INITIATE: How to engage with future internet research

May 20, 2020
Welcome!

Dana Elman

Innovation Delivery Manager, Digital Catapult

Opening remarks, agenda and introduction

Agenda - Morning Webinar

09:30	**Opening remarks, agenda and introduction**
09:40	**Welcome note**
09:45	**INITIATE project overview**
10:00	**University of Bristol** - Testbed capabilities
10:10	**University of Edinburgh** - Testbed capabilities
10:20	**Coffee break**
10:30	**Lancaster University** - Testbed capabilities
10:40	**King's College** - Testbed capabilities
10:50	**Digital Catapult** - Testbed capabilities
11:00	**Q&A**
11:10	**The INITIATE Portal**
11:25	**Introduction to the afternoon session**
11:30	**Lunch break**

Dr. Dritan Kaleshi

Head of 5G Technology, Digital Catapult

Welcome Note

Professor Dimitra Simeonidou

Director of The Smart Internet Lab,
University of Bristol

INITIATE Project Overview

INITIATE In a Glance

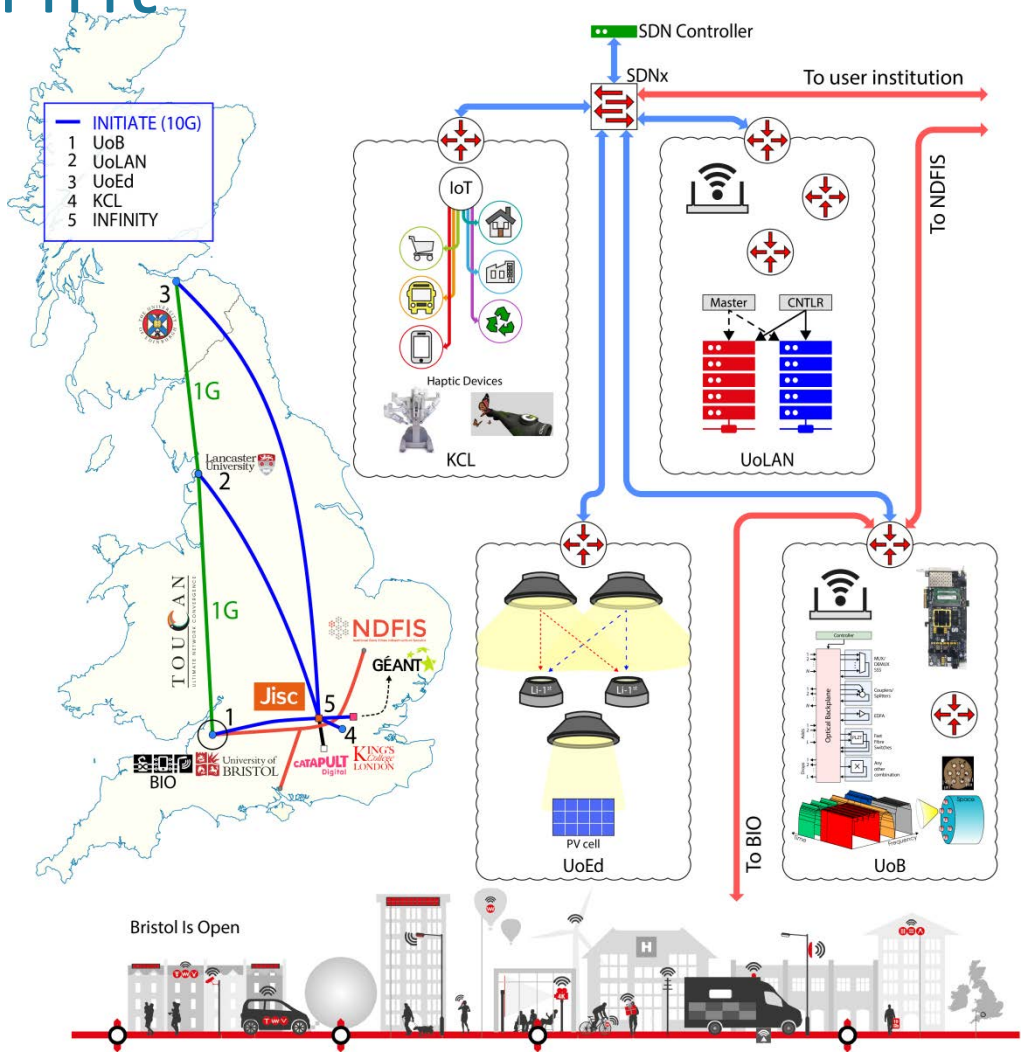
- £1.6M ESPRC funding + £1.3M Industrial funding
  - Industry: BBC, BT, Cambridge Wireless, CORSA, Dante, F5 Networks, Huawei, InterDigital, Keysight, Konica, NI, Ofcom, Thales, pureLiFi, Zeetta
- February 2017-January 2021
- Initially Interconnects 5 UK research laboratories through the UK's first SDN exchange
- A UK facility for fully end-to-end large-scale Future Networks experimentation
- Multi-technology Radio, IoT, Optical, Data Centre and Cloud
- To support research and innovation in future networks:
  - Technologies, Architectures, Services, Applications

INITIATE Objectives

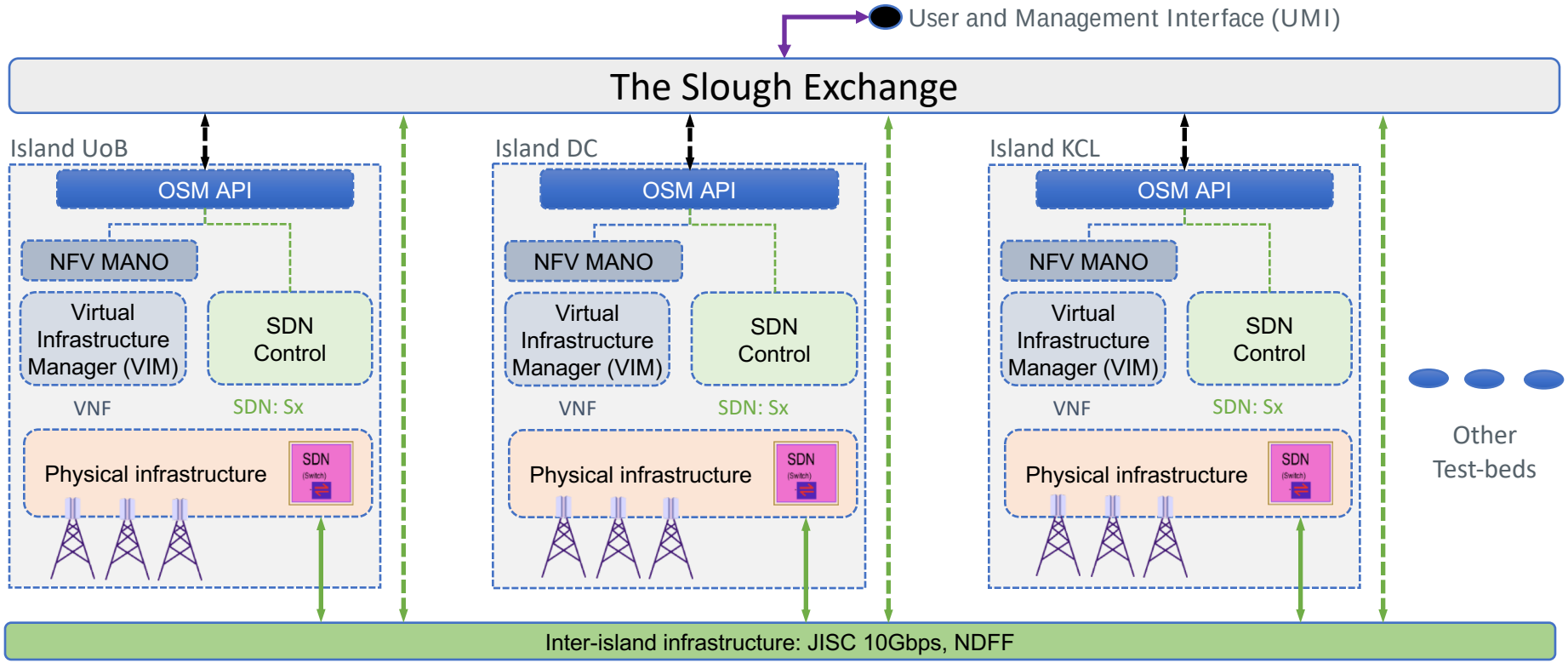
- Establishing a pilot large-scale, multi-technology experimentation facility
- **Develop comprehensive experimental control and user access framework**
- Support collaborative research across UK Universities and Industry
- Engage with vertical applications like autonomous systems, digital health, smart cities etc.
- Scale and support connectivity across the UK and international test networks.

INITIATE Initial Footprint

- Different specialisations across partners (5 Labs)
- An Exchange node to allow dynamic interconnection of physical/virtual experimental resources across different laboratories
- Connections to EPSRC NDFF/TOUCAN and the DCMS 5GUK Test Networks
- Open platform for external experimenters



