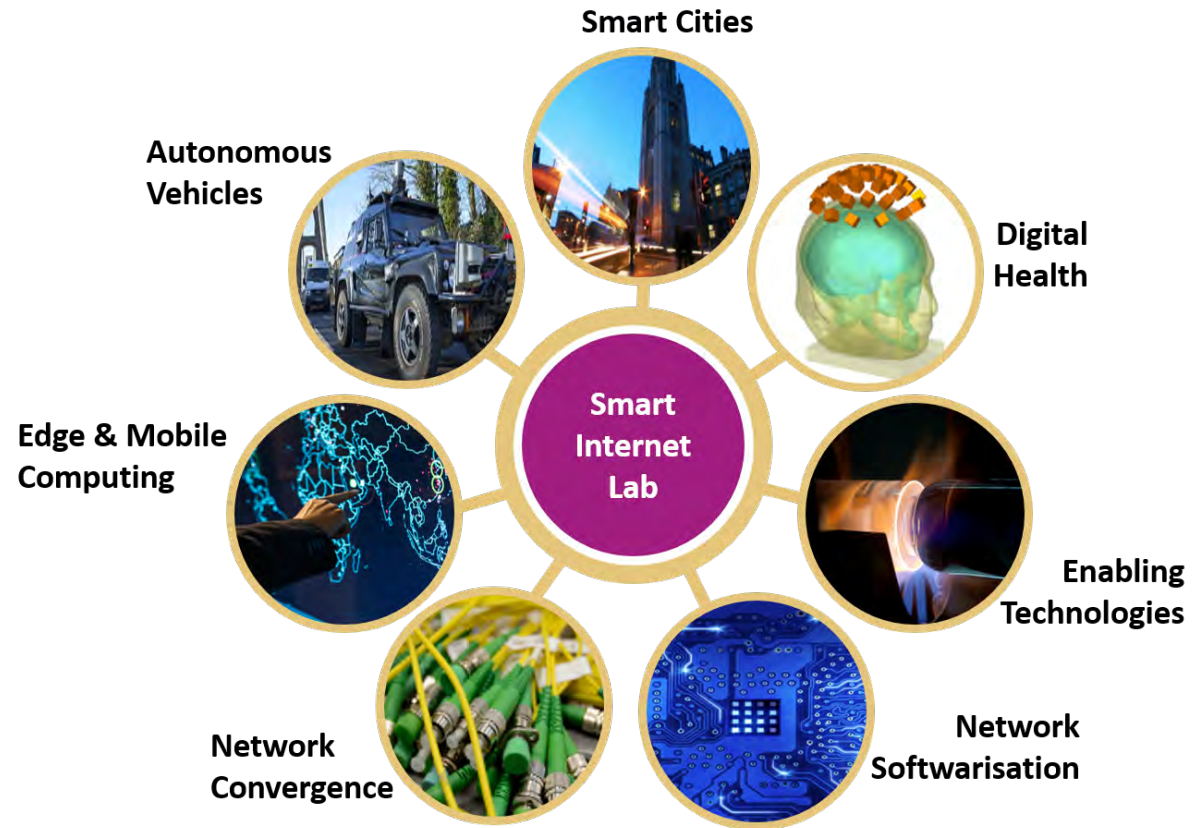
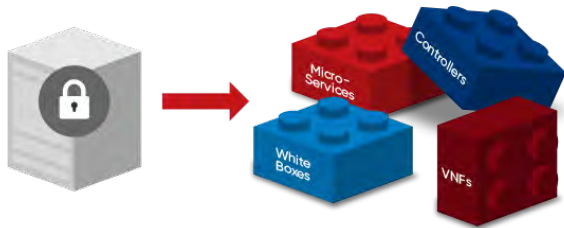


Smart Internet Lab @ Bristol

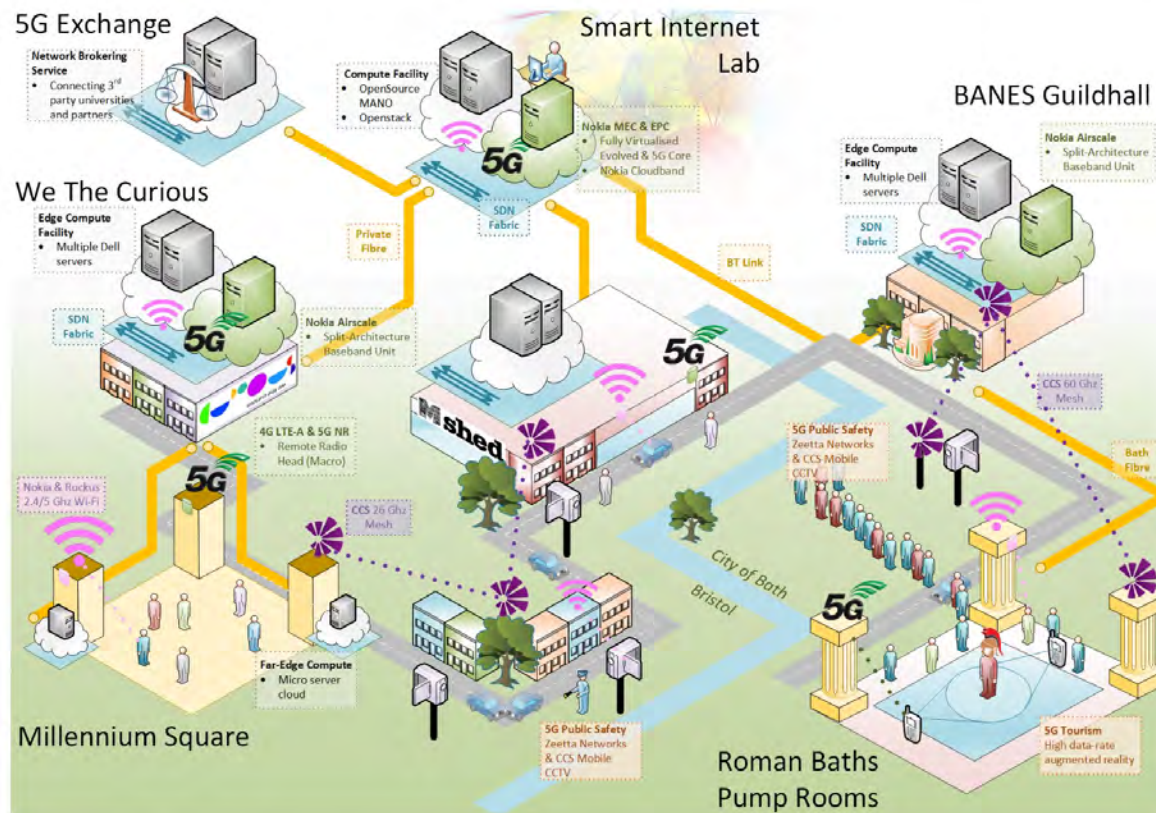
- Combined expertise across optical, wireless, IoT and cloud technologies
- Holistic approach to end-to-end network design and optimisation
- 200 academic and researchers, and growing...
- State of the art research labs
- Strong national and international links with academic and industrial networks
- Large portfolio of projects (RCUK, Government, EU, Industry, international...)



