Bristol Smart Internet Lab's Future Networks 2030 Vision

Smart Internet Lab @ University of Bristol: Global Leaders at Future Network Research and Innovation

Presented on the 13th of January 2020,
To ITU NET 2030 Workshop in Lisbon/PT,
By Xavier Priem, Senior Research Fellow @Smart Internet Lab

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bristol.ac.uk/smart

Smart Internet Lab, Led by: Prof. FREng. Dimitra Simeonidou

Who are we?

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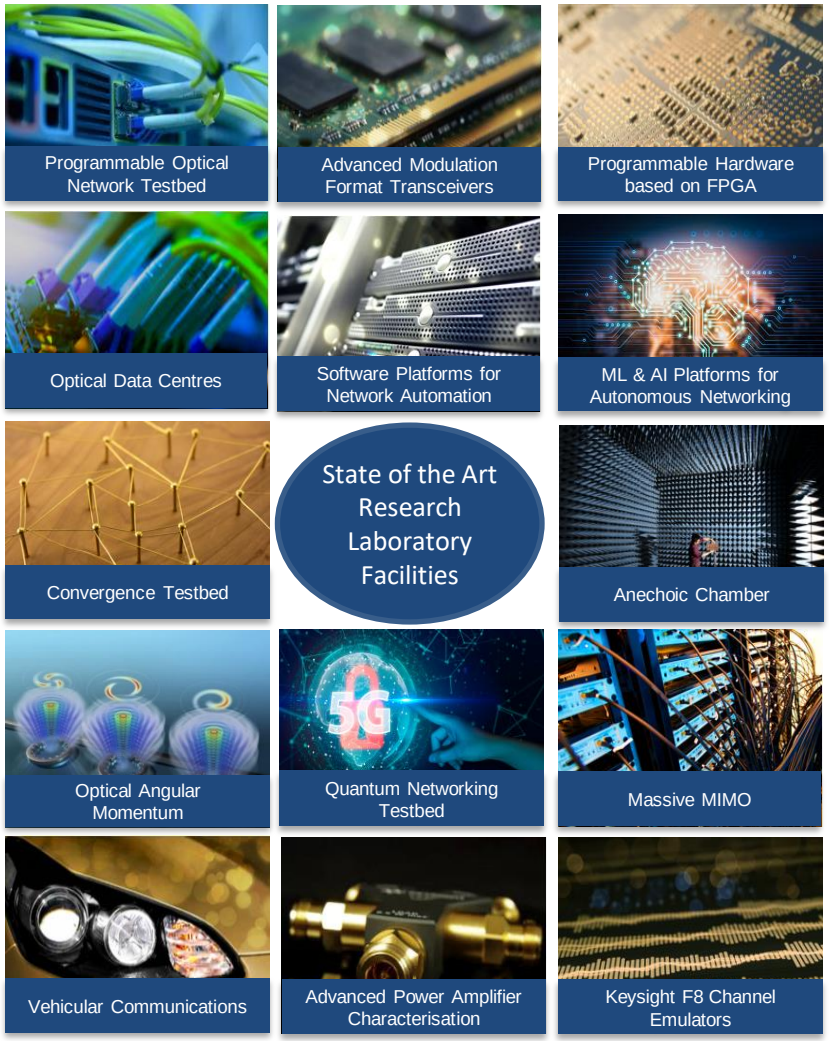
Smart Internet Lab

- A unique interdisciplinary future networks & connectivity research hub with 200 academics and researchers, and growing…
- Founded by three research groups
  - Communication Systems & Networks
    https://www.bristol.ac.uk/engineering/research/csn/
  - High Performance Networks
    https://www.bristol.ac.uk/engineering/research/csn/
  - Photonics and Quantum
    http://www.bristol.ac.uk/engineering/research/pho/
- Combined expertise across optical, quantum, wireless, IoT and cloud technologies (central DC and MEC).
- Extensive expertise on hardware, software, cross-layer optimization and co-design
- Real world deployments and large-scale experimentations

