InfoWare 2019 Panel

Paving 5G+ Networking: Supporting Technologies and Solutions

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Chairman of ITU-T Network 2030
Chief Scientist and VP of Network Technologies, Futurewei

Rome, Italy

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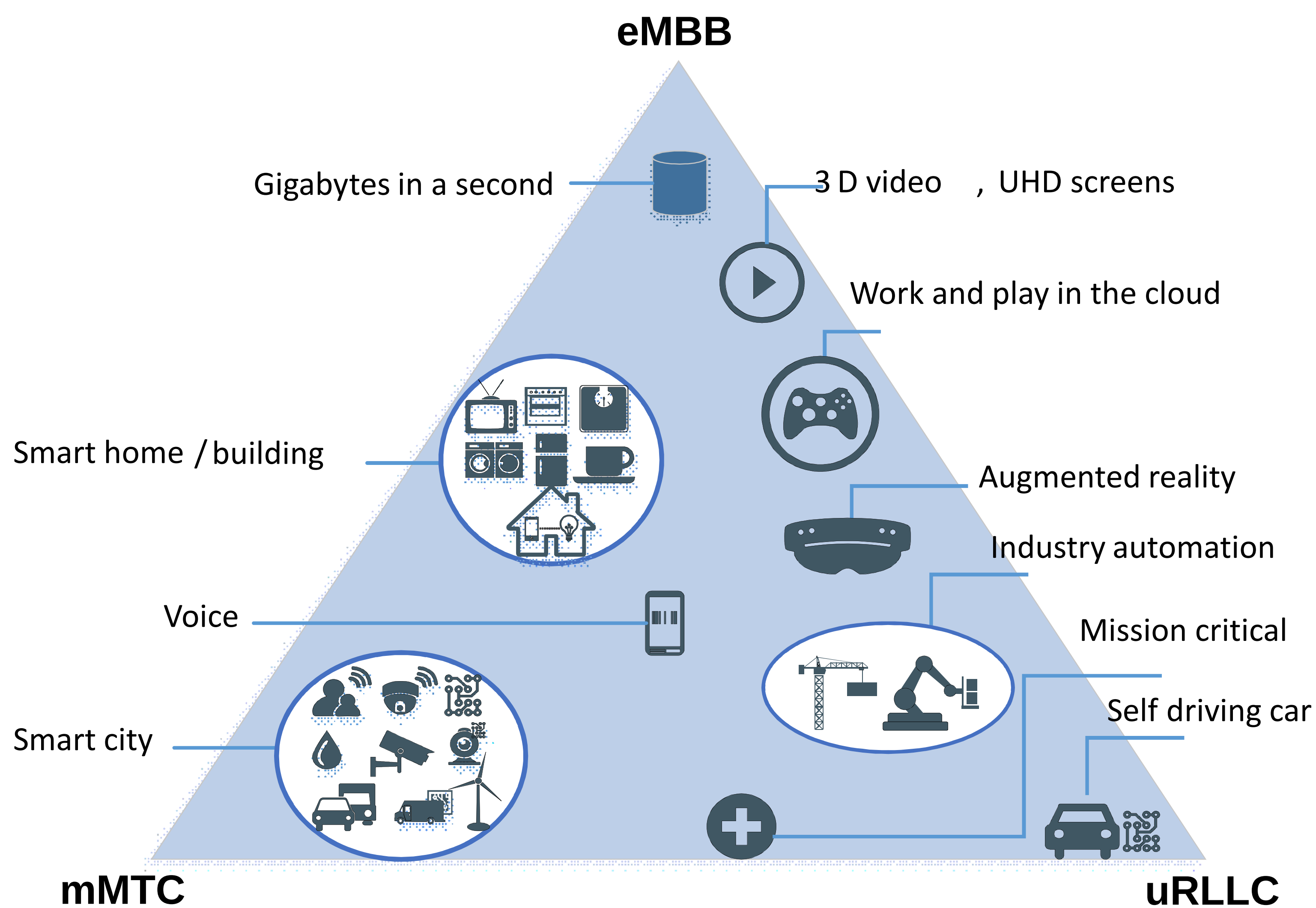
5G: Requirements and Use Cases



5G: Some KPIs

3GPP TS 22.261 Version 2.0.0

Scenario	End-to-end latency (note 3)	Jitter	Survival time	Communication service availability (note 4)	Reliability (note 4)	User experienced data rate	Payload size (note 5)	Traffic density (note 6)	Connection density (note 7)	Service area dimension (note 8)
Discrete automation – motion control (note 1)	1 ms	1 µs	0 ms	99,9999%	99,9999%	1 Mbps up to 10 Mbps	Small	1 Tbps/km^2	100 000/km^2	100 x 100 x 30 m
Discrete automation	10 ms	100 µs	0 ms	99,99%	99,99%	10 Mbps	Small to big	1 Tbps/km^2	100 000/km^2	1000 x 1000 x 30 m
Process automation – remote control	50 ms	20 ms	100 ms	99,9999%	99,9999%	1 Mbps up to 100 Mbps	Small to big	100 Gbps/km^2	1 000/km^2	300 x 300 x 50 m
Process automation – monitoring	50 ms	20 ms	100 ms	99,9%	99,9%	1 Mbps	Small	10 Gbps/km^2	10 000/km^2	300 x 300 x 50
Electricity distribution – medium voltage	25 ms	25 ms	25 ms	99,9%	99,9%	10 Mbps	Small to big	10 Gbps/km^2	1 000/km^2	100 km along power line
Electricity distribution – high voltage (note 2)	5 ms	1 ms	10 ms	99,9999%	99,9999%	10 Mbps	Small	100 Gbps/km^2	1 000/km^2 (note 9)	200 km along power line
Intelligent transport systems – infrastructure backhaul	10 ms	20 ms	100 ms	99,9999%	99,9999%	10 Mbps	Small to big	10 Gbps/km^2	1 000/km^2	2 km along a road
Tactile interaction (note 1)	0,5 ms	TBC	TBC	[99,999%]	[99,999%]	[Low]	[Small]	[Low]	[Low]	TBC
Remote control	[5 ms]	TBC	TBC	[99,999%]	[99,999%]	[From low to 10 Mbps]	[Small to big]	[Low]	[Low]	TBC

