Mobile CORD (M-CORD)
Open Reference Solution for 5G

Bill Snow
ON.Lab/ONF
bill@opennetworking.org
A brief history - SDN origins

2006 - Clean Slate Program - Stanford, Berkeley, NSF
First open source projects - Mininet, OVS ...
Beginnings of Software Defined Networking (SDN)
Created OpenFlow standard

2011 - Open Networking Foundation
    Non profit - advance SDN and OpenFlow for industry benefit
Open Networking Lab
    Non profit - Open Source network infrastructure development for public benefit

2014 - Open Network Operating System (ONOS) launched
2016 - Central Office Rearchitected as a Data Center (CORD) launched
Both are Linux Foundation Collaborative Projects
Partners

6 Leading service providers make solutions relevant to them
10 Leading vendors help make solutions real & ready for deployment
ONOS® is building a better network.

The Open Network Operating System (ONOS) is a software defined networking (SDN) OS for service providers that has scalability, high availability, high performance and abstractions to make it easy to create apps and services. The platform is based on a solid architecture and has quickly matured to be feature rich and production ready. The community has grown to include over 50 partners and collaborators that contribute to all aspects of the project including interesting use cases such as CORD.
ONOS Project Collaborators

Collaborating organizations help grow the community and grow the impact.
CORD®: REINVENTING CENTRAL OFFICES FOR EFFICIENCY & AGILITY

CORD Summit
Check out the slides and videos from the July 29 CORD Summit:

WATCH VIDEOS AND SLIDES
CORD Project Collaborators
ONF Innovators
"Many people might not realize that running their own cellular networks is not only possible but also doesn’t require substantial technical expertise" – Khashif Ali, Facebook
Key Takeaways

CORD is bringing economics of the datacenter and agility of the cloud to the access network through open source collaboration.

M-CORD is CORD optimized for the mobile network – both access and core are virtualized and disaggregated.

M-CORD is the perfect platform for building 5G solutions.
CORD (Central Office Re-Invented as Data Center)

High Level Architecture

- Large number of COs
- Evolved over 40-50 years
- 300+ Types of equipment
- Huge source of CAPEX/OPEX

SDN enabled Central Office Fabric

- SDN Controller
  - ONOS
- VNF/Services Mgmt.
  - XOS
- Leaf-Spine Fabric
- Commodity servers, switches, and network access

Cloud

NFV

White Box

White Box

White Box

White Box

White Box

White Box

White Box

White Box

White Box

White Box

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White Box

White Box

White Box
CORD Project

CORD Vision

• Built around commodity servers and white-box switches, and to the extent possible, leverages merchant silicon.

• Enables disaggregation, and is not restricted to running bundled legacy VNFs in virtual machines.

• Leverages SDN to both interconnect the virtual and physical elements and as a source of innovative services.

• Extensible platform that can be customized to include multiple access technologies and services.

• Adopts best practices in building, composing, and operating scalable multi-tenant cloud services, including support for multi-tenancy.
CORD - Multi Access Architecture

- Enterprise SDN-WAN with programmability, packet-optical convergence
- Mobile
  - Enable 5G w/ Disaggregated/Virtualized RAN & EPC, Mobile Edge
- Residential
  - vOLT, vSG, vRouter, vCDN

ONOS + OpenStack + XOS

- Enterprise Metro Ethernet
- BBU (Multi-RATs)
- PON OLT MACS
- ROADM (Core)
• EPC – Disaggregated and virtualized - running on (distributed) access cloud over programmable VN/fabric

• RAN - Disaggregated (split stack into CU & RU), virtualized CU, configurable and programmable by ONOS
M-CORD as an Access Cloud

ONOS-Controlled eNB (slicing)
Radio Access-as-a-Service – customized business solutions for verticals
CORD Software Components

Orchestration (ONAP…)
Service definitions (Tosca…)

XOS – Data Model, Synchronizers

VM, Container as a service (OpenStack, Docker…)

Network as a service (ONOS…)