http://www.bristol.ac.uk/engineering/research/smart/



Our Research Themes, Applications & Verticals

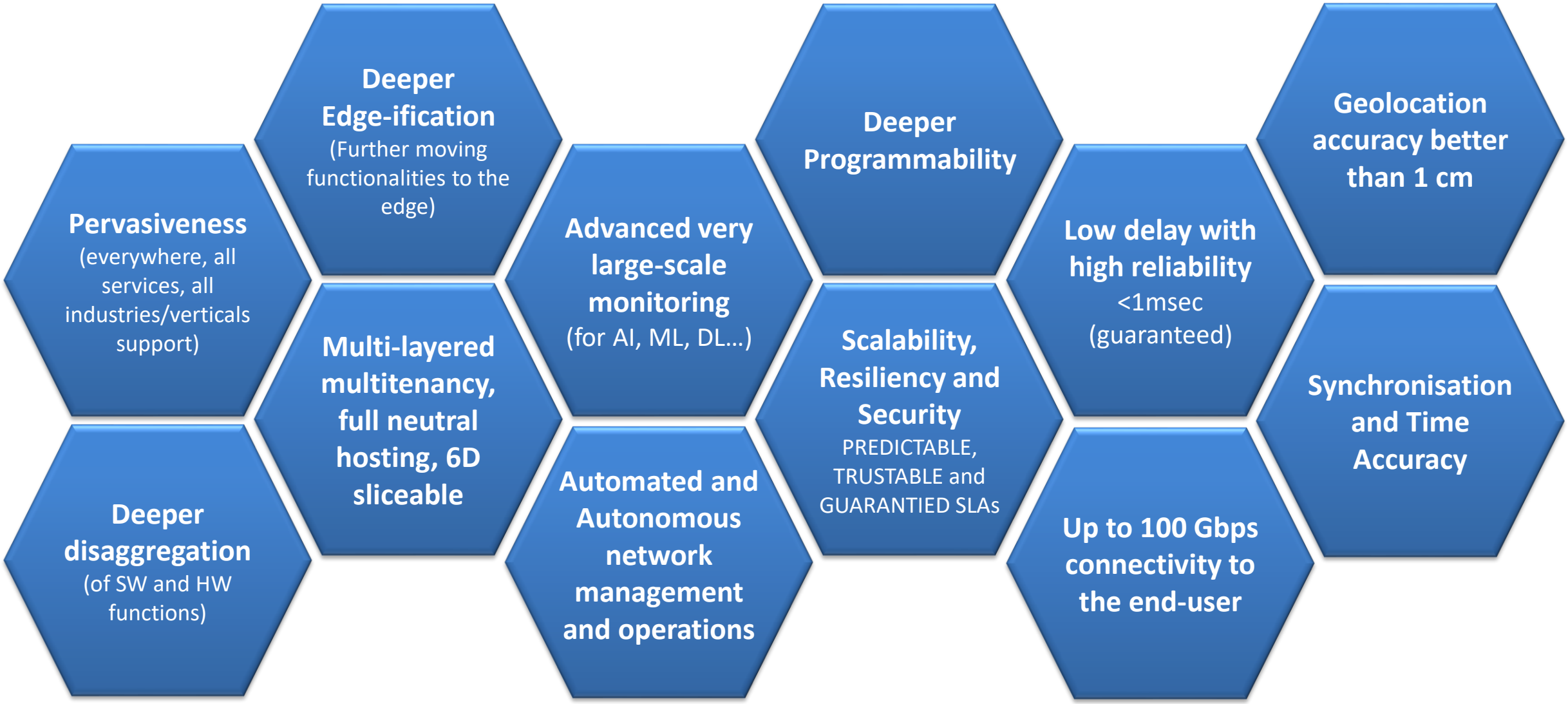
Networking Research Themes:

- Enabling Technologies
- End-to-end 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 (technical and business)
- 5G and Beyond

Application and Vertical Sectors:

- Smart city/region
- Connected transport and Transport Logistics
- Assisted Living
- Smart tourism
- Digital Culture/Media
- Music and Sports
- Public safety/Crowd Control
- High Value Manufacturing

Smart's Future Networks 2030 (r)Evolution Vision: 12 foundation pillars / paving stones on the path



Architecture principles and some samples of the work we do to enable and ground our Future Networks Vision…

Pervasiveness (everywhere, all services, all industries/vertical s support)

Multi-layered multitenancy, full neutral hosting, 6D sliceable

6D Sliceable Space for Shareability & Multitenancy
with finest viable granularity (technically and economically)

