H2020's 5G-CrossHaul and InterDigital's EdgeHaul™ – Enabling Transport Technologies

January 14, 2016
San Jose, California USA

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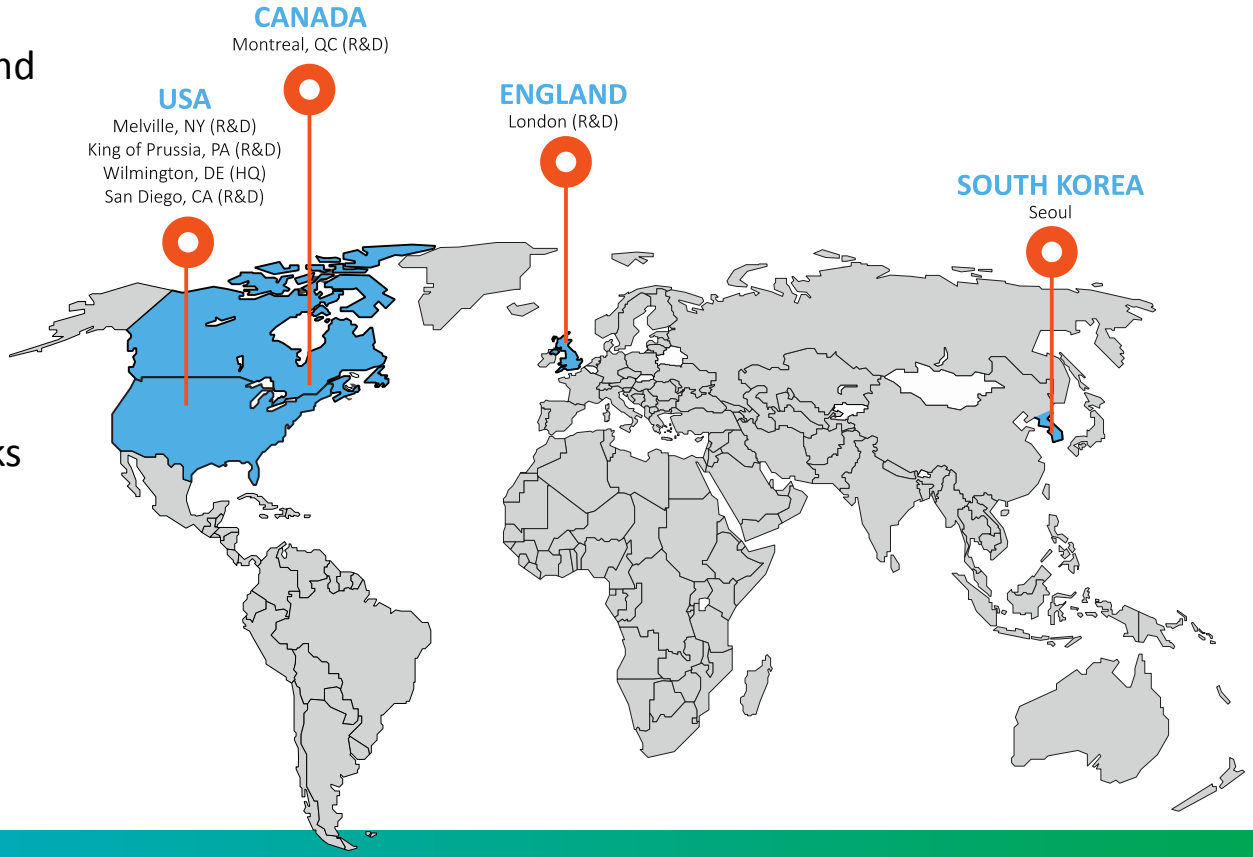
INTERDIGITAL.

InterDigital Snapshot – Invention, Collaboration, Contribution

- Four decades of discovery and innovation in wireless
- Pioneer in digital wireless technologies
- Key contributions to global wireless standards
- Inventing solutions for more efficient broadband networks
- ~170 engineers (~80% of whom hold advanced degrees)



Agenda

- Transport Evolution, Trends, Drivers
- Two Enabling Technologies for 5G Transport
  - EdgeHaul: 60GHz Small Cell Mesh Backhaul Platform
  - 5G-Crosshaul: Unifying Fronthaul and Backhaul Transport
- Summary

Transport Network Evolution

2G/3G

- Up to 2 Mbps Cell Capacity
- Macro Based
- Dedicated wired & P2P wireless

4G LTE

- 100 MBps Cell Capacity
- Hierarchical with Small Cell Layer being added

5G

- 1 GBps Cell Capacity
- Heterogeneous Networks
- Cloud-RAN

Two 4.5G - 5G Enabling Technologies for this presentation:

EdgeHaul™
mmW Wireless Transport

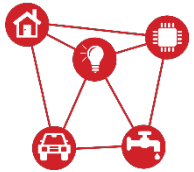
5GXCrosshaul
the integrated fronthaul/backhaul
A H2020 5G-PPP Project

5G Transport: Trends and Drivers

Diversification
of use cases

Mission Critical
(Lower Latency, reliable)

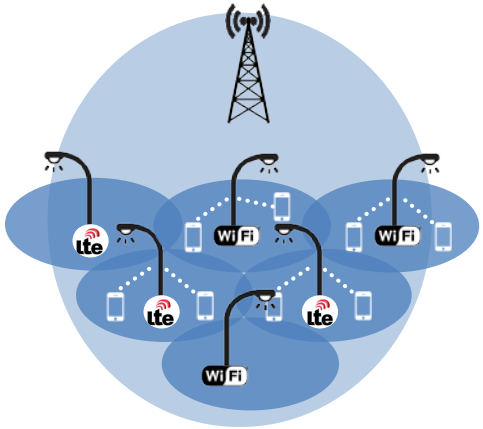
Massive # of things
(sensor networks, etc.)



Massive applications ->
Higher Capacity

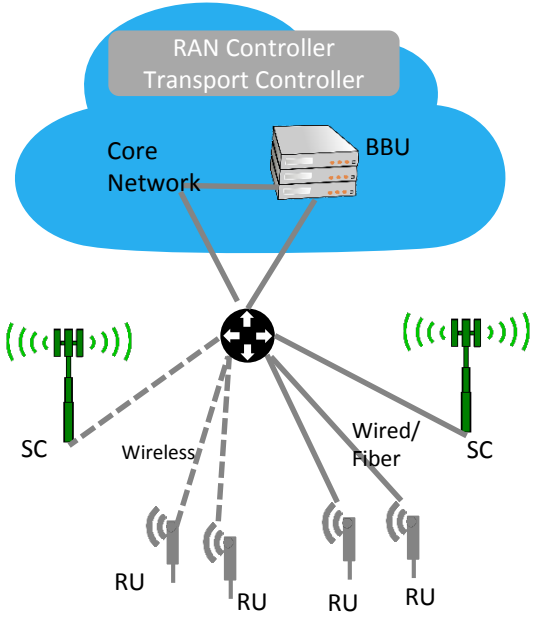
Densification

Easily scalable mass deployment of
heterogeneous small cell networks



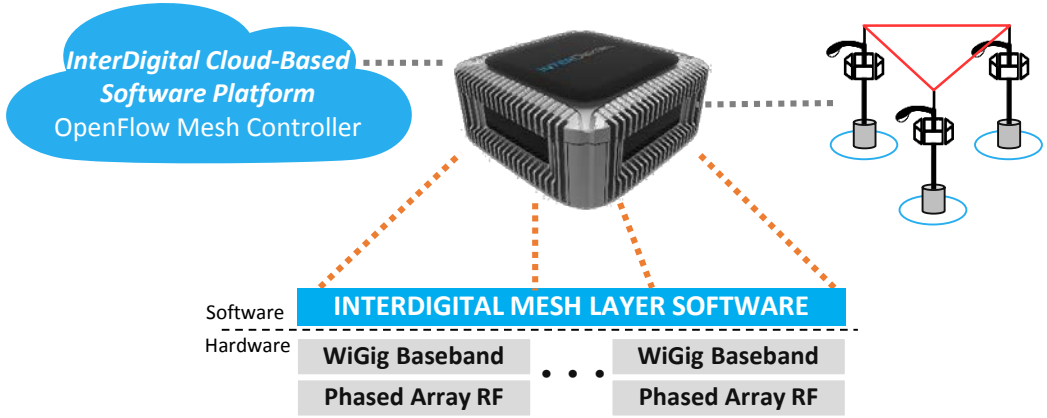
