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Nokia Networks

Air interface evolution towards 5G

Presenter: Klaus I. Pedersen, Nokia Networks

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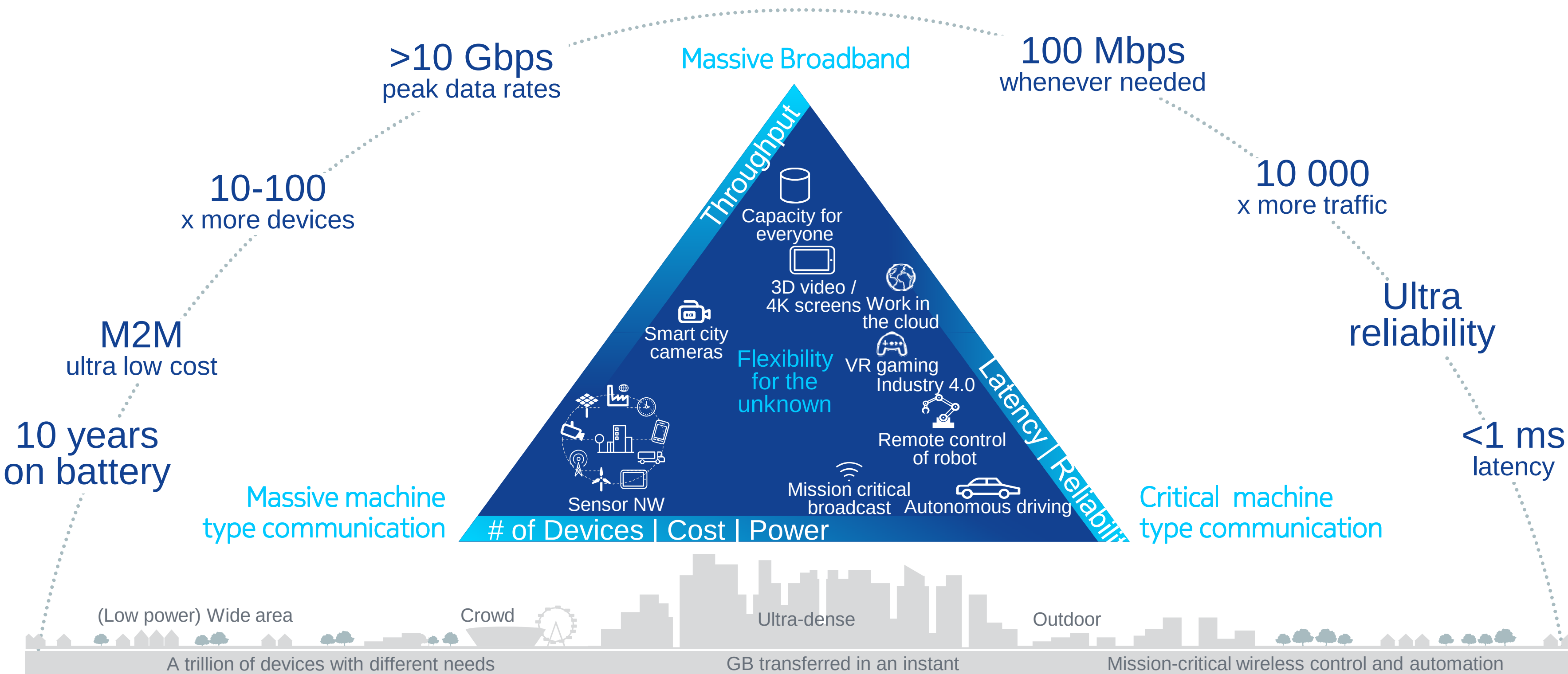
5G will enable very diverse use cases with extreme range of requirements