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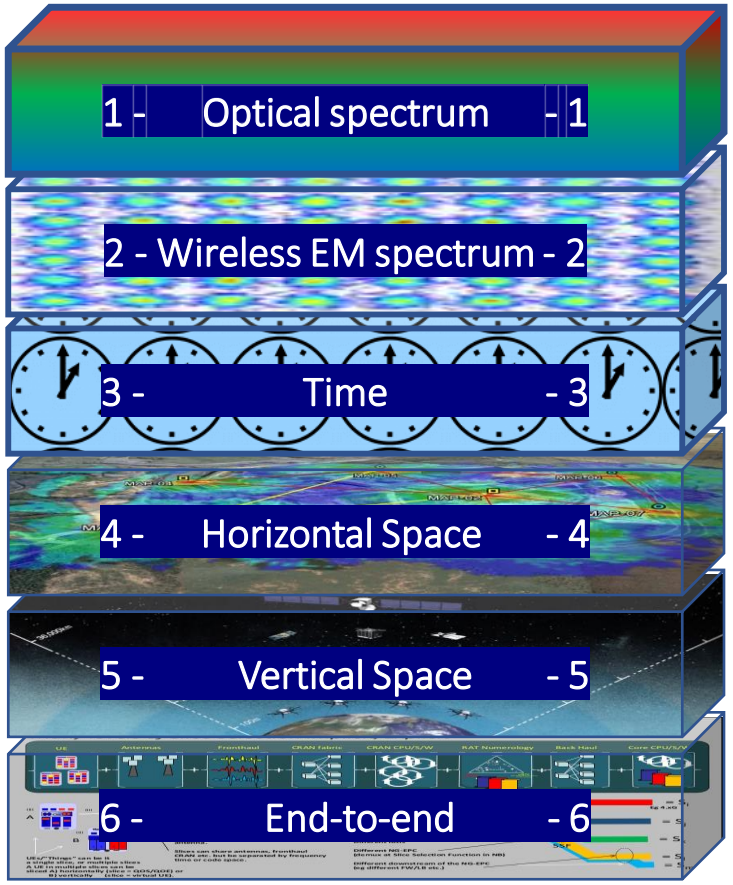
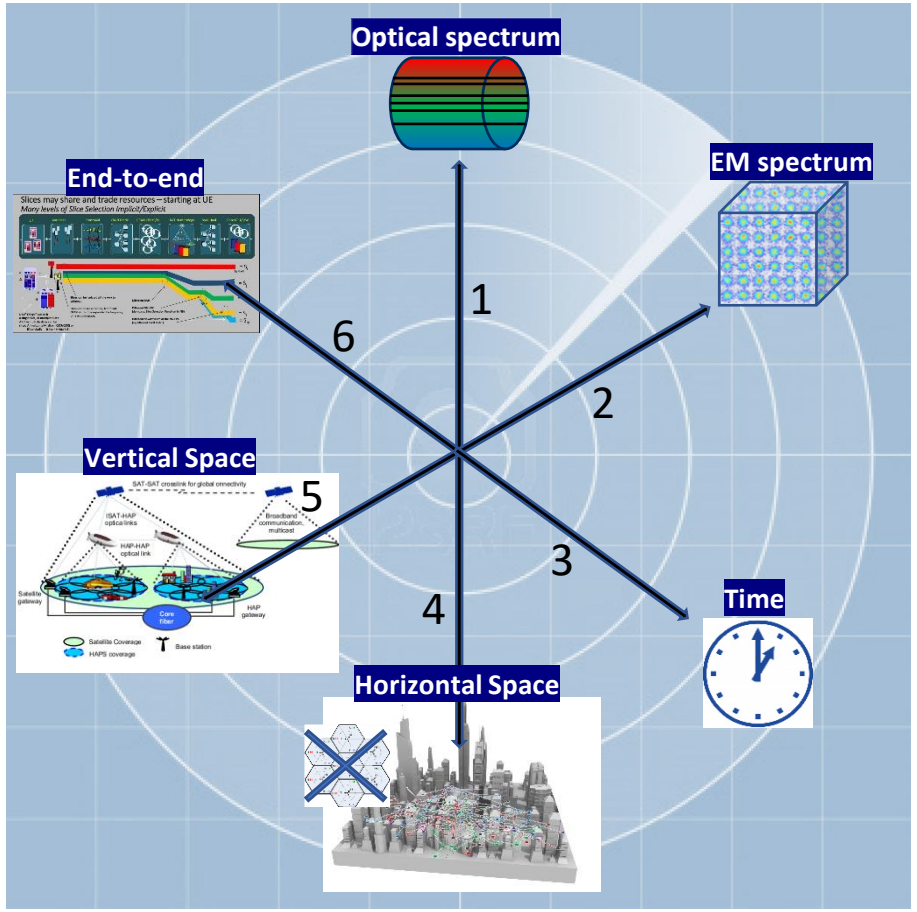
Dimension / Domain
(with D intersections)

Research Axes
(incremental or radical)



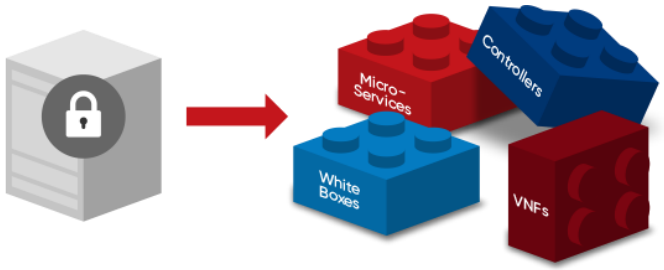
- Sliceable Optics, shared lambdas, …
- Horizontal & Vertical Flexible Sharing
  CBRS, DSS, LSA, LAA, MultiFire…
- Division across all other 5 Ds and at all scales
  but with high precision synchronisation
- Remove Cells => Radio Connectivity Ocean
  AI based, Cognitive, Collaborative
- GEOSAT, LEO/MEO, HAPS
  Sp-RAN, Sp&D-Core, Sp&D-EC, Sp&D-BH
- E2E NS^naaS Multilayer
  Multitenancy SLAs , Dist-AI, Dist/Fed. SDN & Orchestration,



