G and beyond

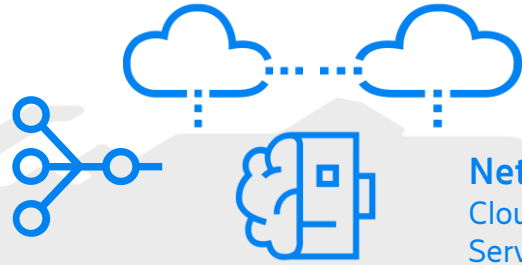
New use cases
Manufacturing and industrial IoT
Automotive and ITS
XR (AR/VR/mixed reality/...)
Fixed wireless access



Radio access
Higher frequencies
Integrated access and backhaul
New topologies and mesh



Networking
Encryption compatible/collaborative optimizations
Artificial Intelligence / Machine Learning
Intelligent SON- oriented



Devices & Hardware
Co-operative transmission / D2D
Zero energy
Zero cost

Network Implementation
Cloud based
Service based
AI
Open source
Network service mesh

Integrated connectivity and edge compute

Zero-touch

Trusted networking

Longer-term radio-access evolution

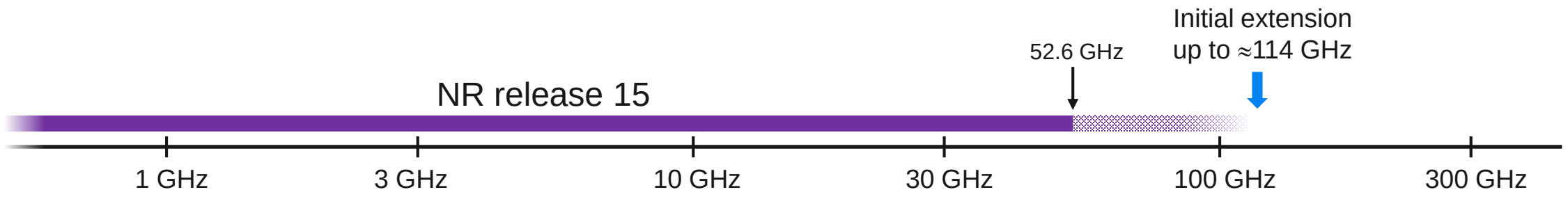
- Continued expansion into higher frequencies
- Flexible network topologies
- Device co-operation
- Technology components for massive IoT
- Cellular as a sensor
- Machine learning and artificial intelligence in the wireless-access network

Extension to higher frequencies

NR release 15 supports operation up to 52.6 GHz

Initially considering extension up to approximately 114 GHz

Assumption: Reuse current NR waveform with extended numerology

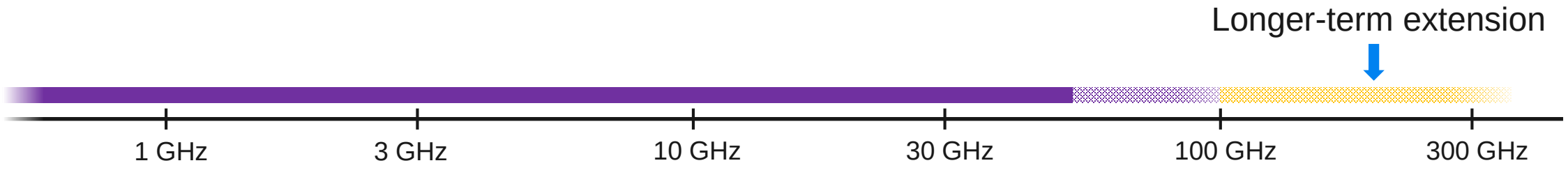


Extension to higher frequencies

Further extension beyond 100 GHz as part of longer-term radio-access evolution

Based on experience gained from first mmw NR deployments

Potential re-evaluation of basic air-interface design



Flexible network topologies

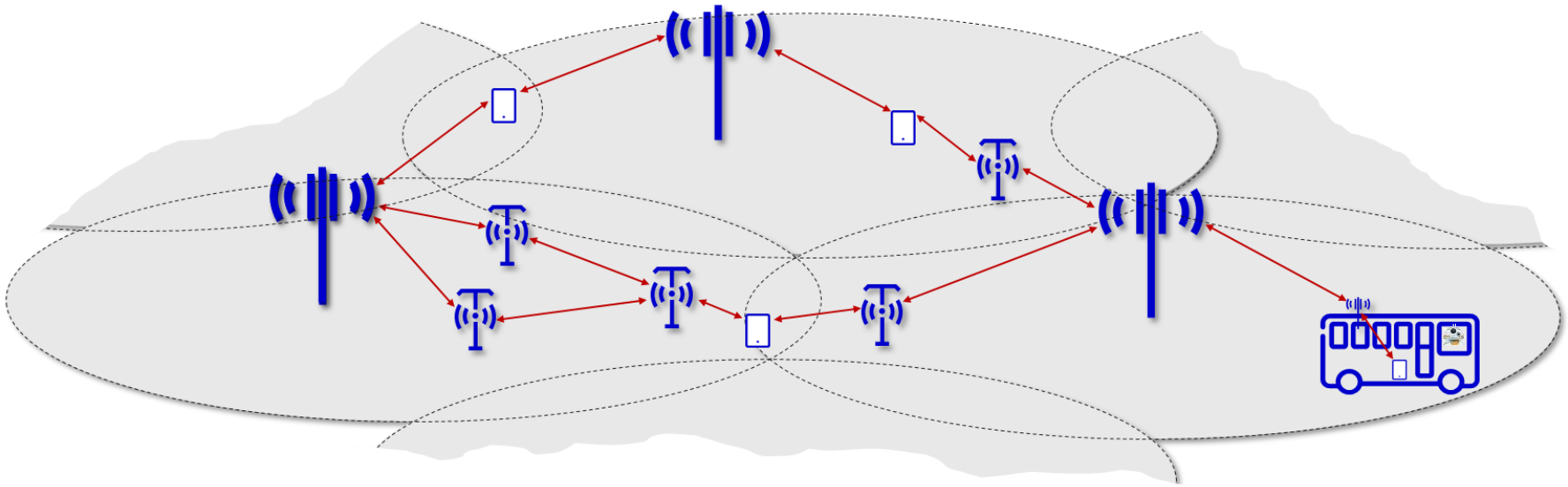
From a cell-focused topology towards a “best-path” topology under network control

