Open Smart Networks and Services in Future Communications

November 24th 2021

5G IA
INFRASTRUCTURE ASSOCIATION

The voice of the European industry for the development, deployment and evolution of 5G

Open Smart Networks and Services

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Abstract

Open, disaggregated, intelligent, secured, efficient and fully interoperable networks are the baseline on which 6G and future mobile networks should be built

Topics of interest

1. Openness in RAN, transport, Core and services
2. Disaggregation in open network architectures with open interfaces
3. Open source-based designs and platforms
4. Virtualization with innovative Open AI/ML methodologies and platforms
5. Near-real-time multi-resource allocation protocols and scheduling algorithms
6. Minimize complexity of radio units/digital units, maximize chip cloudification
7. Faster and more compressed fronthaul designs
8. Energy efficiency as part of novel architectural solution with new metrics
9. Security as integral/by design part of the architecture
10. Advanced 3rd party apps to interact with networks running at the edge
11. Extensive use of APIs in RAN, transport and core
12. Automation of zero touch provisioning, development of lifecycle CI/CD platforms
13. E2E Service Management and Orchestration (SMO) and use cases
14. Multi-vendor federated Electronic Management System (EMS)
15. New eastbound/westbound interfaces and APIs

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Openness in RAN, transport, Core and services

- Avoid vendor lock-in, reduce total cost of ownership, enhance supply chain ecosystem
- Foster competition & innovation, promoting a "Network of Collaboration"
- Potential vulnerabilities can be isolated and replaced more easily

Disaggregation in Open architecture and interfaces

- Native architectural HW/SW disaggregation for Whitebox solutions
- Decentralization of the core network infrastructure and multitenancy of the control plane
- Disaggregation of Network Functions for more efficiency, scalability and resiliency
- Open resource-to-resource interfaces and protocol oblivious, vendor-agnostic, multi-tasking

Open source-based designs & platforms

- HW and L1 SW abstraction in chips for faster integration of processor architectures
- Drive architecture for inline accelerators
- Modular technology to allow upgrading equipment for new demand on services

Virtualization in infrastructure with innovative Open AI/ML processes

- Multi-layer system orchestration, able to control E2E processing resources
- Self-resource adaptation/healing of the network to the user behavior in real time
- Seamless migration from different cloud services and infrastructure with common directives

Near-real-time multi-resource allocation

- Adapt resource reservation as a function of the load status at another resource
- Near-real-time adaptive rescaling of resource reservation by programmable schedulers
- Unconstrained resource pooling (resource fusion) at the infrastructure level

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Minimize complexity, maximize chip cloudification	• Minimize complexity of RU/integrated Massive MIMO antenna panels • Maximize chip cloudification to develop non-distributed architectures with high efficiency
Faster and more compressed fronthaul designs	• Minimize fronthaul requirements with high secured compression to allow more RAN centralization
Energy efficiency with new metrics	• Simplify architecture, overhead, and source code to minimize energy usage • Implement capabilities like passive IoT • Provision equipment capable to sense their environment • Metrics on open interfaces for measuring energy consumption in disaggregated components
Security by design	• Cyber Security rules by using a risk-based approach and zero-trust architecture principles to define security policies and requirements • HW native encrypting and ciphering processing
Advanced 3rd party apps	• Use spare computational resources at the edge to run 3rd party SW • Allow direct interaction with low level components of the E2E • Deploy services through a common API to handle/adapt network resources

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Extensive use of APIs	• Create a flat network environment with a Network as a Service (NaaS) approach • Avoid the transport network traditional lock-in by meeting the systems openness and compatibility
Automation of ZTP, development of lifecycle CI/CD platforms	• Develop flexible, scalable, reliable and resilient automation tools for fast and prompt deployment and operation • Quick site provisioning in a large-scale environment, with minimal manual intervention
E2E Service Management and Orchestrator (SMO)	• Service Assurance, analytics, dynamic inventory and common policies • Universal OSS • Single NFV Orchestrator (NFVO), Transport Domain Orchestrator (TDO) and Fixed Access Domain Orchestrator (FDO)
Multi-vendor federated Electronic Management System (EMS)	• Support for network elements from different vendors and provide a single NBI towards a Universal OSS to simplify fault, configuration, accounting, performance and security (FCAPS) management, scale and address security in multi-vendor deployments
New eastbound / westbound interfaces and APIs	• Link the RAN with third party supporting services or vertical's control systems. For instance, if a digital twin can help the RAN to optimal services, it could interface with RAN through these interfaces

Thank you for your attention!

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http://5g-ia.eu

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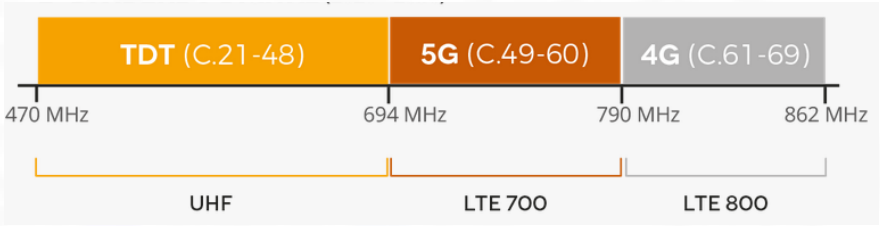
The UHF band represents "prime real estate" in terms of use, capacity and reach (for wireless technologies)

Pascal Lamy
Report

6G Broadcast … and the 600 MHz band

Prof. David Gomez-Barquero
Universitat Politècnica de València (UPV)
iTEAM Research Institute

Recap: Digital Dividends



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- **Geneva-06 allocated the band 470-863 MHz to broadcasting**
- **WRC-07 allocated 800 MHz broadcast band to mobile broadband**
- **WRC-12 allocated 700 MHz broadcast band to mobile broadband**
- **WRC-15** ***considered additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT)"***
  - Candidate bands included 470-694/698 MHz in all three Regions
  - Outcome was **No Change in Region 1**, **but with a compromise of a WRC-23 agenda item**, and some allocation/identifications in Regions 2 and 3
- **WRC-19**
  - *Set agenda for WRC-23 to review the spectrum use and spectrum needs of existing services in the frequency band 470-960 MHz in Region 1 and* ***consider possible regulatory actions in the frequency band 470-694 MHz in Region 1*** *on the basis of the review, in accordance with Resolution 235 (WRC-15);"*

But in the US, the 600 MHz band is already being used by 5G

Recap: Pascal Lamy Report about the Digital Agenda for Europe (2014)

- The **700 MHz band (694-790 MHz)** is currently used by terrestrial broadcasting networks and wireless microphones) should be dedicated to wireless broadband across Europe by **2020 (+/- two years);**
- Regulatory security and stability for terrestrial broadcasters in the remaining UHF **spectrum below 700 MHz to be safeguarded until 2030**;
- A **review by 2025** to assess technology and market developments.

There is a real window of opportunity at 2030 for the convergence of broadcast and mobile broadband!
Not only new technologies (6G Broadcast?), but also regulatory framework needed!

Broadcast technologies summary

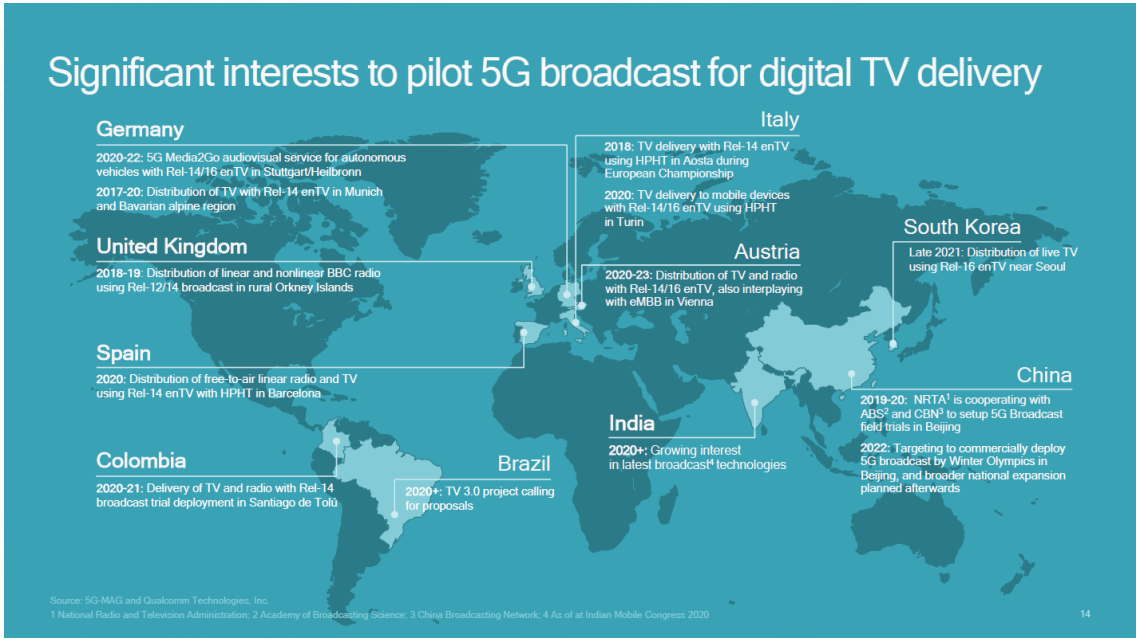
- DVB
  - Latest technology **DVB-T2** (2010)
  - There will be no DVB-T3, working on IP delivery (DVB-I)
  - European broadcasters started to participate in 3GPP in 2014
- ATSC
  - Latest technology **ATSC 3.0** (2017)
  - Working on ATSC 3.0 5G Broadcast core convergence
  - New regulation **Broadcast Internet**
- 3GPP **LTE-based 5G Broadcast**
  - Technology from Rel-14 (**FeMBMS**) with few enhancements in Rel-16 to get the 5G label, and being updated in Rel-17 to adopt broadcast bandwidths
- 3GPP **5G-native MBS (Multicast Broadcast Service)**
  - under development in Rel-17

5G MAG MEDIA ACTION GROUP

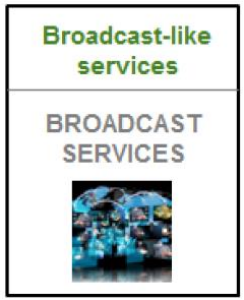
3GPP market representative (2021)

5G Broadcast

- **Strong interest** in the broadcast community
- No ecosystem, **lack of receivers**
- **LTE-based**, room for improved spectral efficiency
- **Third** (Rel-17) **or fourth** (Rel-18) **version** of the 5G standard, a lot of previous devices will not support it!