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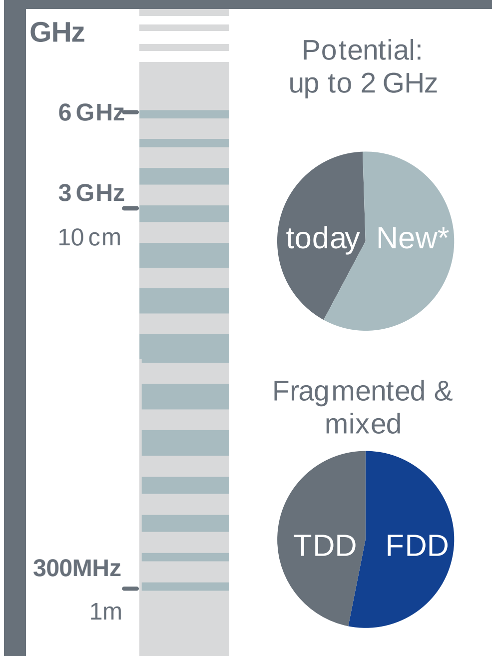
5G is to enable above 6 GHz & optimize below 6 GHz access
- 5G to be initially deployed below 6 GHz due to band availability

< 6GHz spectrum availability



WRC

2015: Some additional bands <6GHz to be identified – in time for 2020 deployments

2019: Expected to identify >6GHz bands – too late for 2020 deployments

Bands

3…6 GHz unpaired band is candidate for first 5G deployments.

Ready for > 6 GHz unpaired bands

Easily extensible to paired bands, also under 3 GHz

- 100-200 MHz carrier bandwidth supported
- High degree of spectrum flexibility required (fragmented spectrum)
- Carrier aggregation / dual connectivity, also with LTE bands

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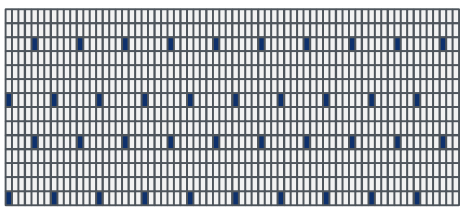
Lean Carrier Design

Lean carrier = no unnecessary transmission of wideband control data.

- Less inter-cell interference
- Lower BTS power consumption
- Lower UE and IoT device power consumption with narrowband AD converter

Transmission activity in empty cell

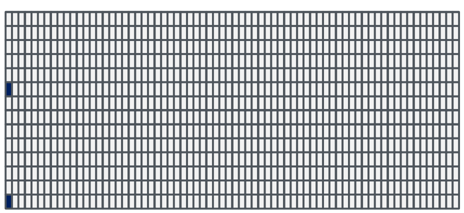
LTE



Continuous transmission of common reference signals

Current solution

5G



No unnecessary transmissions in empty cell

Lean carrier

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Flexible Frame Structure

Solutions

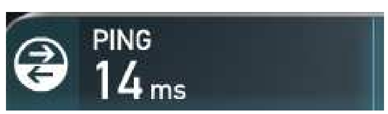
- Flexible frame size
- Flexible control channel
- Beamforming optimized
- Flexible TDD asymmetry

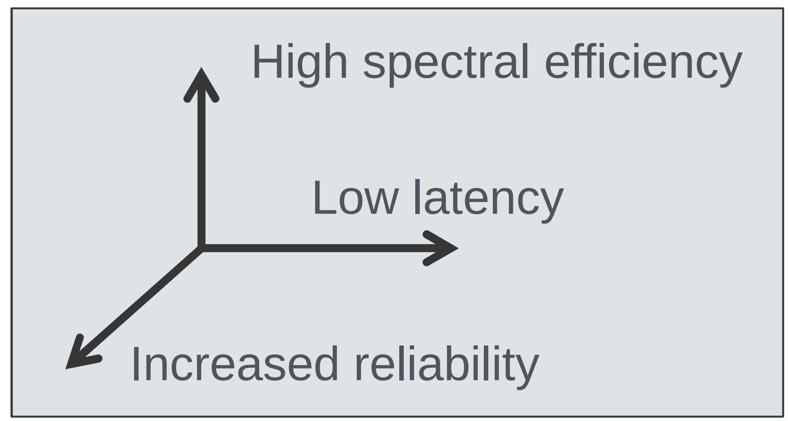
Benefits

- Latency <1 ms
- Efficient mux of users with diverse requirements.
- More efficient interference management
- Higher beamforming gain

Flexible trade-offs between enhanced spectral efficiency, low latency and increased reliability.