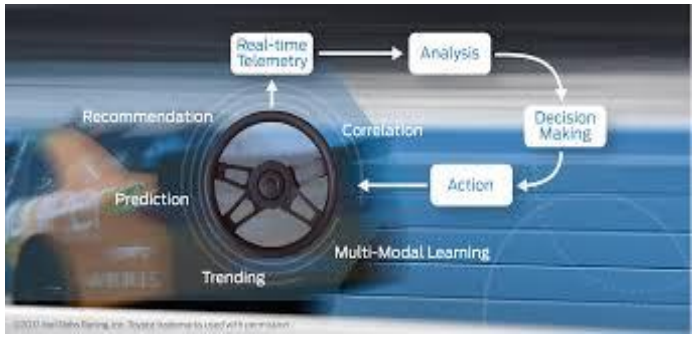
➢ to enable pervasiveness and multitenancy business dynamicity

Architecture Principles

- Disaggregated and composable network infrastructure



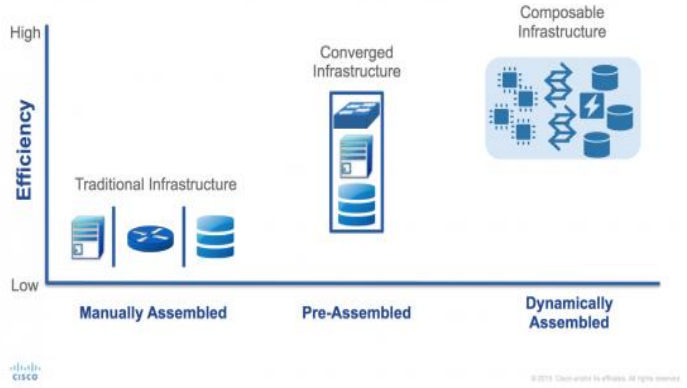
- Self-driving network infrastructure

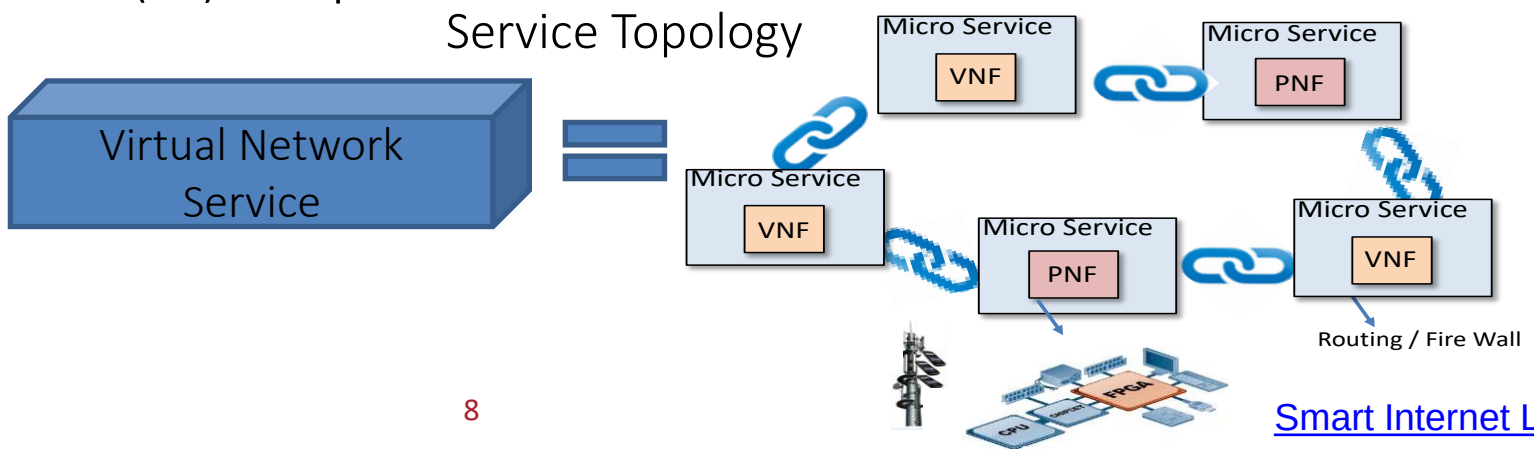


- Technology enablers & challenges
  - Deep network programmability
  - Deep network virtualization
  - Data plane as a micro service
  - ML assisted automation
  - Composable Monitoring and data analytics