Source: Qualcomm



NGMN 5G WHITE PAPER

Broadcast Internet

Promoting Broadcast Internet Innovation Through ATSC 3.0

Released On: Nov 19, 2020

Issued On: Nov 19, 2020

- **ATSC 3.0 — the "Next Generation" broadcast television standard, often referred to as Next Gen TV —allows more efficient use of spectrum than ATSC 1.0, the current digital broadcast television standard. The additional capacity will allow broadcasters to expand their traditional television offerings, as well as provide innovative ancillary and supplementary services—known as Broadcast Internet—that can complement the nation's 5G wireless networks**

https://www.fcc.gov/document/promoting-broadcast-internet-innovation-through-atsc-30-0

What if?

DTT Quo Vadis

— Germany as a case study

Ulrich H. Reimers
Technische Universitaet Braunschweig

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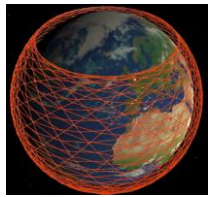
- **Digital Terrestrial Television evolves from a platform to deliver linear TV to fixed rooftop devices to a cost-efficient and scalable mass content delivery platform for TV sets, connected cars, smartphones, tablets and wearables?**
  - **Neutral host:** single infrastructure shared by all MNOs and broadcasters
    - E.g. First Net AT&T
  - **Cellular-like terrestrial infrastructure + NTN**:
    - rooftop, indoor and vehicular coverage
  - **Wideband broadcasting** (~100 MHz): **about 90% less total TX power!**
  - **Virtualized RAN** (O-RAN Broadcast)
  - ….



- **BUT who would own the spectrum? How would operate and maintain the platform? What would be the business relationships among the actors? …**

Conclusions
6G Broadcast and the 600 MHz band

- **6G represents a real opportunity for the convergence of broadcast and broadband networks**
  - WRC'23 could reinforce this opportunity
- **6G should also pay attention to the low UHF band, not only Terahertz**
  - Spectrum refarming of the low UHF band?
- **6G Broadcast should be**
  - Available from the very first release
  - Have a minimum footprint with respect to unicast, but some modifications are needed
  - Supported by NTN, O-RAN broadcast, wideband broadcast
  - …
- **But a new regulatory framework is needed!**
  - US are already innovating on broadcast regulation

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Thanks for your attention!

dagobar@iteam.upv.es

In addition, 6G radio technologies need to be carefully researched to cope with future broadcast/ multicast services, which could be – differently from 5G – taken into account from the very first release, to enable a cost-efficient and scalable mass content delivery platform for TV sets, connected cars, smartphones, tablets and wearables. 6G represents a great opportunity for the convergence of mobile broadband and traditional broadcast networks. In Europe, the 470-694 MHz band is used for the provision of terrestrial broadcasting services at least until 2030, a timeline well aligned with the first 6G release. Especially, 6G wideband broadcasting, which should support infrastructure from low-power low-tower to high-power high-tower, can reduce the transmit power by around 90% and contribute to the green deal initiative while keeping the capacity provided by existing digital terrestrial television systems.

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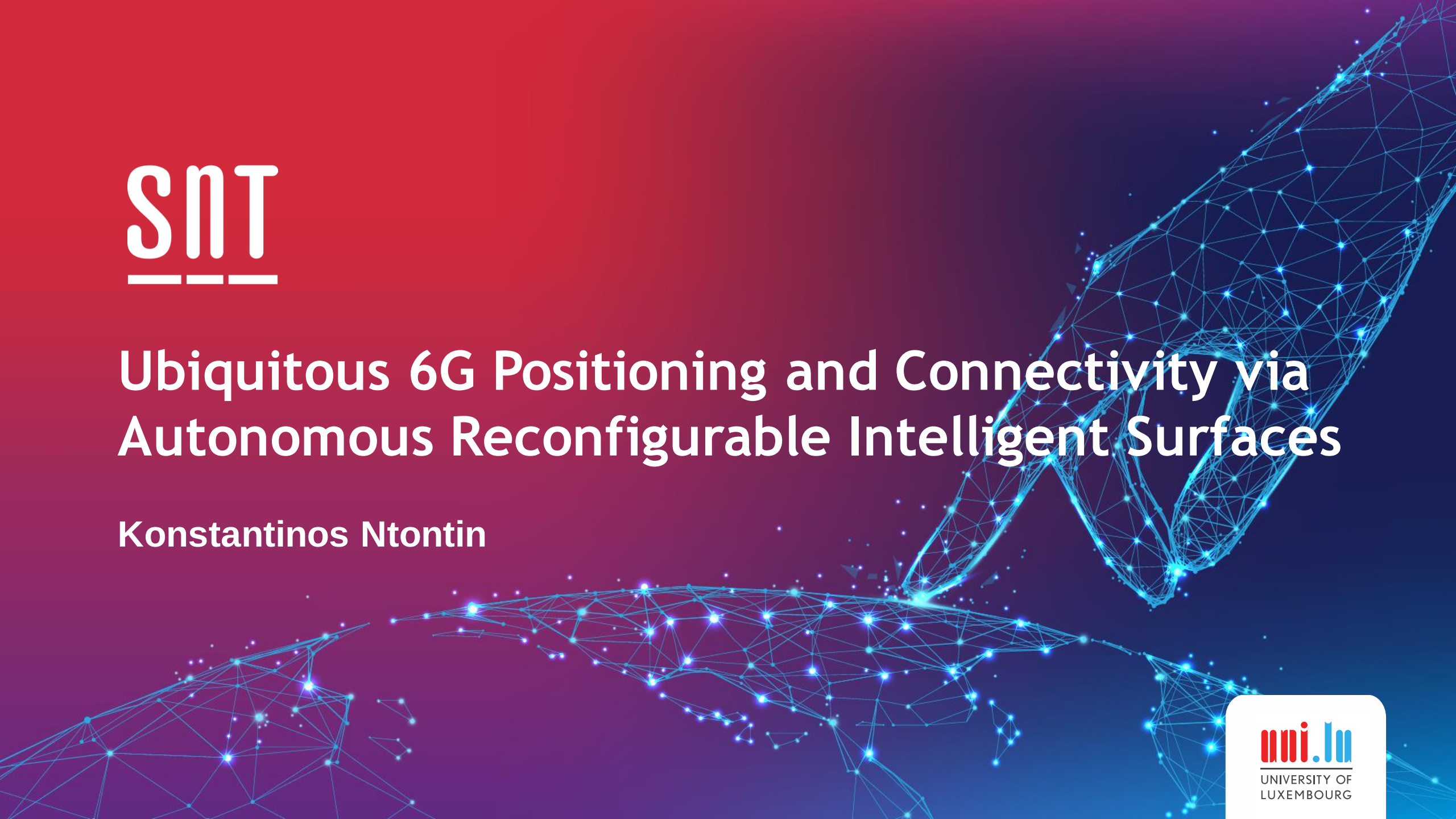
European Vision for the 6G Ecosystem



Ubiquitous 6G Positioning and Connectivity via Autonomous Reconfigurable Intelligent Surfaces

Konstantinos Ntontin

UNIVERSITY OF LUXEMBOURG

Contents

- Background
- Problem and Motivation
- Proposed Solution
- Feasibility Discussion
- Main Takeaways

Background

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Background

- Intelligent and massive connectivity of people and devices the main characteristic of **6G networks**

- Highly accurate localization required. Several applications dictate sub-meter accuracy[1]:
  - Intelligent interactive networks (XR, brain-computer interfaces, tele-presence/tele-control)
  - Smart cities (assisted living, smart transportation)
  - Automated factories

- Sought level of accuracy not possible with GNSS

- Higher bandwidth offered by terrestrial mmWave small cells, key for sub-meter localization

[1]Z. Xiao and Y. Zheng, "An Overview on Integrated Localization and Communication Towards 6G", https://arxiv.org/abs/2006.01535

- Background
- **Problem and Motivation**
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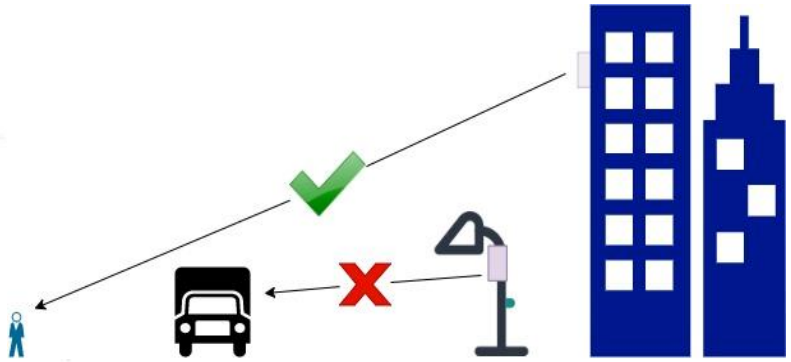
Problem and Motivation

Problem

- Mmwave bands are more susceptible to blockages than sub-GHz counterparts. Could hamper localization accuracy and resulting connectivity

- Intuitive solution→Higher small-cell densification. 3 problems with this:
  - Cost
  - Increased energy consumption
  - Restricted to where power grid reaches, mostly lamp posts, bus stops, information kiosks. Not adequate elevation. Lengthy process for approval to tap nearby buildings



Motivation

- Could we provide a cost-effective solution without a power-grid supply requirement?

