Transforming Telecommunications

*Through Open Source*

Bill Snow

bill@onlab.us
First, a story

6 Months ??? To provision a fiber you own??

Fiber from our provider
Why do I have to wait so long??

Experienced Azure Design & Implementation Architects

Build applications using any language, tool, or framework on a fully automated self-service platform that enables the provisioning of scalable resources within minutes.

Microsoft Azure
The Internet is not ready for your future

Mobile streaming

Ultra HD Video

Internet of Things

Smart Highways

Augmented/Virtual Reality

Differentiated Services
The Internet infrastructure - “core”

A fiber transport network

Packet Routing Layer built on top of the fiber

Connected in Central Offices
Internet Infrastructure - “edge”

Your phone connects to a 4G cell tower (100-300 users)

...or maybe through copper wires....

Your home connects to a “head end” - DSL, Cable, Fiber

Cell towers, head ends, copper wires all connect to the central office
Just as voice calls from land lines must be routed, your data has to be switched.

It is done by switches from telecom equipment suppliers...Cisco, Huawei, Juniper...

Which are interconnected in racks at the central office.

*For this presentation, switch and router are used interchangeably.*
## What’s wrong?

<table>
<thead>
<tr>
<th>Current infrastructure is built for</th>
<th>We NEED infrastructure built for</th>
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<tbody>
<tr>
<td><strong>Mobile - Voice calls</strong></td>
<td><strong>Video</strong></td>
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<tr>
<td>Set up, maintain connections</td>
<td>High data rates</td>
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<tr>
<td>Low data rates</td>
<td>Long duration</td>
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<tr>
<td>Long duration</td>
<td>Strict latency/jitter requirements</td>
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<td><strong>Fixed - Email, Web</strong></td>
<td><strong>Mobile</strong></td>
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<td>Low to medium data rates</td>
<td>Ubiquitous access</td>
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<td>Low to medium duration</td>
<td>Multiple radios (4G, Wi-Fi, other)</td>
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<td><strong>No guarantees</strong></td>
<td><strong>IoT</strong></td>
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<tr>
<td>Latency or its variation (jitter)</td>
<td>Huge # short duration connections</td>
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<tr>
<td>Data rate</td>
<td>Low latency requirements</td>
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**Strict guarantees**

- Latency, jitter
- Data rate
The perfect storm for Telecom Providers

Revenues down - lack of service agility
  Infrastructure not programmable

Expenses up - operational expense
  Infrastructure changes not automated
  Diverse equipment (config/manage)

...and capital expense
  Equipment still specialized (high margin)

AT&T’s mobile data grew 250,000% in the last year...and is growing exponentially*

*Chris Rice, SVP AT&T, at Linux Foundation Open Source Leadership Conference February 2017
Adding insult to injury...
Adding insult to injury...

Virtual Network
Your private network in the cloud

- Build a hybrid infrastructure that you control
- Bring your own IP addresses and DNS servers
- Secure your connections with an IPsec VPN or ExpressRoute

Get granular control over traffic between subnets
Create sophisticated network topologies using virtual appliances
Get an isolated and highly-secure environment for your applications

Try it now

Already using Azure? Try Virtual Network now >
Adding insult to injury...
Cloud providers are thriving

Use Telco infrastructure like “dumb pipes”

Build and support their own data centers, hardware and software

Agile, low cost infrastructure that scales rapidly and automatically

Pay as you go services

Self serve portals
Why can’t I just get everything from a Cloud Provider?

They can lease fiber to build a core…but they don’t own the edge…

Cell towers

Home, office: DSL, Cable, Fiber

Central Offices

And the edge is too expensive to build
Can’t my telco be like a Cloud Provider?

Less than a dozen types of “boxes”
Few vendors
Low Capital Expense - commodity boxes
Low Operational Expense
  Standard software
  Standard management interfaces
  Automated lights out operation
Up to 300 different “boxes”
Many vendors
High Capital Expense - vertically integrated
High Operational Expense
  Custom software
  Custom management interfaces
  Not automated - manually configure
So, where do we go from here?

Either

A cloud provider deploys new, ubiquitous edge access....

Or...

The telcos transform their infrastructure
Open Networking Lab

Transforming Networks into Agile Platforms for Service Delivery

Leveraging SDN Principles, Disaggregation, Open Source Platforms and Software Defined Standards to Deliver Open Innovation Pipeline

Learn More
Partners

7 Leading service providers make solutions relevant to them
10 Leading vendors help make solutions real & ready for deployment
ONOS Project Collaborators

Collaborating organizations help grow the community and grow the impact.
CORD Project Collaborators

Some collaborators are also involved in ONOS and some are involved in CORD only.
A brief history - SDN origins

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

2011 - Open Networking Foundation
      501(c)(6) - advance SDN and OpenFlow for industry benefit
Open Networking Lab
      501(c)(3) - 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
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.
Before SDN

Expensive (80% margin)
Proprietary Software
Each vendor has different HW/SW
SW evolution tied to HW
Complex control (distributed)
Growth increments expensive

