Introduction

To

‘Quantum Security Capabilities in 5GUK Test Networks’

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- 5G UK Test Networks

The UK 5G Testbeds and Trials Programme

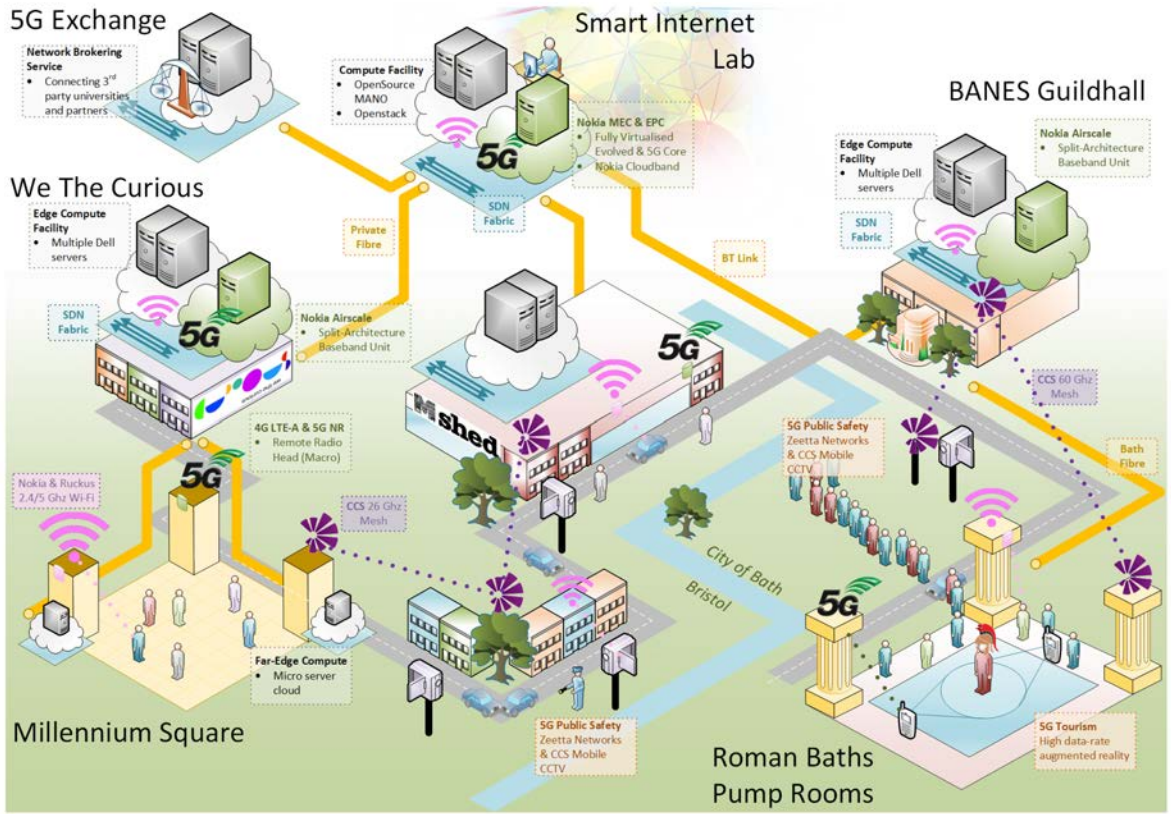
- The 2016 Autumn Statement included **£740m capital funding** from July 2017 to 2020-21 across the Local **Full Fibre Networks and 5G** Testbeds & Trials Programme

- The 5G Testbeds & Trials Programme is seeking to contribute to the development of a '5G ecosystem' in the UK by supporting both **technology trials** and **deployment pilots** to stimulate the development of 5G use cases and business models and, we hope, work towards solving some of society's biggest challenges

- The 5G Testbeds & Trials Programme intends to:
  - Stimulate the UK to become a strong contributor to the 5G sector, with leadership in specific industry verticals
  - Help to accelerate 5G deployment in the UK
  - Foster a diverse and efficient 5G ecosystem in the UK

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/652263/DCMS_5G_Prospectus.pdf

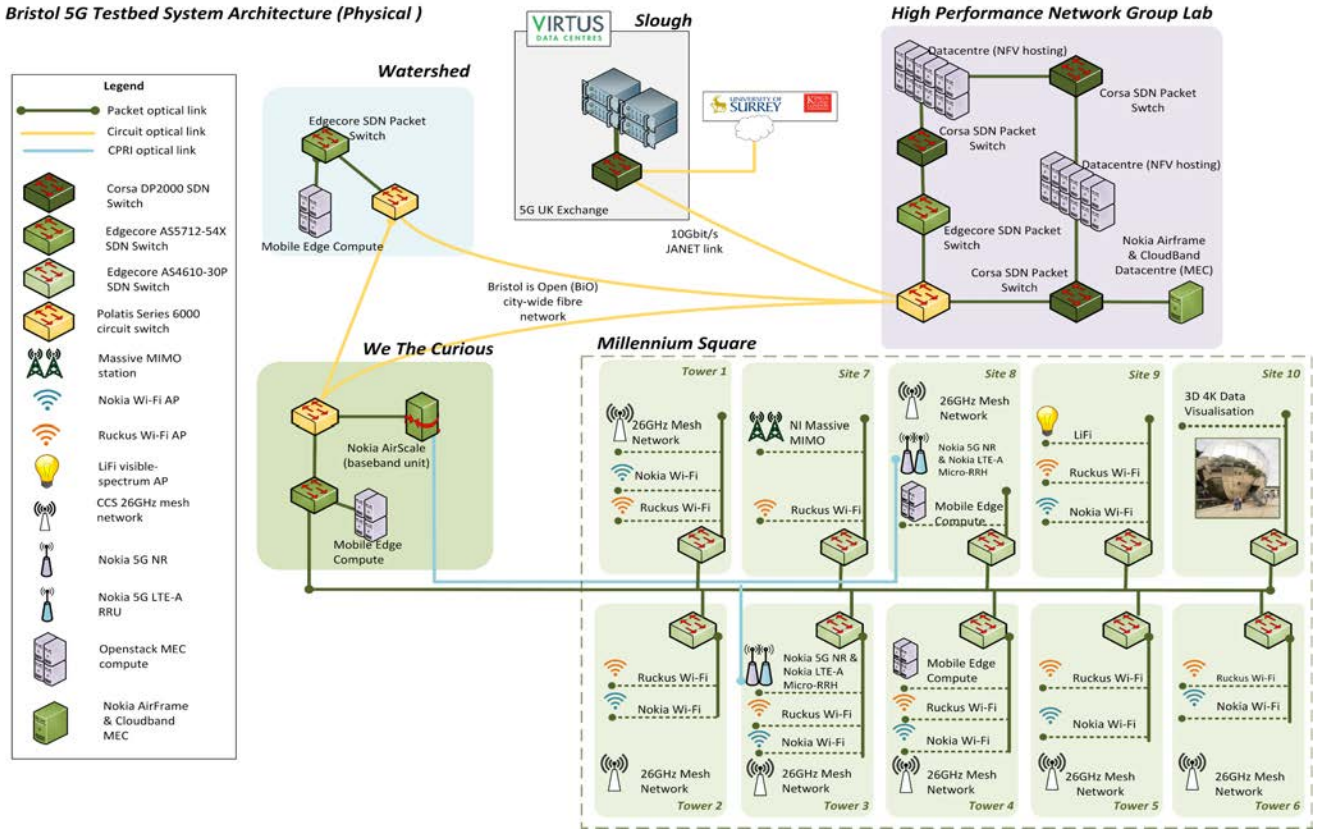
5G Testbeds at West of England Region



Six Primary Sites

- Smart Internet Lab, **University of Bristol**
- We The Curious**, Millennium Square, Bristol**
- Watershed, **Waterfront, Bristol**
- M-Shed Museum, **Harbourside, Bristol**
- The Pump Rooms, **Roman Baths, Bath**
- Connection to KCL and Digital Catapult, **London**

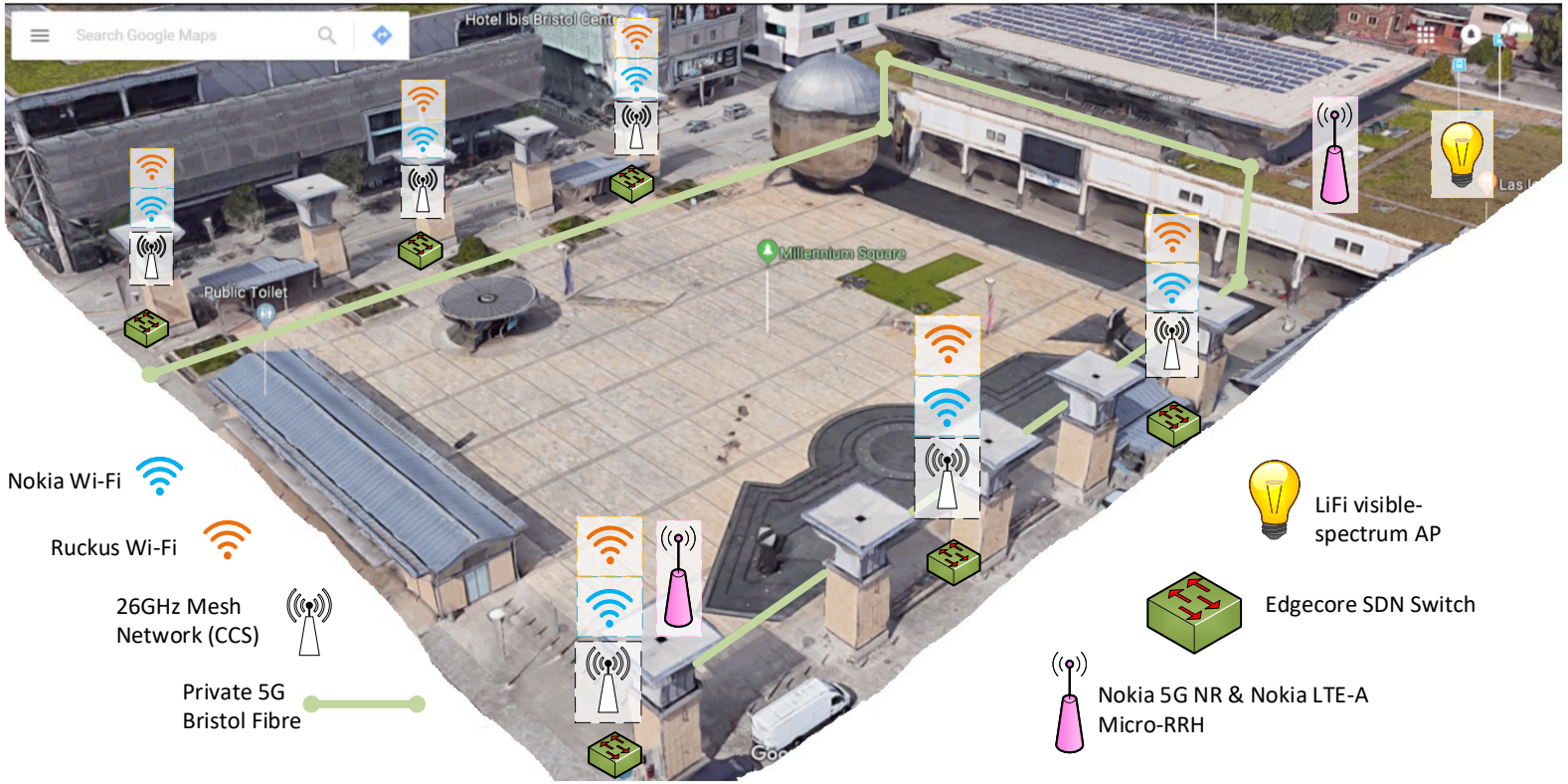
5G UK Test Network

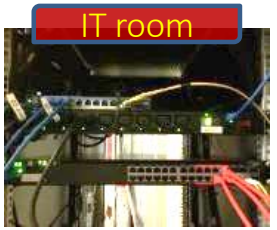


Heterogeneous Networking

- LTE-A and 5GNR Cellular from Nokia
- 26 & 60GHz mmWave mesh networks from CCS
- SDN and network slicing from Zeetta
- MEC and cloud compute via Openstack
- End-to-End orchestration through OSM
- Comprehensive network monitoring tools
- Slice creation and management for use-cases