Practical LTE latency 10-20 ms





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Example of flexibility in terms of variable TTIs

Fundamentals:
- Short RTT calls for a short TTI size.
-The relative control overhead is larger for short TTI sizes.
- Longer TTI allows higher TBS, better time diversity, efficient FEC.

Broadcast use case:
Scheduled with long TTI size to maximize FEC gains from time-diversity.

Low cost MTC use case:
- Scheduled on moderate BW with longer TTI size
- Low BW and long TTI is attractive from cost and coverage p.o.v.

MCC use case:
- Short TTI size to meet latency requirements.
- TTI size adapted according to latency constraints.

MBB use case:
Start TCP sessions with short TTI size to quickly overcome the slow-start phase, followed by using medium size TTI to minimize control overhead.

Observation: A flexible frame structure with dynamic adjustment of TTI size per user is *one possibility.*

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Waveforms – Flexibility for Different Services

Use case	Optimization target	Waveform
Mobile broadband synchronous transmission	Spectral efficiency	Similar solution as in LTE like OFDMA and SC-FDMA
TDD beamforming optimization	Same waveform in uplink and downlink for beamforming	Uplink and downlink harmonization
Base station power efficiency	Low RF requirements (peak-to-average-power)	Single carrier solution for high bands in downlink (Zero Tail is similar to single carrier)
Small packet asynchronous transmission	Low overhead for small packets	Other solution could be considered

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Overview of New Waveform Options

OFDM
- Low transceiver complexity
- Simple MIMO
- Frequency domain scheduling

SC-FDMA
- Low amplifier requirements
- Advanced receiver required
- Limited frequency scheduling

LTE solution
- Downlink OFDM
- Uplink SC-FDMA
- OFDM fine for synchronous transmission also in 5G

ZT-DFT-OFDM (Zero Tail)
- Lower out of band emissions
- Similar performance as SC-FDMA

FBMC (Filter Bank Multicarrier)
- Lower out of band emissions
- No Cyclic prefix overhead
- MIMO extension difficult

GFDM (Generalized Frequency)
- Lower out of band emissions
- Low Cyclic prefix overhead
- High receiver complexity

UFMC (Universal Filtered)
- Lower out of band emissions
- High receiver complexity
- Robust to frequency offset

New waveforms
- Lower emissions
- Less Cyclic Prefix overhead
- Some gain for asynchronous transmission like IoT
- Flexibility for different subcarrier spacings
- Good to have same solution in uplink and downlink

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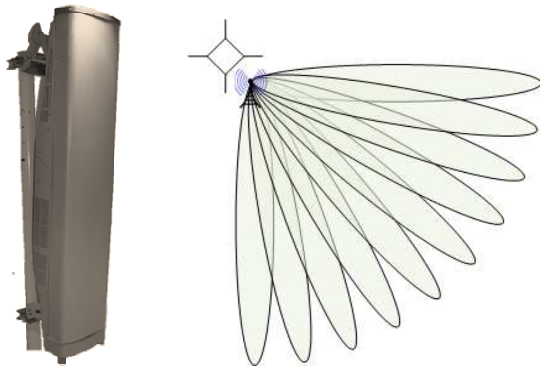
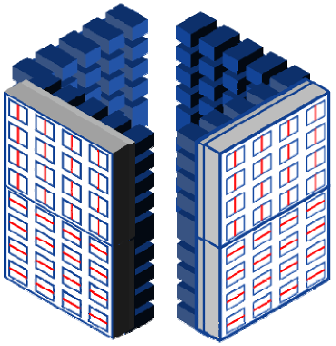
UE Agnostic Massive MIMO and Beamforming

UE agnostic MIMO	Network capacity can be upgraded with base station MIMO without new 3GPP definitions and without new devices. This solution applies for any frequency bands.
Massive MIMO	Large number of antenna ports (>32) can be utilized at high frequency bands to boost the link performance and minimize interference. Grid-of-beams (GoB). Hybrid eNB antenna architectures.