High Performance Network Group



5G Testbeds at West of England Region



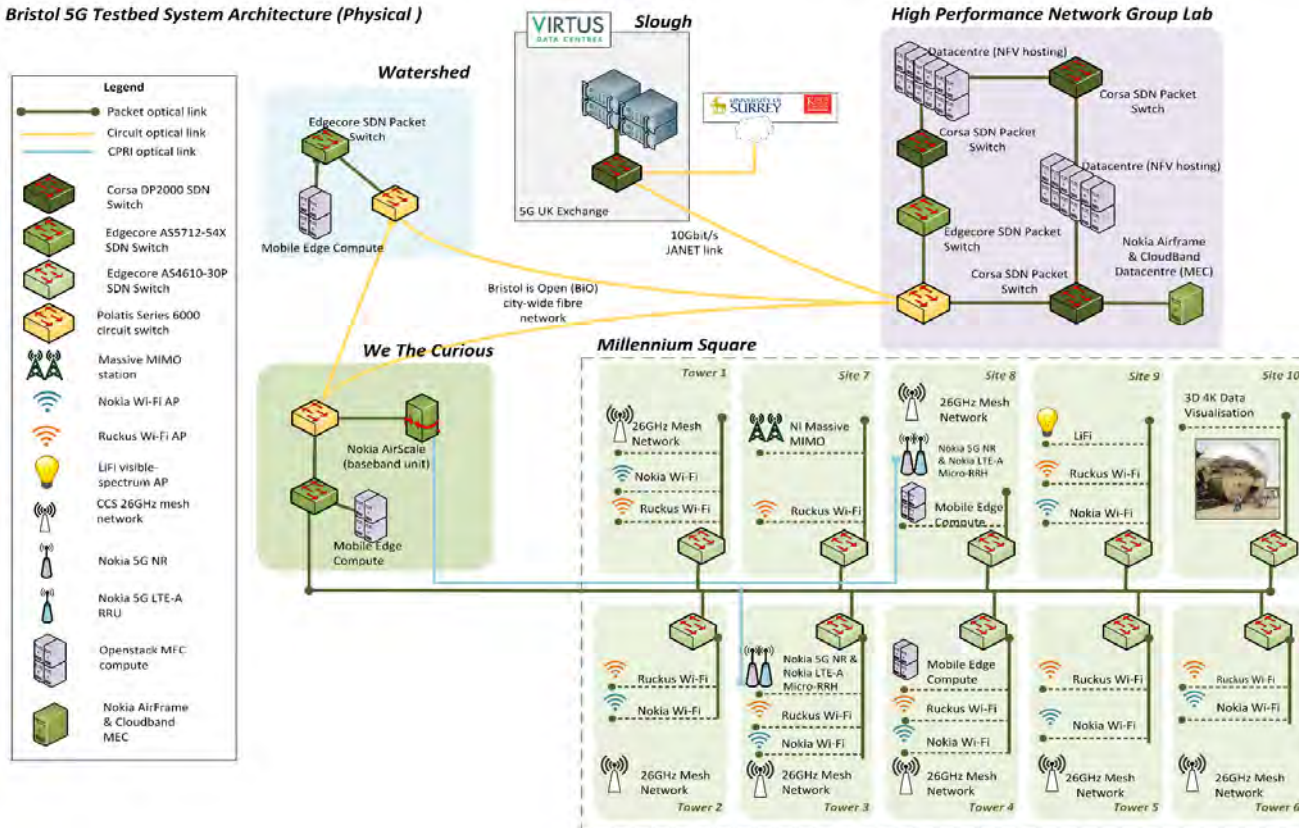
Six Primary Sites

- 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

Bristol 5G Testbed System Architecture (Physical)

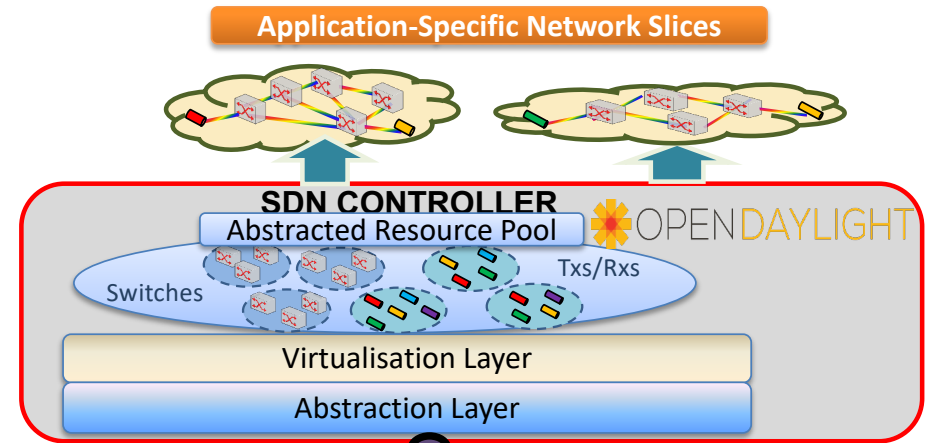


Heterogeneous Networking

- LTE-A and 5G NR 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

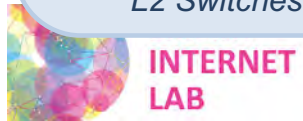
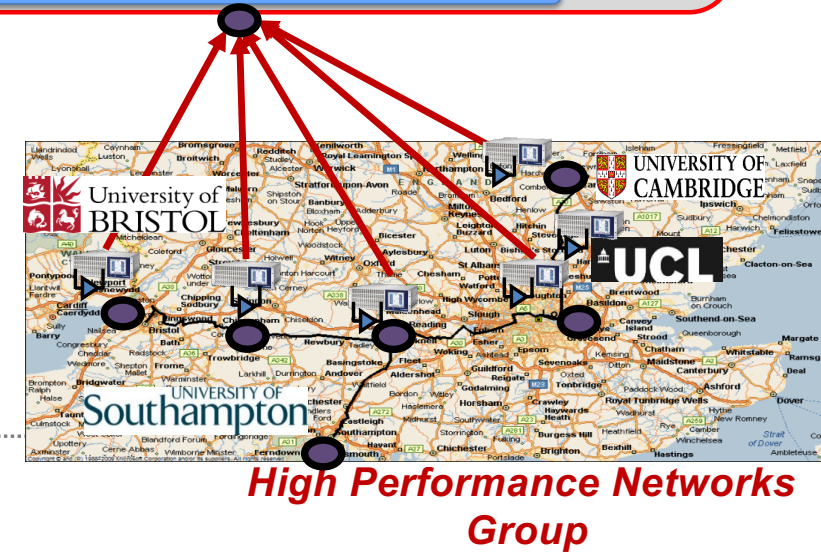
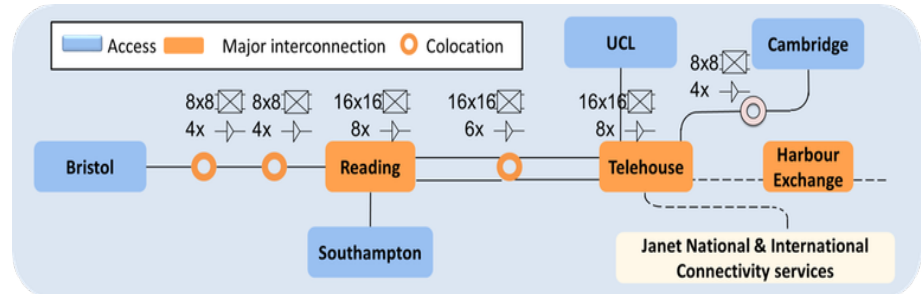
Part of National Dark Fibre Facility (NDFF)

- 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

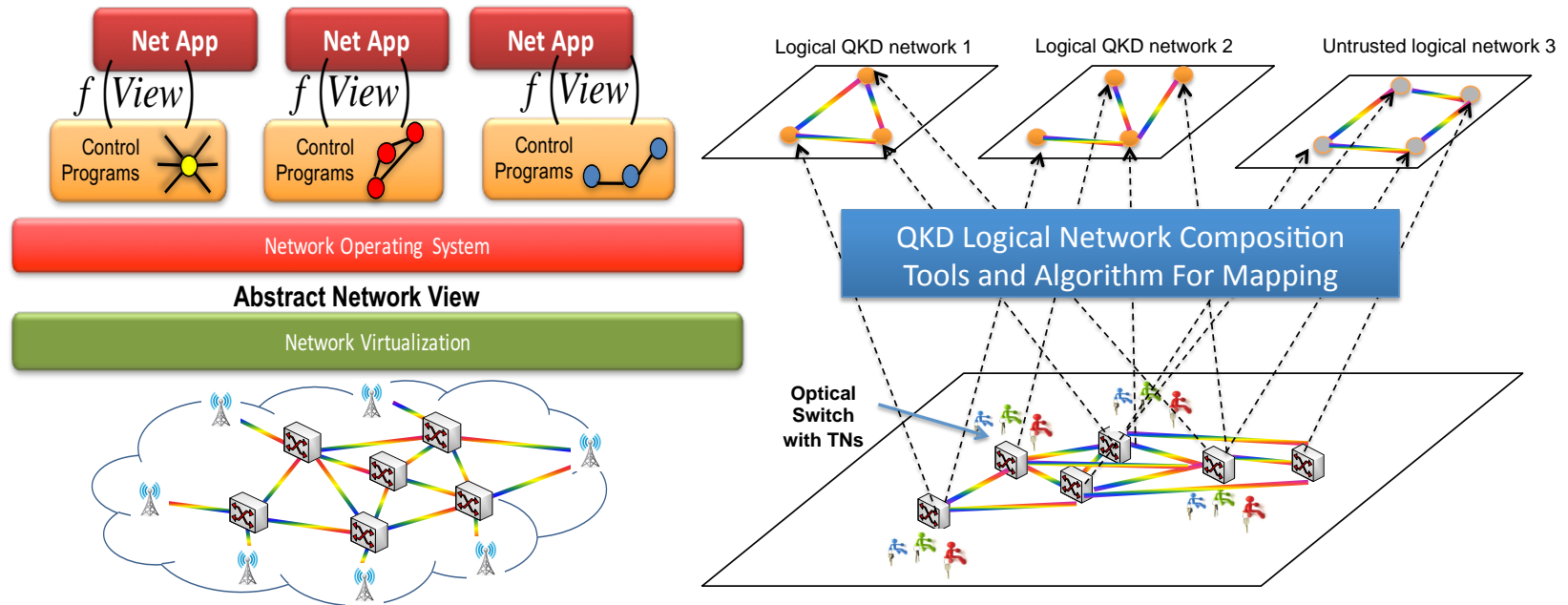
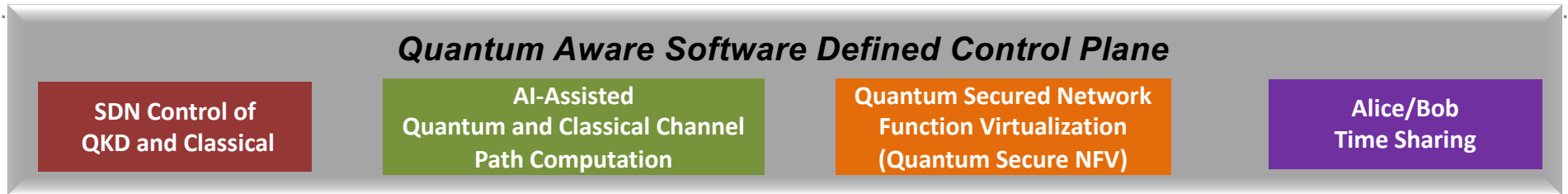


