
Networks for the Future
of Higher Education
ciena

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1. Introduction

Educational Technology (EdTech) is transforming the way higher education students learn and how curriculum is delivered. The global COVID-19 pandemic accelerated digital transformation in higher education and has created the potential for new digital education tools to transform classrooms and prepare students for the global information economy of the 21st century.

EdTech is evolving at a rapid pace. Online learning is increasingly prevalent and more widely available. Students untethered from the classroom can connect from anywhere and collaborate with other students across the world—at any time. Tools such as virtual and immersive reality, Artificial Intelligence (AI), social media in education, and 'adaptive learning' (where online course materials adjust to the student) are driving a new kind of collaboration between students and educators.

Underlying EdTech's evolution is the communication network, which is becoming even more critical to support the increased performance, agility, and resiliency demands of the latest cloud-based, mobile-centric, multimedia education tools and anytime, anywhere learning environments.

Administrators, department heads, and professors expect the network to adapt and support the newest latency-sensitive, bandwidth-intensive applications.

The new demand for online learning has resulted in significant changes to the way networks are utilized. Students, professors, and parents are now—more than ever—reliant on dependable, agile, and high-performance network infrastructure to connect to online learning platforms. The network needs to be intelligent, trusted, and ready for anything.

This eBook provides insights on the requirements of networks that support educational tools and infrastructure, including the following:

- The benefits of getting EdTech right
- What is happening in EdTech
- Requirements for networks supporting education
- Impact of COVID-19 on networking requirements
- Ciena's experience building education networks

2. The benefits of getting EdTech right

There are several key benefits of maximizing the potential of EdTech:

- Support and improve the provision of online learning
- Allow connections with segments of students who are not easily engaged in classroom learning, such as adult learners with established careers
- Support large-scale improvements in student productivity, particularly for non-classroom-based education
- Enable assessment at scale and with integrity
- Increase student engagement and retention
- Enable personalized and adaptive approaches to learning
- Facilitate lifelong learning
- Support efficiencies in administrative functions

3. What is happening in EdTech

Between speaking to customers and researching more broadly, there are a number of emerging trends in EdTech globally:

- **Video-based learning** is increasingly prevalent. YouTube and other streaming services are valued educational media.
- **High-quality digital content** is consumed in unstructured and typically shorter sessions.
- **Collaborative technology** is pervasive. Common tools such as Facebook, Google Classroom, Zoom, or Skype are widely used; education-focused apps are growing in use.
- **Mixed reality** is growing up; AR and VR are utilized to improve learning outcomes.
- **Blended learning** with digital technologies enables students and teachers to collaborate remotely, with improvements to online learning allowing for a mix of on-campus and off-campus learning.
- **Online learning platforms** (such as Open Colleges' Open Space) are proliferating.
- **Personalized learning** utilizes AI-based platforms that adapt to each student's individual strengths and challenges.

These trends are driving networks to new limits. Massive bandwidth is not enough; low latency is essential; resiliency is critical; and changing traffic patterns drive a need for new levels of network agility.

The following statistics summarize trends in U.S. education technology:

63% **of campuses use smart technologies** to improve learning environments and outcomes[1]

U.S. research and education institutions moved and shared **62 petabytes of data in just one month**[2]

41% **of students rely on three or more devices** for their coursework[3]

Connectivity is already challenged: Nearly **70%** of higher education leaders anticipate needing an increase in bandwidth over the next 12–24 months[4]

For many universities, improving student outcomes is a top priority. Increasingly, education leaders are turning to technology to help accomplish this goal. Modern classroom tools boost engagement, support collaboration, and personalize learning to each student's unique needs. But these tools are also bandwidth-intensive and produce large amounts of data while demanding flexibility. To harness the benefits of innovative EdTech solutions, universities need a modern network that can readily adapt to changing demands.

