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K-12 Network Evolution Essentials.
Paving the Digital Highway

by
Daniele Loffreda

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CONTENTS

Executive Summary 5

Introduction – K-12 Broadband Networking Drivers 6
- Digital classrooms require fast and reliable Internet access 7
- On-demand software solutions demand high-capacity networking 7
- How much bandwidth does a district need? 9

K-12 Broadband Networking Architectures 10
- WAN implementation options 10
- Satisfying diverse performance demands 11
- Fiber is the technology of choice for today's networks 12

E-Rate Broadband Funding Opportunities 12
- E-rate fiber service options 13
- Outsourcing ongoing network operations 16
- Choosing the lowest-cost option 17

Request For Proposal (RFP) Considerations 18
- RFP recommendations 18

Top Reasons E-Rate Funding Requests are Denied 20

A Brief Introduction to Optical Networking 22
- Fiber deployment options 23

Private Network Implementation and Operations Considerations 24

Additional Resources 26

Abbreviations 27

EXECUTIVE SUMMARY

New digital education tools have the potential to transform America's classrooms and prepare students for the global information economy of the 21st century. But legacy K-12 networks often struggle to meet the increased performance, agility, and resiliency demands of the latest cloud-based, mobile-centric, and 'anytime, anywhere' learning environment. Administrators, curriculum directors, and teachers often assume the network will be able to support these bandwidth-intensive applications... until it cannot. A network crash results in lost instruction time and frustrated teachers and students.

Forward-looking school districts are taking advantage of the U.S. federal government's E-Rate program to fund next-generation fiber optic broadband networks that offer greater capacity and reliability. Fast, dependable, and flexible, fiber has emerged as the networking technology of choice for K-12 broadband initiatives. The E-Rate program provides funding for a variety of fiber network installation and operating expenses. But the program application and approval process—sorting out the various program options and demonstrating eligibility—can be challenging for school district leaders and technology planners.

This eBook demystifies next-generation networking for the EdTech revolution. It reviews network designs that yield the highest-capacity transmission for the available budget dollars in 'lit,' 'dark-fiber,' and 'self-provisioned' options. It also explains how to structure an RFP to obtain the best pricing for Category One services within the E-rate program.

This book covers:

- K-12 broadband network drivers
- Next-generation K-12 network requirements and architectures
- Fiber optic networking benefits and deployment options
- E-Rate program fiber funding opportunities
- Next-generation K-12 network RFP recommendations
- E-Rate funding request considerations
- Private optical network design and operations guidelines

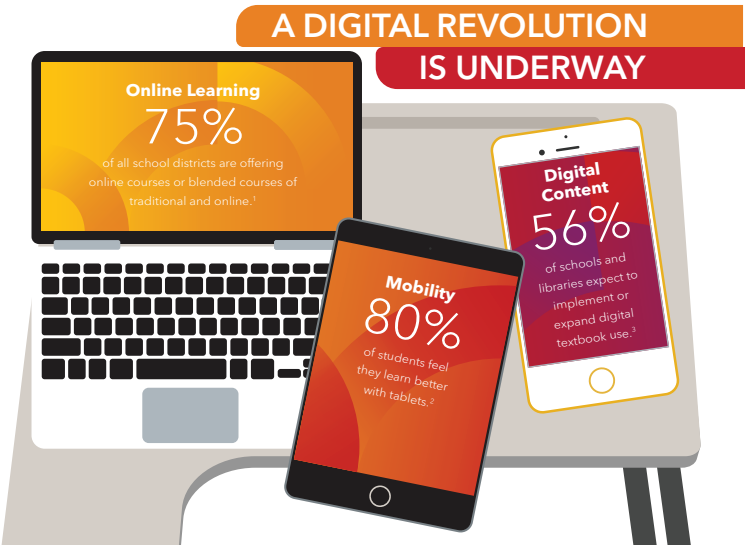
INTRODUCTION – K-12 BROADBAND NETWORKING DRIVERS

According to the COSN IT Leadership Report 2017 – Broadband & Network Capacity is a top priority for IT leaders. This priority is closely tied to the others in the top 3 ranking – Mobile Learning and Cyber security.

http://www.cosn.org/sites/default/files/CoSN_ITLdrship_Report_2017_040317.pdf

Advances in information technology are fundamentally transforming America's K-12 schools. Online courseware, learning analytics, and personalized instruction are reshaping the classroom and improving education. Mobile devices and the cloud are revolutionizing the student experience. Armed with laptops, Chromebooks, and tablets, today's students can access digital curricula, engage classmates and teachers around the world, and conduct research anywhere, at any time.

Dependable, high-speed Internet connectivity is critical to the success of America's primary and secondary schools. STEM initiatives, Common Core Standards, the Every Student Succeeds Act, and other evolving educational programs stress the importance of technology and online skills development for today's students. Fast, ubiquitous broadband access is essential for preparing students for the digital workplace of the 21st century.



