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White Paper

Knowing When to Deploy PON for Federal Applications

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Contents

Doubling down on IT investments

The United States federal government is the largest single purchaser of IT in the world. In 2013, it will spend an estimated 79 billion dollars on IT products and services, with the Army, Navy and Air Force accounting for 22.3 billion dollars.[1] Over the past ten years, IT spending has totaled more than 600 billion dollars.[1] Given the recent explosive growth in spending on cybersecurity initiatives—according to Delaware Senator Thomas Carper (D), "Federal agencies have spent more on cyber security than the entire GDP of North Korea…"[2]—the trend in IT spending shows no sign of slowing any time soon.

"The Federal Government is the largest single purchaser of IT in the world, spending approximately $75 billion annually on over 6,000 separate IT investments. Given the significant size of this investment, agencies must ensure they provide strong oversight and financial stewardship of taxpayer dollars spent on IT."

— CIO Council, Management Best Practices Committee, December 8, 2011

At the same time, there are concerns over how federal IT dollars are being spent. In June 2009, the Office of Management and Budget (OMB) launched the IT Dashboard, an online resource allowing the OMB and the American public to monitor IT investments across all agencies in the federal government.

In its 2011 year in review, the government's CIO Council, Management Best Practices Committee, wrote:

"The Federal Government has spent over $600 billion on information technology (IT) over the past decade. Far too often, IT projects, especially large projects, cost hundreds of millions of dollars more than they should, take years longer than necessary to deploy and deliver technologies that are obsolete by the time they are completed."

With a 2014 budget of 38 billion dollars[1], IT infrastructure accounts for nearly half of all money the federal government spends on IT. Ensuring that these projects deliver the greatest possible value requires that federal CIOs and CTOs squeeze more productivity and longevity from every infrastructure solution while, at the same time, remaining flexible enough to respond to an ever-changing IT landscape. In an effort to make the best use of public funds, federal IT managers have started gravitating toward passive optical networks as an alternative to traditional copper-based Ethernet.

Growth of passive optical networks

Beginning in the mid-1990s, the telecom industry started investing in passive optical network (PON) technology as a way to deliver improved bandwidth and services to subscribers—and an alternative to active copper- and fiber-based Ethernet networks. Cost-effective, scalable and with plenty of speed and bandwidth, the technology provided key benefits for companies needing to move more data, video and voice content over longer spans and to a large number of users.

In 2009 the federal government began evaluating PON for use in data networking applications. Since then, passive optical networks have started to gain acceptance across federal agencies and facilities as a viable option to traditional distributed Ethernet. The primary interest from both Department of Defense (DoD) and civilian agencies is driven by the need to reduce the CapEX and OpEx associated with new and existing network infrastructure. Federal CTOs and CIOs have also been attracted by PON's ability to merge separate voice, data, video and building automation networks onto one network and one fiber. This allows for quicker installation, streamlined and less costly maintenance and the elimination of intermediate network equipment with its associated power needs. By reducing energy requirements across the network, PON provides federal facilities a greener solution that reduces total cost of ownership (TCO) of the network.

Making the grade in secure applications

Another factor favoring PON technology is security. Inherent security features include the elimination of electromagnetic emissions and resistance to radio frequency interference (RFI). In cases where network cabling is used to transmit unencrypted classified National Security Information (NSI) through areas of lesser classification or control, PON solutions can typically be used with either hardened or alarmed carriers. For federal IT personnel faced with upgrading capacity or reach in networks using protected distribution systems (PDS), PON also offers key advantages that will be discussed later in this paper.

Whether implemented in a hardened carrier or alarmed carrier, there are also various security management controls built into each specific PON solution. The scope and level of protection varies by manufacturer. The CommScope Ethernet passive optical network (EPON) solution, for example, enables IT personnel to identify and quarantine rogue optical networking units (ONUs) and provides media access control (MAC)-filtering for blacklisting and whitelisting end-user devices. Multiple configurable system alarms provide an additional layer of physical security.

