

APPLICATION NOTE

Transformation of Government Networks

Provincial, state, and municipal governments are scrambling to provide 'smarter' services to constituents on an 'anytime, anywhere, any device' basis. Many are finding that traditional network technologies cannot support the new on-demand, data-intensive environment.

Governments at all levels are faced with a host of challenges. Citizens and businesses expect flexible access to government services that adjust according to their preferences. Governors and mayors want to spur economic development and streamline operations. Corporations consider the availability of high-speed fiber networks a prerequisite to locating facilities in the area.

Public sector CIOs are deploying new digital technologies to meet these challenges. These include Artificial Intelligence (AI), sensor arrays, Mixed Reality, remote monitoring devices, drones, and driverless vehicles. They are also pushing basic analytics closer to the devices, while maintaining predictive and prescriptive analytic capabilities within the data center. CIOs are also faced with the challenge of maintaining the security and privacy of the increased flow of citizen data.

These changes are driving increased data volume, variety, and velocity, necessitating a network evolution to support increased bandwidth and variable traffic patterns. At the same time, capital spending is scrutinized for true need, citizen benefits, and operational efficiencies. Given the current climate of natural disasters, political uncertainty, and uneven finances, the economic path for most governments over the next several years is unclear. CIOs need to transform technology platforms to realize improved efficiency and yield new public benefits.

Fortunately, the evolution of technology is making network transformation possible while delivering rich dividends in operating efficiency and public benefit through a modernized networking infrastructure. As IT networks have evolved, the tendency has been for governments to build overlays for new applications. Initially, legacy voice networks were combined with data traffic through technologies such as ATM, while optical technologies such as SONET and DWDM provided bandwidth growth, high-

Benefits

- Eliminates inefficient parallel, application-specific networks
- Uses optical transport and deterministic switched Ethernet to provide flexible, agile agency operations
- Offers a universal architecture compatible with embedded optical, Ethernet, and IP/MPLS assets
- Features the industry's most efficient optical wavelength utilization and service convergence
- Improves network latency and efficiency through Layer 2 switching

grade reliability, and resiliency. As Ethernet spread into Wide Area Network (WAN) applications, techniques emerged to encapsulate packet data over circuit connections, and MPLS emerged to control traffic through the core network. Despite advances, application-driven network construction often results in a tangle of application-specific networks operated under the domain of one state or local government.

Inherently inefficient, application-specific networks require significant capital outlays each time a new application is adopted. Operating a set of networks requires specialists trained in the unique technologies germane to each. As demand for the application grows or declines, there is no single means to scale network capacity, nor is there a unified vision to accommodate emerging applications that directly yield public benefit, such as intelligent traffic systems or smart connected street lights. As a company that specializes in network strategy and technology, Ciena offers governments a means to evolve their networks to become more agile, improve operating efficiency, and provide quality services to constituents.

Applications and supporting technologies

For government agencies, networks should operate on an 'as-a-service' basis to replace proprietary systems while ensuring the desired level of traffic prioritization. As networking, communication, and computing technologies evolve, new applications will continue to emerge. This application note considers various applications and their enabling networking technologies.

Emerging applications

In the traditional view of government IT, a network application was limited to two categories: voice and data. Older telephone circuit networks were adapted to accommodate data generated by computer networks. 'Bursty' computer data was mapped into rigid circuit timeslots, resulting in inefficient bandwidth utilization.

This simplified approach was sufficient when technology could offer little benefit to the deeper needs of a specific application. But newer networking technologies, such as Optical Transport Network (OTN), switched Ethernet, and the emerging Software Defined Networking (SDN) offer the ability to match application needs to the network's capabilities and cost-effectively scale to meet today's growing bandwidth demands. Just one example is the Quality of Service (QoS) concept, in which specific applications or end-users are assigned a service level. Higher levels of service such as Public Safety are assigned higher

quality levels, usually equating to deterministic performance, lower latency, and higher effective network bandwidth. QoS control allows an agency to allocate network resources based on application need and desired performance.

Emerging 'smart' applications use the network to yield new public benefit. This benefit could be an enhancement to an existing service or an entirely new use of technology. For example, acoustic sensors combined with smart lighting systems and pan-tilt-zoom video cameras can reduce crime rates. High-definition video cameras used with road sensors and smart traffic signals can help reduce congestion and accident rates. Other examples of technological advances resulting from new applications include virtualization and cloud computing, or software-as-a-service. Enabled by very large data flows through high-speed network backbones, cloud applications allow users to access large memory banks or predictive analytics capabilities distant from the actual end-user. The challenge is to implement a network that can support legacy applications and adapt quickly to support these emerging applications with minimal incremental cost.