Digital classrooms require fast and reliable Internet access

Slow connectivity can hamper the performance of online applications and impair the student experience. Districts that have fully adopted digital learning technology have experienced 50 percent year-over-year growth in bandwidth usage,[1] but those that are unprepared for this surge are experiencing an increase in unplanned network outages. Education technology leaders must upgrade broadband networking infrastructure to support the increased capacity demands of today's bandwidth-intensive interactive learning tools and multimedia content.

Table 1 summarizes the typical per-session bandwidth requirements for common digital education activities. Estimating the peak number of students, teachers, and administrators performing these actions at any point in time will provide a rough calculation of a district's overall capacity requirements.

Activity	Typical Bandwidth (Per Individual Session)
Taking an online class	.25 Mb/s
Searching the Web	1 Mb/s
Downloading digital instructional content	1 Mb/s
Engaging with simulation	5 Mb/s
Streaming an HD video	5 Mb/s

Table 1. Typical bandwidth usage for various applications[2]

On-demand software solutions demand high-capacity networking

When planning network capacity, it is important to consider all traffic sources and traffic flow patterns. The vast majority of school districts run classroom applications, school administration systems, and office applications on the same network, often at the same time. Many are migrating school

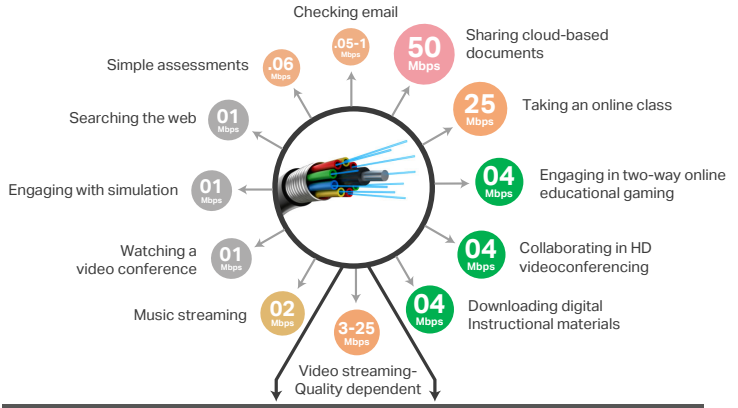
[1] 2016 Education Superhighway State of the States Report, January 2017
[2] The Broadband Imperative II: Equitable Access for Learning, SETDA, September 2016

administrative systems and business applications to the cloud to reduce IT cost and complexity. Examples include:

- **Online administrative systems** – scheduling applications, student information management systems, transportation logistics applications
- **Business systems** – finance, human resources, payroll
- **Office productivity suites** – Google Docs, Office 365
- **Communications systems** – voice and unified communications solutions
- **Building and campus management solutions** – HVAC, energy, and security and surveillance systems

Many of these on-demand applications require high-capacity, low-latency connectivity or the network gets congested, dropping traffic and slowing applications to a crawl. Too often, this happens at the least opportune time, such as during district-wide online assessments. The figure below provides bandwidth estimates for common outside-the-classroom online activities of faculty, administration, and staff.

COMPETITION FOR BANDWIDTH – SAMPLE PER USER REQUIREMENTS



⇒ Learn more about K-12 broadband networking drivers in Ciena's *Powering 21st Century Learning* infographic.

How much bandwidth does a district need?

Determining the broadband capacity requirements for a specific district can be a challenge. A number of factors come into play, including:

- Number of schools by type (elementary, middle, and high schools), offices and data centers, and distances between them
- Peak number of students, administrators, and faculty concurrently accessing the network
- District demographics—older students tend to consume more bandwidth
- Adoption of digital, collaboration, and Augmented Reality learning technologies
- Use and mix of cloud-based IT administrative and office solutions
- Adoption of mobile devices—laptops, tablets, smartphones
- Projected growth in users and application traffic

The State Educational Technology Directors Association (SETDA) has established some general Internet Service Provider (ISP) guidelines for various sizes of school districts, summarized in Table 2. In addition, SETDA recommends at least 10 Gb/s WAN connectivity per 1,000 users for each district school or office by the 2020-21 school year.

District Size	ISP Connectivity Recommendations for 2020-21 School Year
Small School District (fewer than 1,000 students)	At least 4.3 Mb/s per user (minimum 300 Mb/s for district)
Medium-sized School District (approximately 3,000 students)	At least 3.0 Gb/s per 1,000 users
Large School District (more than 10,000 students)	At least 2.0 Gb/s per 1,000 users

Table 2. ISP recommendations for various-sized school districts[3]

[3] The Broadband Imperative II: Equitable Access for Learning, September 2016

K-12 BROADBAND NETWORKING ARCHITECTURES

In a typical K-12 network architecture, schools and offices are connected over a Wide Area Network (WAN) to a central data center, which connects to the Internet via an ISP. All cloud/Internet traffic is 'backhauled' across the WAN to the data center and handed off to the ISP, as shown in Figure 1.