Network Deep Disaggregation

- To allow any service to mix-and-match and use compute, storage and network resources upon request (on-the-fly)
- To support high scale: on demand levels (services, users); devices (IoT, bodynets, etc.); points and types of technologies of access
  - Distributed/decentralised solution focusing at the edge where requests arrive (access, service, etc.)
  - Targeted, customised solutions tailored for local network conditions and dynamics (temporal and space locality)
- Enable high network dynamics: variable amounts and types of traffic; devices (IoT, etc.); on-the-fly dynamic service (re)composition





Deeper disaggregation (of SW and HW functions)

Automated and Autonomous network management and operations

Deeper Programmability

Self-Driving Network, Self-Composability

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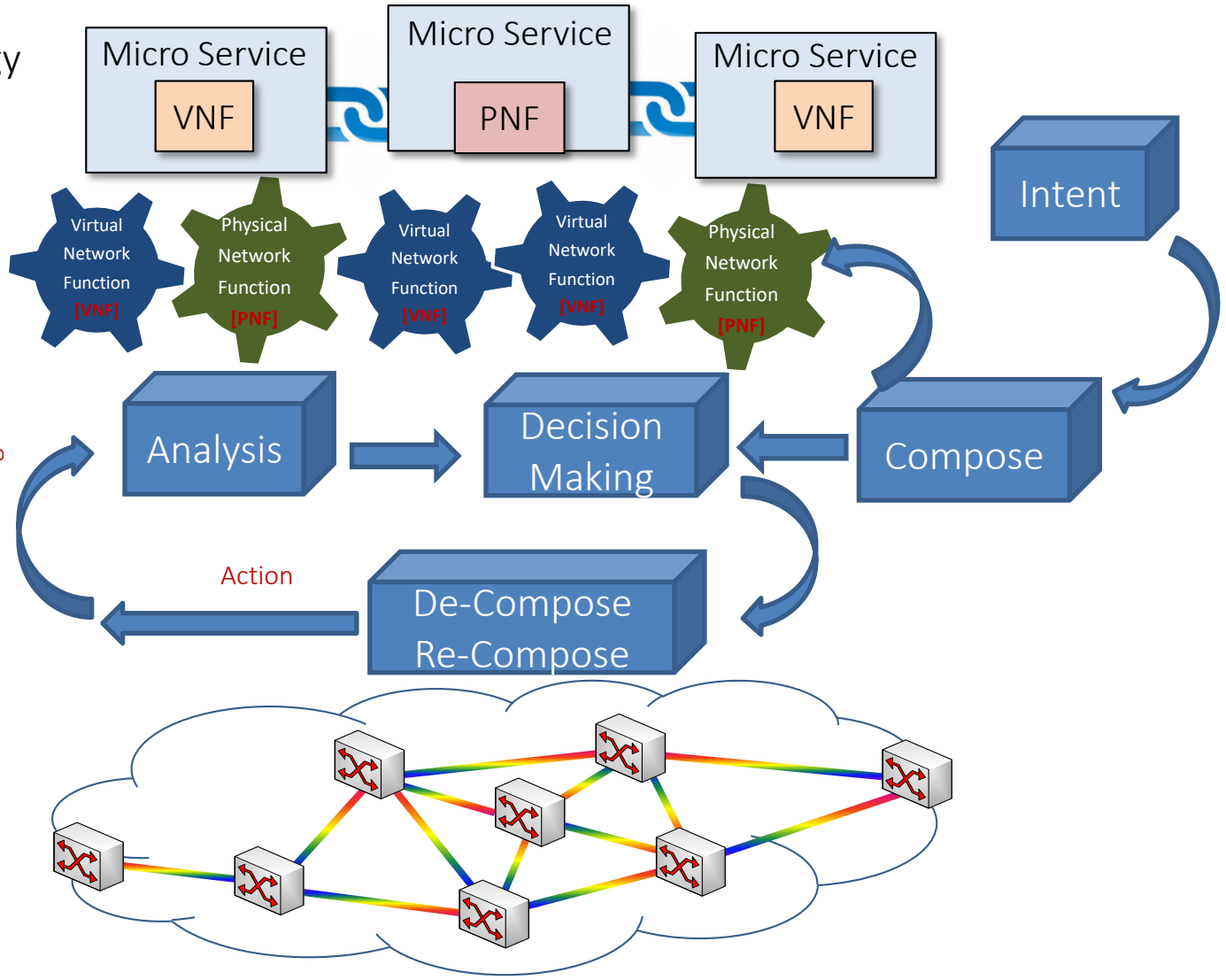
Virtual Network Service