The emerging network applications below—specific to regional, state, and local government agencies—produce a variety of public benefits:

Intelligent Transportation Systems (ITS) – These systems monitor weather, congestion, traffic patterns, and road hazards to optimize flow, reduce traffic accidents, and improve the driver experience. These systems have evolved from providing basic visual signals for drivers and regional monitoring systems to more predictive and interactive capabilities that include real-time rerouting, vehicle-to-vehicle communication, dynamic traffic light, variable speed enforcement, and collision avoidance. Applications in the experimental phase include driverless transport, unmanned aerial vehicles, and variable-rate toll roads.

Public safety – The next generation of emergency services allow combined voice, text, and video sharing between citizens and emergency personnel. Body and dash cams can yield valuable evidence, speed up court decisions, and increase transparency. High-resolution video surveillance combined with facial recognition software and tracking capabilities can help identify perpetrators more quickly. Sensitive acoustic sensors can pinpoint gunshots and, when combined with violator data bases, can help solve or prevent crimes. A comprehensive public safety network also provides means for E911 backup, police, fire, and Emergency Medical Service (EMS) communications.

Connected lighting – Networked control of street lighting systems can provide energy savings, reduce maintenance costs, and offer the ability to integrate street lighting with multiple other intelligent systems: traffic light controls, security cameras, electric vehicle charging stations, environmental sensors, and digital signage.

Public broadband access – Governments have realized that broadband access is a key enabler of economic development and the ability of all citizens to benefit from the ‘digital economy.’ They are leveraging public sector funding programs and public/private partnerships to deploy middle- and last-mile access networks to achieve objectives for ubiquitous broadband access.

Telemedicine – These networks specifically address the needs of public healthcare and human services agencies to improve access for rural areas and better connect patient records to points of care. Advanced imaging technologies connected to high-bandwidth networks provide national access to doctors and specialists and improve patient care and operating efficiency. Initiatives to improve electronic health record systems require a telemedicine network capable of remote data backup and wide-area access.

Supporting Technologies

These emerging applications are supported by a universal network built on optical transport and Ethernet switching technologies.

Optical Transport

Optical networking provides a highly resilient, scalable, and secure means for transport of all application data around a national, regional, or local area. The cost and prevalence of deployed fiber optics makes the technology practical. OTN is a mechanism to integrate legacy traffic gracefully with emerging packet-based data from applications such as ITS, public safety, or public broadband. OTN scales well with leading-edge backbone standards for 10, 40, and 100 Gb/s. As a relatively new global ITU standard, OTN provides reliability and manageability equivalent to SONET, with the flexibility to support all the data-intensive applications emerging today. Figure 1 illustrates an OTN wrapper. OTN offers several advantages to the network operator. First, the OTU container is an efficient and transparent structure to multiplex, provision, and switch traffic from high-bandwidth applications, including legacy TDM, storage,

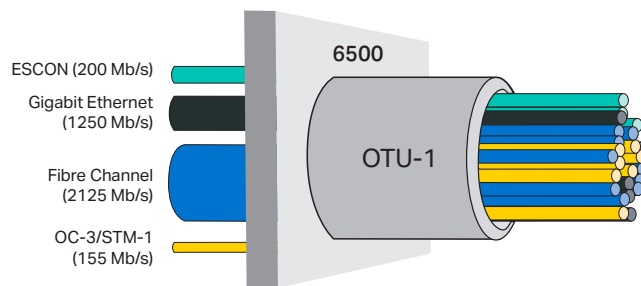


Figure 1. The OTN wrapper

mainframe, digital video, and Ethernet sources. This efficiency leads to better wavelength utilization while offering improved monitoring and management of client traffic.

Ethernet Switching

Ethernet as a data networking technology has been in wide use for many years, keeping pace with the network speeds demanded by applications, but has evolved from a purely Local Area Network (LAN) technology to serve the WAN as well. Because of its maturity and ubiquity, Ethernet technology is inexpensive and familiar. Ethernet is also an elegant means to deliver traffic generated from any application currently in use or imagined. Connectivity can be established quickly with little hands-on provisioning effort. Access to the core MPLS network is greatly simplified; reliability is very high through the introduction of several resiliency standards, assuring 50ms restoration times, and switching at Layer 2 offers an efficiency improvement of roughly 40 percent in terms of strain on IP/MPLS routers. When IP routing is not necessary, using IP-aware Ethernet switching can reduce aggregation costs and the number of upstream router ports required.