Real Latency on the Internet

https://enterprise.verizon.com/terms/latency/

Verizon Enterprise Latency Statistics (ms)												
	2019					2018						
	May	April	March	February	January	December	November	October	September	August	July	June
Trans Atlantic (90.000)	69.986	69.950	69.930	69.965	69.888	70.531	70.965	70.376	70.529	70.489	70.423	70.225
Europe (30.000)	11.706	11.234	10.592	11.099	11.478	10.954	10.070	11.215	11.257	11.239	11.237	11.291
North America (45.000)	31.352	31.531	33.523	33.782	36.083	36.084	39.243	38.468	37.999	37.618	35.244	35.037
Intra-Japan (30.000)	11.221	11.932	13.093	12.910	12.761	12.616	12.894	11.704	13.332	12.674	10.872	10.929
Trans Pacific (160.000)	99.336	99.320	99.238	99.237	99.242	99.240	99.250	103.168	102.561	101.381	101.369	101.372
Asia Pacific (125.000)	85.806	85.201	85.119	86.840	86.726	98.990	87.173	85.007	107.209	84.737	86.923	87.648
Latin America (140.000)	90.968	88.450	87.782	119.633	-	-	-	-	-	125.605	123.193	122.551
EMEA to Asia Pacific (250.000)	144.462	119.350	119.239	118.699	116.281	115.876	115.030	113.885	113.836	120.111	119.401	115.683

Eugene Borcoci, Ph.D.
Professor of University Politehnica Bucharest, Romania

- Network Architecture
- SDN/NFV
- 4G/5G networking and slicing
- Fog/edge computing
- Vehicular communications
- 5 books, 4 textbooks, over 170 papers

HUAWEI

Dirceu Cavendish, Kyushu Institute of Technology, USA/Japan

<A picture comes here>

- ❑ Packet networks
- ❑ Network security
- ❑ Broadcast and wireless systems
- ❑ Distributed Computing and/or Web Services

HUAWEI

Xiaohong Peng, Aston University, UK

- Wireless communication systems and networking
- 4G/5G resource allocation
- Connected & autonomous vehicles
- QoE/QoS
- Video streaming and quality assessment

HUAWEI

Position Statements

DEBATE

Are there any technical gaps between 5G requirements and the current technologies?

Can the 5G KPIs be achieved by the current technologies?

How successful or useful is network slicing?

Can SDN/NFV help achieve 5G KPIs?

How about Trust, Security and Privacy in 5G?

How successful or useful are these technologies?

- Network slicing
- MIMO
- NR
- Any others?

What new technologies and solutions do we have yet to develop?

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Panel on Future Networking

Topic: 5G+Networking: Supporting technologies and solutions

Multi-domain and multi-tenant aspects in 5G slicing

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Multi-domain and multi-tenant aspects in 5G slicing

- The 5G (fifth generation): **new generation of mobile networks** offering a large range of services to satisfy various customer demands

- Different from 4G concept: “one-fit-all”, 5G supports
  - dedicated, separated - logical slices – on top of a shared infrastructure
  - customization for various business demands with different requirements

- Driving forces for 5G: IoT, smart cities, industry, governance, IoV/automotive, safety/emergency, entertainment, environment, etc. → multiple types of “verticals” and tenants

- Standardization/fora organizations and projects are involved
  - NGNM, 3GPP, 5GPPP, ETSI, ITU-T, GSMA, BBF, ONF, IETF, IEEE, many int’l and European projects

Multi-domain and multi-tenant aspects in 5G slicing

- **5G Network slicing** –**multi-tenant, multi-domain, E2E, multi-provider/operator context** → many open research issues and challenges, especially in management and control (MC)subsystems

- The overall system architecture and then the design depend on the model defined to solve the above aspects

- Examples- 5G slicing M&C aspects
  - Service/data model & mapping on slices- for *multiple tenants*
  - Customized slice design and preparation, stitching / composition in a *single domain* and *cross-domain*
  - Network slice life cycle management, monitoring and updating

Multi-domain and multi-tenant aspects in 5G slicing

- **Tenant ? –** several variants of definitions- related to the 5G business models

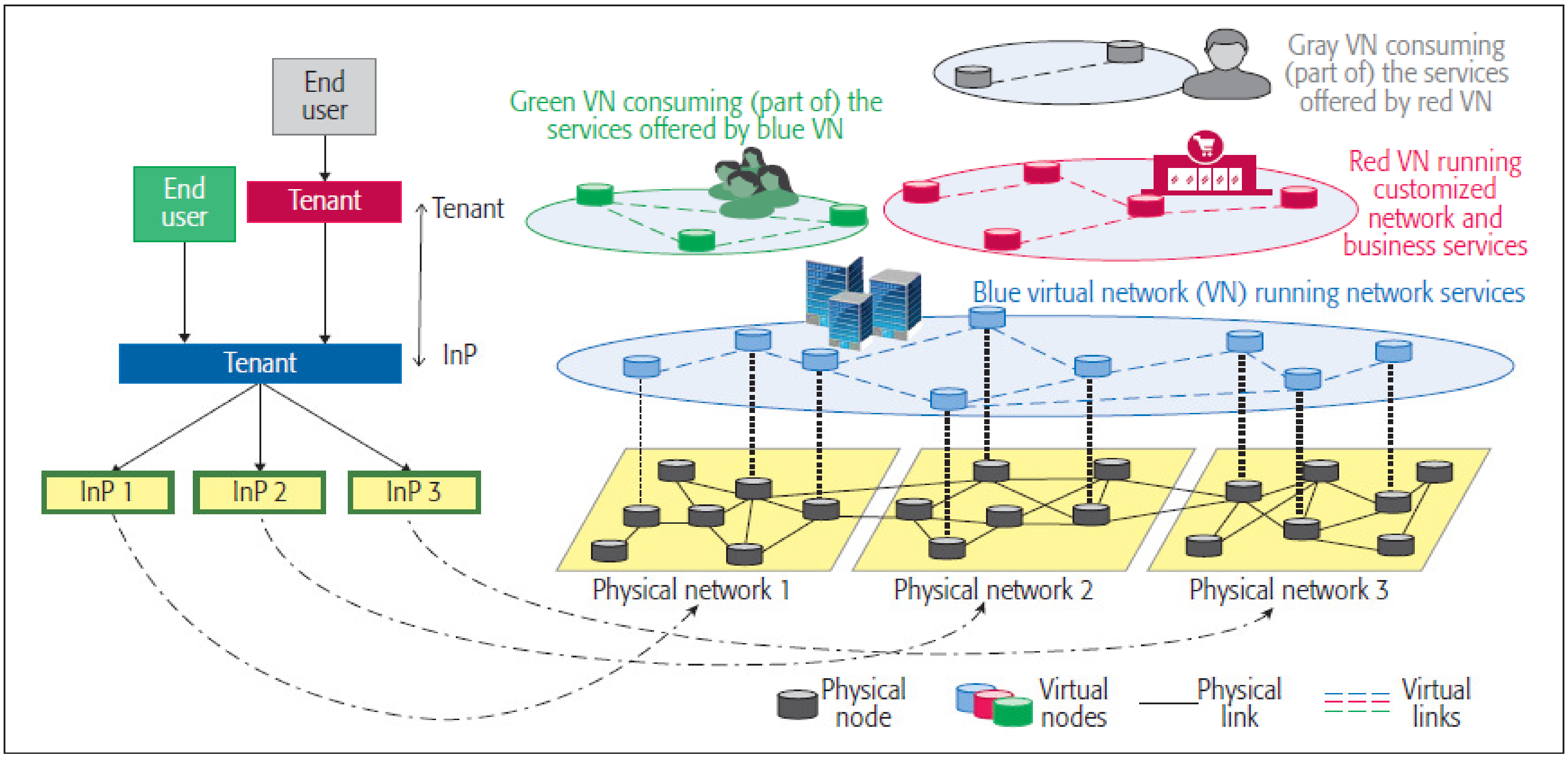
- **Business model (actors)- variant 1 of definition**
  - **Infrastructure Provider (InP) –** owns and manages a PHY network and its resources
    - The resources, (WANs and/or data centers (DCs) are
      - virtualized
      - and then offered through APIs to a single or multiple tenants

