Mobile-CORD
Enable 5G with/on CORD

ONOS/CORD Partnership
http://opencord.org/
M-CORD Drivers = Operator Challenges

In the last 5 years

100,000% Increase in Wireless Data Traffic

$50 Billion Spectrum investment (~50 Mhz)

$5 Billion LTE System investment (RAN, EPC)

FREE WiFi

Alternative “shared” access (WiFi, LAA, LTE-U)

New and very diverse devices with IoT

Vendor Lock-in Interfaces

Slowing revenue growth
M-CORD Drivers: Proprietary to Open

State of the infrastructure: Built with closed proprietary boxes

• Inefficient utilization including sub-optimal use of precious radio resources
• Inability to customize for various customers
• Slow in creating innovative services
• Cannot support industry-specific IoT scenarios

Mobile infrastructure needs re-architecting – To enhance Mobile operators’ competency
About MCORD

- **Mobile CO Re-architected as DC**
  - Economics of DC
    - ✓ Infrastructure mainly built with commodity H/W and white-boxes
  - Agility of a Cloud provider
    - ✓ Software platform that enable rapid creation of new services

- **Mobile Edge**
  - Provide services at the edge of network to leverage the Benefits of;
    - ✓ Proximity to Users
    - ✓ Reduced latency, Reduced backhaul load
    - ✓ Utilizing information related to Radio Resource

- **Micro-services**
  - Provide services and infrastructure well suited for the targeted enterprise;
    - ✓ Lightweight platform on-demand
    - ✓ Independency and autonomous control in accordance with centralized orchestration
    - ✓ Enterprise specific SLA
M-CORD guiding concepts

- SDN/NFV
- Open source
- Open interfaces (RAN/Core)
- Open platforms
- Commodity hardware
- Programmability
- Observability
- Service assurance, Performance
- Coexistence with existing infrastructure
Capabilities to be Explored on M-CORD

✓ Enhance resource utilization
  • Real-time resource management
  • Exploit multiple Radio Access Technologies
  • Real-time analytics framework

✓ Provide customized services and better QoE to customers
  • Customized service composition
  • Differentiated QoE based on service requirements: latency and throughput
  • Enable use cases: IOT, smart cities, hospital, education, industrial M2M apps

✓ Agile and cost-efficient deployment
  • On-demand deployment
  • Virtualized /disaggregated RAN and EPC
  • Commodity H/W and open source

QoE: Quality of Experience, RAN: Radio Access Network, EPC: Evolved Packet Core
M-CORD: Best of Mobile + CORD

Disaggregated /Virtualized RAN
- BBU, RRU front haul fabric

Disaggregated /Virtualized EPC
- MME, SGW, PGW

Mobile Edge Services
- Caching, SON, Billing

SDN Control Plane - ONOS
NFV Orchestration w/XOS

SDN Fabric

Commodity servers, switches, network access

Platform for next gen mobile services + Software defined RAN
• **Everything-as-a-Service (XaaS)**
• **CORD Controller consolidate all configurations and control**
• **CORD Controller mediates all inter-service dependencies**
M-CORD Architecture Framework

- **Disaggregated/Virtualized RAN**
- **Disaggregated/Virtualized EPC**
- **Mobile Edge Services**

**XOS** (Service Orchestration)

- **OpenStack**
  - Nova
  - Ceilometer
  - Neutron

- **RAN/EPC Control Agent**
- **VTN**
- **Control APPs**

**ONOS** (Networking)

- **Leaf-Spine Fabric**
- **White Box**

- **Mobile Core**
  - MME
  - PCRF
  - PGW
  - EPC Control Functions
  - Centralized EPC

- **M-CORD mobile edge**

- **RRUs**
- **vBBU**
- **vMME**
- **vSGW**
- **vPGW-C**
- **vPGW-D**
- **Content Caching**

[ M-CORD mobile edge ] [ Mobile Core ]
Mobile CORD POC (March 2016)

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

UE1

RRUs

UE2

vBBU

vSGW

vPGW-C

vPGW-D

XOS

ONOS

OpenStack

Content Caching

Commodity Servers, Storage, Switches, and I/O
M-CORD Service example: Video from the Edge

- Local service : UE1 → vBBU → vSGW → local-PGW
- Non-local Service : UE2 → vBBU → vSGW → global-PGW
Expected Service Opportunities on M-CORD

- mHealth
- Platform for Mission-critical IoT
- Connectionless services for Massive IoT
- Network Slicing for new service of diverse SLAs
- Analytics and Security
M-CORD PoC: Infrastructure & Collaborators

- **vBBU RRU**: Remote Radio Unit, (v - virtualized)
- **vPGW-C**: PDN Gateway Control plane
- **vPGW-U**: PDN Gateway User plane
- **vMME**: Mobility Management Entity
- **vSGW**: Serving Gateway
- **eSON**: Self Organizing Network
- **ONOS**: Open Network Operating System
- **XOS**: eXtensible Operating System
- **ON.LAB**: Open Networking Lab

