Feeling the (Pain of) Convergence:
mmWave, 5G, SDN, NFV, IoT, ION, MEC, ...

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Expectation Always Grows with Success!

Expectation for runners:
- When you run 100 meters in 10 seconds, you are expected to run it in 9.5 seconds
- When you reach 9.5 seconds, you are expected to run it in 9 seconds
- You will always be expected for something newer and harder!

Expectation for the Internet
- TCP/IP was initially expected to send/receive “lettergrams”
- When the Internet can successfully support “textual” applications, it is expected to support “image applications”
- When the internet can support “voice applications”, it is expected to support “video” applications
- When the internet can support video applications, it is expected to support “immersive experience” applications. But can it really support it?
Evolution of Internet Applications
AR/VR: New Way to Live, to Play, to Work, to Share, to Design, to Experience, to Go beyond the Screen
Can the Internet Support any New Applications?

New Requirements
- High Throughput (1-10Gbps)
- Low Latency (1ms)

Obstacles
- Physics
  - Light speed: 300km/ms
- Protocols
  - 40-year old design
  - Real Transport: 100km/ms
- Economics
  - CapEx
  - OpEx

Emerging Technologies
- mmW
- 5G
- IoT
- V2X
- ION
- SDN
- NFV
- MEC
Panelists

- **Tommy Svensson**: Challenges and Opportunities with mm-wave Communications in 5G
- **Valerio Frascolla**: Mobile Edge Computing, a key building block for 5G networks
- **Eugen Borcoci**: Centralized SDN control in distributed IoT environment - is it possibly an efficient cooperation?
Thank you

www.huawei.com
Panel on Communications on ICN & SPACOMM

Topic: Feeling the (Pain of) Convergence: mmWave, 5G, SDN, NFV, IoT, ION, MEC, ...

SDN, NFV, MEC.. in IoT Environment?

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NexComm Conference, 23-27 April, Venice
Convergence: mmWave, 5G, SDN, NFV, IoT, ION, MEC, ...

Facts:
- Internet and Telecom convergence → Integrated networks: Future Internet
- Novel services, applications and communication paradigms
  - Internet of Things (IoT) and Smart cities, M2M and Vehicular communications, Content/media oriented communications, Social networks,
  - Internet of Everything (IoE), etc.
- Novel, emergent technologies are changing networks and services architectures:
  - **Supporting technologies**
    - *Cloud Computing*
    - *Fog/Edge Computing /Mobile Edge Computing /Cloudlets*
    - *Software Defined Networks (SDN)*
    - *Network Function Virtualization (NFV)*
    - *Advances in wireless technologies: 4G-LTE, LTE-A, WiFi, 5G*

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- **Software Defined Networking (SDN)**
  - SDN – applicable in Clouds, WANs, IoT, vehicular, 5G
  - **SDN concepts and advantages:**
    - **Control Plane (CPI) and Data Plane (DPI) separation**
    - centralized logical control and view of the network
      - underlying network infrastructure is abstracted to applications
      - common APIs (northbound I/F)
    - Open I/Fs Southbound I/F CPI (controllers - DPI elements)
      - E.g. OpenFlow
    - **Network programmability**: by external applications including network management and control
    - **Independency of operators** w.r.t. network equipment vendors
    - Increased network reliability and security

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- SDN – architectural planes separation

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Network Function Virtualization (NFV)

- Using COTS computing HW to provide **Virtualized Network Functions (VNFs)**
  - Sharing of HW and reducing the number of different HW arch.

  **High flexibility in assigning VNFs to HW**
  - better scalability (hope)
  - decouples functionality from location
  - enables time of day reuse
  - **Virtualization** → flexibility and resource sharing

- **Rapid service innovation** through SW-based service deployment
- Higher **operational efficiencies**
- **Reduced power consumption**
  - (VNF migration, instantiation, …)
- **Standardized and open I/Fs**: between VNFs infrastructure and mgmt. entities
Convergence: mmWave, 5G, SDN, NFV, IoT, ION, MEC, ...

NFV vision (source: ETSI)
Convergence: mmWave, 5G, SDN, NFV, IoT, ION, MEC, ...

- SDN and NFV –complementary (orthogonal?)
  - SDN - horizontal separation in planes
  - NFV - vertical separation: HW/SW (applicable in both CPI and DPI)
  - They can be developed together
    - NFV provides functionalities
    - SDN provides “Tools”

- Cooperation
  - ETSI
  - ONF
  - IETF
  - ....