  - **Slice Tenant (ST) –**leases virtual resources from one or more InPs in the form of a virtual network, where the <u>tenant can realize, manage, and provide network services to its users</u>
    - ***Note: in this model the ST creates the slices and the associated services***

  - **End user (EU) :** consumes (part of) the services supplied by the tenant, *without providing them to other business actors*

Multi-domain and multi-tenant aspects in 5G slicing

- **Tenant ?** – (cont'd)
  - **This example : recursive model**



Source: J. Ordonez-Lucena, P. Ameigeiras, D. Lopez, J.J. Ramos-Munoz, J. Lorca, J. Folgueira, Network "Slicing for 5G with SDN/NFV: Concepts, Architectures and Challenges" , IEEE Communications Magazine, 2017

Multi-domain and multi-tenant aspects in 5G slicing

- **Tenant ?**
- **Business model (actors)- variant 2 of definition**

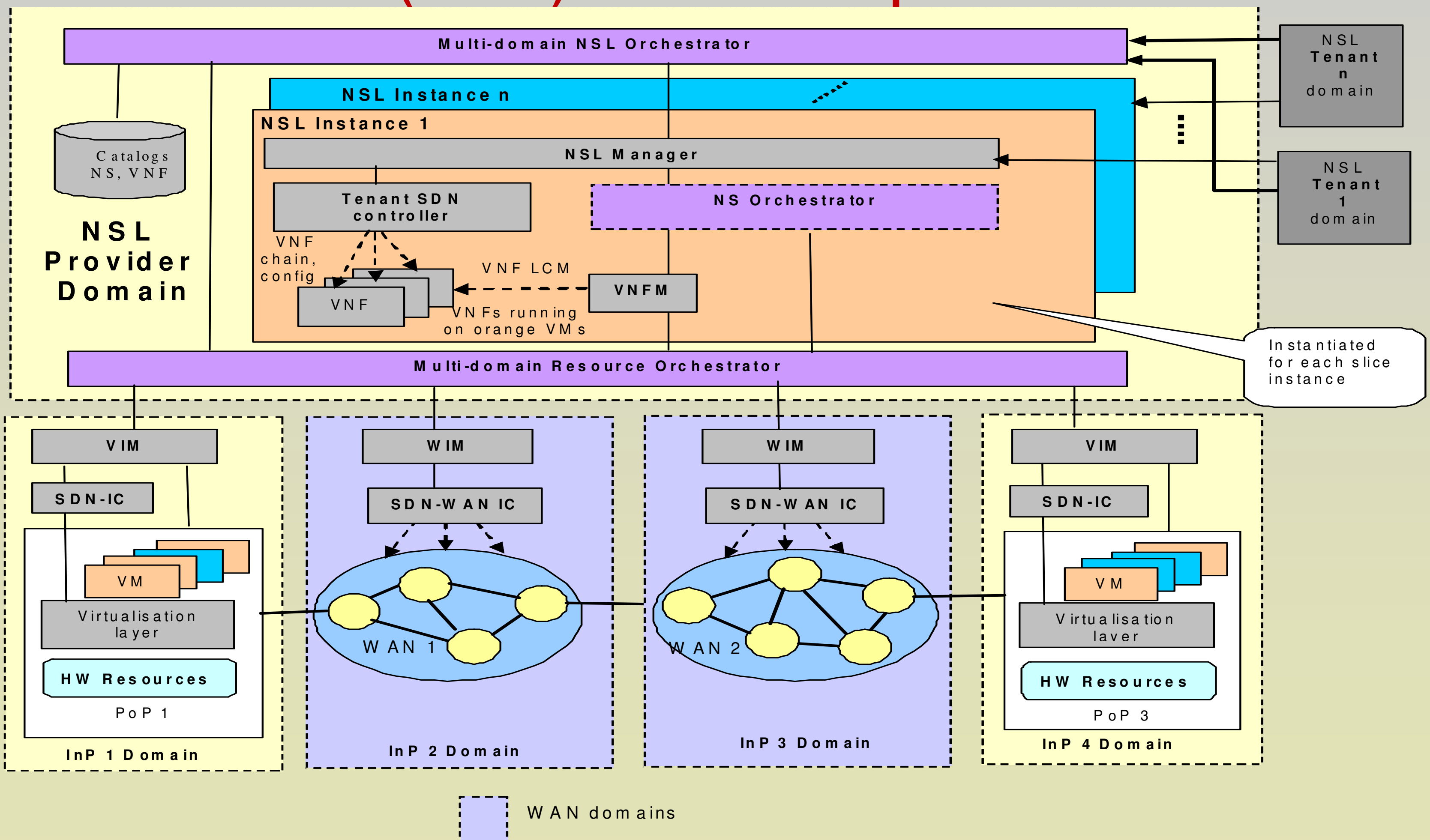
Infrastructure Provider (InP)– owner of the PHY infrastructure (network/cloud/data center) and lease them to operators
  - It can become an SLP if it leases the infrastructure in slicing fashion