5G UK Test Network



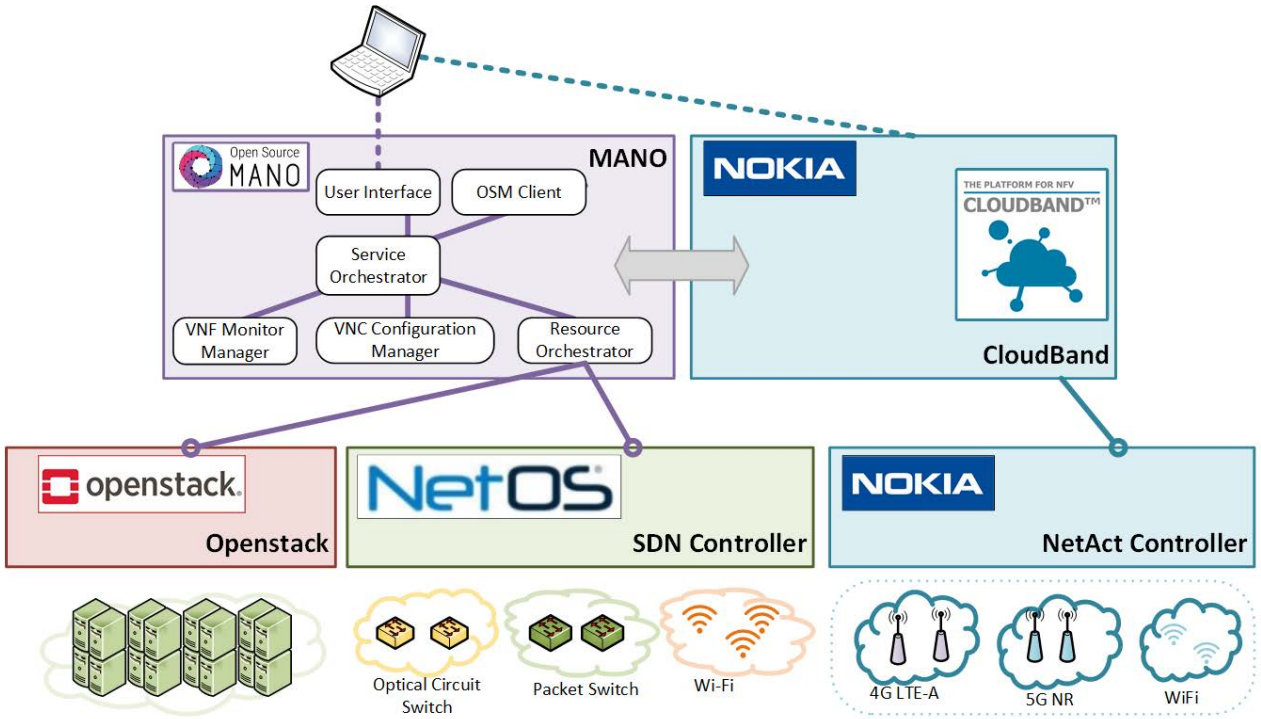


Control and Virtualization: Focus on Open Source

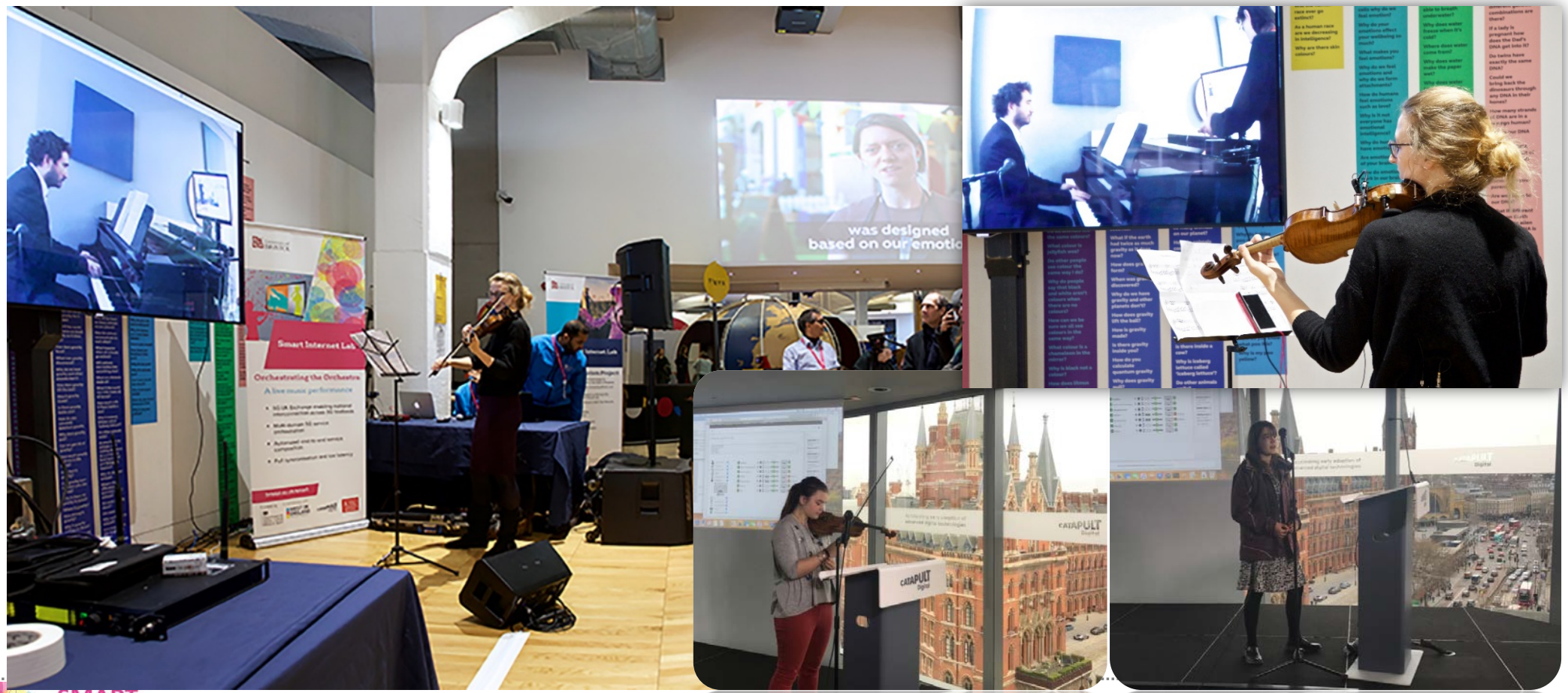
- NFV platform
  - Open Source Mano (OSM)
  - Interrogation with Open stack
  - OSM monitoring tools deployed and extended
  - ML integration with the orchestration platform

- SDN control framework
  - NetOS SDN controller
  - Integration with OSM and physical layer

- Nokia Controller and NFV
  - Deploying Cloudband, NetAct



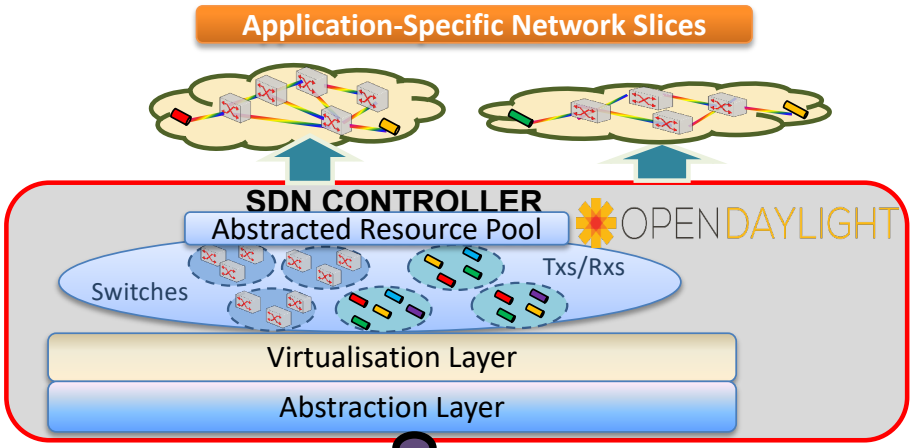
Live Demo: 16 March'19



- National Dark Fibre Facility

Part of National Dark Fibre Facility (NDFF)

- NDFF is a facility to support research on future networks
- 630 km experimental installed optical fibre network
- Software Defined Networking (SDN) Platform for full programmability of optical networks
- Research collaboration between universities



NDFF Technology:

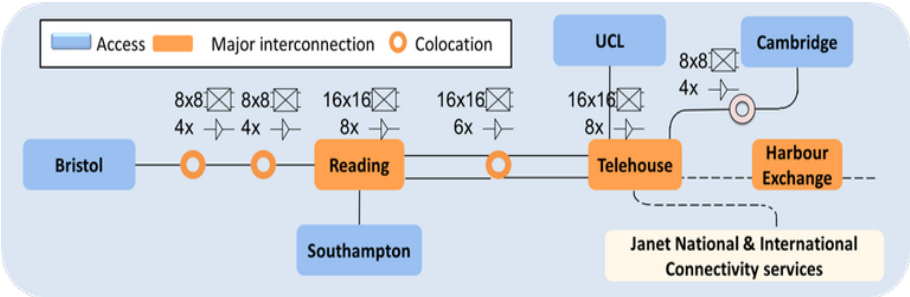
SDN-enabled optical switches

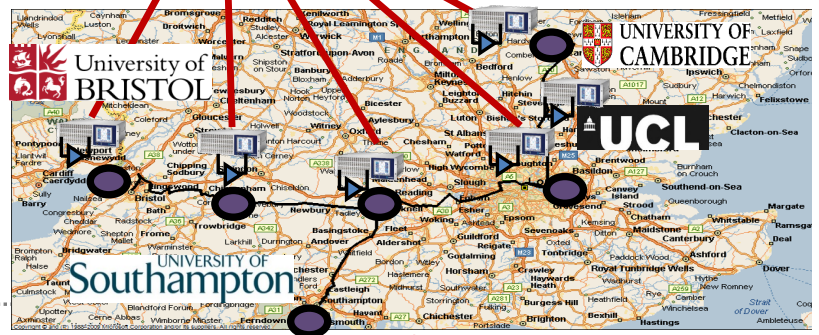
Optical Amplifiers

Dispersion Compensation Modules

Optical Transceivers 10Gb/s DWDM

L2 Switches





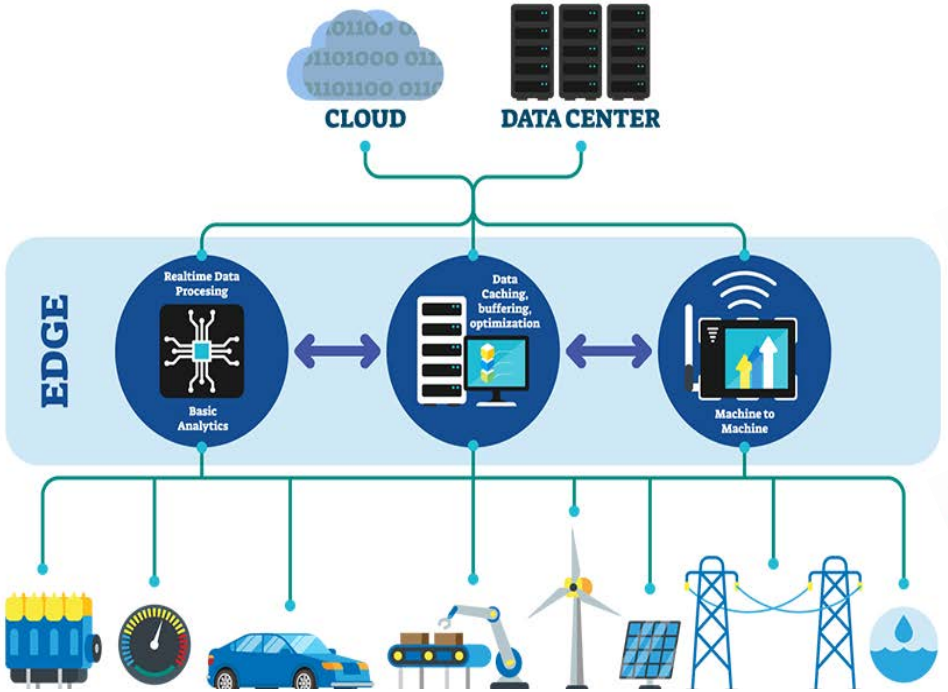
INTERNET LAB

- QKD for 5G

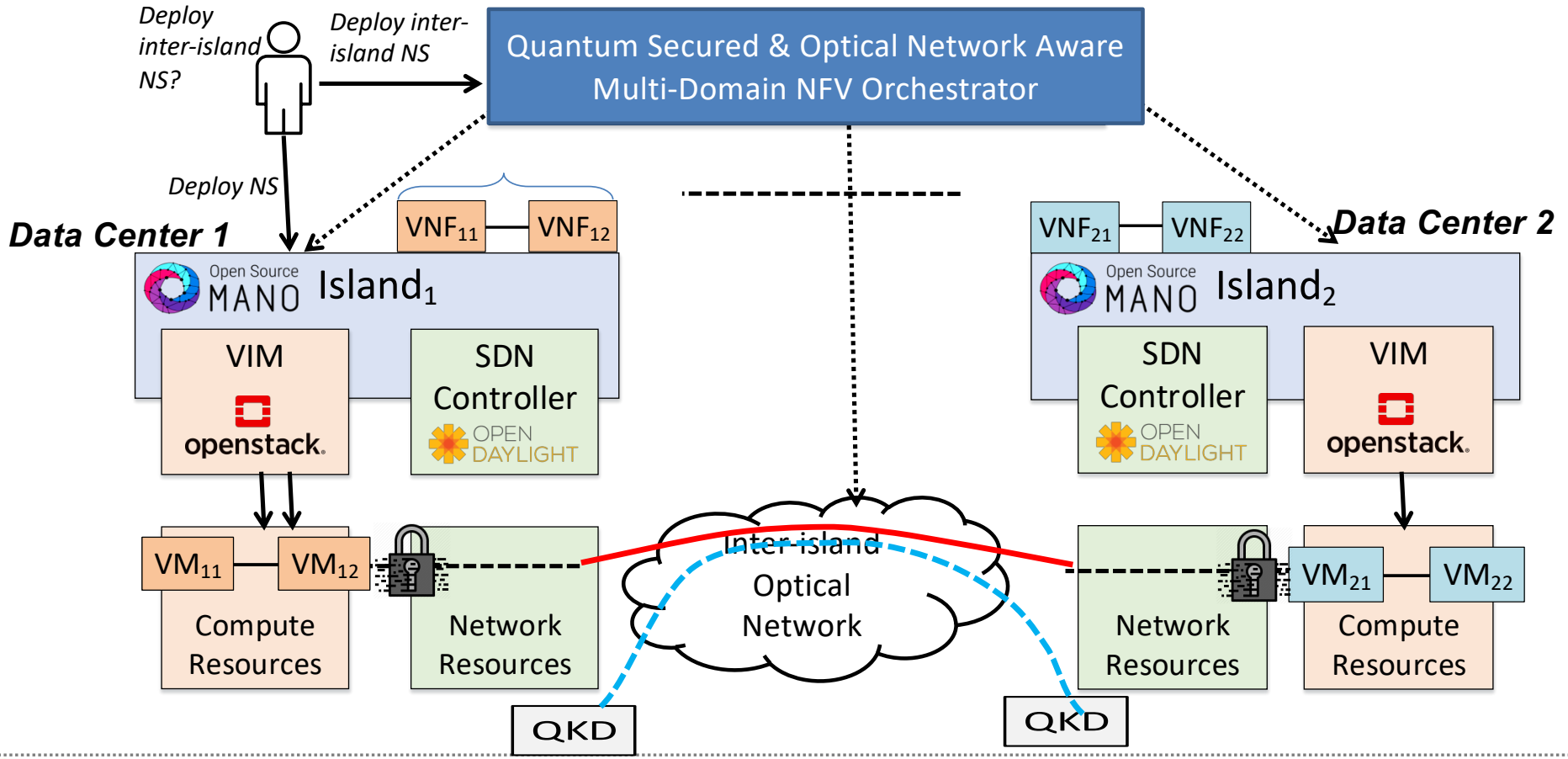
Quantum Security for 5G

- Dynamically deploy Optical network connectivity for VNF chaining in multiple Data Centers
- Dynamically Mix & Match VNFs from multiple islands
- Use inter-DC optical network for high bandwidth and low latency VNF requirements
- Create secured inter-DC connectivity for VNF chaining using QKD within same fiber as classical traffic
- **Highly dynamic secure optical connectivity from multiple access devices to edge and metro DC for 5G Virtual Service**

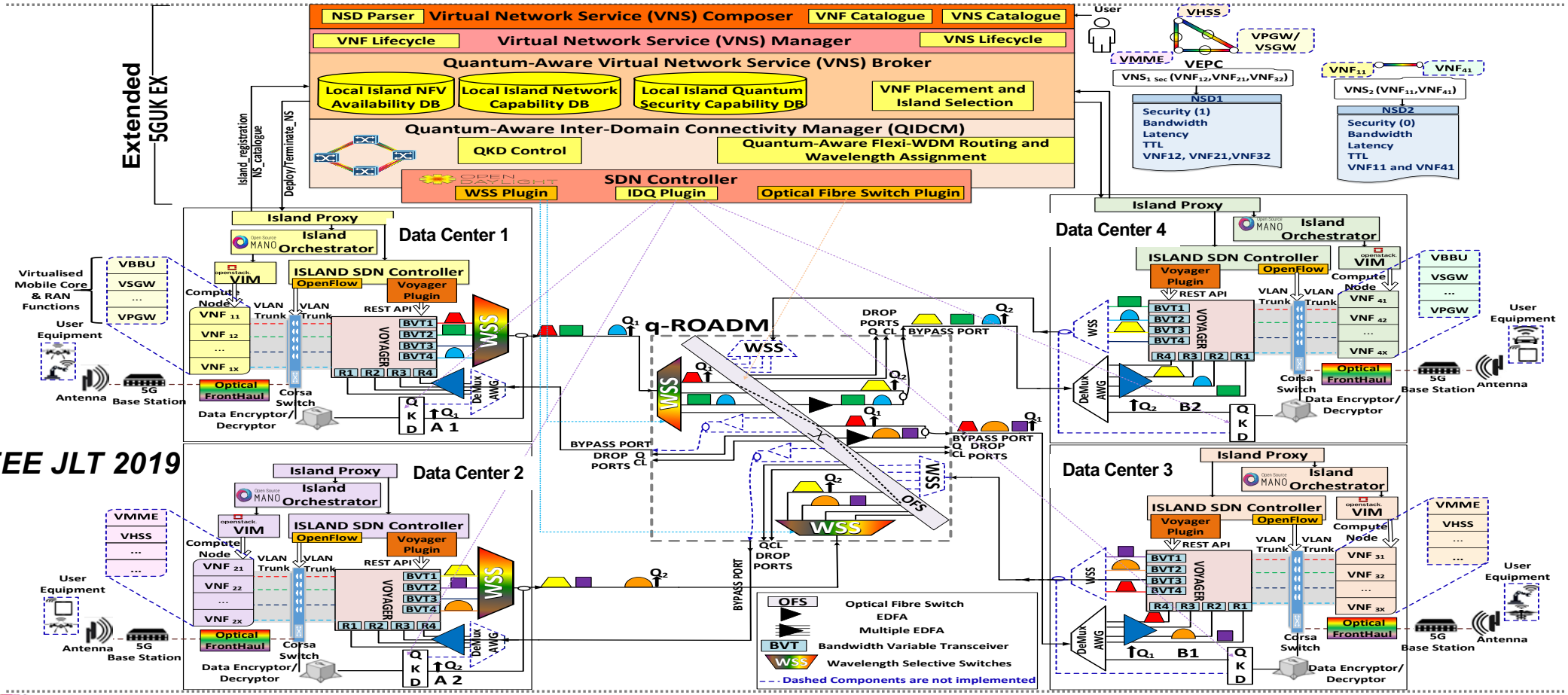
5G Network Service = VNF1 + VNF 2 + VNF3