[2]C. Sbeglia, "Is powering small cells the greatest densification challenge?", RCR Wireless News

- Background
- Problem and Motivation
- **Proposed Solution**
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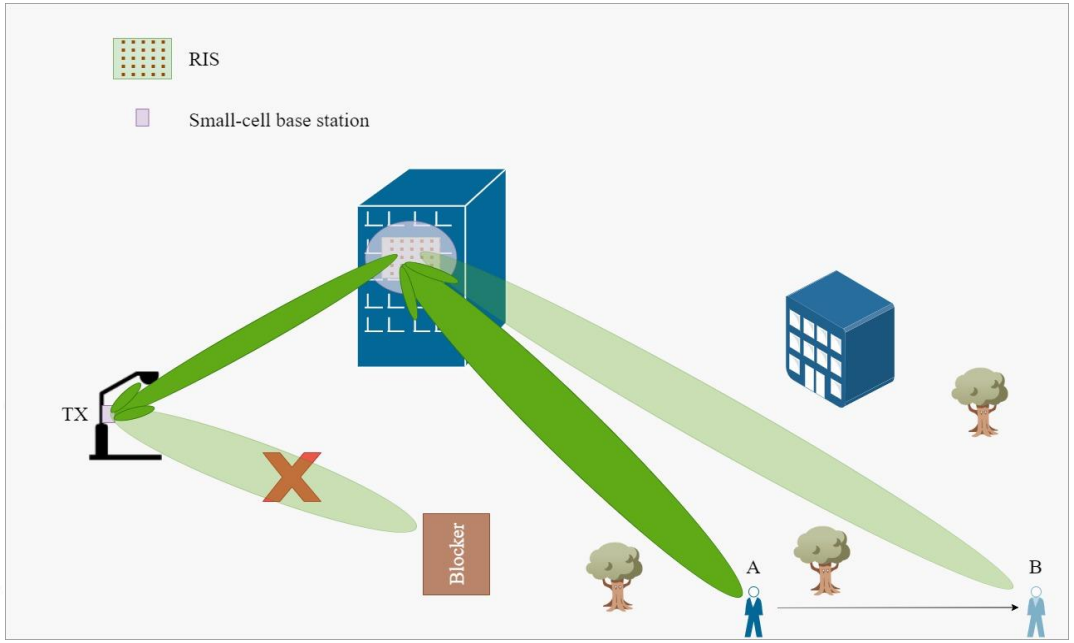
Wide-Scale Reconfigurable Intelligent Surface Deployment

- Reconfigurable Intelligent Surfaces (RISs) are two-planar structures of large number of conductive elements (dipoles, ring resonators, etc) of sub-wavelength adjacent distance

- Mainly proposed as communication alternative, of notably lower cost and energy consumption, to conventional active relaying. Only small amount of energy for their reconfiguration



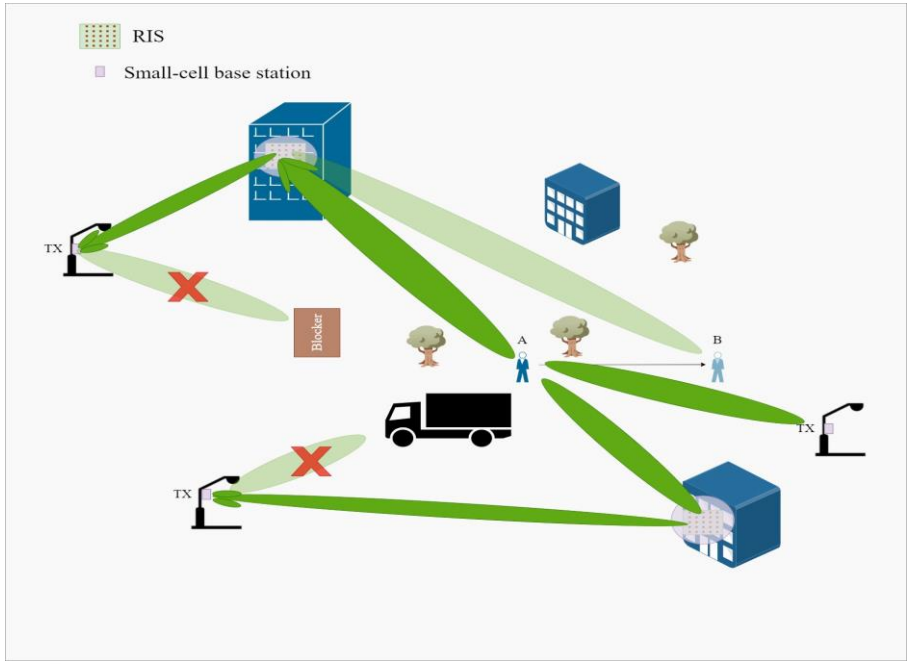
- Companies interested in the technology[3]. Trials performed, testbebds developed, ETSI group[4]

[3]https://www.nttdocomo.co.jp/english/info/media_center/pr/2021/0126_00.html
[4]https://www.etsi.org/committee?id=1979

- Background
- Problem and Motivation
- Proposed Solution
- **Feasibility Discussion**
- Main Takeaways

Feasibility Discussion

- Several 6G position papers suggest RISs a key technology for simultaneous communication and localization[5] [6]. For localization, they can work as virtual anchors



- However, conventional designs need power supply to operate. Could be bottleneck. Could be operated ***autonomously*** though through wireless energy harvesting?
- Recently suggested that automomous operation is possible[7]. Even more recently, testbed developed comprising RFIDs (backscatter communication)[8]

[5]C. De Lima *et al.*, "Convergent Communication, Sensing and Localization in 6G Systems: An Overview of Technologies, Opportunities and Challenges," in *IEEE Access*, 2021
[6]J. He and others, "Beyond 5G RIS mmWave Systems: Where Communication and Localization Meet", https://arxiv.org/abs/2109.07729
[7]K. Ntontin, "Toward Autonomous Reconfigurable Intelligent Surfaces Through Wireless Energy Harvesting", https://arxiv.org/abs/2108.07953
[8]I. Vardakis and others, "Intelligently Wireless Batteryless RF-Powered Reconfigurable Surface", https://arxiv.org/abs/2105.14475

- Background
- Problem and Motivation
- Proposed Solution
- Feasibility Discussion
- **Main Takeaways**

Main Takeaways

- Several 6G use cases requiring sub-meter level localization. Can be terrestrially achieved through mmWave small cells. How to counteract blockages though?
- Straightforward solution of active relay densification problematic due to cost, increased energy consumption, and power-grid unavailability for sufficiently elevated sites
- RISs to the rescue solving the above provided they can operate autonomously through wireless energy harvesting. Recent suggestions it is possible together with testbed realization
- In my opinion, autonomous RISs the only viable solution for a cost-effective and energy-efficient ubiquitous 6G positioning and connectivity

Thank You!

Questions?

UiO : Faculty of Mathematics and Natural Sciences
University of Oslo

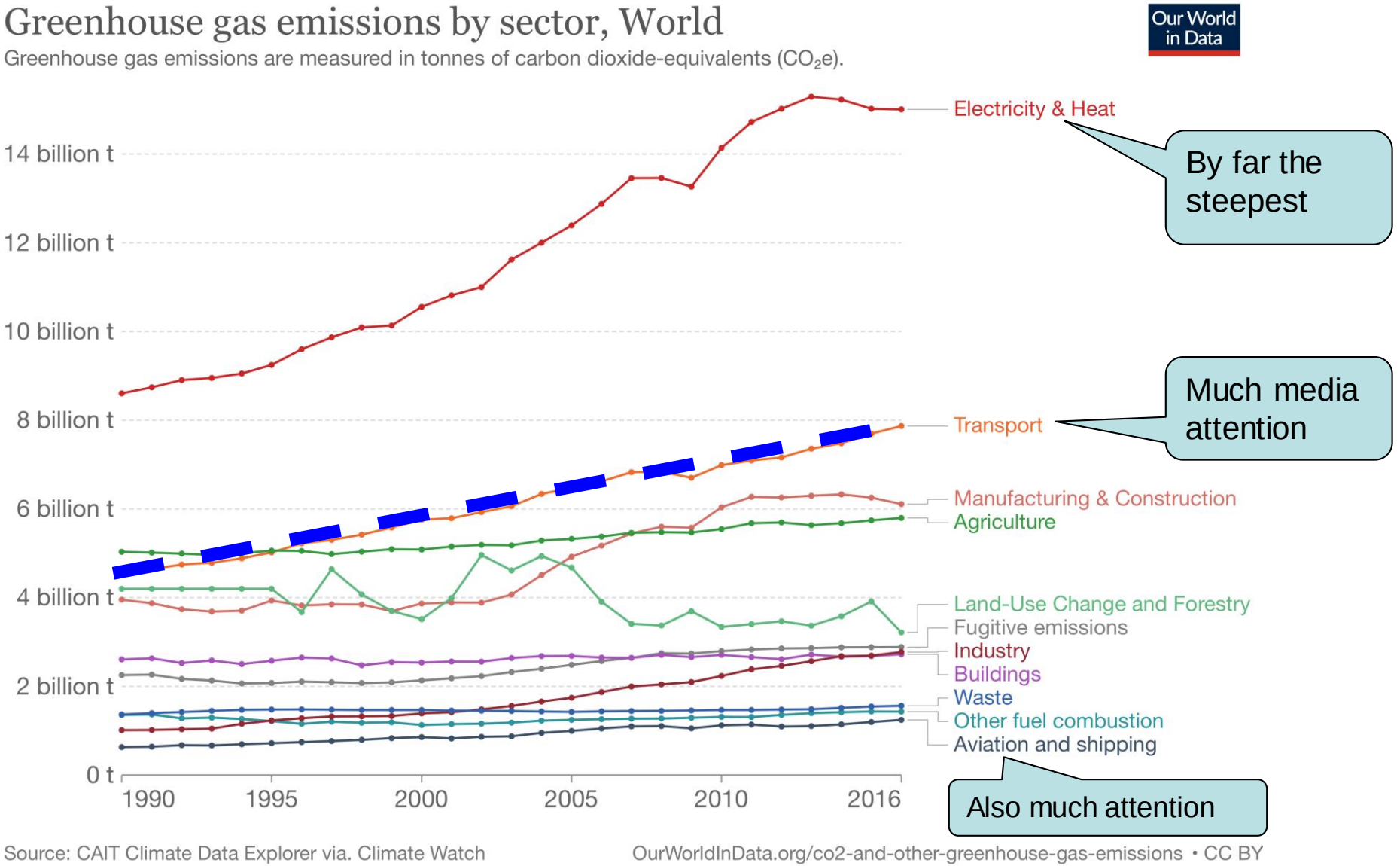
Department of Informatics
Networks and Distributed Systems (ND) group