There is clear evidence that slow network connectivity can hamper the performance of online applications, impair student experience, and frustrate teachers. In the U.S., many universities that have fully adopted digital learning technology have experienced significant year-on-year growth in bandwidth requirements.[5]

Educational institutions that are unprepared for this surge are experiencing an increase in unplanned network outages—often at the worst possible moments, such as during online testing. This has resulted in a rush to increase capacity demands to meet the needs of bandwidth-intensive interactive learning tools and multimedia content. As a result, many universities are planning additional investments in campus network infrastructure.

1 2019 Connected Campus Survey of 155 Higher Education Decision-Makers
2 https://www.internet2.edu/blogs/detail/7185
3 2019 CDE Connected Campus Survey of 1,000 College Students
4 2019 CDE Campus Experience Survey of 514 College Students
5 2019 CDE Campus Experience Survey of 514 College Students

4. Requirements for networks supporting education

EdTech is evolving. Interactive digital courseware, learning analytics, online assessments, and personalized instruction are reshaping the classroom and improving education.

Student/learner mobility and **cloud-based** technologies remove the constraints of the physical classroom. Students are also increasingly equipped with mobile devices, and desktop PCs were displaced by laptops—which are now increasingly sidelined by tablets and smartphones.

Geographic diversity: Students and teachers can engage remotely, so professors, instructors, and classmates are able to interact at any time and from anywhere. Thus, the traditional concept of 'school hours' is being challenged.

Dependable, secure, high-speed network connectivity is critical to the success of university students, researchers, and staff. The following sections examine networking requirements for EdTech, including:

- Bandwidth requirements
- Distribution and traffic patterns
- Connectivity options
- Encryption
- Other considerations

4.1. Bandwidth requirements

When planning network capacity, it is important to consider all traffic sources and traffic patterns. Most universities run classroom applications, campus administration systems, research programs, and office applications on the same network, often at the same time. Many are migrating school administrative systems and business applications to the cloud to reduce IT cost and complexity.

University EdTech use cases that drive network bandwidth include:

- Student requirements and admissions
- Teaching and learning
- Testing and assessment
- Accreditation and credentials management
- Data analytics
- Internship management
- Student financing and parental engagement
- Infrastructure tools such as learning management systems

4.1.1. Bandwidth requirements per endpoint

The following table outlines per-session bandwidth requirements for common digital education activities. Overall bandwidth requirements can be estimated by considering the number of students in a network catchment area and considering oversubscription and statistics gains.

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
Skype group-video session	8 Mb/s
Downloading a 6144MB movie in 8 mins	100 Mb/s

Table 1. Typical bandwidth requirements

Source: The Broadband Imperative II: Equitable Access for Learning, SETDA, 2016

Table 1 above provides minimum guidance and does not take into consideration multiple applications running concurrently. For example, students utilizing Zoom with 1080p video will require >3 Mb/s up/down but will require additional bandwidth if concurrent applications—such as online courseware, web browsing, or other applications—are running.

Bandwidth requirements are very likely to grow as EdTech applications evolve. For example, cloud-based AR/VR (as required for applications like immersive reality) may require bandwidths of up to 700 Mb/s and sub-10 ms latency.

4.1.2. Bandwidth requirements for non-classroom activities

Activities outside the classroom can also drive bandwidth. This includes administrative and staff online activities, outlined in the following table.

Activity	Typical Bandwidth (Per Individual Session)
Searching the web	1 Mb/s
Checking email	.5 to 1 Mb/s
Music streaming	2 Mb/s
HD video conferencing	4 Mb/s
Sharing cloud-based documents (Office 365/Google Apps)	50 Mb/s

Table 2. Bandwidth required for non-learning activity

Source: The Broadband Imperative II: Equitable Access for Learning, SETDA, 2016

Adoption of cloud-based administration and collaborative tools will drive non-classroom activity bandwidth requirements.

