On the Advanced 5G Infrastructure for “Anything as a Service”: Looking at a True Digital Society in H2020 and Beyond

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Sydney, 07-10 Sept 2014
Short bio

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• VP Huawei European Research Centre
  › Board member NetWorld2020 ETP and 5G Infrastructure Association
  › Head of Central Research Institute
    ▪ Future Wireless, Network and IoT (V2X) Technologies
    ▪ iAudio, 3D Video and Light/Soundfield Technologies

• 20 years in ICT field: Huawei, nsn, Nokia, Military Navy

• 150+ R&D projects: 2G, 3G, 4G and 5G
  ▪ Research and development
  ▪ Network planning and optimization
  ▪ Network vision and technology strategy
  ▪ Original contributions to any quality deliverable

• Visiting professor, University of Surrey, UK

• D.Sc. (Finland) and M.Sc. (Italy) in Technologies with distinction

• Knowledge network: >2,700 contacts (EC, Customers, Partners)
Where are we today?

“The smart phone is the extension of what we do and what we are, the mobile is the answer to pretty much everything.”

Eric Smith, Google, MWC 2010
Vision

“The smart phone is the extension of what we do and what we are, the mobile is the answer to pretty much everything”
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“Client Server”
⇒ Bit pipe and Free Communication Services

2010

“Bearer Graph”
⇒ Nervous system of the Digital Society and Economy

2020

“5G will become the new lifeblood of the digital economy and digital society”
Neelie Kroes, VP European Commission
Key recommendations and capabilities

![Diagram showing various categories like Speed, Traffic capacity, Reliability, Mobility and coverage, Energy efficiency, Number of Devices, Latency, and Spectrum and bandwidth flexibility.]

- **Future IMT**
- **IOT Advane**
- **IMT 2000**
- **Low**
- **High**
- **Ultra-high**
- **Best Effort**
- **Low**
- **High**
- **Ultra-high**
- **Energy efficiency**
- **Number of Devices [B]**
- **Reliability**
- **Traffic capacity**
- **Speed [Mb/s]**
- **Spectrum and bandwidth flexibility**
- **Mobile broadband**
- **Mission-critical machine communication**

**Cellular bands**
- **2010 WRC-2007**
  - 450-470 CDMA450
  - 698-790 2x30MHz
  - 790-806 non-IMT in EU
  - 2300-2400 non-IMT in EU
  - 3400-3600 200MHz in EU

- **2020 WRC-2015**
  - 470-694 224 MHz
  - 694-790 (Region 1) 30 MHz
  - 1350-1517 (L-Band ext) 100 MHz
  - 2700-2900 200 MHz
  - 3800-4200 400 MHz

**Visible light**
- 300 – 984 MHz

**Unlicensed Cellular bands**
- 300 – 984 MHz
- 40 GHz
- 2.5 GHz
- 10m
- 0.5 – 2km
- 50-100m

**Cellular bands**
- 428 MHz
- 300 – 984 MHz

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What is our network and services vision?

- 1000x higher wireless area capacity and 10G true immersive experience
- 100 billions of connections and 5x lower E2E latency (1ms target)
- 90% energy saving per provided service

1) FULL Immersive Experience
2) ANYTHING as a Service
Looking at new “Services and Service Capabilities”…

“Bearer Graphs” for Anything or Everything as a Service: DaaS, KaaS, NaaS, RaaS, SaaS, MaaS, and LaaS….

“Server”

“Client”
Looking at “Full Immersive Experience”…

8K = 2x4K pixels
4K = 2x2K pixels
2K = 2048 x 1080 pixels

Holovizio Lightfield Display [Holografika]

3D reconstruction obtained from a number of pictures captured from collaborating different viewpoints [Microsoft Photosynth]

Huawei audio lab with 22.2 channels system

The Stanford multi-camera system

Pope election in 2005 and 2013 – Comparison

FHD

http://en.wikipedia.org/wiki/Ultra_high_definition_television

http://www.text100.com/hypertext/2013/04/homo-numericus/
Example: movie projectors tomorrow (lasers)

30-50 Mb/s for a single view transmission and Zero-Latency (adaptive) interaction client-server *

*) For luminance (brightness), chrominance (color), resolution, viewpoint, etc. adaptation

Looking at the “Second Machine Age”…
Focusing on leveraging technologies around machine intelligence, big data and connected networks

“The Second Machine Age is the time when machines are now able to take over a lot of cognitive tasks that humans can do.”

[Erik Brynjolfsson and Andrew McAfee, MIT Center for Digital Business]
Example: The iCub robot platform ( [www.iCub.org](http://www.iCub.org) )

5,000 sensors!

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Specs</th>
<th>Bandwidth</th>
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</thead>
<tbody>
<tr>
<td>Cameras</td>
<td>2x, 640x480, 30fps, 8/24bit</td>
<td>147Mbit/s uncompressed</td>
</tr>
<tr>
<td>Microphones</td>
<td>2x, 44kHz, 16bit</td>
<td>1.4Mbit/s</td>
</tr>
<tr>
<td>F/T sensors</td>
<td>6x, 1kHz, 8bit</td>
<td>48kbit/s</td>
</tr>
<tr>
<td>Gyrosopes</td>
<td>12x, 100Hz, 16bit</td>
<td>19.2kbit/s</td>
</tr>
<tr>
<td>Tactile sensors</td>
<td>4000x, 50Hz, 8bit</td>
<td>1.6Mbit/s</td>
</tr>
<tr>
<td>Control commands</td>
<td>53DoF x 2-4 commands, 100Hz/1kHz, 16bit</td>
<td>3.3Mbit/s (worst case), 170kbit/s (typical)</td>
</tr>
</tbody>
</table>

(a) optical flow computation used for object tracking
(b) binocular disparity and 3D structure estimation


∥ Force control latency requirement = 1-5 ms ∥
What are the fundamental enabling technologies?