In 2012, PON was certified by the Defense Information Systems Agency (DISA) Joint Interoperability Test Command (JITC) for use in operational DoD networks, and can thus be implemented in both classified and unclassified networks. Since then, PON has steadily gained acceptance as an alternative or complement to distributive Ethernet.

In 2010, the CIO, G-6 of the U.S. Army, citing the cost-effective deployment of PON solutions such as Gigabit PON (GPON), issued the Technical Guidance for Network Modernization, which stated:

"All camps, posts and stations undergoing modernization shall aggressively adopt GPON and broadband wireless networking technologies by fiscal year (FY) 2013 in order to decrease operating costs and capital expenditures."

This guidance was reinforced in the May 2012 memorandum issued by the Commanding General, NETCOM, stating:

"NETCOM has identified a requirement for all new construction and all major renovations to utilize Gigabit Passive Optical Network (GPON) technology. Any deviation from the requirement to utilize GPON for said projects will require a waiver from the CG, NETCOM prior to execution."

A practical perspective

Many industry experts, including CommScope, believe that PON plays an important role in the evolution to more efficient, scalable high-capacity networks. But PON is not a panacea and should be viewed holistically as one of a range of potential solutions. For some applications, traditional copper- or fiber-based Ethernet local area networks (LANs) may provide a better solution than a PON. For other applications, an integrated network with both PON and traditional distributed Ethernet may be applicable. CommScope has developed this white paper in order to help federal CIOs, CTOs and IT managers make a more informed decision when it comes to whether or not to pursue a strategy involving passive optical networks.

As a provider of multiple enterprise network solutions—including copper- and fiber-based Ethernet, GPON and EPON—CommScope offers a broad view that takes into account the specific advantages of each strategy. This report is designed to provide an unbiased analysis of the strengths of a PON deployment and the circumstances under which it may be the best option.

PON basics

PON is a point-to-multipoint, fiber-to-the-premises (FTTP) network architecture in which unpowered optical splitters enable one strand of singlemode optical fiber to serve multiple users with data, video and voice services. A PON is comprised of two main active (powered) components—an optical line terminal (OLT), typically located in the data center or equipment room, and ONUs at the end-user locations. A network of singlemode fiber and passive (non-powered) optical splitters connects the OLT to the ONUs; the fiber and passive equipment between the OLT and ONUs is often simply referred to as the optical distribution network (ODN).

The OLT provides the interface between the network's core router and the passive infrastructure. It encodes the Ethernet data for transmission on the PON and manages the upstream data traffic from the network ONUs. The ONUs distribute the signal via twisted-pair data cable to a variety of Internet protocol (IP)-enabled devices, such as computers, wireless access points (WAPs) and voice over IP (VoIP) phones. A fiber cable infrastructure consisting of singlemode optical fibers and passive optical splitters connects the OLTs and ONUs and distributes the data signals, reducing the amount of physical cable and active equipment in an installation.

PON takes advantage of wavelength division multiplexing (WDM), using one optical wavelength for downstream traffic and another for upstream traffic. Passive optical splitter technology directs downstream signals to multiple users. Upstream signals are combined at the splitters using a multiple access protocol, usually time division multiple access (TDMA). PON supports the full network data speed (typically 1Gbps or 10Gbps) to the end-user device in both upstream and downstream directions.

Depending on the number of users supported, bandwidth requirements and type of end-user equipment, a PON can be engineered with single or multiple fiber trunks and a variety of splitters and ONUs. The optical split ratio of the passive splitter can vary from two to 64, but ratios of 32, 16 and eight are most typically used.[3] The ONU is typically available in a number of formats that support single or multiple users or a wireless access point, and are often available with analog telephone service and Power over Ethernet (PoE) options.

Ethernet PON (EPON) versus Gigabit PON (GPON)

Within the PON landscape, two major technologies have emerged. EPON and GPON. Both technologies draw heavily from the standards developed for broadband PON (BPON). For example, both make use of the same type of optical distribution framework and both use identical wavelength plans—1490 nm for upstream traffic and 1310 nm for downstream traffic.