Ethernet technology has evolved to deliver more than simple data connectivity. Driven by the needs of a competitive carrier market, connection-oriented Ethernet technologies are now available to create a network that combines the flexibility and cost-efficiency of Ethernet with the reliability of connection-oriented protocols such as SONET and ATM. Current innovations—including Provider-Backbone Bridging with Traffic Engineering (PBB-TE) and 802.1ad provider bridging (or Q-in-Q tagging)—allow agencies to construct and operate highly reliable networks with the capability to scale to many thousands of Virtual LANs (VLANs). The advantages of Ciena’s rich Ethernet feature set, offered in the Packet Networking portfolio and the eMOTR modules for the 6500 Packet Optical platform, are outlined in Figure 2.

Attributes	Legacy Ethernet	Carrier Ethernet	Packet Networking Portfolio/Carrier Ethernet plus....
Standardized Services	LAN Connectivity	E-Line, E-LAN, E-Tree	Universal TDM, ATM, FR, L2 VPN and transport LAN Broadcast, Multicast, Unicast LAN. Port or virtual E-Line, E-LAN, E-Tree with any encapsulation
Scalability	4K VLANs	Q-in-Q Service and agency VLANs	10Ks of VLANs Simultaneous L2VPNs with Q-in-Q, H-VPLS, PBB-TE
Reliability	Spanning Tree Protocol	Resilient Spanning Tree Protocol	50ms restoration PBB-TE dual-homing
Service Management	Vendor-specific	Common EMS Mgmt Model, some OAM	Uniform comprehensive monitoring FCAPS Partitioning, Link and Service OAM, Distributed Topology Discovery
Quality of Service	Best-effort, Two to four queues	Drop precedence and up to eight queues	Up to 64 internal QoS levels Hierarchical metering/shaping, L2ACLs, L2-3 remarking

Figure 2. Packet Networking Portfolio comparison

Layer 2+ Ethernet Switching: Delivering Efficiency and Optimizing the MPLS Network

Agencies can realize great efficiencies by looking deeper into traditional network hierarchical functions. In some cases, switching and transport functions are difficult to merge. However, Ethernet switches typically cost approximately 40 percent less than IP/MPLS routers. Furthermore, utilization of Ethernet for access and aggregation simplifies the network, increasing security and resiliency. Advanced capabilities in Layer 2 switches can optimize the use of expensive routers, providing a cost advantage through use of Layer 2 or '2.5' switching.

One example of Layer 2.5 switching is the implementation of Internet Group Management Protocol (IGMP) snooping. This protocol allows Layer 2 switches to peek into the packet's IP header and make decisions on multi-cast forwarding.

For example, the network in Figure 3 features a camera at node A that functions as a multi-cast transmitter; B, C, E, and F are intended receivers. Without IGMP snooping, a VLAN generally is used to broadcast to all ports that may need to receive the traffic; data is sent through the router and forwarded correctly to nodes B, C, and E. However, all other receivers co-located with the intended receivers also receive the packets, flooding the databases at D and G with unintended data.

These packets will be ignored by the unintended listeners, but the result is wasted processing time and capacity throughout the network. This process tends to slow down IP routers, especially in large multicast networks where, for example, video streams to many end-users. Reducing the loading on the router improves network latency and user perception. In a public service network application, a security video feed would function more reliably, and a storage network feed would operate faster and without errors.

