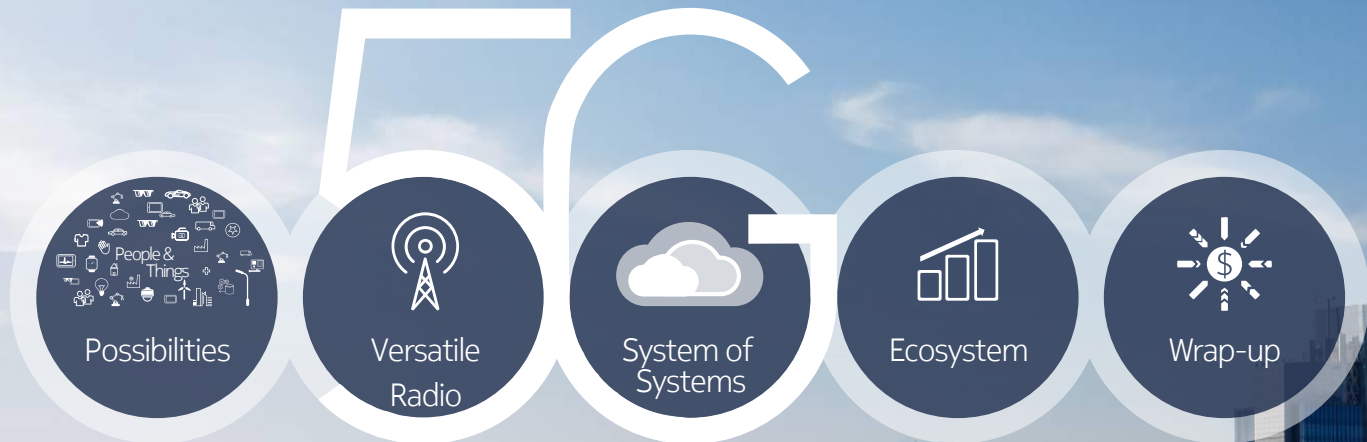


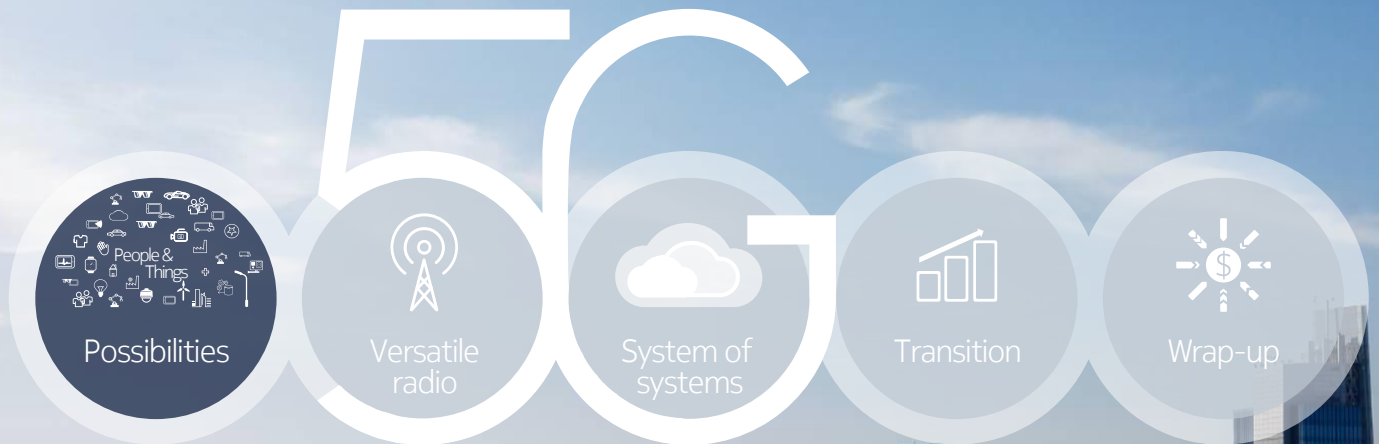
5G Technology Aspects



GSMA/GSA Session : Forward Thinking for Spectrum
Getting Ready for 5G
16.11.2017, Bangkok

Dr. Ulrich Dropmann
Head of Standardization
BellLabs/CTO – Nokia

Public



Making 5G a reality

5G is all about enabling revolutionary use cases



Use case evolution – 5G business starts now

Business driver

Automotive

- 1.2 million lost lives - 90% of crashes by human error
- Time & energy waste by traffic
- Industry to re-define mobility

Health

- Aging societies - leveraging remote medical support
- 2030: 52 million deaths by non communicable diseases

Events and tourism

- Tourism is 9.8% of world GDP with growing competition
- Event visitors expect better connectivity and apps

LTE Advanced LTE Advanced Pro

Assisted driving

- Vehicle hazard warnings
- HD location updates and situational awareness for intelligent vehicles
- Automated traffic and parking steering

Predictive health surveillance

- Remote diagnostic surveillance and assessment risk
- Early disease forecasting

Augmented location experience

- Location finder
- Multicast
- Video replay on-demand
- Augmented reality

5G

Automated driving

- Cooperative advanced cruise control
- Vehicle Platooning
- Smart intersection control
- Dynamic environment zones

Remote treatment

- Robot assisted examination and tele-consultation in 4D and 5D
- Remote surgeries

Freely selectable 3D views

- Freepoint viewing
- Player perspective
- Virtual reality

Use case evolution – 5G business starts now

Business driver

Industry 4.0

- 50% higher productivity
- Mass individualization
- Defragmentation of communication systems

Homes and buildings

- Cost efficient multi Gbps access deployment
- Efficiency and security gains, a multi B€ market

Mega cities

- Public safety, efficient energy supply and traffic management for dense urban population