Cloudification

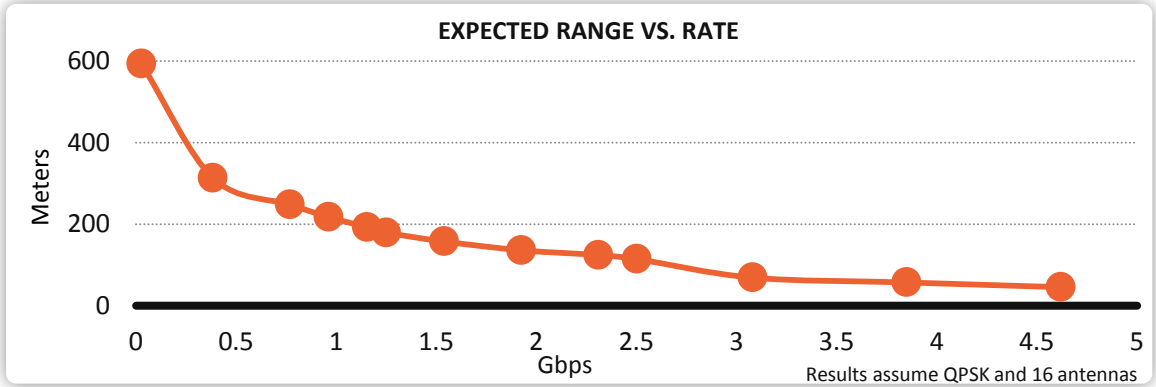
Software Defined Mobile Core and
RAN – Centralized BBU Processing



EdgeHaul™ - Millimeter Wave Wireless Transport

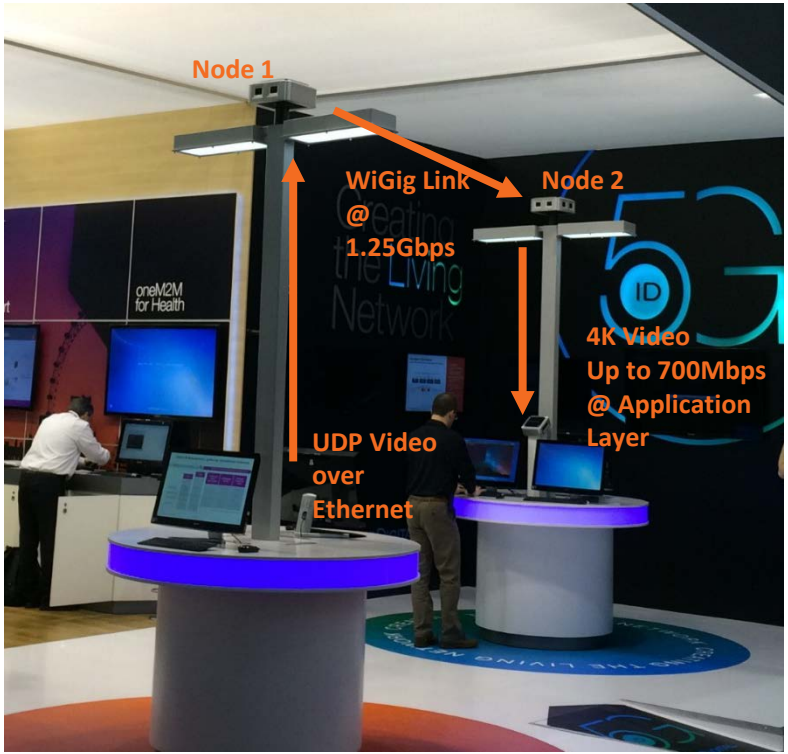
- **Low-cost, high capacity**, scalable design for today's small cell backhaul and future 5G millimeter wave access
- Leverage high volume **WiGig** baseband
- **60GHz Phased Array** with electronic beam steering reduces installation cost and provides interference management
- High throughput over range suitable for urban small cell