Reference Architecture: Model-Based

CORD Controller

Mobile Subscribers

Controller

RU

Controller

CU

Controller

vMME

Controller

vHSS

Controller

v-SGW-c

Controller

v-PGW-c

Controller

v-SGW-u

Controller

v-PGW-u

Controller

Net Cookie Check

Controller

ONOS

Controller

OpenStack

Controller

Monitoring & Testing

Arrows show associations, not data flow

Think of service graphs, not just chains
Runtime Interface

- On-board, Provision Services
- Instantiate, Control Instances
- Report Inventory, Analytics
Scale Down – Lite-and-Right CORD

Single/Partial Rack (No Spine Switches)

Minimal Compute (All services, including ONOS, XOS and RAN CU, run in containers)

If you also “scale down” the software so the Service Graph includes just RU + CU, the resulting configuration = “SD-RAN”
Why Model Driven? Beyond Micro Services

Micro Service Arch
- Single Application
  - Single Trust Domain
  - Fixed Set of Services
- Fixed Infrastructure
  - Virtualization Technology
  - Network Functionality

CORD’s Service Control Plane
- Multi-Tenant Platform
  - Mediate Trust Across Domains
  - Configurable Set of Services
- Programmable Infrastructure
  - Multiple Virtualization Technologies
  - SDN Control Apps as Services
Model-Driven Design

Models are the definitive specification of the architecture
- Defines the abstract objects and the relationships among them
- Predicates (first order logic) defines actions on models

Architecture is “executed” to operationalize the system
- Represents the system’s authoritative state
- Auto-generates all Northbound APIs
- Enforces security policies and engineering invariants
- Activates the data plane (backend components)
Model-Driven Design

Architecture evolves over time

- On-board new models to extend the architecture
- Add invariants (predicates) to reflect experience
  - New user requirements (from operators)
  - New engineering constraints (from developers)
Summary – beyond micro services

Micro-Services are a tried-and-true way to build scalable apps
DevOps is an agile way to manage and control scalable services
But...

Limited security model → Single trust domain
Limited flexibility → A solution, not a platform
Limited use of SDN → Plumbing, not a source of services

Solution...

Layer Operations-as-a-Service on top of Micro-Services
Leverage centralized Data Model to “drive” DevOps tools
Leverage SDN as a source of innovative services
M-CORD PODs

**M-CORD Micro**
- Built with Intel NUCs and 4-port OF Switches
- 2 x 3 spine-leaf
- Lowest cost
- Targeted for demos and lab trial

**M-CORD Mini**
- OCP compliant
- 6U compact
- x86 and ARM COTS servers
- Low cost
- Targeted for lab trial and PoCs

**M-CORD Mini (ARM)**
- OCP compliant
- 6U compact
- ARM COTS servers
- Low cost
- Targeted for lab trial and PoCs

**M-CORD POD**
- Telco OCP compliant
- 16U
- Targeted for field trial
- Modular and scalable
- x86 and ARM COTS servers
Mobile CORD Enhancements to LTE

1. Build CORD Platform: commodity HW, open source SW
2. Disaggregate, virtualize boxes
3. “Slice” the RAN and Core (Cloud scaling)
4. Add “network cookies” to apps and classification at RAN
5. Add connectionless gateway
## M-CORD as an Enabler for Rapid Innovation

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# M-CORD as an Enabler for Rapid Innovation

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<td>A scalable UPF with associated CPF realized on the SDN control plane</td>
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Open Source Disaggregated EPC*

Programmable E-UTRAN (3GPP RAN)

M-CORD

LTE+

*Radisys and Sprint/Intel versions both 3GPP compliant
M-CORD Innovations at ONS 2017

**INFRASTRUCTURE**

1. Optimized CORE for IoT
2. Scalable & Connectionless CORE
3. End to End Network slicing

**SERVICES**

4. Premium Safety Service
5. Analytics as a Service

Virtualized, Disaggregated, and Programmable
M-CORD Innovations: Optimized CORE for IoT