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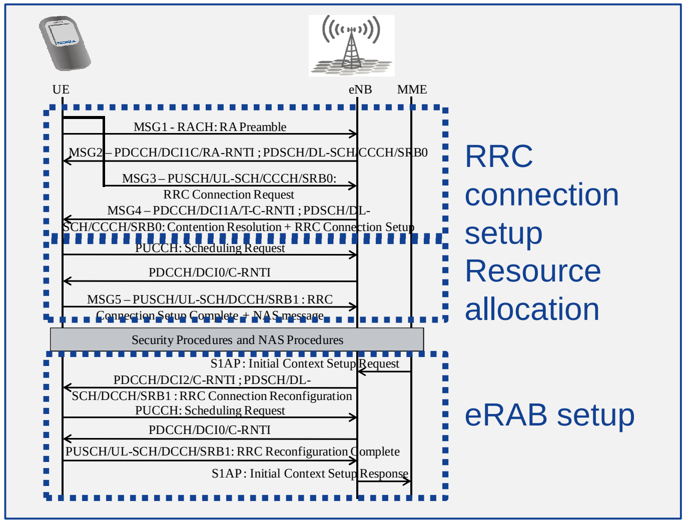
Small Packet Efficiency – Massive MTC access

Solutions

- Contention based transmission
- Coding scheme enhancements
- Session on demand

Benefits

- Lower synchronization requirements
- Faster decoding for small packets
- Minimized signalling overhead



- LTE: more than 10 radio signalling messages required for call setup, and additional signalling for call release
- LTE: uplink synchronization, capacity request and resource allocation required
- Potential for improvements!

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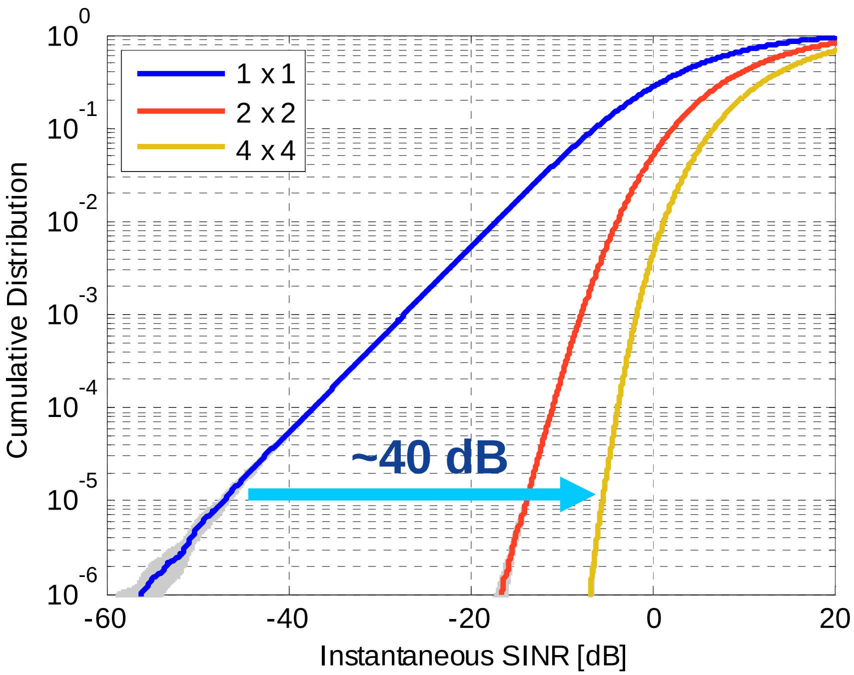
Mission Critical Communication (MCC) – Ultra Reliability

Ultra reliable communication:
Successfull transfer of a payload of B bits within a time of T seconds with high probability (e.g. 99.999%).