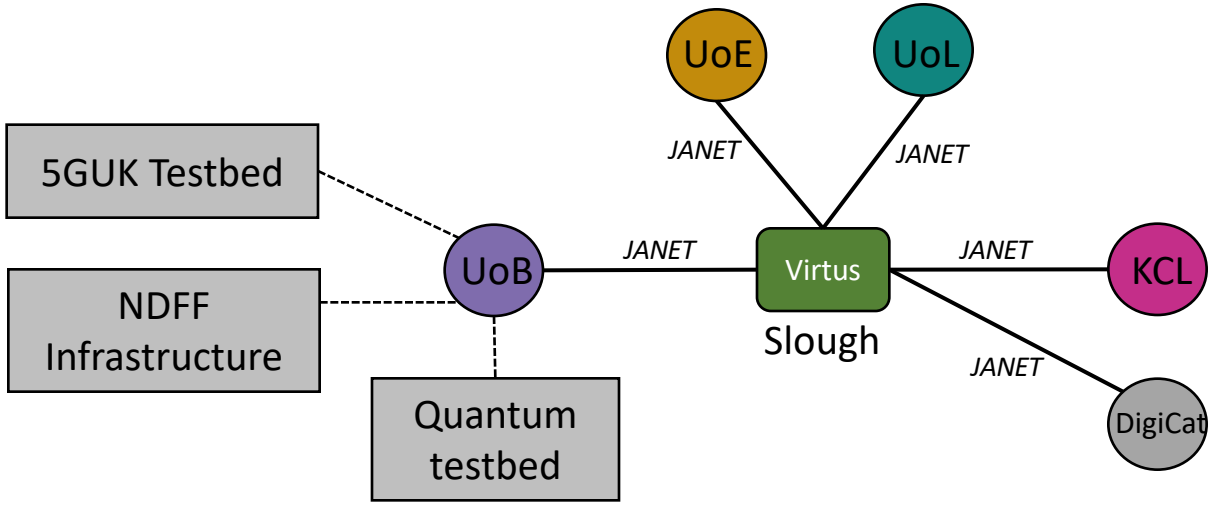
The Slough Exchange



Interconnection facility

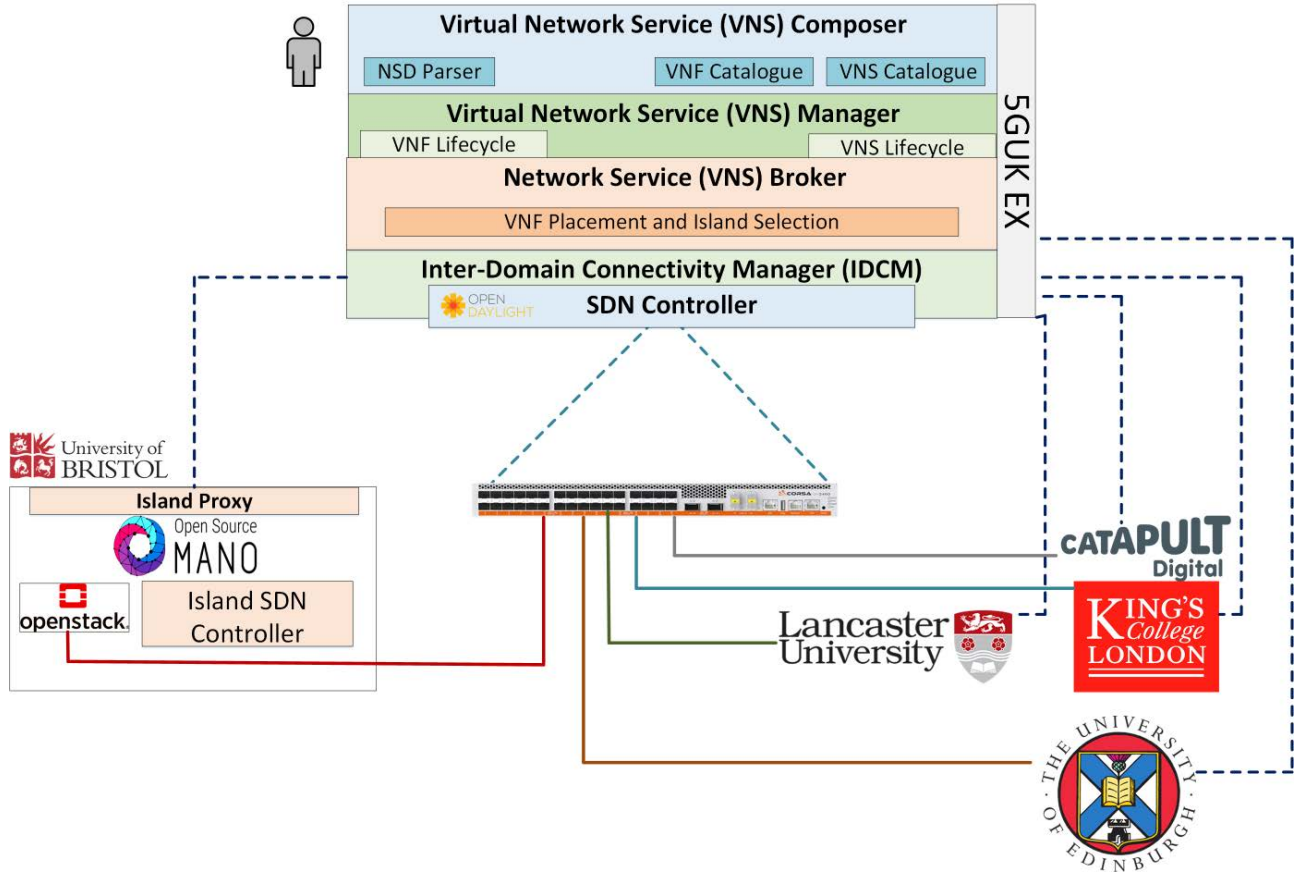
- 10Gbps (Jisc/JANET) L2 fibre connectivity to all the partners.

- Soon to connect to Dark Fibre facility (NDFF) adding UCL, Southamoton & Cambridge
- Interconnection Facility at Virtus Datacenter (Slough)
  - Corsa DP2400 SDN capable 10G packet Switch
  - Dell T630 (64 cores, 128Gb RAM, 650Gb storage)
  -
- Services running at Slough:
  - Exchange: Over-the-top orchestrator connecting multiple testbeds using the Management And Network Orchestration (MANO)
  - SDN Services to interconnect datapath.

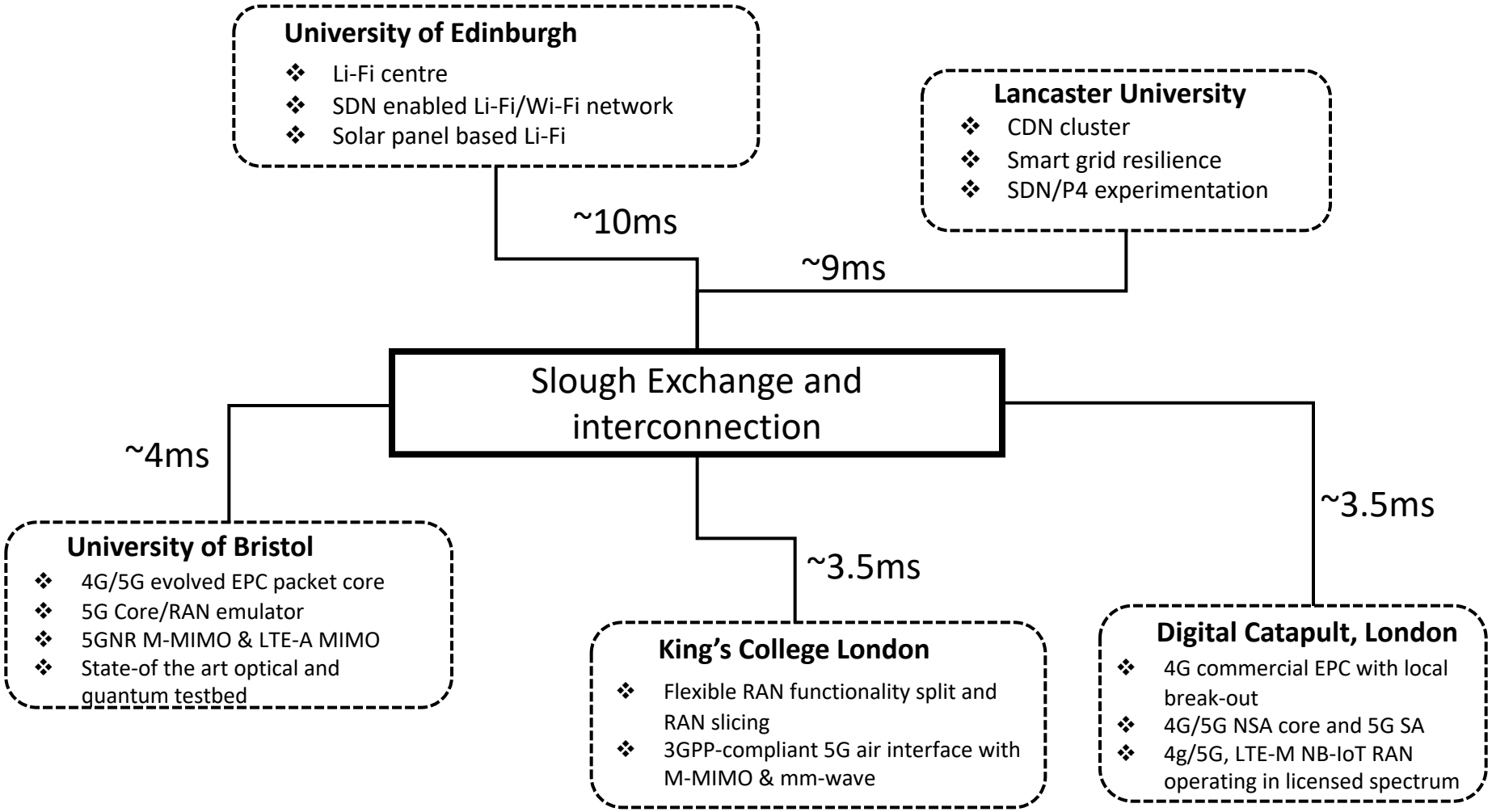


Exchange Overview

- Exchange:
  - ETSI NFV standard based multi-domain orchestrator.
  - Faster and dynamic network interconnection and Virtual Network Service deployment across multiple network domains.
  - Supports L1/L2/L3 Network services.
  - Allows creation of mesh topology among the testbeds.
- Can interconnect multiple access and cloud technologies across network domains.
- Can enable interconnection between multiple different testbed infrastructures(NDFF, 5GUK, INITIATE, Quantum etc.)



Interconnection performance



INITIATE Showcases

Orchestrating the Orchestra

Multiple musicians at different location.

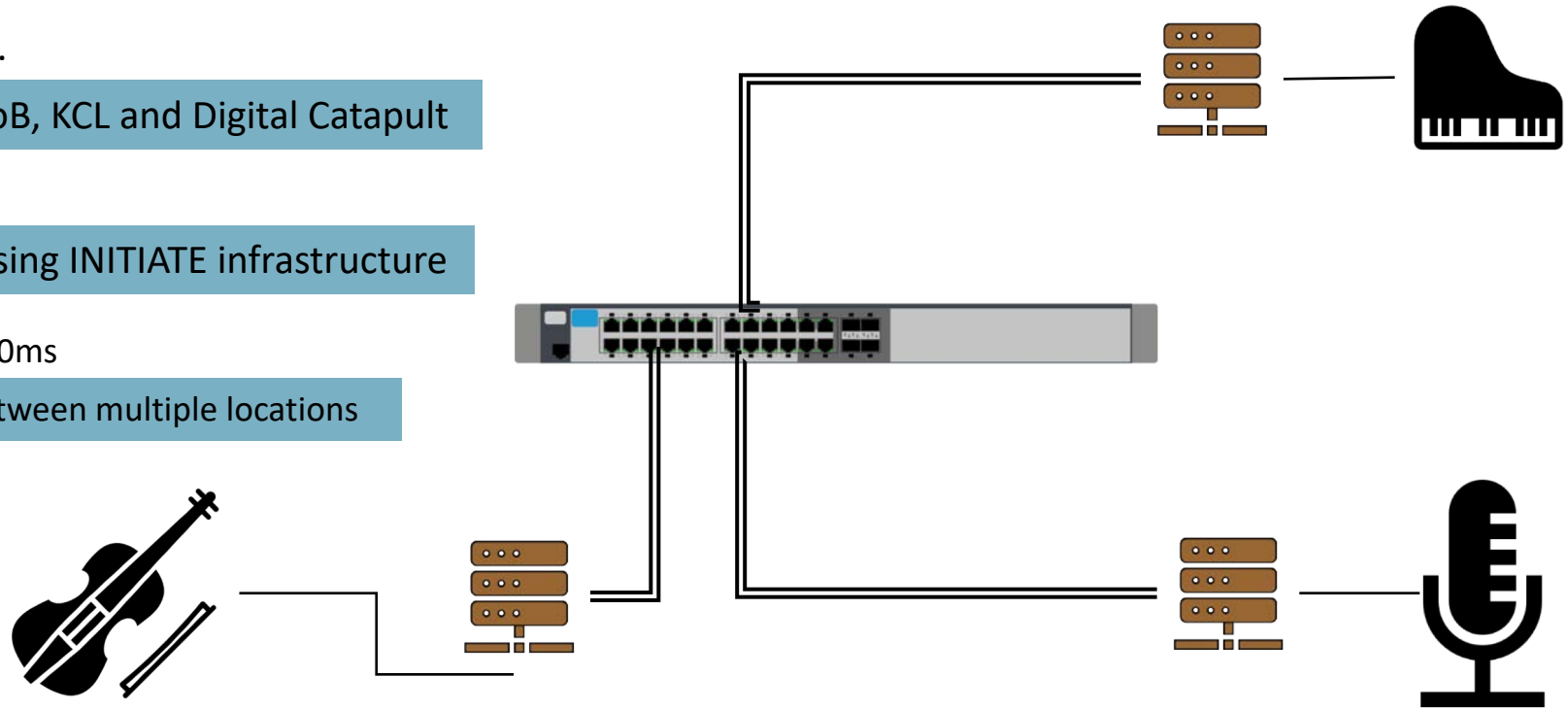
UoB, KCL and Digital Catapult

Collaboration needed in real-time.