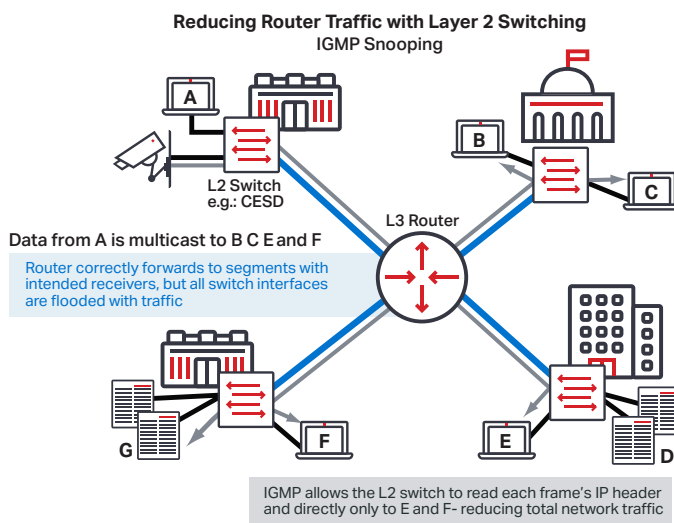


Figure 3. Layer 2.5 switching with IMP

A View of the Transformed Network

A transformed network is a modernized network that leverages technology to provide efficient delivery of multiple applications and ensures data security, integrity, and resiliency without incurring exceptionally high operating costs. Ciena offers a view of a converged network well-suited to meet the demands of a modern government agency.

Network Consolidation

Construction of a consolidated network must allow for graceful migration from embedded elements to the new architecture. The network also should provide a mechanism for flexible deployment of services while scaling to meet growing traffic

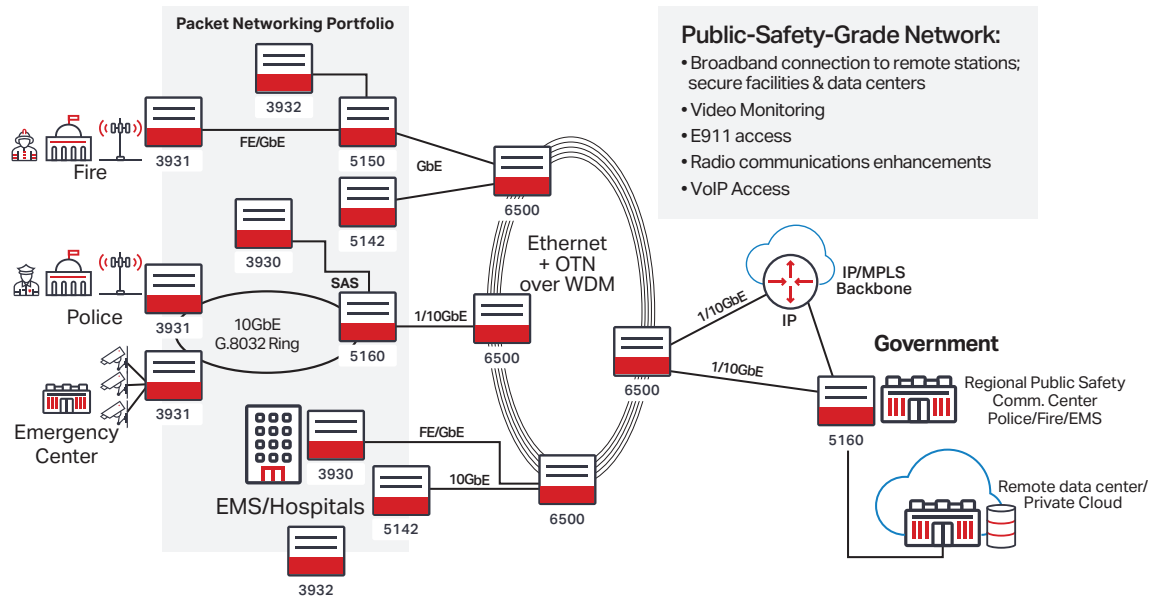


Figure 4. A modernized public safety network

demand. Ciena offers two unique platforms to accomplish this consolidation. First, the 6500 combines optical transport and switching functions with Ethernet and OTN capabilities. These features open up enormous deployment capabilities that can be matched to current agency demands and scaled as needed. Second, Ciena offers the Packet Networking portfolio. This set of Ethernet aggregation and delivery switches may be deployed independently or coupled with the 6500 to form a network scalable to hundreds of thousands of end-users while assuring highly resilient operation.

A sample network architecture is shown in Figure 4. In this hypothetical public safety network case, the 6500 forms a Wavelength Division Multiplexing (WDM) ring, transporting Ethernet data and other OTN encapsulated traffic around a regional public safety area. This ring can be scaled to support up to 2 Tb/s, carried over multiple Dense WDM (DWDM) wavelengths. As needed, Reconfigurable Optical Add/Drop Multiplexer (ROADM) modules may be deployed to allow future upgrades for flexibly adding, dropping, or switching individual wavelengths in the optical domain without Optical-Electrical-Optical (OEO) conversion. Also shown in Figure 4 is an on-board Ethernet switch module, Ciena's GE/10G eMOTR, deployed on the 6500 at nodes where Ethernet switching is desired. In other cases, multiplexing Ethernet traffic onto OTN wavelengths without Ethernet switching may be advantageous. Both functions are supported easily on the 6500.