— Multi-site connectivity

— Multi-hop

— Mobile relays

— …

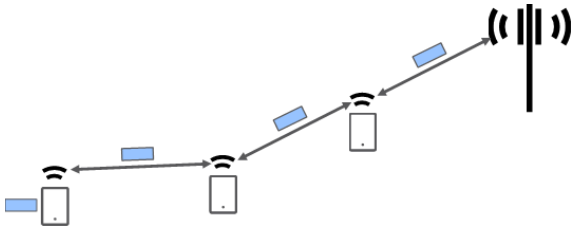


Device co-operation

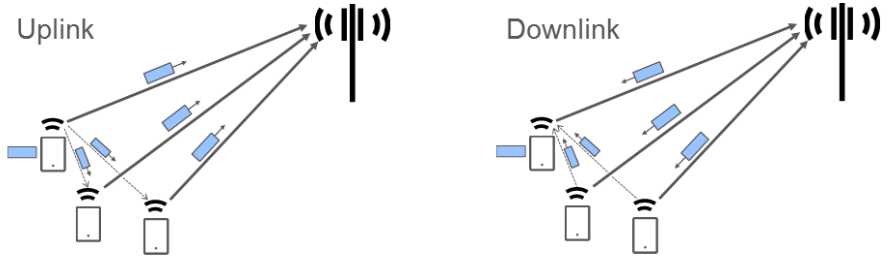
Turning devices into integrated components of the overall connectivity fabric

- Device-based relaying
- Co-operative transmission and reception
  - Turning multiple physical devices into a single virtual device with many antennas
- Especially for future IoT applications

Device-based relaying



Cooperative transmission/reception



Massive IoT in the 5G era

LTE based technologies will be the main technologies for massive IoT also in the 5G era

— Cat-M and NB-IoT

Cat-M ("enhanced MTC")

— Extension of LTE introduced in Release 13
— Lower device complexity/cost by enabling devices with reduced bandwidth (20 MHz ⇨1.25 MHz)
— Enhanced coverage (+15 dB)
— Longer battery life due to enhanced DRX

NarrowBand-IoT

— Separate air-interface spectrum compatible with LTE
— 200 kHz bandwidth
— Stand-alone, inband, or guardband deployment
— Intended to replace GSM for mMTC applications

Potential technology areas for future mMTC evolution

— Industrial sensors (cost reduced devices with multi-Mbps data rates without coverage extension functions)
— Zero cost devices
— Zero energy devices.

“Zero-energy” devices

Devices operating on ambient energy only

— Non-radio-based energy source (e.g. solar-powered devices)

— Radio-based energy source (e.g. energy harvesting, backscattering)

Energy harvesting

— Device power extracted from RF wave

— Can be combined with backscattering

Backscattering

— Communication by changing properties of “reflected” wave

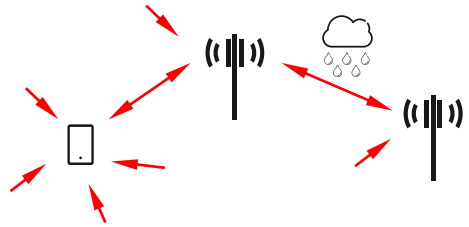
— “RF ID over a larger distance”

Example use cases: cargo tracking in a factory hall

Combined with “printables” for “zero-cost”

"Cellular as a sensor"

- Usage of radio signals to "sense" the surroundings
- Examples:
  - Wheather prediction using pathloss measurements (already demonstrated in practice using MiniLink)
  - Local maps created based on signal reflections of mm-wave signals



Artificial Intelligence in Wireless Networks

Challenges for AI in wireless networks:

— Very large number of parameters to be optimized

— Reward-function design often complicated, e.g. number of handover failures minimized by not allow users in bad radio coverage

— Limited support for data access and actuation

1. Machine learning in current networks

— ML applied to RRM algorithms

— Joint training of algorithms to ease integration

2. Enhancements for machine learning

— Additional device measurements / information

— Improved access to data (RAN/CN/OSS interfaces)

— Downloadable neural networks

3. AI-native Air Interface (AI-AI)

— Enable the use of machine-learning algorithms in all parts of the system, potentially even adapting the basic waveform

1. Machine learning in current networks

2. Enhancements for Machine learning

3. AI-native Air Interface (AI-AI)