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SDN and NFV – are complementary - example
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- SDN control of IoT- example 1


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- SDN control of IoT - example 1 (cont’d)
- Functional modules of the controller and gateways


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- SDN control of IoT- example 2 (ICN-style architecture)

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- MEC Use Cases example- IoT
- Internet of Things (IoT)
  - IoT devices: Often limited (processor, memory capacity) → need for messages aggregation, security, low latency...
  - r.t. capability → grouping of sensors and devices is needed for efficient service.
- Possible Solutions:
  - IoT manipulated close to the devices (e.g., MEC server)
  - This also provides an analytics processing capability and a low latency response time.


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Conclusions

Significant effort exist towards convergence/cooperation

Technologies
- SDN- NFV
- SDN- NFV- 4G-5G
- CC- EC/Fog- 5G
- EC/Fog-MEC- Cloudlets
- CC-SDN-NFV- IoV
- CC-SDN-NFV- IoT

Issues: eliminate parallelism and overlapping between standardization efforts

Different functional and business aspects
- Management and control
- Slicing and virtualization
- Security, privacy
- Scalability
  - Interoperability
- Seamless deployment characteristics
- Support for apps and services

New business models
- ......
Thank you!

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References

2. ETSI GS NFV 002 v1.2.1 2014-12, NFV Architectural Framework

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- Backup slides
List of Acronyms

- BS  Base Station
- BSS  Business Support System
- CC  Cloud Computing
- CCN  Content Centric Networking
- COTS  Commercial-off-the-Shelf
- EC  Edge Computing
- EPC  Evolved Packet Core
- ETSI  European Telecommunications Standards Institute
- FC  Fog Computing
- FCN  Fog Computing Node
- IoT  Internet of Things
- LTE  Long Term Evolution
- MEC  Mobile Edge Computing
- M&O  Management and Orchestration
- MME  Mobility Management Entity
- NF  Network Function
- NFV  Network Functions Virtualization
- NFVI  Network Functions Virtualization Infrastructure
- NO  Network Operator
- NP  Network Provider
- NS  Network Service
- OSS  Operations Support System
- SDN  Software Defined Network
- SLA  Service Level Agreement
- SP  Service Provider
Intro to Panel on “Feeling the Pain of Convergence: mmWave, 5G, SDN, NFV, IoT, ION, MEC, …”

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**METIS Scenarios and Test Cases**

- **Great service in a crowd**
  - Amazingly fast
  - Ubiquitous things communicating

- **Best experience follows you**
  - Super real-time and reliable connections

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**Source:** METIS Deliverable D1.1 “Scenarios, requirements and KPIs for 5G mobile and wireless system”, [https://www.metis2020.com/](https://www.metis2020.com/)

Additional use cases has been proposed by NGMN Alliance, ‘NGMN White Paper,’ Feb. 2015 (available online [https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.pdf](https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.pdf))
METIS Overall Technical Goal

A system concept that, relative to today, supports:
› 1000 times higher mobile data volume per area,
› 10 times to 100 times higher number of connected devices,
› 10 times to 100 times higher typical user data rate,
› 10 times longer battery life for low power Massive Machine Communication (MMC) devices,
› 5 times reduced End-to-End (E2E) latency.

Source: METIS Deliverable D1.1 “Scenarios, requirements and KPIs for 5G mobile and wireless system”, https://www.metis2020.com/
Integrate existing and evolving access systems on a packet-based platform to enable cooperation and interworking. “Optimally connected anywhere, anytime"
We have done it once already –
On the terminal side!

Flexibility versus Efficiency

*Picture source: http://onpr.com/choosing-the-right-smartphone-its-easy-to-decide/
From hexagonal cells to unstructured beam spaces

Source: mmMAGIC WP4 presentation, ETSI workshop, Sophia-Antipolis, Jan 28, 2016
Network slicing - Where should we do the computing?
Challenges and Opportunities with Demanding Verticals

“Integrated Moving Networks”

• **Mutual benefits!**
• **Better mobile systems efficiency:** Vehicles collect side information to improve the resource allocation and performance of the mobile network
• **More reliable V2X links:** Connect non-vehicular users to the Traffic Safety/Traffic Efficiency protocols (Pedestrians, cyclists, pets, …)
• **New disruptive business opportunities:** exploiting vehicle sensed data
The research leading to these results partly received funding from the European Commission H2020 programme under grant agreement no671650 (5G-PPP mmMAGIC project).

THANK YOU!