Service Topology



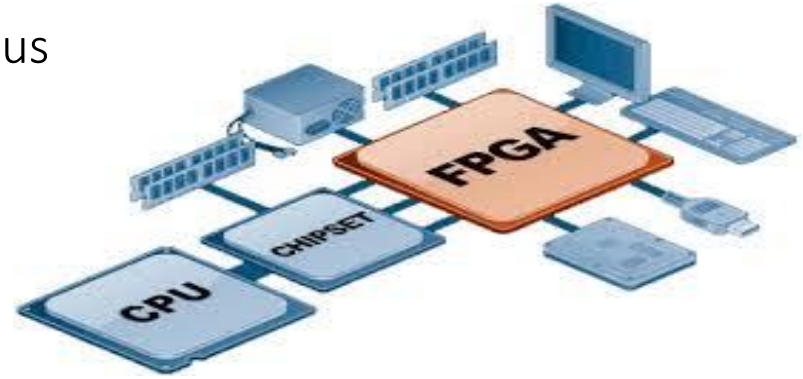
- Machine Learning Assisted and Deep Learning Network Service and Function Composition and Operation

- Function Service Profiling & Monitoring
- Infrastructure Abstraction
- Function Placement

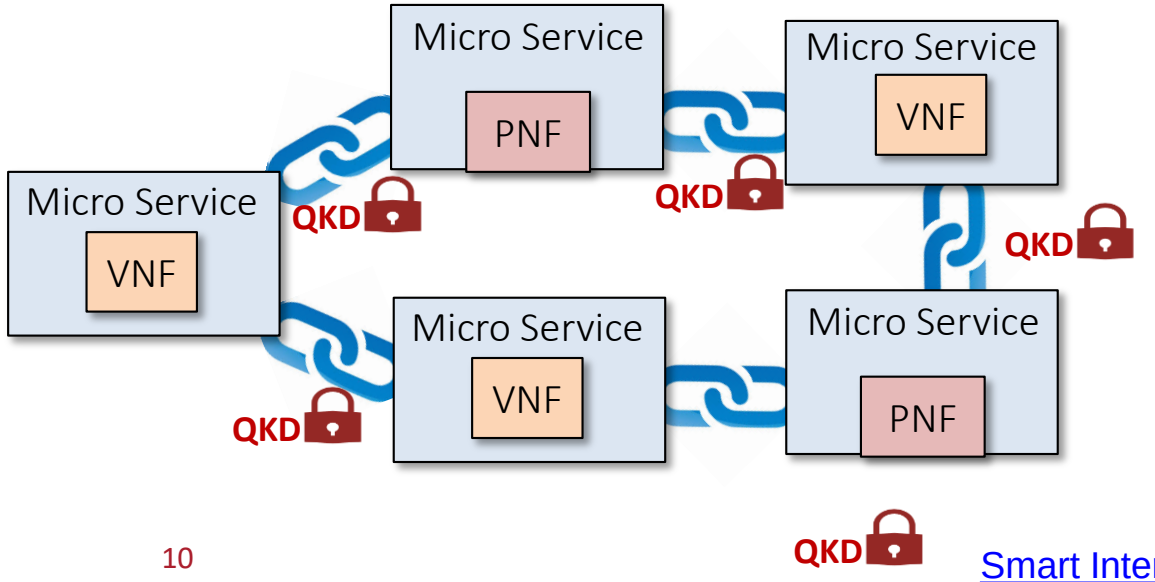
- Methods
  - Game Theory
  - Neural Network
  - Adaptive Regression

Deep Network Programmability and Security

- Programmable Hardware & Network HW Function Virtualization
  - Low latency, high-speed and highly synchronous
  - Function in HW on demand
  - Providing enhanced edge functionality