Each 6500 node is fed through Gigabit Ethernet (GbE) or 10G interfaces from service aggregation points on the access side,

and through an aggregation switch or an IP/MPLS router on the backbone WAN side. Selection of the specific switch type and size depends on the density of end-users, expected traffic fill, and anticipated growth. In this network, the region's fire, police, and EMS systems are coordinated through a unified communications and information structure. Remote facilities, such as fire substations and headquarters, share broadband capabilities. Radio communications can be enhanced through RF devices located in radio dead zones wired back to the environmentally hardened 3931 Service Delivery Switch. These 3931s may be connected to remote Service Aggregation Switches, such as the 5150, which can also operate in extreme temperatures. On the police side, security cameras may be connected reliably to the broadband network. A hospital's medical control officer may be linked directly with both EMS personnel and the medical database.

Ciena Solutions

Ciena offers all the elements essential to transforming a network into a modernized government network that adapts to changing mission needs while improving operating efficiency. A team of network specialists stands ready to aid in planning and implementing a network that meets every agency's needs.

6500 Packet-Optical Platform

Ciena's 6500 Packet-Optical Platform converges comprehensive Ethernet, TDM and WDM capabilities into one platform for cost-effective delivery of emerging and existing services, from the access edge to the backbone core. As the pioneer of 40G/100G coherent technology for

commercial optical systems, the 6500 includes a full suite of field proven, plug-and-play coherent 40G and 100G solutions for metro, long-haul terrestrial, and submarine applications. With the 6500, legacy applications can still be supported. The 6500 offers both muxponder-based and central-fabric-based packet and OTN transport and switching solutions to maximize networking resource utilization for all connectivity requirements and quickly respond to any service request.

Network layer convergence is the answer to scaling today's networks to flexibly meet changing bandwidth demands. Ciena's 6500 enables network consolidation by providing E-suite modules, including eMOTR, that fully integrate packet switching within transport, providing sub-GE grooming for improved wavelength efficiencies and traffic prioritization.

6500 Features & Benefits

- Adapts to a wide variety of requirements with a minimal set of equipment, reducing standardization and operational costs
- Utilizes next generation OTN/Packet technologies for the most efficient use of network resources
- Provides industry leading 10G, 40G/100G coherent and control plane capabilities for scale and service differentiation
- Enables fully featured Ethernet service management options enabling full Layer 2 functionality on packet switching modules
- Maximizes operational efficiencies with the ability to tailor customer solutions via various chassis options

As government CIOs consolidate data centers, implement hybrid shared cloud strategies, and consolidate platforms to support the Internet of Things (IoT), network connectivity requirements will increase substantially. Ciena's Waveserver and Waveserver Ai were created to provide a server-like experience for web-scale applications. They provide simple, scalable metro Data Center Interconnect (DCI) in a rack-and-stack 1RU form factor. Their designs combine two key principles: best-in-class coherent technology and web-scale IT.

Waveserver and Waveserver Ai features and benefits

- Cost-effective – Huge amount of bandwidth, up to 400 Gb/s in a compact, 1RU form factor
- Network agnostic – Can work over different vendors' photonic systems as alien wavelengths
- Provides a new business and operational experience for deploying web-scale DCI solutions, with simplified planning, ordering, installation, operation, and maintenance

Offers an ultra-low-latency, AES-256 wire-speed encryption solution for highly secure in-flight data protection