There are, however, significant differences in the approaches used by each. EPON is a native Ethernet solution that leverages the features, compatibility and performance of the Ethernet protocol. GPON, on the other hand, is fundamentally a transport protocol that leverages the techniques of synchronous optical networking (SONET), synchronous digital hierarchy (SDH) and generic framing protocol (GFP) to transport Ethernet signals. Ethernet services are adapted at the Ethernet interfaces of the OLT and ONTs and carried over an agnostic synchronous framing structure from end to end.[4]

Both GPON and EPON are well suited for the transport of a broad range of services, including fiber-to-the-home (FTTH) delivery of voice, Internet data, and cable access broadband video. As carrier-class Ethernet continues to gain widespread acceptance as a universal data networking solution for commercial and residential markets, EPON is becoming the technology of choice for service providers looking to grow their revenue-generating services. This is due in large part to EPON's inherent ability to transport IP data, and the ease with which it can integrate with existing and future Ethernet equipment.

PON-friendly applications

As stated, there are some applications for which PON is especially suited. These include:

- Applications requiring anticipated system upgrades to high-security areas or where the rerouting of cable may be difficult.
- Installations involving widely dispersed nodes requiring very long runs of fiber
- Projects where costs—especially initial deployment costs—are a key concern and user bandwidth can be adequately managed

Scalability within high-security environments

A key network concern within most DoD applications is information and system security and the ability to integrate with protected distribution systems (PDS). While both PON and active Ethernet can be used with hardened and alarmed carriers, PON offers significant advantages when it comes to upgrading or expanding the structured cabling network.

Whether constructed of electrical metallic tubing (EMT) or rigid steel ducting, a properly designed and installed NSTISSI no. 7003-compliant hardened–carrier PDS provides excellent protection from unauthorized network access. The PDS can, however, present obstacles when the need for more throughput or capacity dictates changes to the installed network.

Figure 1 illustrates a typical high-security application where the data network is installed in a hardened-carrier PDS. In the case of a copper-based Ethernet network, upgrading service to the controlled access area or secure controlled information facility (SCIF) requires replacing all the cabling and switches throughout the network, including those contained in the PDS. Pulling new cable through the existing PDS or expanding the PDS to accommodate the additional cable can be disruptive and costly.

PON eliminates these problems, enabling simultaneous deployment of a second optical wavelength that can be used to carry 10GbE traffic on the existing 1GbE fiber strand. Even if all fibers inside the PDS are being used for 1Gbps service, an upgrade to 10Gbps is possible without disrupting existing users or installing new cable. The 1GbE network can then be left in place or eliminated as users are upgraded.

If cost is an issue—or if initial bandwidth needs can be met with a 1Gbps network—PON enables the gradual transition from the lower speed to the higher speed network. As the number of users or application demands increase, they can be migrated as needed to the 10Gbps service with no changes to the fiber distribution network inside the PDS. The CommScope C9264 OLT, for example, is shipped 10Gbps-ready. So, upgrading from 1Gbps to 10Gbps simply requires replacing the line cards within the OLT and replacing the user's ONU. For minimal disruption, it is also recommended to plan ahead and install a wavelength demultiplexer-multiplexer (WDM) with the initial system.

PON's lighter, thinner fiber and compact equipment also provide more options for routing cable and locating components such as fiber distribution hubs and OLTs. As a result, PON enables a more flexible topology and may increase options for PDS design.