4.2. Distribution and traffic patterns

In ordinary circumstances, bandwidth requirements are primarily driven by a highly digital approach to teaching which varies between university systems. Contributors to bandwidth and network requirements include:

- Number and type of sites—main campus, affiliated institutions, satellite locations, administrative offices, research centers, and data centers
- Distances between campuses, satellite sites, and research centers
- Peak number of students, professors, teaching assistants, and other staff concurrently accessing the network
- Adoption of digital, collaboration, and mixed-reality learning technology
- Use and mix of cloud-based IT administrative and office solutions
- Adoption of mobile devices by students and staff—laptops, tablets, smartphones, etc.
- Projected growth in users and application traffic

4.3. Connectivity options: What's the best network for you?

Wherever possible, fiber-based connectivity is the best choice for universities. Fiber provides the highest capacity, lowest latency, and most reliable connectivity.

Fiber-based connectivity can be provided in several different ways:

Private network

Educational institutions have two options when considering a private network:

- The first is to procure fiber-optic cables, deploy them underground or along utility poles, and then deploy the packet-optical network switches to light the fiber. Educational institutions also must have experienced IT staff to maintain the fiber and manage network operations.
- The second option is to lease dark fiber from a service provider. With dark fiber, the service provider owns and maintains the fiber, but the educational institution owns and manages the packet-optical switching equipment used to light the fiber. Some dark fiber service providers may agree to bundle the network equipment within the dark fiber lease contract.

Some educational institutions may deploy their own fiber cables or private 5G, especially for intra-campus networks. For Wide Area Networks (WANs), the majority find that leasing dark fiber is the best choice for university systems that need to quickly scale from 10 Gb/s to 100 Gb/s. The growing availability of dark fiber, along with innovations in packet-optical networking technology, has made a private network much more attractive.

Dark fiber is usually leased from a service provider for an extended period—often 20 years. Dark fiber pricing and availability vary widely from area to area. In some markets, affordable dark fiber may be plentiful, while it might not even be available in others.

To drive down costs and ensure the highest data transmission rate possible, university systems opting for dark fiber networks should choose converged packet-optical platforms. These innovative network platforms provide the flexibility to support multiple services, future demands, and various protocols on a common infrastructure. These converged 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.