Slice Provider (SLP) – typically a telecom SP, owner (or tenant) of the infrastructures from which network slices can be created
  - ***Note: in this model the Slice Provider is distinctly defined as slice-constructor***

Slice Tenant (ST) - the user of specific network/cloud/data centre slice, in which customized services are hosted
  - STs can make requests – to SLPs- for creation of new slices by using a service model
  - Note this ST may have one or more End Users

Multi-domain and multi-tenant aspects in 5G slicing

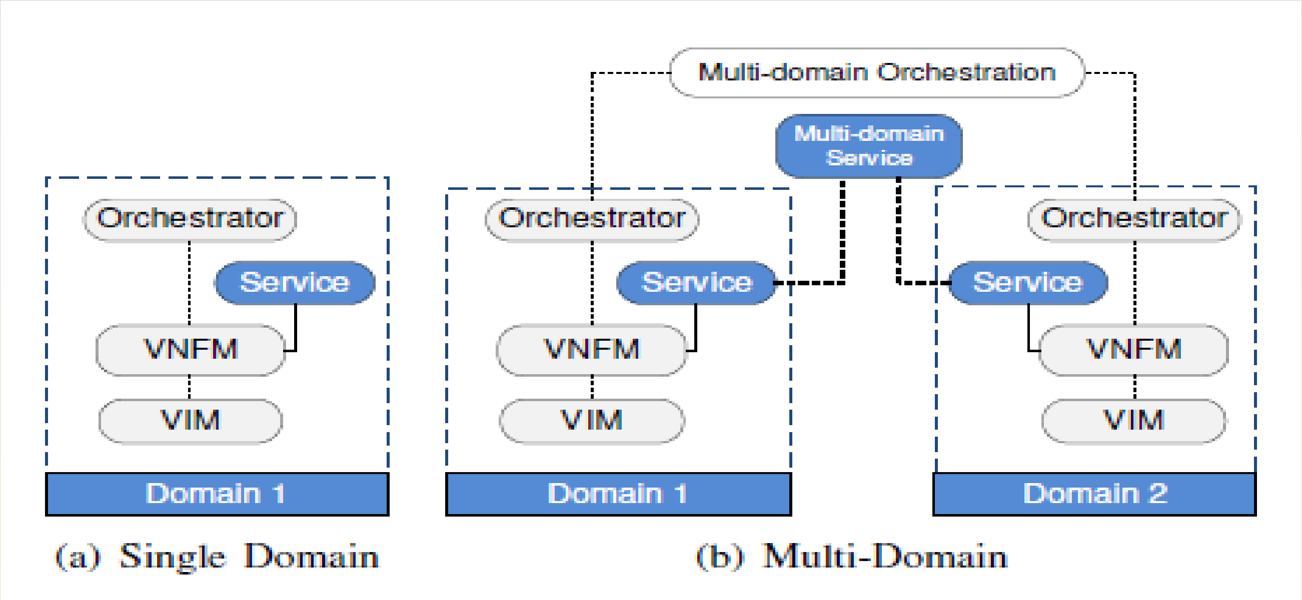
- Tenant ?
- Business model (actors)- distinct Slide provider- architecture



Multi-domain and multi-tenant aspects in 5G slicing

- **Multi-domain-related aspects**
  - **E2E NSL overall objective:** to provide slices
    - **E2E multiple-domain**
    - logically isolated and independent
    - including: the *terminal, RAN resource, core network (CN), transport network (TN)*
    - with customized network M&C for different scenarios, service and vertical industry
  - **Challenges (still - open research issues)**
    - Multi-domain orchestration architecture capable to construct **multi-domain slices**
      - - by provisioning
      - - on demand
    - while preserving different administrative domains independence and their own M&C policies

- **Multi-domain-related aspects**
  - **Architectural generic solution**
    - Example: multi-domain NSL orchestrator + domain individual orchestrators



VNFM- Virtual Network Function Manager; VIM – Virtual Infrastructure Manager

Source: K.Katsalis, N.Nikaein, Andy Edmonds, Multi-Domain Orchestration for NFV: Challenges and Research Directions, 2016 15th International Conference on Ubiquitous Computing and Communications and 2016 International Symposium on Cyberspace and Security (IUCC-CSS), https://ieeexplore.ieee.org/document/7828601

Multi-domain and multi-tenant aspects in 5G slicing

- **Multi-domain-related aspects**
  - **Architectural solutions**
    - **Example 1**: (see previous architecture- slide)
      - multi-domain NSL orchestrator
      - multi-domain Resource orchestrator
      - domain individual managers (VIM, WIM)
    - **Example 2:**
    - Novel top architectural plane - **Service Broker (SB)**
      - to handle slice requests from verticals, Mobile Virtual Network Operators (MVNO), and application providers
      - collects service capability information from admin. domains, creating a global service support repository
      - interacts with the Operating/Business Support System (OSS/BSS)
      - Involved in admission control and negotiation

Source: T.Taleb, et. al., "On Multi-domain Network Slicing Orchestration Architecture & Federated Resource Control", http://mosaic-lab.org/uploads/papers/3f772f2d-9e0f-4329-9298-aae4ef8ded65.pdf

Multi-domain and multi-tenant aspects in 5G slicing

- **Multi-domain-related aspects**
  - **Architectural solutions**
    - **Example 2** (cont'd)
      - Multi-domain Service Conductor (MSC) stratum - service management across federated domains
      - **Cross-domain Slice Coordinator -** defined for each E2E slice
      - **Orchestration plane**
        - Each domain will have a dedicated one, involving the NFV style architecture for the M&C
      - **Example 3**
        - ……

Multi-domain and multi-tenant aspects in 5G slicing

- **Conclusions**

- **5G slicing- still open research areas**
  - Vertical extension of : multi-tenant capabilities
  - Horizontal extension; E2E multi-domain capabilities

- **Examples of projects on 5G slicing:**
  - 5G Essence, 5G-Picture, 5G City, 5G-Monarch, 5GTango, 5G-Xhaul, CogNet, Matilda, NOMA, NORMA, SESAME, SliceNet, Transformer, etc.