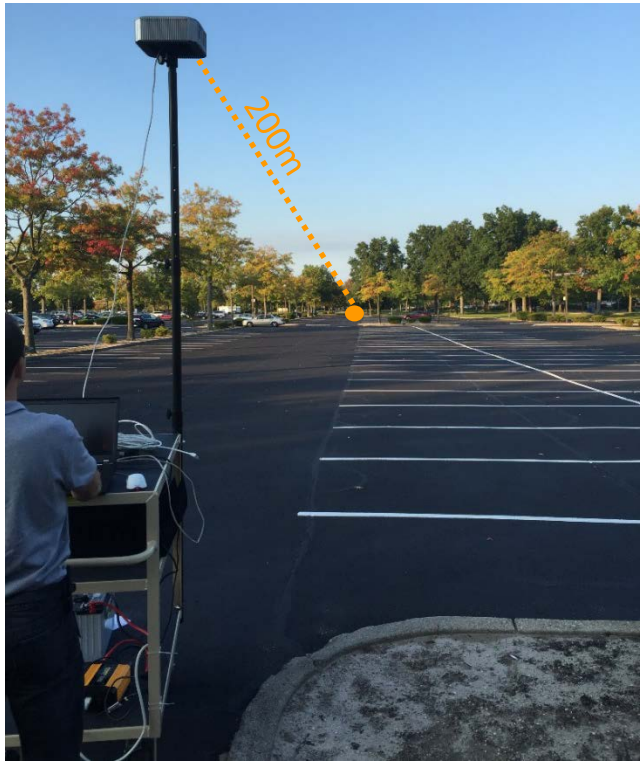


EdgeHaul™ Demonstration and Field Trials

Mobile World Congress 2015

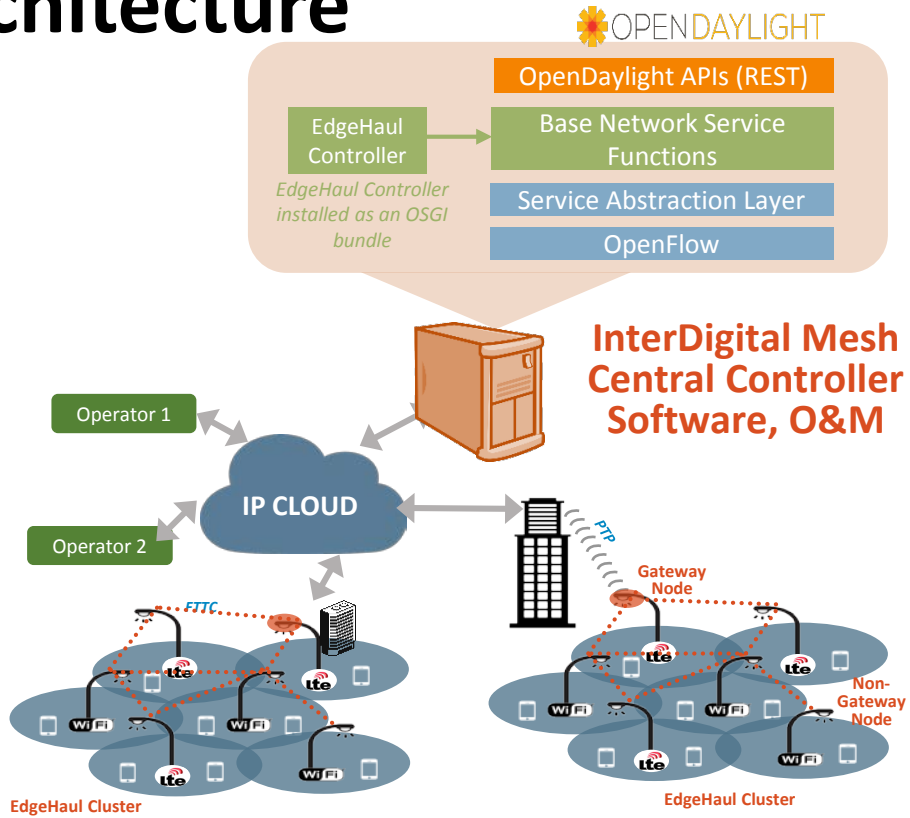


Fall 2015 Outdoor Range Testing



EdgeHaul™ System Architecture

- EdgeHaul is a centrally controlled multi-hop mesh network of mmWave backhaul nodes
- Clusters of initially ~10 nodes each are connected by mesh to Gateway
- System scales by replicating clusters
- Key System Components
  - **EdgeHaul nodes** contain virtual switch (OpenVSwitch) and mmWave MAC/PHY/RF air interface
  - **Mesh Controller Software** built on SDN framework (OpenDayLight) for flexibility to integrate with 5G multi-vendor heterogenous networks
  - **O&M Software** run on cloud server with a web-based interface for remote O&M

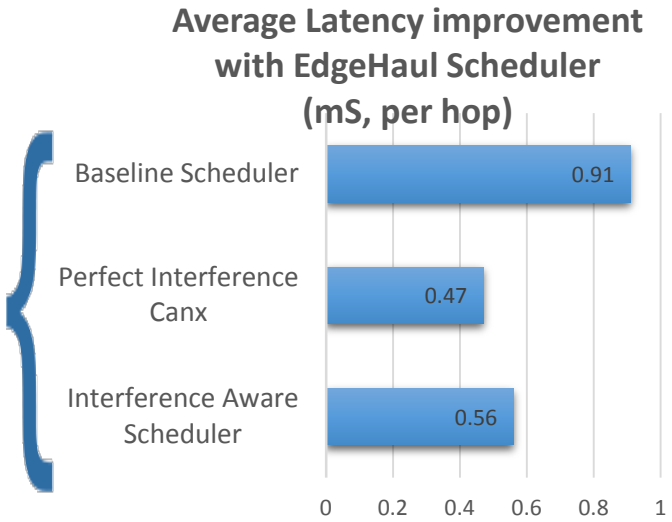


Intelligent software to build a Carrier Grade Edge Network from commercial WiGig hardware

