CORD: Network Edge Platform for Service Delivery

Washington DC | Dec 8th 2016
ONOS + CORD Partnership and Community

<table>
<thead>
<tr>
<th>ON.LAB</th>
<th>SERVICE PROVIDER PARTNERS</th>
<th>VENDOR PARTNERS</th>
<th>COLLABORATORS</th>
<th>VOLUNTEERS</th>
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<tbody>
<tr>
<td></td>
<td>AT&amp;T, China Unicom, Comcast, Google, NTT Communications, SK Telecom, Verizon</td>
<td>Ciena, Cisco, Ericsson, Fujitsu, Huawei, NEC, Nokia, Radisys, Samsung</td>
<td>60+ Companies</td>
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Domains of Use: Residential, Mobile, Enterprise

- **Residential**
  - vOLT, vSG, vRouter, vCDN

- **Mobile**
  - Enable 5G w/ Disaggregated/Virtualized RAN & EPC, Mobile Edge

- **Enterprise**
  - SDN-WAN with programmability, packet-optical convergence

**Leaf-Spine Fabric**

- **ONOS + Trellis+ XOS + OpenStack/Docker**

**Commodity Servers, Storage, Switches, and I/O**

**Field Trial**

**POC at ONS**

**POC at ONS**

**Leaf-Spine Fabric**

**BBUs (Multi-RATs)**

**PON OLT MACs**

**Enterprise Metro Ethernet**

**ROADM (Core)**
CORD POD – Software Stack

- Access-as-a-Service
- Subscriber-as-a-Service
- Internet-as-a-Service
- CDN
- Monitoring-as-a-Service

XOS

OpenStack / Docker

- Ceilometer
- vSG
- vCDN

ONOS

- VTN
- Fabric Control
- Multicast Control
- vOLT
- vRouter
CORD Differentiators and Value Prop

• **Unique and strong partnership**
  – ON.Lab + Providers + Vendors + a growing collaborating community

• **Integrated solutions platform for “service” delivery**
  – A complete platform ready for trials and deployments

• **A common platform for three critical and huge domains of use**
  – Residential, enterprise and mobile

• **Leverages merchant silicon and white boxes**
  – Not only for servers and switches but also for access (GPON, LTE/cellular, …)

• **Built with best in class open source platforms**
  – ONOS, Trellis, XOS, Docker, OpenStack, …
5G Pillars from M-CORD Perspectives

- More Spectrum
- Software-defined Networks
- Cloud Technologies
- Mobile Edge Computing
- Functional Disaggregation
- Network Slicing
- Network Functions Virtualization
- New Air Interface(s)
M-CORD Objectives: An Open Platform for 5G

Replace vertically integrated legacy hardware in cellular networks with CORD platform
- Reduced Capex and Opex
- Increased agility, new services

Utilize end to-end network slicing, based on SDN/NFV/Cloud principals (RAN, Core, front & back haul)
- Offer NaaS to other providers
- Offer differentiated services
- Provide dynamic finer control of network to suit IoT and other new types of services

Provide a platform for enabling & onboarding new localized edge services

Offer a platform with open source and disaggregated components for new use cases
- Ability to evaluate new architectures: GTP tunnel-less for fixed mobile/IoT devices
- MME decomposition into separate functional entities to suit different use cases and slice

Support programmable observability and analytics framework of CORD
- Enable real time closed loop operation of the RAN, EPC and the CORD platform
- Reduce the extent of monitoring infrastructure by enabling dynamic monitoring and instantiation of probes as and when needed
M-CORD = Best of Mobile + CORD

Disaggregated /Virtualized RAN
Disaggregated /Virtualized EPC
Mobile Edge Services

BBU, RRU
front haul fabric
MME, SGW, PGW
Caching, SON, Billing

Cloud-Agile Service Customization
Dynamic radio resource optimization
Open Control Interfaces
Network Slicing
Programmable Data Plane
Deep Observability

SDN Control Plane - ONOS
NFV Orchestration w/XOS

Commodity servers, switches, network access
Disaggregated/Virtualized RAN and EPC

### Traditional Architecture

- RU/DU integrated eNBs
- Limited Scalability
- Inefficient coordination
- Sub-optimal spectrum usage
- High Cost

### Target Architecture

- Disaggregated & Virtualized RAN
  - High Flexibility & Scalability
  - Centralized Coordination
  - Spectrum usage optimization
  - Reduced Cost
  - Enable New Innovative Services

### RU/DU integrated RAN

- Limited Scalability
- Inefficient coordination
- Sub-optimal spectrum usage
- High Cost