**Collaborators:**
- CAVIUM
- radisys
- NEC
- eSON
- airhop communications
- COBHAM

**UE, App Emulator**

**[M-CORD POC Rack]**

**Abbreviations:**
- **RRU**: Remote Radio Unit
- **vBBU**: Baseband Unit
- **vMME**: Mobility Management Entity
- **vSGW**: Serving Gateway
- **vPGW-C/D**: PDN Gateway Control plane/Data plane
- **SON**: Self Organizing Network
M-CORD: Roadmap
(POCs and Potential Lab trials)

http://cord.onosproject.org/
M-CORD Next POCs Goal

- Next POCs with
  - Enhanced integration
  - New features
  - New use cases

Success criteria
- Abstractions
- Slicing
- Programmability
- Open interfaces
- Performance
- Valuable edge services

5G Technology building blocks and Use cases + New collaborators

M-CORD POC (at ONS 2016)
M-CORD Proposed Expansions

RAN disaggregation

- RAN control applications: LTE, 5G...
- MCORD platform
- MCF fabric
- Microcell
- Macrocell
- Picocell
- RAN data-plane

EPC disaggregation

- EPC control applications: MME, SGW-C, PGW-C, PCRF
- MCORD platform
- Disaggregated EPC (SGW-C, PGW-C)
- EPC data-plane

Connectionless services

- IoT Control applications
- MCORD platform
- Light & flexible connectivity protocol

Real-time analytics

- Analytics applications
- MCORD platform (XOS)
- Probe

Edge services

- Customized Service app.
- MCORD platform

Network slicing

- Network Slices: LTE, 5G, IoT, Enterprise
- MBB, MVNO, Testbed
- Fabric slicing
- RAN slicing
- Core slicing
Work areas for next M-CORD PoC

M-CORD control platform
- Low Latency, QoS & Fabric Slicing, Analytics, Security

Mobile Infrastructure
- RAN: Multi-RAT, Disaggregation, Split Architecture, Slicing, SON/Analytics
- EPC: Disaggregation, Slicing, Policy & Charging
- Connectionless service (Non-GTP based)

Services
- mHealth, IoT, Gaming, VR/AR
Subject: “E2E Slicing”

- **RAN+CORE E2E Slicing**
  - RAN Slicing by programmable eNB based on SDN architecture
  - **CORE Slicing** based on ‘Data-place as a service model’ by XOS service composition

- **E2E Monitoring** of Sliced N/W

- **Services**
  - Service Composition
  - Service Composition
  - A-CORD integration
  - Performance Testing
Network Slicing

Set of manageable mobility resources to deal with dynamics of Specific:
- Devices Types
- Flow Types
- Traffic Control Policies
- Security Control Policies
- Location based Policies
- RAN Access Attributes / RB
- Time Window

Manage resources designated to network slices
Analyze real time observability

Fundamental Pillars of SDN Based Network Slicing
M-CORD view: Network Slicing

Orchestration – CORD (eCOMP, XOS, OpenStack, ONOS)

Resource Recomposition
vBBU, vRAN, vEPC, VNFs

Centralized CORE  HW/SW Resources
(VNFs, MME, SGW, PGW, PCRF, SON, Mobile Control Applications)

Distributed CORE  HW/SW Resources
(SGW, PGW, Edge Services / MME, PCRF, SON, Mobile Control Applications)

RAN  HW/SW Resources
(BBU, RF, RRH, Spectrum Pool, Backhauls...)

Slice#1
Slice#2
Slice#3
Slice#4
Network Slicing: w/ Distributed M-CORD

- Deploy distributed and isolated local networks for specific services or customers
- Each local network slice comprises fully or partially virtualized network functions
- Local networks can be sliced within itself for different services and customers (e.g. #3)
- Good for quick implementation while holding legacy infrastructure
M-CORD Network Slicing Model

USE CASE SERVICE SLICES

Service Chaining & Network Slicing Agent

Intelligent E2E Orchestration and Services Exposure (XOS)

Open Stack, etc.

Edge Cloud Orchestration

Cloud Orchestration

ONOS

CN Control Agent

RAN Control Agent

DYNAMIC E2E NETWORK SLICES
Subject: “Connectionless Service”

- **Connectionless** Service
  - Non-tunnel based cost efficient Network for static IoT devices
  - Compose and Slice Data-plane for connectionless services
- **Enhanced Observability** by Smart NIC

- **SDN-based configuration**
- **vBBU**
- **Radio Unit**
- **Data-plane service**
- **Smart NIC**
- **OVS Offload**
  - In-Net Observability
- **‘Data-plane’ for Connectionless Service**

Connectionless Service composition

ON.LAB ONOS XOS

M-CORD Connectionless Service PoC Plan
**LTE end-to-end stack**

- Each network element has control and data plane.
- eNB has radio component and core network component.

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**SDN model**: Service Gateway

1. Implement traditional gateway function like charging, policy.
2. Subscriber flow managed via OpenFlow(+).
M-CORD Monitoring Implementation

Deep observability and proactive analytics for Sliced Network, VNFs, Fabric by using programmable probe

BBU-C  Mobility-C  GW-C

ONOS

CORD Fabric

White Box  White Box  White Box  White Box

RRU  eNB  SGW  PGW

Service VNFs
Call to Action

Share your specific proposals to be part of the next M-CORD POCs

Engage and bring your resources (infrastructure + developers) to build the POCs

To influence 5G solutions and potential use cases in close collaboration with the leading service providers, ON.Lab, other partners and collaborators

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