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Smart Internet Lab

5GUK Test Network

Smart Railways & Smarter Cities
5G Technologies

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20th Feb. 2019

bristol.ac.uk/smart

Smart Internet Lab

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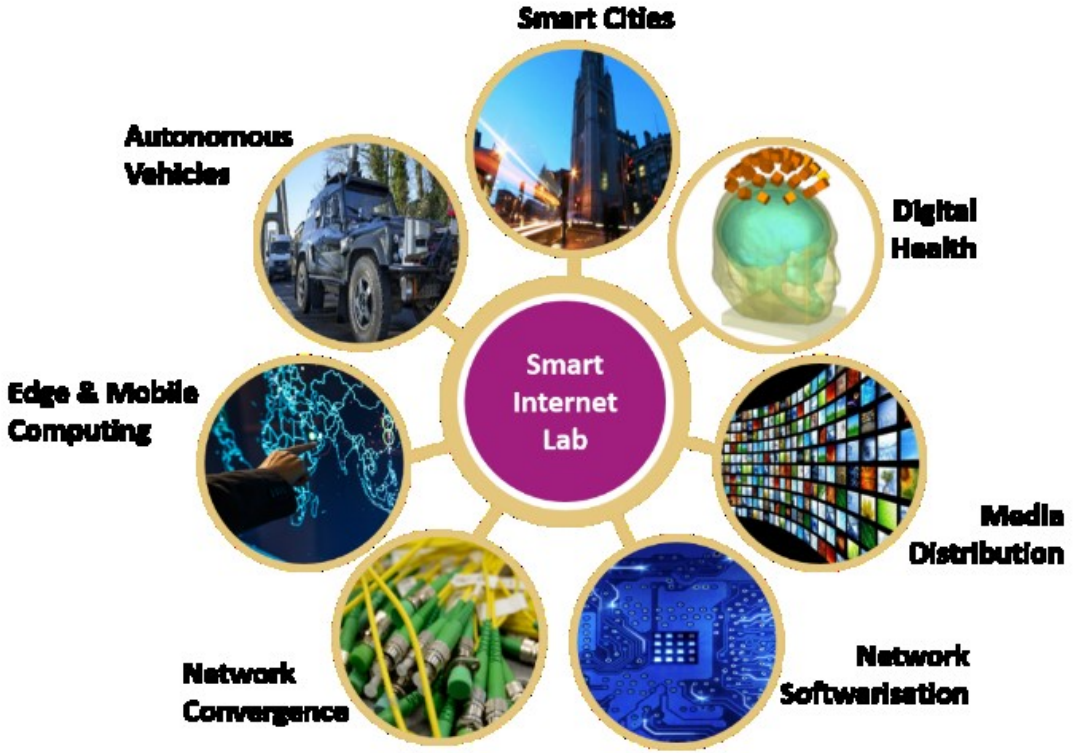
- Brining academics and researchers together from
  - Communication Systems & Networks (CSN) Research Group
  - High Performance Networks (HPN) Research Group
  - Photonics Research Group
  - Research Institutes
- Creating an Urban 5G Innovation Platform -
  to address grand societal and industrial challenges,
  and to meet continuing cultural demand
  for improved technological infrastructure and performance.



5G – An Introduction

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Enhanced Mobile Broadband (**eMBB**)
Ultra Reliable Low Latency Communications (**URLLC**)
Massive Machine Type Communications (**mMTC**

- **Radio and Hardware**

- **Software and Virtualisation**

Technology

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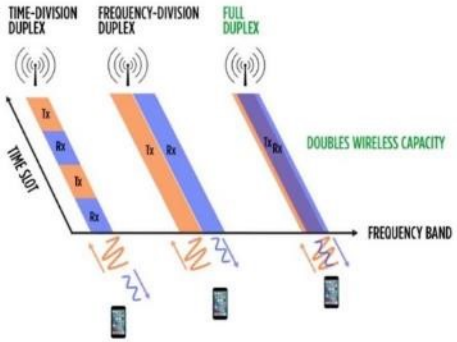
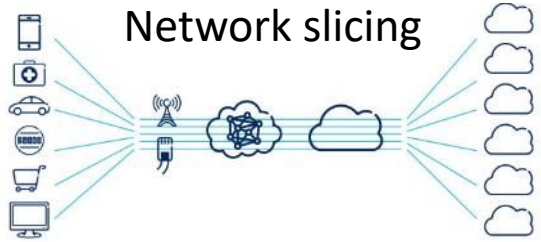
Full duplex