Wireless Transport Challenges

- Wireless transport must evolve along with wired transport to meet 5G requirements
- Example challenges and possible solution paths

Challenge Areas		Possible Path
Link Capacity	Support multi-Gbps for various fronthaul functional splits	• mmWave Spectrum • Spatial Multiplexing
System Capacity	Aggregation of multiple cell's FH/BH traffic	• Statistical multiplexing of diverse traffic • MU-MIMO
Latency	< 1ms for Backhaul < 0.1ms for Fronthaul	• Air-interface scheduling to preserve SLA requirements • Fast Forwarding
Reliability	99.999 Availability	• Redundant routes via mesh connectivity
Automation	Network Deployment and Resource Optimization	• Cloud-based Transport Controller (SON, link provisioning) • Radio Environmental Mapping



5GXCrosshaul The 5G Integrated Fronthaul/Backhaul

Partners (21)

Project Duration

Jul 2015 – Dec 2017

EU Funding

7.95mio Euros

Project Traction

Baseline architecture and Common Frame Format

www.5g-crosshaul.eu

Project Elevator Pitch

Unifying the transport of existing and new **fronthaul and backhaul** traffic into a **“common-haul” SDN/NFV-based** packet switching network, that supports **5G RAN** performance targets at **reduced costs**

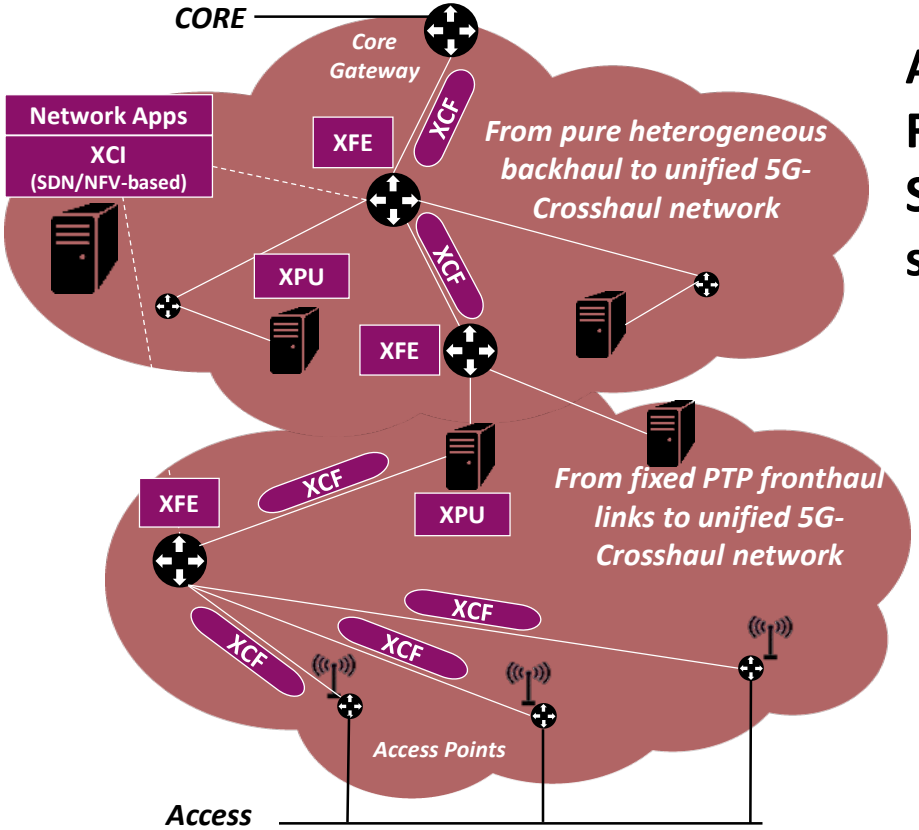
A high capacity low latency transport solution that lowers costs and guarantees flexibility and scalability