LTE Advanced LTE Advanced Pro

Cognitive maintenance

- Sensor connectivity for monitoring and predictive maintenance
- Augmented (AR-supported) maintenance
- VR supported plant planning

Building management

- Energy management
- Home security
- Home maintenance: notification of leaks, smoke or high water levels

Public safety and supply

- Mission control for public safety
- Video Surveillance
- Connected mobility across all means of transport
- Environment monitoring
- Public parking and traffic steering

5G

Artificially intelligent production

- Common communication platform for all manufacturing use cases
- Wireless zero latency robot collaboration
- Autonomous vehicles in warehouses

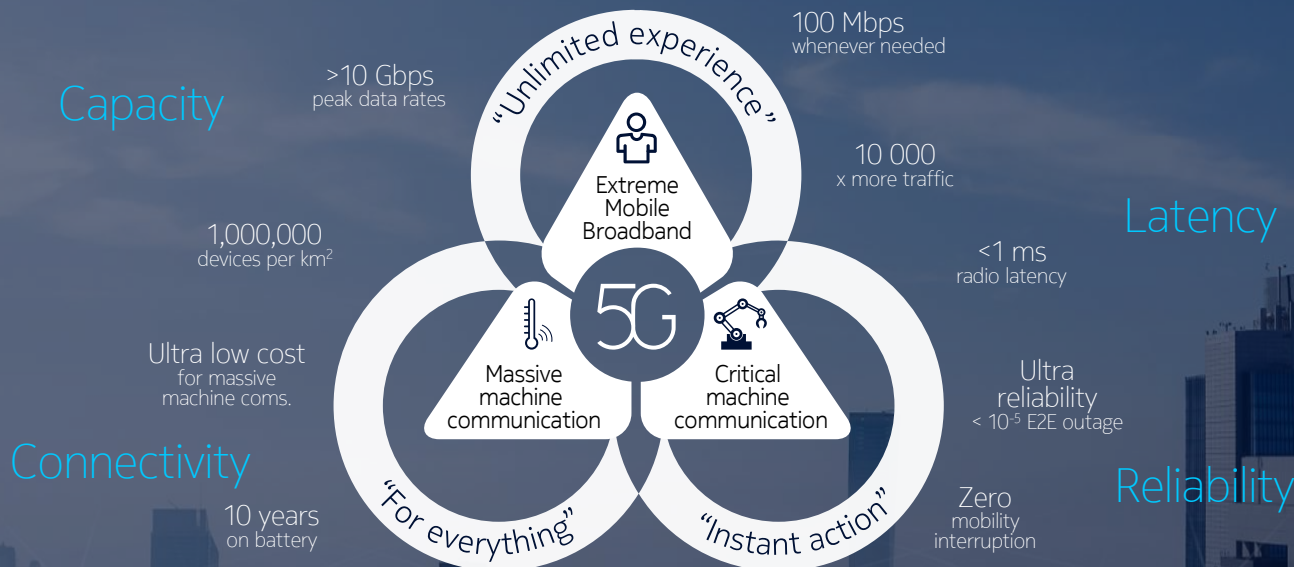
Super-efficient home

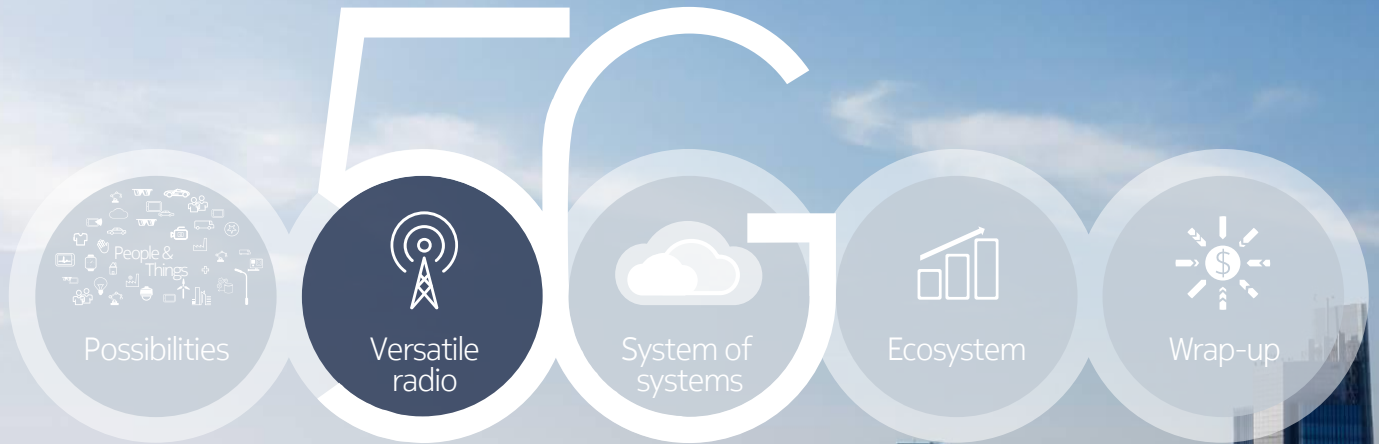
- UHD media to every home
- Home automation