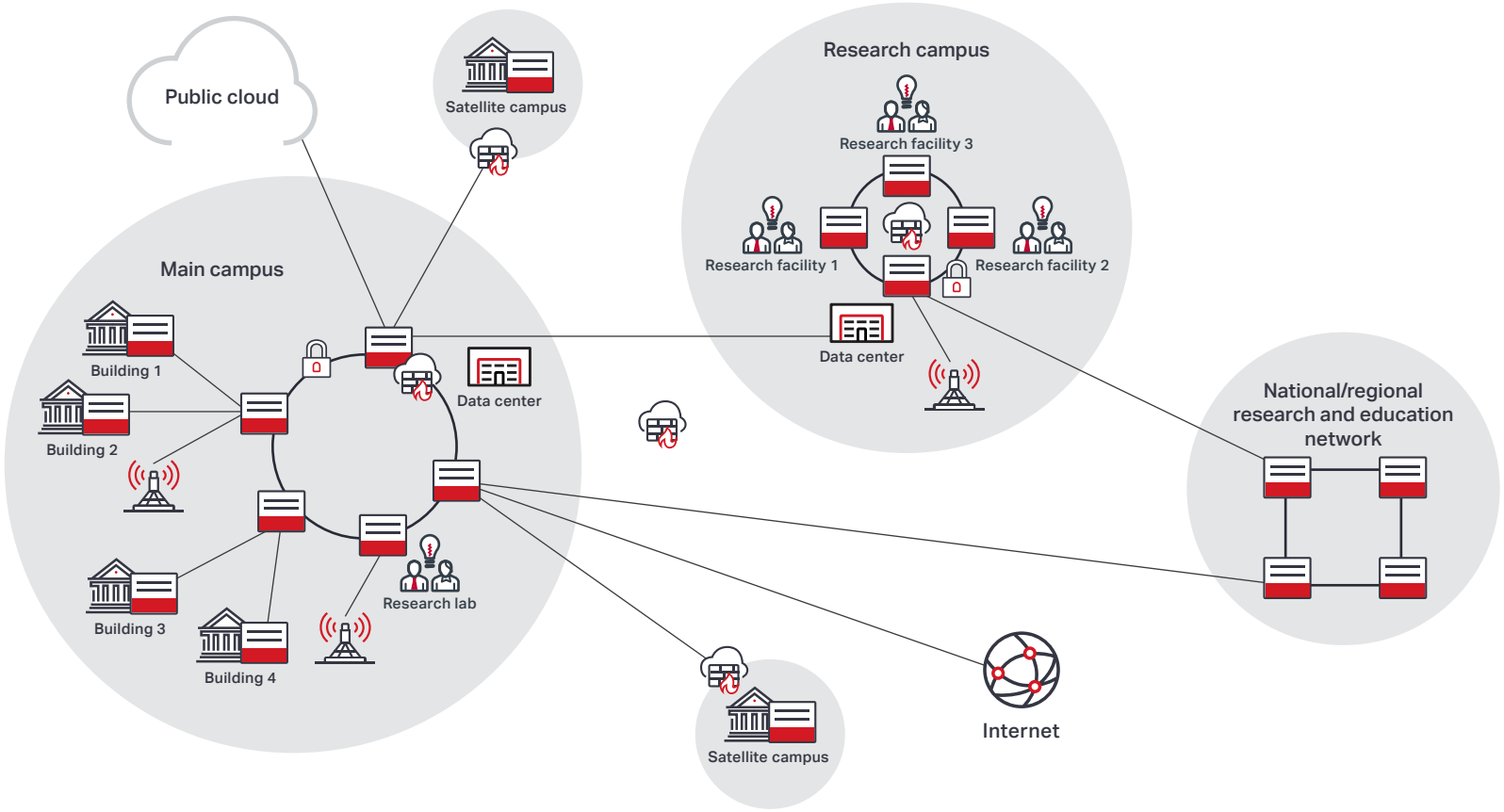
Converged packet-optical networks can help contain capital expenditure by collapsing network layers and consolidating equipment; they can also contain operational expenditure by unifying provisioning and management functions and reducing recurring energy and rack space costs. The ability to transport and dynamically prioritize multiple traffic types is critical to providing the rich digital learning environment students and staff demand. The addition of Dense Wavelength Division Multiplexing (DWDM) allows for the transport of more data across the dark fiber, helping to maximize return on network investment.

Encryption

Research and education institutions are prime targets of cyberattacks because their networks contain many types of information—from proprietary research data to information about users' personal lives, financial records, and health. Institutions employ multiple security standards to safeguard their networks and must comply with federal security regulations or risk losing eligibility for federal research funding and financial aid programs. Encrypting data communications and stored data are among the required security features.

Research and education network architecture

The image below depicts a typical educational institution network configuration.



This network configuration includes intra-campus networks and external connectivity to satellite campuses, research campuses, national and regional research and education networks, and internet and public cloud providers.

Intra-campus networks

Campus networks combine Ethernet access from dispersed school buildings and wireless cell sites—which increasingly include 5G— that aggregate to a 10 Gb/s or 100 Gb/s optical ring that connects research labs and a data center. Ethernet switches at each site can combine connectivity workloads with virtualized network functions like virtual firewall, router, load balancer, and others. This reduces the number of network devices needed in each campus building while still delivering the required workload.

Multi-building research campuses typically connect individual research centers on a 10 Gb/s or 100 Gb/s ring. The campus data centers can replace numerous physical application servers with a single high-end compute device that supports multi-tenant, virtualized application workloads.

To ensure that data is secure as it traverses the network, AES-256-compliant encryption technology within the optical network equipment as well as a private network provide an unparalleled level of data security and privacy.

Wide Area Network

The campus networks are connected to satellite campuses, research campuses, national and regional research and education networks, internet service providers, and public cloud providers via 10 Gb/s or 100 Gb/s circuits.