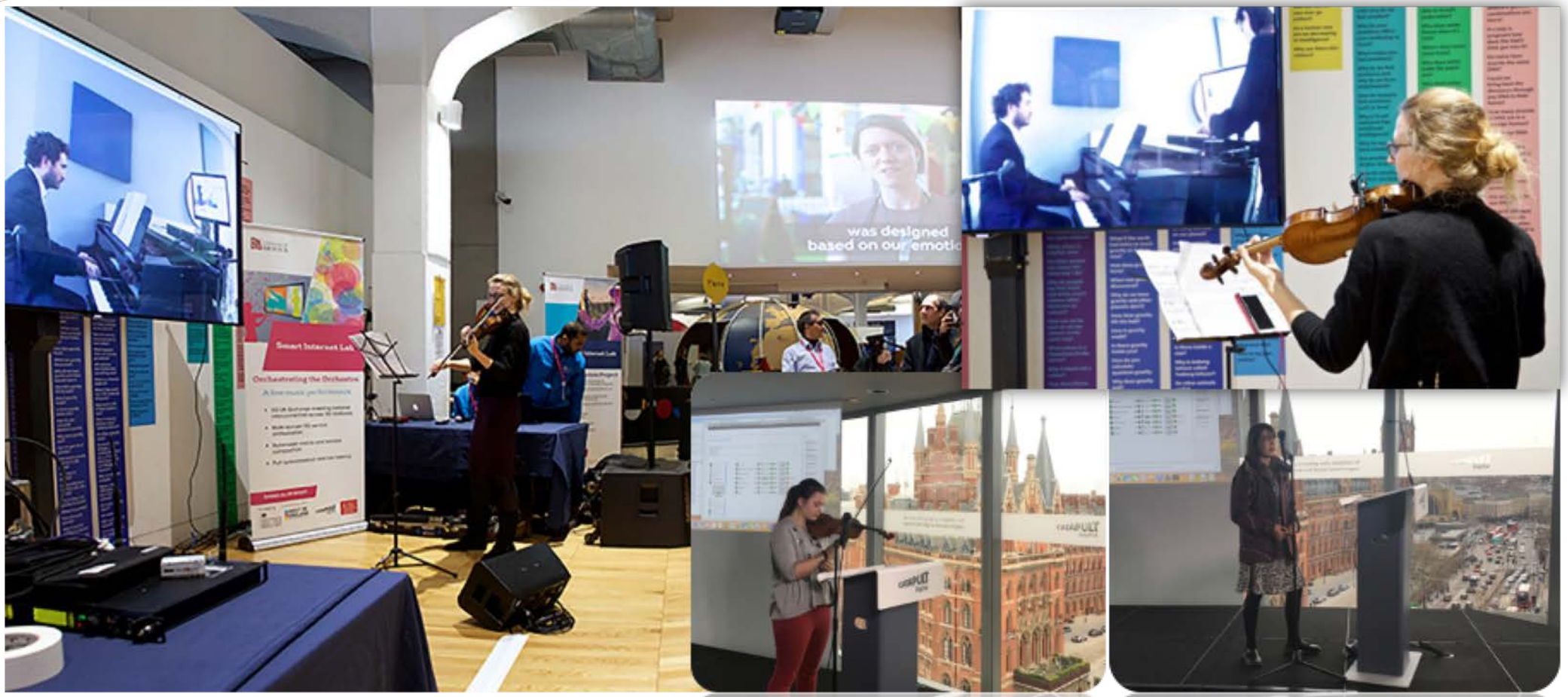
Sites connected using INITIATE infrastructure

Approximate latency between musicians : <30ms

Under 30ms latency achieved between multiple locations



INITIATE



EPSRC
Engineering and Physical Sciences Research Council

University of BRISTOL
Smart Internet Lab

THE UNIVERSITY OF EDINBURGH

Lancaster University

KING'S College LONDON

CATAPULT Digital

INITIATE Showcases

First 5G Music Lesson

Music Instructor located physically separated from students

Bristol, London and Birmingham

Multiple hops and additional connections required

INITIATE connected with the BT/EE's commercial 5G network

Approximate latency between musicians: ~30ms

Under 30ms latency achieved between multiple locations

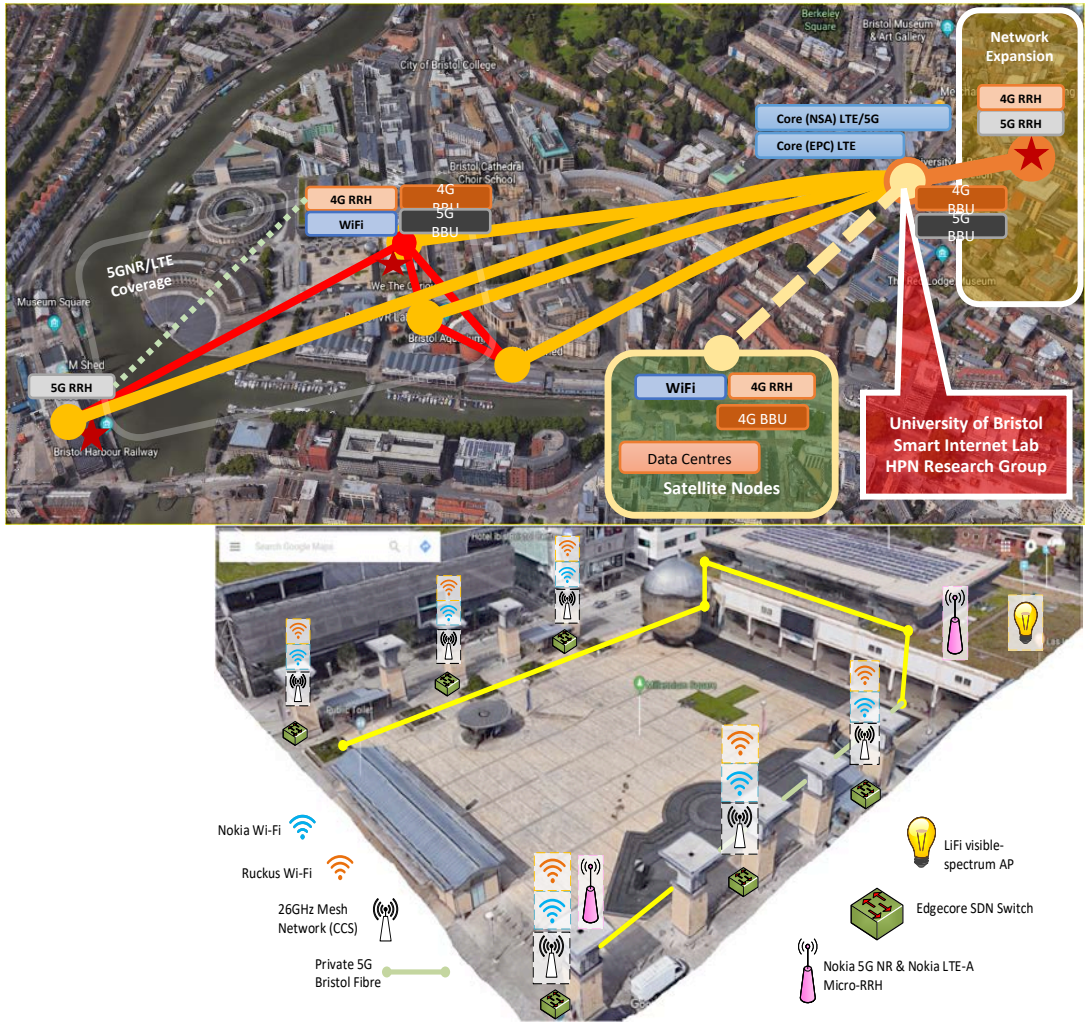
Navdeep Uniyal

Senior Research Associate,
University of Bristol

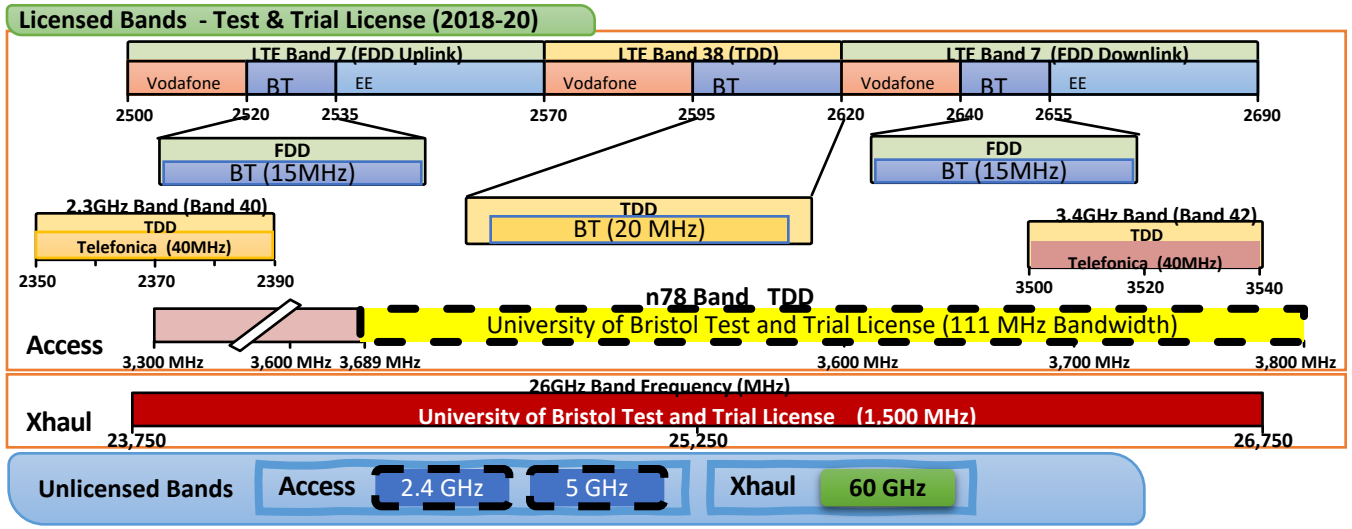
Testbed Capabilities

Smart Internet Lab Testbed

- Multi-site testbed:
  - HPN Lab (central datacentre)
  - We-The-Curious (science museum)
  - Millennium Square (open public space)
  - M-Shed Museum
- Capabilities:
  - Layer-2, optical switches.
  - FPGAs and P4 enabled switches.
  - GPU servers to support AR/VR applications.
- Further connections:
  - NDFF testbed
  - GEANT testbed



Radio and Access solutions

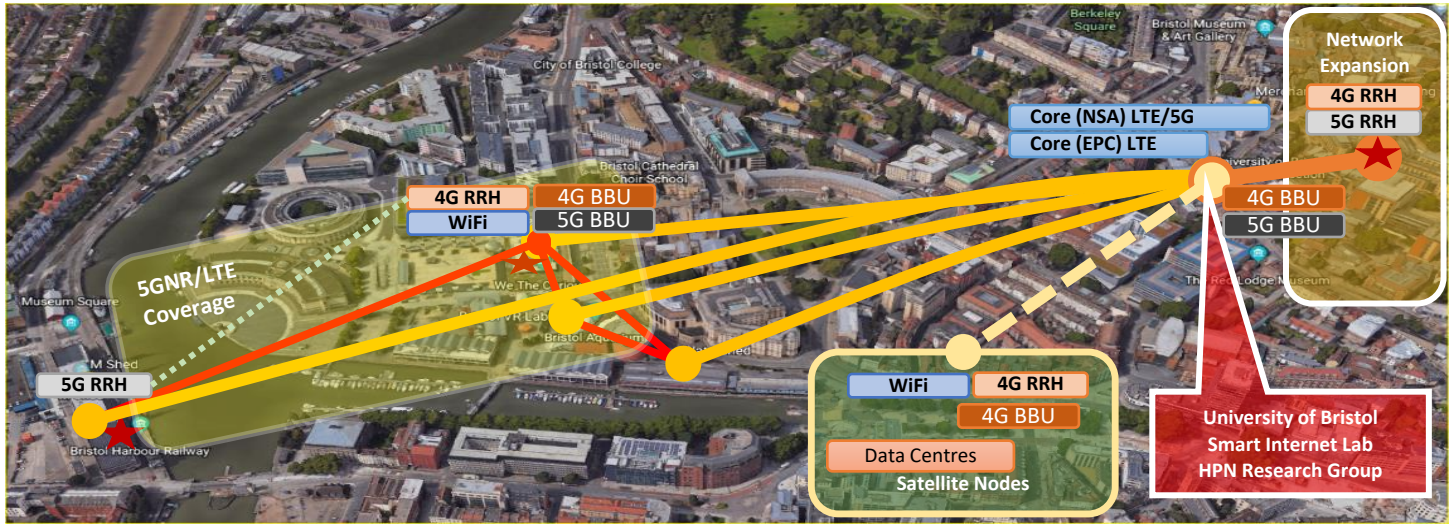


- Self-organising multipoint-to-multipoint wireless mesh network
  - CCS MetNet. A 26GHz with 112MHz T&D licence providing 1.2Gbps throughput
- Massive MIMO NR radio demonstrator
  - National Instruments (NI) Massive MIMO demonstrator 128 antenna base station
  - 12 client UE devices (TDD band 42 at 3.5GHz with 20MHz bandwidth)

- Multi-vendor Wi-Fi
  - SDN enabled Ruckus Wi-Fi (T710 and R720)
  - Nokia Wi-Fi (AC400)
- Nokia 4G and 5G NR
  - 4G EPC & LTE-A (Dual FDD licensed bands for 1800MHz and 2600MHz; with 15MHz T&D licence)
  - 5G Core & 5G NR Massive MiMO (TDD band 42 at 3.5GHz; with 20MHz T&D licence)
  - 28Ghz fixed-wireless access demonstrator for two-weeks exhibition

Optical network and Compute resources

- SDN enabled optical (Fibre) switched network
  - Polatis Series 6000 Optical Circuit Switch
- Voyager switches with combination of L2 capabilities and optical transponders.
- Fibre network with star topology
  - Centre at Smart Internet Lab
  - Fronthaul between the baseband units and RRH
  - Used as 10Gbps L2LAN connections between sites
  - Or dark fibre links within the sites.
- INITIATE's 10Gbps JANET link terminates at Smart Internet Lab datacentre.