NDFF Technology:

- SDN-enabled optical switches
- Optical Amplifiers
- Dispersion Compensation Modules
- Optical Transceivers 10Gb/s DWDM
- L2 Switches

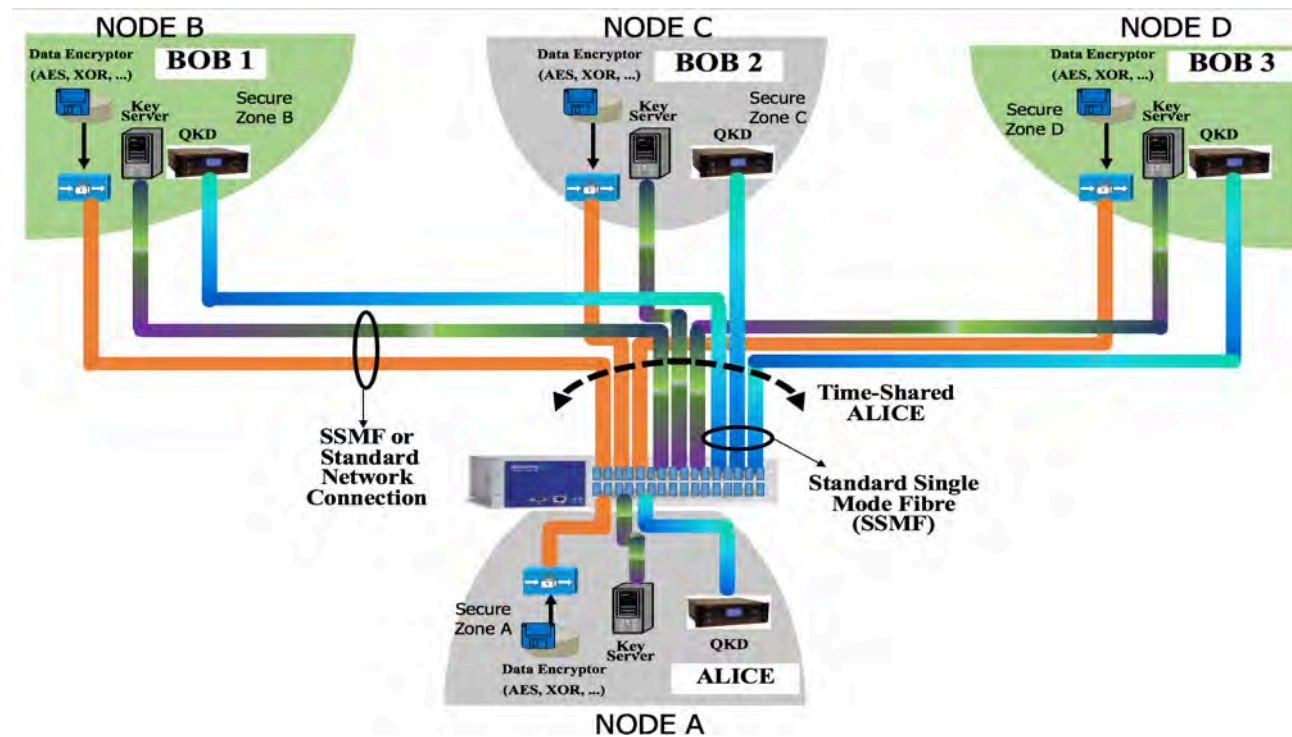


Software Deined QKD Control Plane



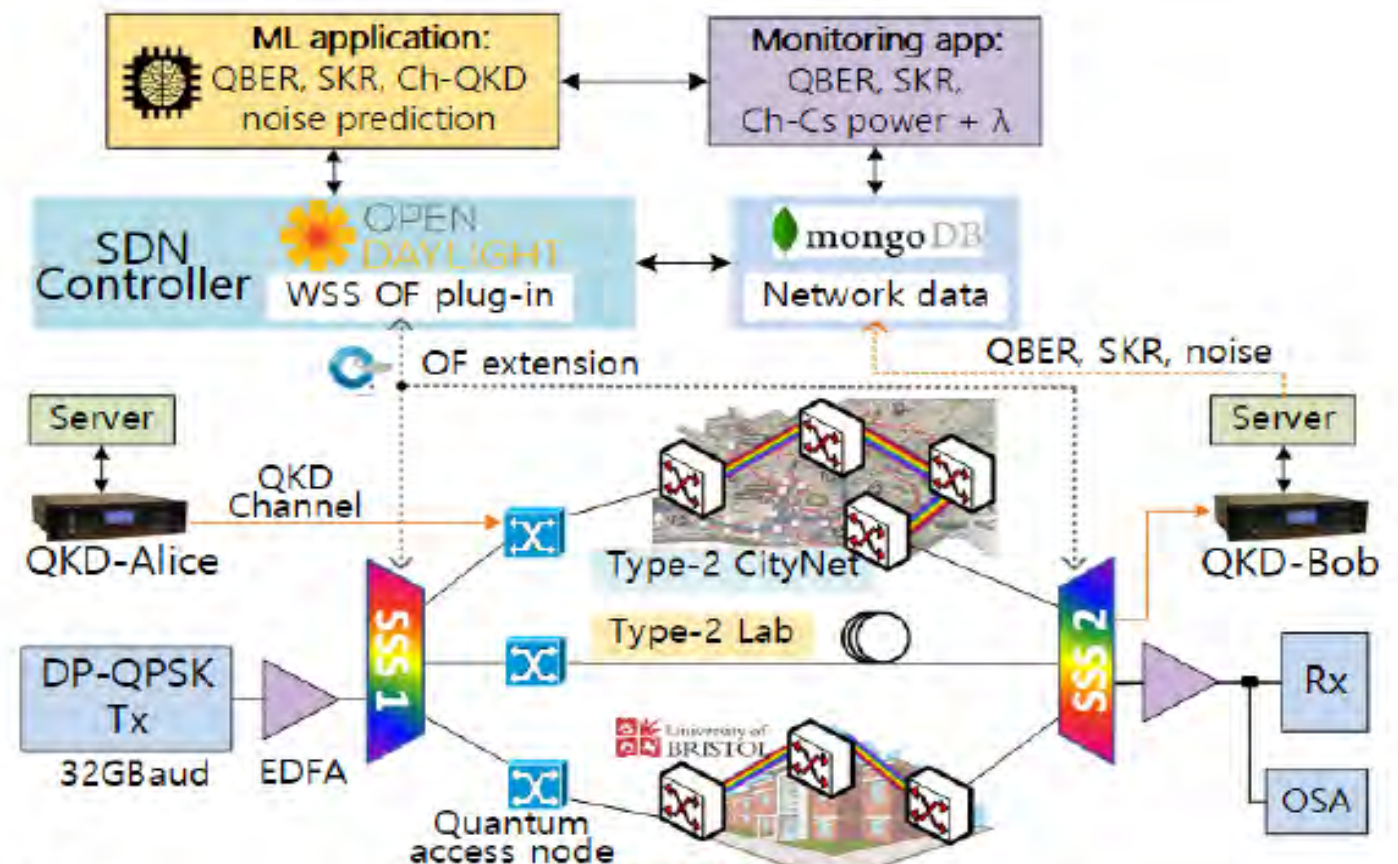
Time Shared SW Defined QKD

SDN Control of QKD and Classical With Time Sharing Algorithm

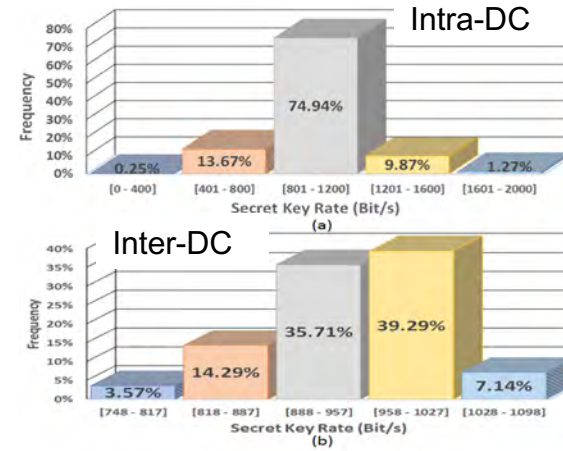
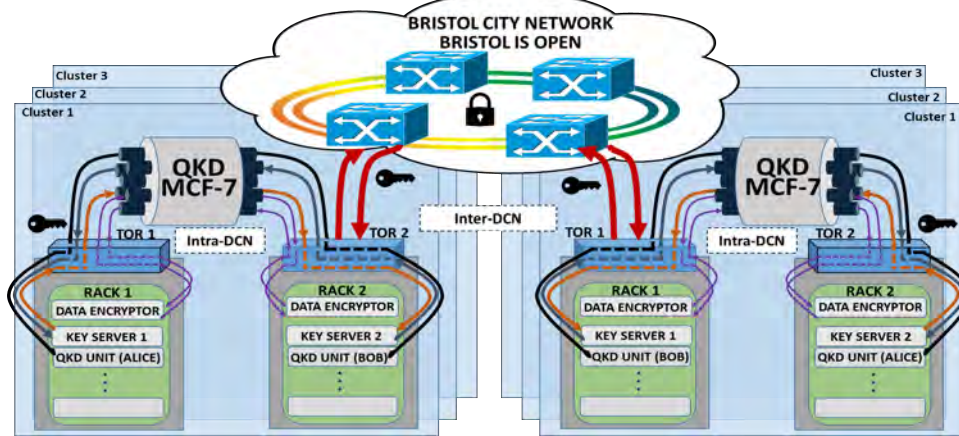