4.4. Other requirements

In addition to connectivity and bandwidth, several other factors should be considered, as shown in Table 3, below.

Consideration	Impact
On-demand capability	• Key to respond to changing demands of education; new tools will be adopted, driving changed traffic patterns and inevitably more bandwidth • Networks should be designed with flexibility and adaptability in mind
Network resilience	• For both learning and administration, network availability is key; as tools move online, outages have more significant impact on learning outcomes
Manageability	• 'Single-pane-of-glass' operations are key to ensuring effective manageability of all aspects of network and service lifecycle – from service creation, modification, assurance, and fault management, through the ongoing optimisation
Security	• Network integrity as well as specific security capability (such as encrypted connections, firewalls, intrusion detection, etc.) are needed to ensure student and teacher privacy
Contracting flexibility	• Should be flexible to allow for changing needs, including bandwidth, flows, security, networking, and features driven by rapidly evolving EdTech software and methodologies
Catering to future needs	• EdTech evolution will drive new requirements; edge compute, cloud connect, and virtualised services—as well as requirements yet to be defined—may be required and will need to be provisioned rapidly and with minimal impact

Figure 2. Other networking considerations

4.5. Operational considerations

Networks typically consist of technologies and solutions from multiple vendors. This can result in complex 'swivel chair' operations—where different teams need to access different systems to plan, provision, and assure services. This complexity can make it slow to diagnose and resolve issues. Worse, operations staff may not even be aware of issues until the customer calls.

'Single-pane-of-glass' operations is key to ensuring effective manageability of all aspects of network and service lifecycle—from service creation, modification, assurance, and fault management, through ongoing optimization.

Different models exist in transitioning to simplified operations, including:

- Utilizing an umbrella operations environment such as an orchestrator or domain controller to unify operations across vendors
- Utilizing a single vendor across all network domains

There is no 'right' answer, but operational efficiency should be a primary concern when designing networks in support of EdTech.

Outsourcing ongoing network operations

Many educational institutions do not have the resources and skills to fully manage a private network. Staffing an in-house operations team can be expensive and time-consuming. As a result, many institutions turn over network operations to a trusted third party. Educational institutions might consider outsourcing some or all their network operations to a qualified vendor. Acting as a virtual member of a university's IT team, the vendor can remotely monitor and control the private network—helping to identify, isolate, and resolve issues quickly and efficiently.

4.6. Recommendations

For both educational institutions and service providers, the key is to be adaptable. It is not possible to foresee what the future in EdTech will bring, but educators and service providers can prepare for it.

For educators, new tools and ways of teaching will drive changes. Deploying a private network that can adapt to changing needs is essential.

- **Grow with demand** – Architect your network to be able to meet your current needs while maintaining the scalability to support future capacity requirements.
- **Flexible traffic flows** – As education moves from a hub-and-spoke model such as video consumption to a more collaborative or peer-to-peer model, ensure your network provides the topology and flexibility to accommodate changes.
- **Integrity** – Networks should be configured with infrastructure and process reliability, and backup connections, backup sites, and operational integrity should be verified; consider how onsite-to-cloud–based operations may be impacted by network integrity.
- **Security** – A network must be assured to protect students, teachers, and university property.
- **Features** – Requirements may change over time; simple service add-ons (such as firewalls or IP VPNs services) may evolve to necessitate things like edge compute; ensure your network can accommodate these possibilities.

Ciena has proactively partnered with the global higher education community for decades. This collaboration helps drive research and development for the evolution of optical and packet networking technologies, helping to develop the higher education networks of the future.

A converged packet-optical solution from Ciena provides a scalable, flexible, high-capacity transport of transit and protect traffic—from streaming video to massive data flow transfers—to support the changing demands of the research and education community. To find out more about how Ciena solutions can help you provide a higher quality experience to students, professors, researchers, and administrators, contact us here.

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