5G – How will NRENs Evolve?

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Outline

• 5G Introduction
  • What is tomorrows need
  • WAN Opportunities
  • Techno-Economic Drivers
  • 5G Design principals and Ecosystem

• 5G beyond the NRENs
  • Introduction Survey and Results
  • NRENs 5G
    • Education as a Vertical Market
    • Role and Conclusion

• References
Expectation – Traffic Evolvement

2020: A New Networking & Connectivity Era
The world is changing...

- Pre-Internet Era
- 1st Discovery Era (Browsers)
- 2nd Discovery Era (Search)
- 1st Sharing Era (Video & eGoods)
- 2nd Sharing Era (Personal Context)
- 2nd Commerce Era (Everything)

- 4.3 ZB/Yr
  Connected Everything + Contextual Automated Experiences

- 2.6 ZB/Yr
  8K Video + Cloud Hosting User-Generated Content

- 1.0 ZB/Yr
  Connected Everything + Contextual Automated Experiences

Bell Labs
WHAT DO WE NEED @ TOMORROW’S FULLY CONNECTED WORLD?

**Massive Broadband mBB**
To deliver GB BW on demand

**Massive Control**
Response: 1 ms

**Massive Sensing**
1 b/s over 10 years off an AAA battery

**Massive Content**
Exceptionally faster data rates
Significantly lower Network latency
Massively increased mobile data volumes
Extended battery life for remote devices

**Ultra critical machine-type Communication (uMTC):**
To allow immediate Feedback with high reliability, and enabled Robot control and autonomous driving

**Massive Machine type Communication mMTC:**
To connects billions of sensors

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Tomorrows Need
WAN Opportunities

The Three New Huge Wide Area Network Opportunities

- Monitoring & Sensing
  > 10B units / year

- Switching & Sensing
  ~100B units / year

- Tracking & Tagging
  ~1T units / year

IEEE 5G Summit, Dresden, 5G Lab Germany’s Vision, Gerhard P. Fettweis, Frank H. P. Fitzek, Technische Universität Dresden
Momentum and Techno-Economic Drivers

A number of techno-economic drives are Converging to create a paradigm change in Design and Operations of future networks.

- Progress ICT
- Pervasive diffusion of ultra broadband access
  - Fixed and Radio Access
- Failing (costs) of hardware
- Maturity of Virtualization
- Wider Open Source community
- Probably powerful terminals (APs)

Source: Towards 5G Software-Defined Ecosystems
Technical Challenges, Business Sustainability and Policy Issues
5G – Brief Summary of Main Architecture Components

Programmable E2E connected and compute infrastructure
RADIO NETWORK SEGMENT - Evolution in:
• Capacity / Performance / Spectrum Access
NON RADIO NETWORK SEGMENT - Evolution in:
• Native Flexibility / Programmability conversion

5G Mobile Network Architecture
• Challenge: By 2018, the global mobile traffic will increase from 2.6 to 15.8 Exabyte’s.
• Physical/New Virtual Network Function*
• Edge Cloud / Central Cloud deployments
⇒ Need to integrate LTE-A evolution on RAN level
⇒ 5G network slice

*Challenges through service abstraction and virtualized computing, storage, and network resources

Physical Network and Computing Facility
• C-RAN with a option of flexible process split RAN/C-RAN
• Flexible access to, and unified management of, both network and compute resources
• Flexibility, elasticity and dynamic configurability across data, control and management planes (optimal utilization of infrastructure resources)
5G Design Principles

- Leverage spectrum
- Cost-effective dense deployment
- Coordinate and cancel interference

- Common composable core
- Fixed and mobile convergence

- Simplify operations and management
- Automation and self healing
- Service Orchestration
5G – Ecosystem a Vision

Business Function/Service Layer
- Spec and Implementation Business process
- Provisioning of application related functions

Orchestrator functions will allocate Computer and network resources to the Services targeting diverse and dedicated Business driven LOGICAL networks