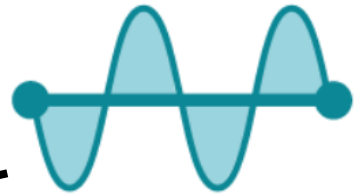
Advanced coding

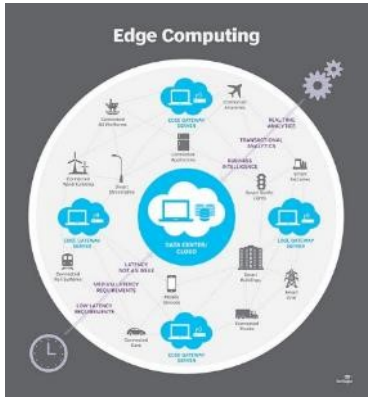
Spectrum sharing

Network slicing

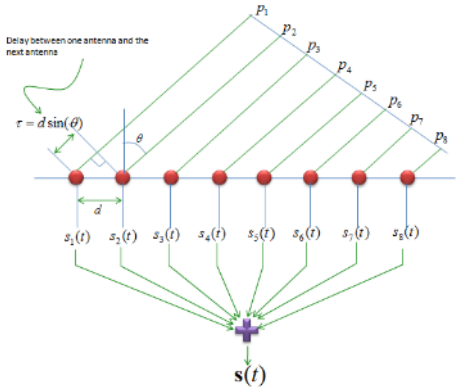


mmWave





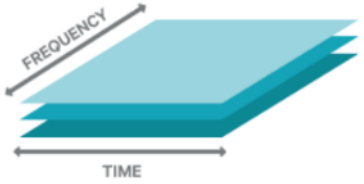
Edge computing

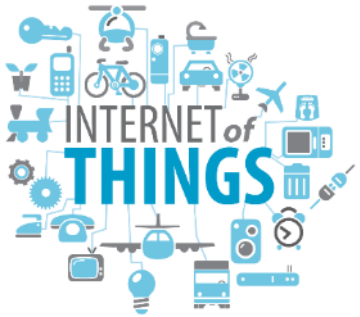


Beamforming

Low power consumption

Compatible





IoT

Massive MIMO

Heterogeneous Integration

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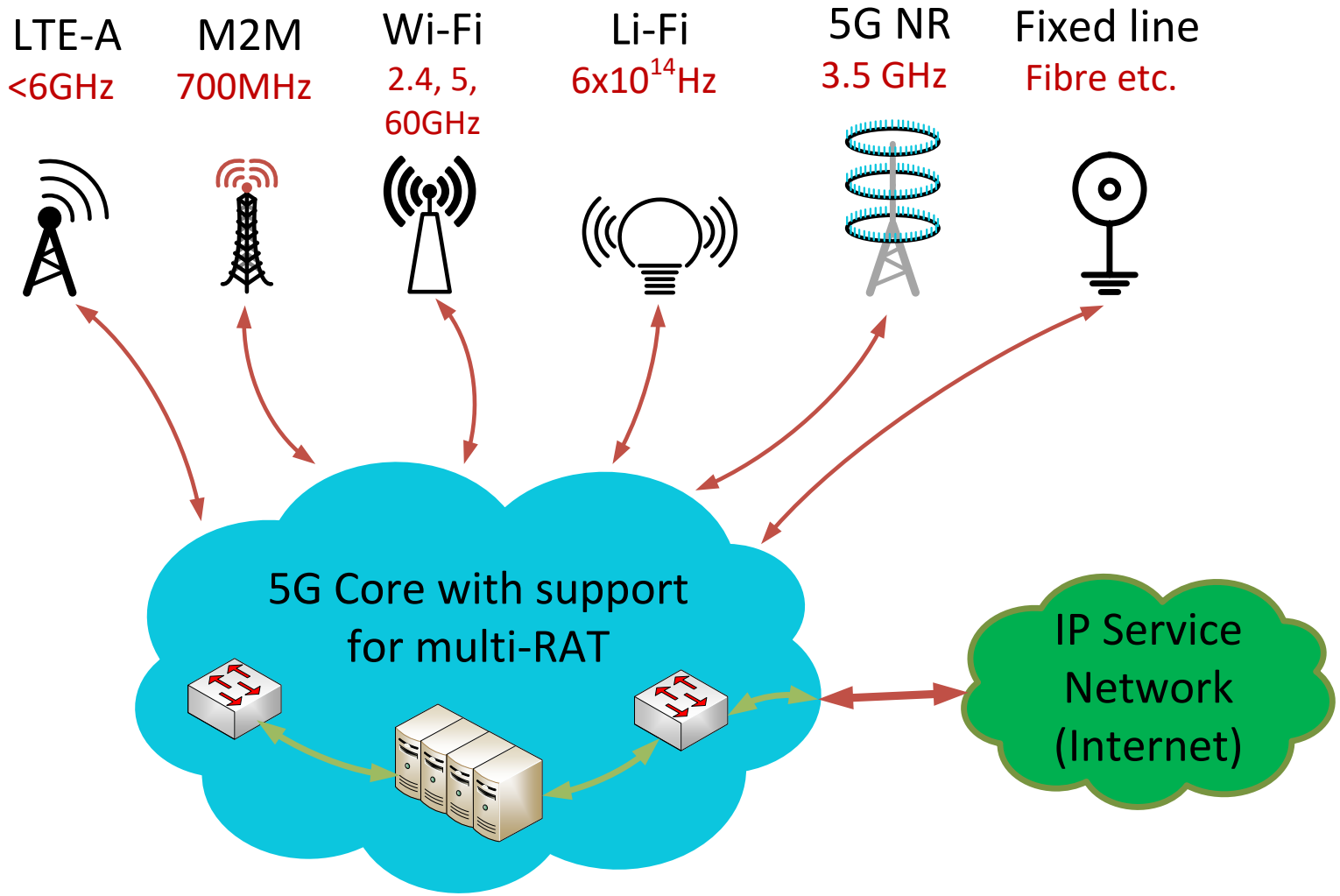
- 5G will be a multi-RAT solution
- All managed by the core network
  - 2G, 3G, LTE, LTE-A
  - 5G NR (massive MIMO & mmWave)
  - Wi-Fi ac and ax, WiGig
  - Fixed line, LiFi, etc
- Evolution from discrete and separately managed networks
- Big step to combine IEEE with 3GPP
- Flexible and adaptive core



An intelligent core network is imperative

Enabling Technologies

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Radio and Hardware

- mmWave
- Masive MIMO
- Beamforming

Software and Virtualisation

- Network Function Virtualisation
- Software Defined Networking
- Multi-Access Edge Computing

Radio

- $C \approx W \cdot n \cdot \log_2(1 + SNR)$

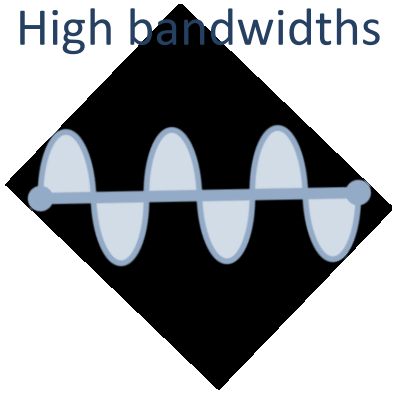
Capacity *Spectrum* *Antennas* *Signal Quality*

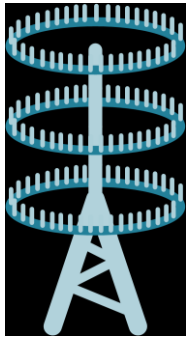
Massive MIMO

Exploit spacial diversity

mmWave

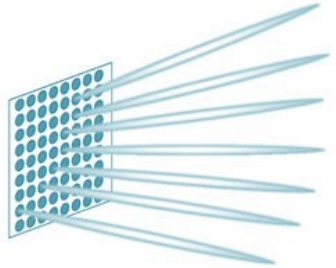
High bandwidths





Beamforming

Improved SNR



Network Slicing

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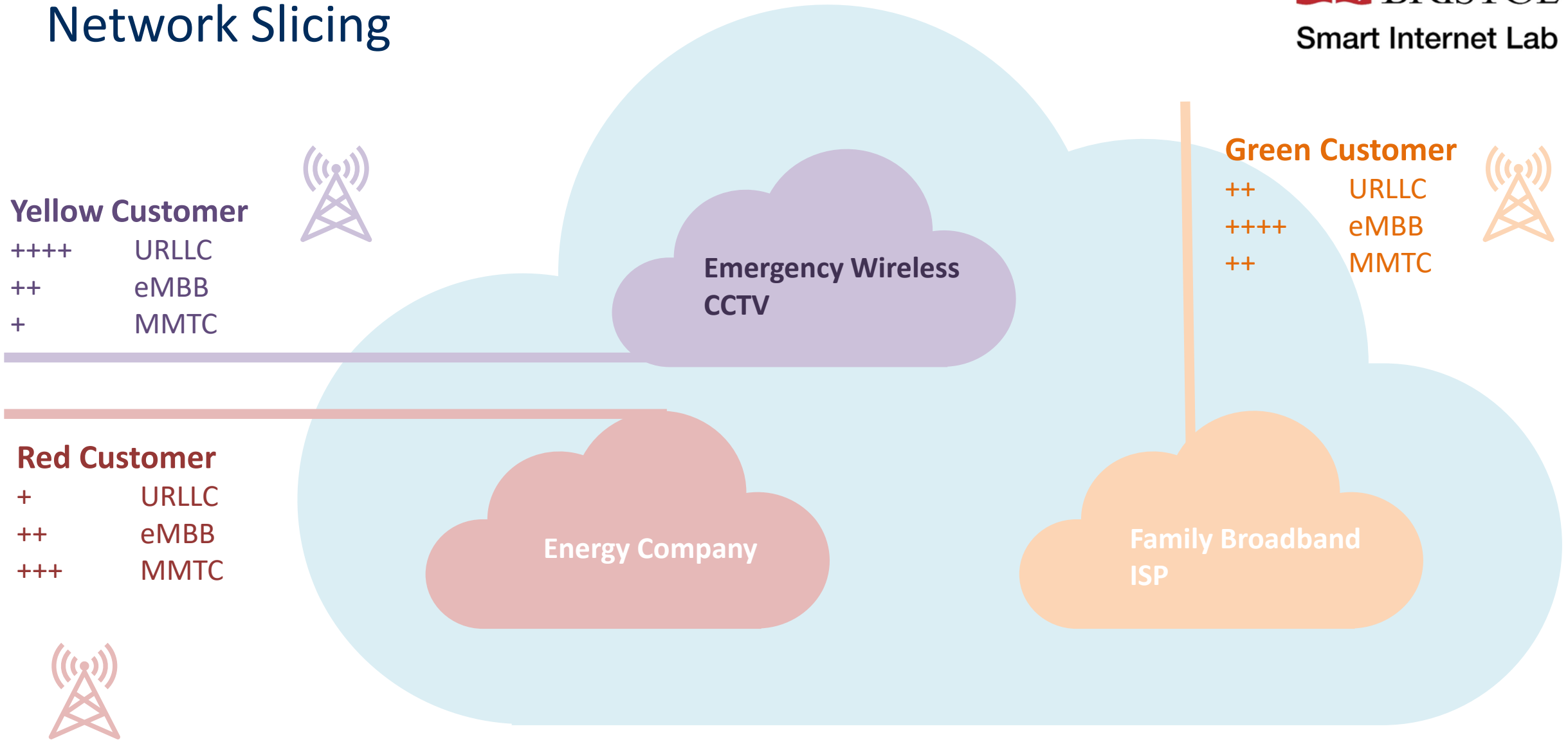