Super efficient mega cities

- Intelligent traffic infrastructure
- Surveillance drones
- Tourism AR/VR

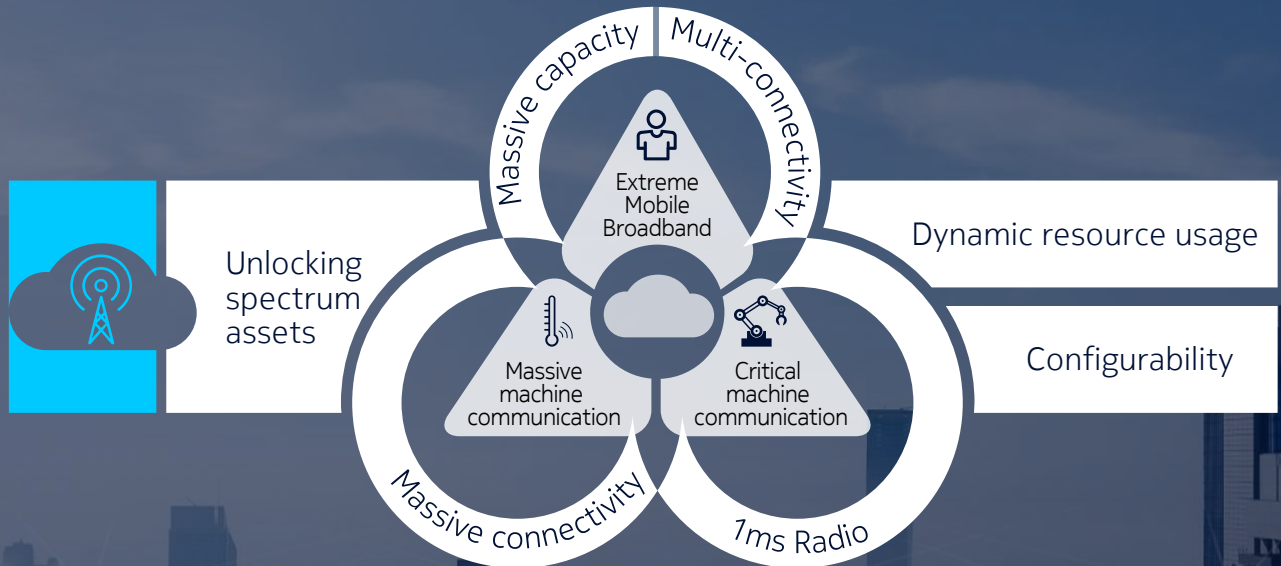
Revolutionary use cases demand widest system capabilities





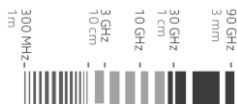
Making 5G a reality

Versatile radio– Scalability, performance and efficiency

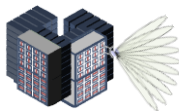


Main 5G Radio Technology Components

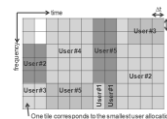
All kind of **spectrum** and bandwidth



Scalable Massive **MIMO**, 3D MIMO, beamforming and beamsteering



Flexible frame design, dynamic optimization, large bandwidth



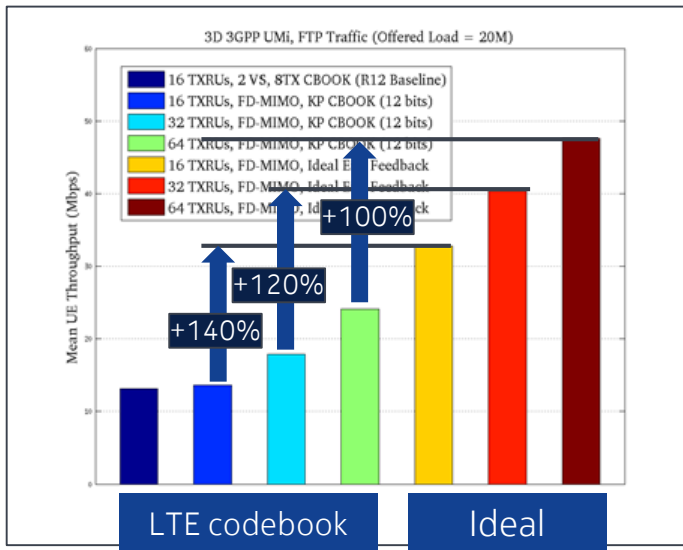
Multi-connectivity and aggregation



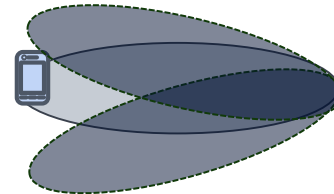
Cloud RAN for massive scalability & openness



Beamforming Gain Potential with MU-MIMO



- There is a major difference in MU-MIMO gains with ideal feedback and with LTE codebook.
- The ideal results are +100..+140% higher. Room for improvement in 5G.



Flexible Design : 5G Lean Carrier

Lower power consumption

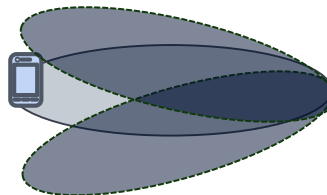
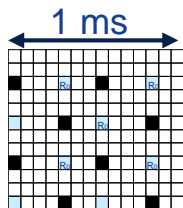
Zero users – zero power consumption