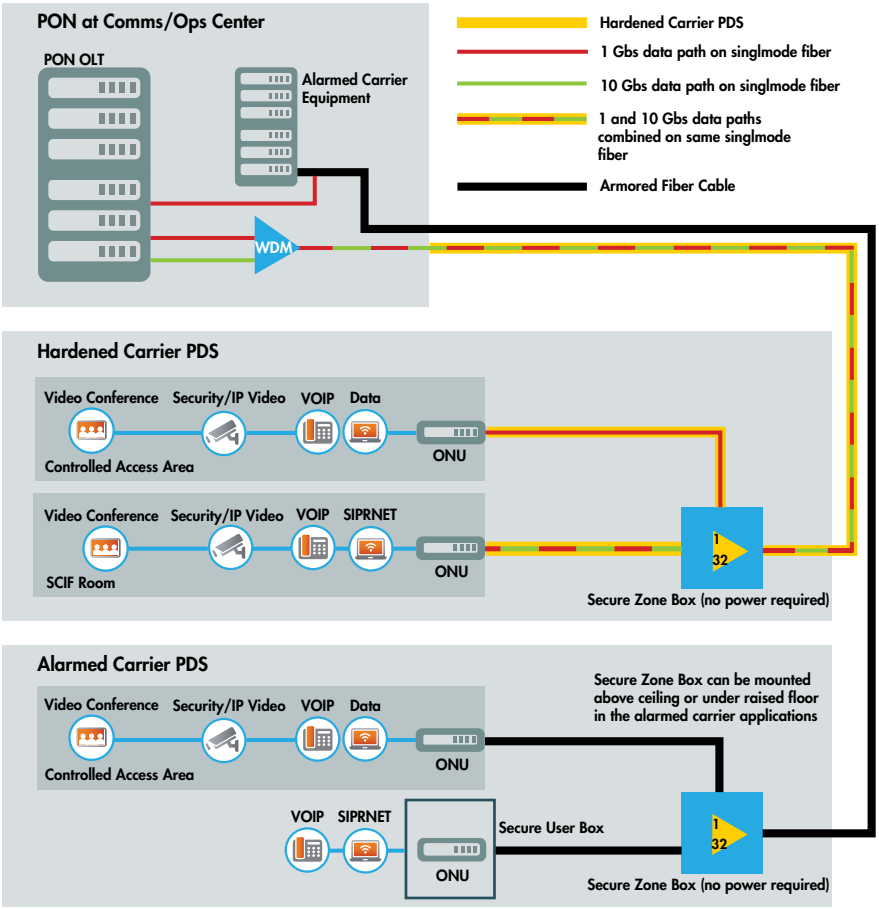


Figure 1

As Figure 1 shows, PON can also be integrated with an alarmed-carrier PDS solution. Specialized alarmed-carrier management equipment is used to insert signals onto the fiber and detect tampering of the fiber or fiber bundle. This equipment, typically provided by a third-party supplier, is generally compatible with most PON manufacturers' solutions. CIOs and CTOs can potentially offset the added cost of the alarmed management equipment by using interlocking armored fiber in the distribution network to eliminate the cost of the hardened-carrier equipment, such as EMT and steel conduit. Use of an alarmed carrier versus hardened carrier also eliminates the need for regular daily inspections, enabling personnel to focus on other duties. When integrated with a passive optical network, this solution is referred to as secure PON, or SPON.

Widely dispersed network

One of the biggest advantages a PON solution has over an active copper-based Ethernet network is its ability to span long distances without degrading performance. Depending on the network speed, a typical copper-based active Ethernet solution can span approximately 100 meters while a multimode fiber can range up to 300 meters from the equipment closet to the network node. Extending the network farther requires additional switching equipment plus mounting, powering and cooling for the necessary active equipment.[5]

For spans greater than 300 meters, PON is an attractive solution. The low-loss characteristics of singlemode fiber enable PON to support a maximum physical reach of 20 kilometers for a typical EPON implementation. The ability to serve large areas spanning many square kilometers with a single network makes PON an excellent choice for deployment over a post, base or large multistory buildings.

It should be noted that a fiber-based Ethernet network can provide a similar reach, but at a significantly higher cost.