University of Bristol Test Network layers

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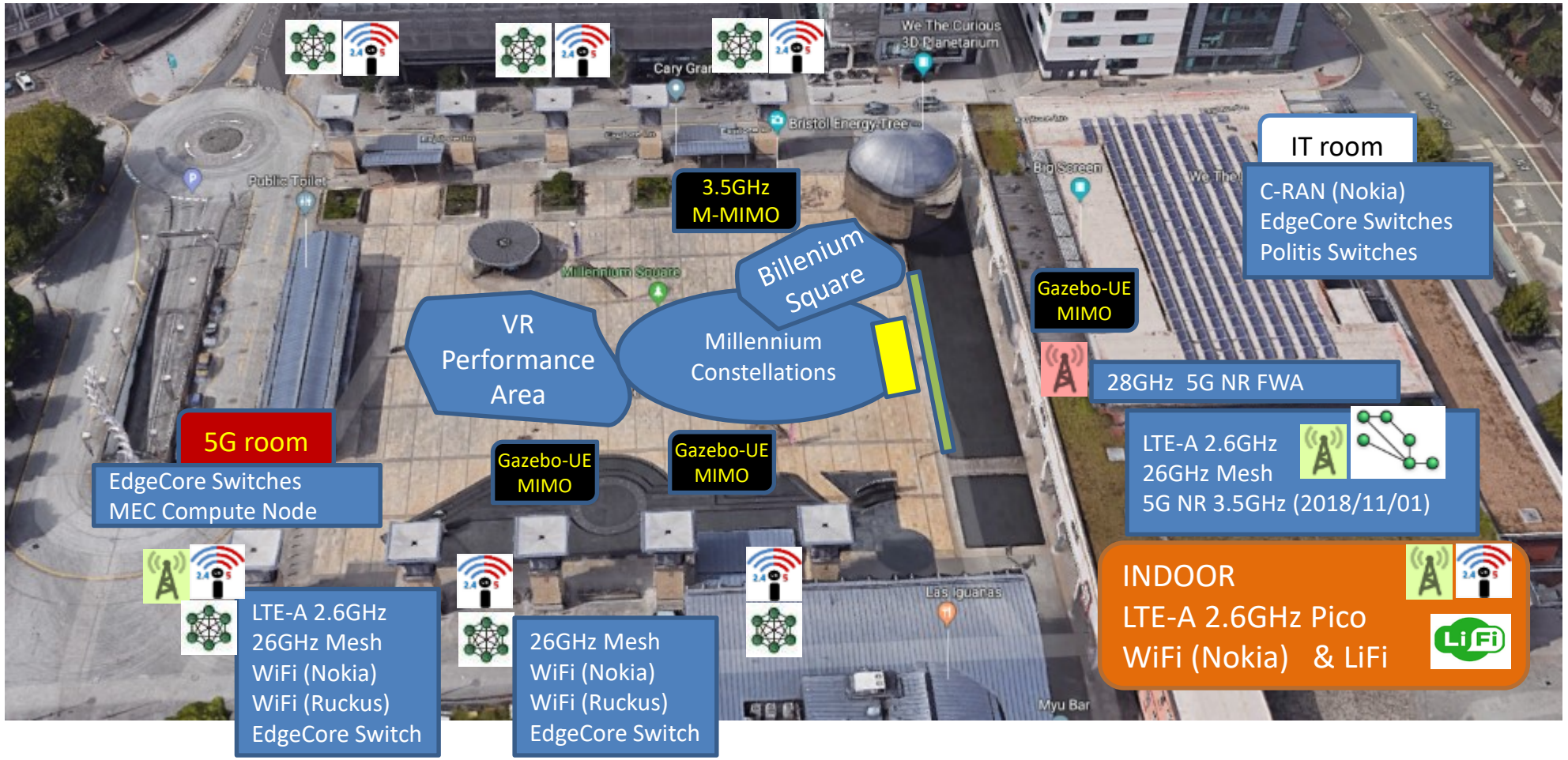

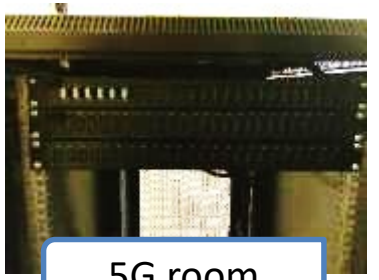

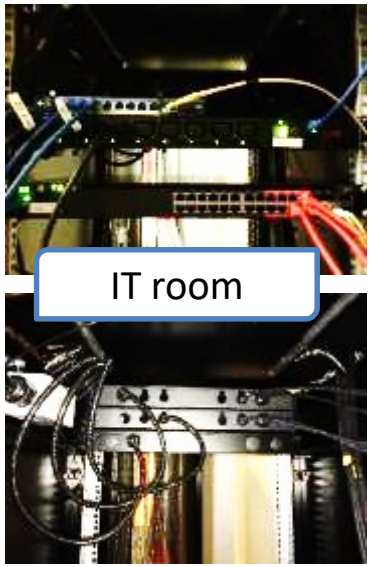

Technology

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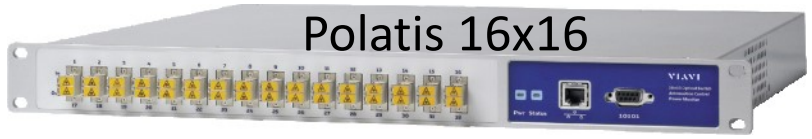
Dell T630

Corsa DP2100


Polatis 16x16

Ruckus T710


CCS Metnet

SM Fibre


Edgecore AS4610-30P


Massive MIMO

Massive MIMO (indoor radio propagation)

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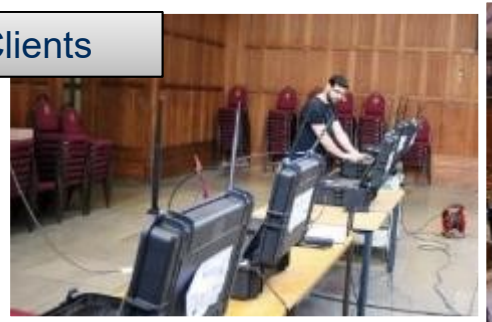
Testing at Wills Memorial Building

- Evaluated the new Over The Air (OTA) sync method
- Demonstrated 12 video streams in UL & DL
- Ensured Reliability of Service
- Outdoor radio propagation was also carried out before the public demonstration

M-MIMO 3.5GHz Physical Layer

12 User Clients



Safety

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BS EN 50385: 2017

- Product standard to demonstrate the compliance of base station equipment with radiofrequency electromagnetic field exposure limits (110 MHz - 100 GHz), when placed on the market for - General public