- Thank you !

Internet 2019 Panel

Paving 5G+ Networking: Supporting Technologies and Solutions

5G Security Aspects

Dirceu Cavendish, Kyushu Institute of Technology, Japan

5G Networking

5G Salient Characteristics

- Flexible and efficient spectrum usage (including millimeter wave)
- Efficient data transport: control/emergency/low latency
- New use cases
  - Automotive: connected cars (cV2V, cV2I), ADAS
  - Healthcare: smart medical devices, remote healthcare
  - Smart homes/cities: surveillance, home automation

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5G Security

5G service slicing

- Slices
  - Smartphone service
  - Vehicle service
  - M2M services (e.g. healthcare)
- Cellular security protocols:
  - Authentication and Key Agreement (AKA)
  - Extensible Authentication Protocol (EAP)

Cloud computing - New cloud/virtualization technologies have become commonplace.

- Cloud security issues:
  - Users lack control and visibility of resources/data
  - Unauthorized cloud services risk assessment/monitoring (transparency)
  - CSP application programming interfaces (APIs) as attack “entrances”
  - Separation of multiple CSP tenants in shared cloud resources
  - Data replication on virtual redundant cloud network resources increases data leakage risk

How cloud security mechanisms interact with 5G networking elements

- End-to-end protocols:
  - IoT device seeking mutual authentication/secure communication with cloud infrastructure
- Cellular security protocols (AKA, EAP) interaction with cloud security

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5G Vehicular Networks and Security

5G Vehicle communication

- Vehicle to Vehicle (V2V)
  - Milliseconds latency: “5G direct”
  - Reliable and continuous signal
- Vehicle to Infrastructure (V2I)
  - Efficient cloud services: CDN, edge computing

Threat types	**Mitigations**
■ Vehicular sensoring	
■ GPS: spoofing ■ Radar: Small dangerous objects	■ Multiple sensor sources for consistency checks
■ Camera: object occlusion; object distraction; non-standard road demarcation	■ Multiple position camera sources and checks
■ Proximity: position/range attacks	■ Secure/tiered 5G protocols/services
■ Autonomous Driving Aided System	
■ Image processing pattern recognition failures (e.g. stop sign miss)	■ Emergency procedures: collision avoidance procedures
■ Auto driving logic failure: unexpected scenario; software error	■ Self-learning: cloud crowdsourcing driving performance, near misses, and collision events

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Healthcare and 5G security

5G enabled Healthcare

- Vital signs tracking wearables
- Secure remote consultation
- Remote assisted surgery
- 2D/3D scanning

Threats	Mitigations
Vital signs tracking/monitoring	
– Location (GPS) spoofing	Multiple sensor sources with consistency checks
– Authentication spoofing	Multifactor authentication
– Personal Health Information(PHI) leakage	Cloud/Network encryption
Secure Remote Consultation	
– PHI leakage	Cloud/Network encryption
Remote assisted surgery	
– Denial of Service attack	Secure/tiered 5G services
Imaging Scanning	
– Image processing pattern recognition failures	Secure Cloud AI services

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Relevant security technologies

Private Public Key Infrastructure (PKI):
private certificates issued for limited authentication scopes

- Internal enterprise PKIs.
- Cloud based private PKI infrastructure/services: intermediate root/keys management (secluded Hardware Security Module)

Identity based authentication:
authentication based on prover claimed identity only

- Requires small hardware prover footprint (IoT devices)
- Convenient for verifier (public keys only)

Physically Uncloneable Functions (PUFs):
hardware authentication based on unique physical properties of each electronic device

- Unique circuit/chip unit identification (IoT scalable)
- On demand (authentication epoch) key generation
- Low power/processing

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Birmingham

Approaches to 5G and B5G

Xiaohong Peng

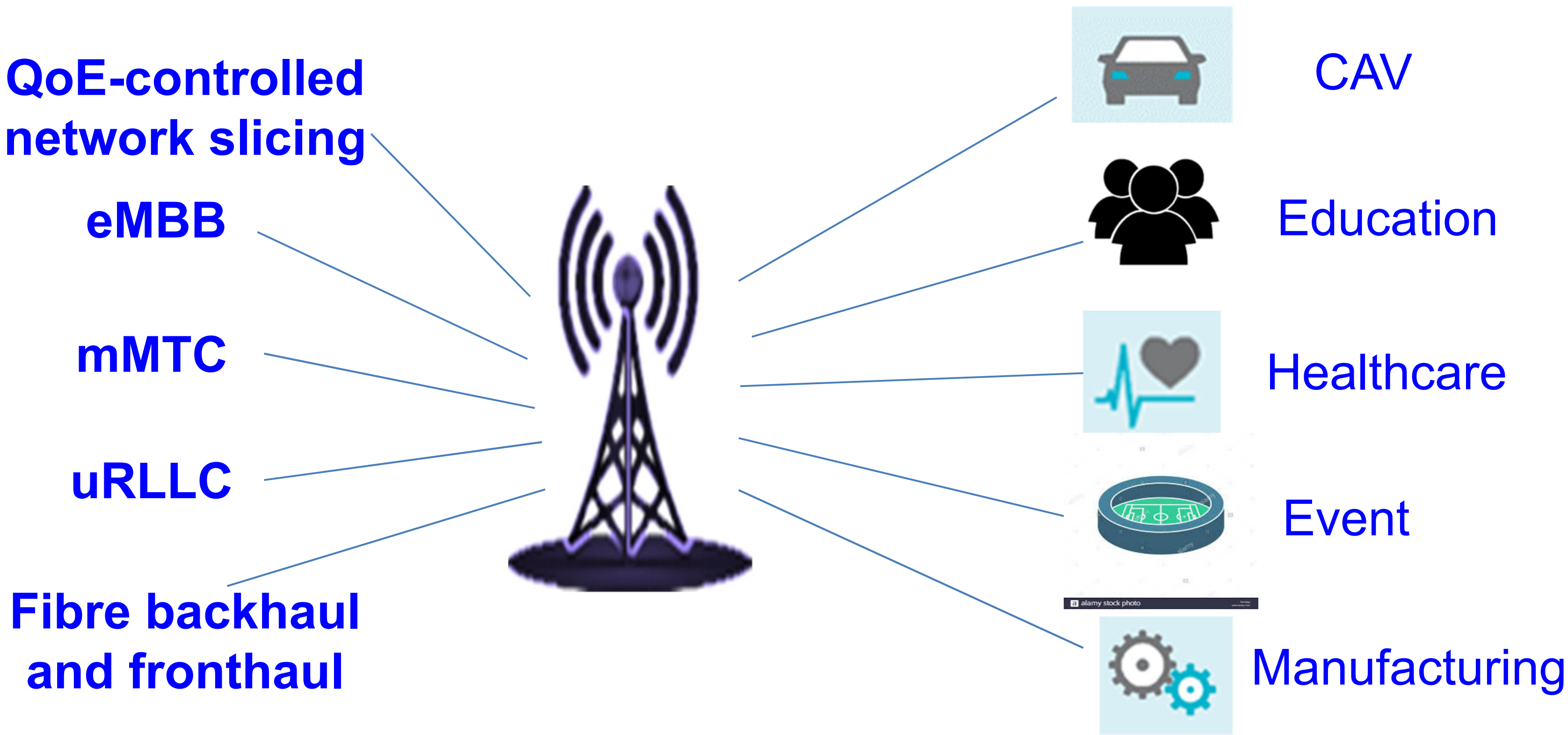
Wireless Communications & Networks
– 5G Research Group