With SDN

Inexpensive (30% margin)
Open Source Software
Commodity HW/SW
SW evolution independent from HW
Simplified control (centralized)
Growth increments inexpensive
SDN: Disaggregating, commoditizing

Before SDN
- Expensive (80% margin)
- Each vendor is different
- SW evolution tied to HW
- Complex control (distributed)

Custom sheet metal
Custom software
Custom control card
Custom interconnect
Custom line card
Custom chips (ASICs)

Data
Control Plane
Data Plane

Open Source software
Commodity Server
Open Source

OpenFlow
Data
Commodity Access Device
Control Plane
Data Plane
Standard chips
SDN: Centralizing Control - ONOS Project

Server Cluster

Apps

Northbound - Ease of App Development

Cluster State Management

Southbound Plug-ins

OpenFlow

Netconf

... 

Built by Operators, for Operators
Proof point Google
was involved in original Clean Slate Program
used SDN principles to build their inter-datacenter network
has run production traffic for more than 5 years!
We have all benefited from SDN!

But….their work is not
In open source…. 
SDN Example: NTT transport network
NTT: Central control of transport network

**Logically Centralized Control**
1. Optimize resource usage
2. Dynamic traffic provisioning
3. Multi-layer resiliency

**Disaggregated Transport Network**
1. Reduces CAPEX & OPEX
2. Eliminates vendor lock-in
3. Allows rightsizing and piece-wise upgrades
NFV: Virtualizing Network Functions

Networks are built with boxes - not virtualized
Cap Ex high
- Proprietary, vertically integrated, function rich
- Duplicate features/functions
Op Ex high
- Proprietary SW, Mgt, manually connected
Not agile
- Cabled together
Scaling cost effectively difficult: must buy more boxes
NFV: Virtualizing Network Functions

Disaggregate the functions in the boxes

Virtualize the functions - containers, VMs…

Build the functions so they can be scaled independently - micro-services

Interconnect the functions as needed, with virtual networks

Orchestrate the functions and connections to create custom services

*Combining SDN, NFV and Cloud gives you*

- *Economics of a data center*
- *Agility of the cloud*
CORD®: REINVENTING CENTRAL OFFICES FOR EFFICIENCY & AGILITY

CORD Summit
Check out the slides and videos from the July 29 CORD Summit
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 controlled Central Office Fabric

- SDN Controller
  - ONOS
- VNF/Services Mgmt.
  - XOS

Leaf-Spine Fabric

- White Box

Commodity servers, switches, and network access

Cloud

SDN

NFV
Domains of Use: Enterprise, Mobile, Residential

Enterprise
SDN-WAN with programmability, packet-optical convergence

Mobile
Disaggregated/Virtualized RAN & EPC, Mobile Edge Service

Residential
vOLT, vSG, vRouter, vCDN

ONOS + Trellis+ XOS + OpenStack/Docker

Leaf-Spine Fabric

Commodity Servers, Storage, Switches, and I/O
Example 1: Residential CORD - AT&T

Residential Services: vOLT, vSG, vRouter, vCDN

ONOS + OpenStack + XOS

Fabric

AT&T U-verse:

Laptop → Simple CPE → GPON ONT → AT&T Open GPON

Third-party Provider portal
Service Provider Portal
Subscriber Portal

Example 1: Residential CORD - AT&T

https://youtu.be/_GH_8THoaLA

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Laptop → Simple CPE → GPON ONT → AT&T Open GPON

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Residential Services: vOLT, vSG, vRouter, vCDN

ONOS + OpenStack + XOS

Fabric
Benefits

Lower opex - remove CPE complexity - fewer “truck rolls”

Lower capex - commoditized devices

Increase revenues - Agility of service creation

Ease of growing business - self provisioning of new/upgraded services through portals
Example 2: Mobile CORD
Quick 4G Mobile Tutorial

Challenges

● Expensive to add capacity
  Spectrum available
  Cell density

● Expensive, Vertically
  Integrated, boxes

● Signaling Overhead High for
  IoT
  Connected vehicles

● No “slicing” makes it hard to
  Add new Services
  Share infrastructure
Example 3: 5th generation mobile network

How? First, address physics....
- More spectrum, software defined radios
- Higher density of cells

Then, apply CORD
- SDN
  - Separate data and control
  - Use commodity devices
  - Open source software
- NFV
  - Disaggregate, virtualize functions
  - Orchestrate functions as new services
- Cloud
  - Functions as microservices
  - Scale independently, “slice” end to end
Example 2: 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
End to End Open Source software enabling fast 5G innovation

Slicing, cookies, classification
  Mobile Virtual Network Operators
  Differentiated traffic
    QoS for video
    Premium public safety application

Optimized core reducing latency
  IoT
  Real time communications - smart highway
Mobile CORD (M-CORD) @ ONS2017

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, xpose
Open Source in Networking has come a long way!
Your parent’s Internet is not good enough

Open Source is fundamentally changing the way the Internet is built

ONOS and CORD are two projects leading change from the beginning

We need your passion and expertise to create a better network for future generations - get involved
Thank you!

Join the journey
onosproject.org
opencord.org