The Final Piece To The Incomplete R-CORD Puzzle

Automated Fiber Switching (AFS) accelerates R-CORD deployments while significantly improving economics, service delivery and flexibility.

Introduction

Central Offices (COs) are not going away anytime soon. They are strategically located in the center of every city, and are critical assets for all types of current and future communications services. Many carriers within the Telecom and Cable markets are seeking new network architectures that make use of technologies and products that are based on data center architectures to achieve lower costs and service flexibility. To that end, the industry has developed the **Central Office Re-architected as a Datacenter (or CORD)** reference network architecture. CORD re-architects the Telco CO into a Data Center(DC) to introduce cloud-style economies of scale and agility. However, the immediate cut-over to a cloud-style agile operations environment for Telcos and Multiple System Operators (MSOs) would be far too expensive to roll out with entirely new equipment day one. Telcos and MSOs need to be able to economically and flexibly utilize existing equipment, while simultaneously and expeditiously extending network capabilities when deploying new classes of service. This drives the selection of CORD Network Elements (NEs) types in real-world deployments.

The goal of CORD is not only to replace legacy NEs with more agile counterparts, but to also enable the CO to quickly support more attractive and meaningful services in various deployment scenarios. Therefore, CORD has a wide array of use cases including:

- R-CORD: or Residential CORD, defines the architecture for Residential broadband
- M-CORD: or Mobile CORD, defines the architecture of the Radio Access Network (RAN) and Evolved Packet Core (EPC) of LTE/5G networks
- E-CORD: or Enterprise CORD, defines the architecture of Enterprise services such as E-Line and other Ethernet business services
- C-CORD: Cable-MSO CORD
- A-CORD: for Analytics that addresses all four use cases and provide a common analytics framework for a variety of network management and marketing purposes

With the simplification that Automated Fiber Switching (AFS) brings to CORD deployment and ongoing operations, the integrated AFS-CORD architecture can achieve a 75% reduction in OPEX. Maximum AFS benefits are realized when seamlessly integrated into the full array of CORD use cases for residential, mobile and enterprise deployment scenarios, as illustrated in Figure 1:

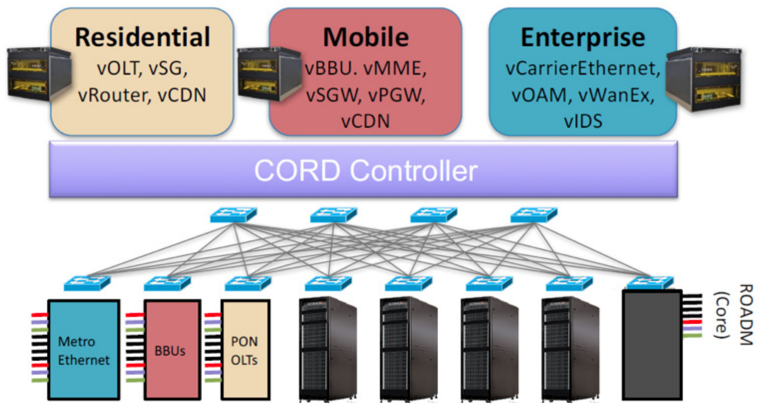

Figure 1 - AFS Applicability in CORD Use Cases

R-CORD Overview

From a subscriber and network deployment volume perspective, R-CORD is considered the largest use case opportunity. The R-CORD architecture spans the Telco CO, access network and the home/enterprise equipment. R-CORD includes virtualization of legacy NEs common to today's access Passive Optical Network (PON) — Optical Line Termination (OLT), Customer Premises Equipment (CPE), and Broadband Network Gateway (BNG), as shown in Figure 2:

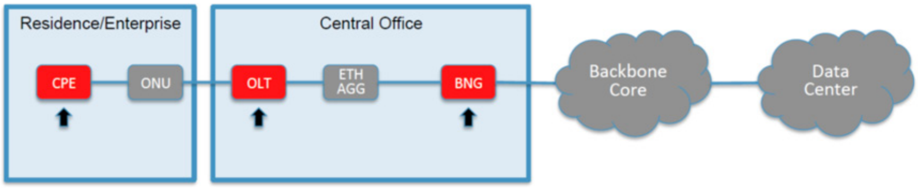

Figure 2 – Key R-CORD Network Elements (NEs)