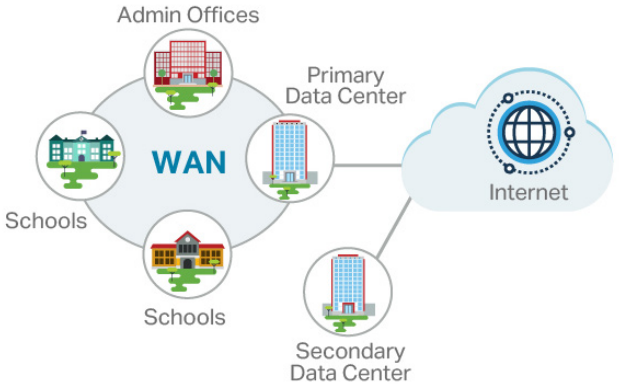


Figure 1. Simplified K-12 network architecture

In smaller districts, data centers are often collocated with high schools or administrative offices. Larger districts often implement secondary data centers with separate Internet connections to ensure continuous availability in the event of data center catastrophes or ISP outages.

WAN implementation options

There are many options for implementing a school district WAN, including deploying Ethernet private line services, optical private line services, Multiprotocol Label Switching (MPLS) Virtual Private Networks (VPNs) from a telecommunications service provider, or building out a private fiber optic network. School districts should consider a number of factors when evaluating WAN deployment options, including:

- **Network capacity and scalability** – what are the current and future bandwidth requirements?
- **Application characteristics** – Does the network support delay-sensitive applications like HD video conferencing?
- **Network security and availability** – What levels of resiliency and data protection are required?

- **Staffing** – How well-staffed is the network operations team? What type of skills do they possess?
- **Project timelines** – When does the new network need to be up and running?
- **Agility requirements** – Once the network is deployed, how quickly will the district need to turn around adds, moves, and changes?
- **Cost constraints** – How much CAPEX and OPEX are budgeted for the project?

Satisfying diverse performance demands

Application performance and availability requirements can vary widely across a district. High schools, administrative offices, and data centers may require high-capacity, low-latency connectivity, while applications running in elementary and middle schools may be less bandwidth-intensive and delay-sensitive.

In practice, many districts leverage a mix of equipment and protocols across the extended network. Figure 2 depicts a slightly more detailed K-12 reference network architecture with distinct access, aggregation, and core segments. In this example, elementary schools connect via a 100 Mb/s—10 Gb/s access network, middle schools via a 10 Gb/s aggregation network, and high schools, administrative offices, and data centers via a 100 Gb/s core network.

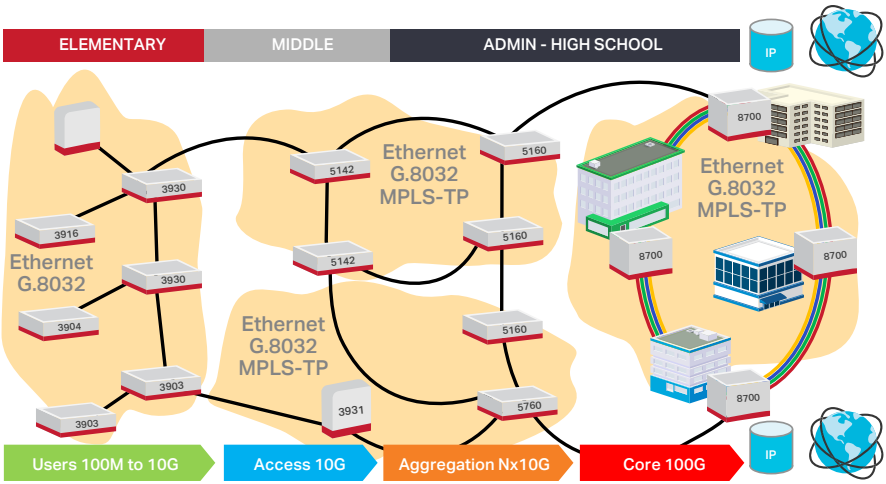


Figure 2: More detailed K-12 network architecture

Fiber is the technology of choice for today's networks

Fiber has emerged as the technology of choice for today's K-12 networks. Fiber optic networks provide high-capacity, low-latency connectivity for bandwidth-hungry, delay-sensitive applications. In short, fiber networks are fast, reliable, and convenient.

