INTRODUCING THE 5G-PPP 5G-XHAUL PROJECT

Anna Tzanakaki (University of Bristol, NKUA)
1. CONSORTIUM OVERVIEW

- IHP GmbH (Coordinator)
- ADVA Optical Networking
- Airrays GmbH
- Blu Wireless Technology
- COSMOTE
- Fundació i2CAT
- Huawei Technologies
- TU Dresden
- Telefónica I+D
- TES Electronic Solutions
- University of Bristol
- University of Thessaly

- Universities (3x), Research Institutes (2x), SMEs (2x), Operators (2x), Industry partners (3x)

- 3 years duration
- Started: 01/07/2015
- 7.2 million euro EU funding
The 5G-XHaul data plane considers an integrated optical and wireless network infrastructure for transport and access.

The wireless domain comprises small cells complemented by macro cells.

Fronthaul and backhaul can be supported through mmWave and Sub-6 wireless technologies or using a hybrid optical network platform combining both passive and active optical technologies.
5G-XHaul Input to the 5G PPP View on 5G Architecture

- 5G PPP View on 5G Architecture – (White Paper), [https://5g-ppp.eu/white-papers/](https://5g-ppp.eu/white-papers/)
- 5G PPP View on 5G Architecture - Section 5 - Physical architecture, V. Jungnickel, Fraunhofer HHI, WORKSHOP 1: International Workshop on 5G Architecture, EuCNC 2016
5G-XHaul OVERARCHING LAYERED ARCHITECTURE

- **Development focus**
- **Cloud RAN**
  1. RF to Baseband
  2. Cycle Prefix & FFT
  3. Resource demapping
  4. Receive processing
  5. Decoding
  - **MAC**

- **Traditional RAN**
  - **managed RF in**
  - **physical network**
  - **virtualization**

- **element management (EM)**
- **virtu**

- **virtual network**
- **virtual wireless forwarding**
- **virtual optical**

- **virtual BH**
  - **virtual BH (upper layers)**
  - **virtual BH (lower layers)**

- **Control & Management & Service Orchestration**

- **high network bandwidth**
- **increased BBU sharing**

- **low network bandwidth**
- **limited BBU sharing**

A. Tzanakaki et al., "5G infrastructures supporting end-user and operational services: The 5G-XHaul architectural perspective," 2016 IEEE International Conference on Communications Workshops (ICC), Kuala Lumpur, Malaysia, 2016, pp. 57-62
Bristol 5G city network topology with mmWave backhauling

Multi-objective optimisation model aims to identify the optimal resources and policies that can support the required services in terms of both topology and resources.

Optimal FH and BH service provisioning, with the overall objective to maximise the energy efficiency of the infrastructure and minimize end-to-end service delays.

A. Tzanakaki et al., “Wireless-Optical Network Convergence: Enabling the 5G Architecture to Support Operational and End-User Services” IEEE Comms Magazine, August 2017
**Numerical Results: Energy-Delay**

- Figs a) and d): average traffic per BS and spatial traffic distribution for the wireless access domain.
- The C-RAN approach offers significant energy savings (60-75%) (Fig. b).
- Overloading of network resources to support FH, the C-RAN case increases the end-to-end service delay in the BH (Fig. c), which remains below 20ms for a 100 Mbps flow request.
- The BH service delay for C-RAN vBBU is lower compared to the delay for the C-RAN fixed BBU case.
DATA-PLANE: WIRELESS

- mmWave (60GHz) Front End design
  - Antenna & BFIC

- mmWave Base Band design
  - MIMO/Beam alignment and tracking/P2MP
  - Channel modelling

- Synchronization in wireless backhaul: 1588v2, ToF based

- Functional splits for 5G-RANs (NGFI):
  - Impact on transport requirements
  - Specific development for Massive MIMO

- Self-backhauling: Joint access and backhaul
DATA-PLANE: OPTICAL

- Hybrid passive/active optical network solution supporting joint FH & BH
- Active: Time Shared Optical Networks (TSON)
  - Elastic BW allocation (time slices)
  - Extensions for elastic grid
  - Native mapping of Ethernet and CPRI
  - Synchronization
- Passive: flexible WDM-PON
  - 40λs, 10-25 Gbps/λ, 20-40 Km
  - Color-less ONU (out-of-band mgmt)
  - Switch off ONU for energy saving
  - Flexible assignment BBU-RRH

5G-XHaul WDM-PON architecture
DATA-PLANE: WDM-PON & TSON INTEGRATION

- Testbed configuration of TSON and WDM-PON
  - Integration using BIO dark fiber
DATA-PLANE: MASSIVE MIMO FH OVER WDM-PON

CPRI over WDM

Colored DWDM

λ-agnostic DWDM

Baseband unit (I/Q samples)
AIR

CPRI

Transponder

ONU

RRH
AIR

UE receiver
TUD

ADVA

5G-XHaul

11
CITY-TRIALS: BIO INFRASTRUCTURE

**Optical Network**
144-fiber core network connecting 4 active nodes, full optical switching, flexi optical

**Wireless & Mobile Net.**
Wi-Fi 802.11ac, LTE, mmWave, Massive MIMO, 60GHz backhaul

**RF Mesh Network**
8 Fiber-connected lampposts with 1,500 photocells and any-sensor hosting capability

**Computing Infrastructure**
HPC facility, commodity compute/storage, private cloud and edge mobile computing
SAMPLE OF PLANNED DEMONSTRATION IN BRISTOL (JUNE’18)
Thanks for your attention!

Questions?

www.5g-xhaul-project.eu