Application: military base

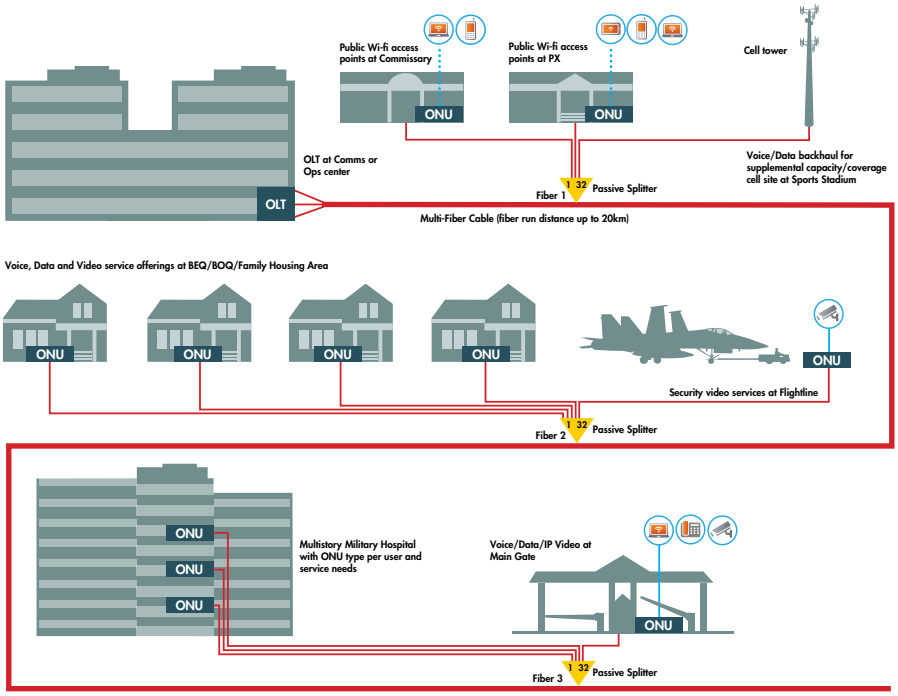


Figure 2

Figure 2 illustrates a typical PON architecture for a dispersed, multi-facility military base. In this example, a single passive network is used to serve personnel, facilities and systems spanning dozens of square kilometers.

The PON connects to the core router and the wide-area network via the OLT interface in the operations center. A singlemode, three-fiber trunk feeds three optical splitters. At the first splitter, one singlemode fiber is routed to a variety of on-post service facilities where it carries traffic for public Wi-Fi access points (WAPs), as well as voice and data backhaul for the cellular network. The cellular network in this example is a dedicated cell site used to increase signal strength or network capacity within a fixed area. This is especially important for locations like the special events center where coverage may be difficult to obtain or where a large number of simultaneous users could strain the network's capacity.

The second splitter delivers fiber-based voice, data and IP video services to support the closed-circuit video surveillance system at the flight line, VoIP, data services, and potential on-demand

video services throughout the barracks and on-base housing. The system in this example also supports PoE for the IP video camera, which helps reduce installation and material costs.

The third split provides voice, data and IP video to the main gate and can support from several hundred to tens of thousands of network nodes, devices and users throughout the administrative offices. Where PON is deployed within an existing office building, its interoperability with Ethernet means it could potentially be used in conjunction with the existing legacy system, making the transition to a new service less disruptive. In such cases, it may be possible to use plug-in optical transceivers with existing Ethernet switches or routers to integrate those devices with the PON.

Cost-efficiency and streamlined topology

A key benefit to using PON is the ability to consolidate all video, data and voice traffic into a single network for higher CapEx and Opex savings.

Figure 3 illustrates the degree to which a PON can streamline network design. Combining three networks into one produces significant savings in cabling and installation costs and minimizes disruption during installation. Deploying a passive network also enables the CIO or CTO to eliminate active components like work group and distribution switches, uninterrupted power supplies (UPS), and cooling and battery backup systems. The overall result is higher CapEx savings.