Quantum Security for 5G



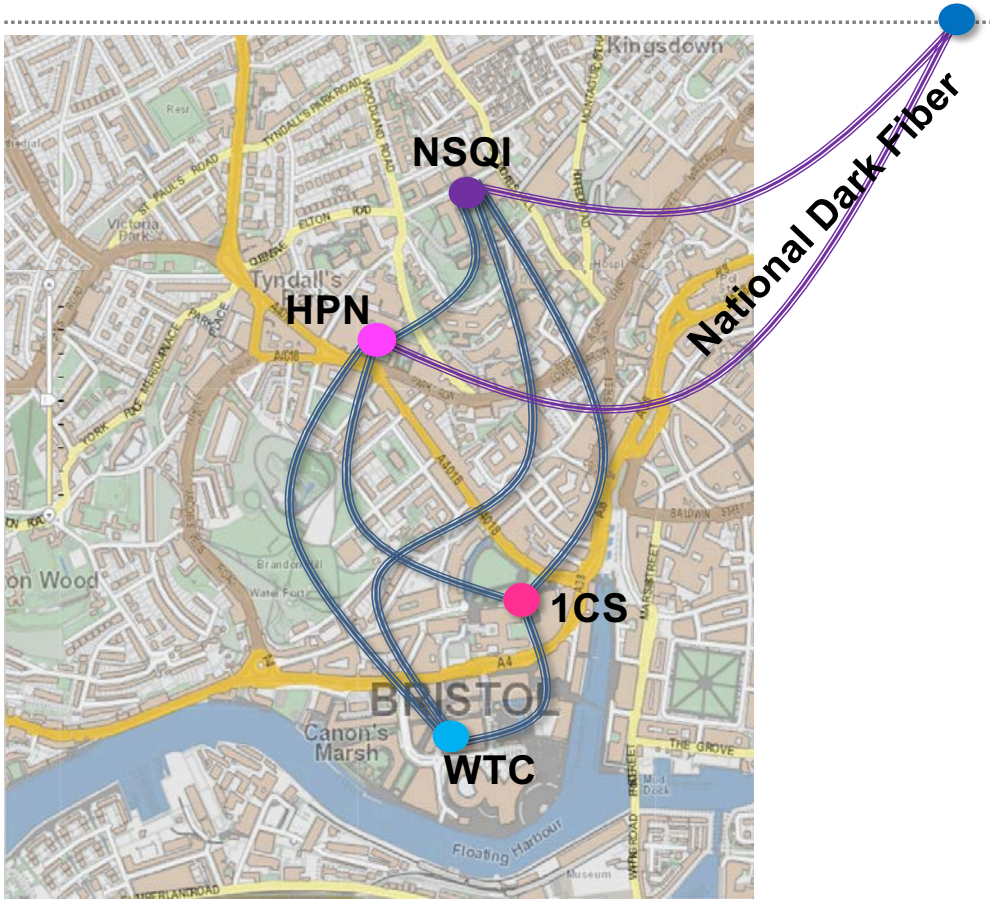
Multi-layer Network-Aware & Quantum-Aware Multi-domain NFV Orchestrator *[World First Dynamically Switched QKD]*



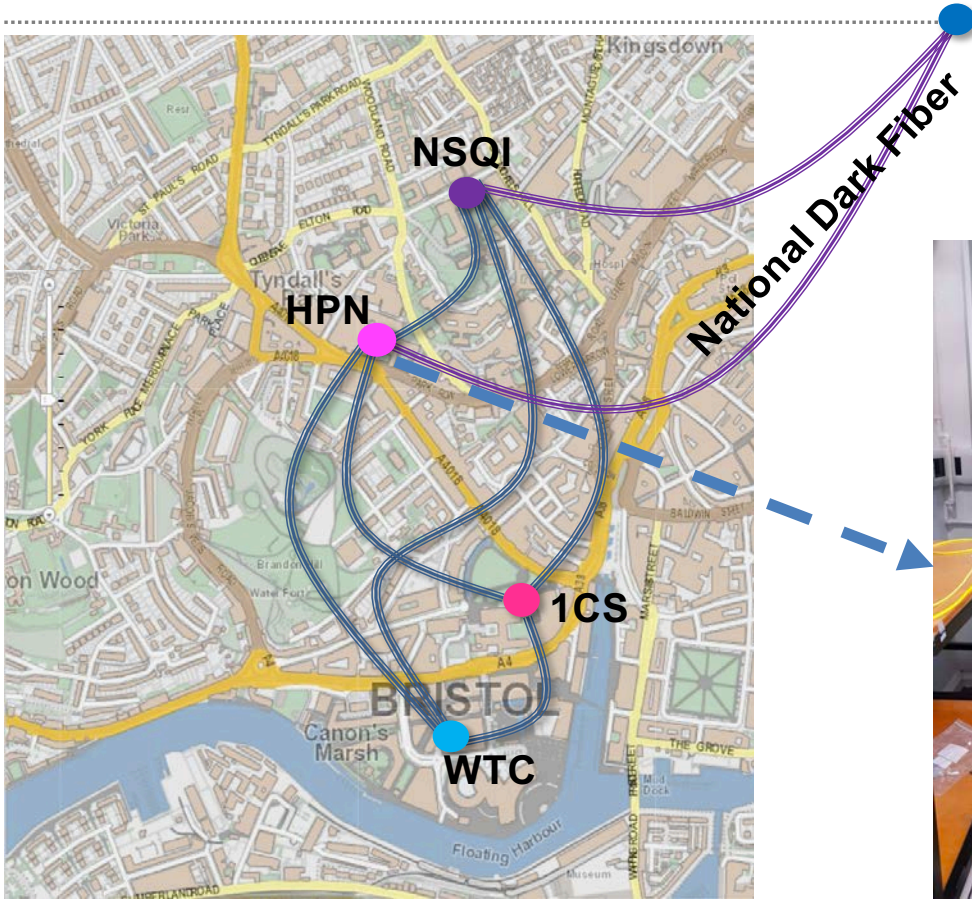
IEEE JLT 2019

- Test-bed over view

Test-bed

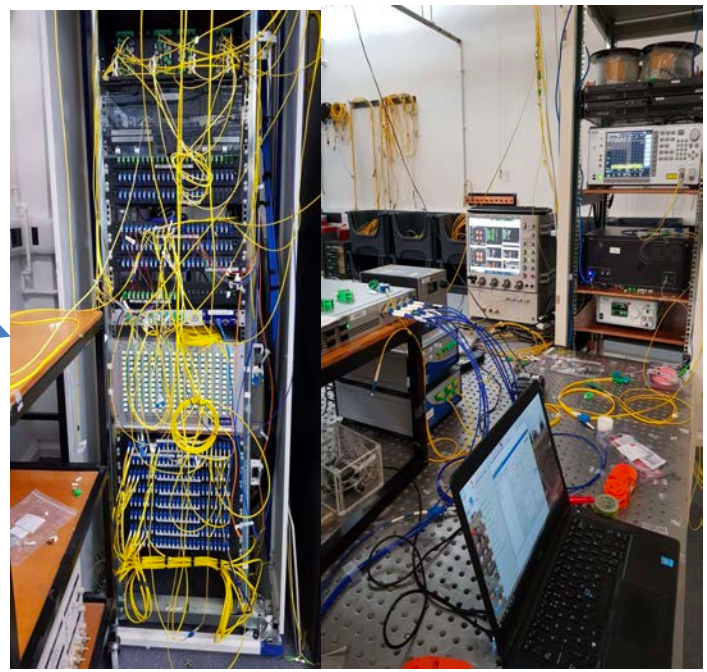

NSQI
HPN
1CS
WTC
Bradley Stoke
National Dark Fiber
Kingsdown
Tyndall's
Park
Victoria
Park
on Wood
BRISTOL
Canon's
Marsh
Floating Harbour

Test-bed



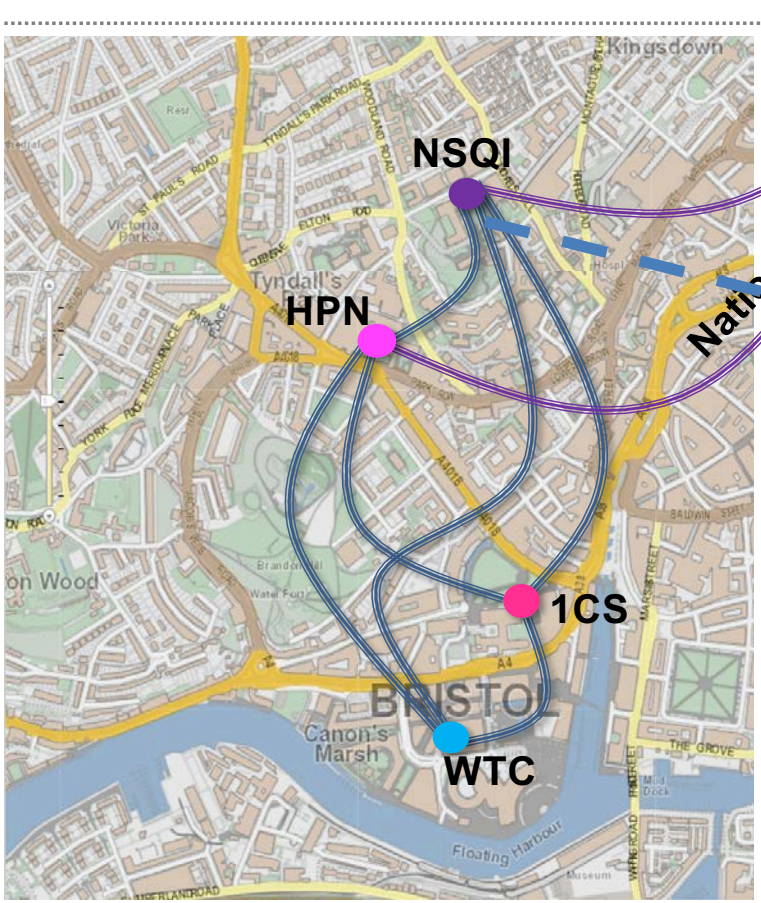
Bradley Stoke

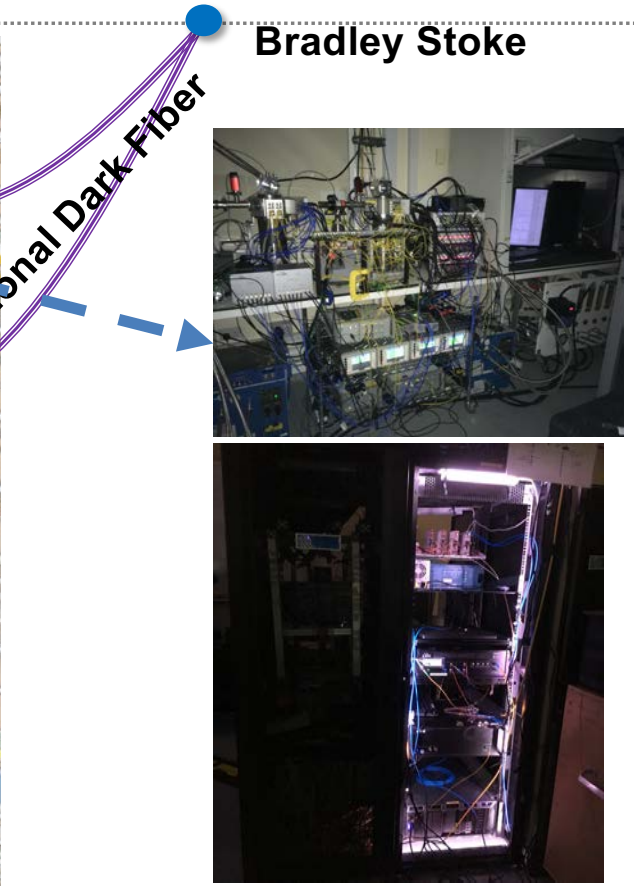
National Dark Fiber



Edge Computing
Dynamic qROADM
Q-Aware SDN Controller
8x200G 16-QAM
Optical Switching
Alice & Bob