Logical Networks – network slices, will contain specialized networking and Computing function

Novel network functions – Requirement: Efficient transmission and data processing Low latency ➔ Mobile Edge Cloud

5G PPP Architecture W-Group, View on 5G Architecture, Whitepaper 1.0, July 2016
5G beyond the NRENs – The Survey

**Perspective to fill in the survey:**
- from an NREN perspective
- Network provider, academic ICTs
- from a Researcher perspective
- from the End-User perspective
- from the Outreach perspective

**Survey in Section:**
- Affiliation: Identifying 5G Community
- NREN Campus: Current type of Network traffic and used Standards
  - NREN Campus and 5G:
    - 5G type of traffic, content experience, what is needed connecting everything everywhere
    - NRENs focus on 5G, the technical, economic drivers and use cases
  - NREN evolution in 5G:
    - Impact the academic network, NRENs discipline on 5G, 5G enabled services
    - Convergence Wireless/Wired, Constraints
- GEANT and 5G: How they see the role of GEANT

**What’s your Role / Affiliation?**

- NREN NOC / IT team: 42.4%
- Researcher (Universities or private research Lab): 27.3%
- Experimenter in R&D: 12.1%
- Student: 10%
- REN: 6.1%
- End-User: 4.2%
- Wireless Product: 3.9%

33 Responses = 100%
NRENs Traffic Evolvement / 5G Relevance

What is your traffic evolvement in the past 5 years?

- Rather Everything: 68%
- Rather Video and Goods: 13%
- Rather sharing data on the personal context: 13%
- Campus <-> cloud: 3%
- don't know: 3%

What impact will 5G have on the academic networks and related technologies?

- very important: 32%
- important: 58%
- not very important: 7%
- insignificant: 0%
- don't know: 3%
Traffic flowing through the R&E is very diversified with the user requirements:

- Primarily on MASSIVE CONTENT, demanding high speed networks
- Critical scenarios requiring low responses
- Prolonged Battery Live.

What is needed to connect everything, everywhere?
NRENs answers to Society Impact of 5G

Biggest Impact:

*Internet of Things* is for the NRENS a new subject from establishing infrastructure to deployment of services (e.g. collecting environmental data, health care patient information...).

With “*connected cars*”, we focus on “massive response”, to delay sensitive Networks (e.g. Health care, art performance).

*Embedded communication, virtual reality* brings us closer to (N)RENs R&E vertical (market).
5G Impacts/Challenges to the (N)REns

5G Network Architecture to address key challenges:
- By 2018, the global mobile traffic will increase from 2.6 to 15.8 Exabyte's.
- Edge and core cloud deployments will require massive content delivery,
- Storage and processing as well as complex processes control

To elaborate a Physical Network and Computing Facility
- A Cloud Radio Access Network (C-RAN) with a option of flexible process split RAN/C-RAN
- Flexible access to, and unified management of both, network and compute resources
- Flexibility, elasticity and dynamic configurability across data, control and management planes
  (optimal utilization of infrastructure resources)

Network Softwarization and Programmability required:
- Converged Data Plane functions:
- Infrastructure Softwarization functions virtualization, and programmability,
- Network Virtualization (NFV), standard of networking in 5G
NREN’s 5G Obstacles

Obstacles:
Lack of mature 5G ecosystems implies lack of use cases and missing budgets/funding.

Current generation of networks are not fully exploit and close the circle to missing 5G ecosystems.

33 Responses = 100 %
Drivers:

10-100x higher and 5x lower latency
let suppose the perspective of traditional Networking, focus on massive content.

100x more devices with +20 dB better coverage asking for new Standards, additional Spectrums.

10+ years battery live forces connecting things (devices), the IoT (LoRaWAN) world.
NREN’s 5G - Most Important Use Cases

Most Important Use Cases:

**Connecting devices** coupled with **additional broadband capacity** will be seen as the future perspective, the 5G world.