Removing many of the active network components also reduces ongoing costs associated with cooling, power requirements and maintenance. In a 2009 study[^], Network Strategy Partners analyzed the expected five-year savings on CapEx and OpEx for a passive optical LAN versus copper Ethernet, in single- and multi-facility scenarios. The analysis indicated that switching to the passive solution would result in a 39-percent reduction in CapEx for a single building and 41 percent for a multi-building deployment. OpEx could be expected to drop by 52 percent (single building) and 71 percent (multi-building). It should be noted that the amount of CapEx and OpEx savings will vary with design and application.

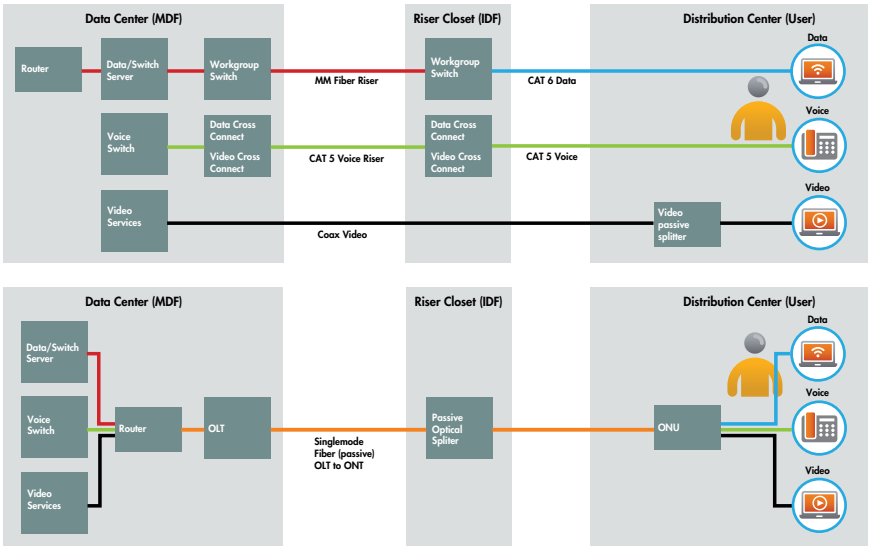
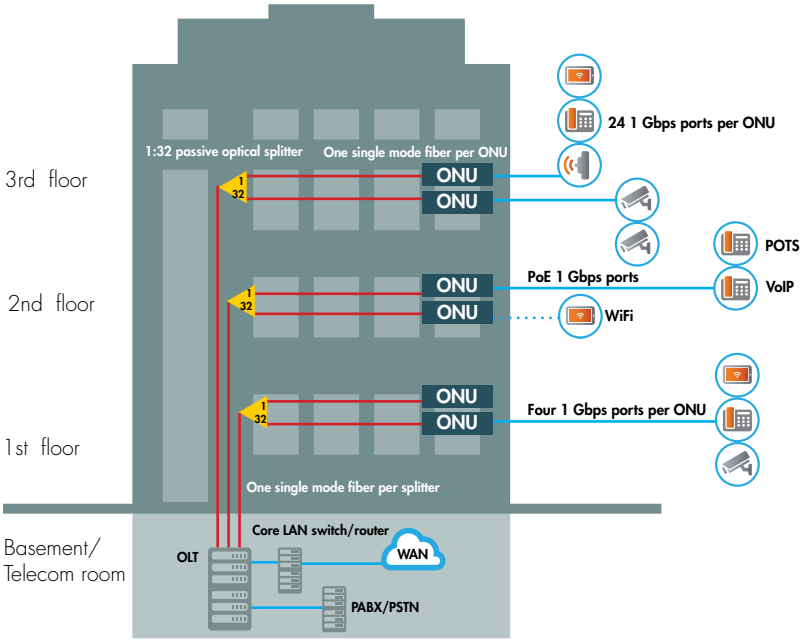


Figure 3

Application: multistory, multi-agency building

Figure 4 describes the PON topology for a typical multi-agency, multistory federal building.

