5G Facts and Myths

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1. Challenges
Telecom operator’s perspective

Revenue vs. Traffic Growth

Need to lower the cost of GB

Traffic does not need to scale with traffic
5G technical KPIs

- Higher system capacity: 1000 x capacity / km²
- Energy savings and cost reductions
- Reduced latency: < 1 ms
- Higher data rate: 100 x typical data rate (even for high mobility)
- Massive device connectivity: 100 x connected devices (even in crowded areas)

5G requires completely redefined RAN infrastructure
4G base station software current situation and problems

- locked to particular hardware (chipset)
- underperforming and overpriced
- does not use radio resource efficiently
- poorly scalable (lack of virtualized components)

Why not to address the new challenges and solve current problems at the same time?
2. Observations
Network architecture transition - latency

Networks of the past

- OTT service
- EPC

Networks of the future

- vEPC
- MEC server
- OTT service
- SD-RAN

RAN functionality running on specialized hardware and using large and expensive radios

RAN functionality running primarily in the cloud (on MEC servers) and using very simple and cheap radios
Network architecture transition - capacity

Networks of the past

Macro base station
- Long distance
- High power
- High cost
- Physically large – visible
- Low Capacity / area
- Low spectrum efficiency [bit/s/Hz/m²]

One base station serves multiple terminals

Networks of the future

Small cell base station
- Short distance
- Low power
- Low cost
- Physically small – discrete
- High Capacity / area
- High spectrum efficiency [bit/s/Hz/m²]

One terminal is served by multiple base stations
Throughput and means to influence

Use infrastructure wisely
  - Virtualization / slicing

Use spectrum wisely
  - Small cells
  - Smart RRM

Add more resources
  - Massive MIMO
  - Millimeter waves
3. What does 5G standard bring?
What does 5G standard bring?

- **Flexible Subcarrier Spacing**
  - 15, 30, 60, 120, 240 kHz

- **Channel Coding**
  - Data: LDPC Coding
  - Control: Polar Coding
5G standardization

- Operator
- Vendor
- Vendor

- ETSI
- 3GPP
- TIP
- xRAN/O-
4. Conclusions – is this 5G?
Technical comparison

**4G**

- 1 Radio Frame (10 ms)
- 1 subframe (1 ms)
- 12x15 kHz

**5G**

- 1 Radio Frame (10 ms)
- 1 subframe (1 ms)
- Or 12x120 kHz, 12x240 kHz

<table>
<thead>
<tr>
<th>Channel Coding</th>
<th>4G</th>
<th>5G</th>
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<tr>
<td>Data</td>
<td>Turbo Coding</td>
<td>LDPC Coding</td>
</tr>
<tr>
<td>Control</td>
<td>Convolution Coding</td>
<td>Polar Coding</td>
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5G services (?)
5. Conclusions – skip the „G” and focus on what is needed
Network architecture transition

Networks of the past

- EPC cabinet
- base station cabinet
- base station tower
- databases

Networks of the future

- MEC server (COTS) including: vRAN, vEPC, possibly applications
- Share among many base stations
- Small cell base stations: RRH, DAS, femto, pico
Network slicing

- **vEPC**
- **OTT service**
- **SD-RAN**

**Slice A:** public safety network

**Slice B:** OTT service provider

**Slice C:** hospital private network

All virtual resources provided on SaaS basis and running on COTS servers

Physical resources owned by e.g., shopping malls, municipality, church, etc
Market transition

• Remember the world with only big movie productions?

• Similar change is happening for mobile networks
Transformation already happened in other domains
Cost per GB

Source: Mobile Experts
Customization for verticals

Public safety VNF add-ons:
- D2D mode
- Extra protection

Automotive VNF add-ons:
- Latency reduction
- D2D mode

IoT VNF add-ons:
- PHY signaling reduction
- NB IoT support
5G vertical markets and use cases

5G blurs the boundaries between verticals, which can be served by universal RAN infrastructure.

**Factories of the Future**
- Time-critical process control
- Non-time-critical factory automation
- Remote control
- Intra/Inter-enterprise communication
- Connected goods

**Energy**
- Grid access
- Grid backhaul
- Grid backbone

**e-Health**
- Assets and interventions management in hospitals
- Robotics
- Remote monitoring
- Smarter medication

**Media & Entertainment**
- Ultra High Fidelity media
- On-site Live Event Experience
- User/Machine Generated Content
- Immersive and Integrated Media
- Cooperative Media Production
- Collaborative Gaming

**Automotive**
- Automated driving
- Share My View
- Bird’s Eye View
- Digitalization of Transport and Logistics
- Information Society on the road
„We are at the dawn of an era in networking that has the potential to define a new phase of human existance”

„This era will be shaped by digitization and connection of everything and everyone with the goal of automating much of life, effectively creating time by maximizing the efficiency of everything we do [..]”

The future X network. A Bell-Labs perspective
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BACKUP
Use case: private network

Airport

Island

Factory within Industry 4.0

Private network in rural area
Rajeev Suri, Nokia CEO, said five segments enhanced by digital networks – health, energy, transportation, communication and production – will lead the world into a new golden age, all underpinned by 5G.

“In 2018, the telco is expected to generate $150 billion in total EBITDA as a result of delivering enterprise solutions to customers. Yet we see that telcos who embark on a path to 5G – such as moving from 4G to 4.5G and 4.9G or focusing on SDN and a move to cloud will see massive growth in revenue and earnings in their enterprise businesses from today’s relatively small base. We are talking about over 80 per cent growth in revenue and nearly 100 per cent growth in EBITDA between 2018 and 2020. Pretty good, I would say.”
Market: in-building trends

Source: Mobile Experts
Network architecture transition

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Networks of the future

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Solution: software-defined RAN

Fully software-defined and NFV-compatible RAN functionality ready to be deployed on physical (base station) or virtual (MEC servers) resources using proprietary technology.
Why small cells:

- THE ONLY solution to meet 1000x network densification
- Improve capacity, quality AND allow for low power operation
- Easy and cheap to manufacture (more a consumer electronics)
- Applicable to residential, enterprise, urban, and rural areas
- Market worth 6 billion USD in 2020
5G new use cases

Source: ITU Vision for IMT-2020
Market: TCO comparison

Macro v. Outdoor Small Cell TCO comparison

Source: Mobile Experts; Note: Total cost reflects capex plus 8-year opex expenses
Market: low E-glass penetration

Source: Mobile Experts