ML-assisted and SW QKD Network Supporting Co-existence

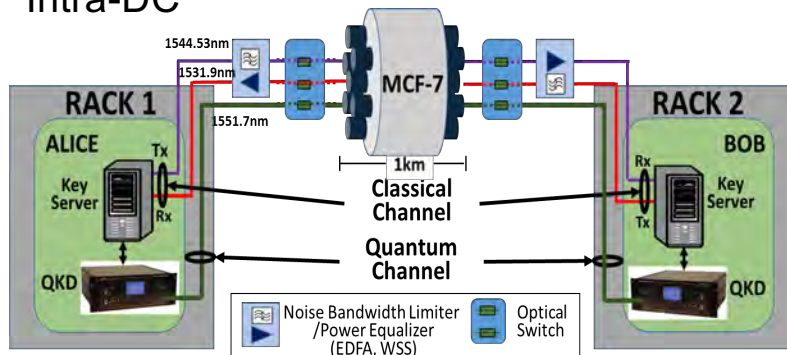
- Apply real-time monitors network-wide (spectrum, power, noise, channels spacing, secret key rate - SKR, QBER, probability of detection..)
- Feed and train the Machine Learning algorithm to optimize Q-Ch
- Develop SDN architecture to re-configure the network based on the ML output



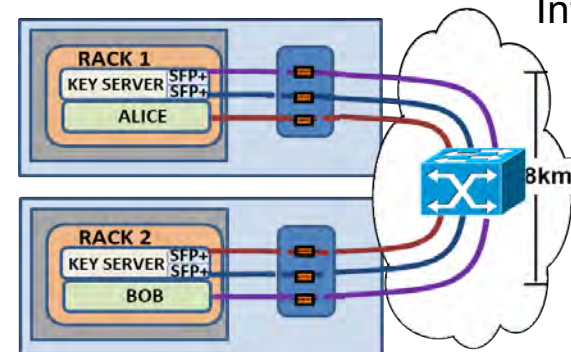
QKD over Multicore Fibres for DC [World record Co-Existence 11.2Tbps]



Intra-DC



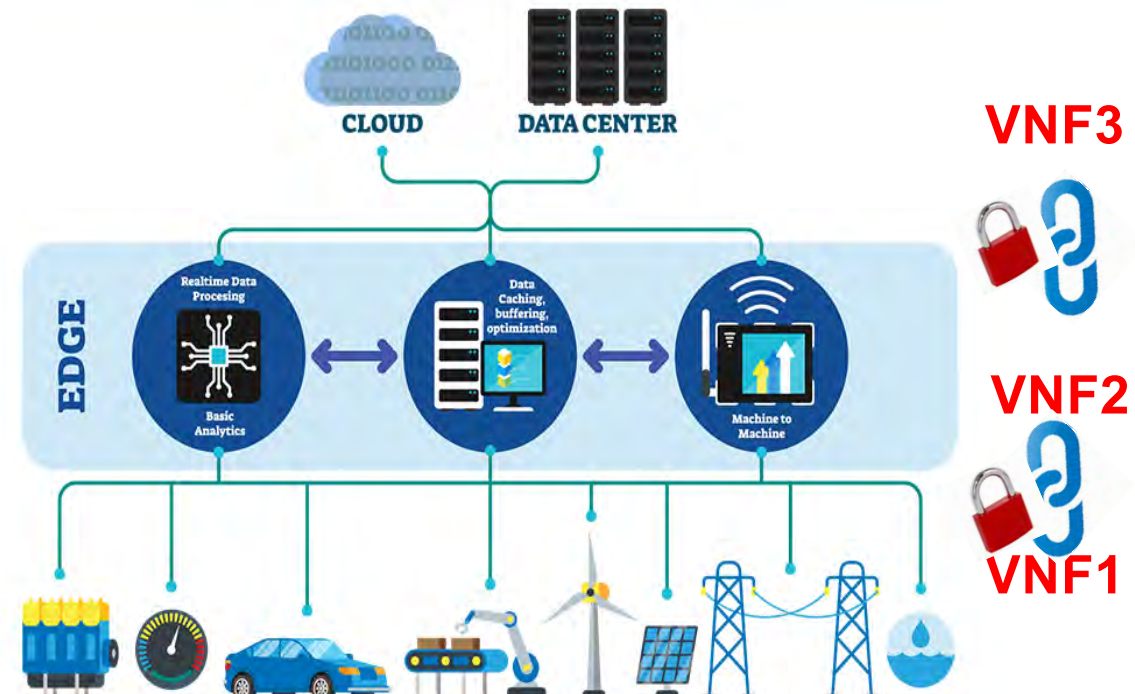
Inter-DC



Quantum Security for 5G

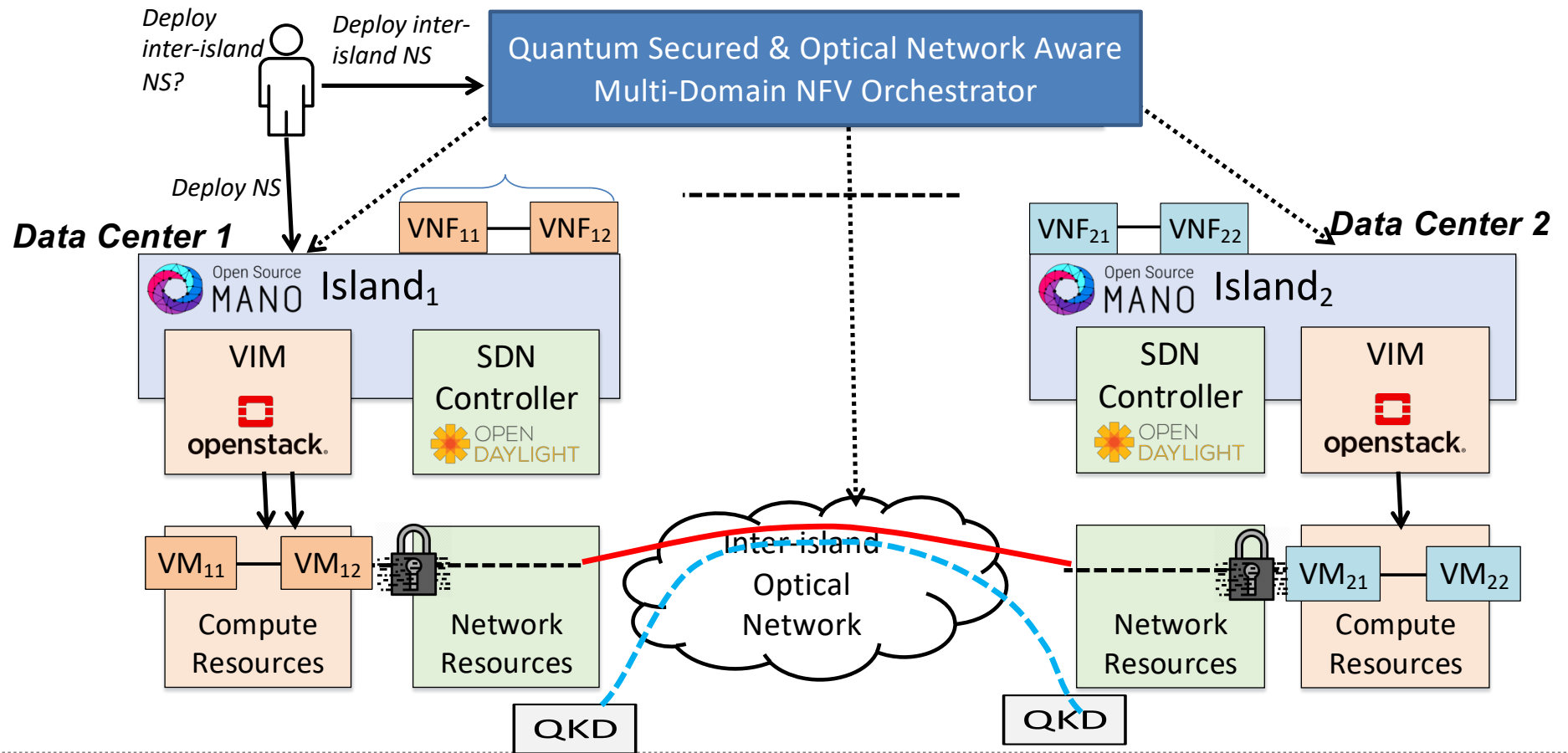
- Dynamically deploy Optical network connectivity for VNF chaining in multiple Data Centers
- Dynamically Mix & Match VNFs from multiple islands
- Use inter-DC optical network for high bandwidth and low latency VNF requirements
- Create secured inter-DC connectivity for VNF chaining using QKD within 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