The R-CORD strategy is to reformulate key NEs as software running on commodity servers, white- box switches and commodity silicon-based PON Input/Output (I/O) blades. In R-CORD there are 2 "sides" of I/O, referred to East/West traffic flows. One, shown on the right (west) in Figure 3, is for Metro Transport (referred to as I/O Metro) connecting each CO to the regional or large city Tandem Office. On the left side of the figure is the access network (referred to as I/O Access).

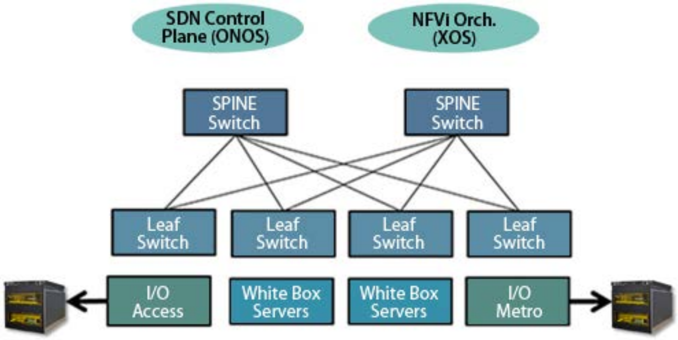

Figure 3 – R-CORD General Architecture

The important difference with traditional Data Centers is the CORD architecture does not focus on optimizing statistical multiplexing of traffic over north-south interfaces. Rather CORD implementations manage massive amounts of east-west physical fiber connections, in addition to east-west bandwidth traffic. Management of these connections, along with Virtual Machine (VM) instantiation optimization is easily realized when integrated with a software definable AFS technology based appliance.

R-CORD Equipment Deployment Strategies

An OLT NE is a chassis that has power supplies, fans, and a backplane. The backplane is the interconnect technology to send bits from one card or "blade" to another. The OLT typically includes two management blades (for 1+1 redundancy), two or more "uplink" blades (Metro I/O interfaces) and the rest of the slots contain "line cards" (PON Access I/O interfaces). In GPONs, the line cards have multiple GPON Access ports each supporting 32 or 64 homes. Thus, a single OLT with 1:32 optical splitters can support upwards of 10,000 homes depending on deployed port density.

Within the CORD framework, OLT "disaggregation" maps the physical OLT NE to the R-CORD architecture (See Figure 4). The backplane is replaced by a leaf-spine switch fabric. This fabric "interconnects" the disaggregated OLT I/O blades. The management and control functions move to a separate Management Plane. The new Metro I/O and Access I/O blades become an integral part of the R-CORD architecture since they are I/O shelves within the R-CORD platform. This Access I/O blade is also referred to as the GPON OLT MAC.

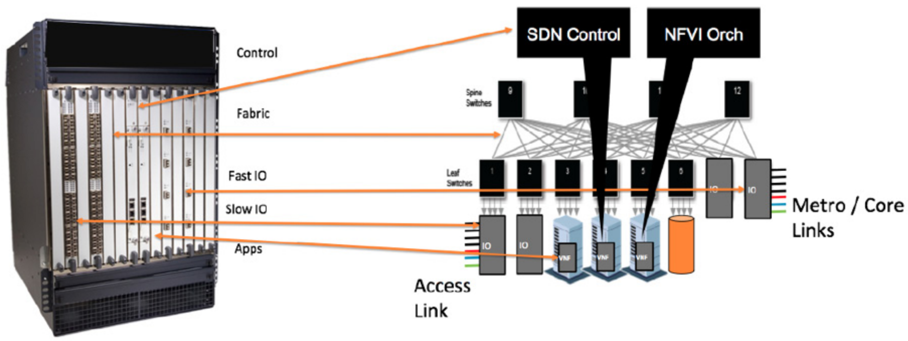

Figure 4- Disaggregating OLT

R-CORD is intended to run on a collection of servers and white box switches, coupled with a "disaggregated packaging" of media access control (MAC) technologies such as GPON. These hardware elements when coupled with an AFS are organized into a rackable unit, referred to as an Access Rack, which is one layer of compartmentalization up from POD server racks of a traditional Data Center. We recommend the configuration for a reference R-CORD Access Rack consist of four hardware elements:

1) **Servers** – supporting VM instantiations
2) **Switches** – both leaf and spine switches
3) **I/O Blades** – "OLT pizza box" GPON MAC interfaces and GE uplinks
4) **AFS** – supporting fiber management and fiber network reconfigurations

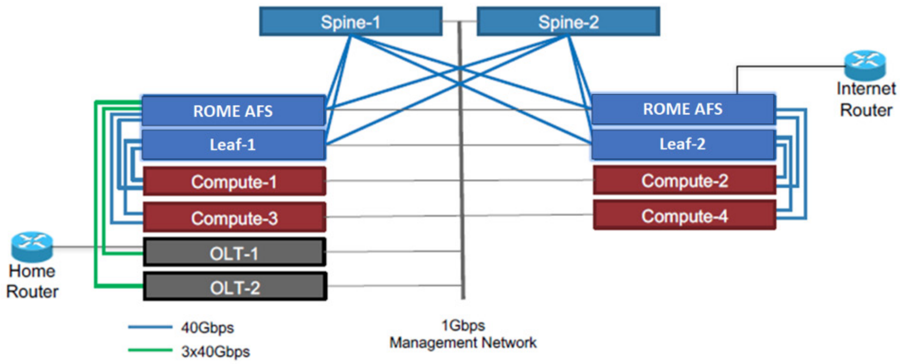

Figure 5 - R-CORD Access Rack Hardware

In summary an Access Rack has the following characteristics:

- It is organized as two "virtual racks" each with two leaf switches and a set of servers/blades.
- It includes four switches arranged in a leaf-spine configuration, with two serving as leaf switches (one per virtual rack) and two serving as spine switches. The leaf switches fiber downlinks to the rack's servers and fiber uplinks to the spine (via AFS), while the spine switches use downlinks to leaf switches (via AFS).
- It includes two OLT pizza boxes. All the I/O blades are collocated in the first "virtual rack" and connected to the AFS.
- It includes four servers and are spread across the two "virtual racks" and connected to the corresponding pair of leaf switches (via AFS).
- It includes one physical AFS, terminating all fiber connections within the two racks for maximum reconfigurability and flexibility.

<u>Efficient AFS Integration for Protection and Load Balancing</u>

Replacing hardware devices with software running in VMs is a necessary first step, but is not sufficient to satisfy Telco network services and on-going operations requirements. All the devices in a hardware-based CO must be connected in a meaningful way to support Telco operations and software reconfigurability. This process is often called *Service Orchestration*, and if Telcos are to enjoy the same agility as cloud providers, the NE abstractions that underlie the orchestration must fully embrace (1) the elastic scale-out of virtualized functionality, and (2) the effective composition of disaggregated (unbundled) functionality. A model that simply "chains" VMs together as though it is operating on individual hardware-based components will not achieve either goal. Interconnection flexibility can only be achieved by utilizing AFS technology at strategic points within the Telco network, as illustrated in Figure 6:

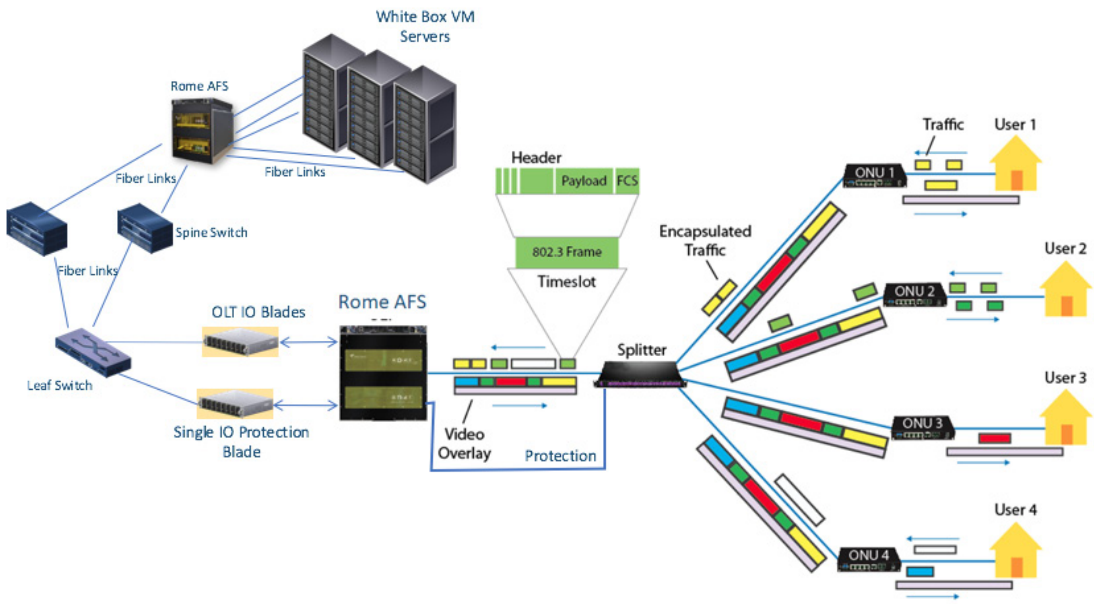

Figure 6 - AFS Seamless CORD Integration

Strategic placement of AFS equipment is critical for facilities based Telcos. For example, no amount of R-CORD deployments will solve backhoe fades or squirrel chews of Outside Plant (OSP) fiber cables. Only an AFS providing protection switching and centralized remote OSP cable testing can address the needs of Telcos managing real-world R-CORD networks. Telcos can use AFS products for testing multiple PONs with the same OTDR. This approach enables a single OTDR to handle testing for an entire CO.

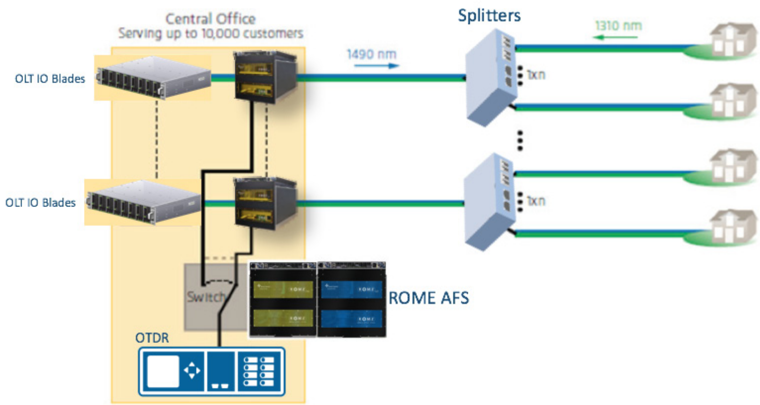

Figure 7 - Outside Plant Cable Testing

With and AFS, the network operations center (NOC) can remotely test facilities from the NOC, enabling them to troubleshoot before sending any technicians into the field. Expensive OTDR test equipment can be centrally located, readily available and shared over multiple OLT IO MAC blades.

Another example of the need for AFS integration is facilitation of dynamic stand-up instantiation of Virtual Network Functions (VNFs) such as GPON-MAC I/Os, application-layer functions, Firewalls, caching, etc. AFS supports efficient topology reconfiguration for fiber interconnects amongst VNFs.

