How CORD will impact your central office

For telecommunication service providers, bandwidth demand continues to grow exponentially, while subscribers and revenue grow at a far more modest pace. Investments in new services and additional network capacity are necessary to stay competitive, but the cost per bit has not been falling as quickly as traffic has been growing. Over time, the gap widens.

What can be done to reduce costs, both CapEx and OpEx? And how to efficiently create new revenue streams?

Virtualization of network functions is a key enabler to reducing costs and new service development. The CORD initiative (central office re-architected as a data center) offers a framework for implementation. This white paper takes a closer look at virtualization, CORD, its applications and benefits, and implementation considerations.

Virtualization: making networks more agile and cost-effective

Historically, high-performance networking equipment—leading-edge throughput and features, with the highest availability—has been equipment built with custom silicon (ASICs) and purpose-built hardware. Network functions such as switching and routing, firewalls, G/EPON termination and session border controls were performed by specialized equipment dedicated to that function. This compartmentalization has worked well but also has its drawbacks: vendor lock-in and specialized knowledge and training, resulting in high costs. If congestion occurred, building faster links and over-dimensioning were reliable but expensive ways of relieving it.

To realize more cost-efficient and agile networks, a cloud computing-based virtualization approach has emerged in recent years. Virtualization means replacing functions performed by dedicated physical hardware with virtualized software applications that run on general-purpose commodity hardware.

Software-defined networking (SDN) and network functions virtualization (NFV) are key technologies that enable virtualization in the data center and central office environment. The combination of NFV and SDN allows providers to break through the "service silo" model and lowers the relative cost of capital assets by using commercial off-the-shelf hardware and software, resource pooling, network visibility and analytics.

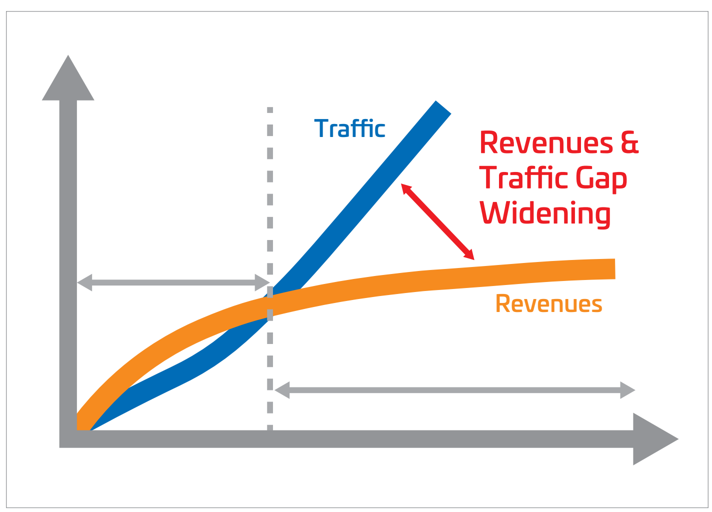


Figure 1: The growing gap between traffic and revenues

Major transformation brings great agility

On a fundamental level, SDN separates the network control plane from the forwarding plane providing centralized control. SDN allows customized network designs to improve throughput, linking combined virtualized network functions into service chains that are independent from any specialized hardware.

already enjoyed successful market adoption and is forecasted to generate $1.3 billion in service revenue by 2020 .

SDN/NFV adoption approaches critical mass

SDN/NFV technologies have been a driving force behind the impressive growth and scale of large content and OTT