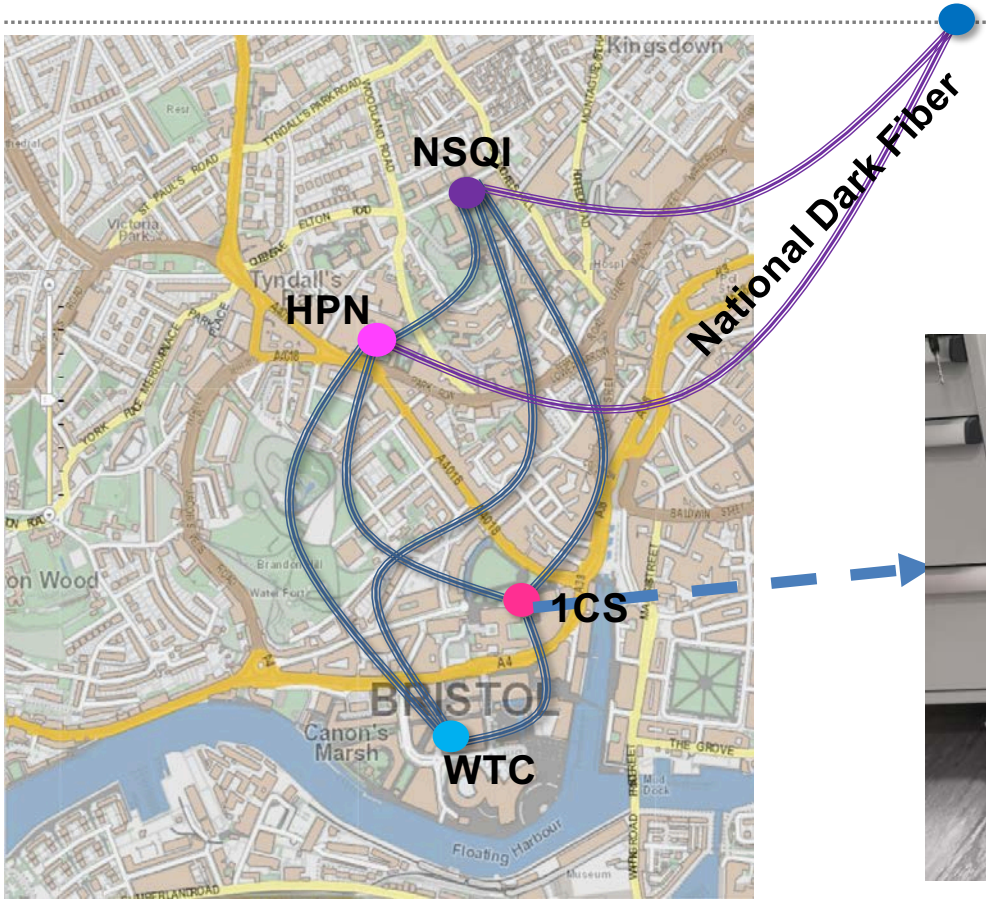
Test-bed





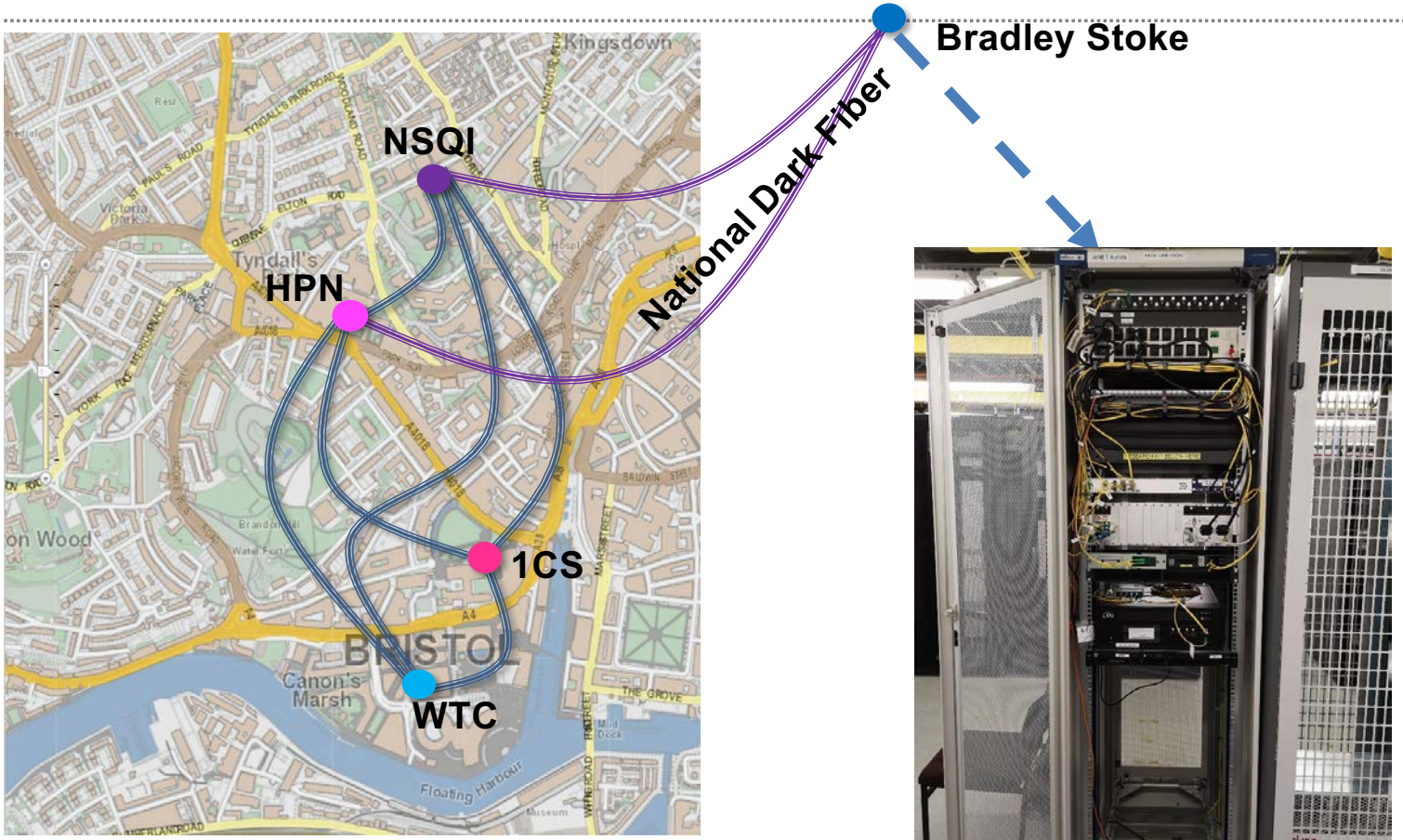
Cryogenic Detector
Q handheld
Optical Switching
Alice & Bob

Test-bed



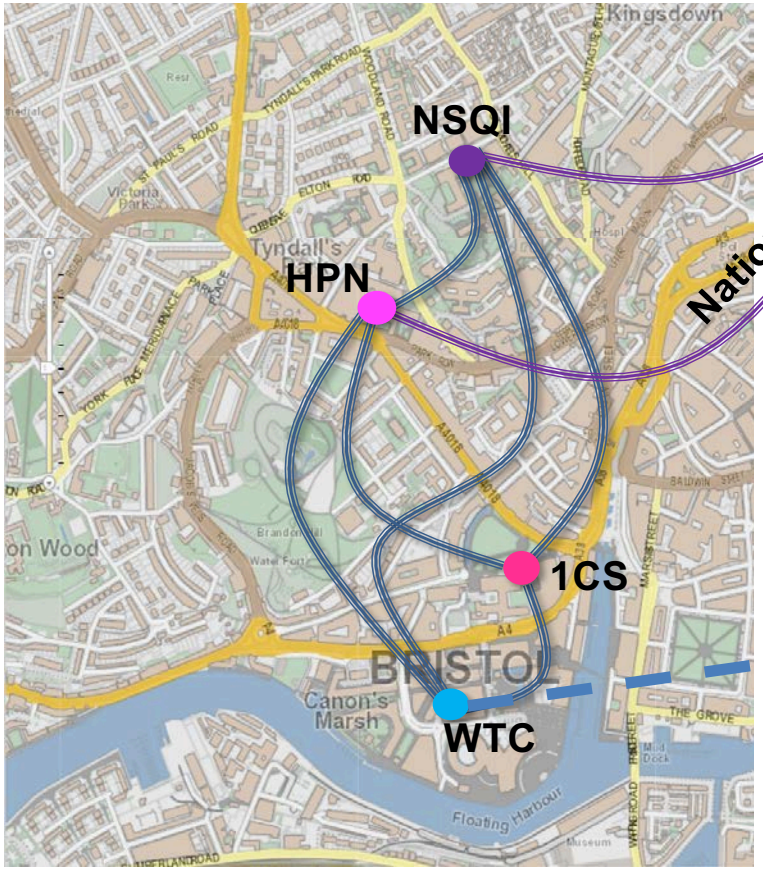
Metro DC
Classical Switching
Alice

Test-bed



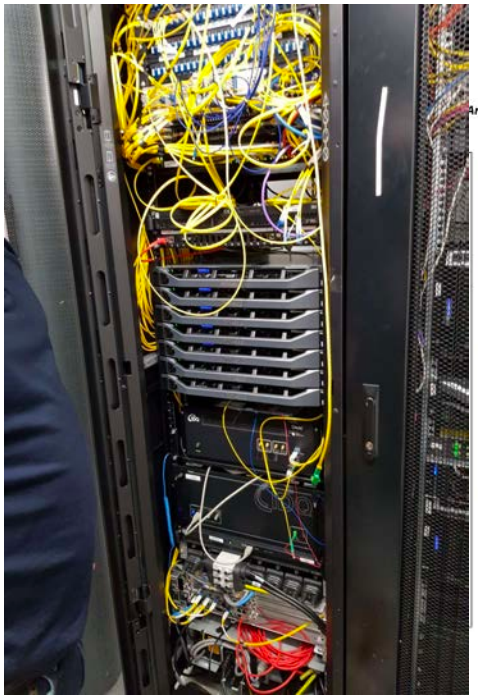
Remote/Core DC
Classical Switching
Alice