Aston Institute of Photonic Technology

Aston University

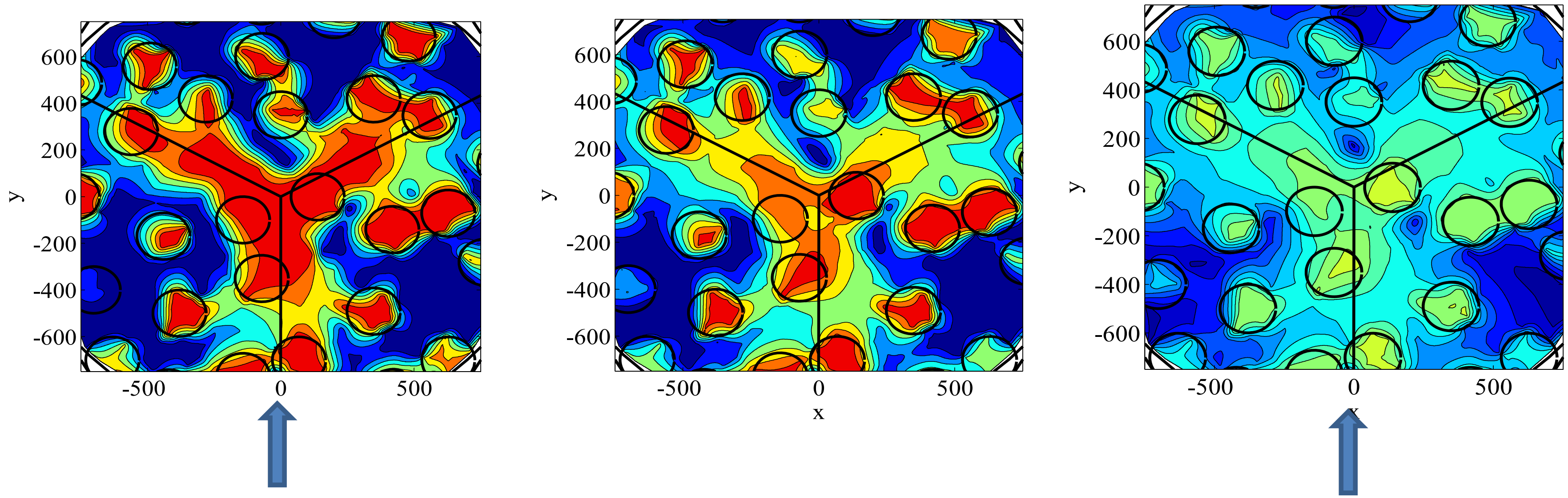
Panel Session at IARIA Vehicular2019, 3^{trd} July 2019