Green InterNetworking

Visions for Future Communications Summit

Strengthening the Path Towards 6G

Ozgu Alay and Michael Welzl


Greenhouse gas emissions by sector, World
Greenhouse gas emissions are measured in tonnes of carbon dioxide-equivalents (CO_2e).
Our World in Data
14 billion t
12 billion t
10 billion t
8 billion t
6 billion t
4 billion t
2 billion t
0 t
1990
1995
2000
2005
2010
2016
Electricity & Heat
Transport
Manufacturing & Construction
Agriculture
Land-Use Change and Forestry
Fugitive emissions
Industry
Buildings
Waste
Other fuel combustion
Aviation and shipping
By far the steepest
Much media attention
Also much attention
Source: CAIT Climate Data Explorer via. Climate Watch
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

GHG emissions from telecom electricity

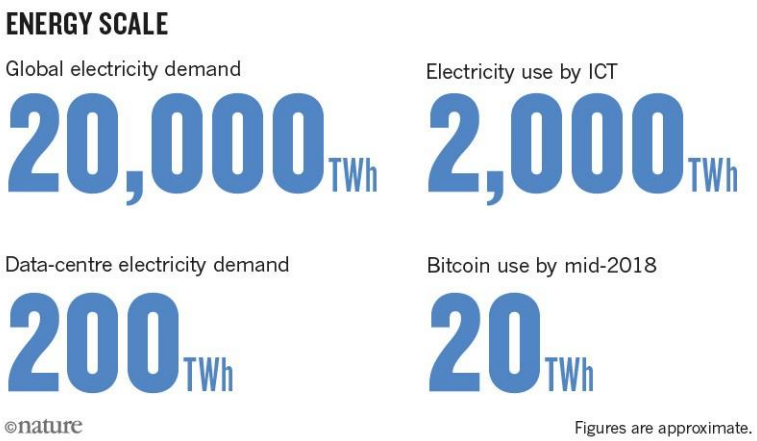
- Much-cited "SMARTer2030 repor[illegible]states th[illegible]T has a CO_2 "footprint" of 2.7% of global e[illegible]issions in 20[illegible]
  - CO_2 != GHG, but [illegible] emissions of the electricity sector
    https://[illegible]
- Numbers fr[illegible]
  - **If this relatio[illegible]20 GHG emis[illegible]**
- Consider: avia[illegible]
  - Our est[illegible]but conservative

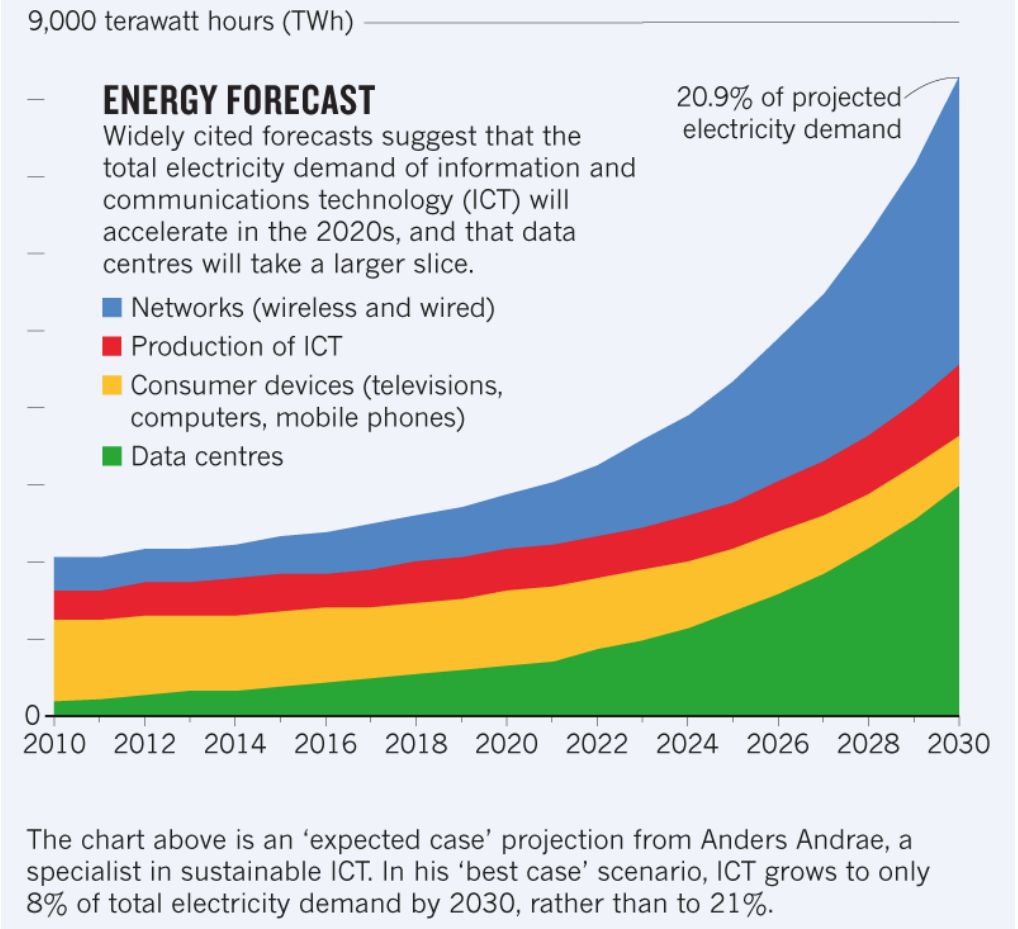
The Internet uses a lot of power!

[1] J. Lorincz, A. Capone, and [illegible]Vu. Greener, energy-efficient and sustainable networks: State-of-the-art and new trends. Sensors, 19(22), 2019.]

[2] *[M.K.Weldon.TheFuture X Network: A Bell Labs Perspective. CRC Press, Inc., USA, 2015.]*

Internet GHG emissions: future trends



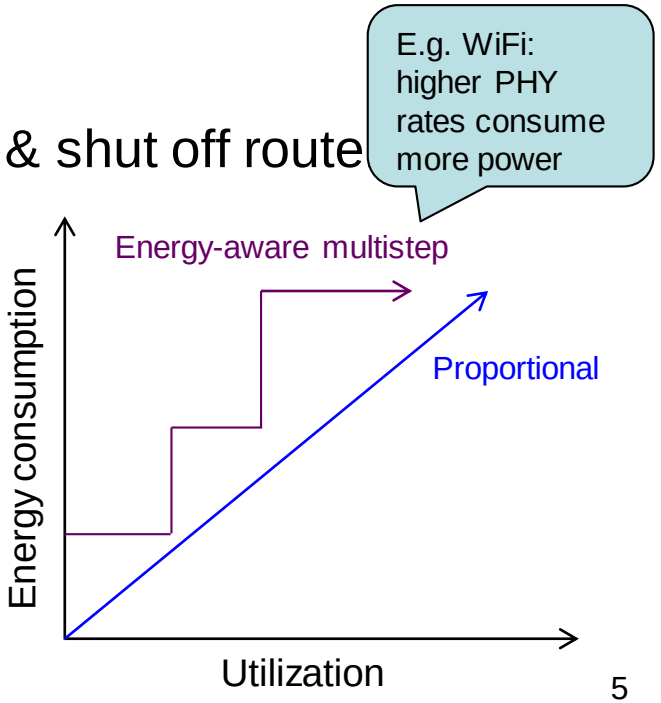


Source:

https://www.nature.com/articles/d41586-018-06610-y

General strategies

- Virtualization
  - Multiple services operating on the same hardware; can, e.g. reduce material related GHG emissions
- Small Cells and Massive MIMO
  - Higher data rates, and more efficient use of resources
- Resource consolidation
  - E.g., energy-aware routing: reduce paths & shut off route non-peak times
- Selective connectedness
  - Sleep modes (especially in IoT)
- Proportional computing
  - Scale energy usage with utilization



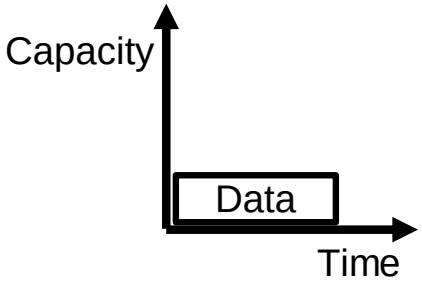
Energy efficiency of “general” Internet

- traditionally “lower layers” (specifically, the link layer) and “upper layers” (specifically, Internet standards in the transport and application layers) of telecommunications are disjoint
  - Applications make no assumption on the lower layers
  - Lower layers make no assumption on the upper layers (unknown data arrival times or importance)

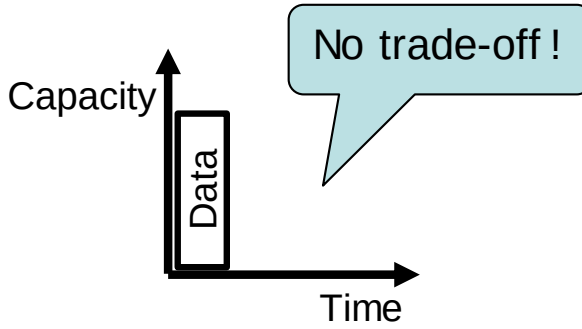
- The concept of slices provides some information but very high level…

Exposing the link layer and the application layer to each other

- Poor congestion control wastes time and power



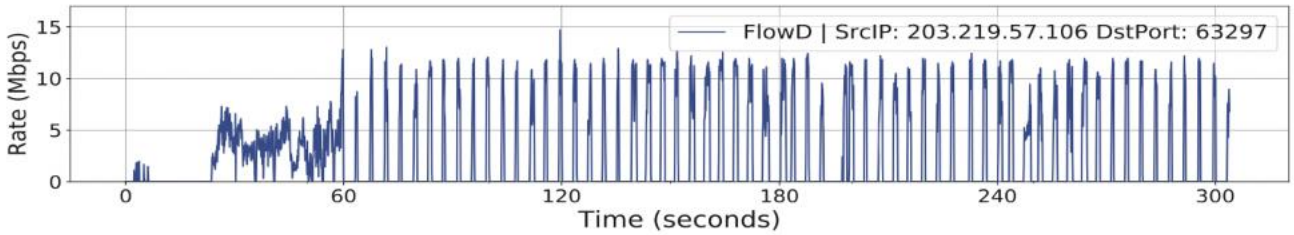
Poor resource utilization



*Good resource utilization: better performance **and** better energy-efficiency*

- Slices and Proxies for energy efficiency
  - Non-urgent and non-interactive data

- Traffic patterns can guide sleep cycles and resource management



Real Netflix traffic trace

A View on Future Networks

Visions of Future Communication Summit 2021

Thursday, 25th of November 2021

Xavier Priem, EUREKA CELTIC-NEXT Cluster Director

About CELTIC-NEXT

CELTIC-NEXT
∑eureka Cluster

is the EUREKA ECP* Cluster
for next-generation communications
for a secured, trusted, and sustainable digital society.