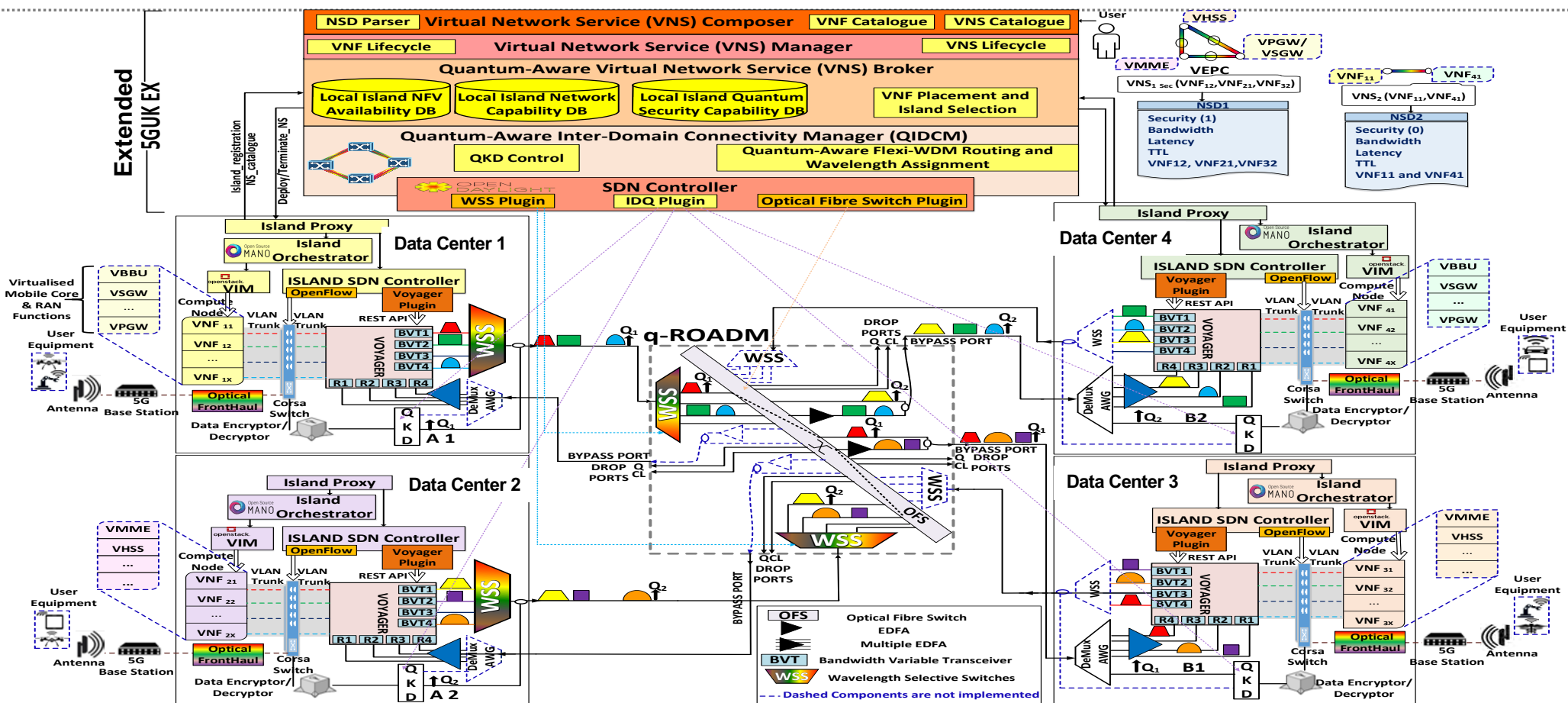


High Performance Networks Group

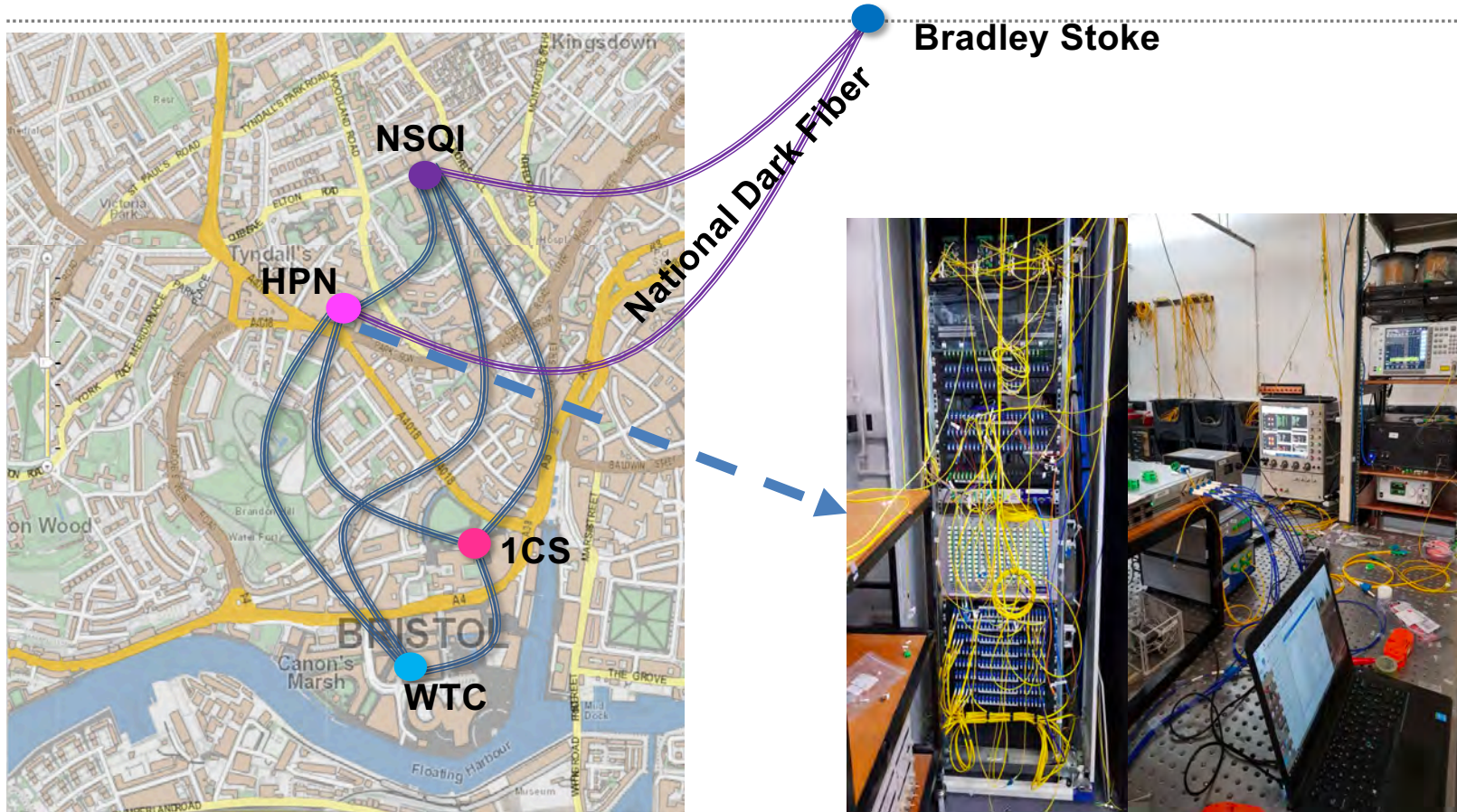
Quantum Security for 5G



Multi-layer Network-Aware & Quantum-Aware Multi-domain NFV Orchestrator



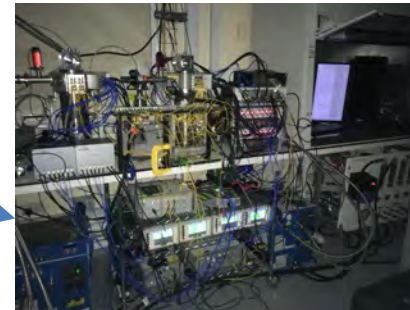
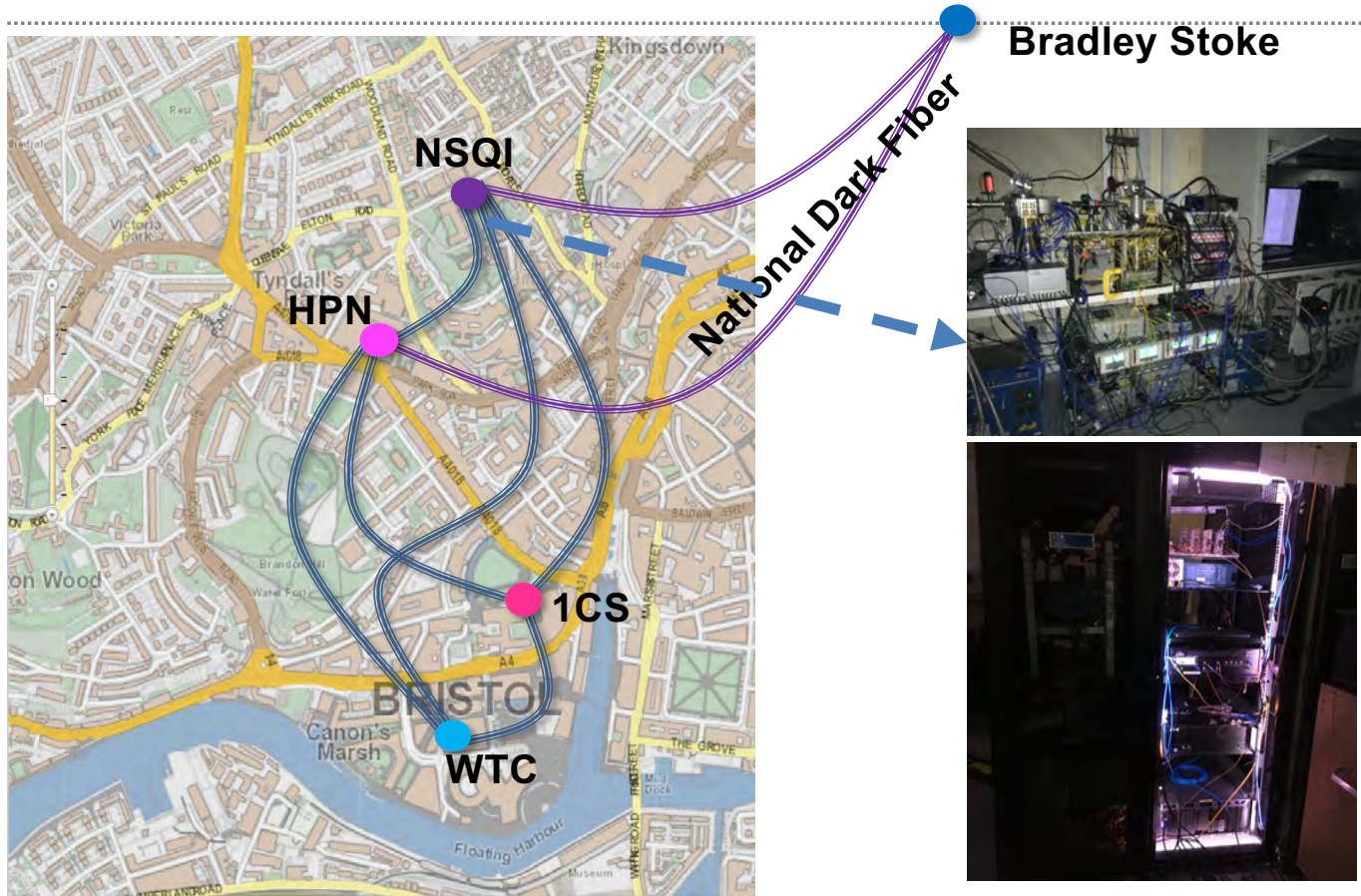
Test-bed