### Control/data plane integrated EPC

- Limited scalability
- Discrete control
- Proprietary H/W for all-purpose
- High Cost

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RU: Radio Unit, DU: Digital Unit, BBU: Baseband Unit, SGW: Serving Gateway, PGW: PDN Gateway (C: Control plane, D: Data plane), MME: Mobility Management Entity
Mobile Edge Service

Entire service is processed at the central infrastructure
- Overload on backhaul, transport and core EPC
- Inefficient use of network resources
- Deterioration on QoE of the users
- Overprovisioning to handle peak traffic

“Mobile edge, where operators can leverage their core competencies to overcome their limitations”

Service can be processed at the edge with M-CORD
- Mobile edge’s best advantage is ‘Proximity to End Users’
- Innovative and Customized services to target customers - IoT, Smart cities, education, industrial M2M, etc
- Better efficiencies & new revenue opportunity for operators
Mobile CORD POC (March 2016)

UE1

UE2

Service Provider View

Enterprise Customer View

Caching Service Monitoring Service eSON Service

BBU, MME, SGW, PGW Services

ONOS + OpenStack + XOS

CORD Fabric

White Box

White Box

White Box

White Box

White Box

TeraVM

INTERNET

vBBU

MME

vSGW

vPGW-C

vPGW-D

XOS

ONOS

OpenStack

Content Caching

Commodity Servers, Storage, Switches, and I/O

POC at ONS 2016
M-CORD Software Architecture

- Mobility Functions modeled as XOS services
- Utilizes XOS service composition
M-CORD PoC (March 2016)

- **Disaggregated and virtualized RAN**
  - Simple programmable Remote Radio Heads
  - vBBU on commodity servers

- **Disaggregated and virtualized EPC**
  - Data plane management by ONOS
  - PGW, SGW, MME as “VNFs as a Service”

- **Mobile edge service**
  - Select EPC processing at the edge + eSON/A-CORD
  - Caching and other services from the edge
  - Customized for enterprises and applications

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M-CORD ONS 2016 PoC
Infrastructure & Collaborators

- vBBU RRU
- vPGW-C vPGW-U
- vMME vSGW
- eSON
- UE, App Emulator
- ON.LAB ONOS XOS

[ M-CORD POC Rack ]
M-CORD Roadmap

- Disaggregated/Virtualized RAN
  - RAN Slicing
  - Observability and Analytics
  - Flexible Disaggregation
  - Core Slicing
  - Observability and Analytics
  - Connectionless

- Disaggregated/Virtualized EPC
  - E2E Network Slicing
  - E2E Network Analytics

- Mobile Edge Services
  - CDN
  - Streaming
  - Public Safety
  - IOT

- M-CORD Mini
  - Agile development, experimentation, PoC demonstration
M-CORD Building Blocks & Capabilities

RAN disaggregation
- RAN control applications
  - LTE, 5G...
- M-CORD platform

EPC disaggregation
- EPC control applications
  - MME, SGW-C, PGW-C, PCRF
- Disaggregated GW
- EPC data-plane

Connectionless services
- IoT Control applications
- M-CORD platform
- Light & flexible connectivity protocol

Real-time analytics
- Analytics applications
- MCORD platform (XOS)

Edge services
- Customized Service app.
- MCORD platform

Network slicing
- Network slicing
- LTE, 5G IoT, Enterprise, MBB, MVNO
- Fabric slicing
- RAN slicing
- Core slicing
nFAPI Integration & Development View

Service Orchestration

- Configuration Management
  - RRU
  - nFAPI

- Slicing Mgr. Portal
  - vRAN
  - vEPC

- XOS Service Composition
  - VTN
  - Analytics

ONOS

- Radio Resource Control
- Slicing Manager Control
- Backhaul Route Control

vRAN

- Frequency Selection Agent
  - RRC-Layer Management
- PHY-Mac Split Abstraction
- Slicing Agent Protocol

vEPC

- Open Source nFAPI+ Drivers & APIs
  - MAC Scheduling Unit

PHY

- RRU-SDR
  - RF/SDR

Combined Or Split Options N-FAPI modes
**Progress Update (as of 3 Oct.)**

**M-CORD mini**

- Plan for 10 Dev/Lab kits
- Building small form factor vBBU – in progress
- Integration plan – in progress
  - Pricing issues
Deployment Path with Open Platforms such as CORD

3GPP Standards

Network Deployment Architecture

Physical Network Functions

Open Source

3GPP Standards

Virtual Cloud Native Network Functions

Network Deployment Architecture (Standards?)

WWW.OpenCord.Org
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Dec 8th 2016
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