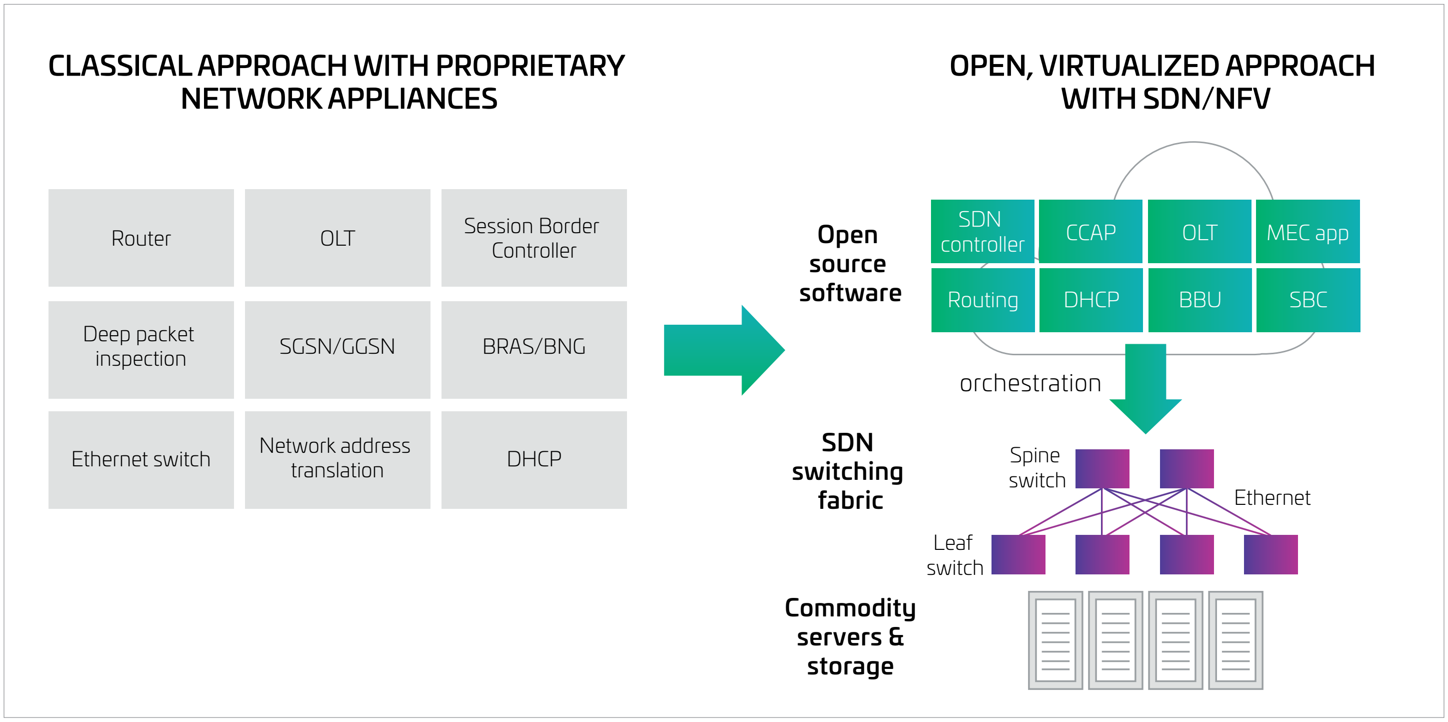


Figure 2: From proprietary appliances to an open, virtualized environment

NFV begins with converting specific legacy hardware (switching elements, for example) into software programs that run on a common off-the-shelf (COTS) hardware infrastructure. These standardized hardware infrastructures form resource pools that scale up capacity based on demand, and accelerate deployments for new applications and services.

For access networking equipment, NFV is emerging: virtualized optical line terminals (v-OLT), converged cable access platform (v-CCAP), and baseband units (v-BBU) have become available. SD-WAN, an SDN-based approach to providing dynamic WAN connectivity for enterprises, has

(over-the-top) providers. Market size estimates range from $54 billion to $168 billion by 2022 , depending on the scope. The potential for SDN and NFV to radically transform network capability, customer service and organizational profitability has caught the attention of service providers as well as third-party software developers. The ETSI NFV industry specification group, founded in 2012, has focused on NFV standardization and multivendor interoperability for telecom service providers.

CORD: Bringing data center best practices to the central office

There are many similarities between a virtualized central office and a data center. Utilizing decades of knowledge in developing and optimizing data center architectures and functionality in the central office would appear to be a logical step. That's where CORD comes in. CORD is an integrated, open-source solution platform that combines NFV, SDN, and highly flexible, scalable commodity "clouds" to bring data center economics and cloud agility to the central office.

