5G Roadmap to backhaul and fronthaul integration and 2016 Trial plans

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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 to less-stringent (in terms of capacity, latency, jitter and cost) and scalable solutions that can cope with the high (small cells) densification and (massive) MIMO technologies foreseen in 5G: **Access Virtualization through flexible functional split between the RU and 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**.
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
Solution Building Blocks

A holistic approach for converged Fronthaul and Backhaul under common SDN/NFV-based control, capable of supporting new 5G RAN architectures (V-RAN) and performance requirements

Main building blocks

• **XCF – Common Frame** capable of transporting the mixture of various Fronthaul and backhaul traffic

• **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
Consortium and Project Traction

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
Baseline Architecture

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

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

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

North Bound Interface

South Bound Interface

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XCF 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
- 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
XCF Baseline Format

- Focus on Carrier grade Layer-2 switching for fronthaul and backhaul traffic
- Backwards compatibility with existing formats is prioritized
- Two existing formats are under consideration as XCF baseline templates:
  - Ethernet-based MAC-in-MAC (PBB-TE – Provider Backbone Bridge Traffic Engineering)
  - MPLS-TP (Transport Profile)
- An instantiation of each of the above templates is under development to represent the XCF for enabling intelligent forwarding by new switches (XFE)
  - Instantiation is developed through redefining some existing control information and eventually add new control information to optimize with the forwarding
- XCF design is planned for release in June 2016

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**MAC-in-MAC based XCF template**

<table>
<thead>
<tr>
<th>B-Dst Address</th>
<th>B-Src Address</th>
<th>TPID</th>
<th>P</th>
<th>D</th>
<th>E</th>
<th>C</th>
<th>E</th>
<th>P</th>
<th>I</th>
<th>VID</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B-Dst Address</td>
<td>B-Src Address</td>
<td>TPID</td>
<td>P</td>
<td>D</td>
<td>E</td>
<td>C</td>
<td>E</td>
<td>P</td>
<td>I</td>
<td>VID</td>
<td></td>
</tr>
</tbody>
</table>

Ethernet II header with EDP-encoded B-VID and I-SID tags

<table>
<thead>
<tr>
<th>C-Dst Address</th>
<th>C-Src Address</th>
<th>TPID</th>
<th>P</th>
<th>D</th>
<th>E</th>
<th>C</th>
<th>E</th>
<th>P</th>
<th>I</th>
<th>VID</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C-Dst Address</td>
<td>C-Src Address</td>
<td>TPID</td>
<td>P</td>
<td>D</td>
<td>E</td>
<td>C</td>
<td>E</td>
<td>P</td>
<td>I</td>
<td>VID</td>
<td></td>
</tr>
</tbody>
</table>

Ethernet II header with EDP-encoded S and F tags

**Multi-tenancy**

**Priority**

**Network separation (customer)**

**ECMP**

**Alternative: QinQ MAC-in-MAC encapsulation**

IP, RoE, NGFL, ...

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# MPLS-TP based XCF template

Assuming Ethernet payload, and MPLS over Ethernet at the link layer

<table>
<thead>
<tr>
<th>B-DA</th>
<th>B-SA</th>
<th>TPID</th>
<th>P C P</th>
<th>D E I</th>
<th>B-VID</th>
<th>Type (0x8847)</th>
<th>MPLS packet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0x8847 = MPLS label switched packet</td>
<td></td>
</tr>
</tbody>
</table>

- **Service identification**
- **Traffic Priority**
- **Network separation (customer)**
- **Multi-tenancy**

<table>
<thead>
<tr>
<th>Label</th>
<th>T</th>
<th>C</th>
<th>EOS</th>
<th>TTL</th>
<th>Label</th>
<th>T</th>
<th>C</th>
<th>EOS</th>
<th>TTL</th>
<th>0000</th>
<th>rsvd</th>
<th>Sequence number (16 bits)</th>
<th>payload</th>
</tr>
</thead>
</table>

- LSP label (4 bytes)
- PW label (4 bytes)
- Control word (4 bytes)

<table>
<thead>
<tr>
<th>C-DA</th>
<th>C-SA</th>
<th>TPID</th>
<th>P C P</th>
<th>D E I</th>
<th>VID</th>
<th>Type</th>
<th>User data</th>
</tr>
</thead>
</table>
Summary and Next Steps

- 5G-Crosshaul project aims at integrating Fronthaul and Backhaul for envisioned 5G Virtualized RAN architectures
- The integration is tackled in both the control and data planes
  - A common SDN/NFV-based control infrastructure (compatible with ODL/ONOS SDN and ETSI NFV architecture frameworks)
  - A unified data plane with common switching of FH and BH traffic across heterogeneous technologies
- The data plane focuses on Carrier Grade Layer-2 packet switching (XCF)
  - Ethernet-based PBB-TE and MPLS-TP as candidate baseline templates for support of legacy switches (backwards compatibility)
  - New instantiation of the above templates for new switches (XFE)
- Standardization roadmaps include relevant working groups in IEEE, ITU-T, 3GPP, IETF, ONF, and ETSI (amongst others)
- First proof-of-concept demonstrations are planned from Q2 2016