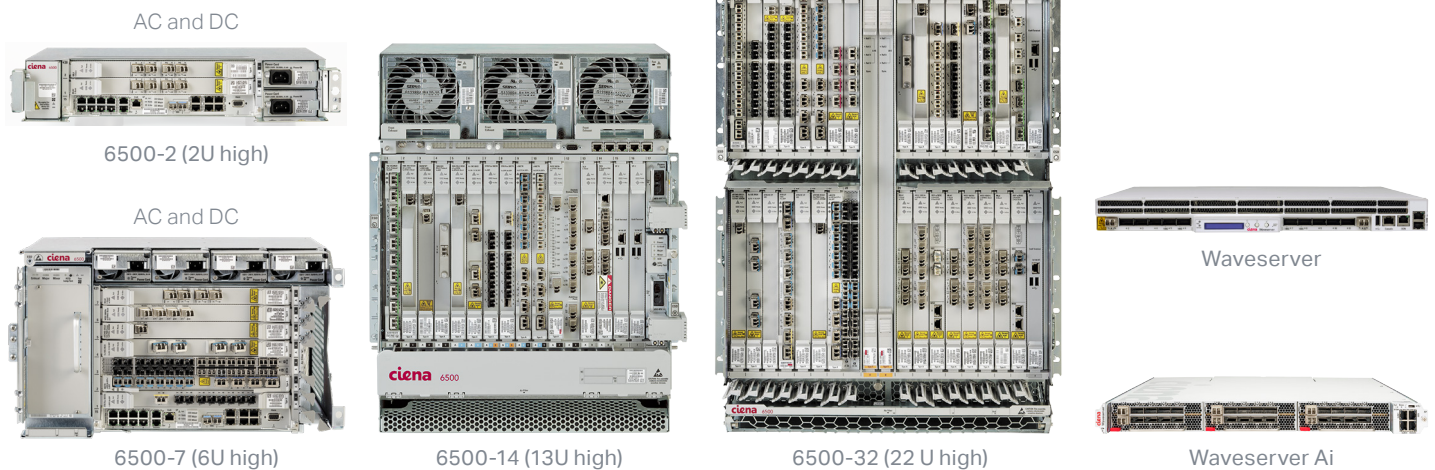


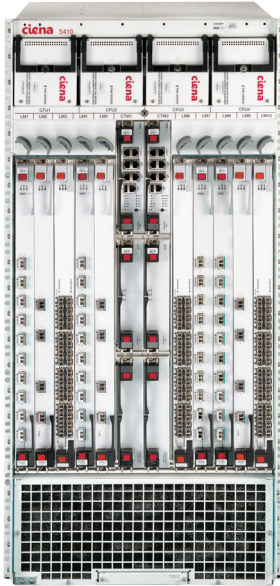
Figure 5. 6500 and Waveserver form factors

Packet Networking Portfolio

These carrier-class Ethernet switch platforms for Ethernet business and transport applications allow rapid delivery of data services with low-touch provisioning. The platforms, shown in Figure 6, range in port density and features to match small office to large core node application needs. Ciena is an industry leader in the development and implementation of

PBB-TE, and is one of the first vendors in the market to deliver a solution that supports both traditional MPLS- and PBB-TE-based solutions. Additionally, these platforms enable delivery of Metro Ethernet Forum (MEF) Ethernet 2.0 services, along with reliability and QoS capabilities far exceeding those of traditional LAN implementations.

Service Aggregation Switches: 5410, 5160, 5142



5410



5160



5142

- Aggregates 10/100 Mb/s, GbE and 10GbE services
- MEF CE2.0 certified solution for service differentiation and acceptance
- Industry-leading OAM toolset for service verification and testing

Service Delivery Switches



3932



3930



3916



3931



3902

- Purpose-built for specific functions and cost points in the network
- Intelligent demarcation for increasingly high-performance, high-bandwidth needs
- Small physical and power 'footprint' limiting significant operational and infrastructure costs

Figure 6. Ciena's Packet Networking portfolio

Ciena Software

A network solution is made whole through powerful hardware elements, with flexibility and capabilities extended through comprehensive software features. Ciena's software suite is an integrated solution composed of both a common service-aware operating system running on the network elements and the unified network and service management portfolio. Ciena software provides agencies with significant advantages to managing all aspects of the network services lifecycle, including service creation, delivery, management, and assurance. The unified management capabilities ensure a consistent and expected look and feel across the network while facilitating the required end-to-end service awareness and network intelligence necessary for capitalizing on the ever-changing landscape of end-user requirements. The software has a consistent look, feel, and ease of operation, which results in reduced agency training and operation costs.

Ciena Specialist Services

Ciena's network specialists offer services ranging from network analysis and design to deployment project management. A truly modernized network begins with a rigorous analysis of agency needs, embedded network assets, IT objectives, and economic constraints. This analysis serves as a blueprint for building and operating the network. Ciena's services are wide-ranging—from basic planning, design, installation, and support to education and Network Operations Center (NOC) activities. Ciena's U.S.-based team of dedicated engineers is available to aid in the design and implementation of any agency modernization effort.

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