Static IoT on current LTE leads to excessive signal overhead

- MME disaggregation
- IoT GW
- Core slicing

Optimized Mobile CORE for Static IoT
M-CORD Innovations: SDNized Scalable CORE

- Flow classification at RAN
- GTP & GTP-less support
- Scalable Connectionless GW

IoT + Non-IoT on current LTE leads to excessive signal overhead
M-CORD Innovations: End to End Slicing

Requirements:
- Network slicing
- Differentiated traffic treatment for diverse devices, users, & services
- Mobile Virtual Network Operator (MVNO)

M-CORD

- RAN & CORE slicing
- E2E Orchestration & Network Slicing as a service

Dynamic & Programmable End to End Slicing
**M-CORD SERVICES:** Network Cookies & Public Safety

- Traffic classification
- Network cookie
- User-driven application

Premium Public Safety Service
M-CORD SERVICES: Adaptive Analytics Service

Service assurance solution requires:
- Model driven approach
- Dynamic analytics

Model Driven Assurance and Testing as a Service
Mobile CORD (M-CORD) @ ONS 2017

Mobile CORD: Open Reference Solution for 5G

Contributing Members

AT&T, China Unicom, Google, Intel, radisys, SK telecom, Verizon

Collaborators

ARGELA, CAVIUM, COBHAM, Lime Microsystems, Quortus, Sprint, VIAVI, xPese
CORD Project and xRAN Consortium Align to Build Carrier Grade Software for Next Generation Radio Access Network (RAN)

FEBRUARY 23, 2017

xRAN and M-CORD partnership show immediate value of ONF’s new software defined standards approach
Extensible Radio Access Network
Common Goal – modular, extensible RAN
  Decouple Control and User planes
  Modular eNB stack
  Standard NB/SB interfaces
  Multi-vendor
  Logically centralized control

Dr. Sachin Katti, Stanford professor, xRAN founder is Chief Scientist for Mobility at ONF
XRAN+M-CORD: A Standard Software Substrate for Next Generation Mobile Infrastructure

ON.Lab to focus on implementation of xRAN into M-CORD platform with active guidance and participation of Sachin Katti

Architecture and interface/API spec

- XRAN Standardized Northbound API
- ONOS (w/ XRAN Controller) + XOS + OpenStack/Docker
- XRAN Standardized Southbound API

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<th>APPLICATION CONTROL</th>
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MOBILE / MEC (MOBILE EDGE COMPUTING)

China Unicom & Cavium Trial M-CORD

SAN JOSE, Calif. and SHANGHAI, China -- Cavium, Inc. (NASDAQ: CAVM), a leading provider of semiconductor products that enable secure and intelligent processing for enterprise, data center, wired and wireless networking and China Unicom today announced a targeted program for testing 5G target use cases on M-CORD SDN/NFV platform by using Cavium silicon-based white box hardware in M-CORD racks populated with ThunderX® ARM-based data center COTS servers and XPliant® programmable SDN Ethernet switch-based white box switches.

China Unicom and Cavium will shortly commence trials in several locations in mainland China to explore the new service.

Cavium and China Unicom will demonstrate Multi-access Edge Computing (MEC) use cases developed through previously announced collaboration with China Unicom utilizing the ON.Lab M-CORD (Mobile Central Office Re-architected as data center) SDN/NFV platform at the Mobile World Congress Shanghai from Jun 28th – Jun 30th 2017. The conference will take place at the Shanghai New International Expo Centre (SNIEC), in the China United Network Communications Group Co., Ltd (“China Unicom”) booth at stand location W4.B20.
M-CORD Roadmap

- OPEN SOURCE EPC
- xRAN INTEGRATION
- MULTI-ACCESS CORD
- PRIVATE LTE
- FIELD TRIAL READY M-CORD
Key Takeaways

CORD is bringing economics of the datacenter and agility of the cloud to the access network through open source collaboration.

M-CORD is CORD optimized for the mobile network – both access and core are virtualized and disaggregated

M-CORD is the perfect platform for building 5G solutions
Thank you!

Join the journey
onosproject.org
opencord.org