Virtualization and Compute solutions:

- Open Source MANO
  - Openstack as the VIM
  - SRIOV and GPU Passthrough available.
- Nokia CloudBand:
  - Network EPC and NSA (proprietary solutions)
  - Nokia MEC

Network Management:

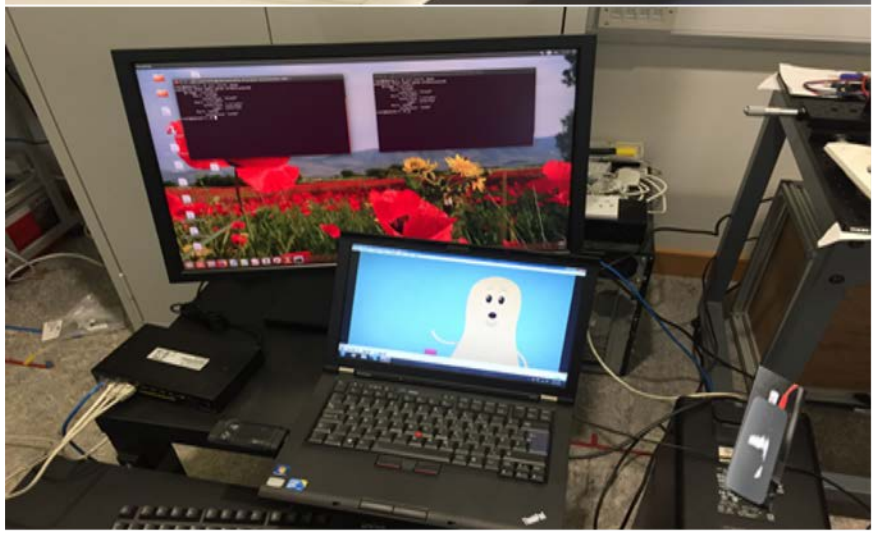
- SDN Controllers:
  - NetOS (Zeetta nw)
  - ONOS, ODL
- NetACT, Flexizone (Nokia)
- vMEC, EPC core, EPC-NSA 5GCore, IP Service router.
- OpenVPN based.

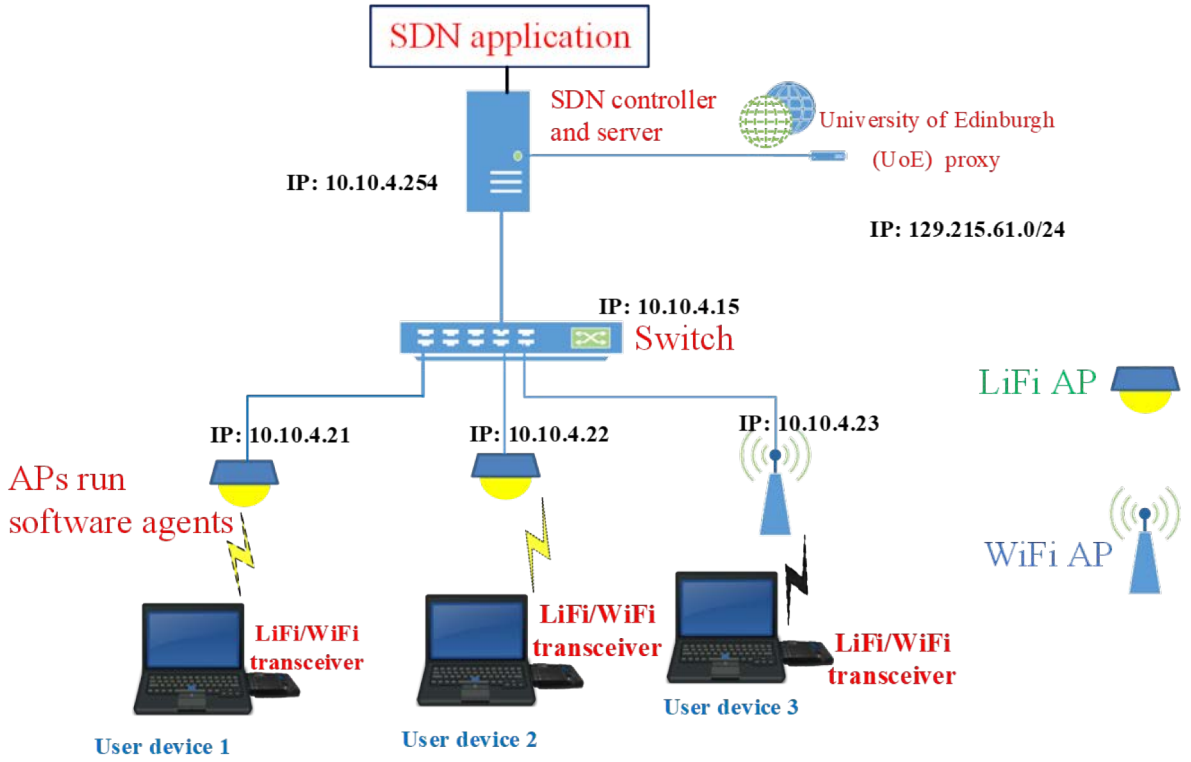
Professor Harald Haas

Chair of Mobile Communications,
University of Edinburgh

Testbed capabilities

Principal Lab Networking Testbed





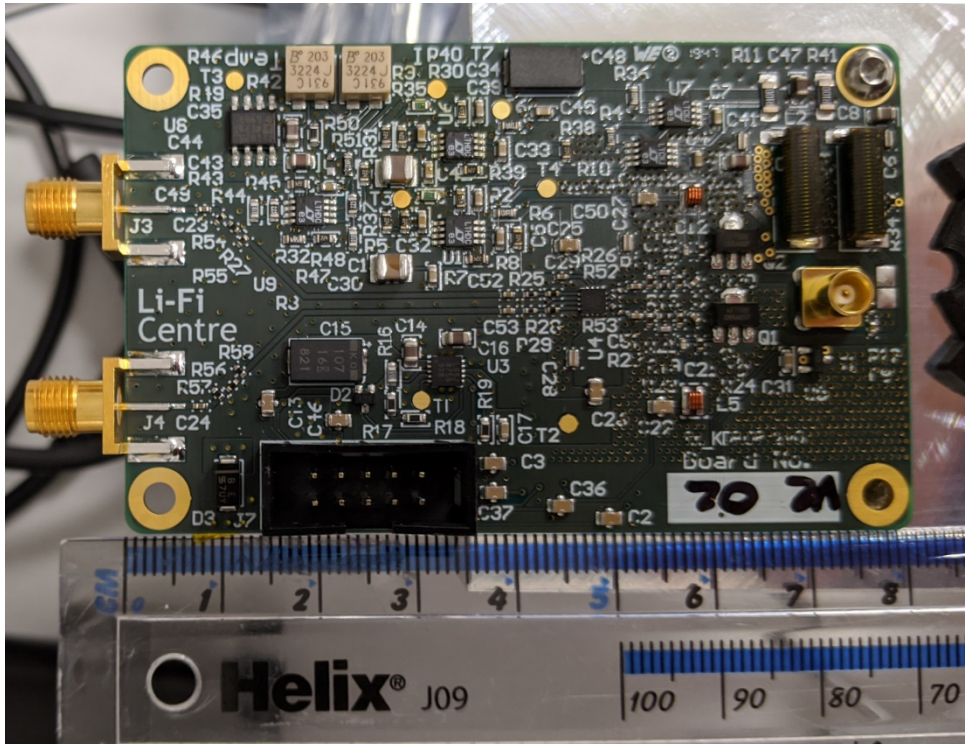
An experimental SDN-enabled LiFi/WiFi hybrid network testbed

Basic networking equipment

Optical wireless communication testbed

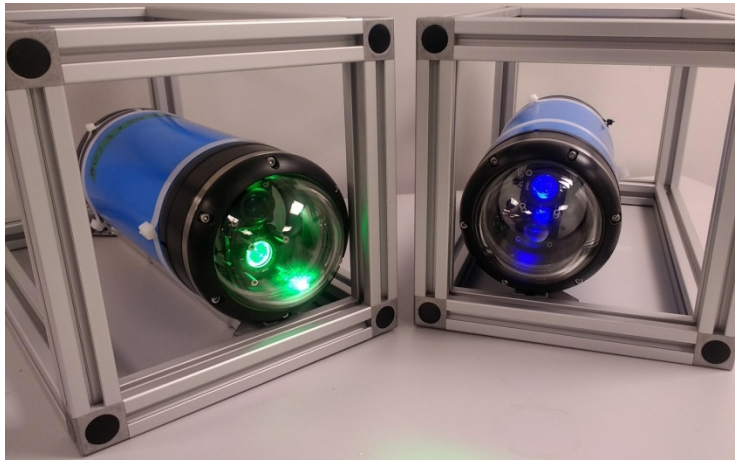
- Traffic and signal generators – capability of testing 1 Tbps optical wireless systems
- Multimedia server
- SDN controller OpenDayLight (ODL)
- LiFi indoor network
- PowerEdge server R440 server to support cloud applications and data storage
- HP switch 3810
- Laptops with LiFi dongles running as user devices
- Free-space optical communication system

Networked 1 Gbps LiFi Modem for experimentation



Extended Testbed capabilities

- 20 Gbps optical wireless backhaul. Features:
  - All optical relaying
  - Deployed in real-world cabin environment
- Novel Outdoor FSO system using solar panels as data detectors
  - Deployed on Orkney (5G RuralFirst)
  - Trialled at DSTL and UK Army
- Underwater communication test facilities (e.g., Flowave)
- Multi-access point LiFi network
  - to experiment on interference management, handover, multiuser access, etc.
- 20 Gbps LiFi link (3 m distance) demonstrated at CES 2020
- NI PXI Testbed (12 FPGA's, DAC/ADC)
  - LiFi dimming demonstrations



Dr. Steven Simpson

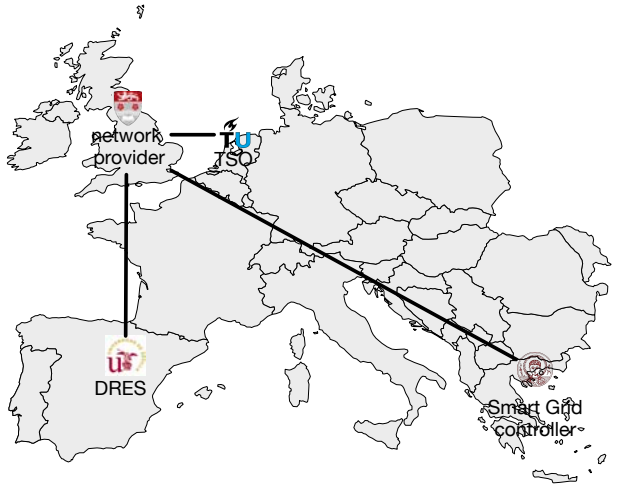
Senior Research Associate
Lancaster University