The nervous system of the true Digital Society and Digital Economy

1. Sensing
2. Rendering
3. Actuating
4. Edge computing
5. Networking

<Match, Action> ≤ 1ms
Ex: Network architecture SDN/NFV based (logical)

[Image of network architecture with labels:
1. Device Controller
2. Edge Controller (i) and Edge Controller (ii)
3. Orchestration Controller
M-MIMO
L1-3 Routing/Forwarding
Public
Private

Main research initiatives globally

**EU**
- Framework Program 7, e.g. METIS and 5GNow projects
- 5G PPP in Horizon 2020

**UK**
- 5GIC at University of Surrey

**US**
- Intel Strategic Research Alliance (ISRA)
- NYU Wireless Research Center
- 4G Americas

**China**
- 863 Research Program
- Future Forum
- IMT-2020 (5G) Promotion Group

**Japan**
- 2020 and Beyond Ad-Hoc Group under ARIB’s Advanced Wireless Communications Study Committee

**Korea**
- 5G Forum as PPP
What is 5G and where will R&I be placed in EU?

**European Commission**

- Neelie Kroes
  (Vice-President of the European Commission responsible for the Digital Agenda)


- **FI PPP**
  Next Generation of Ubiquitous Ultra-High BB network infrastructure which will support the Future Internet (FI)

- **5G PPP**
  Next Generation of Ubiquitous Ultra-High BB network infrastructure which will support the Future Internet (FI)

**H2020: Advanced 5G Network Infrastructure (700M€)**

5G Public (EU) Private (Industry, SME, Research) Partnership (5G PPP)

- **Research**
  - Strand Radio network architecture & technologies
    - 1000 fold traffic increase, versatile requirements
      - Network architecture, new frequency bands, latency;
      - Increased frequency re-use, versatile low-cost radio access infrastructure (SIT to > 1Gbps) + low energy
      - Flexible backhaul solutions
      - Architecture for 5G "transceivers" and micro-servers, HW building blocks
      - Key hardware building blocks to support various spectrum usage scenarios
      - Preparing for large scale demonstrators and test-beds (possibly leveraging existing experimental facilities)
  - Strand Convergence beyond last mile
    - Integration, unified control
      - Ubiquitous access continuum
      - Cooperative, cognitive fixed and heterogeneous resources, with fixed optical access reaching at least 10 Gbps
      - Reuse and sharing of functionalities
  - Strand Network management
    - Opex, capex, QoS, QoE
    - Network (SDN) and service management (metrics)
    - SDN+ automation
    - Security across domains
  - Type of Action: Research and Innovation – Large projects
    - Budget: € 98 Million

- **Innovation**
  - Strand Virtualisation and SW Networks
    - Flexibility, beyond firmware implementations
      - Virtualisation of net.functions, migration
      - Orchestration of resources
      - Flexible backhaul solutions
      - Integration service layers with network layers, reconfigurability
      - Openness, OTT integration, E2E SLA, third party providers
  - Type of Action: Innovation – Large projects
    - Budget: € 25 Million

- **CSA**
  - Support Actions
    - Coherence and impact
      - Programme integration, analysis of outcomes
      - Societal issues
      - International activities
      - Support to standards
      - Support to policies
      - Web site
      - Roadmaps, including experimental facilities
  - Type of Action: SA – Small projects
    - Budget: € 2 Million

Coordinated submission (5GPPP PPG) to open call: 16 PP + 2 CSA

www.5g-ppp.eu
<table>
<thead>
<tr>
<th><strong>5G Infrastructure Association: Actions in priority order</strong></th>
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<tbody>
<tr>
<td><strong>5G Vision</strong>: scenarios, requirements, enabling technologies, high level roadmap</td>
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<td><strong>International cooperation</strong>: EU-China and EU-Japan joint declaration, MoU, implementation</td>
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<td><strong>Spectrum</strong>: Requirements, analysis, recommendations on usage for regulators and upcoming WRC</td>
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<td><strong>5G Pre-standards</strong>: what, how, who and by when to be standardized</td>
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<td><strong>Public relations</strong>: Key messages, Web site, conferences, panels, press releases, incl. international cooperation</td>
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Towards “IMT for 2020 and beyond”…

- **5G**
  - Research and Technology Trials
  - Standard
  - Product R&D
  - Deployment

- **LTE**
  - R12
  - R13
  - R14/15

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<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Time</th>
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<td>2022</td>
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Conclusions

Focus on technology fields around machine intelligence, big data & connected networks

Collaborate and develop capabilities for leading the new paradigms

Exploit PP funds, enable technology adoption and market uptake

Create win-win conditions/instruments for national and international investors
Thank you
References