Less interference from reference signals

Minimized intercell interference improves capacity

More efficient beamforming

Dedicated user specific reference signals for massive MIMO

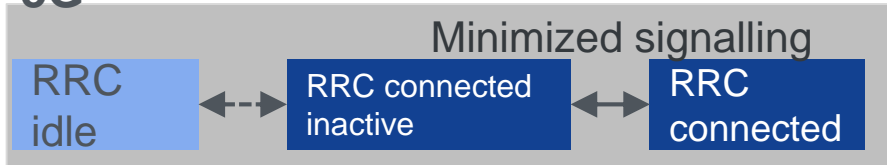


5G True Always-On

LTE



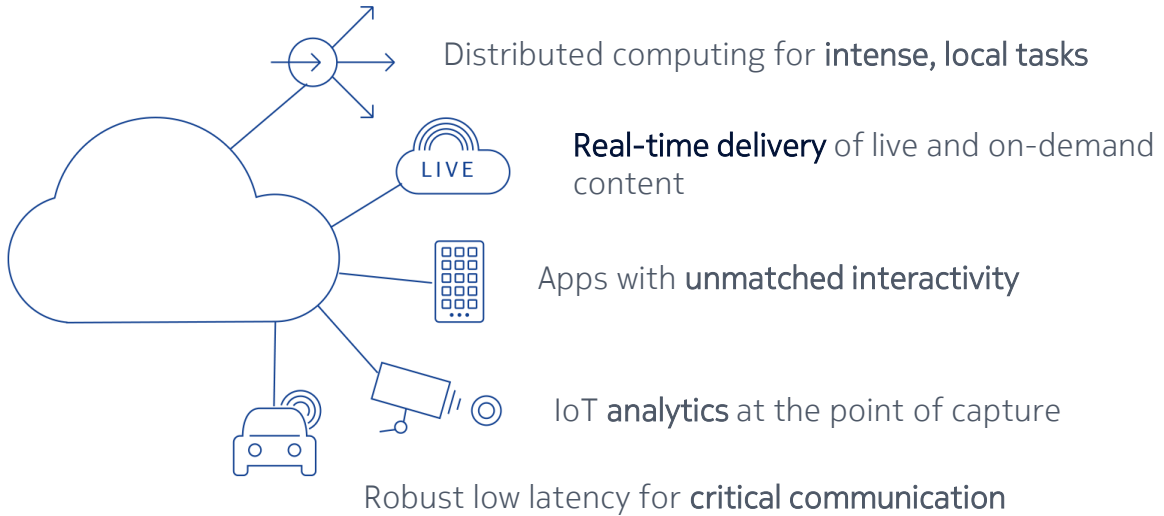
5G



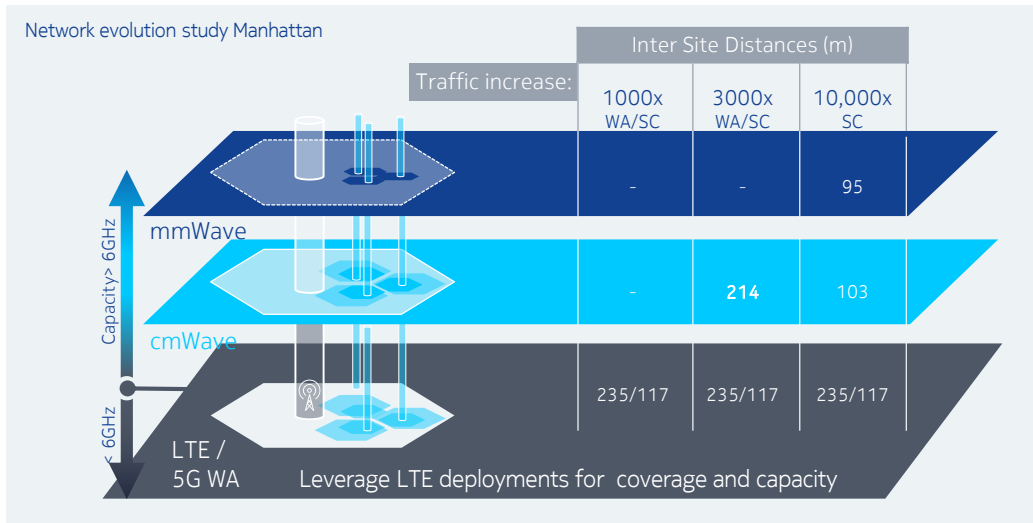
- Maintain RRC connection
- Minimize signalling and power consumption

RRC = Radio Resource Control

Multi-Access Edge Computing (MEC) in 5G



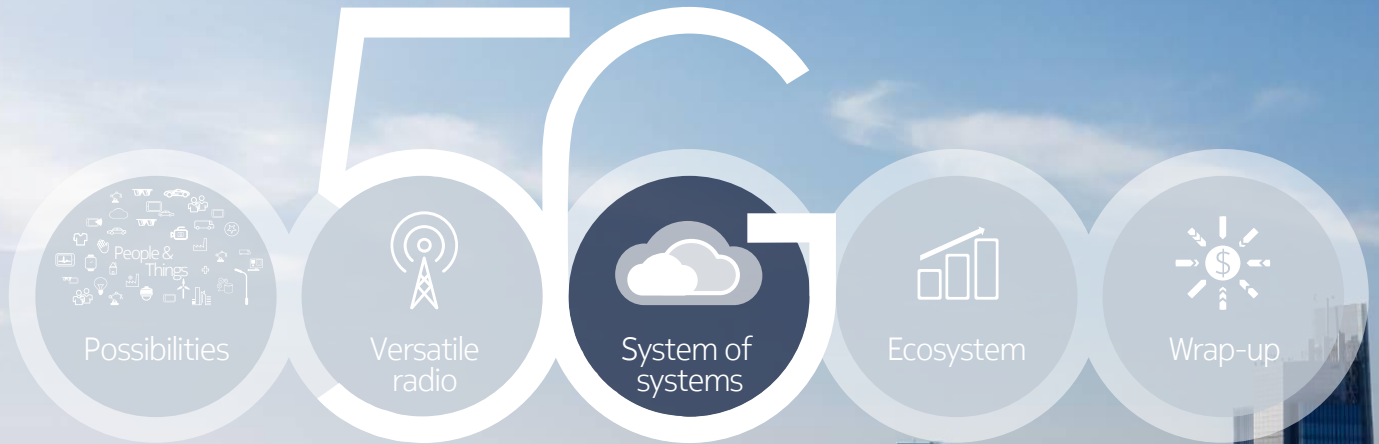
All Spectrum needed to adress traffic explosion