Possible enablers (examples):

- Diversity and redundancy
- Short TTI sizes, robust control CH
- Efficient error correction coding
- Active interference management
- Cell densification

SINR statistics for different MIMO options:



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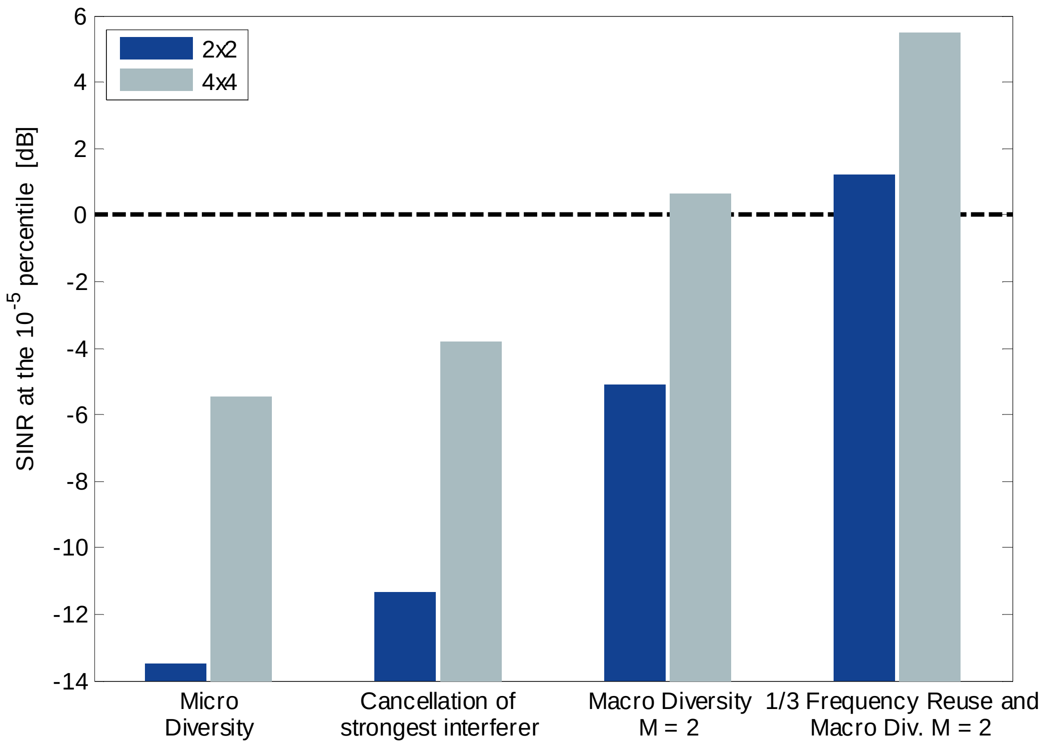
Example of SINR Outage Performance

Results for a traditional three-sector macro scenario



SINR target at 0 dB is a reasonable value for reliable low data rate communication.

Reaching the 0 dB SINR target with high reliability (10^{-5} outage) requires both high order micro-scopic and macro-scopic diversity.

Interference cancellation and/or resource partitioning helps as well.

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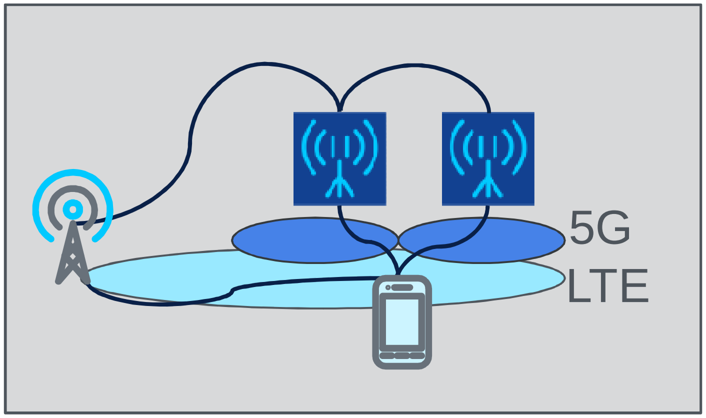
Multi-Node and Multi-Technology Aggregation