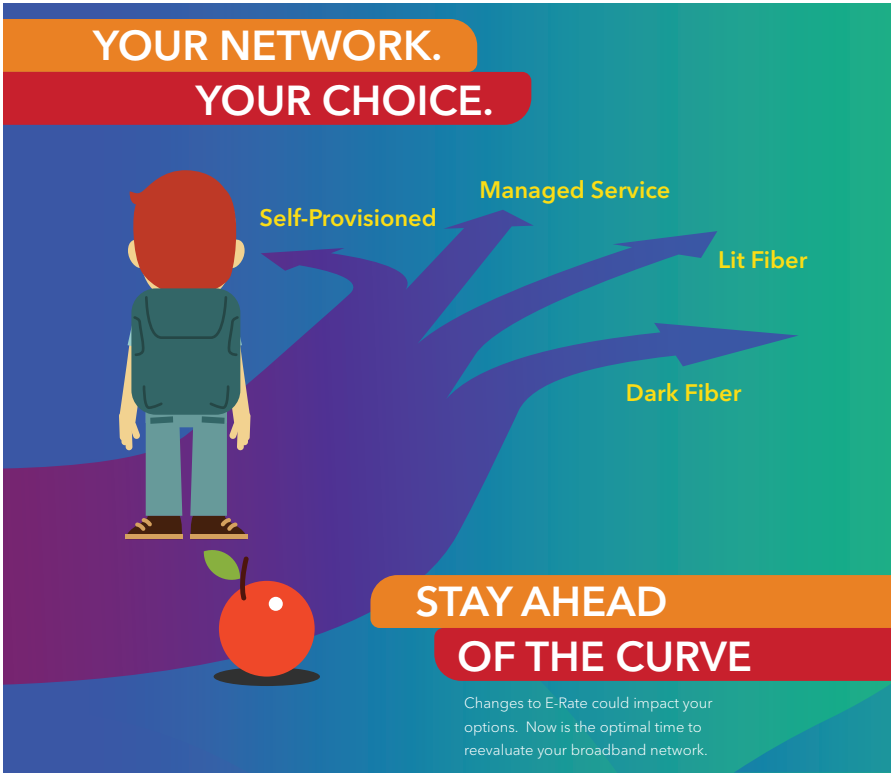
- **Fast** – With the latest optical multiplexing technology, dozens of 100 Gb/s channels can be delivered over a single fiber pair for unmatched price-performance.
- **Reliable** – Fiber networks support resilient architectures with redundant links and paths to ensure continuous availability in the event of a cable cut or equipment failure.
- **Convenient** – Fiber technology is compatible with existing networking equipment like Ethernet switches.

⇒ Learn more in Ciena's on-demand webinar, *Creating a Digital Learning Foundation: Networks that Enable Learning at the Speed of Light*.

E-RATE BROADBAND FUNDING OPPORTUNITIES

E-Rate is the U.S. government's largest educational technology program. Established in 1996 to help school districts obtain affordable Internet access and telecommunications services, E-Rate is administered by the Universal Service Administrative Company (USAC), under the direction of the FCC.

In 2014, Congress implemented a series of E-Rate regulatory reforms and increased the annual E-Rate funding cap by $1.5 billion per year. Recognizing that fiber is the best option for enabling high-speed broadband, the 2014 E-Rate Modernization Order provides new financing options and expands support for certain fiber network construction costs and equipment expenses, giving school districts more choices for building out network infrastructure.



E-rate fiber service options

E-Rate Category 1[4] includes three distinct types of fiber services: lit fiber, dark fiber, and self-provisioned fiber.

Lit fiber

With a lit fiber service, the school district leases optical capacity from a service provider for a recurring monthly fee. The service provider owns and maintains the fiber optic cabling as well the equipment used to light the fiber. The simplest option to deploy and manage, lit fiber is the most common way districts interconnect schools, offices, and data centers today. It is often the best choice for districts requiring 100 Mb/s to 10 Gb/s WAN capacity. Service

[4] The E-Rate program includes separate funding for Category 1 initiatives (broadband Internet access, WAN, and last-mile connectivity) and Category 2 initiatives (LANs, WLANs, and other internal connections).

providers offer a variety of lit fiber options, including managed Ethernet private line services and managed optical wavelength services.

Note: *Providers typically price managed Ethernet and wavelength services by capacity. If a district upgrades the speed of service, it may need to reapply for E-Rate funding.*

Dark fiber

Dark fiber refers to fiber optic cable that has been installed but not activated. With a dark fiber service, the service provider owns and maintains the fiber, but the school district owns and manages the electronics used to light the fiber. Some dark fiber service providers may agree to bundle the electronics within the dark fiber lease contract. In some cases, the electronics could be an optical transceiver for an existing Layer 2 switch. In most cases, the district will need to purchase new optical or packet-optical switching equipment to activate the fiber.

Dark fiber is often the best choice for districts that need to quickly scale from 10 Gb/s to 100 Gb/s WAN capacity. Dark fiber is faster to reconfigure than lit fiber since customers maintain end-to-end control over the optical connection. Districts can upgrade the capacity of the fiber by simply replacing the electronics at each end, without service provider intervention. And, unlike with lit fiber, there is no need to reapply for E-rate funding when upgrading capacity.

Dark fiber pricing and availability can vary widely from region to region. In some U.S. markets, affordable dark fiber may be plentiful, while it might not even be available in others.