Economically feasible capacity for 10,000x traffic

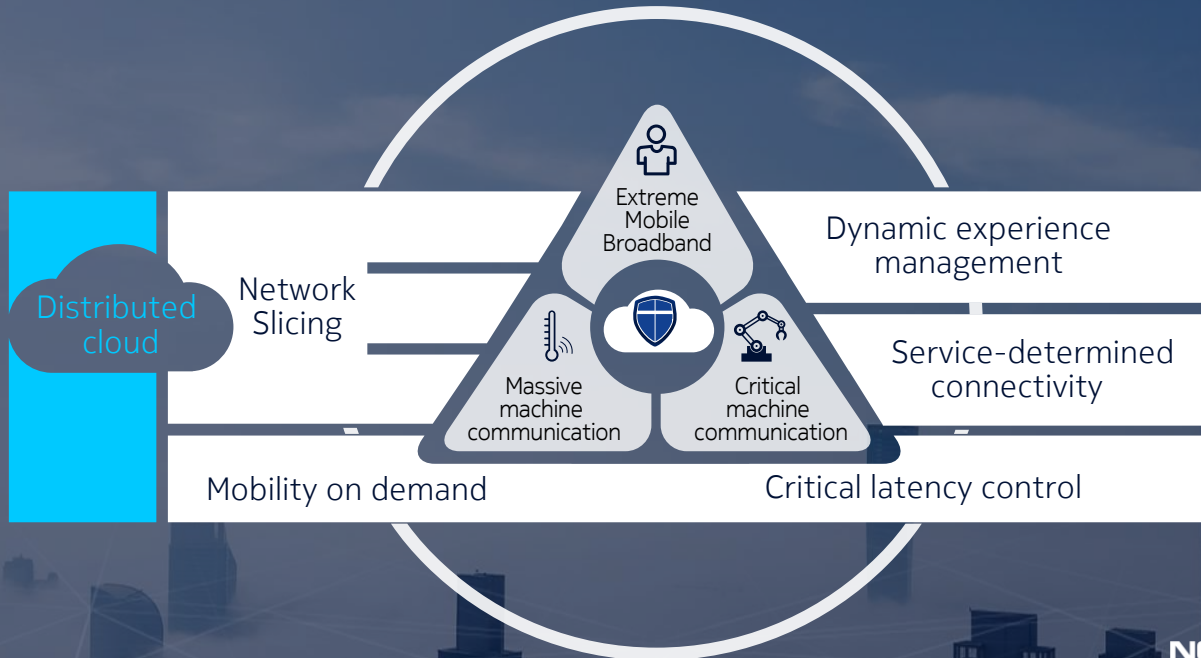
Grow with traffic demand while building on existing investments