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

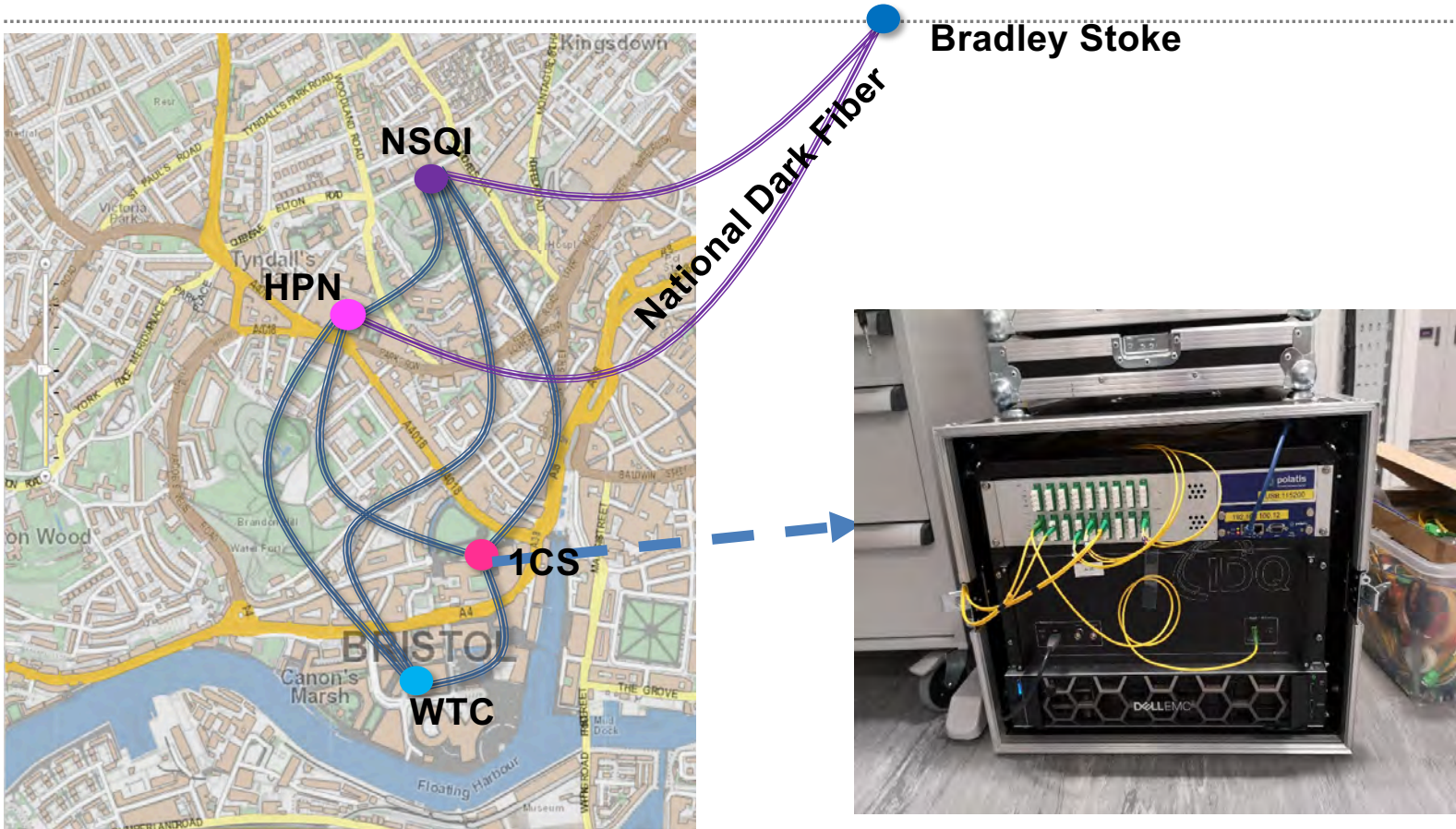


Test-bed



*Cryogenic Detector
Q handheld
Optical Switching
Alice & Bob*

