A Holistic Approach to Future Networks Research

Prof. Dimitra Simeonidou FREng, FIEEE
Director Smart Internet Lab, Co-Director Bristol Digital Futures Institute
University of Bristol, UK
Smart Internet Lab@Bristol: Who are we?

Founded by three research groups

• Communication Systems & Networks,
• High Performance Networks,
• Photonics & Quantum (Optical Comms)

Combined expertise across optical, wireless, IoT and cloud technologies

Research across:

• Enabling technologies, Systems and Networks, Services and Applications

Holistic approach to end-to-end network design and optimisation

Extensive expertise on hardware, software and co-design

Real world deployments and large-scale experimentation

Current research portfolio: 22 projects (EPSRC, Research England, DCMS, EU, Industry

bristol.ac.uk/smart
End-to-End Network Research @ Smart Internet Lab

#1 – Multi-access Convergence (Radio + Fibre) & Mobile Edge Computing
Integration of MEC and network edge (programmable hardware)
AI and processing at the edge: Infer User preferences for network service requests

#2 – Wireless, Fibre & Satellite Backhaul
High performance, elastic high bandwidth backhaul

#3 – Network Slicing & Service Orchestration
Dynamic network slices, multitenancy, protection and prioritisation of services
End-to-end intelligent service orchestration-multi-technology & multidomain

#4 – User Experience
Use cases relevant to the industry and public
Co-creation: Users Involved in the innovation Cycle
Test Networks @ Smart Internet Lab

Digital Catapult (London)
KCL London

Campus Core Network
Harbourside (Centre), Bristol

NCC and CFMS @ Science Park
Science Park (High Value Manufacturing)

Avonmouth Port
M4/M5 & Avonmouth (Highways and Ports)

Digital Catapult
KCL (London)

City Scale Network
5G Exchange Slough Virtus Data Centre

Private Leased Line

Bath: Roman Bath
Cathedral square, Bath

• Smart City
• Freeport Zones
• Transport
• Logistics
• Manufacturing
• Security
• Assisted Living
• Robotics

• Smart tourism
• Digital Media
• Music & Sports
• Public safety
• Connected Homes

bristol.ac.uk/smart
Key Research Focus on Future Networks and 6G
Future Networks Trends

- Deep disaggregation, starting with RAN (SW and HW functions)
- Softwarisation and Cloudification
- Full Convergence (IoT, wireless, optical, satellite, subsea, computing)
- Edgeification (Moving functionality to the edge)
- Automated, Autonomous Networks
- Native Resiliency and Security
- Towards Net zero networks
- Petabit Networking
- Networks +Sensing & Human-centricity
- Quantum Internet
- Time Critical Networks
- Future Networks Trends: Full Convergence (IoT, wireless, optical, satellite, subsea, computing)
- Open Architectures starting with RAN (Open RAN)
- Softwarisation and Cloudification
- Automate, Autonomous Networks
- Native Resiliency and Security
- Towards Net zero networks
- Petabit Networking
- Networks +Sensing & Human-centricity
- Quantum Internet
- Time Critical Networks
From Automated to Autonomous Networks

Self-Composable and Self-Driving Networks

Zero Touch and ML Assisted Network Orchestration

- Autonomous VNF Placement
- VNF Life Cycle Management
- Predictive Network Function Profiling & Scaling

MultiTech, Multidomain Orchestration

- Optical
- Edge Computing
- Wireless Network

End-to-End Slicing

Disaggregated Networking

- Disagreed/Virtualized RAN
- Disagreed Optical Network

Telecom Infra Project (TIP), O-RAN, ONF

Deep Learning, Adaptive Learning, Federated Learning and Game Theory

bristol.ac.uk/smart
Disaggregated RAN: Evolution Towards Open RAN

Why?