*Eureka Clusters Program, launched on 17/6/2021

CELTIC-NEXT is…

- **A Public Private Partnership** with Eureka Countries and some regions
- **Open** to any organization willing to contribute to industry-driven ICT research and innovation collaborative projects
- **Over 1000 private and public organisations:**
  - large industry players
  - small & medium-sized enterprises (50% of programme participation)
  - academic/research institutions
- **Several Calls per year: Spring, Autumn, Flagships, and EUREKA ECP Joint Thematic Calls**

Opportunities to collaborate globally...

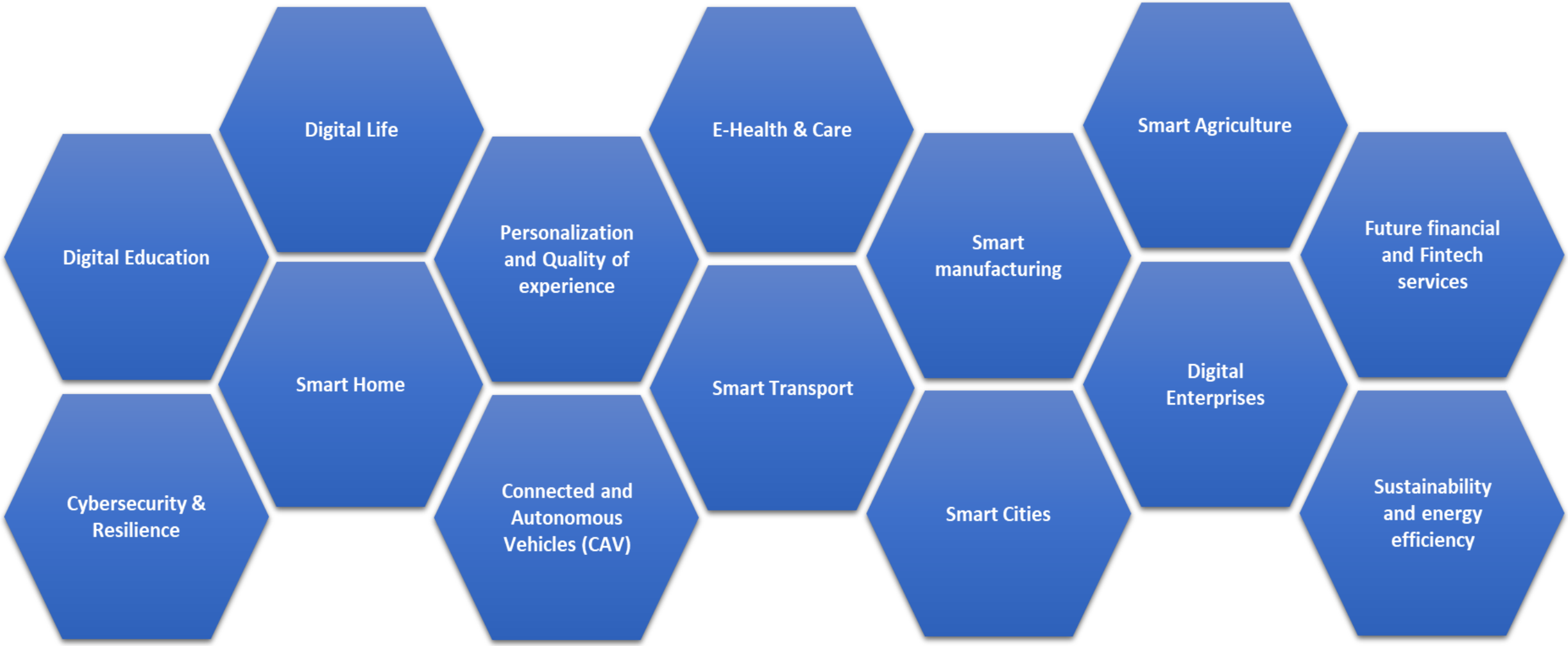
- Europe
- Canada
- South Korea
- South Africa
- Singapore

And potentially more countries in the future

CELTIC-NEXT Vision

CELTIC-NEXT
Eureka Cluster

High level application fields targets



But... currently not (fully) addressed problems

- Digital Divide (not connected communities -> pervasiveness)
- Continuous connectivity (from disjunct cells to cell-less and connectivity smart grid / generalised neutral hosting)
- Fully automatised operations (remove human bottleneck from the loop, speed and mistakes) while keeping understanding and control of the network
- Resilience (in normal and disaster operations)
- Trust (onboarding of humans into the technology, no more anti-5G)
- Security (cyber and physical)
- Spectrum usage (make it really dynamically (shared) managed and monetized)

What 6G should transform connectivity to…

- PERVASIVE with High Location Accuracy
  - everywhere, all services, all industries/verticals support
- GLOBAL
  - but not based on Roaming ->worldwide services dynamic presence
- INCLUSIVE /EXPANDABLE
  - like adding atoms, molecules, proteins, to a living organism
- AUTONOMOUS & SELF-COMPOSABLE
  - dynamic inclusion assets & services, dynamic adapting architecture
- PREDICTABLE, TRUSTABLE and GUARANTIED SLAs
  - Resilience, QoS and Timing
- DYNAMIC RESILIENCY
  - VARIABLE 9's depending on services' SLAs
- DECENTRALIZED INTELLIGENCE
  - no more centralized control system and DB
- SHARABLE & MONETIZABLE/TRADABLE
  - generalised active neutral hosting and 6D physical media brokering
- "OPEN", RECURSIVELY VIRTUALIZED, SLICED
  - new value chains enablement, NSaaS^n
- 6D SLICEABLE
  - optical lambdas, wireless spectrum, geo, space, time, e2e

Future needs of the end users: Main technical areas of research

Ubiquity / Pervasiveness	Dynamic capacity following people seamless mobility	Automation, Reliability, Transparency: Cognitive operations	Protection and Trust	Holographic "transportation" & Real-time Synchronous Digital Twin
• Urban, sub-urban down to rural • Into the home for education and remote working • One Identity for seamless experience • Smart Regions/Cities/Buildings/Homes	• In "normality" • In "crisis" (pandemics, major climate events) • Highly Precise Positioning • Edge Computing • Open-RAN / vRAN • Slicing	• Extensive Monitoring • Big Data Analytics • Artificial Intelligence • ICT supporting large and intense Ai/ML deployment for verticals (connectivity, processing, data storage…) • Transparency or the Imperceptible latency	• Cyber-security • Identity management	• Holographic media teleport • Multi-sense networks • Time engineered applications

Future needs of the end users: High level fields of applications

Human Centred Technologies and Services, for an Augmented Life Experience	Full industrial digitization and support of vertical industries	Futuristic use cases
• Digital divide elimination • Smart Regions/Cities/Buildings/Homes • Smart Transportation • Smart Tourism • Sustainability & Efficiency of Smart Energy Grids • Public Safety & Crowd Control • E-Health & Care • Users in Control and Trust of offered services • Digital support for Education and Remote Education • Digital (Media, Gaming, Sports, Culture and Entertainment) • Remote working and Nomadic Working (Digital Nomads)	• Digital Enterprises • Private Networks for Smart Manufacturing (Indus. 4.0) • Smart Logistics (geolocation IOT networks) • Smart Agriculture • Future Financial and Fin-Tech • ICT support to third party AI based applications • Connectivity Grid / Telecom Infra as 4th Utility, like Energy	• Holographic "Teleportation" • "World" Real-time Synchronous Digital Twin