Test-bed

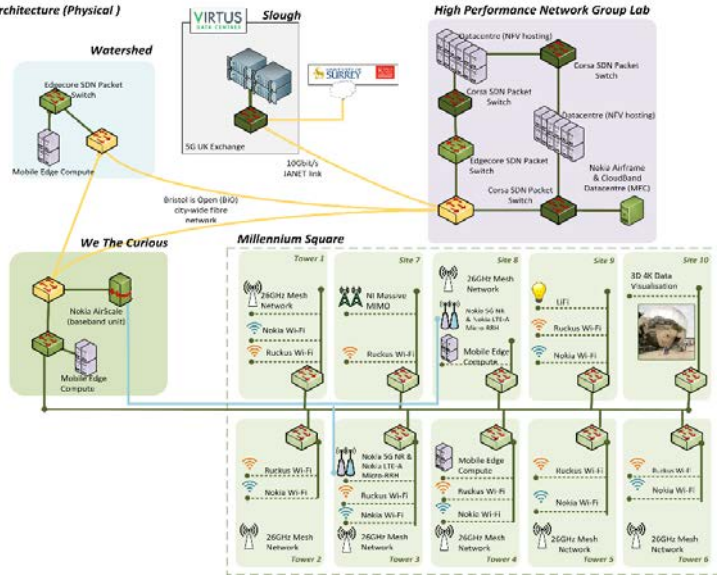


National Dark Fiber

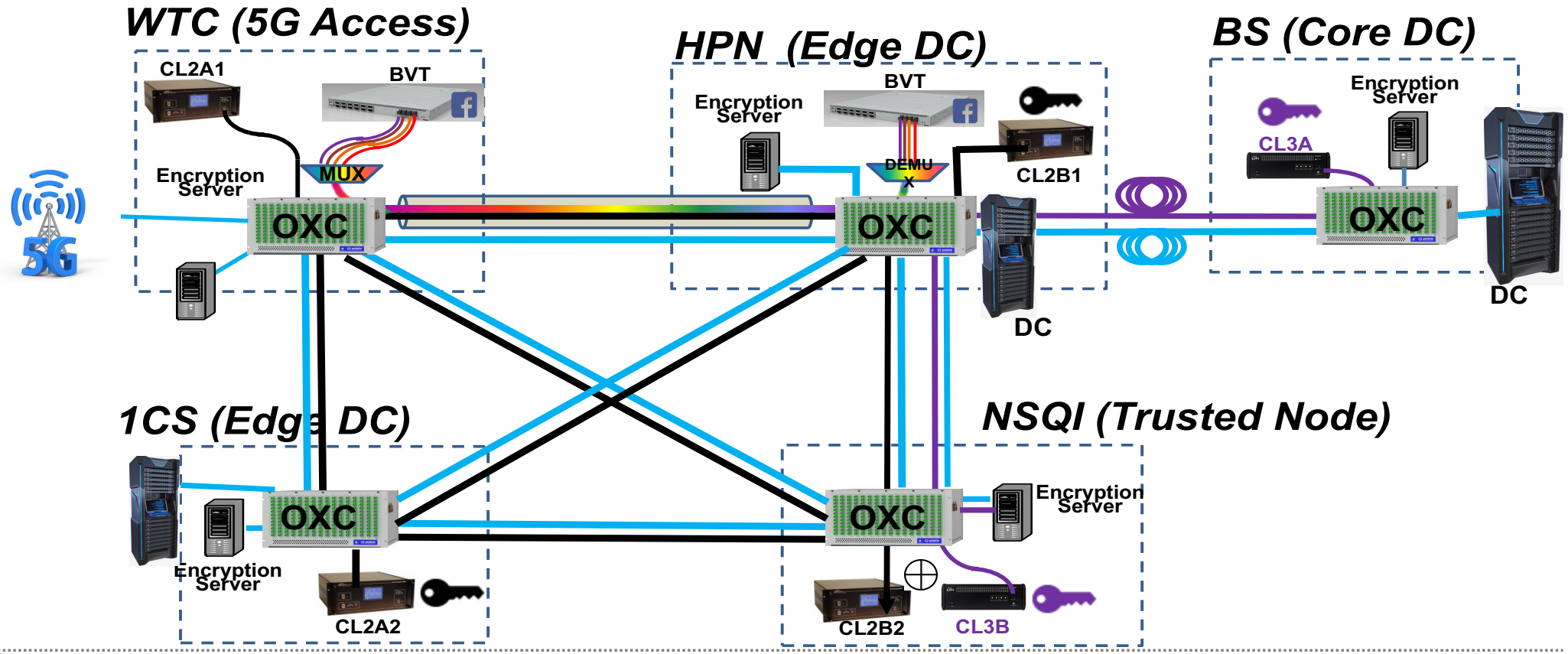
Bradley Stoke



Edge Computing/DC
Optical Switching
Alice
5G Access



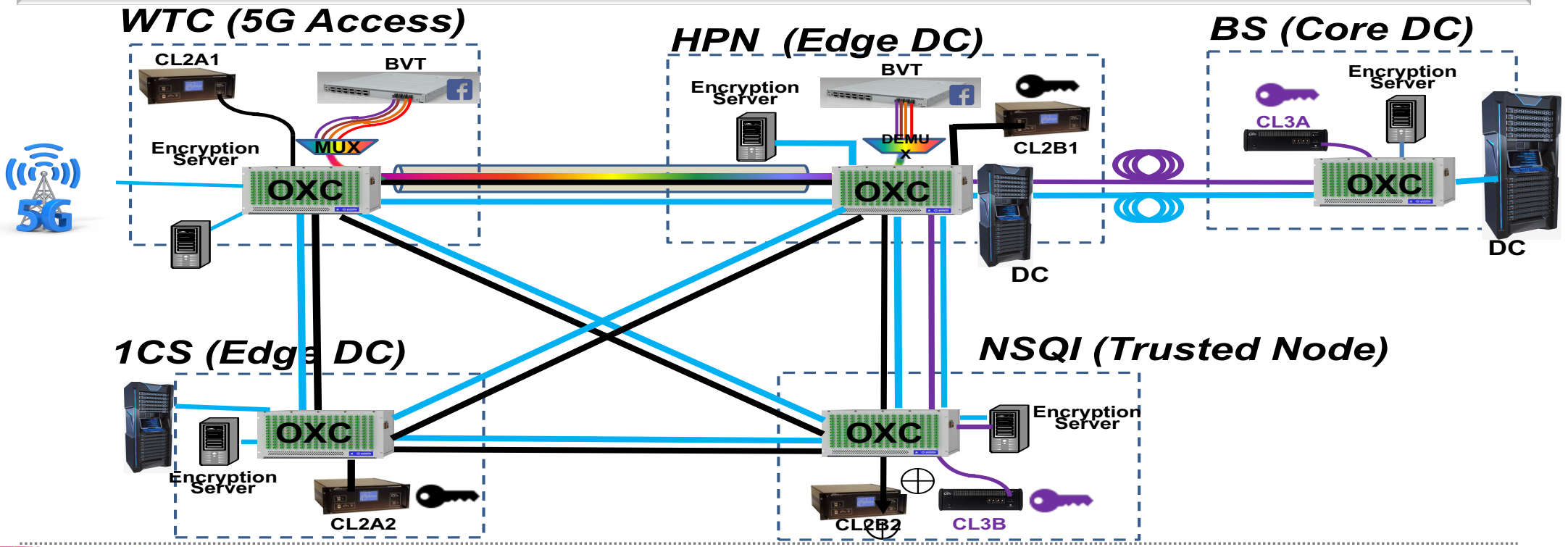
Test-bed


WTC (5G Access)
CL2A1
BVT
Encryption Server
MUX
OXC
HPN (Edge DC)
BVT
Encryption Server
DEMU X
CL2B1
OXC
DC
BS (Core DC)
Encryption Server
CL3A
OXC
DC
5G
1CS (Edge DC)
Encryption Server
OXC
CL2A2
NSQI (Trusted Node)
OXC
Encryption Server
CL2B2
CL3B