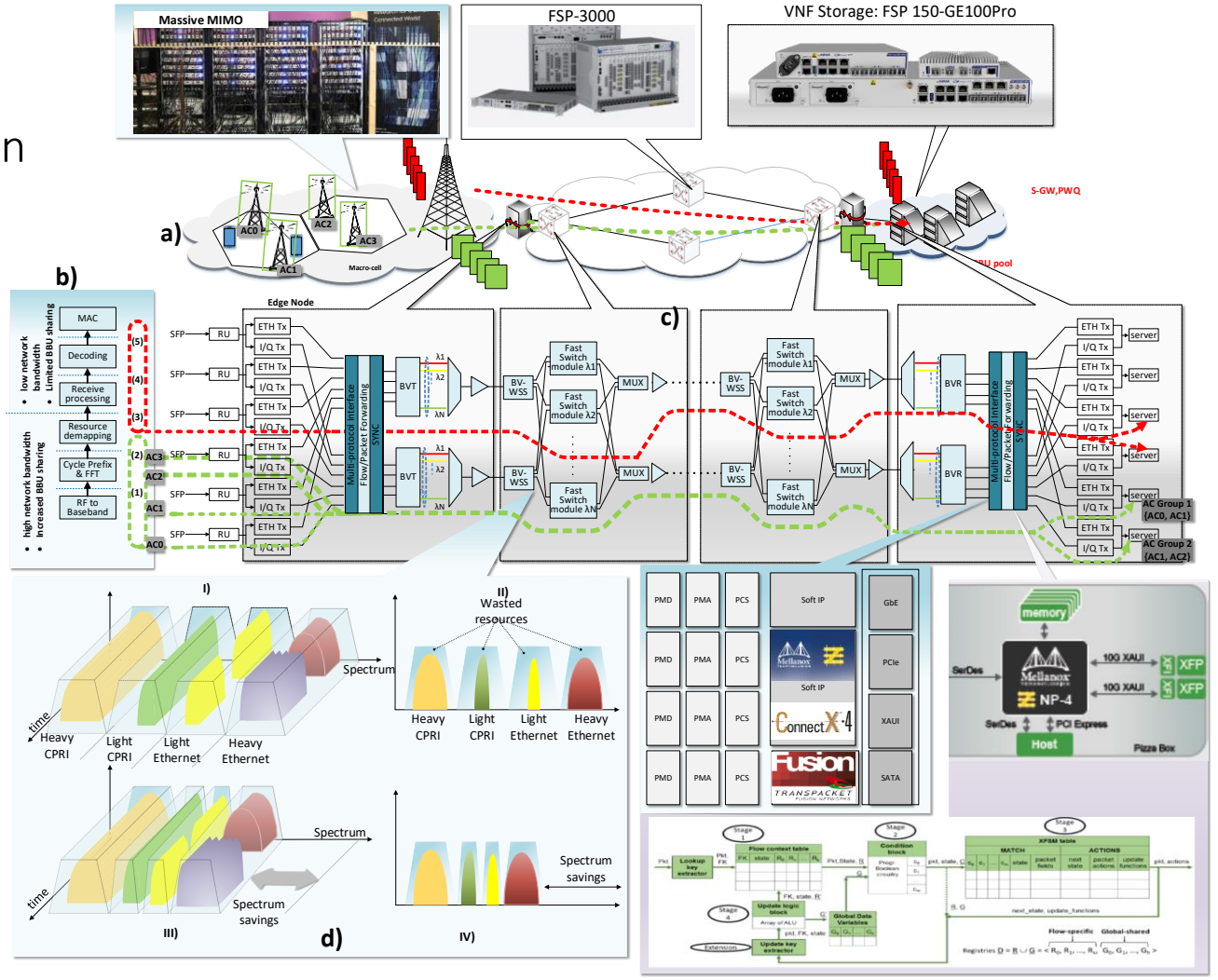


- Quantum secured function chaining
  - Securing communication between VNFs
  - Securing Migration of VNFs



Enhanced Edge Functionality

- Multi-access control
- Manage KPI trade-offs (latency, throughput, location accuracy, density…)
- Traffic management
  - Address local traffic dynamics and network load
  - Address network and computational dynamics
- Key challenges - intelligence at the edge:
  - Data path interfaces
  - Fast reconfiguration
  - Sharing and isolation
  - Synchronization
  - Resilience, security
  - Efficiency, scalability & sustainability