Find out more at https://5g-mmmmagic.eu

Public deliverables: https://5g-mmmmagic.eu/results/#deliverables
D1.1: “Use cases characterization, KPIs and preferred suitable frequency ranges for future 5G systems between 6 GHz and 100 GHz”, released 2015-11-30
D5.1 "Initial multi-node and antenna transmitter and receiver architectures and schemes” released 2016-03-31
D4.1 "Preliminary radio interface concepts for mm-wave mobile communications”, released 2016-06-30
D3.1 “Initial concepts on 5G architecture and integration”, released 2016-03-31
D2.1 “Measurement campaigns and initial channel models for preferred suitable frequency ranges”, released 2016-03-31
6th Globecom’2017 Workshop on International Workshop on Emerging Technologies for 5G and Beyond Wireless and Mobile Networks (ET5GB)

Mon or Fri Dec 4 or 8, 2017, Singapore

Main topics:
• Novel radio access network (RAN) architectures
• Advanced radio resource management (RRM) techniques
• Emerging technologies in physical layer
• Novel services
• mmWave communications
• Energy efficiency
• Spectrum
• Prototype and test-bed for 5G and beyond technologies

Workshop Chairs:
• Wei Yu, University of Toronto, Canada
• Tommy Svensson, Chalmers U. of Technology, Sweden
• Lingjia Liu, University of Kansas, USA

Technical Program Chairs:
• Halim Yanikomeroglu, Carleton University, Canada
• Charlie (Jianzhong) Zhang, Samsung Electronics, USA
• Peiying Zhu, Huawei Technologies, Canada

http://wcsp.eng.usf.edu/5g/2017 (to appear) http://wcsp.eng.usf.edu/5g/2016
http://www.ieee-globecom.org/
From concept to deployment: the visions of the 5GCHAMPION and 5G-MiEdge projects

(Olympic Games are coming ...)

Valerio Frascolla
Intel

2017.04.27, COCORA 2017, Venice
5GCHAMPION (www.5g-champion.eu)

- **Project name:** 5G Communication with a Heterogeneous, Agile Mobile network in the Pyeongchang Winter Olympic Competition

- **Funding scheme:** FP8, Europe-Korea co-funding

- **Duration:** 2016.06 – 2018.05

- **Key Targets:**
  - The first 5G proof-of-concept in conjunction with the 2018 Korean Winter Olympics,
  - Synergize satellite and terrestrial technologies,
  - Strong impact on Standards bodies.

1. CEA-Leti (Coordinator), France
2. Nokia, Finland
3. Intel, Germany
4. Thales Alenia Space, France
5. University of Oulu, Finland
6. Fraunhofer HHI, Germany
7. Telespazio, France
8. iMinds, Belgium
9. ETRI (Coordinator)
10. Seoul Metropolitan Rapid Transit
11. South Korea Telecom
12. HFR
13. Clever Logic
14. Seoul National University
15. Dankook University
16. Hanyang University
17. Korea Telecom
18. Eluon
19. Инсорт
20. Mobigen
21. Gwangju Institute of Science and Technology
Main technology enablers:

- mmWave Backhauling,
- mmWave transceivers with reconfigurable antennas,
- Localised evolved packet core supported by distributed or centralized mobile edge clouds with caching,
- Media streaming functionalities,
- Satellite radio access,
- Satellite-terrestrial positioning.
5G-MiEdge (5g-miedge.eu)

- **Name:** Millimeter-wave Edge Cloud as an Enabler for 5G Ecosystem

- **Funding scheme:** FP8, Europe-Japan co-funding, 2016.06 – 2019.05

- **Key Target:**
  - 5G proof-of-concept in conjunction with the 2020 Japanese Summer Olympics.

- **Key technology enablers:**
  - mmWave Access & Backhaul,
  - User/Application Centric Orchestration,
  - Liquid RAN Control-plane:
    - novel ultra-lean and inter-operable control signaling over 3GPP LTE to provide liquid ubiquitous coverage in 5G networks, based on acquisition of context information and forecasting of traffic requirements.
Main research directions:

- Focus on the ultra High-Speed and Low Latency Communications (uHSLLC) use cases and related technology enablers
- Synergize between mmWave and MEC technologies

Technology enablers for uHSLLC and related KPIs

**5G KPI defined in IMT-2020**

- eMBB
- uHS LLC
- mMTC
- uRLLC
Questions?

Disclaimers

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**5GCHAMPION**: The research leading to these results was supported by the Institute for Information & communications Technology Promotion (IITP) grant, funded by the Korea government (MSIP) (No.B0115-16-0001, 5GCHAMPION), and received funding from European Union H2020 5GPPP under grant n. 723247.
Intel Communication and Devices Group