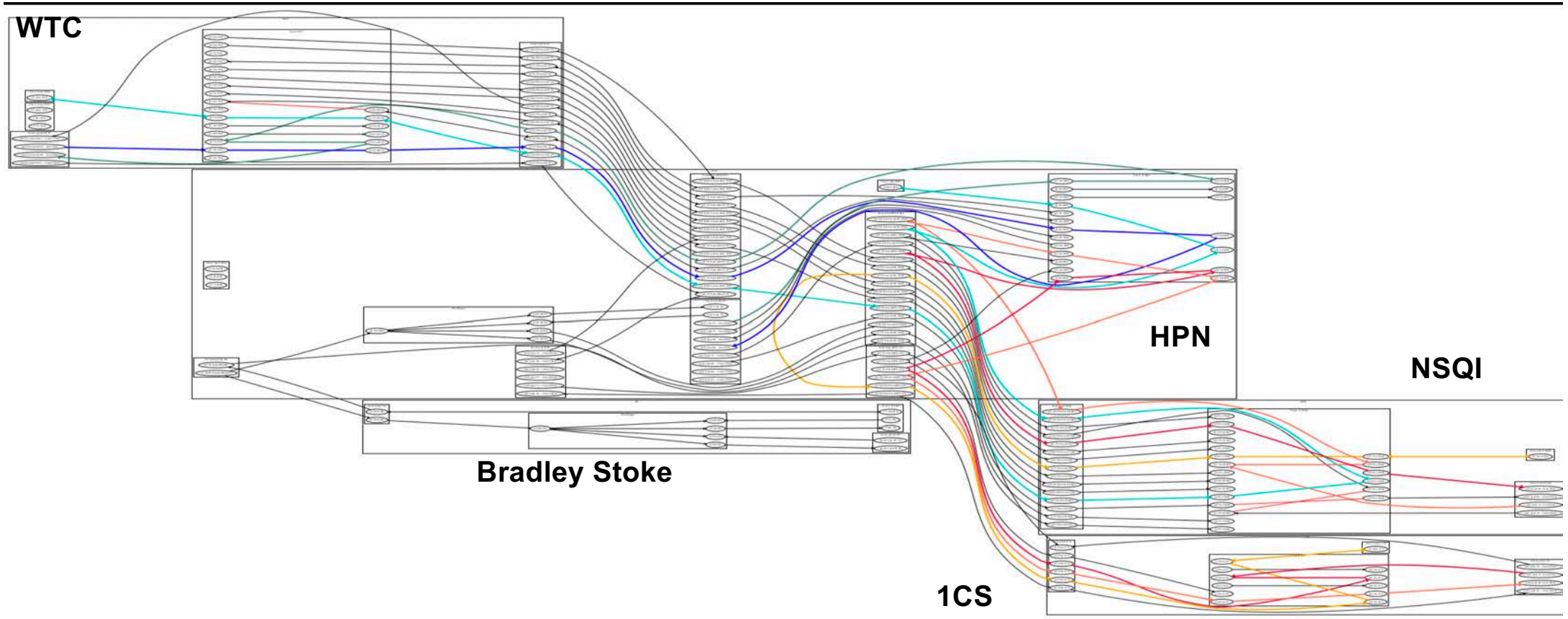
Test-bed

Quantum Aware Software Defined Control Plane

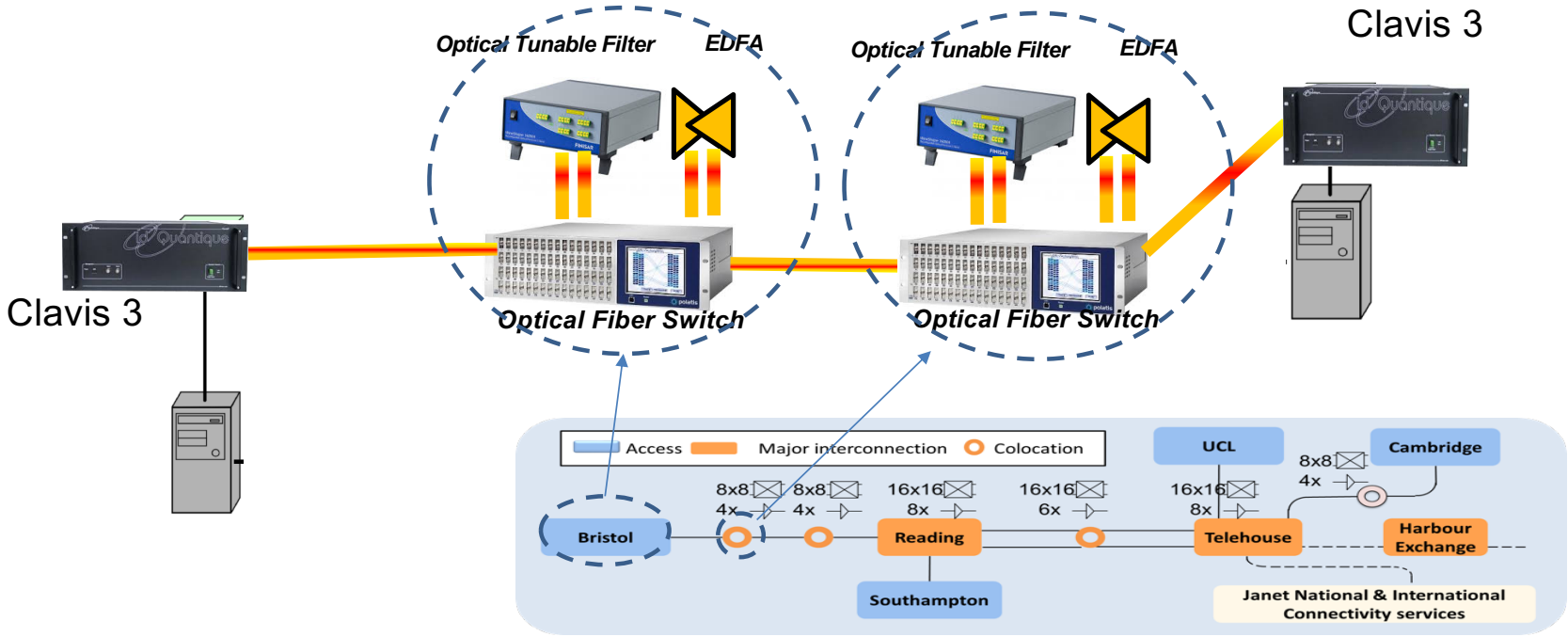
- SDN Control of QKD and Classical
- AI-Assisted Quantum and Classical Channel Path Computation
- Quantum Secured Network Function Virtualization (Quantum Secure NFV)
- Quantum Key Management



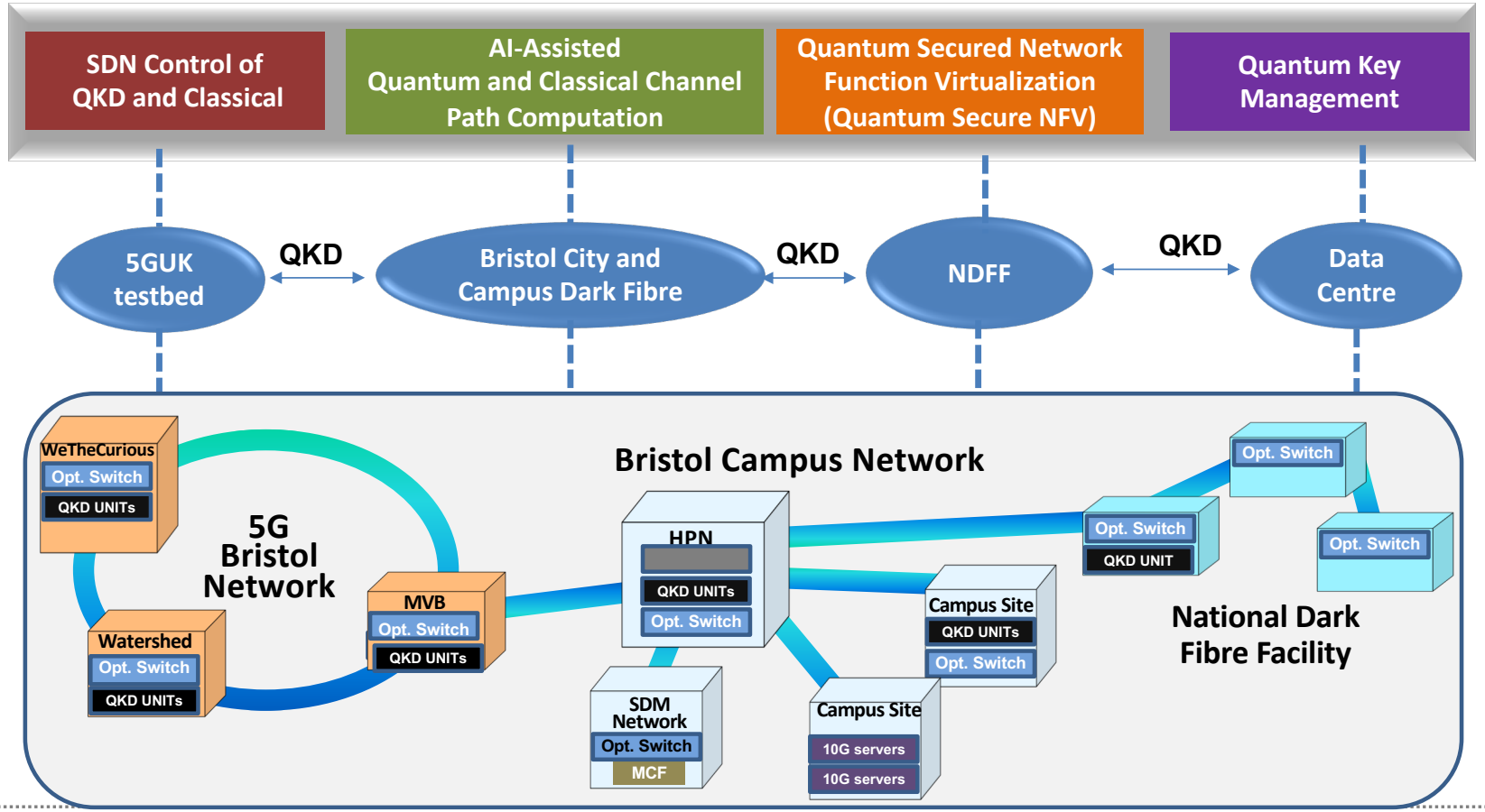
Test-bed Connectivity Topology and Complexity



QKD network implementation on one span of NDFIS



Quantum Mesh Networking Test Network



Demo Scenarios

- Demo 1: Software Defined Multidomain Quantum Secured Network Field Trial

- Demo 2: Fully meshed dynamically switched QKD Metro network

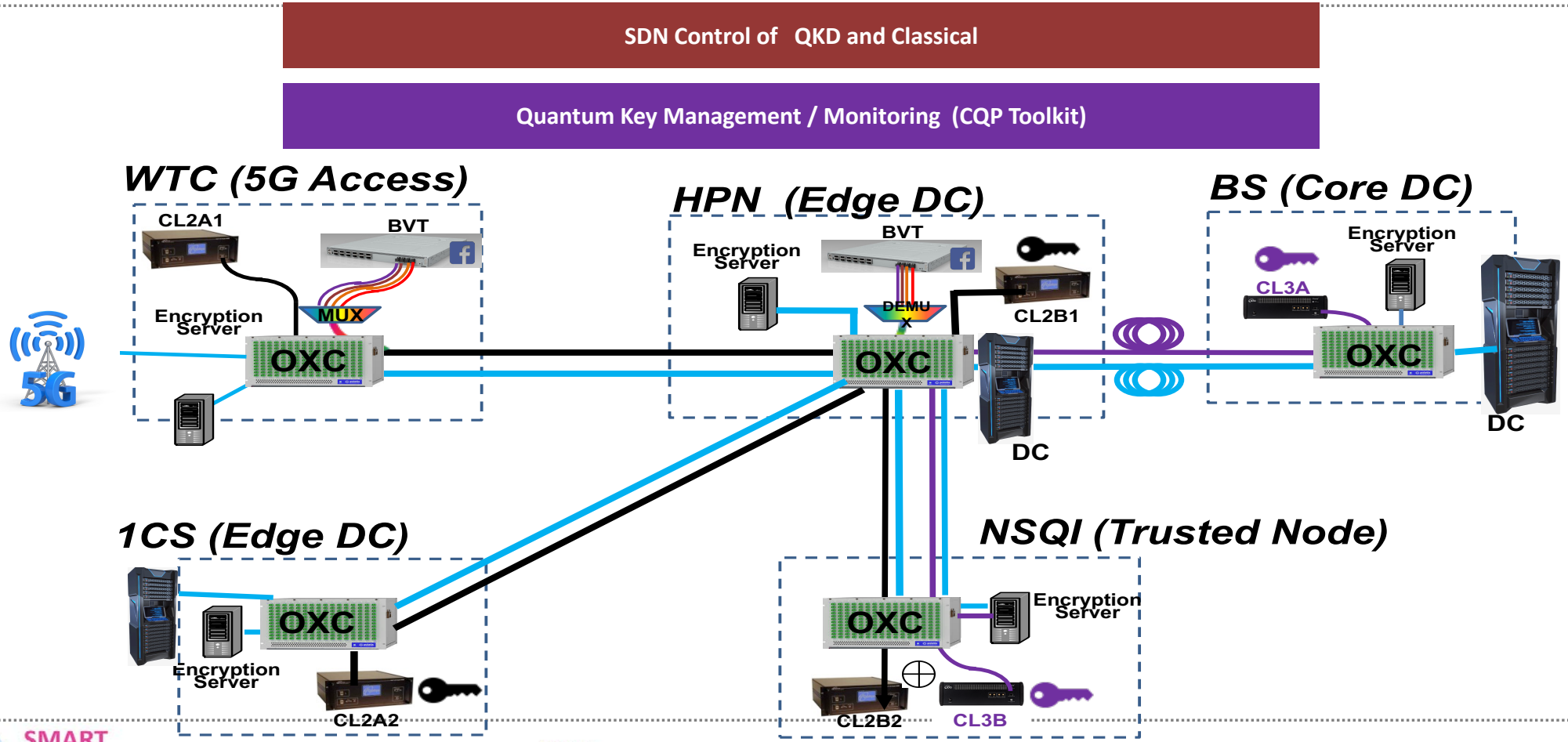
- Demo 1: Software Defined Multidomain Quantum Secured Network Field Trial