Founding CORD members include AT&T, China Unicom, Comcast, Deutsche Telekom, Google, NTT, Turk Telekom, and Verizon. Specific working groups focus on mobile (M-CORD), residential (R-CORD), and enterprise (E-CORD) networks and applications. For MSO/CATV operators, HERD (head ends re-architected as a data center) is equivalent to CORD.

Connectivity and cloud through shared hardware and software

Using commercial off-the-shelf (COTS) hardware and open-source software, central offices can mirror the functionality of data centers. Pooling resources allows dimensioning for aggregate versus peak demand, which reduces costs. Real-time service provisioning is enabled. Commodity servers and switches run a CORD software stack, allowing operators to manage central offices using declarative modeling languages.

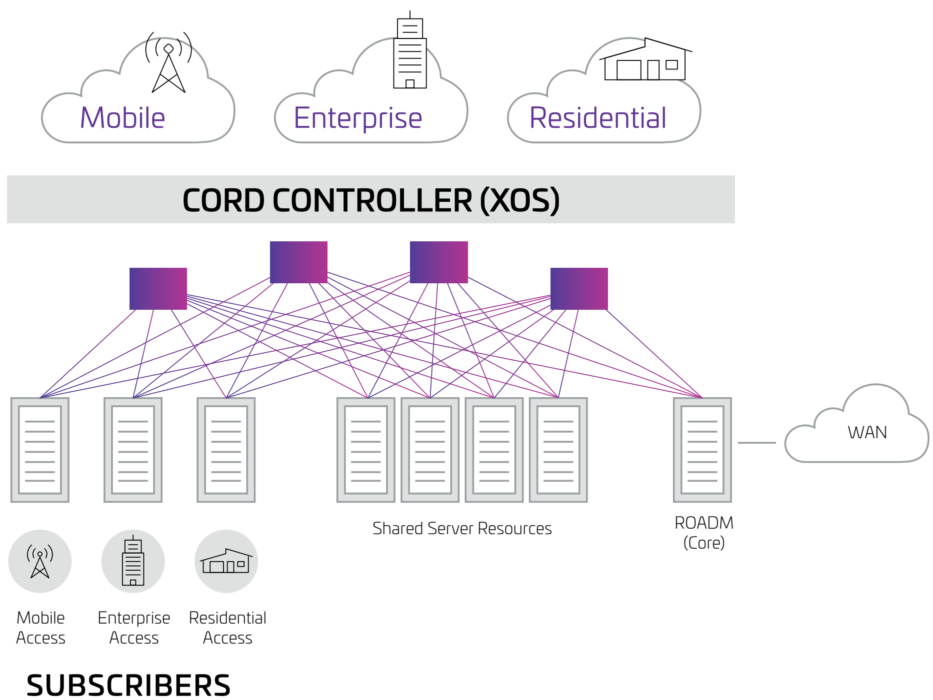
Bringing the edge closer

SDN, NFV and CORD enable access network unification and multi-access edge computing (MEC). The emergence of edge data centers is forecasted to serve a huge increase in network traffic from mobile devices, the internet of things (IoT) and streaming media.

In a traditional scenario, a cloud data center might be located far from the systems' users, possibly on another continent. This distance could introduce an unacceptable response time, or latency, in processing information requests and delivering content. New latency-sensitive applications such as augmented reality manufacturing and autonomous vehicles will require much lower latency that can be delivered only by computing resources in close proximity to the end user.