The target for this tech: Telcos & Switch Vendors

5G Challenges and Motivation

- @High Level: An ambitious set of **5G KPIs** (e.g. capacity, latency, efficiency) to deliver at a time network operators are looking into ways to **reduce costs** (TCO) and **expand the service** offer!
- @Fronthaul: Evolve from today's CPRI or CPRI-like solutions to less-stringent (in terms of capacity, latency, jitter and cost) and scalable solutions that can cope with the anticipated small cell densification and (massive) MIMO technologies: **Access Virtualization through flexible functional split between the Radio Unit (RU) and Data Unit (DU).**
- @Backhaul: Evolve from today's cascade of increasingly heterogeneous and independently managed technologies to a truly integrated transport that is flexible to adapt to various 5G requirements (capacity, latency): **Technology-abstract joint orchestration over common SDN-based control.**

Main Building Blocks



A holistic approach for converged Fronthaul and Backhaul under common SDN/NFV-based control, capable of supporting 5G Challenges

Main building blocks

- **XCF – Common Frame** capable of transporting the mixture of Fronthaul and backhaul traffic over same network
- **XFE – Forwarding Element** for forwarding the Crosshaul traffic in the XCF format under the XCI control
- **XPU – Processing Unit** for executing virtualized network functions and/or centralized access protocol functions (V-RAN)
- **XCI – Control Infrastructure** that is SDN-based and NFV-enabled for executing the orchestrator's resource allocation decisions
- **Novel network apps** on top to achieve certain KPIs or services

Initial Results - Baseline Architecture

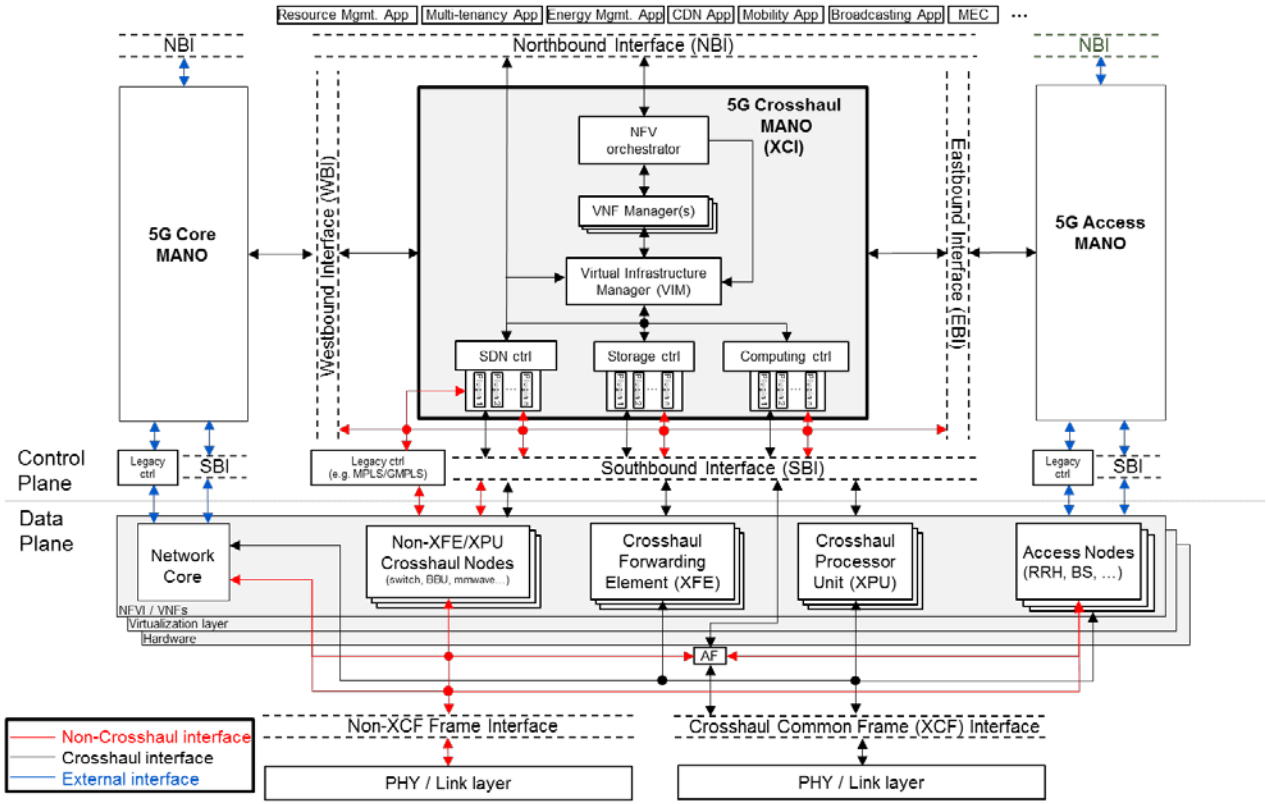
Innovative Network Applications
e.g. Multi-tenancy, MEC, Mobility