IEC 60950-1/EN 60950-1/UL 60950-1/CSA C22.2 No. 60950-1:

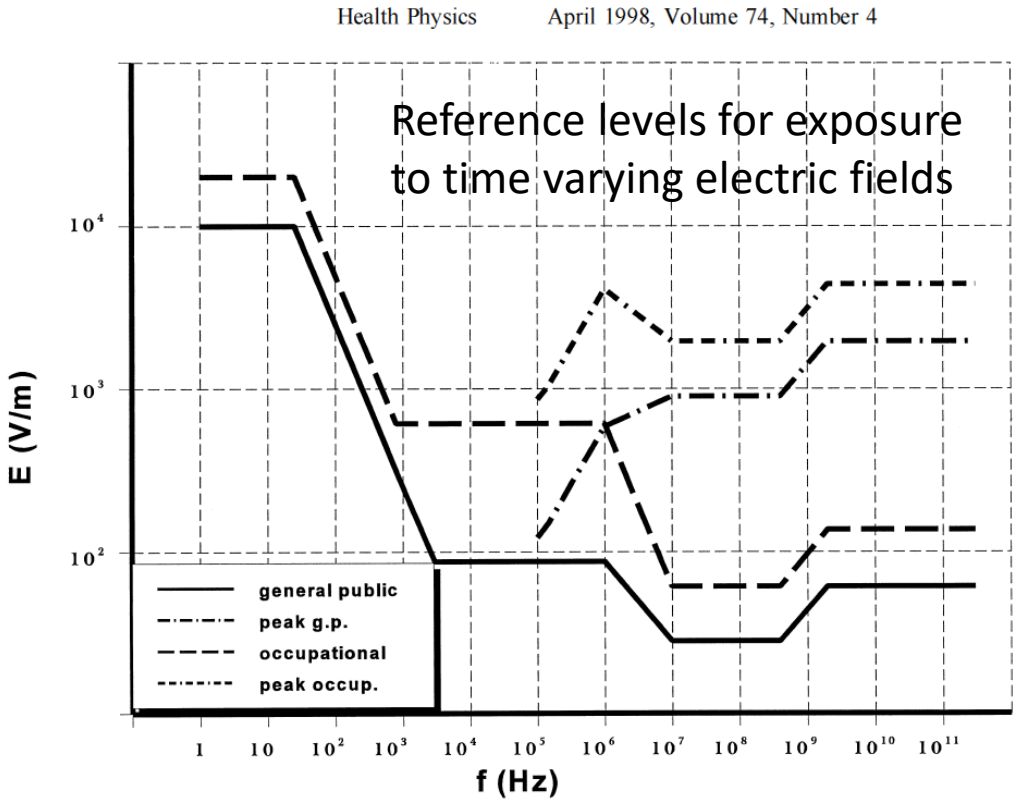
- Information technology equipment - Safety -Part 1: General requirements

IEC 60950-22/EN 60950 22:

- Information technology equipment - Safety - Part 22: Equipment installed outdoor

United Kingdom Public Health England's (PHE's):

- Concerned citizen can contact PHE for health related enquiries: https://www.phe-protectionservices.org.uk/nir/contact



https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf

Safety – Example

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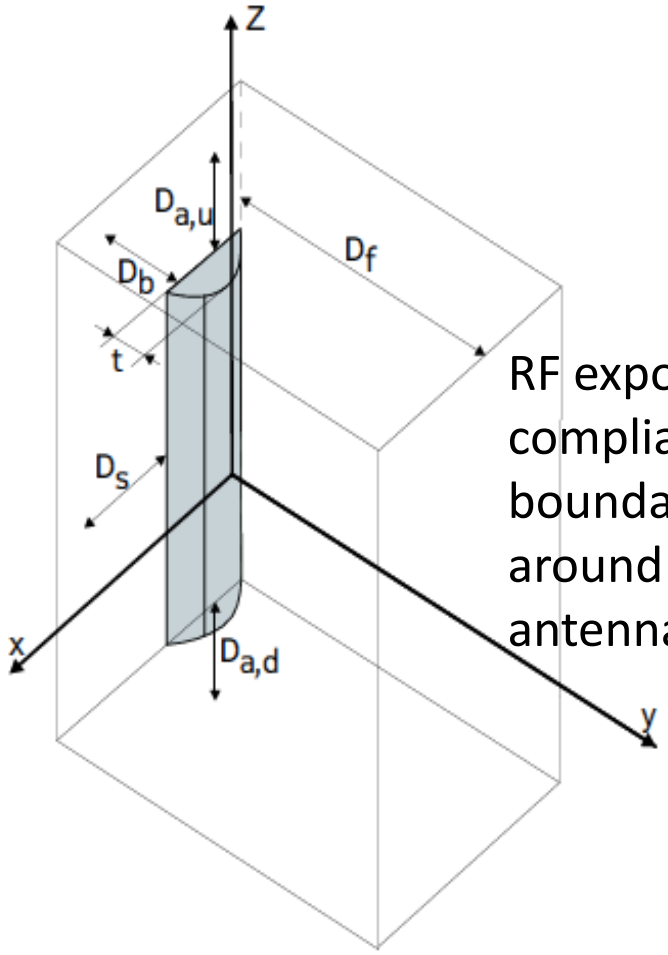
3.5GHz M-MIMO Macro Base Station e.g. total 200W RF power	General Population / Uncontrolled Exposures	Occupational / Controlled Exposures
Maximum Permissible Exposure (Power density) Ref: ICNIRP Guidelines	10 W/m²	50 W/m²
Distance in front (D f)	~ 15m	~ 7m
Distance to the side (D s)	~ 9m	~ 4m
Distance below and above (D a,d and Da,u)	~ 3.5m	~ 1.5m



RF exposure compliance boundary around the antenna

Spectrum

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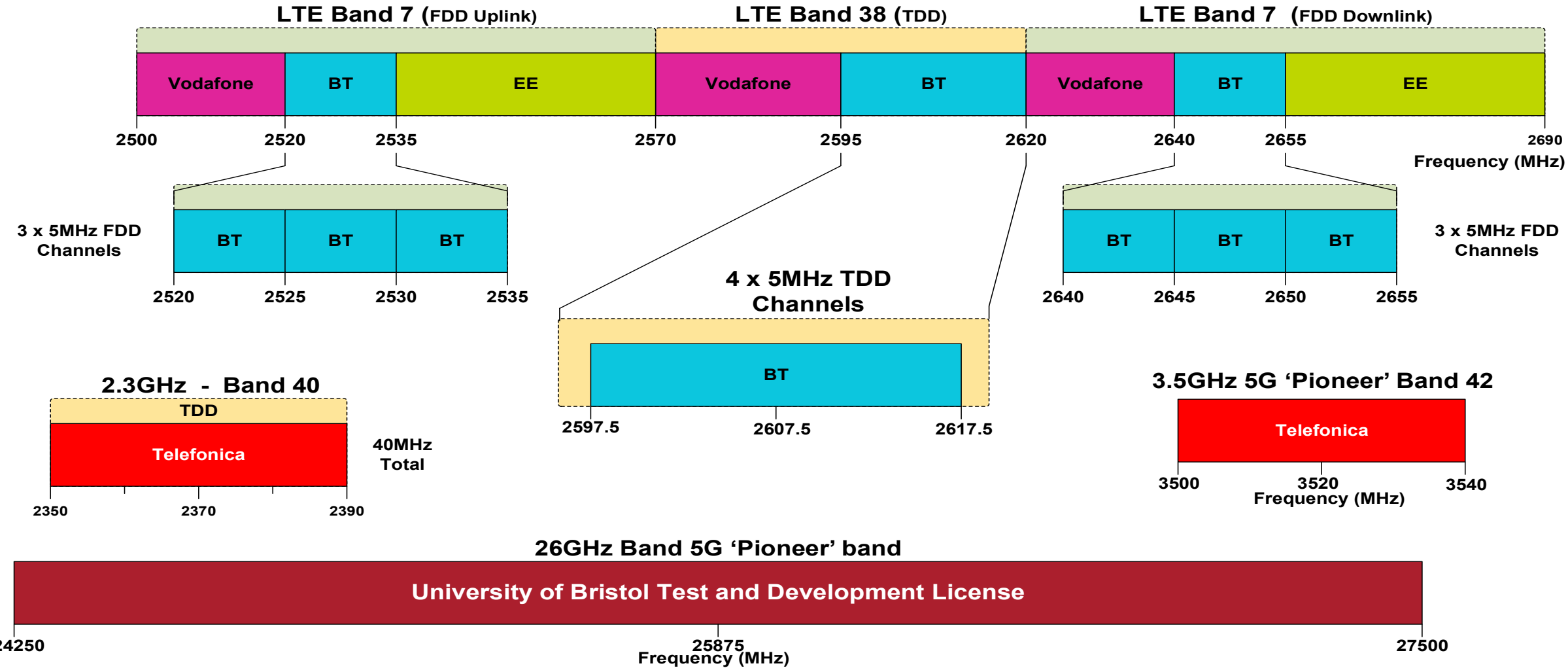