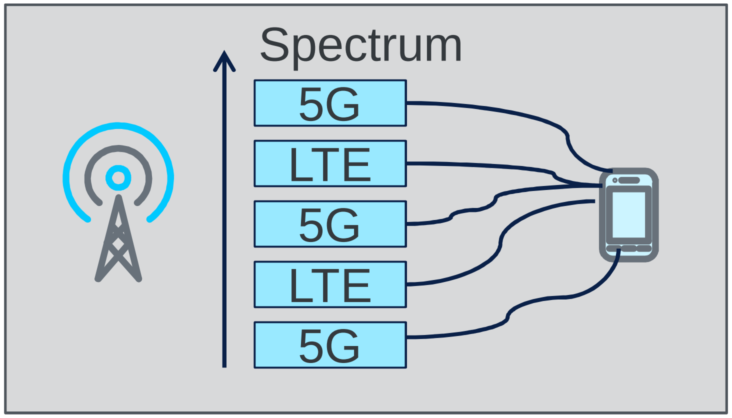
5G can be aggregated together with LTE both from different sites and from multiple bands

- Smooth 5G introduction
- Simpler refarming
- Higher user data rates

Multi-site aggregation



Multi-band aggregation



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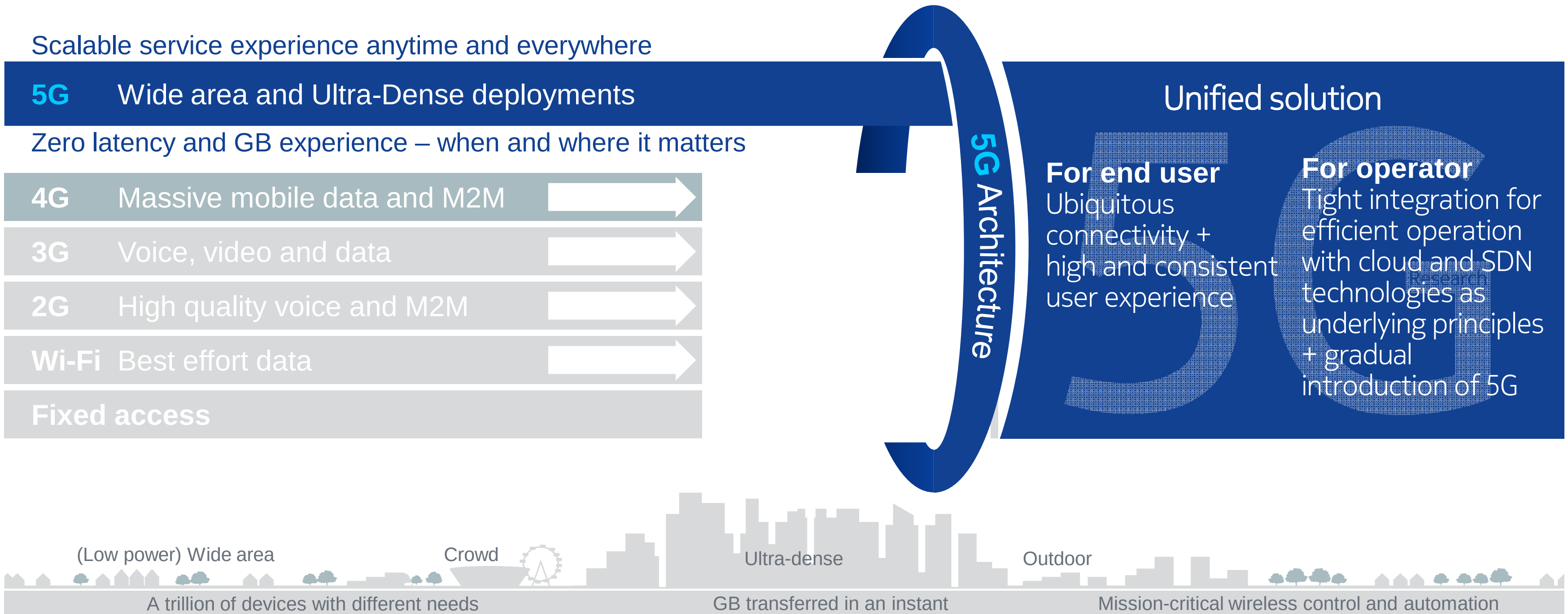
A symbiotic integration of novel and existing access technologies

Nokia 5G system vision



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5G for people and things
New performance levels 2020+
5G
Research
“It is dangerous to put limits on wireless” (1932)
-Gugliemo Marconi
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