Self-provisioned

With a self-provisioned service, the school district builds out and manages its own fiber infrastructure. Self-provisioned services are most often implemented in rural areas where dark fiber or lit fiber options are prohibitively expensive or simply not available. If a district chooses this route, it might consider forming a co-op with local libraries, healthcare systems, community colleges, universities, or government agencies to share funding and management of a joint private fiber network.

Table 3 compares and contrasts the three E-Rate fiber service options.

	Lit Fiber Option	Dark Fiber Option	Self-Provisioned Option
Description	District leases optical capacity from a service provider in the form of a managed Ethernet or wavelength service	District leases un-activated optical capacity from a service provider	District builds out and manages its own optical infrastructure
Network/ service classification	Managed Service	Private Network	Private Network
Fiber owner/ operator	Service provider	Service provider	District
Fiber lease term	Short (monthly service)	Long (often 20 years)	N/A (owned by district)
Electronics owner/operator	Service provider	District	District
Upfront expenses	$	$$ Cable lease is often front-loaded; district purchases electronics	$$$ District purchases electronics and cable plant
Ongoing expenses	$$$ Monthly recurring fees	$$ Provisioning, management, and equipment maintenance	$$ Provisioning and management, and equipment and cable plant maintenance

	Lit Fiber Option	Dark Fiber Option	Self-Provisioned Option
In-house expertise required	Low	Medium	High
Initial turn-up time	Short (weeks)	Long (months)	Long (months)
District's control over network	Low	Medium	High
Adds/moves/changes velocity	Slow	Fast	Fast
Upgrades require E-Rate resubmission	Yes	No	No

Table 3. Comparison of E-rate fiber options

Fund new fiber build-outs with E-rate

The 2014 E-Rate Modernization Order adds support for the upfront, non-recurring expenses associated with the installation of new fiber. Covered charges include cable plant construction costs, design and engineering expenses, and project management fees. E-Rate grants special construction funding for lit fiber, dark fiber, and self-provisioned fiber.

Outsourcing ongoing network operations

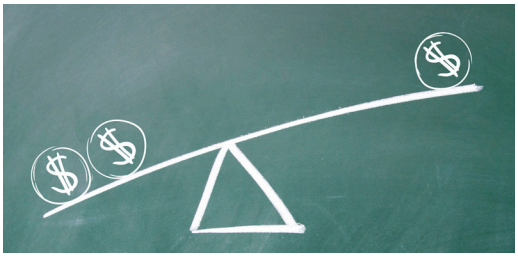
Most school districts do not have the resources and skills to fully manage a private optical network. Staffing an in-house operations team can be an expensive and time-consuming proposition. As a result, many districts turn over network operations to a trusted third party.

Districts investigating the dark fiber or self-provisioned options might consider outsourcing some or all of their network operations to a qualified

vendor. Acting as virtual member of a school district's IT team, the vendor can remotely monitor and control the private network, helping to identify, isolate, and resolve issues quickly and efficiently.

Choosing the lowest-cost option

Choosing the lowest-cost fiber option can be a challenge. It is important to consider several distinct financial models in any Total Cost of Ownership (TCO) analysis. The lit fiber approach is as an OPEX-centric model; customers pay a predictable monthly rate based on capacity. The other options involve a mix of CAPEX and OPEX, and include more guesswork.



With the dark fiber approach, there is a good chance of incurring upfront capital equipment expenses for new optical or packet-optical switching gear. In addition, this option will include ongoing operations expenses including fiber lease fees,[5] equipment maintenance fees, and network management staffing (or outsourcing) expenses.

The self-provisioned approach has the highest upfront expenses. Districts choosing this option will need to design, purchase, and install the cable plant and procure and configure the supporting optical or packet-optical switching equipment. Ongoing operations expenses include management of the cable plant, equipment maintenance fees, administrative staffing or outsourcing expenses, and potentially right-of-way fees.

Districts will need to create a multi-year TCO model to determine which service makes best financial sense over the long run. **More importantly, to receive E-Rate funding for dark fiber or self-provisioned services, a district must demonstrate it has selected the lowest-cost option.**

Costs for lit fiber, leased dark fiber, and self-provisioned services are highly location-sensitive. Districts should get bids from a number of service

[5] Many dark fiber providers offer Indefeasible Rights of Use (IRU) agreements. With an IRU, the lessee maintains partial ownership of the fiber. IRUs are usually long-term contracts (as long as 20 years) and are often paid in full upfront (front-loaded) rather than monthly.

providers to ensure the best solution in terms of pricing, timing, support capabilities, professional service offerings, and service level commitments.

⇒ Use Ciena's Build vs Managed Service calculator to determine which option may be the best choice for a given district.

REQUEST FOR PROPOSAL (RFP) CONSIDERATIONS

Demonstrating that a dark fiber or self-provisioned option is more cost-effective than a lit fiber service can be tricky. The FCC and USAC have not provided specific guidelines for comparing the various options. The more detailed the proposal, the more likely a dark fiber or self-provisioned funding request will be approved.