North Bound Interface

SDN/NFV-based Control plane
Compatible with ODL/ONOS and ETSI NFV architecture frameworks

South Bound Interface

Data plane: Unified across heteroegenous technologies
Support Fronthaul (with flexible functional split) and Backhaul traffic multiplexing



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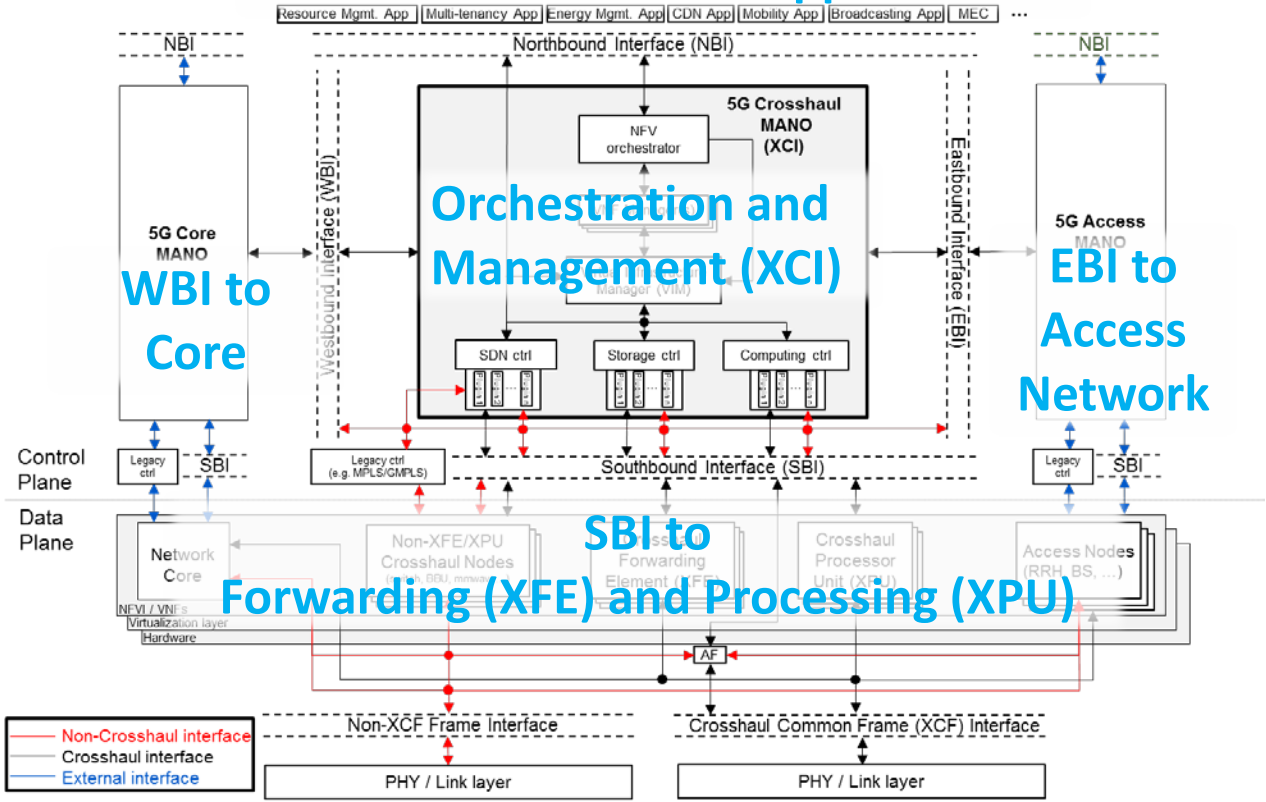
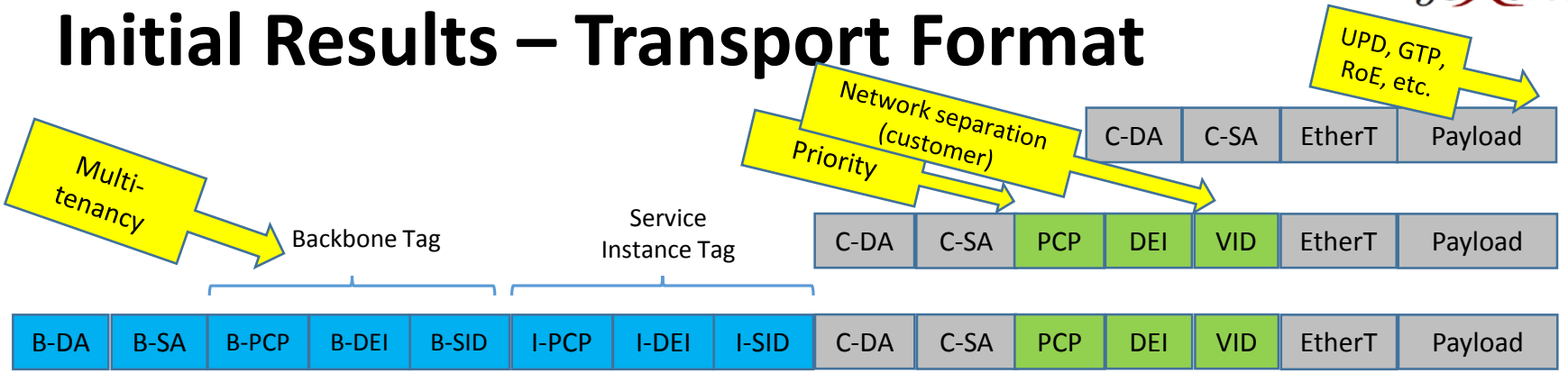