Phase 0

Architecture

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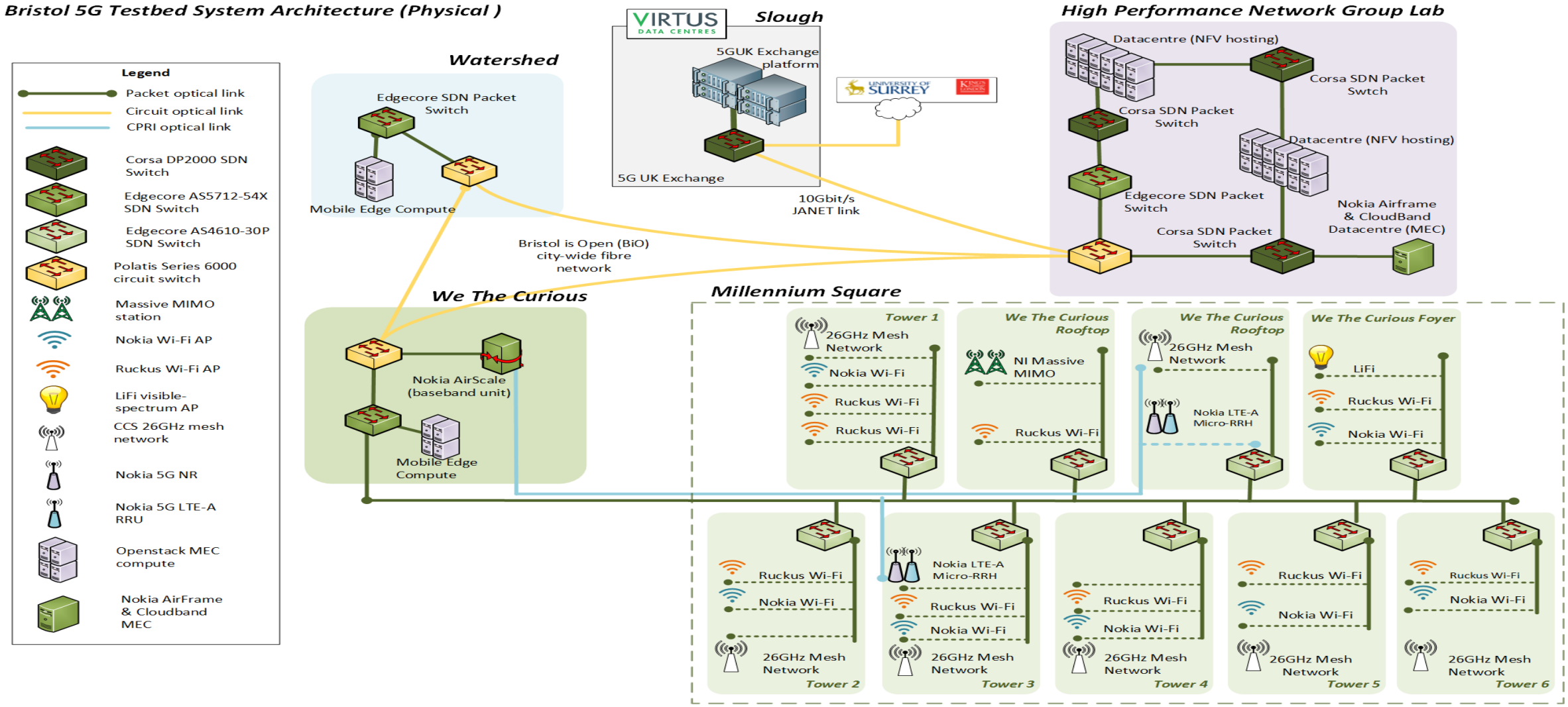

Public Engagement

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[BBC News Channel - Click, OM5G]

https://www.youtube.com/watch?v=5hfZxsGcWB4

5G Smart Tourism - Concept

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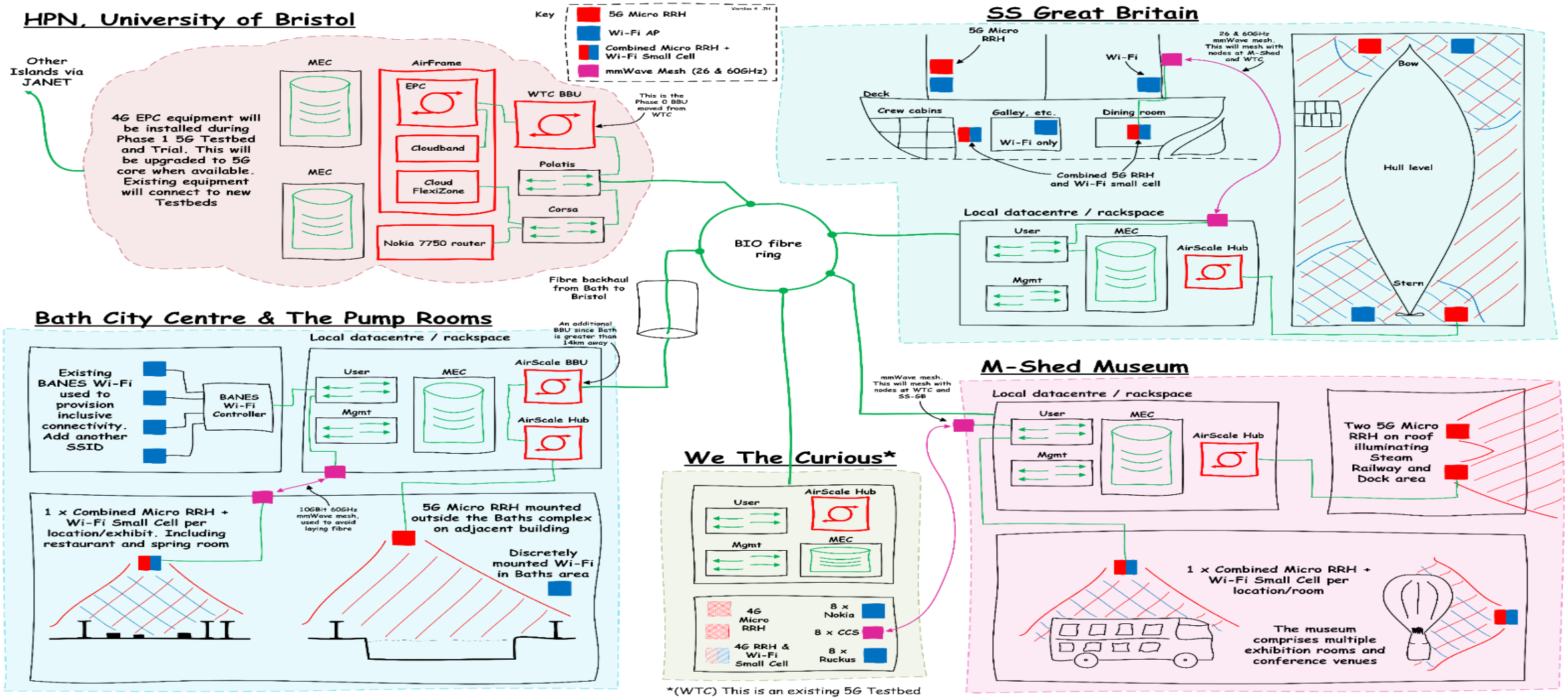