The benefits of CORD

- A transparent, fully integrated path to deploying virtualization in central offices
- Avoid challenges often associated with legacy infrastructure
- No dedicated hardware required, bringing down costs
- Flexibility, scalability and fast upgrades for service offerings—easy to keep up with demand
- Central offices can compete with web-scale operators
- Avoids interoperability and access issues
- White-box servers and switches and open-source software, including Docker, ONOS (Open Network Operating System), OpenStack and XOS
- Great uniformity in the bill of materials
- CORD offers PHY (physical) layers towards access infrastructures: G/EPON, DOCSIS, or 4G/5G RAN
- Essential harmonization of NFV and SDN
- End-to-end visibility of the network



Edge data center use cases

Content and applications that are frequently accessed are cached on servers located closer to end users. This improves the quality of high-bandwidth applications and reduces the amount of backbone traffic, leaving them free for other valued services. Edge data centers also support low-latency next-generation services, and can provide network bypass terminating mobile internet traffic. 5G will drive numerous use cases and business models, since MEC is an essential enabler for more intelligent applications delivered with lower latency.

Locating data centers closer to users doesn't just improve the customer experience; it can also save significant amounts of money in transport bandwidth costs and enable new latency-sensitive revenue services.

A closer look at CORD infrastructure

For an increasing number of service providers, SDN and NFV are the keys to new network architecture—technologies that can deliver higher levels of automation, faster and more agile deployment of services, new revenue streams and greater efficiencies in terms of management, operations and cost.

When implementing a CORD infrastructure, a few essential items need to be considered. CORD doesn't require only different hardware and software than traditional solutions, but also an architectural change to enable a new way in which services are managed and delivered.

Processing in the pod

Ultimately, success depends largely on retooling facilities to accommodate these new networking technologies. The physical CORD adoption in a central office requires a private cloud networking-based approach featuring a data center-like architecture (in many cases deployed in a data center "pod"—a separate space in the facility where processing takes place).

These pods are equipped with a high-density leaf-spine network optimized for cloud-oriented east-west data flow—all deployed on the network edge. This pod architecture can take advantage of the cost savings from lower-cost multimode fiber optics. In a fast-moving environment, the migration to higher speeds is common and, in some cases, frequent. Careful planning of the cabling infrastructure inside the pod is vital to ensure support for multiple migrations.