Initial Results – Transport Format

XCF Key Design Requirements

- Support multiple functional splits simultaneously
  - including Backhaul and CPRI-like Fronthaul
- Multi-tenancy
  - Isolate traffic (guaranteed QoS)
  - Separate traffic (tenant privacy)
  - Differentiation of forwarding behavior
  - Multiplexing gain
- Transport efficiency
  - Short overhead
  - Multi-path support
- Support In band control traffic (OAM info, …)
- Class of Service Differentiation
- Flow differentiation
- Energy usage proportional to handled traffic
  - Sleep mode, reduced rate, …
- Support of multiple data link technologies
  - IEEE 802.3, 802.11 (inc. mmWave), …
- Coexistence, Compatibility
  - Synchronisation: IEEE1588, IEEE802.1AS
  - Ethernet (same switching equipment, e.g. different ports, etc.)
  - Security support

Initial Results – Transport Format



- **XCF Format to be based on existing Ethernet and MAC-in-MAC formats**
  - Reuse legacy of COTS switches to forward XCF, to protect existing investments
  - Support VLAN-tagging for traffic separation within customer's network
- Future areas to be worked
  - Support IEEE 802.11 technology (due to no VLAN support for IEEE 802.11)
    - Option #1: Resort to tunneling in 802.11 domain (i.e. Ethernet in 802.11 frame)
    - Option #2: Attempt an integration of MAC-in-MAC framing in 802.11 networks e.g. through overloading the MAC-in-MAC header
  - Intelligent forwarding across heterogeneous data link technologies
  - Overhead reduction

SA= Source Address
DA=Destination Address
VID = VLAN ID
C-VID= Customer VID
I-SID = 24-bit Service ID
B-VID – Backbone VID
B-DA = Backbone DA
B-SA = Backbone SA
EtherT = etherType
DEI = Drop Eligible Indicator
PCP = Priority Code Point

Summary

- Advances in Wireless Transport and Unified Transport Protocols can come together to deliver Flexibility in 5G Transport
  - Planning to bring EdgeHaul to 5G-Crosshaul demonstrations @ 5G Berlin Testbed
- EdgeHaul: Millimeter wave mesh backhaul built on SDN framework
- 5G-CrossHaul: Integrated Fronthaul and Backhaul for envisioned 5G Virtualized RAN architectures
  - Initial Results after 6 months
    - Defined the baseline architecture compatible with ODL/ONOS SDN and ETSI NFV architecture frameworks
    - Key requirements defined
    - Assumptions agreed for keeping compatibility with legacy COTS switches (MAC-in-MAC support)
  - First proof-of-concept demonstrations are planned from Q2 2016

- Wish List / Discussion
  - Continued understanding of transport requirements from other 5G thrusts: e.g. Mobile Edge Computing, IOT, etc.
  - Standardization roadmaps: IEEE, ITU-T, 3GPP, IETF, ONF, and ETSI (amongst others)

Thank You!