Test-bed



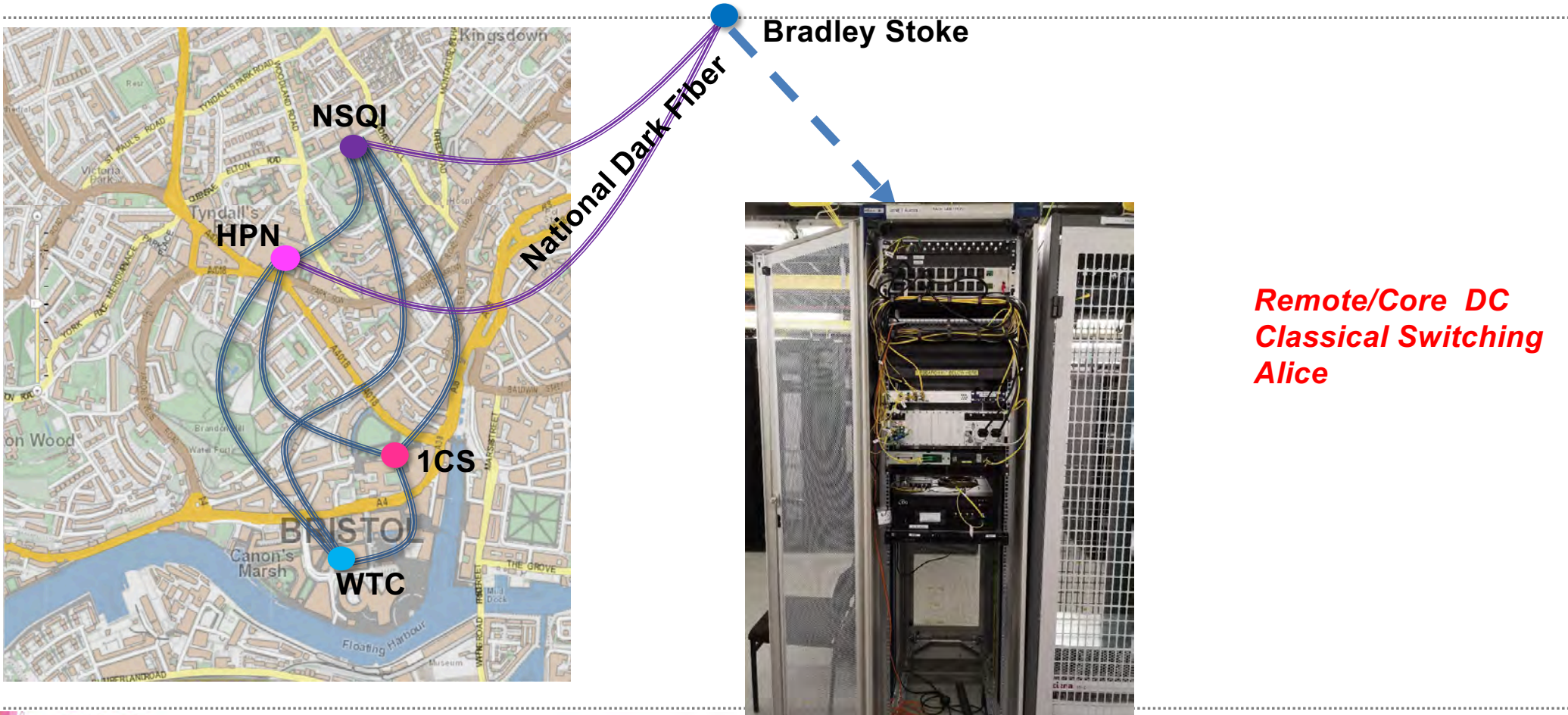
Bradley Stoke

National Dark Fiber

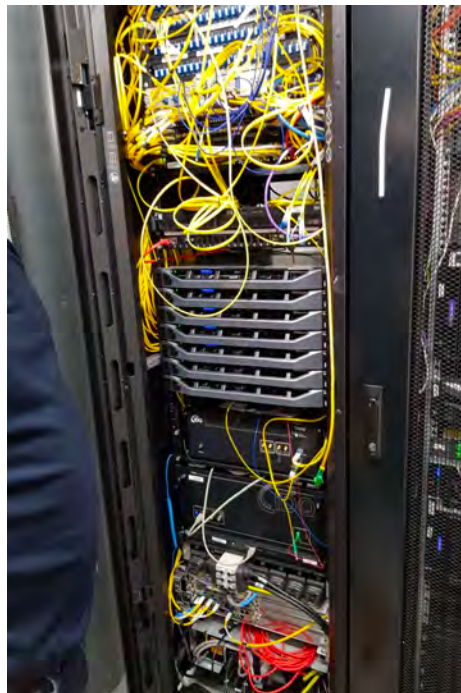
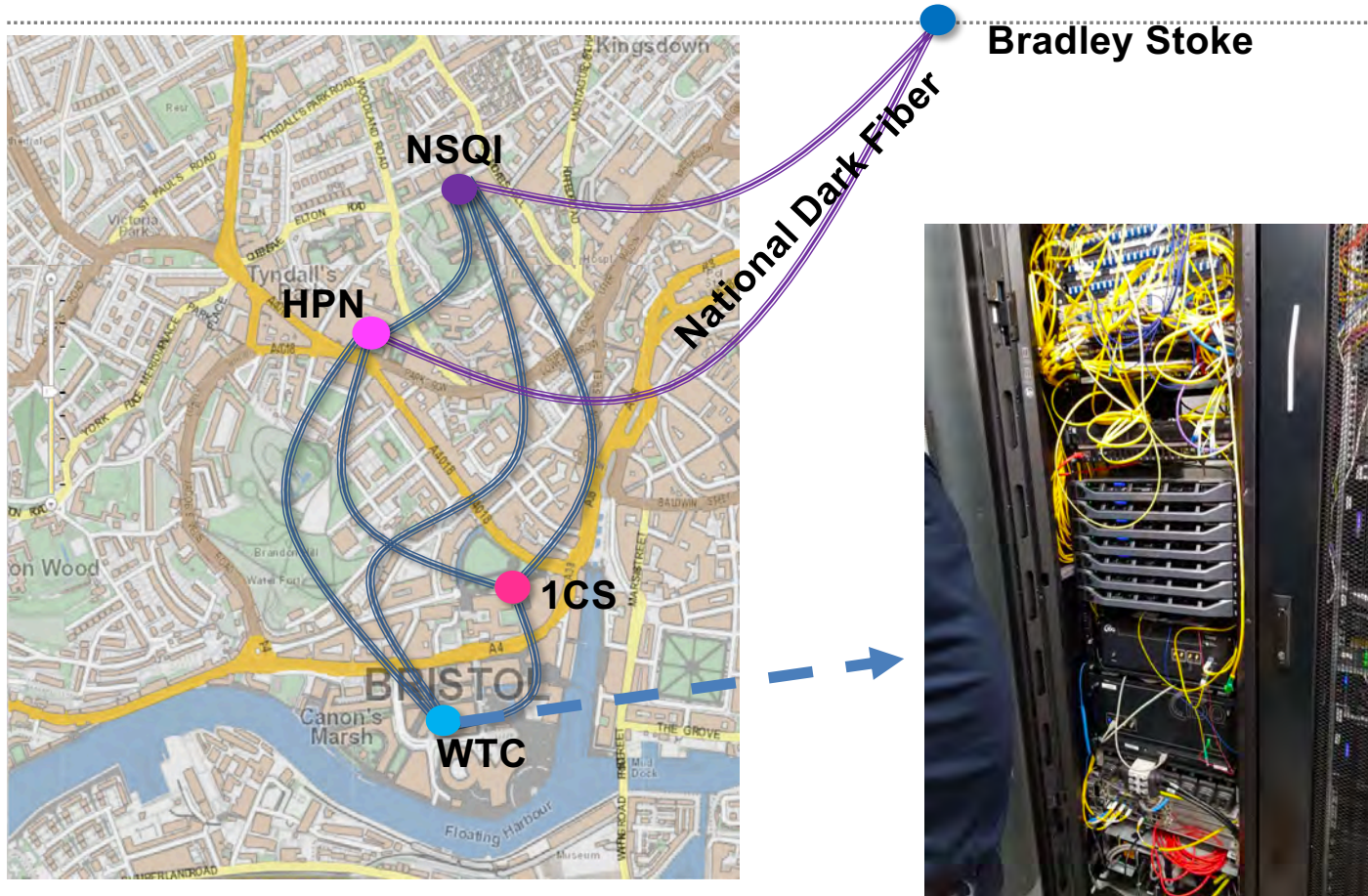