Technologies vs. Use Cases in 5G Networks



Performance Trade-off in 5G Networks

Capacity vs. Coverage



High capacity over a small area

Lower capacity with wider coverage

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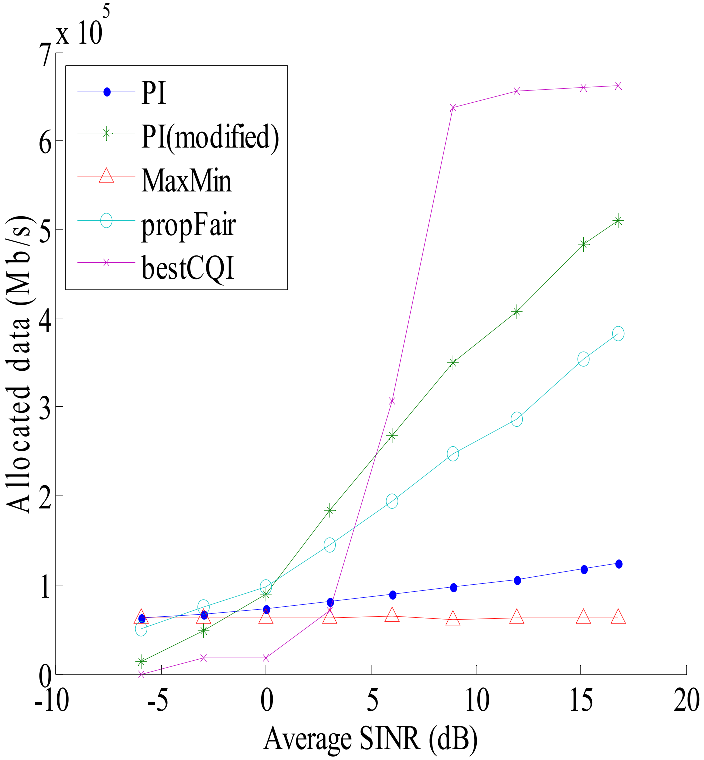
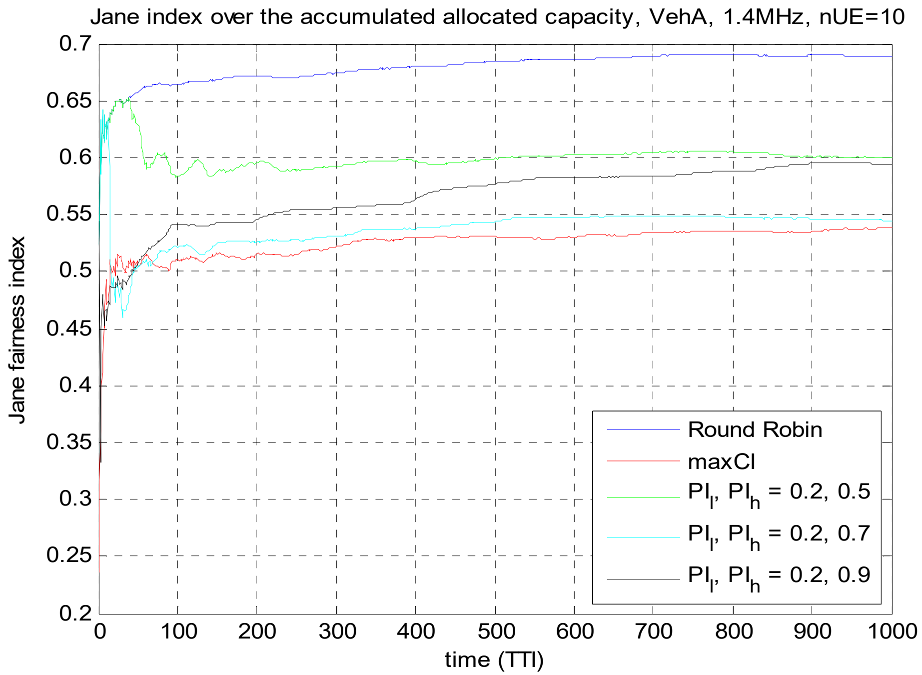
Performance Trade-off in 5G Networks

Performance vs. Fairness





High throughput is always companied by low fairness

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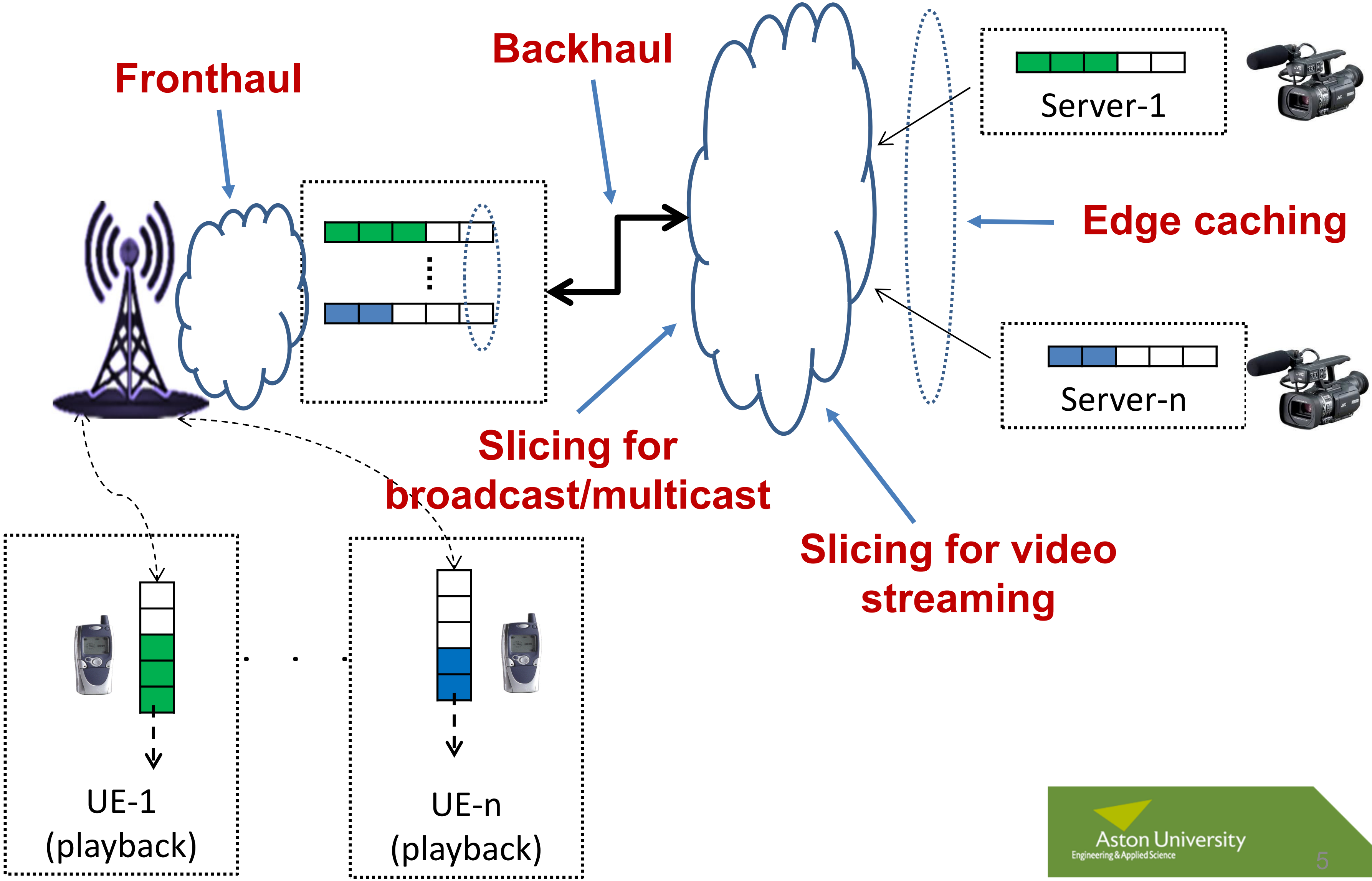
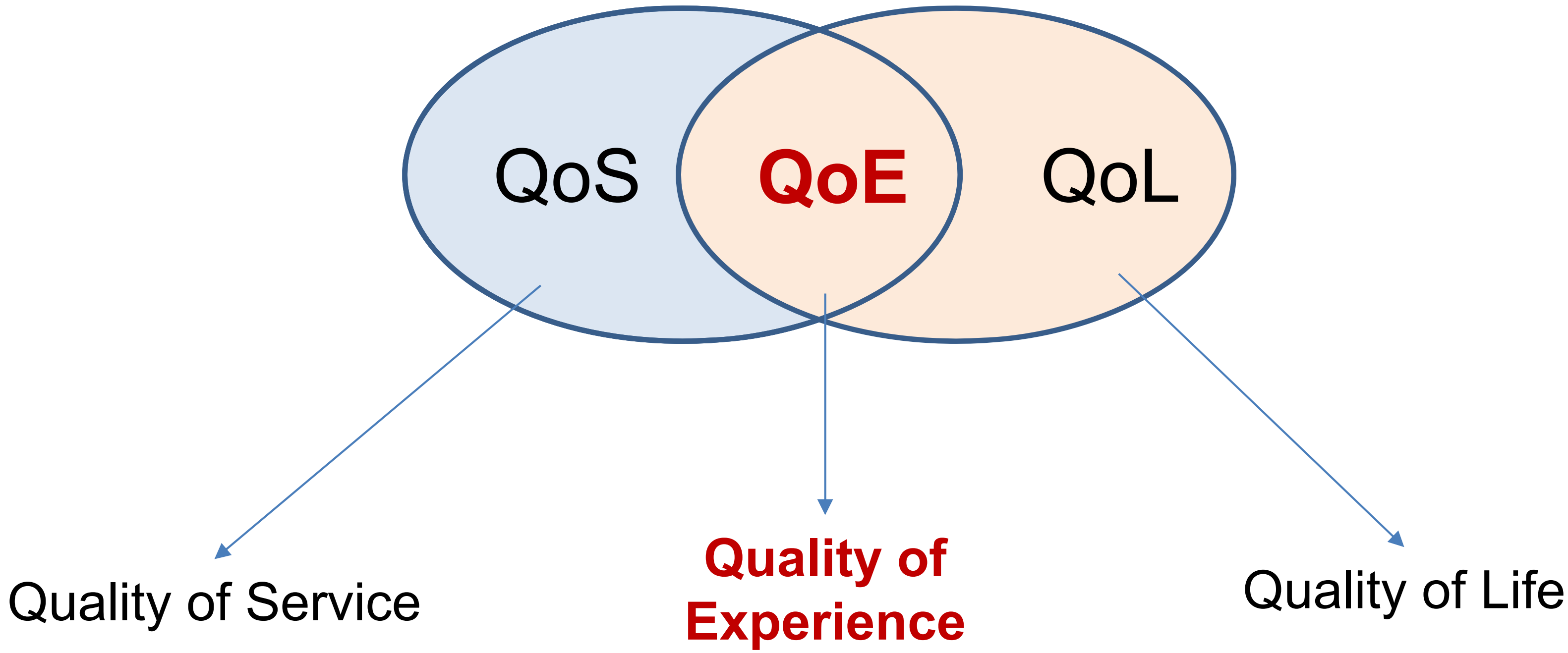
Video Content delivery in 5G Networks