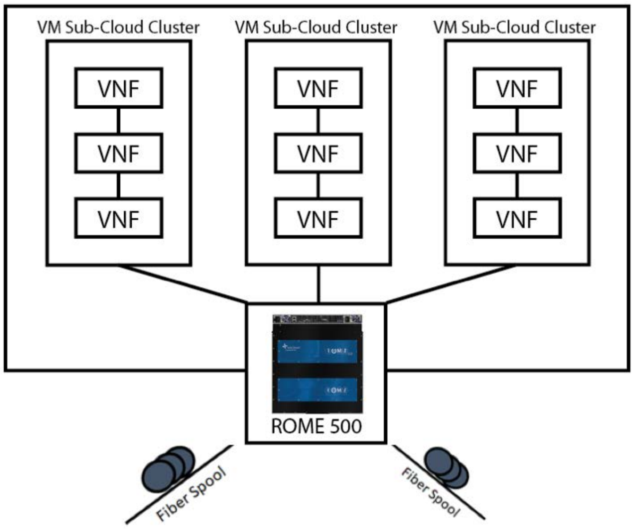

Figure 8 - VM Server utilization and Spin-Up

The AFS (for example the Wave2Wave ROME-500 product) enables the flexibility in provisioning to support the required reliability requirements, regardless of VM Sub-Cloud Cluster equipment design.

Expanded Fiber Management Of CORD Architectures

Although CORD deployment reduces costs versus traditional OLT NEs by disaggregating expensive OLTs into NFV OLT I/O blades (the good news), it dramatically increases the number of fiber ports and patch panels within the CO to manage (the bad news). Therefore, Telcos will have a lot more Fiber Connections to manage during turn-up and provisioning as illustrated in Figure 9.

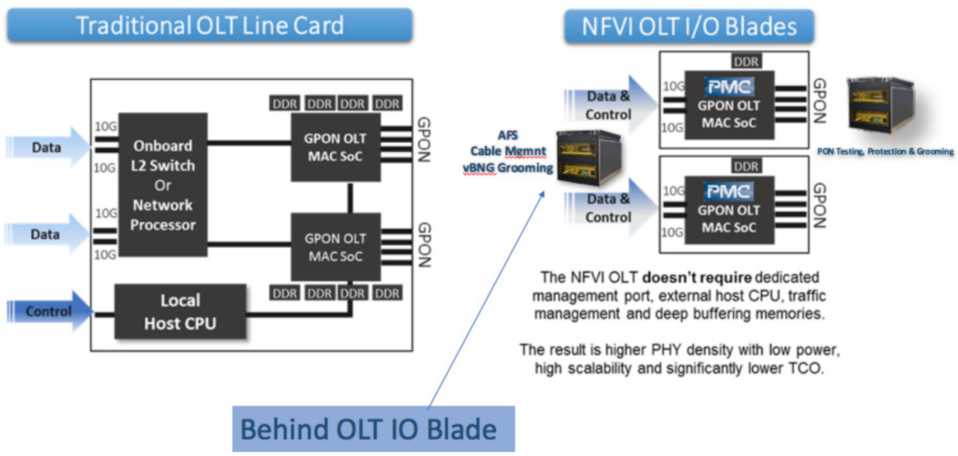

Figure 9 - Port Density Mitigation

Technicians will spend a great deal of time identifying the correct fiber, conducting pre-provisioning tests and running patch cords – all of which drive up OPEX. An integrated AFS minimizes these OPEX and headcount expenses within the R-CORD CO, while simultaneously maintaining proper records.

Conclusion

As we have seen, AFS technology can offer powerful operational benefits when integrated with CORD deployments. These benefits include:

- Even Faster Time To Revenue vs Simple CORD
- Dynamically scaled CORD appliance connectivity
- End-to-end network balancing
- Full flexibility & automation
    - √ Moves/adds/changes, testing/diagnostics, No-Touch Provisioning
- Remote testing & troubleshooting of R-CORD OSP
- Network optimization via near-real time fiber reconfigurations
- Minimized downtime & fewer outages

Finally, AFS should be transparent to bit rate and transmission protocol. AFS systems will enable R-CORD deployments to minimize labor, eliminate mismatches resulting from human error, optimize CAPEX, and facilitate testing and maintenance. Telcos can gain the OPEX savings benefits of AFS immediately, while simultaneously prepositioning the network for future R-CORD evolution.