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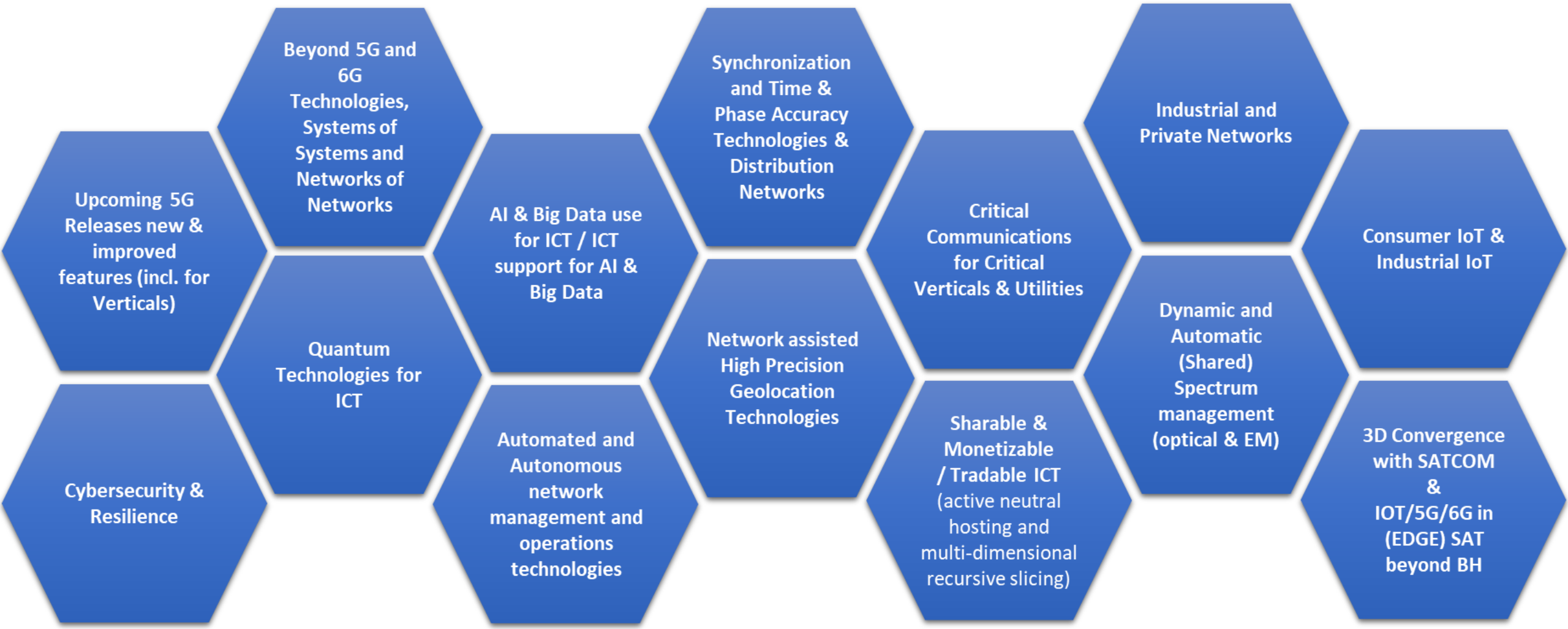
Eureka Cluster

R&D&I Technology pillars for CELTIC-NEXT



Enabling technologies that have to be enabled for verticals

Beyond 5G, from 5G to 6G	Wired and Wireless Industrial ICT	ICT Critical Infrastructure as a Utility, The Critical Connectivity Grid	Space dimension enabled 5G/B5G/6G	Distributed & Smarter Networks

• Enhanced overall architectures to support needed enablers
• End-to-end Horizontal and Vertical Network Convergence
• AI/ML for Digital Infrastructures
• End-to-end Network Automation
• Autonomous Systems and Networks
• Advanced QKD Networking
• Connectivity as a Shared Critical Utility
• Wireless and Wired Tera-Broadband technology:
  • Wireless (electromagnetic and visual light waves):
  • Larger massive MIMO systems
  • No "Cell" Radio Networks with distributed smart mMIMO systems
  • TeraHertz Communications
  • Wired optical:
  • Photonics
  • Optical smart networks
  • Optical spectrum: Sliceable Optics, shared lambdas
  • Increasing Bandwidth in Optical Network: use of additional bands, Higher modulation schemas
  • Quantum communications
  • QKD
  • Entanglement
	•Industrial features of 5G and beyond
	•Time Sensitive Networks
	•Precision Positioning
	•Private Networks
	•More Indoor techs like Terahertz, Visible Light Coms,
	•Non-3GPP convergence (like Wi-Fi, Industry Net Standards…)
	Tera scale Internet of Things (IoT)
		• Macro/Micro Grids' concepts related technologies adapted to ICT as it exists for Energy
		• Full end-to-end Slicing of physical networks and infrastructures (see Smarter Networks)
		• Cyber-security
		  • Quantum QKD
		  • AI/ML & Big Data Real Time Analytics based Security
		  • Reinforcement of Sovereignty
		  • Cyber-attack based Disaster recovery
		• Trust enablers
		  • Security
		  • Auditability
		  • Transparency
			• SAT enabled 5G/B5G/6G
			  • Moving ICT to SAT
			  • RAN in SAT (Space-RAN?)
			  • CORE in SAT (Space-CORE?)
			  • MEC in SAT (Space-Edge Dc?)
			  • MBH in SAT (Space-Mobile Backhaul?)
			  • Value Added Services in SAT
			  • Earth Meshed Network (including Oceans)
			  • SAT to Ground
			  • SAT to Sea
			  • SAT to Air Objects & IOTs
			  • SAT to SAT
			  • => SAT to All
			  • Multimodal SATs
			  • Combining GPS info with Network info
			  • Combining Observation modalities with Network info
			• Avionics communications
			  • Air to Ground
			  • Air to Air
			  • Drones / HAPS
			  • Balloons
				• Deeper "edge-ification" for Distributed, collaborative and hierarchical AI/ML
				• More Multi-Purpose Adaptable Networks:
				  • Universal adaptive core
				  • Programmable network Operating System
				• Advanced very large-scale monitoring (for AI, ML, DI…)
				• Distributed AI/ML
				  • Consuming
				  • Producing
				  • Supporting
				• Intelligent and Automated Dynamic Spectrum Management :
				  • Electro-magnetic Spectrum: Horizontal & Vertical Flexible Sharing CBRS, DSS, LSA, LAA, MultiFire, new enablers…
				  • Optical spectrum: Sliceable Optics, shared lambdas
				• Full Slicing
				  • Real End-to-End leading to:
				  • Multi-layered multi-tenancy
				  • Full neutral hosting
				  • Multi-Dimensions sliceable (incl. Spectrum and Time)
				  • Thanks to: Deeper Network Programmability

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An example of new cooperations

Press Release

Eureka PT Chair | Eureka Cluster – CELTIC | European Space Agency

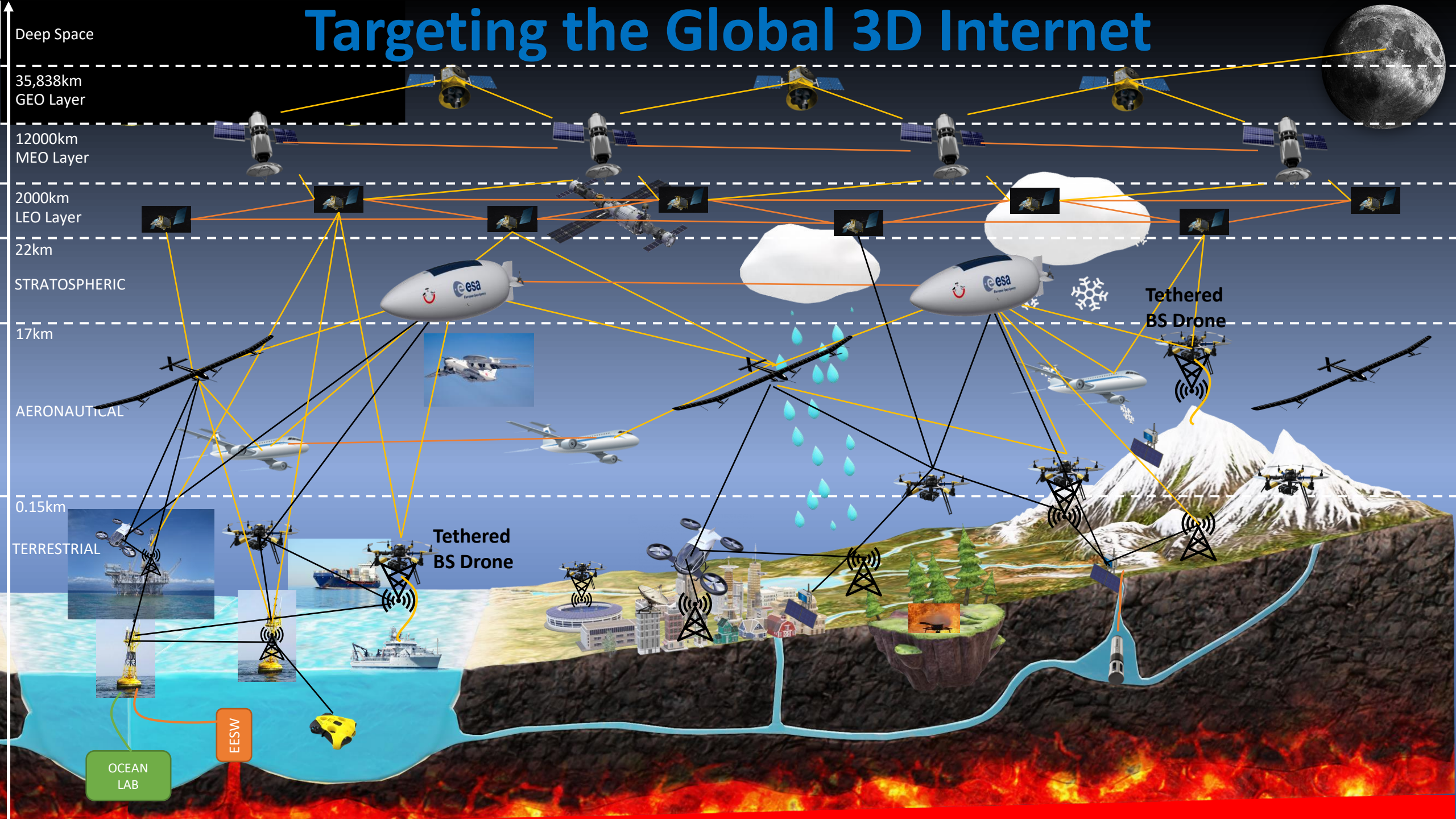
Connecting Terrestrial ICT with Space ICT

Strategic Collaboration between Eureka, CELTIC-NEXT and ESA ARTES

Eureka Chairman Miguel Bello Mora, Elodie Viau – Director of Telecommunications and Integrated Applications and Head of ECSAT at the European Space Agency (ESA), and CELTIC Office Director Xavier Priem.

Porto, 22 November 2021. Eureka Cluster CELTIC-NEXT (CELTIC-NEXT) and the European Space Agency (ESA) signed a Memorandum of Intent (MoI) today, which aims to bring their respective communities closer together. This will enable the faster convergence and development of terrestrial and non-terrestrial network and service technologies in the innovative field of Space ICT.