- Accelerate multi-vendor interoperable solutions in the RAN domain
- Enabling supply chain diversity

Our Research

- Innovation via Adoption of New Technologies (AI/ML)
- RAN programmability through RIC leading to new optimisation solutions
- Opportunity to integrate fibre access with fronthaul/midhaul
- Integration: RAN integration with MEC and 5G Core and their overlapping orchestration platforms
- End-to-End Performance related to multi-vendor solution

bristol.ac.uk/smart
Evolution Towards Open Networking

Open E2E Architecture – Open RAN, MEC and SGC Integration

Service Management & Orchestration (SMO)
- Policy Based Guidance
- Non-Rear Time RIC
- MEAO

Core Network Orchestration
- SDN Control

Service Management & Orchestration (SMO)
- MEAO
- Non-Rear Time RIC
- Policy Based Guidance

Deployment 1
- Option 7.2x
- RU + DU

Deployment 2
- RU + DU

RU
- O-FH

CU
- O-RAN Vendor 1

DU
- Near RT RIC

Edge-Cloud

LADN
- Mm3

MEC Host 1
- Mp1

MEC Host 2
- Mp2

Edge-Cloud

Transport Network

SFC
- NSSF
- NEF
- NRF
- AUSF
- UDM

AMF
- N6

UPF
- N3

SMF
- N4

xApps
- N2

CU
- E2

RU
- O-FH

CU
- E2

RU
- O-FH

CU
- E2

RU
- O-FH

CU
- E2

RU
- O-FH

CU
- E2
Edgification: Enhanced Network Edge Functionality

- Multi-Access (wireless, VLC and fibre)
- Manage KPI trade-offs (latency, throughput, location accuracy, ...)
- Traffic management/aggregation
- Elastic bandwidth allocation (frequency, time, space)
- Programmable packet processing
- Acceleration technologies, including GPUs, Smart NICs, FPGAs and etc.
- Synchronization capabilities (in-band)
- Support for HW accelerated encryption/decryption
- Execution of AI/ML models at the edge
Edgification: Mobile Edge Computing

Research Focus:

• 5G + Edge Computing + AI:
  • Enabling intelligence in vertical sectors
  • Support for privacy-sensitive data processing

• MEC + Open RAN:
  • Share and control easier/better/interoperable MEC resources accessible via multiple distributed units

• Service handover delay in high mobility scenarios

• Security: MEC nodes more susceptible to attacks

bristol.ac.uk/smart
Demands for IoT Driving the Evolution from 5G to 6G

- **Massive IoT Introduction**
- **Machine-to-Machine Communication**
- **Cloud IoT Data Processing & Analytics**
- **AI & IoT (Analyse & Act)**

**Total # of installed IoT devices**
75.4 billion (source Statista)

**Continuous monitoring**
and associated privacy and security has become more important than ever!

**Integration of IoT within the 6G network**

- **One Model – Single standard Interface**
- **Distributed Auto-ML**

**Brain to Machine**

**Human Integration with sensors &**
**Human-centric models**

By 2030 the number of internet connected devices will reach 500B,
59 times more than the predicted world population.

bristol.ac.uk/smart
The Case for Human-Centric Networks

• Today’s mobile networks device-centric: users take part in the interaction only through their personal devices
• If devices are the main users of the network, what will be the role of humans in the service delivery chain?
• Collective Intelligence= Human + Machines + infrastructure
• Sociotechnical principles and social practices as the foundation for the design of future networks (responsible innovation, sustainability, inclusion, privacy, trust...)
• Co-creation of future connectivity and services with the end users
Reality Emulator: An Evolved Digital Twin for 6G Research

Virtual Production:
- Data Analysis/Scaling
- AI/ML, training
- Software-Hardware
- Security
- Protocol Design
- 6G Emulation
- Scenarios’ creation

Real Data

Iterative

Digital Twin Creation

Iterative

Digital Model

Continuous evolution and optimization (pre-trained ML models)

Services

Immersive Experiences (Users)

Multi-user
Multi-purpose
Interactive
Multisensory

bristol.ac.uk/smart
Smart Internet Lab: A Holist Approach to Networks Research

Design of future network and service architectures at scale

Co-creation with the end users: experience driven innovation

Address Security, privacy, Net Zero carbon emission for Telecoms- Responsible Innovation

Addressing societal challenges
Thank you

dimitra.simeonidou@bristol.ac.uk