Extensive deployment studies in NYC, Tokyo and Chicago



Making 5G a reality

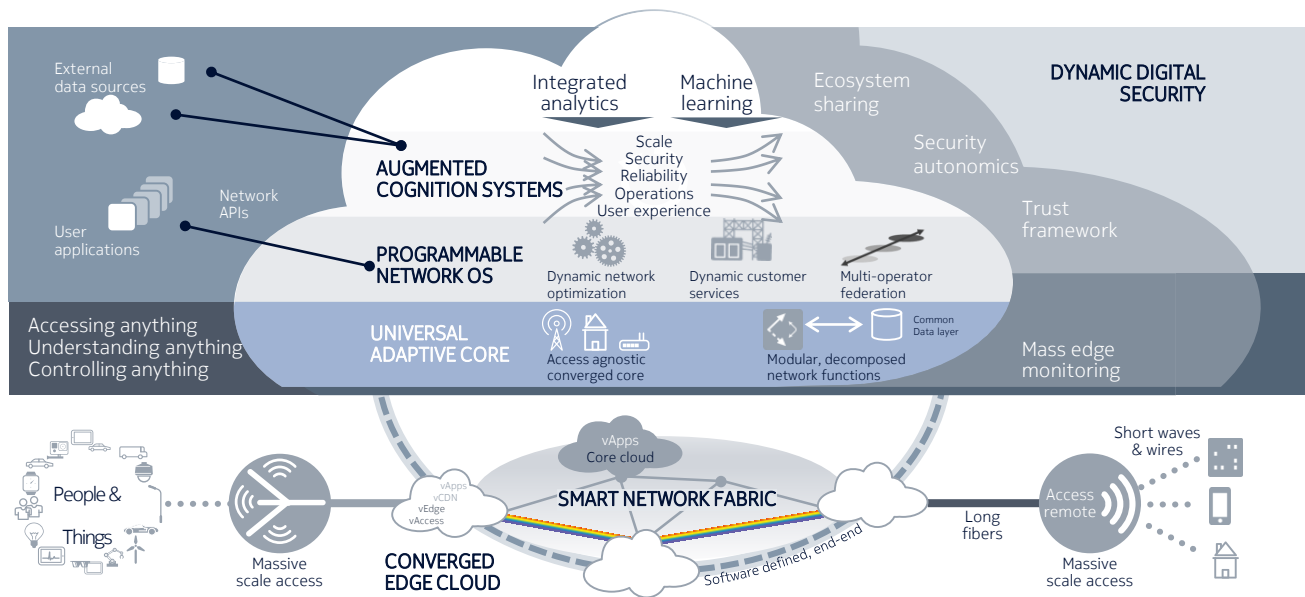
System of systems – capabilities for 5G



NOKIA

NOKIA

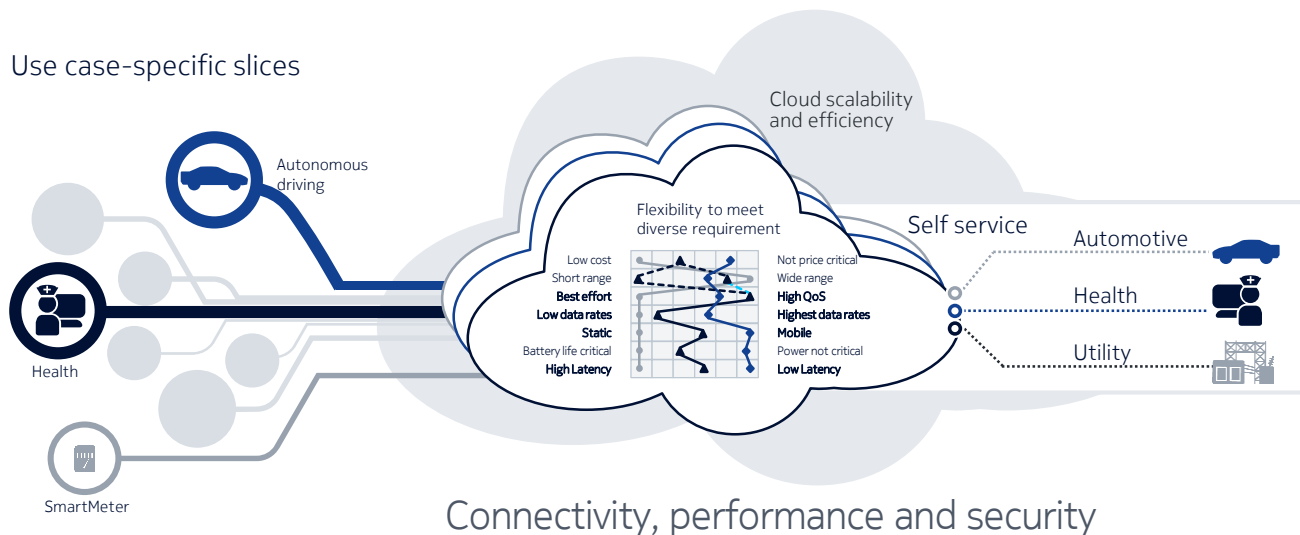
Future-X : The architecture vision for the 5G era