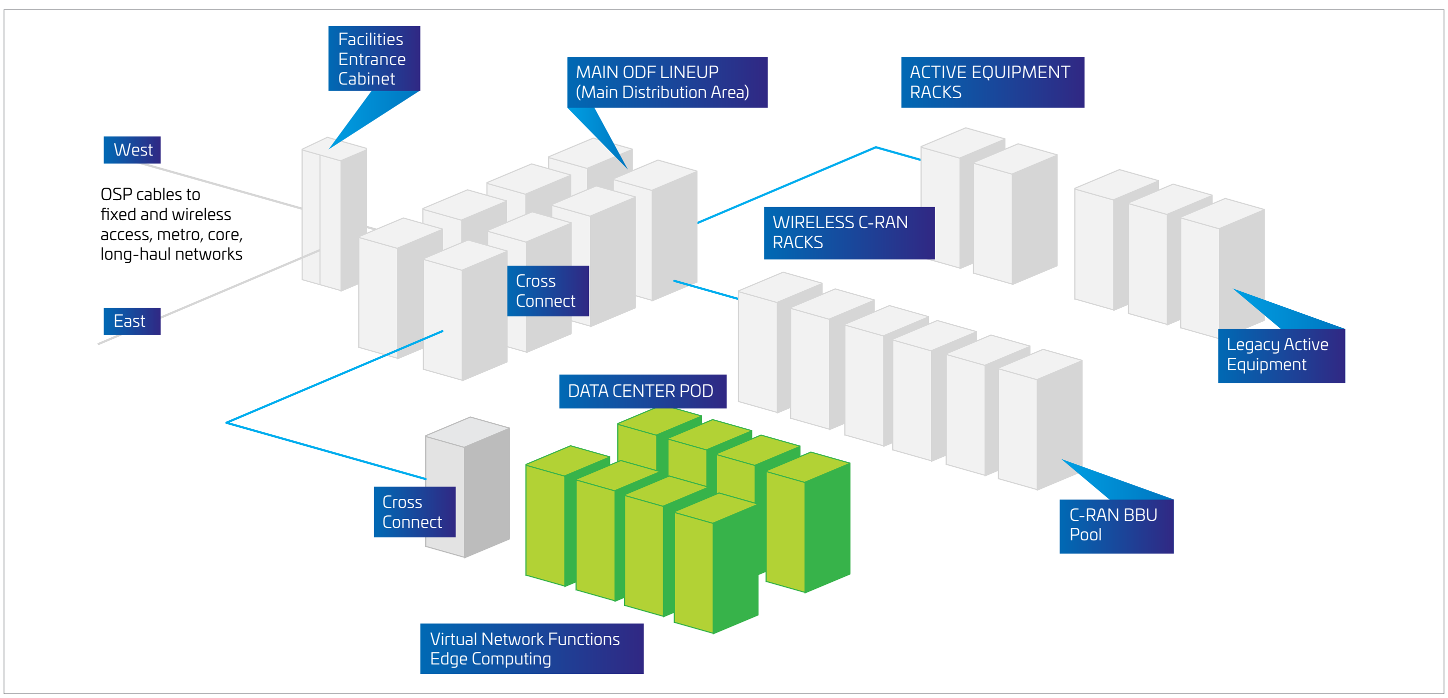


Figure 4: Central office with data center pod (green)

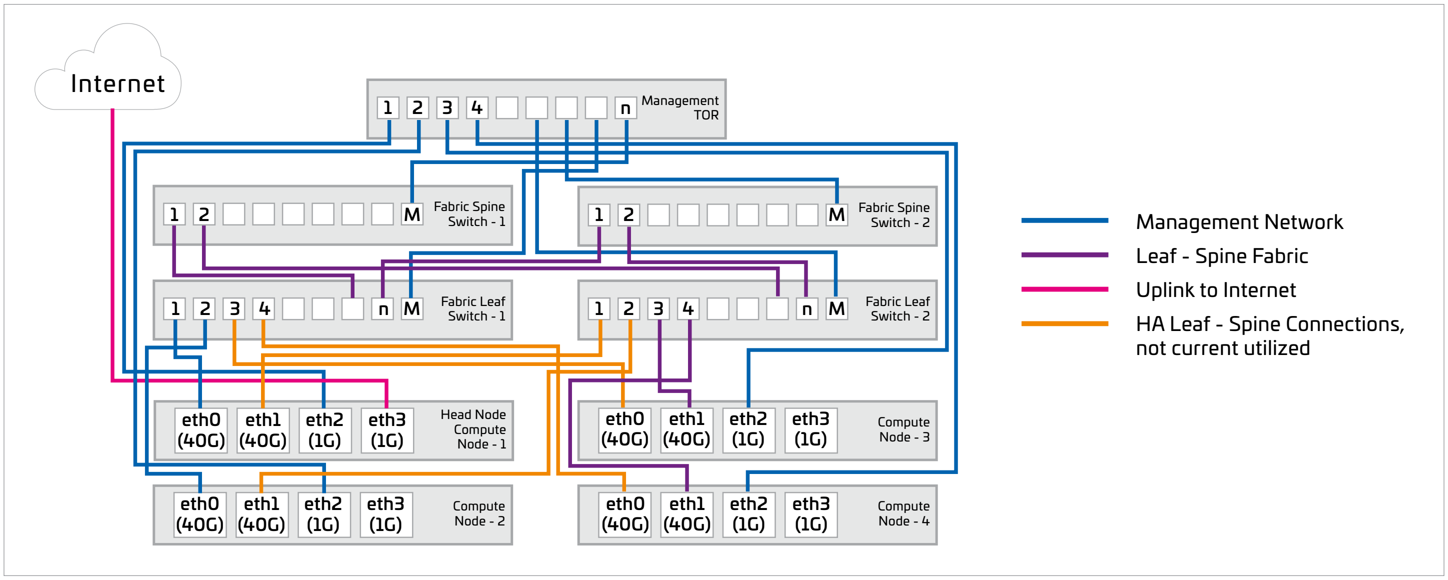


Figure 5: Compute/storage

Considerations for cabling infrastructures in CORD pods

Engineering teams must consider a high-speed migration path for the data center pod. Lane capacities are expected to keep increasing, reaching 400G by 2020 and enabling the next generation of high-speed links for fabric switches. Current requirements may dictate 10G, 40G and 100G links, while the next upgrade might require 25G, 50G, 200G and 400G links.