It’s a Quality Issue



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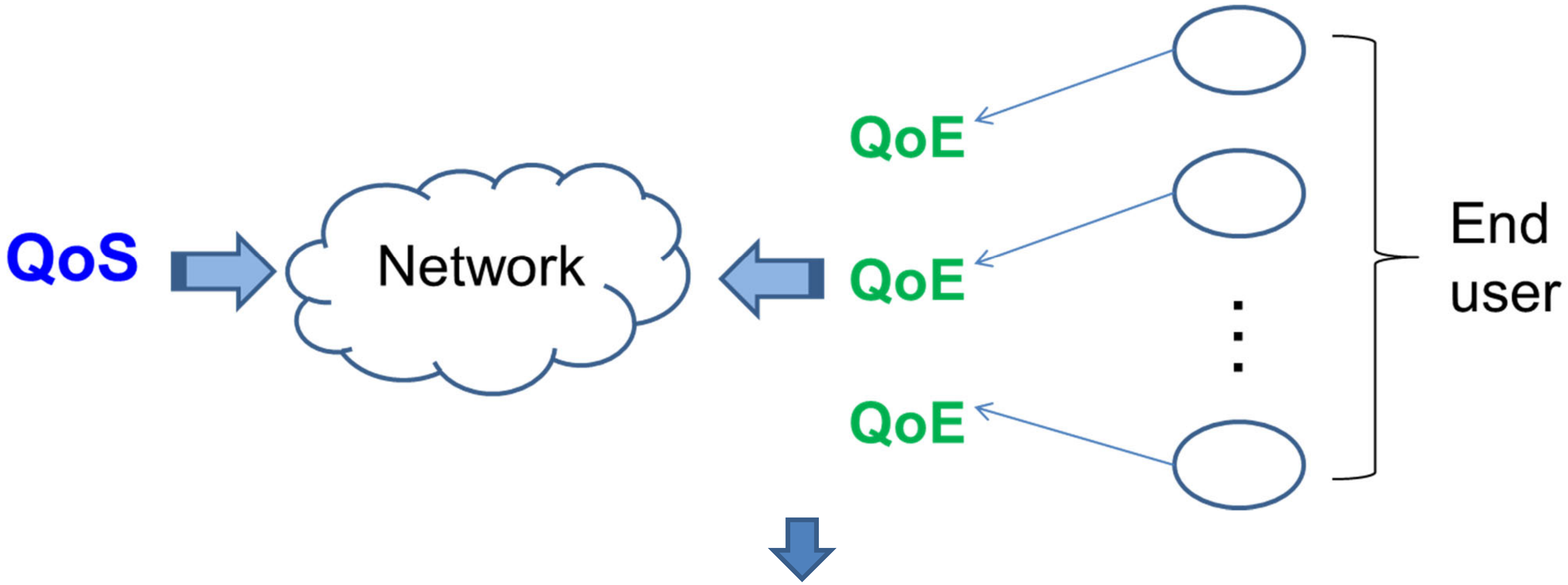
Fundamental Trade-Off

Quality Requirement ⟺ Resource Cost



How to maintain a good march between QoS and QoE?

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Thank You