To improve the likelihood of success, be explicit in the RFP requirements and on the E-rate Form 470 posting to gather as much information as possible and receive the best pricing. Be specific about bandwidth and network performance requirements over an extended period. And be sure to solicit quotes for both lit fiber and dark fiber options from as many providers as possible.

A complete RFP should include separate sections for:

- Network connectivity
- Electronics equipment
- Equipment support and maintenance
- Network design services
- Network deployment services
- Remote network monitoring and management services

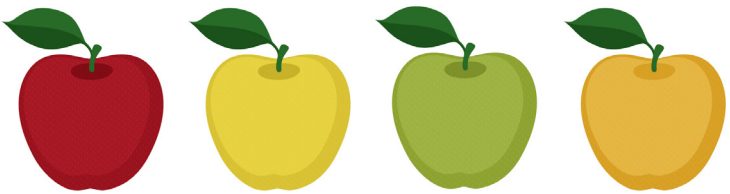
RFP recommendations

To compare the different options fully and accurately, be sure to:

- Clearly define the duration of the service agreement. Dark fiber leases can range from years to decades. Lit fiber services are typically covered by monthly agreements, but most providers offer discounts for long-term commitments. Include provisions for expanding lit fiber

capacity over time. Some service providers may try to lock districts into a specific data rate.

- Provide a thorough description of the environment, detailing locations of current and planned schools, administrative offices, data centers, and any other sites requiring connectivity. Provide current and projected user counts (students, administrators, faculty, and staff) for each site.
- Define the type of service needed for each circuit within the network. Provide guidelines on projected traffic flows, bandwidth requirements, and application type for each site. For example, elementary schools will primarily connect to the internet and require 10 Gb/s connectivity for low-bandwidth multiple-choice learning apps. This information will help responders propose the most efficient and cost-effective network architecture.
- For larger districts, consider defining three or four general site classes, such as low-bandwidth site (elementary/middle schools), medium-bandwidth site (admin offices/high schools) and high-bandwidth site (data centers). This will simplify the RFP and make it easier to compare proposals.
- Specify per-site projected bandwidth requirements for the duration of the contract. Factor in expected growth in user population (students, administrators, faculty, and staff), as well as changes in applications, such as the adoption of bandwidth-intensive cloud-based learning tools or IT solutions.
- Ask responders to break out any up-front costs associated with the fiber plant design and implementation. Examples include special construction costs, optional planning and design services fees, and optional deployment service expenses.
- Ask responders to specify fiber maintenance and operations costs for dark fiber and self-provisioned proposals. Many vendors include fiber maintenance costs and operations expenses in their IRU leases.



- For dark fiber and self-provisioned bids, request quotes for extended hardware and software warranty and maintenance options for electronics equipment. If the district plans to manage the network using internal resources, request quotes for product training and support options. If outsourcing network administration, solicit quotes for remote network monitoring and management services.

By fully detailing the upfront and ongoing costs of all three options over an extended period, districts can construct a highly defendable TCO to maximize their chance of funding.

⇒ Learn more in Ciena's *Creating an Apples-to-Apples Comparison of Dark Fiber, Self-Provisioned, and Lit Services* Infobrief.

TOP REASONS E-RATE FUNDING REQUESTS ARE DENIED

Once the RFP process is complete and a district chooses a vendor, the next step is to submit a funding application form (FCC Form 471) to USAC during the appropriate application filing window. The Program Integrity Assurance (PIA) group within USAC will then review the application and approve it, deny it, or request additional information to ensure compliance with E-rate program rules.

Although it should be self-evident that applicants must adhere to the Form 471 filing window deadlines, many districts fail to submit their applications on time. Filing the Form 471 late will require an FCC Waiver, but there is no guarantee that it will be granted. In addition to filing on time, the information included in the Form 471 must be complete and accurate. As intuitively obvious as that sounds, USAC has denied many applications due to incomplete and/or inaccurate details.

Besides filing late, the most common reason for denying fiber requests is that the products and services requested on a district's Form 471 application are deemed 'substantially different' than those requested on its Form 470 notice. For example, if a district indicates that it is pursuing the 'Dark Fiber Network' option on its Form 470, but then listed 'Self-Provisioned Fiber Network' on its Form 471, it will likely be denied. Another example is a district that selects 'Leased Dark Fiber IRU' on its Form 470, but applies for 'Dark Fiber Special

Construction' on its Form 471. Using the term 'Dark Fiber' as a catch-all term for the non-lit services options, and confusing the terms 'Self-Provisioned' and 'Special Construction' appear to be frequent mistakes.

Another common reason for denial of dark fiber and self-provisionedfunding requests is the lack of corresponding 'Lit Fiber or Third-party Network' bids. Under the E-rate Second Modernization Order, districts seeking a dark fiber option must also include lit fiber bids within their Form 470 posting. Districts seeking the self-provisioned option must include bids from third-party networks in their Form 470 posting.