E2E Network slicing

Enable tailored Network as Service for diverse use cases and Verticals

Use case-specific slices



5G New Core : A cloud-native architecture



Cloud-native architecture



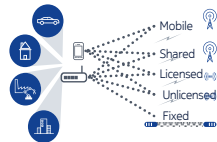
Configurability

Separation of control and user (data) plane

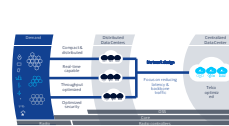
Control plane

User plane

Multi-access



Deployment flexibility



Scalability

Cloud data store such as Shared Data Layer

Shared Data Layer

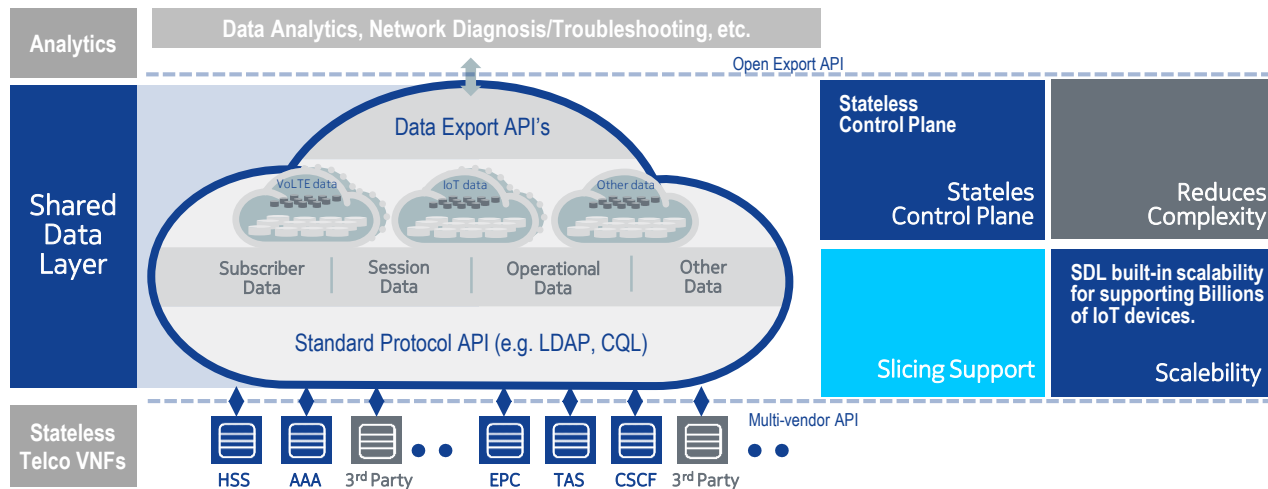
Stateless control plane VNFs

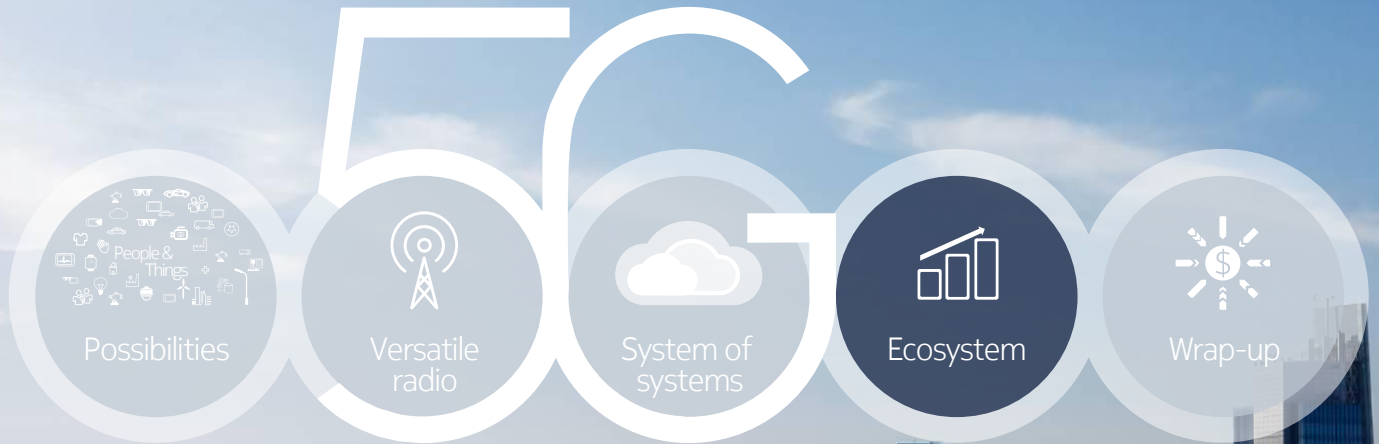
State-efficient VNF processing



Shared Data Layer (SDL) concept

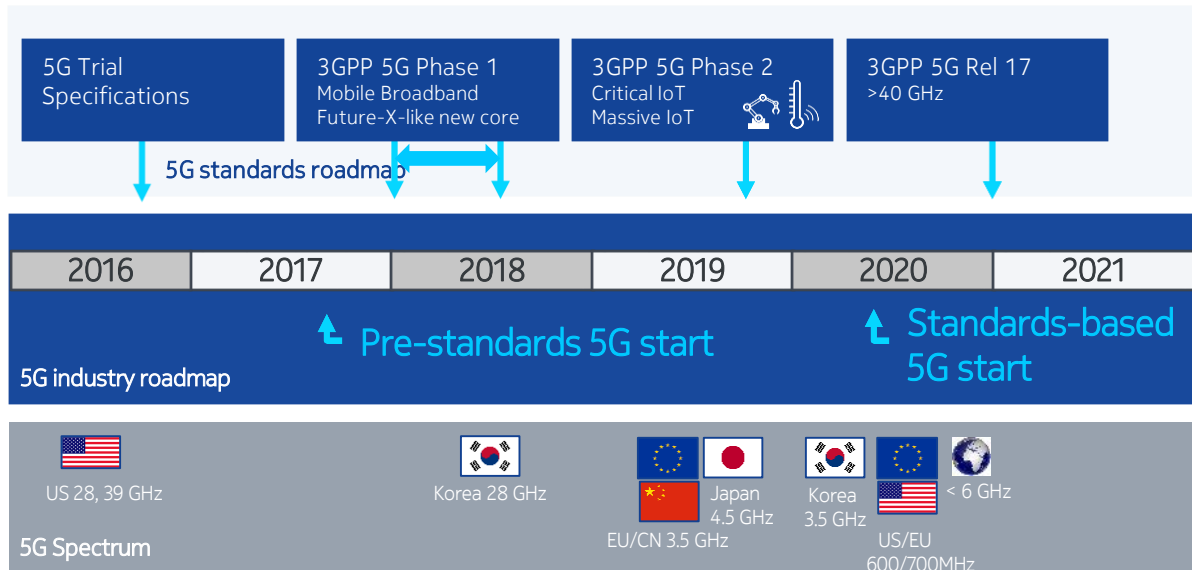
A key component of data-center optimized 5G architecture





Making 5G a reality

5G Industry Roadmap



Potential 5G Bands in (Early) 5G Deployments

600 MHz	LTE/5G	North America
700 MHz	LTE/5G	APAC, EMEA, LatAm
3.3-3.4 GHz	LTE/5G	APAC, Africa, LatAm
3.4-3.6	LTE/5G	Global
3.55-4.2	LTE/5G	US
3.6-3.8	5G	Europe
4.5	5G	Japan China
28	5G	US, Korea Japan
39	5G	US
24.25-27.5	5G	WRC-19 band, Europe
31.8-33.4	5G	WRC-19 band (Fra, UK)
~40,~50,~70	5G	WRC-19 bands

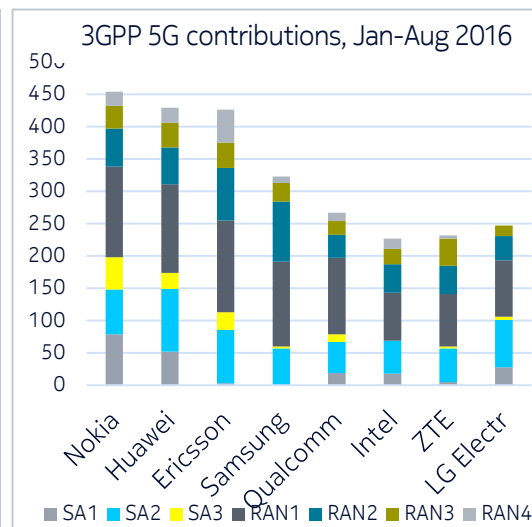
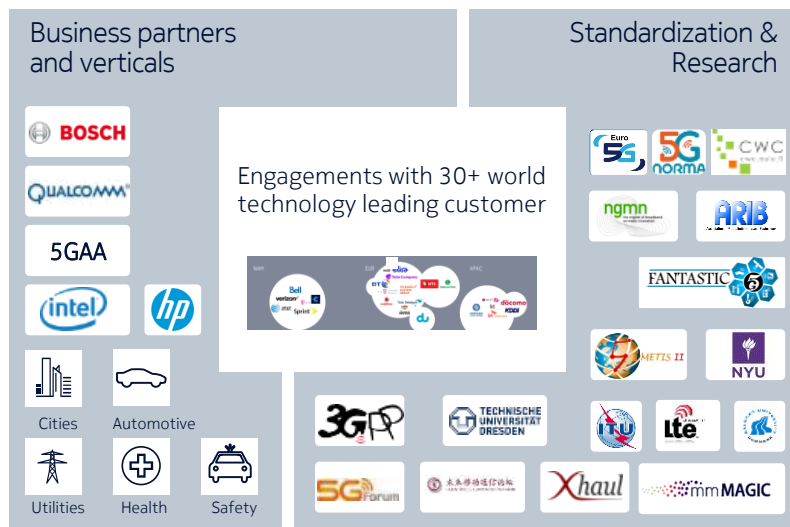
Full coverage with <1 GHz