Phase 1

5GUK Network Expanded

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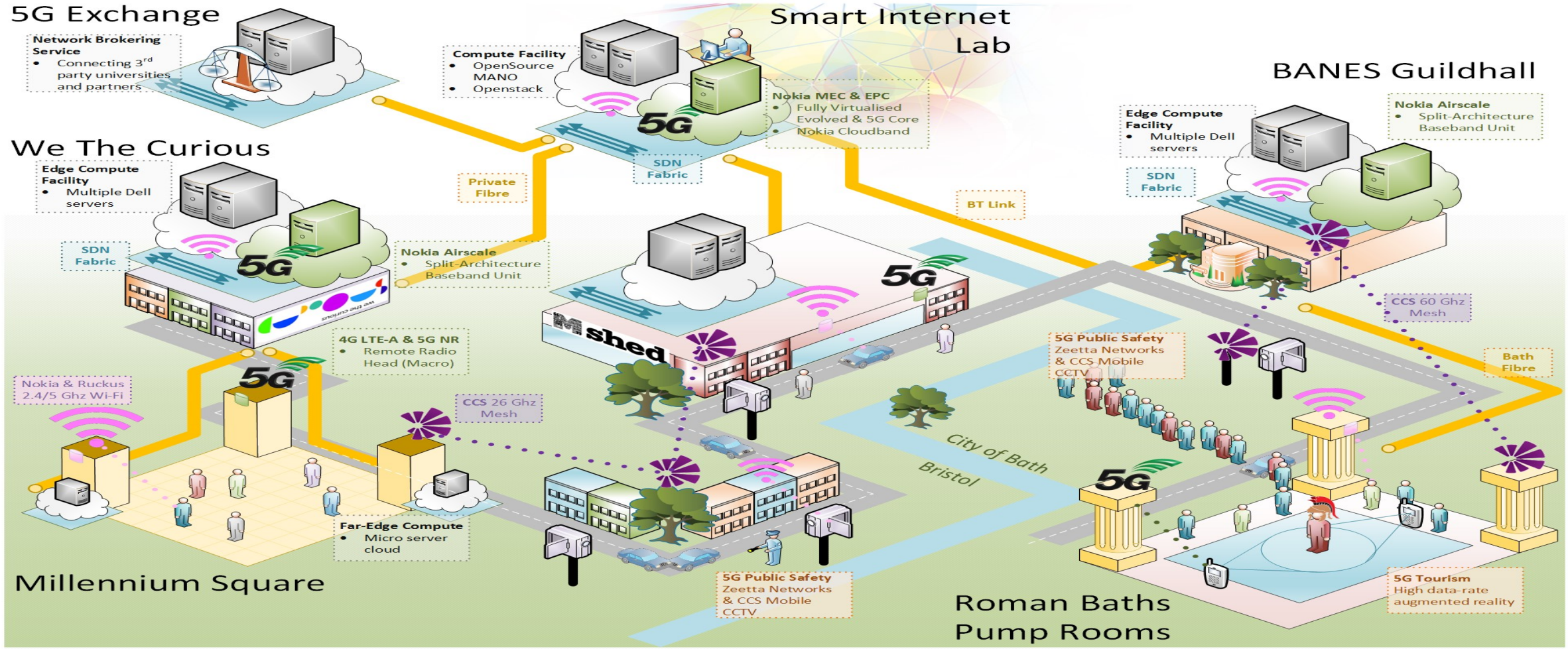

Network Coverage

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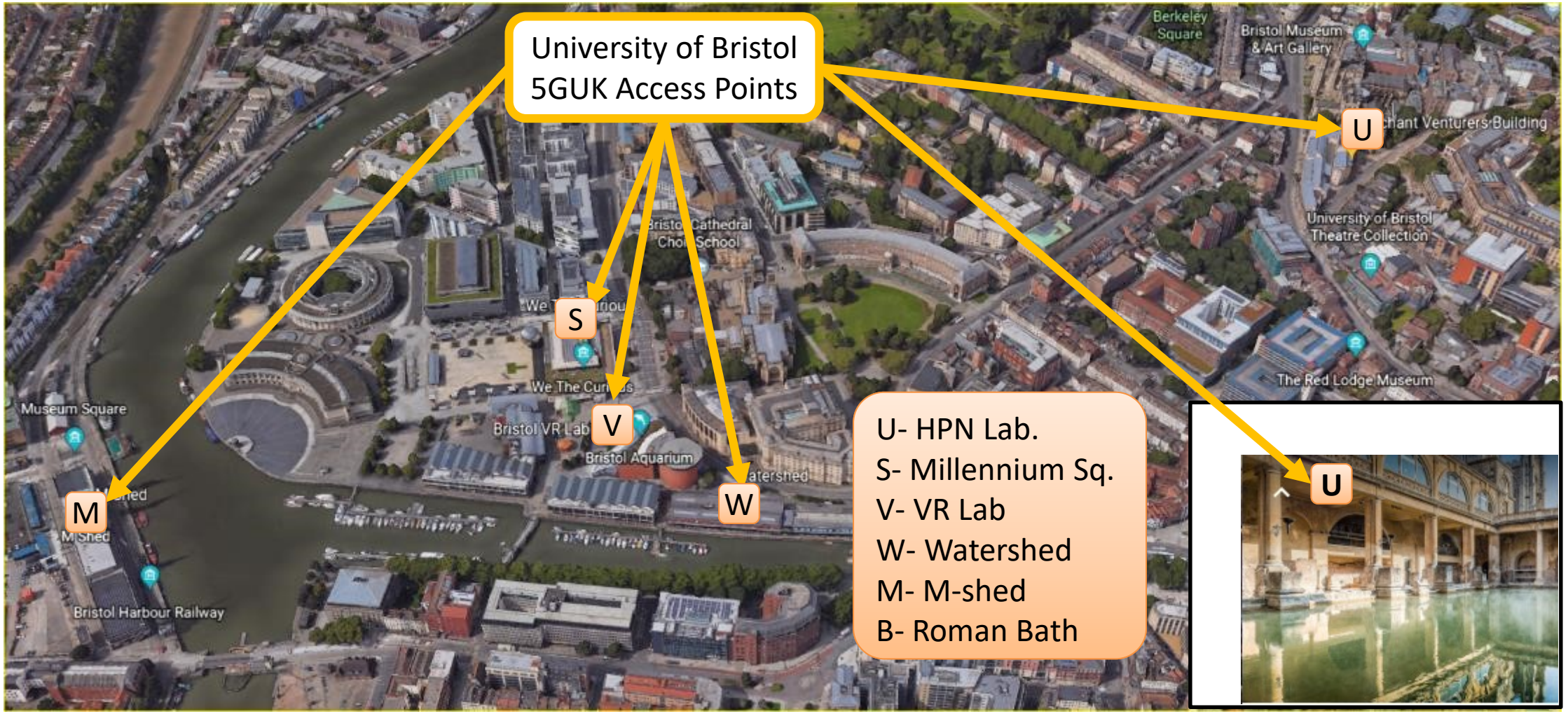