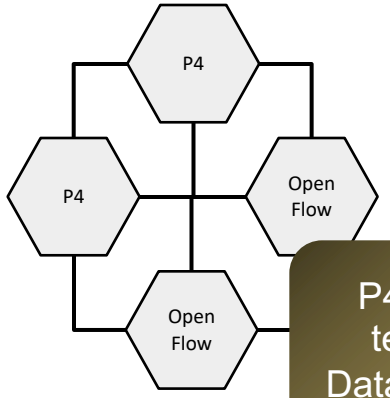
Testbed Capabilities

Lancaster testbed features

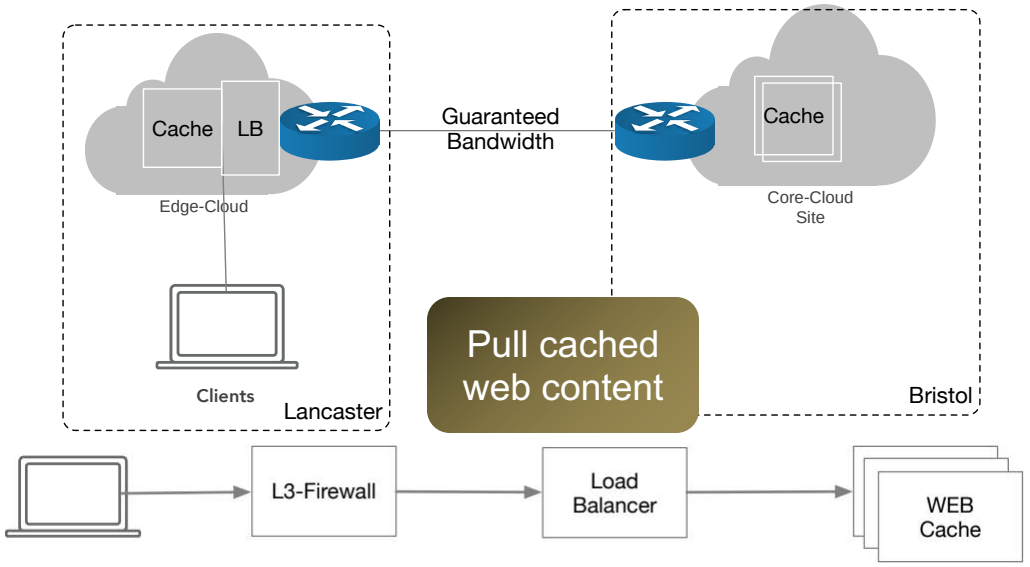
- Computer resource
  - OpenStack cluster: 200 cores, 8 TB mem.
  - Ceph storage service.
- Networking resource
  - 10/40 GbE NICs with pass-though support.
  - 10/40 GbE OpenFlow switches (HP, Corsa, PICA8).
  - 4x10 GbE NetFPGA traffic generation/capture.
  - Precise local resource control via DPB.
- Network Programmability
  - Infolab21 OpenFlow production network.
  - Multi-vendor P4 support (FPGA, NPU, ASIC).
- Rural connectivity
  - B4RN peering, probe hosting.
  - TV Whitespace wireless testbed.

Selected Lancaster applications





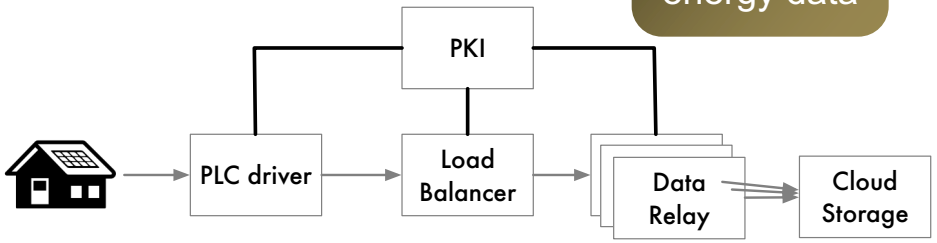
P4/OpenFlow testbed with Dataplane Broker



Pull cached web content

Gather renewable energy data

Act as micro-datacentre



Customize through OpenVPN

Probe and interact with rural broadband network

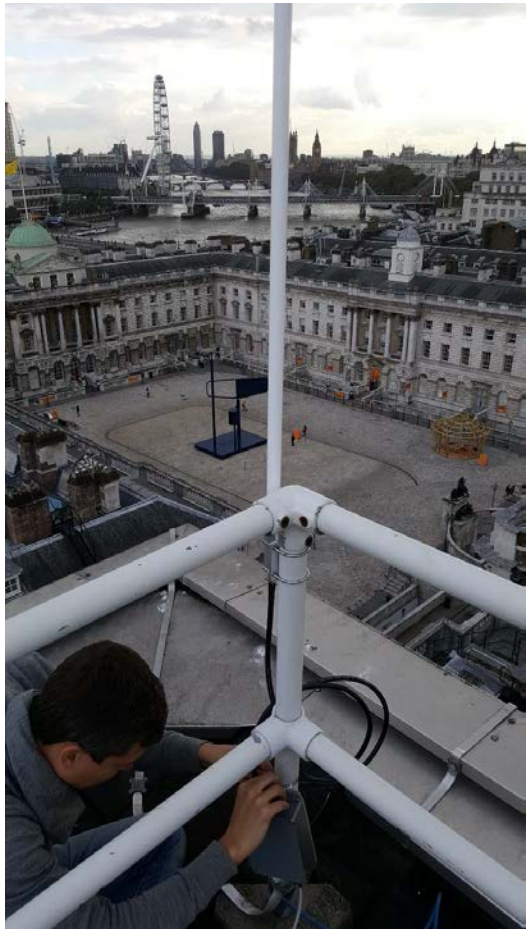
Dr. Konstantinos Antonakoglou

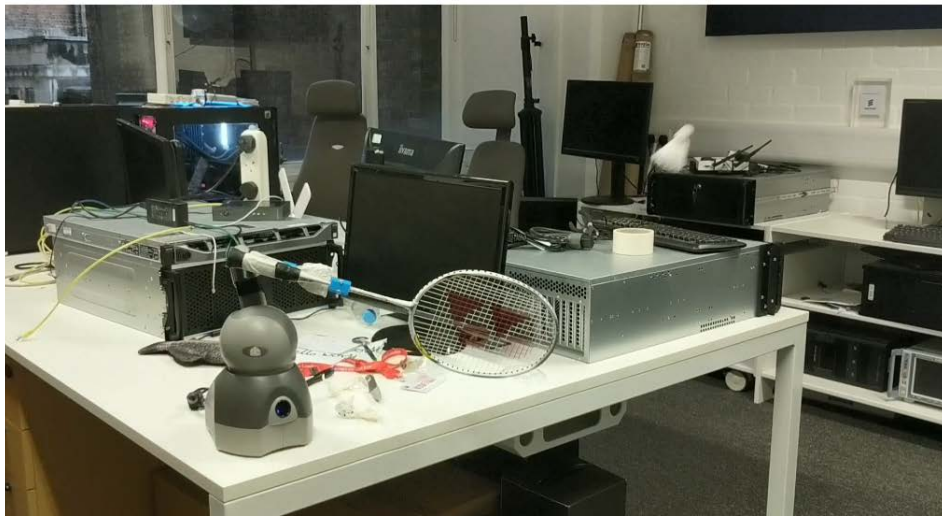
Research Assistant, King's College London

Testbed Capabilities

Main testbed areas

- KCL Tactile Internet Lab
- Converged Core Network
- 5G Antennas at the Rooftop





System Capabilities

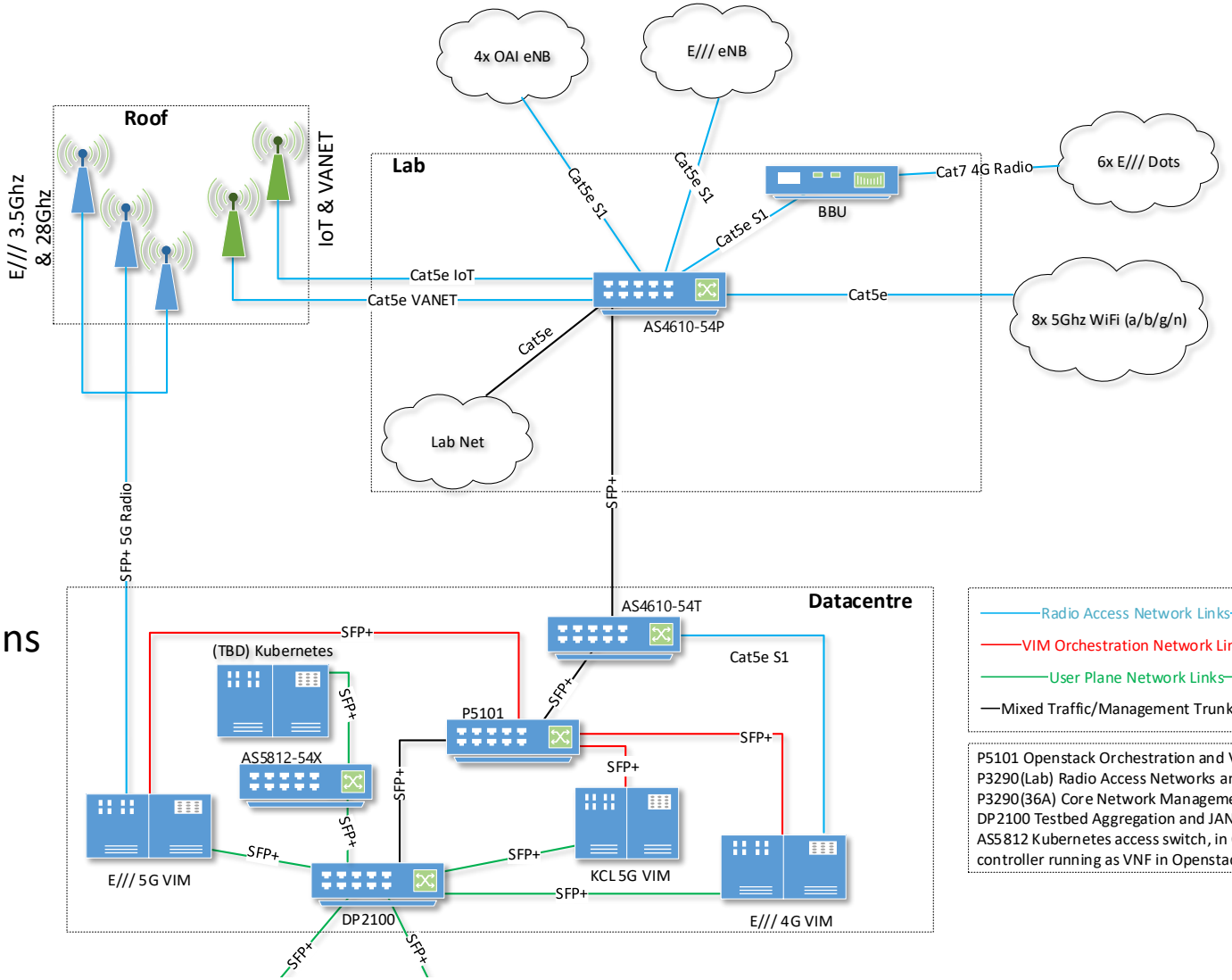
- Wireless access including
  - 5G New Radios: 28GHz and 3.5GHz
  - Open Air Interface 4G LTE
  - Commercial macro cell 4G LTE, and small cell equipped with WiFi
  - Test UEs
- Virtualised RAN and mobile core network
- OpenFlow switches, SDN compliant
- Optimised Openstack deployment for VNF hosting
- Kubernetes deployment for microservices
- MANO orchestrator design, applied to current system

- External connectivity includes
  - 8 dark fibre pairs available for connectivity to the core
  - 10Gbps fibre network for external & industrial access links
  - VPN available for easy connection of remote networks/devices

Use cases & network topology

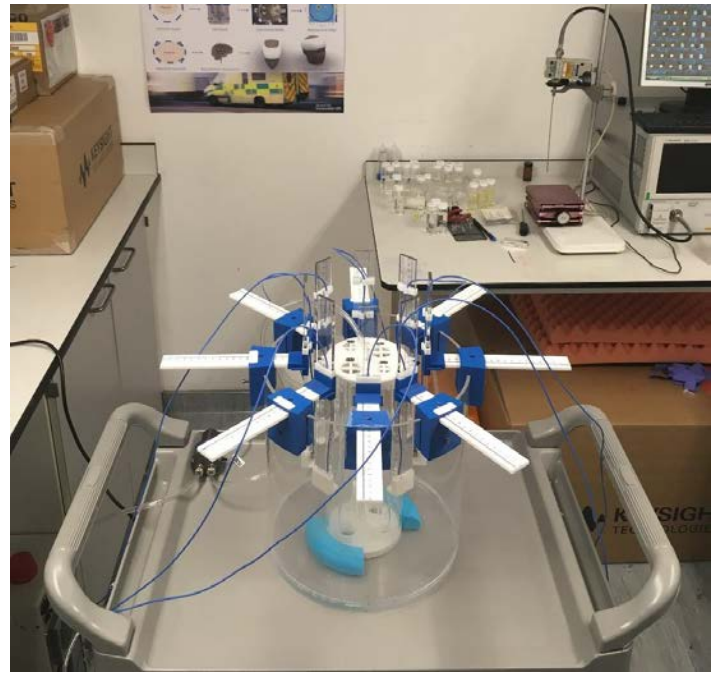
- Telementoring
- UAV control

- Remote diagnosis (e.g., using haptics)
- Edge-assisted/cloud-based AI applications