It is not enough to just include lit fiber or third-party network services along with dark fiber and self-provision bids. The onus is on the district to demonstrate that these options are more cost-effective than the leased fiber bid. Typically, USAC requires that all costs associated with each option, including electronics, fiber maintenance, replacement, and upgrade costs be included for the total lifecycle of the project. USAC has been quite strict in this regard, and many dark fiber and self-provision bids are denied due to lack of quantitative evidence that these options are more cost-effective than lit fiber services. Districts may consider as many factors in their vendor evaluation as they wish, but the price of the E-rate-eligible products and services must be included as a factor and must be weighted more heavily than any other single factor. Districts also need to avoid requesting a specific network equipment manufacturer's make and model on their Form 470 or RFP, unless they include a phrase such as 'or equivalent' to express their willingness to consider bids providing similar functionality.

Yet another common reason for denial of a Form 471 application is failure to conduct an open and fair bidding process. A number of districts mistakenly express a preference for self-provisioned or dark fiber vs. leased lit services in

their RFPs and/or Form 470 postings. Others identify a preferred vendor, providing advance notice of their requirements to a specific vendor, or use an E-Rate consultant that is closely associated with the vendor to whom the contract is awarded.

Finally, many applications for dark fiber or self-provisioned networks are denied because districts confuse the timing for when they intend to deploy the appropriate electronic equipment to 'light' the network. E-rate funding is only available for dark fiber and self-provisioned networks that are constructed and 'lit' in the same year for which they seek funding. For example, some districts secure a long-term dark lease for twelve fiber strands, but only intend to light five of those strands the first year, and the remaining strands over the following three years as bandwidth demand grows. This funding application would be denied because the district does not plan to light all twelve strands within the requested funding year. In this case, USAC would advise the district to resubmit the funding application, requesting funding for just the five strands to be lit in that funding year, and submit additional requests in subsequent years when the district needs to light the remaining strands.

Because many school districts are heavily dependent on the E-rate program to help fund their network connectivity requirements, it is imperative that they comply with all USAC regulations.

A BRIEF INTRODUCTION TO OPTICAL NETWORKING

Optical networking uses thin glass or plastic optical fiber to transmit information in the form of light pulses. Fiber optic networks are more reliable and provide far greater transmission capacity than conventional copper-wire networks. Originally deployed in telecommunications service provider networks, fiber optic networks are now widely used in the business world as well for data center, campus, and WAN connectivity. In fact, fiber is now considered the preferred transport medium for high-speed, mission-critical enterprise networks.

Optical networks can help organizations:

- Provide high-capacity connectivity within and between data centers or across a campus environment

- Efficiently connect remote sites to data centers, private clouds, or public clouds
- Ensure fast network performance for bandwidth-intensive, delay-sensitive applications
- Ensure high network availability for critical applications and IT services
- Overcome distance limitations and reduce CAPEX and OPEX

Modern optical networks use advanced optical amplification techniques, coherent optics, and Dense Wavelength-Division Multiplexing (DWDM) technology to extend fiber reach and capacity. Contemporary DWDM optical systems can carry dozens of 100 Gb/s channels over a single fiber pair for long distances.

Fiber deployment options

Generally speaking, there are two ways to take advantage of optical networking technology: lease a fiber-based circuit from a telecommunications service provider (E-Rate refers to this as the lit fiber option), or implement a private optical network using dark fiber.

Managed service (lit fiber)

Many service providers offer fiber-based managed Ethernet and managed optical wavelength connectivity services. With the managed service approach, the service provider is responsible for the optical networking infrastructure, including the cable plant and the electronics equipment. Most service providers offer point-to-point services and point-to-multipoint services. In addition, Ethernet services can be either 'private' (dedicated) Ethernet circuits or 'virtual' (switched) Ethernet circuits. Many larger districts with numerous schools stretched throughout large geographic areas have significantly reduced their costs by replacing private Ethernet circuits with Virtual Ethernet circuits. Service providers typically charge a fix monthly fee for managed Ethernet or wavelength services. Pricing is usually based on service type, site locations, data rates, and service level commitments.

Private optical network (dark fiber)

With a private optical network, the district builds out and manages its own network using dark fiber. The dark fiber provider typically maintains the fiber

plant. The district is typically responsible for the electronics equipment. Dark fiber is usually leased from a service provider for an extended period—often as long as 20 years. Dark fiber pricing and availability vary widely from area to area. In regions where dark fiber is not available from a service provider, districts will need to construct and maintain their own fiber plant to create a private network (E-Rate calls this the self-provisioned option). To drive down costs and ensure the highest data transmission rate possible, districts opting for dark fiber or self-provisioned networks should converge network layers. In particular, they should choose the electronic platforms that provide the capability to support multiple services, future demands, and various protocols on a common infrastructure. A flexible platform should support network Layers 0, 1, and 2 without the need for separate systems. The ability to transport and dynamically prioritize multiple traffic types is critical to providing the rich digital learning environment students and staff demand. The addition of DWDM allows for the transport of more data across the dark fiber, helping to maximize return on network investment.