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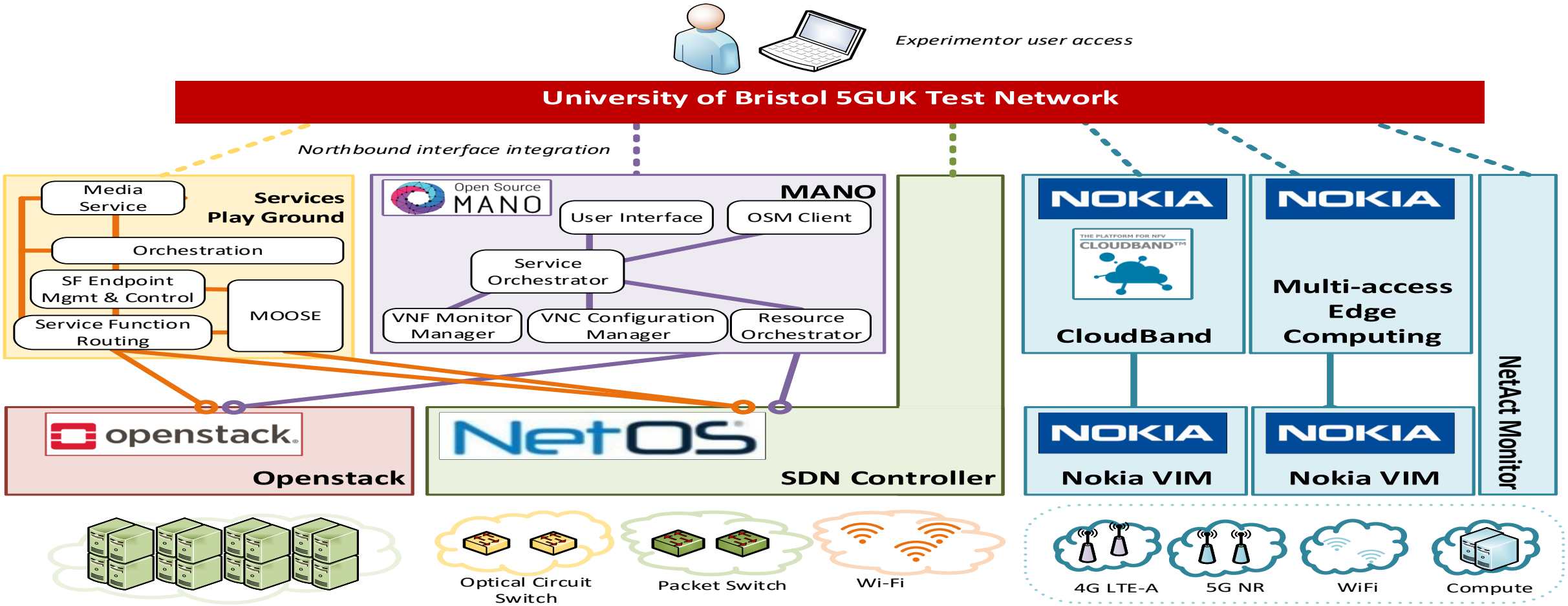

Connecting Across the 5GUK Test-Networks

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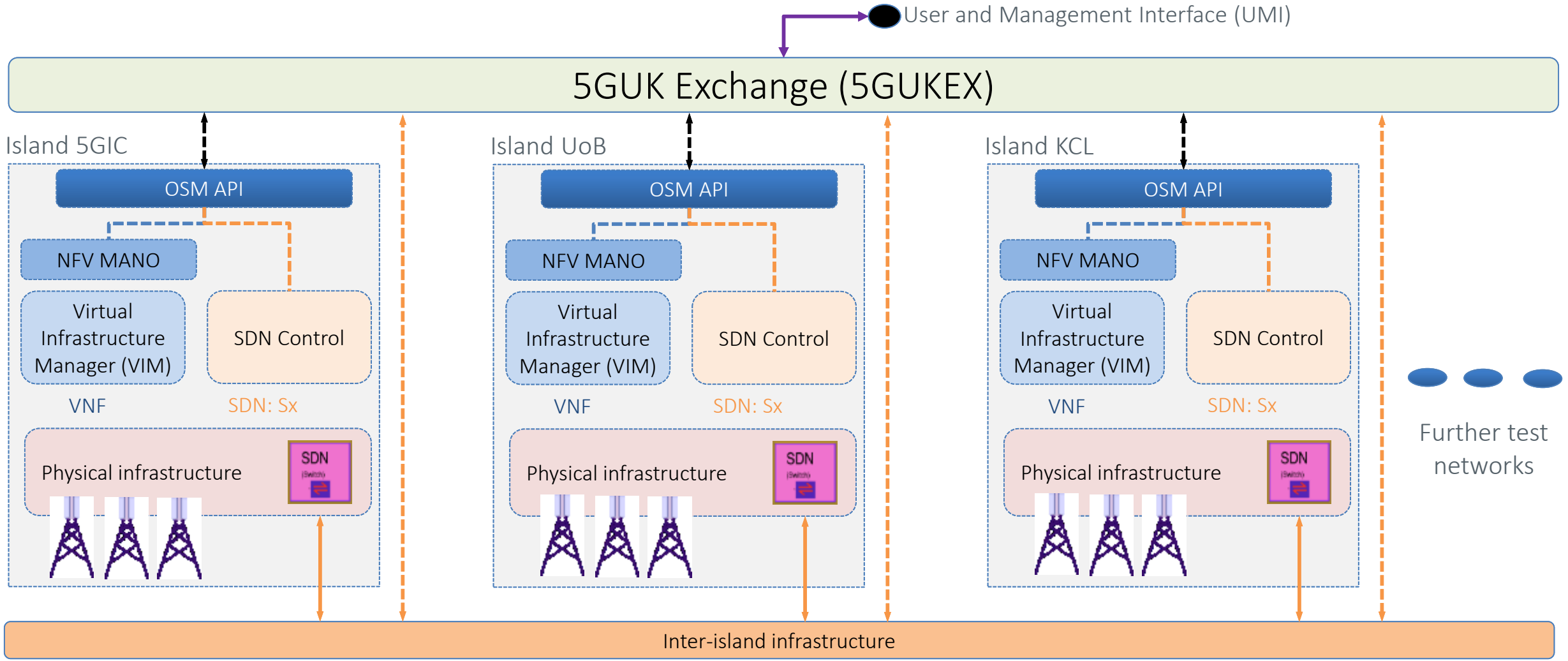

Example of Network Slicing (1/2)