Application-Level Capabilities

- Compute nodes are configured similarly with 128GB of memory and two Intel E5-2699A CPUs of 44 cores each (88 virtual processors) clocked at 2.4GHz.
- 3 x GPU Racks (2 x NVIDIA Titan V, 4 x NVIDIA Nvidia Geforce Gtx 1080)
- 3 x haptic devices (1 x Ethernet and 2 x USB interface)
- 1 x NVIDIA Jetson Nano
- Medical diagnostic devices
- VIVE Pro VR headset

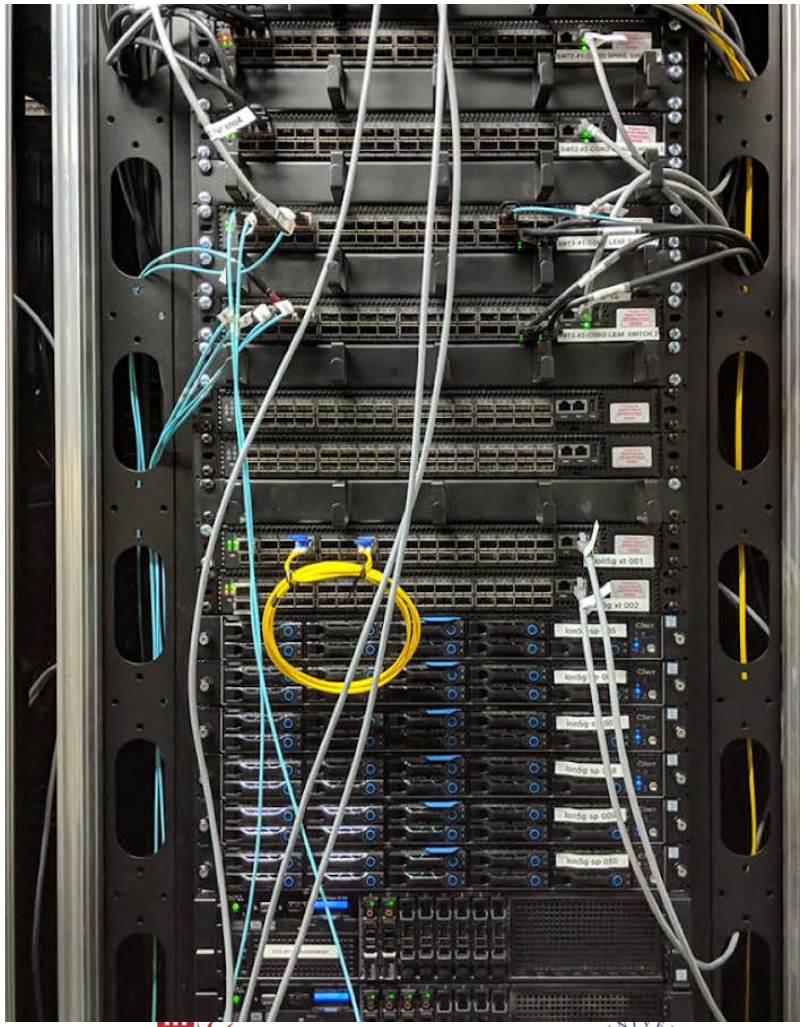


Dr. Kostas Katsaros

Senior 5G Technologist, Digital Catapult

Testbed Capabilities

Digital Catapult's 5G Testbed Facility



Locations:
Brighton Dome and Corn Exchange (1200m2),
Fusebox (650m2),
Digital Catapult London (120 - 600m2)

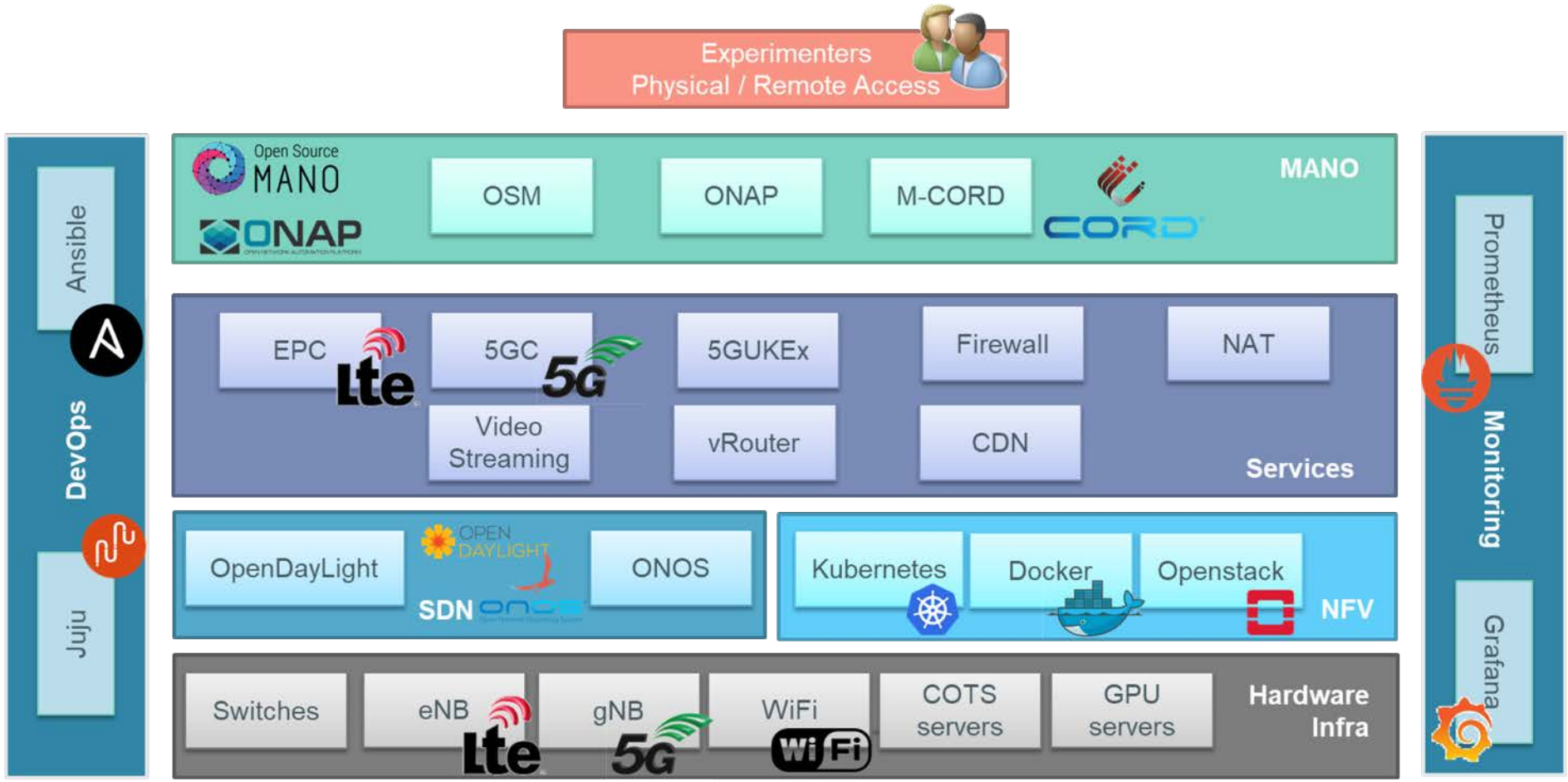
Spectrum:
B7 (15 & 20MHz), B8, B5, B77 3.4-3.6GHz (5GNR)
NOD licence (Ofcom)

Connectivity & computing hardware
18 LTE small cells (Airspan)
5GNR (3GPP Rel.15)
18 WiFi nodes (Cisco Meraki and Ruckus)
14 switches (10 SDN)
>1400 cores compute (Dell servers)
1Gbps intersite connectivity
1Gbps Janet connection with NetPath2
representation in Virtus 5GUKEx
3 PaloAlto enterprise firewalls

Software
Commercial LTE core with local breakout (Quortus)
5G NSA Cores (Open5GCore and Amarisoft)
OpenStack
OSM (modified with University of Bristol)

Devops-enabled operations

High Level Architecture and Components



5G Testbed Accelerator Programme (5GTAP)

Q&A

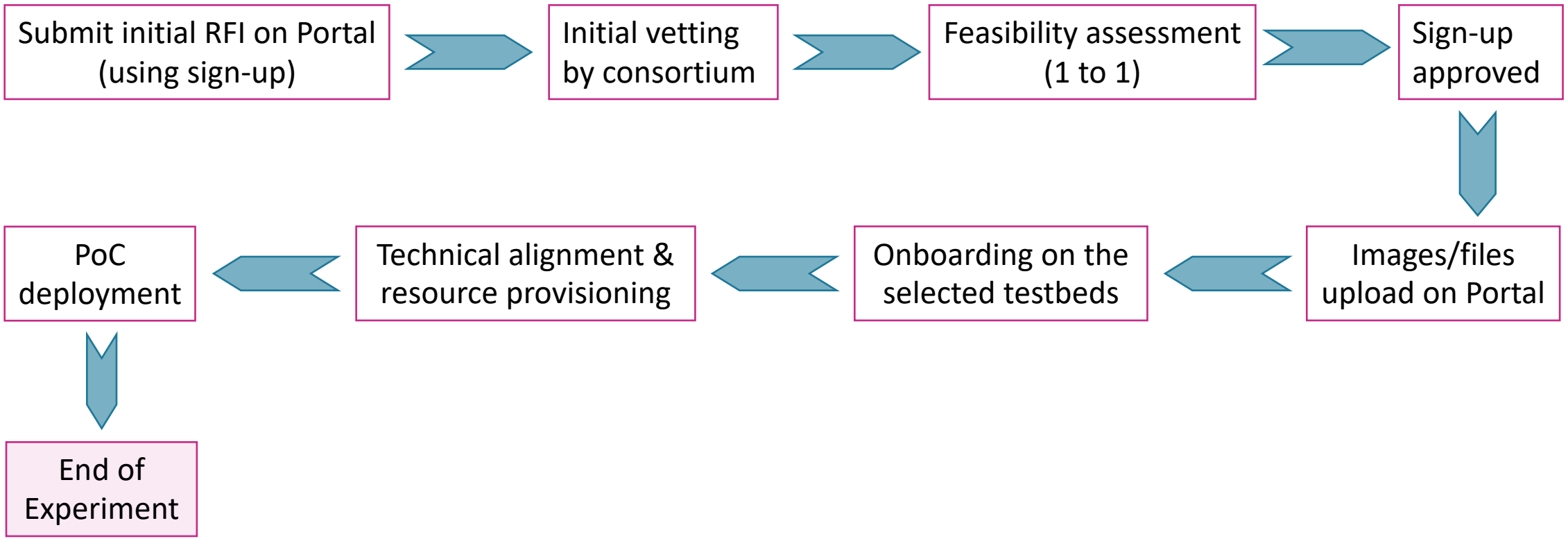
INITIATE Web Portal

Engagement process

Navdeep Uniyal

Dr. Konstantinos Antonakoglou

Engagement Process



Steps explained

- Feasibility Assessment:
  - Identify equipment and network provisioning support
  - Identify access network type
- Technical Alignment and resource provisioning:
  - Record equipment and network details to be used (shared document/DB)
- Onboarding use-case:
  - Provide equipment and configure the network (as needed)
  - Use case deployment by SMEs
  - Monitor network and devices (continuous)
- End of experimentation
  - return equipment, decommission compute/network resource, revoke VPN, remove snapshots

INITIATE Portal

- Registration for '*Request for Interest*'
- Easy to engage portal:
  - Upload images and (or) descriptors.
- Provision to download specific test-site related access tokens.

*Log on to http://initiate.ac.uk

Portal Demonstration

Thank you!