Several factors are driving the surge in data center throughput speeds. Server densities are increasing by approximately 20 percent a year, for example, and processor capabilities are increasing at a similar rate. It is critical to be aware of the industry's Ethernet roadmap for multimode optics. Multimode transceivers offer a much lower cost when compared to singlemode transceivers and are the first choice for data centers.

High speed migration

Cabling infrastructure inside the data center pods must be able to cope with exponentially increasing demand for higher capacity, new architectures and ever-changing network requirements. This can be achieved by introducing infrastructure "building blocks" that enable easy and quick migration to higher speeds and different fiber-optic technologies. The flexibility to deploy higher speeds or lower-cost networks provides agility and minimizes the cost of growth in data centers.

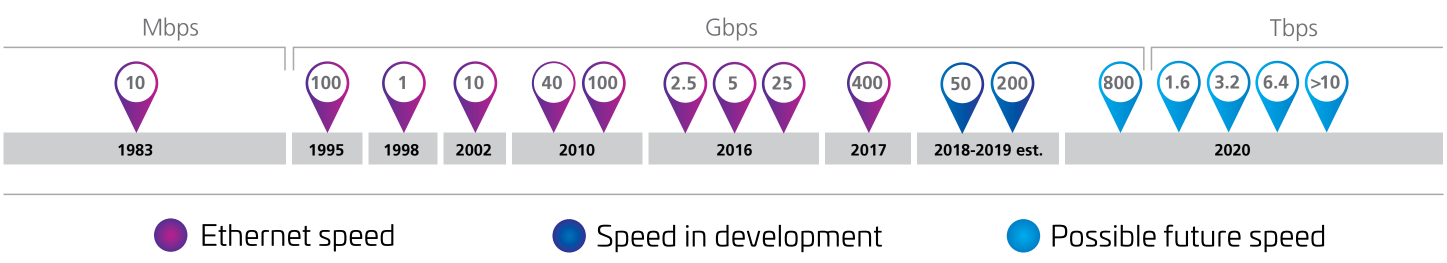


Figure 6: Roadmap for Ethernet speeds (source: Ethernet Alliance)

CommScope's High Speed Migration (HSM) solutions featuring ultra low-loss (ULL) technology have been developed to enable seamless high speed migration in data center pods. ULL technology offers very high flexibility in transmission channel design by exceeding international standard requirements. The following graphic shows support for common duplex and eight fiber optics using CommScope's new ULL preterminated high speed migration solution:

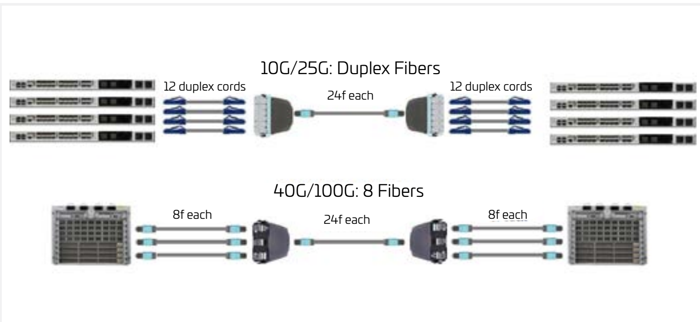


Figure 7: Cabling infrastructure supporting two-fiber applications to eight-fiber applications

The 24-fiber is well suited to either type of optic application. Bandwidth upgrades may involve moving from duplex to parallel links; sometimes, replacing parallel links with newer lower-cost duplex optics will be required. The 24-fiber trunk is constant, with the module at the both ends of the link changing as required.