Demo 1: Software Defined Multidomain Quantum Secured Network Field Trial

GOALS:

- Demonstration of end-t-end Quantum secured channel for edge to metro to remote data centre in the core
- Secured 5G Access connection to remote data center via secured trusted node
- Quantum channel switching for caching of data from remote DC to Edge DC
- Software Define Control plane to control all process and monitor quantum channel

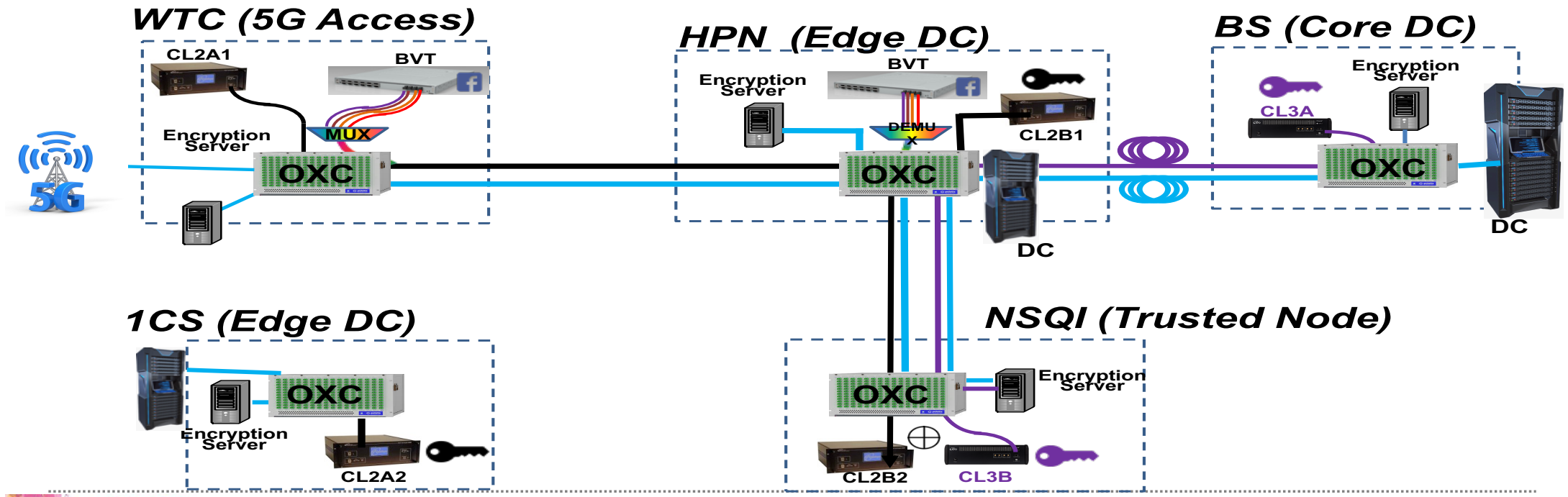
Demo 1: Software Defined Multidomain Quantum Secured Network Field Trial



Demo 1: Software Defined Multidomain Quantum Secured Network Field Trial

SDN Control of QKD and Classical

Quantum Key Management / Monitoring (CQP Toolkit)



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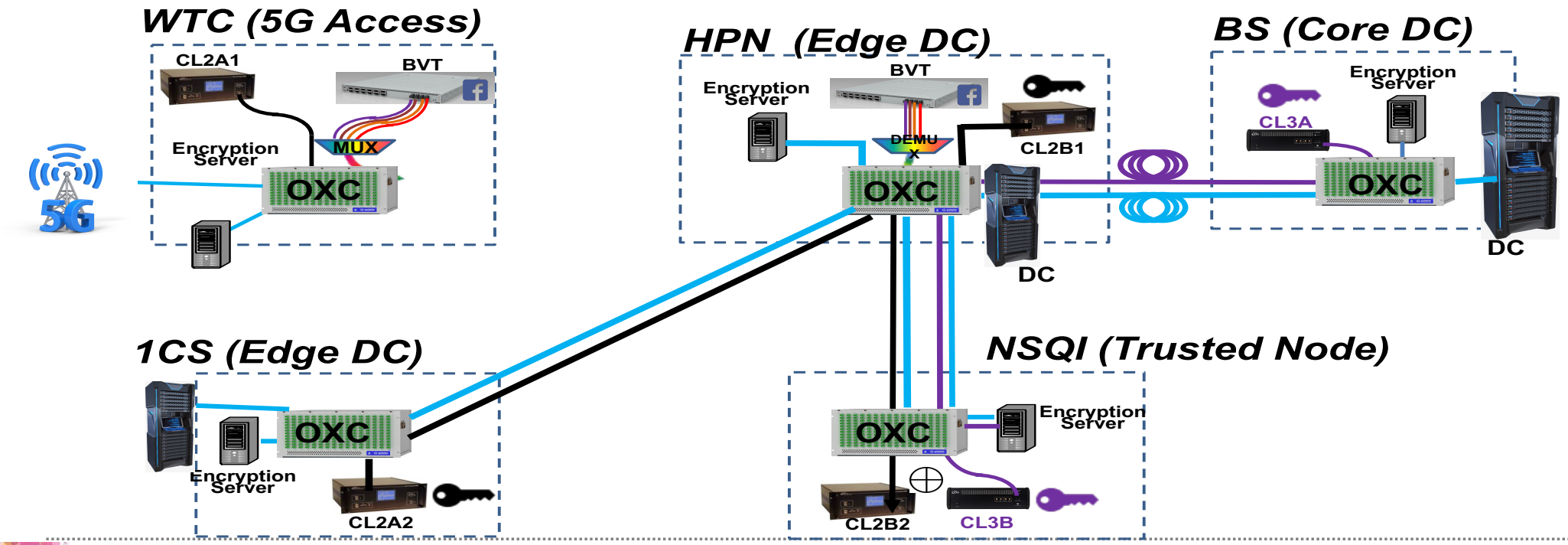
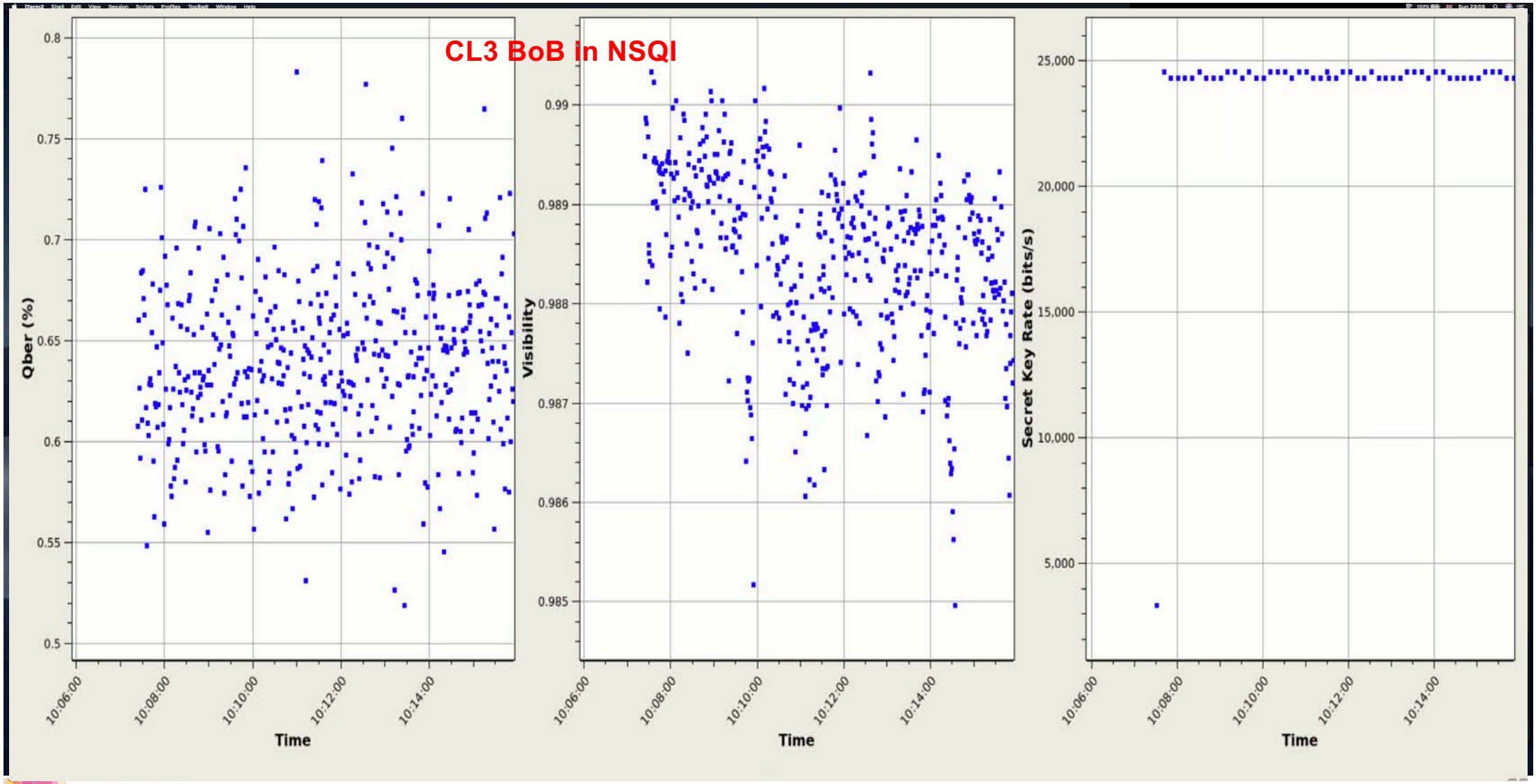


CL3 BoB in NSQI



Acknowledgements

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Dr Rodrigo Stange Tessinari

Dr Djeylan Aktas

Mr Richard Collins

Thank You