The MoI will help to foster economic growth and jobs through coordinated R&DI activities and the commercial exploitation of integrated space and terrestrial systems enabled by 5G and 6G. The collaboration aims to leverage the complementarity of ESA and CELTIC-NEXT and build on synergies to maximise the return on investment and to support achieving the UN Sustainable Development Goals.


Targeting the Global 3D Internet
Deep Space
35,838km
GEO Layer
12000km
MEO Layer
2000km
LEO Layer
22km
STRATOSPHERIC
17km
AERONAUTICAL
0.15km
TERRESTRIAL
Tethered
BS Drone
Tethered
BS Drone
EESW
OCEAN
LAB

Rethink networks towards 4th Utility Critical Infrastructure

- Create the equivalent of a **Connectivity Smart Grid**
- **Open the Value Chain to new Stakeholders**, enabling faster and wider penetration of **(pervasive) connectivity for consumer and vertical markets**
- **The existing Utility Critical Infrastructures need themselves Connectivity to become itself a Critical Infrastructure and form a Digital Enabled Convergent World**
- **Make it available rapidly and widely to foster innovation and growth (incremental deployment, like OS Releases)**
- **No one questioned Electricity/Energy networks about a "killer" use case!**
  - It will be time for Connectivity to benefit from same!
  - Since we might (have) miss(ed) it with 5G, risking to be a futility and/or few-tility,

>5G/6G shall be the 4th UTILITY CRITICAL INFRASTRUCTURE

6G Future Outlook: Evolution or Revolution?

- **Evolutions (even if huge technology research and dev will be involved):**
  - **Terahertz communications**
  - **Full Distributed/hierarchical AI (incl. over MEC / fog) support**
  - **Pervasive Connectivity thanks to 6D slicing/sharing**
- **Revolutions:**
  - **True Disruptive & New business models and Value Chain(s)**
  - **Human Centric Networks, Digital Twins and Human Int. (HI) in the Loop**
  - **HI-AI interaction / interworking / integration**

➢ **6G** shall **become**

the 4th UTILITY CRITICAL PERVASIVE INFRASTRUCTURE to enable HUMAN CENTRIC DIGITAL WORLD

➢ **ECONOMIC, SOCIETAL AND TECHNOLOGICAL INTERDEPENDENCIES MUST BE DEEPLY INTEGRATED IN THE DESIGN OF THE NEXT GENERATION OF NETWORKS**

THANK YOU !

Xavier PRIEM
CELTIC-NEXT - Director

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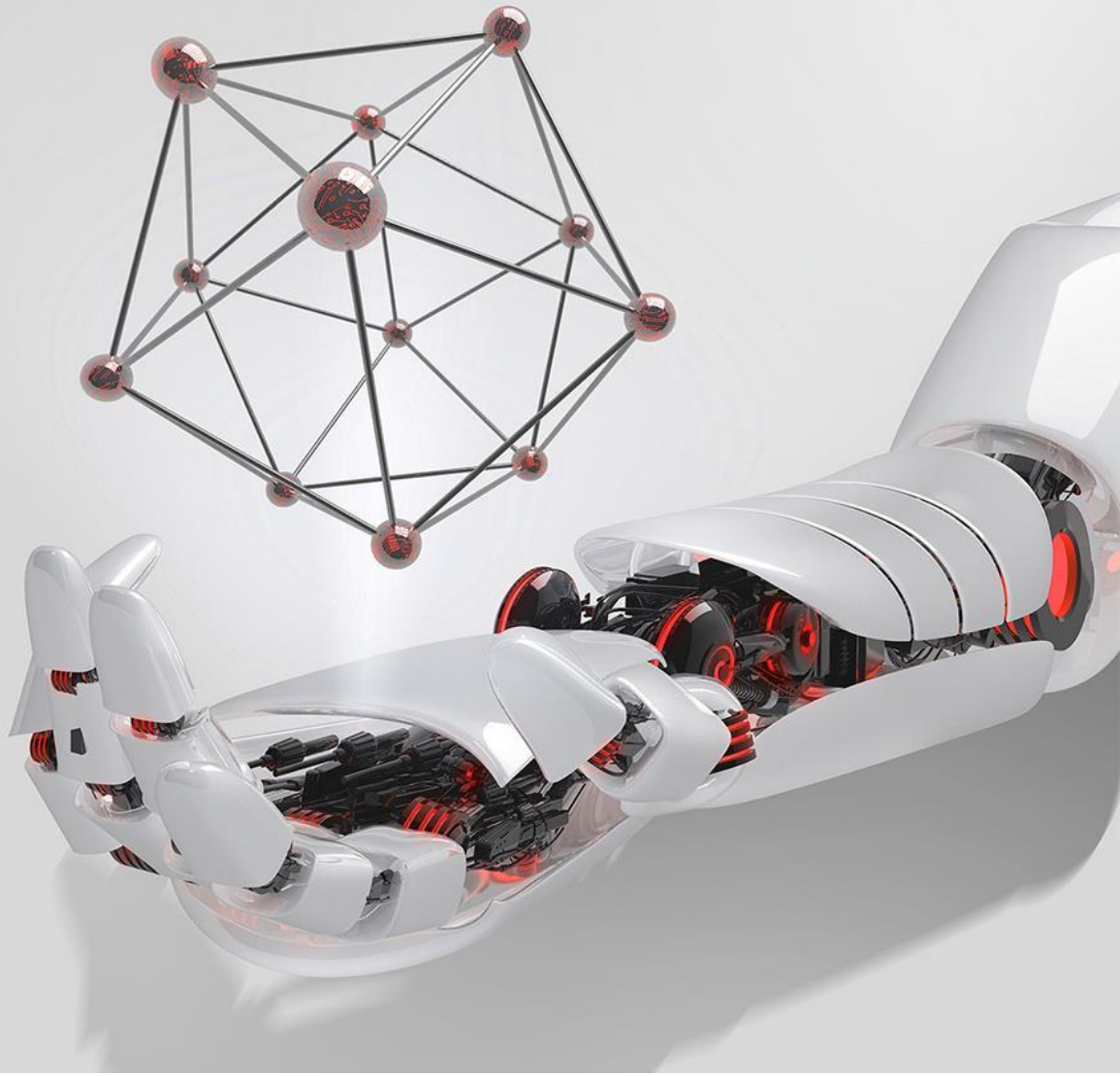
Strengthen the Path Towards the Next Generation Network: Evolved Network Architecture



3rd Visions for Future Communications Summit

Lisbon, Portugal

24-25 November 2021

Europe Standardization & Industry Development Department (ESIDD)
Huawei Sweden Research Centre, Cloud Core Networks (CCN) Lab
Dr. Pouria Sayyad Khodashenas (pouria.khodashenas@huawei.com)

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Research Priorities

Core network technology always played a critical role in the telecommunication evolution

Vision of the next generation network

Function of Social, Technological, Environmental, Economic, Political forces

- Low-involvement commodity (routine purchase decisions)
- A virtual platform that is open for innovative (open innovation booster)
- Significantly reducing operating costs (low OPEX)
- Paving the way towards Zero adverse policies

Fundamental questions:

- Among all possible technology trends which ones should be pushed first / more?
- Shall we privilege some vertical domains over the others?
- How the core network has to evolve?

What to research during 2023 on-wards?

1. Predictive Networking (PreNets)
2. Time-engineered Networking
3. Impact of IP layer protocols
4. Scalability and route optimization

Programmable Time Sensitive Networking (ProTSN)

5. Evolution of the SBA framework
6. Integration of different resources from networking to computation and sensing
7. Extension of edge technology toward far-deep-edge-cloud continuum
8. Flexible and dynamic network products

Unified core (UniCore)

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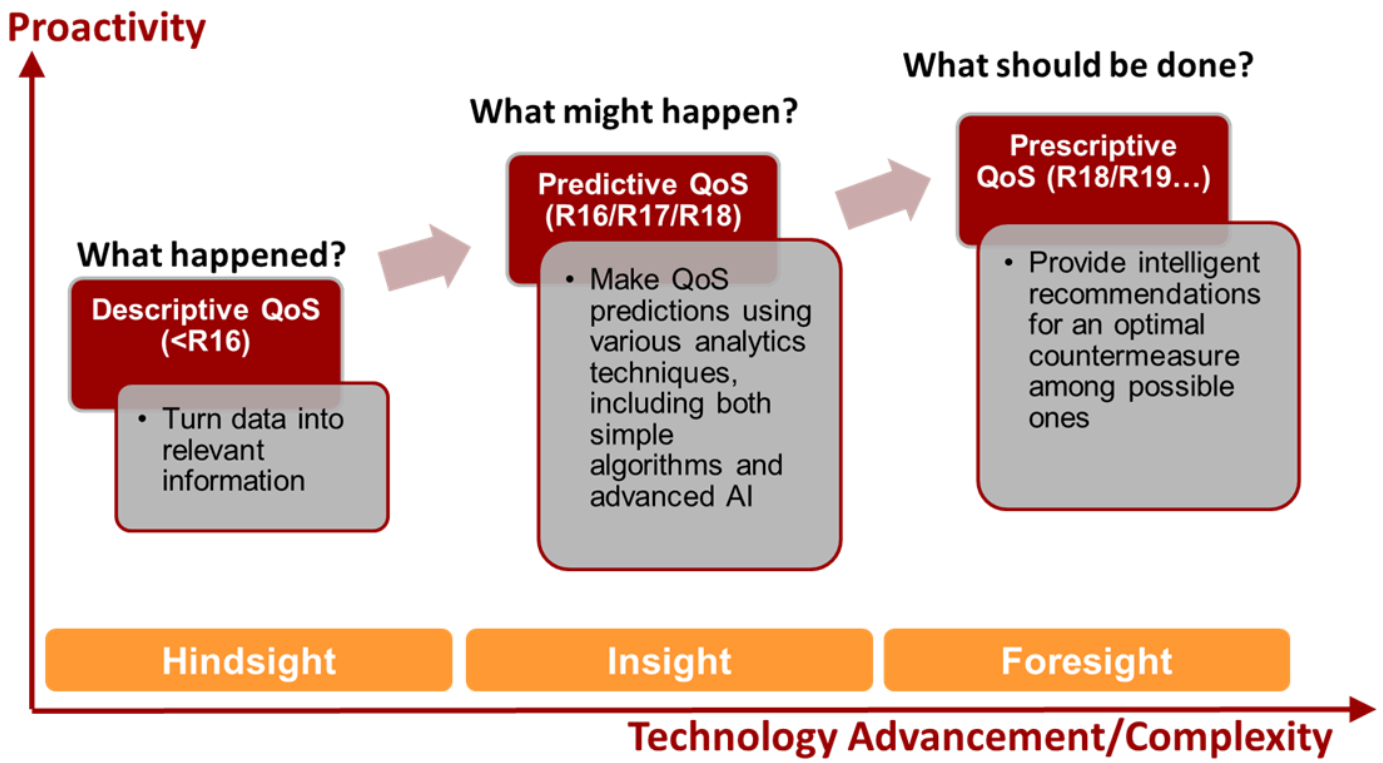
Predictive Networking (PreNets)

How to ensure good coverage for wide area URLLC?
Accept the fact that MNOs cannot provide 100% coverage for wide area URLLC.