High port density is essential to CORD success

The mesh of fiber links in a leaf-and-spine topology creates a high-capacity network resource, or "fabric," that is shared with all attached devices. All fabric connections run at the same speed. The higher the speed, the greater the capacity of the fabric. Fabric networks require a large number of fiber connections—particularly in the switch layer. Equipment vendors continuously work to increase the density of their line cards in order to stay current.

Properly designed fiber apparatuses provide higher connection density while avoiding long-term management issues. This apparatus has been designed to serve demanding environments, including hyperscale and large enterprise data centers. Fast, easy deployment serves large-scale environments with moves, adds, and changes made quickly and easily—without interrupting live channels.

CommScope's extreme high-density (EHD) fiber solutions are perfect for core switching and aggregation layers, high- and ultra high-density spine/leaf architectures and data center cross-connects and interconnects. 144 fibers per rack unit is the current de facto standard in data center cabling. The challenge is ensuring the tightly packed fibers remain accessible, well managed and protected in order to maximize:

- Ease of access to each individual connector
- Proper patch cord routing toward the sides of the cabinet
- Simplified management of the patch cord bundle size

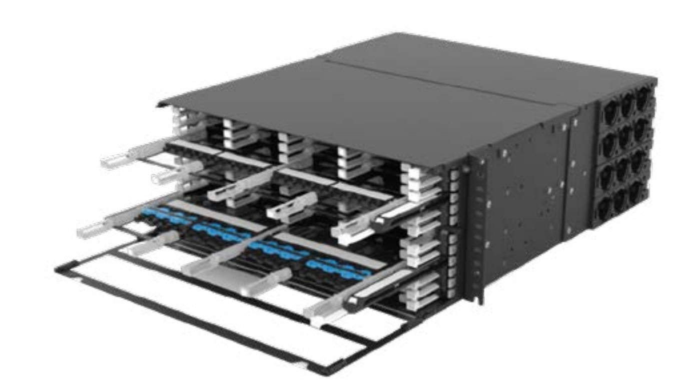


Figure 8: CommScope SYSTIMAX® EHD (extreme high-density) panel

Application Assurance and System Warranty

Because compute and storage networks are evolving so quickly, it's difficult to predict the network infrastructure required to sustain the rapid growth in speed/capacity that will be needed over the next few years. And, when things change, you need the assurance that everything will work smoothly.

Supporting the high speed migration of fiber connectivity within data centers requires integrated sets of tools that simplify exploration, design, deployment and ongoing expansion. You need to be able to easily define channel topology limits, attenuation requirements and functional possibilities in relation to cabling solutions for a wide range of applications, including standards-based, multisource agreements (MSAs) and proprietary specifications.

CommScope offers a suite of tools that simplify the design, deployment and ongoing expansion to support the high speed migration of fiber connectivity within data centers. For example, the SYSTIMAX® Performance Specifications define channel topology limits specific to SYSTIMAX cabling solutions for a wide range of applications, including standards-based, multisource agreements (MSAs) and proprietary specifications. Additionally, the SYSTIMAX Fiber Performance Calculator provides the attenuation requirements for a proposed cabling channel while simultaneously determining which applications the channel will support. CommScope stands behind the Performance Specification and the Fiber Performance Calculator analysis with warranty assurance for all the supported applications. Not only do these tools allow rapid design exploration; they form the basis of our unique SYSTIMAX Application Assurance. Under the terms of CommScope's 25 Year Extended Product Warranty and Application Assurance, CommScope guarantees the cabling will meet specification and that the applications will operate in accordance with the Performance Specifications—in many cases, beyond the distances and channel complexities specified in the standards.

New business strategies based on CORD architecture

The objective of CORD is to replace purpose-built switching hardware with flexible and cost-effective off-the-shelf components and open-source software. This new central office platform efficiently enables demand-based, value-added (cloud) services. Implementing CORD impacts many areas of a service provider's operations—from hardware standards, deployment and maintenance processes to procurement practices. Enabling the rapid introduction of competitive services allows operators and service providers to completely innovate their business models.

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WP-112415.1-EN (03/18)