Dense urban high data rates at 3.5 – 4.5 GHz

Hotspot 10 Gbps at 28/39 GHz

Future mmwave options

Driving the global 5G end-to-end ecosystem



5G Automotive Association



Automotive Industry

Vehicle Platform,
Hardware and Software
Solutions



Telecommunications

Connectivity and
Networking Systems,
Devices and Technologies

Automotive and Telecom Industries to Develop and Accelerate Availability
of Communications Solutions for Connected Mobility, Road Safety,
Autonomous Driving and Intelligent Transportation

5GAA Launched on 27 September, 2016 in Munich

5GAA Members

Global association open to companies and organizations engaged in the automotive and ICT industries and the broader eco-system and value chain for vehicle and road transportation systems

Founding Members



Audi

NOKIA

BMW
GROUP



Rolls-Royce
Motor Cars Limited



DAIMLER



QUALCOMM



vodafone

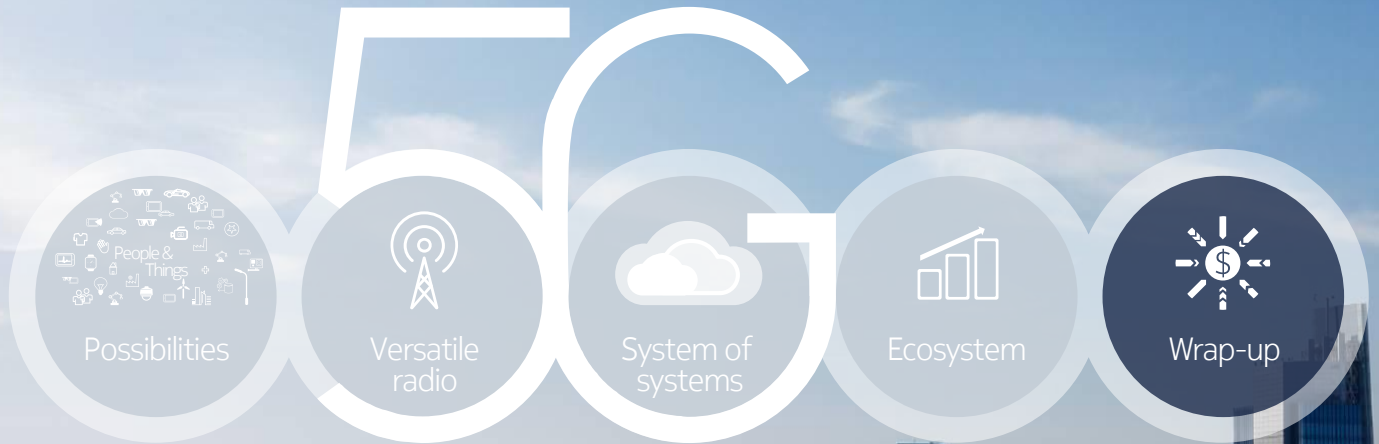


Deutsche
Telekom



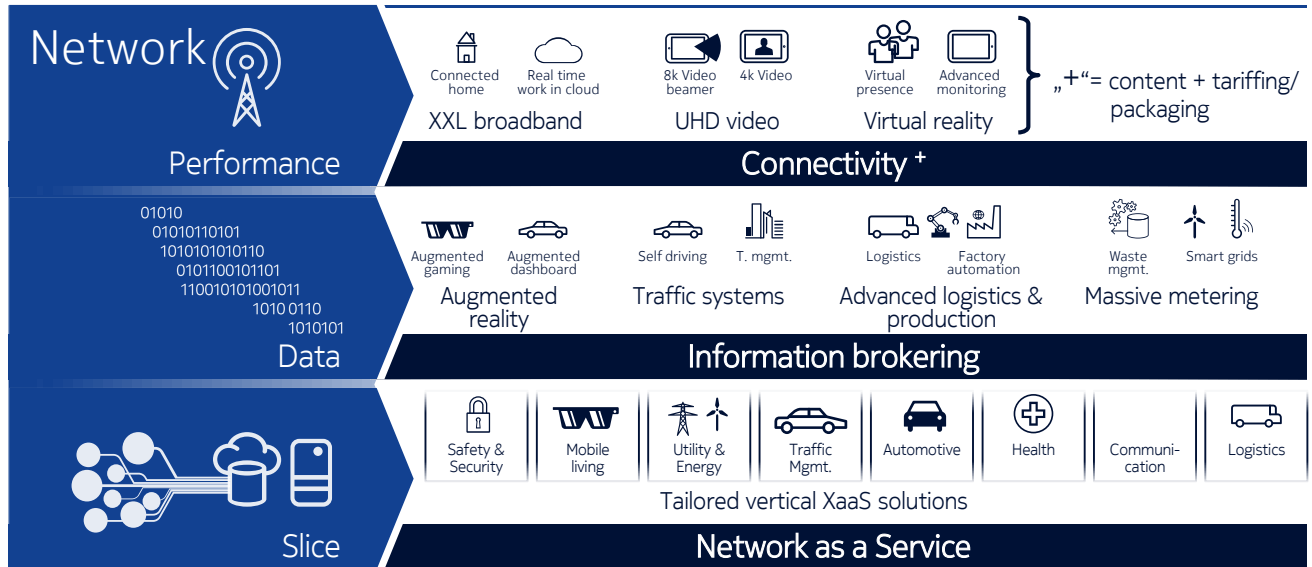
Several LOI received. >55 companies expressed interest in 5GAA

NOKIA



Making 5G a reality

5G key technology component enable new revenue



Making 5G a reality

Enable Novel
Use Case

Cloud-optimized
System of Systems



Versatile 5G Radio

Global
Ecosystem
moves
aggressively

Public

Public

NOKIA

www.networks.nokia.com/innovation/5G