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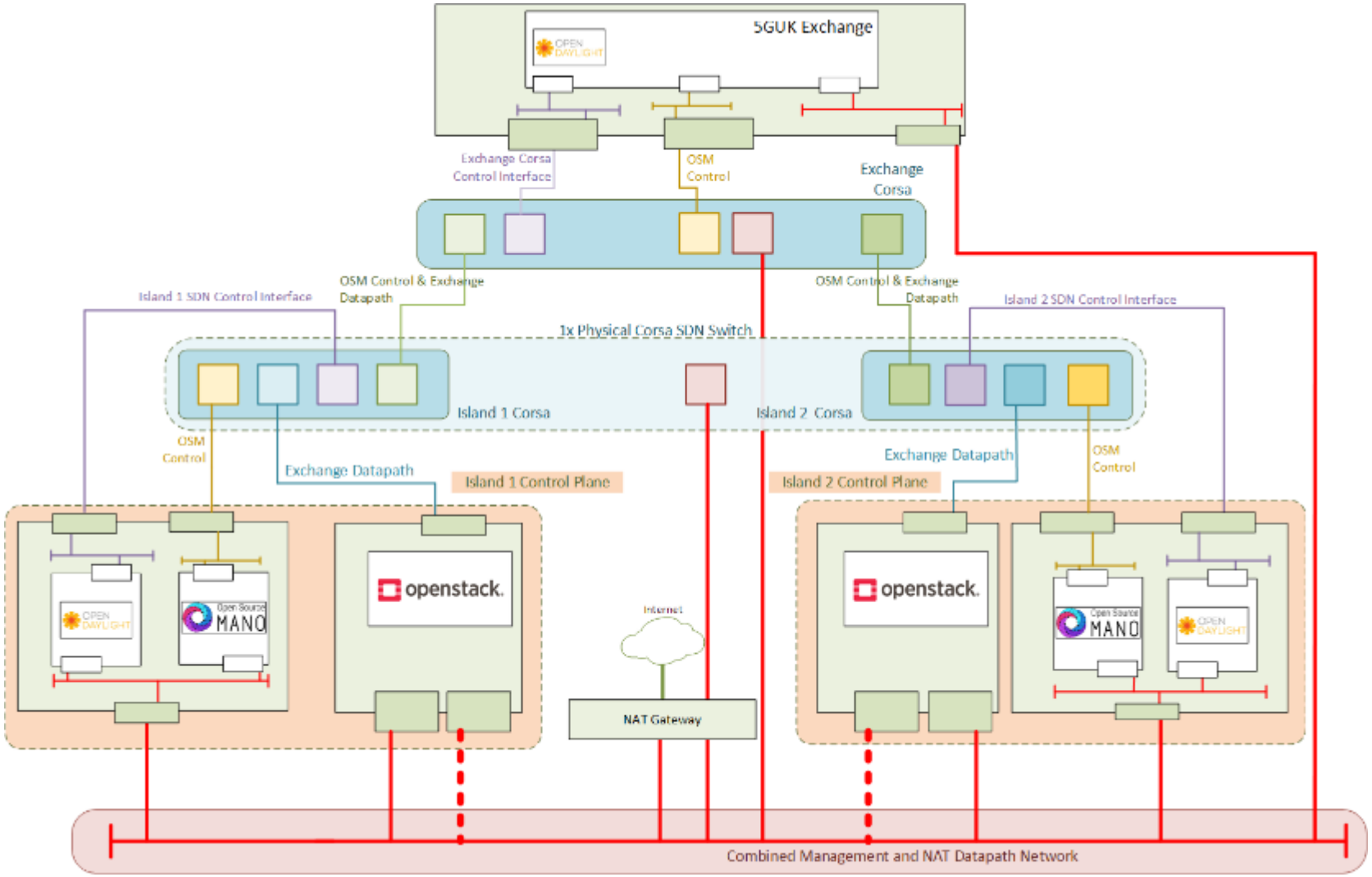

5GUKex

Island 1

Island 2

Example of Network Slicing (2/2)

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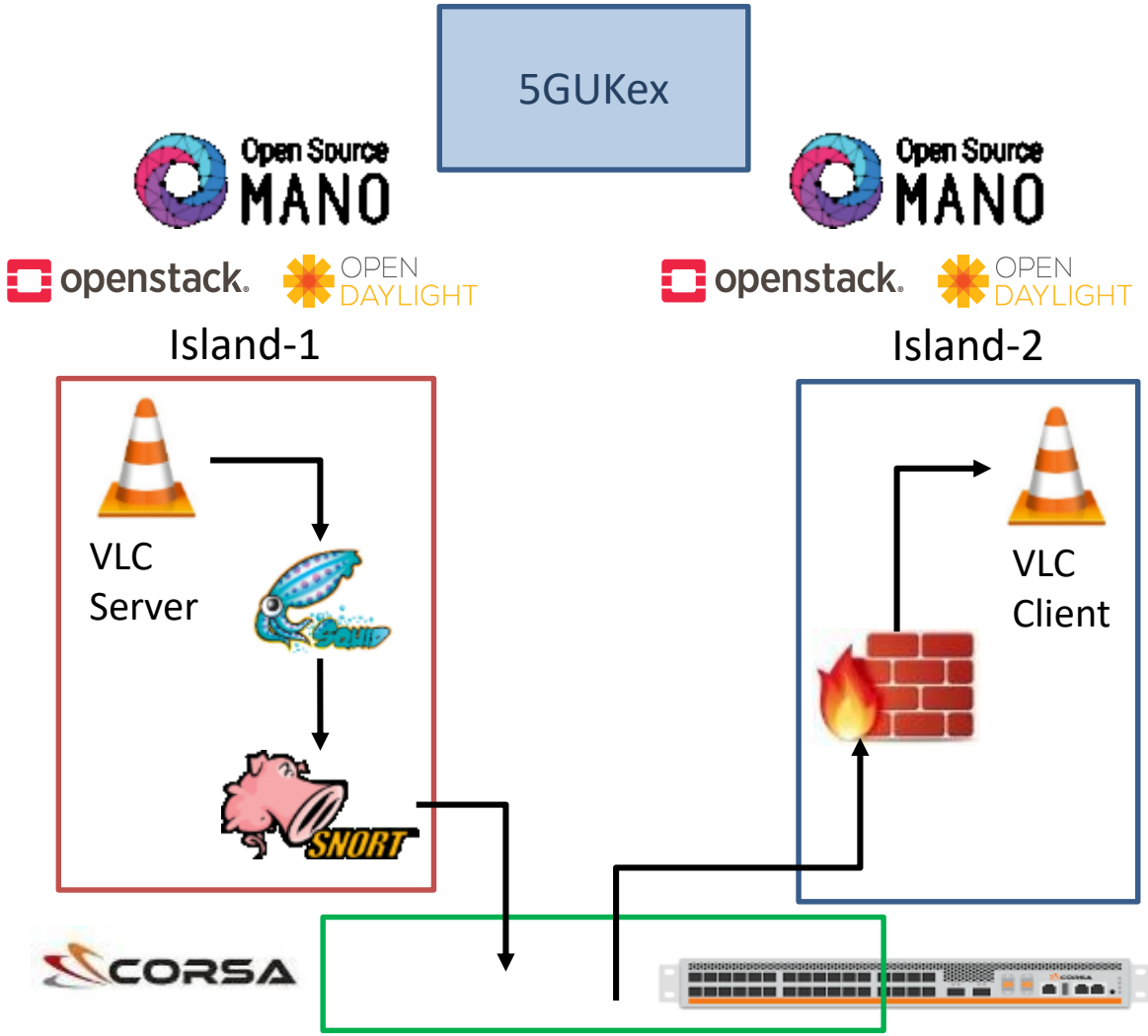
Inter-domain service provisioning through the 5GUKex

- Brokering inter-domain NS requests through 5GUKex to Islands' OSM
- VNF (VM) deployment by Island OSM (OpenStack)
- Inter-island service interconnection through 5GUKex ODL
- Security use case deployed in two islands
  - Media and Proxy server, IDS, FW, media client as VNFs



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Thanks You
&
Question Time

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