Use Predictive QoS to inform the URLLC service *when it can and when it cannot* rely on the network;

PreNets provides the network with the capability to implement autonomic decisions, thanks to the use of **native AI/ML features**.

PreNets =
- Predictive QoS +
- Predictive Mobility +
- Predictive Maintenance +
- Predictive Analytics +
- Predictive Diagnostics ...
- multi-MNO, multi-domain



Some key questions?
- Coordinated data collection
- Collaborative AI/ML framework
- Trustworthiness

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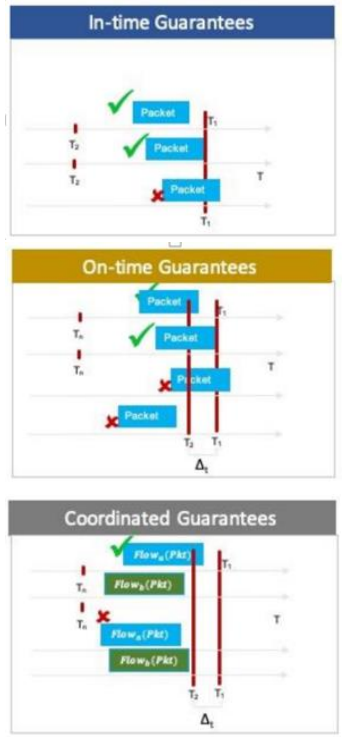
Programmable Time Sensitive Networking (ProTSN)

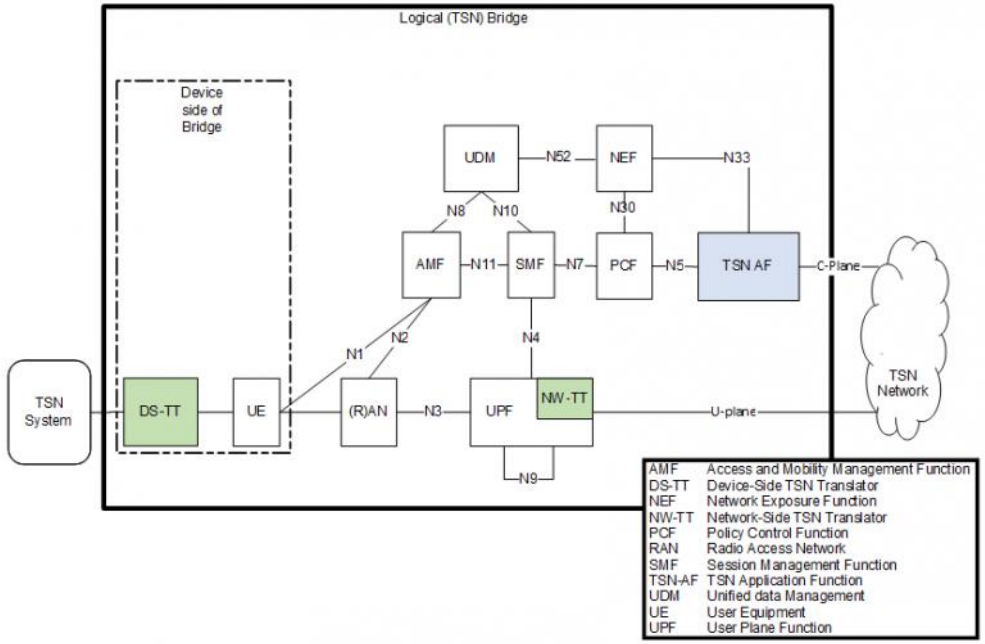
Guaranteeing specified time characteristics to realize beyond best effort.

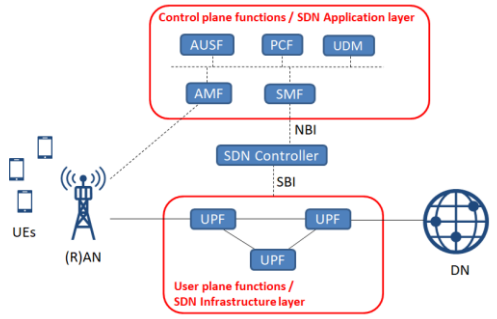
Applications may be supported by **deterministic networking (DetNet)**, **time sensitive networking (TSN)** and **segment routing**.

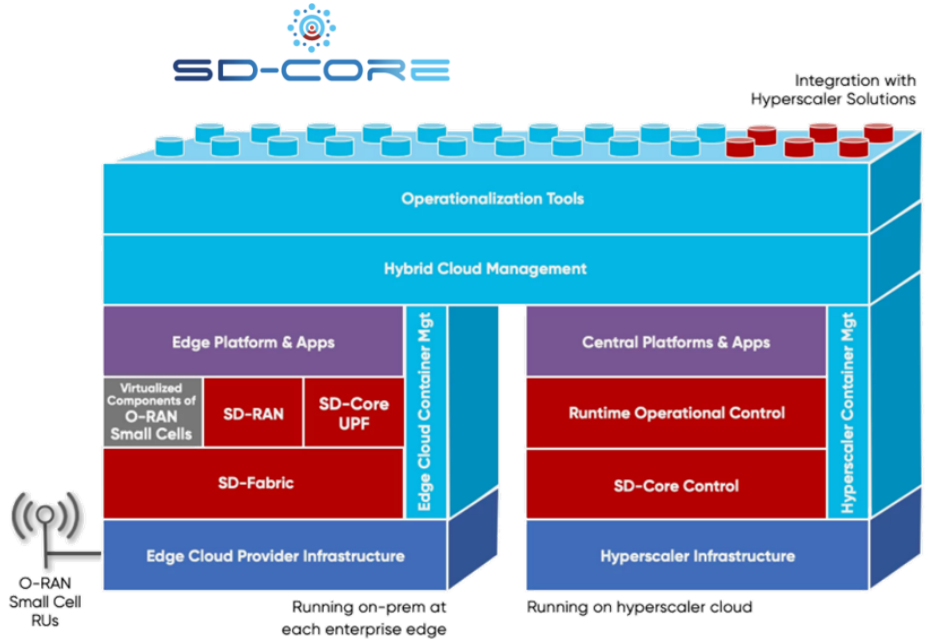
Per-flow principles for data transfer is used instead of per-PDU session principles.

Software defined and programmable user plane









Some key questions?

- SD UP?
- Other novel technologies (P4)?
- Challenges of cloud native mesh networks?

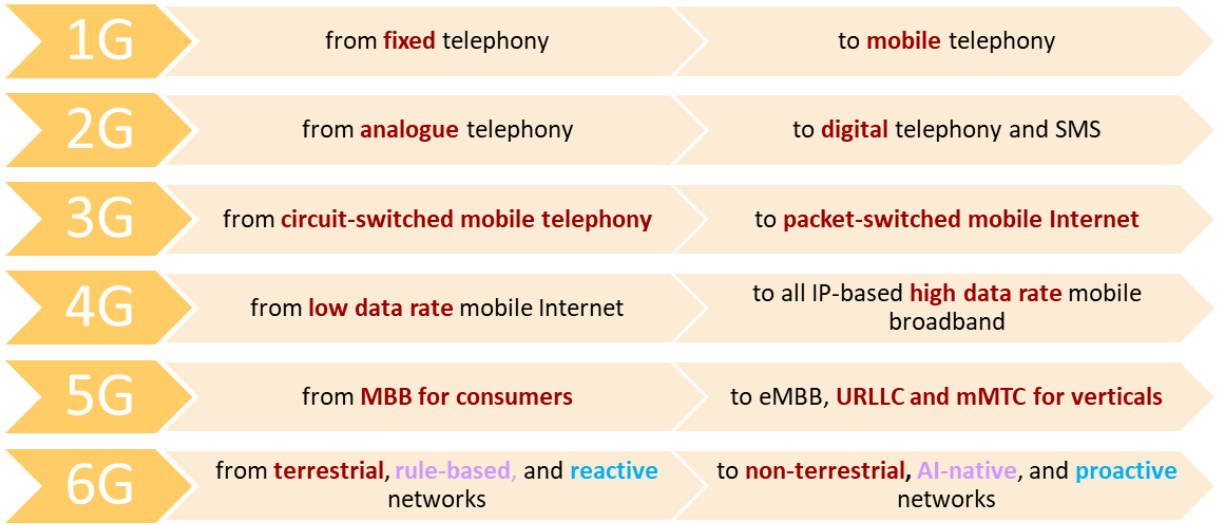
Unified core (UniCore)

Extend SBA framework into:

- **end-to-end multi-plane** (app, control, and management)
- **multi-segment** (access, backhaul, and core), extending it also towards satellite and optical systems

An **AI-Plane (A-Plane)** has to be introduced in addition to U-Plane and C-Plane. Unique plane or multilevel also with OAM AI.

Lambda functions *(an event-driven function that runs code in response to events and automatically manages the resources required by that code)*



- The 3GPP logical network to be come more **disaggregated further**
- Lambda functions to manage **compute and connectivity simultaneously**.
  - On-demand network slices with **just-enough resources** for applications.
  - Client will **pay a low fee per request for the time the application runs**.

Some key questions?

- What is the borderline?
- Business challenges?

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