In this example, the PON ties into the core network via the OLT in the equipment room. Singlemode fiber riser cables connect to passive splitters that serve as fiber distribution hubs on each floor. The passive splitters do not require power or cooling and can be mounted in enclosed areas, such as suspended ceilings.



Multi Agency Federal Building

Figure 4

At each distribution hub, the horizontal fiber splits into multiple fibers that serve the ONUs located throughout the floor. The system is capable of supporting up to 98,304[7] nodes. By switching from bulkier copper Ethernet cables to smaller, lighter fiber and eliminating the need for active equipment and the associated power and cooling requirements, building designers and architects have more freedom in the design and layout of the data network infrastructure.

There are also various deployment options and a degree of flexibility that is not illustrated in the above example. For instance, the PON can be used to support multiple virtual LANs (VLANs), enabling a single network to support multiple separate agencies in the same building or complex. PON technology also supports dynamic bandwidth allocation (DBA), so the bandwidth for each user or device can be customized and allocated based on needs and budgets. Quality of service (QoS) levels can be established for specific applications as well.

When active Ethernet gets the nod over PON

PON delivers a number of significant benefits, but may not be the ideal solution for every IT infrastructure project. For some applications, active Ethernet may be preferable, especially where maximizing bandwidth is the most important concern. As a point-to-multipoint solution, PON can support tens of thousands of users effectively with robust bandwidth sharing. It also enables IT managers to prioritize bandwidth allocation for specific users or groups.

However, when a significantly large number of users need simultaneous access to a high volume of network resources, a high-capacity point-to-point network may be preferable. With any point-to-multipoint network, users share the same data pipe back to the network. To realize the full 1Gbps or 10Gbps speed, users essentially take turns sending data. In instances where a large number of users need access to large amounts of capacity simultaneously, throughput for one or more users may suffer.

An active Ethernet network, however—whether copper or fiber based—provides each user with dedicated access to the network and its fully provisioned bandwidth whenever needed. The point-to-point configuration also moves any potential data bottlenecks back toward the network core, where the traffic volume may be more easily accommodated.

When considering a PON solution, the federal CIO or CTO should weigh the data throughput capability of an active Ethernet solution against the reach, cost-efficiency and flexibility of a PON. If there is any doubt about PON's ability to handle the capacity, a network traffic study should be performed, analyzing the types of devices on the network and the data services required. A CommScope technical representative can assist with this assessment.

Assessing value instead of cost

Overall, PON provides federal CIOs and CTOs multiple advantages in a wide variety of applications, making it more attractive than traditional copper- or fiber-based Ethernet networks. These include the ability to deliver high-speed data, video and voice over a single streamlined network featuring passive, not active, components; the reach to cover a much wider area with a single run of fiber; and the future-ready capability to upgrade quickly and easily to new technologies such as 10GbE.

While the advantages of PON include significant CapEx and OpEx savings, CIOs and CTOs must evaluate PON versus active Ethernet based on the aggregate value. For most applications, a careful analysis of capabilities, performance and cost may suggest that a PON is the best decision. But it is not necessarily true for all cases. It is important that the IT manager enter into the decision-making process armed with accurate and current data but without preconceived bias. To ensure the best selection of technology, it is recommended that the CIO or CTO work with a provider, like CommScope, who handles both PON and active Ethernet and can provide an end-to-end infrastructure solution.

In the foreseeable future, there will continue to be extremely close scrutiny of how federal budgets are allocated and spent. At the same time, the need for improved IT and IT infrastructure capabilities will also continue to increase. For DoD, Department of Justice (DoJ) and federal civilian agencies, the ability to demonstrate long-term value of IT infrastructure projects will continue to be a priority.

References and Notes

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To learn more about CommScope's portfolio of GPON, EPON and active Ethernet solutions for federal networks, contact the CommScope Federal Solutions Team at federal@commscope.com, or visit the CommScope Federal Solutions Web portal.

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