Scalability, Resiliency and Security

QKD Integration in 5G and beyond 5G

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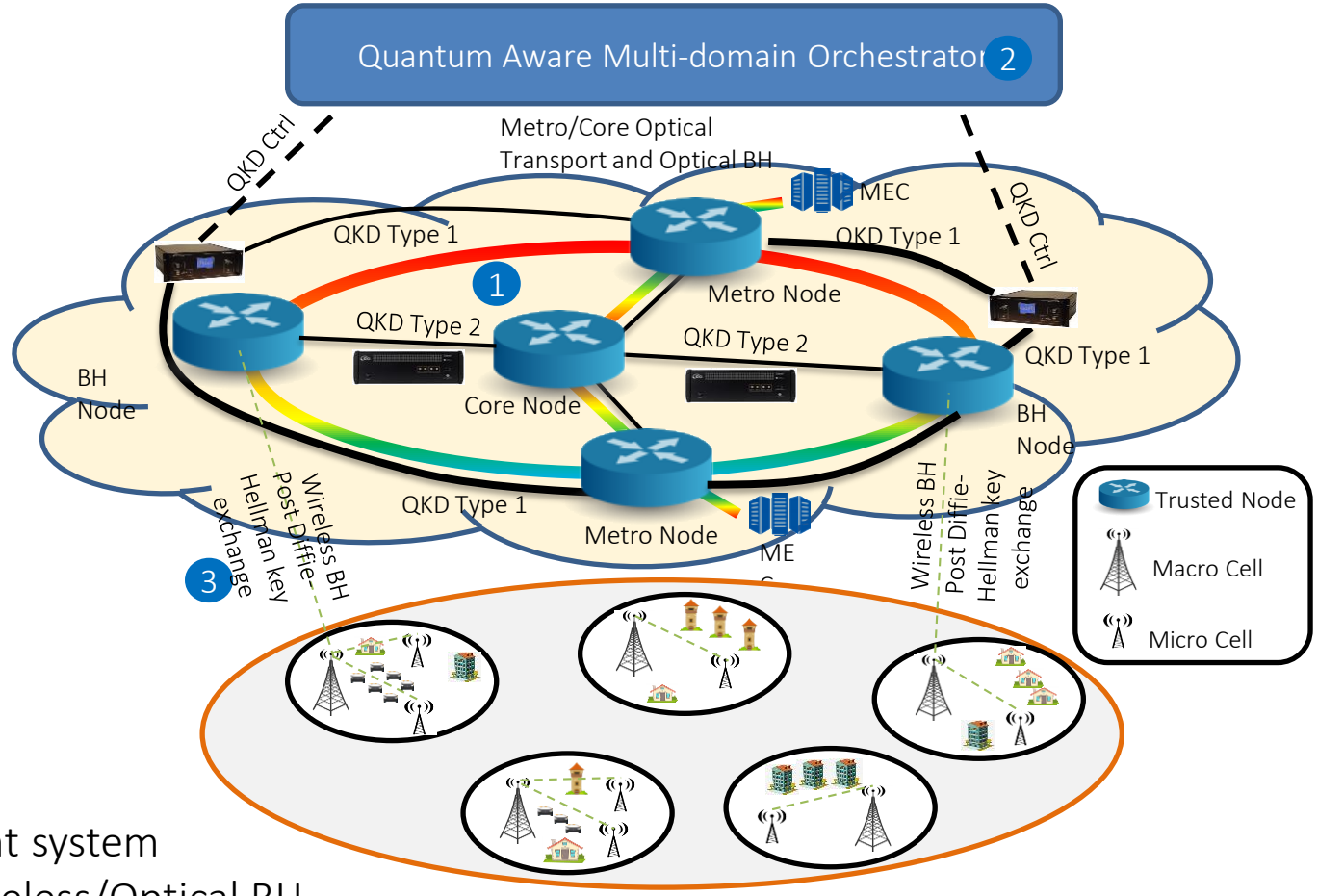
1. Developed the physical layer technologies to integrate QKD with OTN infrastructure:
   - Co-existence of classical/quantum
   - Dynamic QKD for the Edge/Metro

   [ECOC 2019 PDP]

2. Extended OSM MANO to incorporate QKD-awareness:
   - Provision of QKD as an additional security service
   - Use QKD to securely chain VNF through OTN across multiple domains

   [OFC 2019 PDP]



3. Enable Quantum/Classical end-to-end security:
   - Develop Hybrid Key Exchange and Management system
   - Managing Post-Quantum Cryptography for Wireless/Optical BH
   - [QKD over 5GUK demo https://www.bristol.ac.uk/physics/research/quantum/conferences/qkdover5guk/]

Scalability, Resiliency and Security

Emerging QKD research @Smart

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- Complete the “Dynamic QKD Networking”
  - 2nd Logical Step in QKD networking: Multiple Quantum Channels in the same link
  - Full Q-ROADM: multiple-Q/multiple Cl- channels

- Apply QKD in 5G Fronthaul solutions
  - Employ SFP-class cost-efficient of QKD sources for end users
  - Cover the last mile for true end-to-end QKD encryption

- Entanglement-based Quantum Networks
  - Employ entangled sources to distribute quantum states in multiple nodes
  - Use the “WDM” feature of entangled photons

Conclusion

- The first pillar, Pervasiveness, is essential in the future to support Verticals and a true Digital enabled Society (no divide)
- The cost of pervasiveness will be balanced by new business models enabled by Multi-layered multitenancy and shareability capabilities
- Deeper disaggregation, programmability, “edge-ification” are strong necessary enablers for pervasiveness
- Dynamic Scalability, Resiliency and Security will support predictable, trustable and thus guarantied SLAs for verticals

➢ **Future Networks must become the 4th Utility Critical Connectivity Grid Infrastructure and be globally designed as such**

THANK YOU

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Thanks for the contributions from:

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