5G for people and things
Key to the programmable world

Péter Szilágyi, Nokia Bell Labs
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5G will change the world

- **Unlimited experience**
  - >10 Gbps peak data rates

- **Extreme Mobile Broadband**
  - 100 Mbps whenever needed

- **Critical machine communication**
  - 10 000 x more traffic
  - <1 ms radio latency
  - <10⁻⁵ E2E outage

- **Massive machine communication**
  - Ultra low cost for massive machine coms.
  - <10⁻⁵ E2E outage

- **Ultra low cost** for massive machine coms.
  - 1,000,000 devices per km²

- **Ultra low cost**
  - 10 years on battery

- **“For everything”**
  - 10,000x more traffic

- **“Instant action”**
  - Zero mobility interruption

- **“For everything”**
  - >1 Gbps peak data rates

- **“Instant action”**
  - 10 Gbps peak data rates

- **“For everything”**
  - 1,000,000 devices per km²

- **“Instant action”**
  - 10 years on battery

- **“For everyone”**
  - 100 Mbps whenever needed

- **“Instant action”**
  - Zero mobility interruption

- **“For everyone”**
  - <1 ms radio latency

- **“Instant action”**
  - <10⁻⁵ E2E outage
Explosion of possibilities: new performance levels of people and things

**AUGMENTED**
- Augmented gaming
- Augmented shopping
- Augmented dashboard

**INTERCONNECTED**
- Personal robot
- 8k Video beamer
- 4k Video
- Real time work in cloud
- Smart clothes
- Smart watch
- VR gaming

**VIRTUAL**
- Real-time remote control
- Remote Diagnosis
- Real time cloud access
- Virtual 3D presence

**TACTILE**
- Touch & steer
- HD Cams NW

**REDEDICATED**
- Work & game while traveling
- Assisted driving
- Logistics
- Maintenance optimization
- Tracking / inventory systems
- Toll collection
- Traffic steering & management
- Smart grids
- Waste mgmt.

**AUTOMONOUS**
- Self driving
- 3D printing
- Factory automation
- Real-time remote control

**REVOLUTIONIZED**
- Industry 4.0
- Traffic Mgmt.
- Utility & Energy

**SUPEREFFICIENT**
- Reliable emergency communications
- People & Things
- Real-time work in cloud
- Real time in mobility
- 4th industrial revolution
- Connected home
- 3D printing
- Traffic steering & management
- Smart grids
- Waste mgmt.
5G for people and things | Key to the programmable world
System of systems

Network Slicing

Mobility on demand

Extreme Mobile Broadband

Dynamic experience management

Massive machine communication

Service-determined connectivity

Critical machine communication

Fast traffic forwarding

Fast traffic forwarding

Extreme Mobile Broadband

Dynamic experience management

Massive machine communication

Service-determined connectivity

Critical machine communication

Fast traffic forwarding
Network Slicing | Optimized service delivery for heterogeneous use cases
Multiple independent instances on one physical network

Slicing across radio, transport, core edge and central clouds

Cloud scalability and efficiency

Flexibility to meet diverse requirements

Challenge: full automation and self-optimization

5G ready
AirFrame data enter

Self service

Utility

Automotive

Health

Health

SmartMeter

Autonomous driving

Dynamic e2e network slicing

<table>
<thead>
<tr>
<th>Challenge: full automation and self-optimization</th>
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<td>10,000 x</td>
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*5G Novel Radio Multiservice adaptive network Architecture
Fast traffic forwarding | Enabling a new generation of latency critical services
Lowest latency packet forwarding to UEs

10 years 100 Mbps 10-100x ultra low 10 years

10,000 x >10 Gbps 100 Mbps <1 ms

Mission-critical services, e.g. in V2X or industrial applications

Central cloud based > 50 ms latency
Mobile Edge LTE ≈ 10 ms
5G Edge ≈ 2,5 ms
5G D2D ≈ 1 ms

Vehicle2Infra trial on German motorway
Pioneer in Mobile Edge Computing
Autonomous driving live demo
ETSI ISG Chair

UEs | Radio | Aggregation | Core
---|---|---|---
5G AP | 5G AP | Application server | Core Cloud

Native D2D | Mobile Edge cloud computing | Core Cloud

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5G AP

Application server

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10,000 x >10 Gbps 100 Mbps <1 ms 10-100x ultra low 10 years

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Fundamental Architecture evolution is required
Cognitive + converged + cloud-optimized network evolution

1. Converged edge cloud
   - Massive scale access
   - vAccess
   - vEdge
   - vCDN
   - vApps

2. Massive scale access
   - Access remote
   - Short waves & wires
   - Long fibers

3. Universal adaptive core
   - Access agnostic converged core
   - Modular, decomposed network functions
   - Common data layer

4. Smart network fabric
   - Converged edge cloud
   - Software defined, end-end

5. Programmable Network OS
   - Dynamic network optimization
   - Dynamic customer services
   - Multi-operator federation

6. Augmented cognition systems
   - Scale
   - Security
   - Reliability
   - Operations
   - User experience

7. Dynamic Digital Security
   - Ecosystem sharing
   - Security autonomics

Additional elements:
- User applications
- Network APIs
- External data sources
- Humans and things
- Accessing anything
- Understanding anything
- Controlling anything

Technical terms:
- Critical machine communication
- Mass edge monitoring
- Access agnostic converged core
- Multi-operator federation
- Dynamic network optimization
- Dynamic customer services
- Universal adaptive core
- Augmented cognition systems
- Programmable Network OS
- Dynamic Digital Security
Services transformation is a pre-requisite
E2E workflow automation, Cloud infra, Continuous delivery

Present Mode of Operation
- Relaxed* lead times
- Handovers and touch points
- Slow ROI
- Technology driven

Future Mode of Operation
- Ultrashort lead times
- Seamless delivery
- Fast ROI
- Business driven
Maximize use of Pre-5G-technologies
Nokia’s innovations enable Path to 5G now

Massive MIMO & Beamforming
First Massive MIMO, Beamforming and Beamtracking with phased array technology
2Q15

mmWave
First 10 Gb/s throughput in mmWave - 73 GHz
2Q15

cmWave
First 19 Gb/s throughput in cmWave ~15 GHz
3Q15

mmWave
Poc@60 GHz with phased array technology
2Q16

cmWave
42 Gb/s at 28 GHz in Nokia Shanghai Bell Labs
2Q16

5G-Interface pre-3GPP
First real time 8K HEVC video transmission over 5G radio technology
2Q16

Massive Capacity
First >30 Gb/s per user by blending multiple fixed and mobile technologies
1Q16

Multi-connectivity
First 5G+4G for >100 Mb/s anywhere
1Q16

Network Slicing
Network as a service for multiple industries
1Q16

Network operations
Automation and QoE management
1Q16

Mobile Edge Computing
First Mobile Edge Computing with Digital A9 motorway PoC 4Q15

Massive Connectivity
First >1 Million connections in single cell
1Q16

Mobile Edge Computing
Shanghai F1 2Q16

NFV/SDN
Making the Telco cloud, lean, agile and effortless to operate
1Q16

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