Illustrations from the workshop

Charles Waples, Innovation Coordinator

Digital Catapult

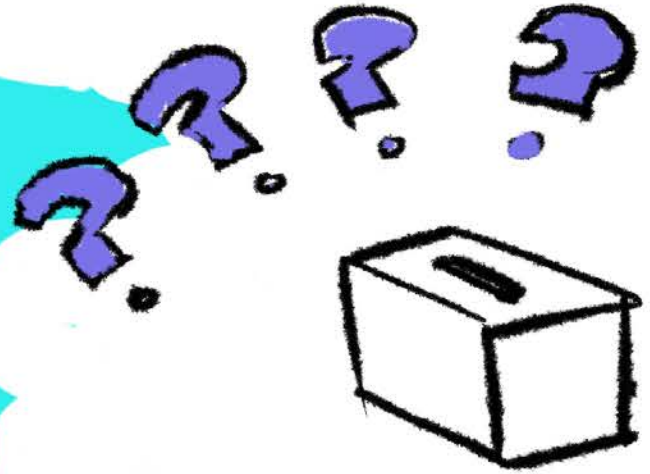
INITIATE

WELCOME AND INTRO..

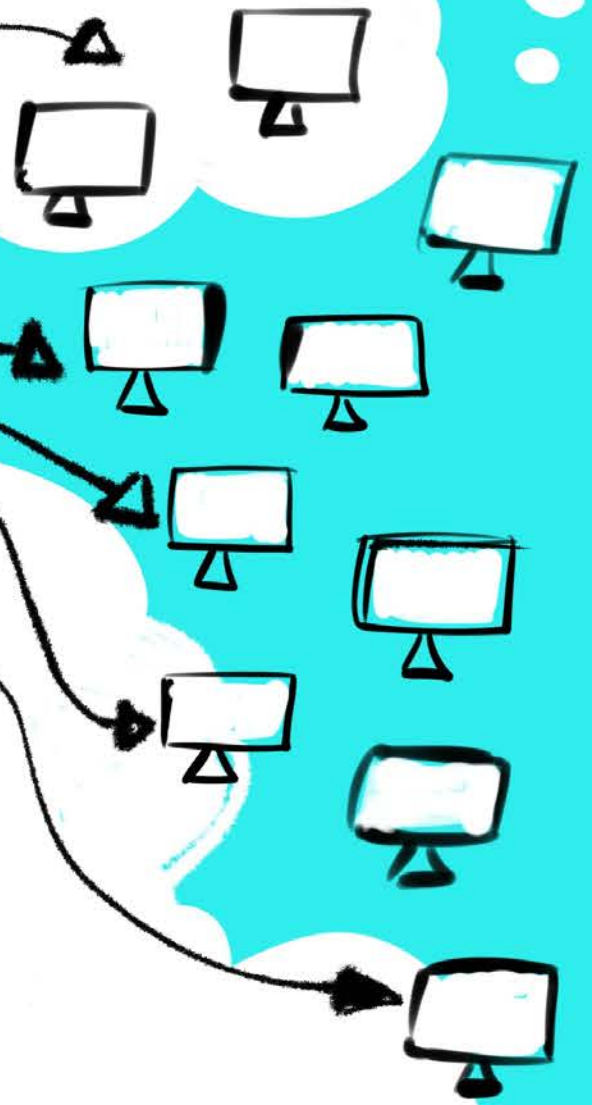
FROM DANA ELMAN...

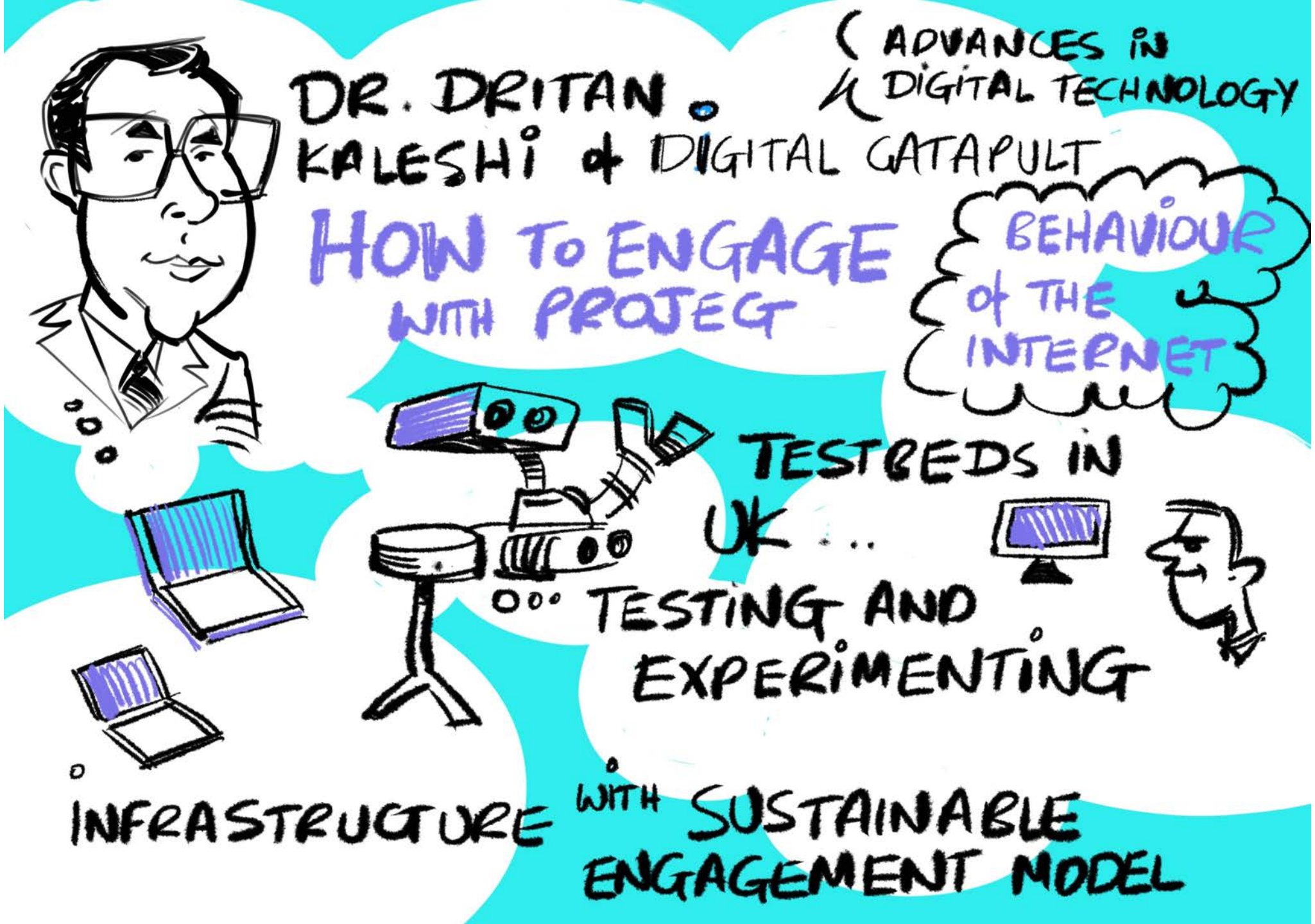
ZOOM!

Q AND A BOX



FUTURE RESEARCH




DR. DRITAN KALESHI
ADVANCES IN DIGITAL TECHNOLOGY
of DIGITAL CATAPULT
HOW TO ENGAGE WITH PROJECT
BEHAVIOUR of THE INTERNET
TESTBEDS IN UK ...
TESTING AND EXPERIMENTING
INFRASTRUCTURE WITH SUSTAINABLE ENGAGEMENT MODEL

BRISTOL UNIVERSITY

OVERVIEW

PROF. DIMITRA SIMEONIDOU

INFRASTRUCTURE

UK... NATIONAL SCALE?

PILOT

TESTBEDS DEVELOPED TO SCALE UP TESTBEDS

CONNECTIVITY TO INTERNATIONAL

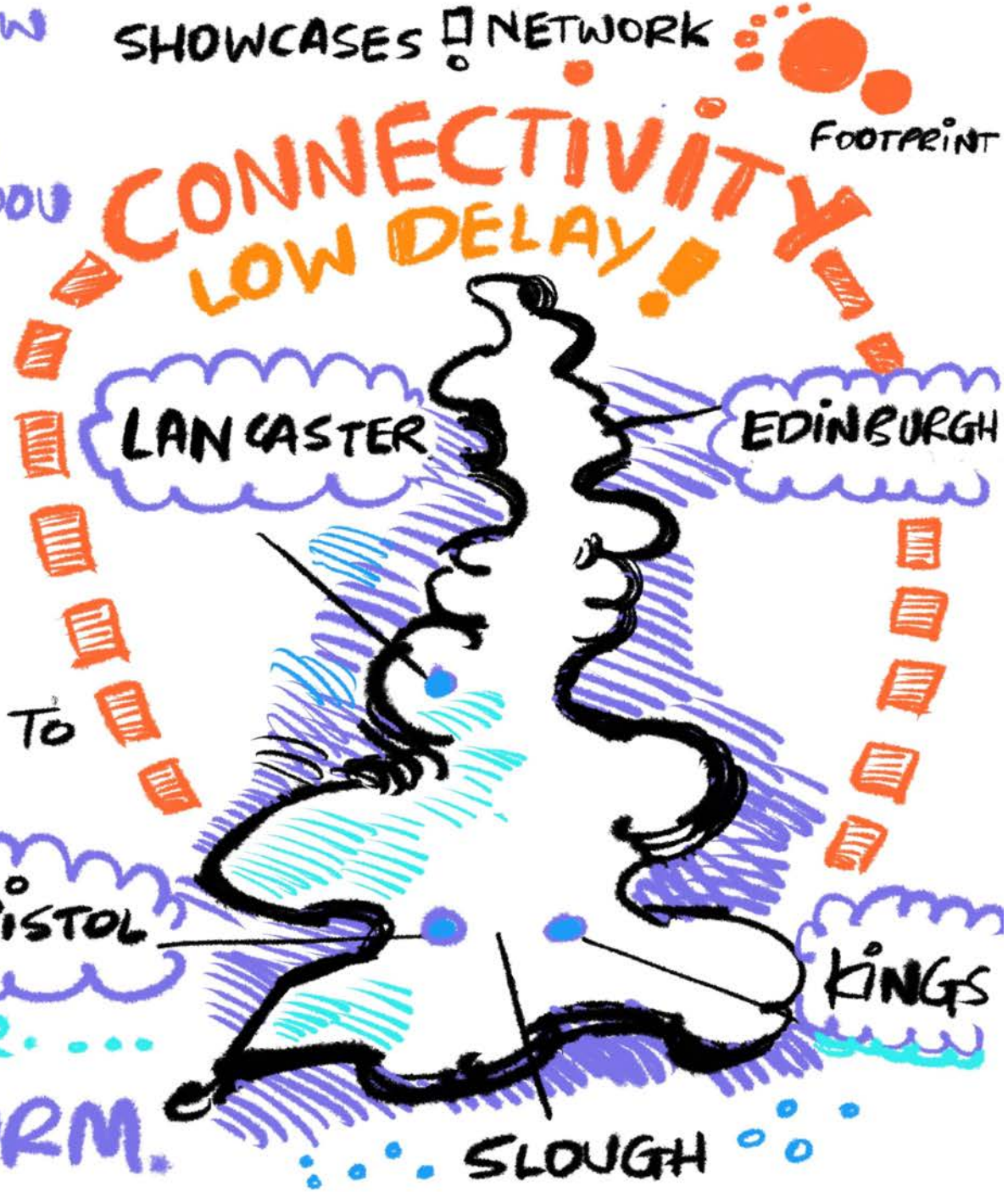
DCMS programme....