*Metro DC
Classical Switching
Alice*

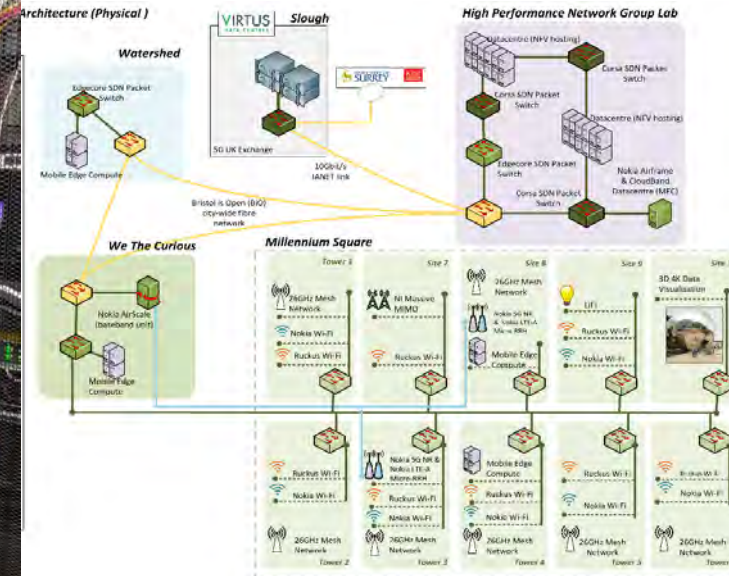
Test-bed



Test-bed



Edge Computing/DC
Optical Switching
Alice
5G Access



High Performance Networks Group

Test-bed

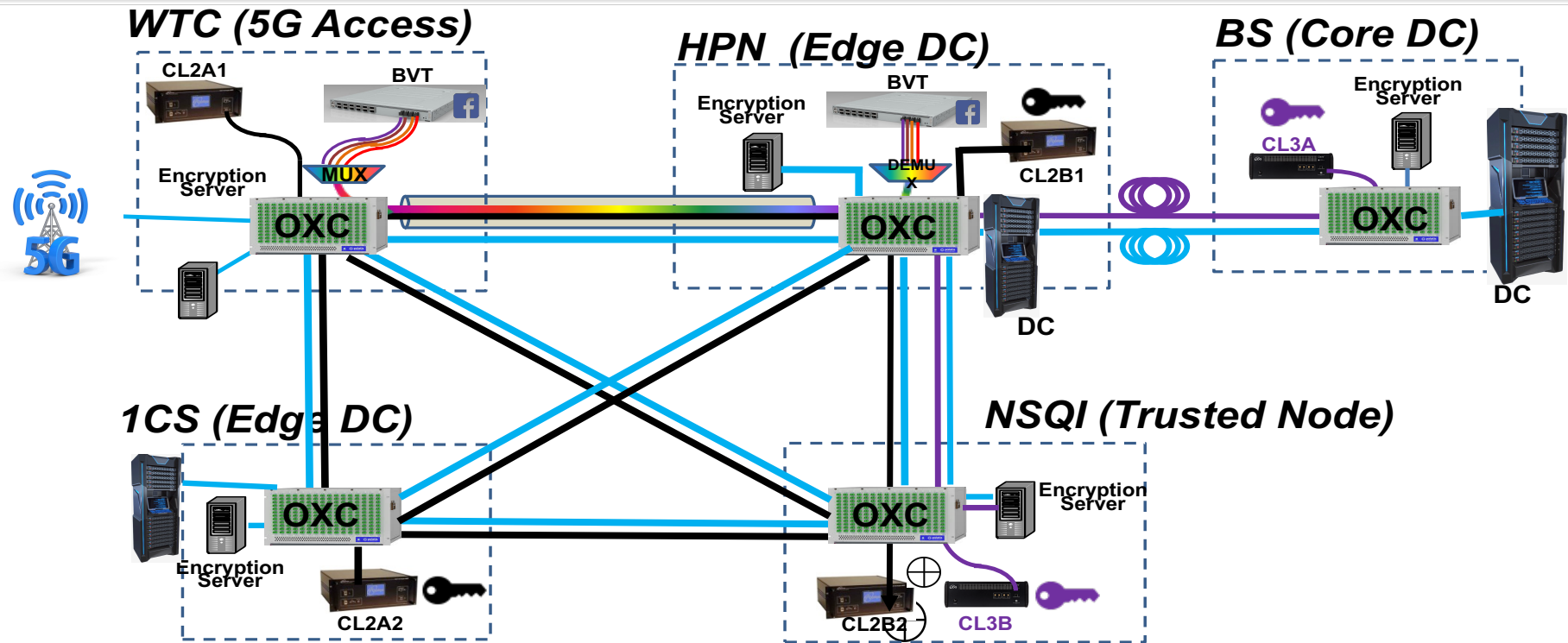
Quantum Aware Software Defined Control Plane

SDN Control of QKD and Classical

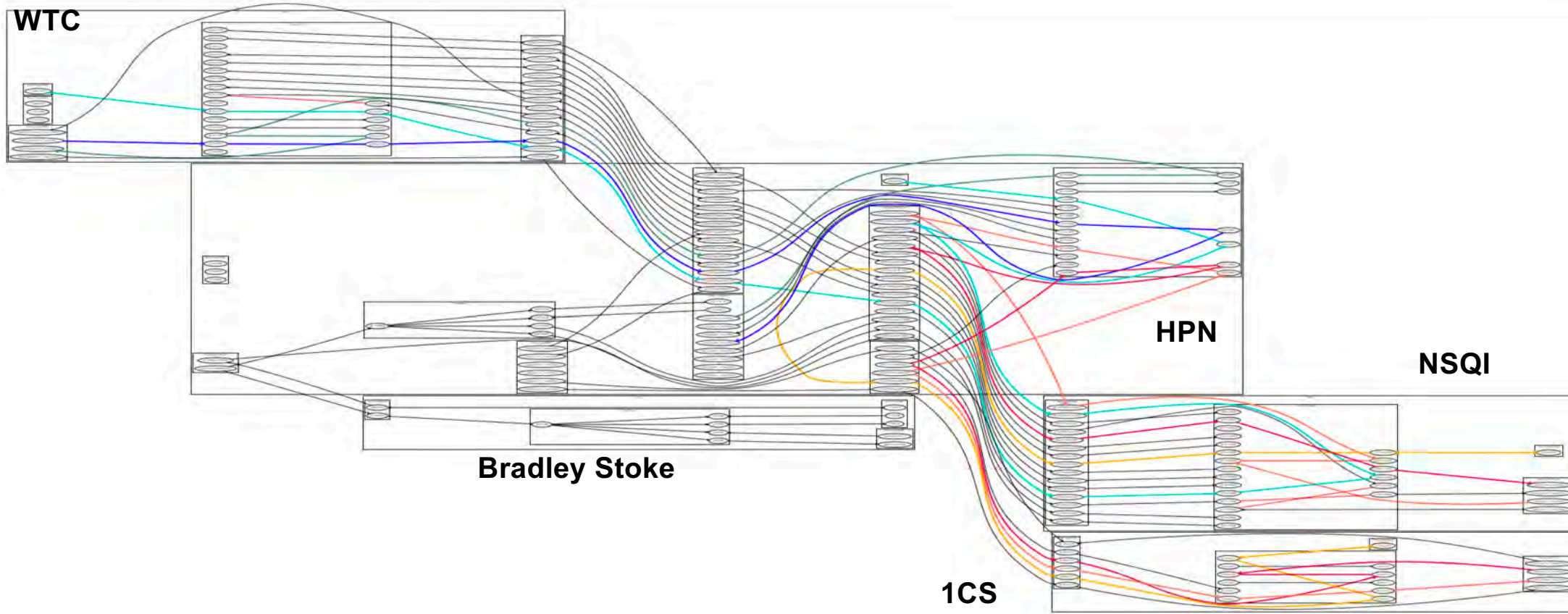
AI-Assisted Quantum and Classical Channel Path Computation

Quantum Secured Network Function Virtualization (Quantum Secure NFV)

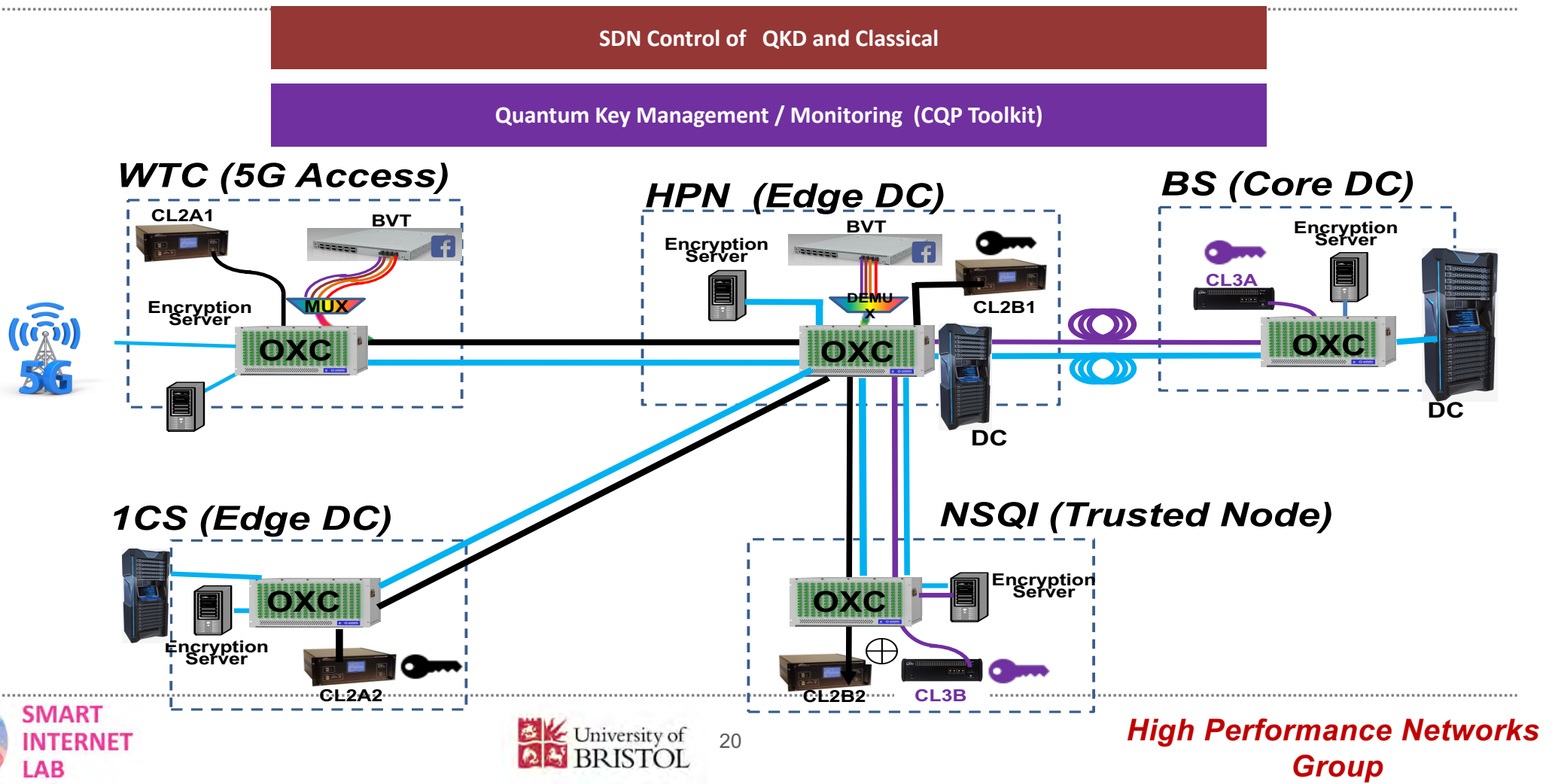
Quantum Key Management



Test-bed Connectivity Topology and Complexity



Demo 1: Software Defined Multidomain Quantum Secured Network Field Trial



Demo2: Fully meshed dynamically switched QKD Metro network