Want to learn more about optical and packet networking? Take advantage of our free "open curriculum learning catalog": http://www.ciena.com/learning/

PRIVATE NETWORK IMPLEMENTATION AND OPERATIONS CONSIDERATIONS

Private networks require careful thought and planning. Each school district must ensure its network meets short-term price-performance objectives and will cost-effectively scale to meet long-term projections. Districts also need to ensure the network fulfills reliability, security, and service level requirements, and that staff can efficiently manage the network and effectively support the user community.

Eliminating network cost and complexity is paramount. Districts can consolidate equipment and streamline operations by implementing a converged packet-optical network. The latest packet-optical platforms combine high-performance Layer 0/1 optical switching capabilities and comprehensive Layer 2 Ethernet switching capabilities in a single platform, with a common administrative interface. Converged packet-optical networks can help contain CAPEX by collapsing network layers and consolidating equipment, and contain OPEX by unifying provisioning and management functions and reducing recurring energy and rack space costs.

Look for a converged packet-optical platform that supports an extensive set of standards-based networking protocols, security features, and embedded management capabilities. Choose a vendor that offers a wide-ranging product portfolio that delivers scalable, cost-effective connectivity across the access, aggregation, and core portions of the network. School districts should consider ease of deployment and ongoing operations—adding connections, boosting capacity, and troubleshooting problems—when evaluating solutions. The latest packet-optical platforms support Software-Defined Networking (SDN) approaches to improve automation and simplify integration with other IT management systems and practices.

Investigate the vendor's warranty and maintenance plans, support capabilities, design and deployment services, and remote monitoring and management offerings. Architecting, implementing, and managing a next-generation network takes time, money and know-how. Districts may want to leverage outside expertise to accelerate schedules, reduce risks, and free up internal staff to focus on other projects.

http://www.ciena.com/products/ciena-specialist-services/

⇒ Learn more in *Learning at the Speed of Light with Dark Fiber Networks* brief.

ADDITIONAL RESOURCES

EducationSuperHighway **www.educationsuperhighway.org**

EducationSuperHighway is a non-profit organization focused on upgrading Internet access in every public school classroom in America. Their website contains a variety of resources and free tools to help districts assess K-12 broadband requirements and solutions.

State Educational Technology Directors Association **www.setda.org**

SETDA is a not-for-profit corporation whose mission is to build and increase the capacity of state and national leaders to improve education through technology policy and practice. Their website provides news and useful information about K-12 broadband initiatives and the E-Rate program.

Universal Service Administrative Company **www.usac.org**

USAC is the not-for-profit corporation responsible for overseeing E-Rate funding. Their website is the online clearinghouse for the E-Rate program, providing news, tools, resources, and application forms.

U.S. Department of Education **www.tech.ed.gov**

The U.S. Department of Education Office of Educational Technology develops national educational technology policy and establishes the vision for how technology can be used to transform teaching and learning. Their website provides a wealth of technology resources for district leaders and technology planners.

ABBREVIATIONS

CAPEX:	Capital Expenditures
DWDM:	Dense Wavelength-Division Multiplexing
FCC:	Federal Communications Commission
IRU:	Indefeasible Rights of Use
ISP:	Internet Service Provider
LAN:	Local Area Network
MPLS:	Multiprotocol Label Switching
OPEX:	Operating Expenses
RFP:	Request for Proposal
SDN:	Software-Defined Networking
SETDA:	State Educational Technology Directors Association
TCO:	Total Cost of Ownership
USAC:	Universal Service Administrative Company
VPN:	Virtual Private Network
WAN:	Wide Area Network

Daniele Loffreda

Daniele Loffreda is Industry Advisor, State/Local Government, Education and Healthcare market development. In this role he leads Ciena's initiatives to apply hardware, software and services technologies to help these sectors ensure that their networks have the capacity to support their digital transformation, optimize their cloud strategies, consolidate infrastructure and improve data security.

Daniele has more than 20 years of experience helping the public sector leverage Information, Communications and Technology solutions provide greater value to their constituents, improve their operations and generate higher returns on public funds. For the past 7 years he has worked with the K-12 sector and the E-Rate program to help districts secure greater bandwidth capacity within constrained budgets.

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Experience. Outcomes.

Get up to speed on the U.S. federal government's E-rate program and the benefits of fiber optical networking. This book helps school district leaders and technology planners sort out the various program options and understand the application and approval process. You will learn how to choose the best fiber network option for your district, how to structure an RFP to get the best pricing, and how to increase your chances of obtaining government funding. We also provide guidelines for designing and operating a private optical network.

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