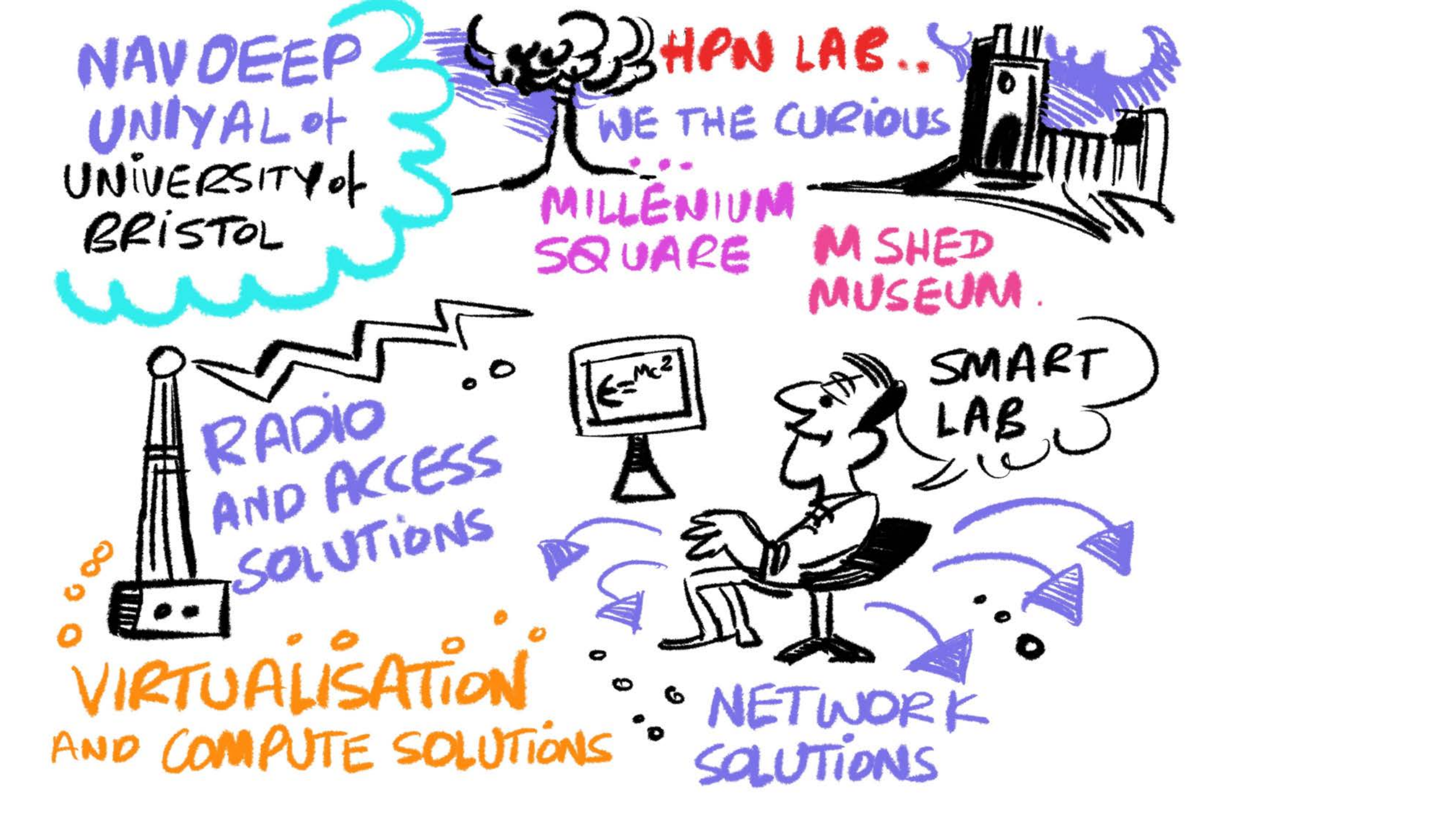
OPEN PLATFORM.

SHOWCASES & NETWORK

CONNECTIVITY LOW DELAY!

FOOTPRINT




NAVDEEP
UNIYAL of
UNIVERSITY of
BRISTOL
HPN LAB..
WE THE CURIOUS
...
MILLENIUM
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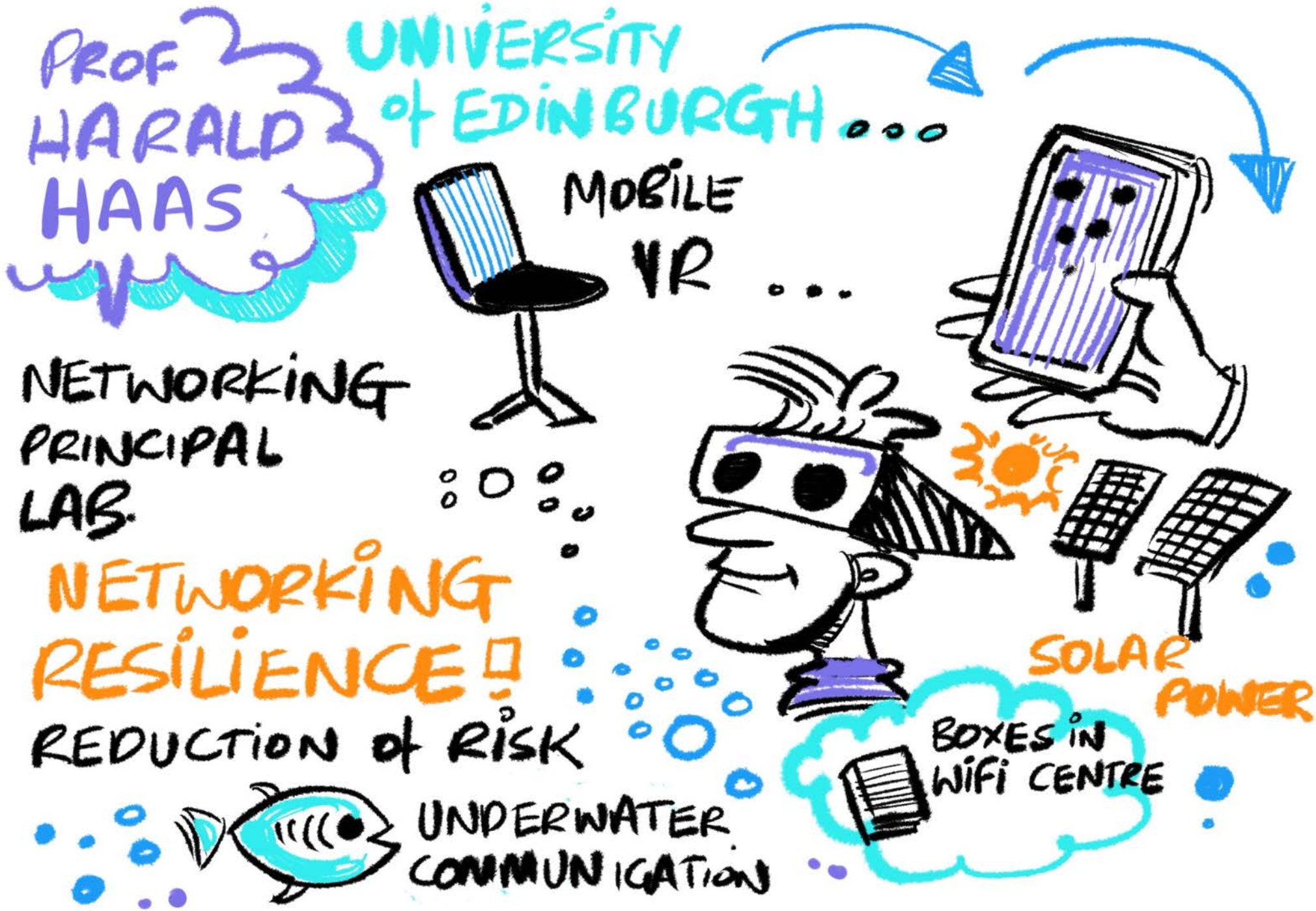
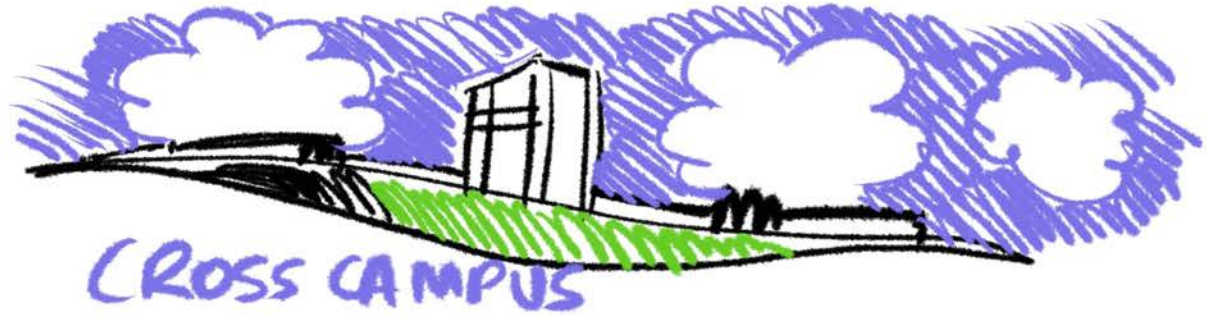
M SHED
MUSEUM.
RADIO
AND ACCESS
SOLUTIONS
$E=mc^2$
SMART
LAB
VIRTUALISATION
AND COMPUTE SOLUTIONS
NETWORK
SOLUTIONS


PROF HARALD HAAS
UNIVERSITY of EDINBURGH...
MOBILE VR ...
NETWORKING PRINCIPAL LAB.
NETWORKING RESILIENCE!
REDUCTION of RISK
UNDERWATER COMMUNICATION
SOLAR POWER
BOXES IN WiFi CENTRE

LANCASTER UNIVERSITY



OPEN FLOW...

CONNECTIVITY TO BARN NETWORK

Dr. KOSTAS ANTONAKOGLOU

KINGS COLLEGE

5G RADIO

SDN COMPLIENT

MICRO

TESTBED CAPABILITIES:

- DIAGNOSTICS
- EQUIPMENT FOR VR

KOSTAS
A dom
D.C.

BRIGHTON
BRIGHTON DOME

LONDON

DATA
CENTRE

5G INTERCONNEGION

PHYSICAL
INFRASTRUCTURE ...

ACHIEVES
KPI'S

OFFER TO SME'S, TO WORK
ON APPS AND

Q AND A.

Q: INITIATE SUPPORT IP OR OTHER TECH?

A: POSSIBLE TO LAYER ON TOP

A: NEW PROTOCOL TRIALS/DEVELOPMENT!

Q: AFTER JAN 2021, - PLANS FOR FACILITY

A: SUSTAINABILITY A BIG QUESTION

1/ INFRASTRUCTURE 2/ TOOLS

OPEN SOURCE CAPABILITY TO BE SHARED...

DEVELOP USER PORTAL...

KEEP AND GROW EXISTING FACILITY!

JOURNEY SHOWCASES ⇦ SCALE/PILOT FORWARD

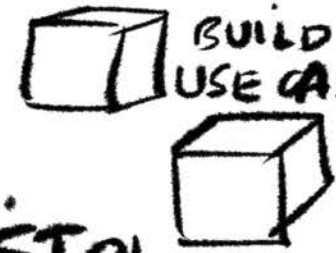
+ 5G TESTBEDS AND TRIALS

+

• TOOLS TAKEN FORWARD/LARGE INTERCONNECTION AWARE & ONGOING INITIATIVES

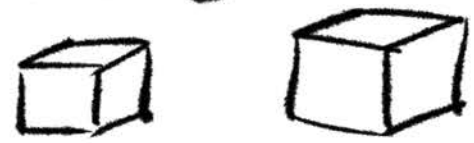
Q: MULTI CAMERA BROADCASTING,
BASED IN RURAL AREA (POOR CONNECTIVITY)
— HARD FOR R AND D...
PLAN TO INCREASE TEST BEDS....
= WELCOME MICRO ENTERPRISE

RURAL EXPANSION



A. YES.

MICRO ENTERPRISE AT BRISTOL
VERY IMPORTANT!
LOCAL USE & TESTBEDS...
FIBRE CONNECTIVITY ... INTO INITIATE
IS A LIVE CATALOGUE



HOSTS WELCOME

RELY ON RELATIONSHIPS

PRECENCE IN EAST ANGLIA

Q+A: Q: HOW WE CAN OFFER ACCESS TO DIFFERENT LAYERS.

A: ADDRESS THIS P.M. eg: COMMERCIAL

= SET OF SERVICES AND ASK DAVID SALMON

Q: DETAILS of ROADMAP/UPGRADE?

A: LOG ONTO INITIATE WEBSITE ...

TECH DETAILS? CONTACT THROUGH SITE

AND IN NEXT SESSION...