**Smart cities** shows real use cases, e.g. Health care, patient information; car park reservations; Traffic monitoring or Environmental Information.

**Virtual Reality** with **low latency**, the tactile Internet requires massive response, immediate with high reliability and robot control, autonomous drive.
**NRENs 5G – Convergence Mobile/Enterprise Networks**

How likely is it that we will see greater convergence between cellular and enterprise networks, when 5G arrives?

![Survey Results](image)

**Massive Content, Sensing and Control implies this convergence** – not immediately, but it comes over the next few years; so the process of convergence is started.

The importance of wireless will increase, but from the NRENs point of view there are limited capacities to further develop the network.

NRENs fears increasing dependencies to larger carriers.

It should be easy to implement a convergence between 5G and the existing network structure already locally exist. So the will of Enterprises is asking for cooperation.
NRENs 5G - Education as a Vertical Market

**5G – A catalyst for Transformation**
of the economy and connected society
- Rely on its infrastructure, which cover network needs
- Contribution to digitalisation of vertical market (education)

**Topics:**
- Advanced mobile technology (IEEE802.11/LTE-A...)
- IoT and Tactile Internet

**Future learning model:**
- International, Immediate, virtual and interactive environments
- Learner centric / skill centric / On demand and personalized
- Student development – enforce critical thinking and collaborative learning

**Applications supporting future learning models:**
- Virtual Reality (e.g. training, simulation)
- Augmented Reality (e.g. direct or indirect view of physical, real-world environment)

**Learning Forms:**
- Virtual Classroom, Virtual team-working, Tele-teaching/monitoring, Virtual universities
- Less intervention from the teachers, mostly through exploring, discovery and peering coaching

Source: References: GSA 5G Verticals Series - Education
## NRENs 5G Role within GEANT - Conclusion

### Make experience with 5G challenges - Adaption, and New technologies

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<thead>
<tr>
<th>Technology</th>
<th>Economy</th>
<th>Collaboration</th>
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<tbody>
<tr>
<td>Wireless Technology (IEEE 802.11x), Port mapped based network access (IEEE 802.1x), IoT-TTN-LoRaWAN, LTE-A, Microwave technology</td>
<td>Resell 5G deals and channel back requirements toward GEANT</td>
<td>Development of Critical Infrastructures and supporting NRENs backbone connectivity.</td>
</tr>
<tr>
<td>WiFi coexisting to ISPs cellular network technologies (LTE-A, Microwave technology)</td>
<td>The Interface to R&amp;E Vertical Market – Virtual, Augmented reality: Offering trainings, virtual network environments, and consulting activities, e.g. in E-learning</td>
<td>Building good test cases for 5G</td>
</tr>
</tbody>
</table>
5G - References

• IEEE 5G Summit, Dresden, October 2016
  • Slides: http://5glab.de/media/

• View on 5G architecture, 5G PPP Architecture Working Group, Version 1.0. July 2016
  • Document: https://drive.google.com/file/d/0B4QzlQzRZg9yLVC4eHEyTjM5M1E/view?usp=sharing

• The Benefits of Cloud RAN Architectures in Mobile Network Expansion, FuJitsu

• Network Function Virtualization in 5G

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  • Documents: https://drive.google.com/file/d/0B4QzlQzRZg9yYTlyc2VSTGVTWHc/view?usp=sharing
Thank you
Any Questions?
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5G Ecosystem – Indicative Research List

High degree of Flexibility:
- Network Slice Flexibility
- Multiple logical networks
- RAN/CN split

Transition from todays Network entities to a Network of Functions.

Management of Control of systems and Resources

Figure 3-1: Indicative list of key research issues in the context of 5G-PPP

5G PPP Architecture W-Group, View on 5G Architecture, Whitepaper 1.0, July 2016
Market potential – From 4G to 5G Challenges