Broadband Imperative III

Driving Connectivity, Access and Student Success

November 2019

SETDA

LEADERSHIP • TECHNOLOGY • INNOVATION • LEARNING

Founded in 2001, the **State Educational Technology Directors Association (SETDA)** is the principal nonprofit membership association representing US state and territorial educational technology leaders. Our mission is to build and increase the capacity of state and national leaders to improve education through technology policy and practice. For more information, please visit: setda.org.

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ABOUT THIS WORK:

Based on SETDA's work around equity of access, the 2012 Broadband Imperative II: Equitable Access for Learning and the 2016 State K-12 Broadband Leadership: Driving Connectivity and Access, SETDA completed this research in partnership with state and private sector leaders including state CIOs, state network managers, E-rate coordinators and digital learning administrators.

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CATALYST FOR DYNAMIC CHANGE

From car services to shopping to career planning, digital tools and resources have dramatically pivoted every aspect of our personal and professional lives. Similarly, the advent of new technologies and increased access to robust connectivity is reshaping the K-12 landscape for teaching and learning. School districts nationwide are leveraging digital instructional materials and resources to deliver transformative and impactful personalized learning opportunities for students and to enhance the administrative coordination of school business. Teachers are no longer confined to the front of their classrooms, delivering content to rows of students restricted to their desks. Instead, they are fostering interactive and collaborative student-led discussions and engaging their students in hands-on, project-based and problem-based learning exercises that often extend beyond the walls of the classroom. Why? School systems are striving to meet the needs of the modern workforce including the need to develop life-long learners that can adapt to ever changing jobs and careers as technology continues to disrupt the digital age workplace.

> ***If we teach today as we taught yesterday, we rob our children of tomorrow.***
>
> **–John Dewey,**
> Education Reformer

Digital resources such as online learning management systems, real-time data analytics tools, videos and web-based collaboration suites enable educators to enhance students' learning experiences in ways that were previously impossible. Technology affords educators the opportunity to choose from a multitude of pedagogical approaches, including project-based, blended, virtual, game-based and collaborative-based learning to personalize education for students. Technology provides educators the freedom and flexibility to explore and engage with new technologies in creative and innovative ways in support of personalization and workforce development.

Illinois: McHenry Elementary School District 15 is preparing grade-schoolers for the jobs of tomorrow that will require creativity and discovery through hands-on innovative STEM and STEAM programming. District 15 provides students with educational opportunities that foster engagement, interaction and achievement through cutting-edge technology utilizing a personalized learning approach. The district provides students access to collaborative spaces offering sequential K-8 cross-curricular opportunities that allow innovation and provide project-based exploration. Program URL Program Video

Kentucky: Fayette County Schools. The Learning Center (TLC) employs a wrap-around approach to individualize student needs is an innovative way to educate "at-risk" students. Each student is individually equipped with digital tools, an adult mentor and a host of on and off campus learning opportunities linked to career interests. Teachers focus on mentoring and mastery of academic and social/emotional skills needed to build self-efficacy. One of the most unique aspects of TLC is eOS (employability operating system) where teachers, counselors, therapists, parents and community partners measure, teach, reteach and communicate employable behaviors and expectations.

Wisconsin: Wisconsin schools have utilized $62.1 million dollars in federal E-rate funding. Since 2016, the state of Wisconsin has seen an 86% increase in fiber connections within Wisconsin school districts. Using these high-speed internet connections, Wisconsin school districts are realizing opportunities for students and communities. Districts around the state are implementing STEM programming, like Watertown Wisconsin's K-8 STEM program. Neenah School District is currently integrating engineering into all elementary grades and supporting community learning by hosting community-wide STEAM Saturdays. For instance, Phelps School District implemented a 6-12 blended learning program with the Wisconsin Digital Learning Collaborative partners. Smaller rural schools, such as the Webster school district, recognized the need to extend connectivity and the school day by adding hotspots to buses, and offer students access to virtual field trips, transcripted courses, and advanced learning via video and web enabled learning.

ESSENTIAL LEADERSHIP FOR STUDENT SUCCESS

Sustained leadership is essential as district and school leaders implement plans to support digital learning environments. Collaborative discussions with all stakeholders, especially academic, instructional, assessment and technology leaders, to understand the district and school goals and the capacity to achieve those goals are paramount. Determining who will have the authority and accountability to implement plans and stakeholder buy-in around the plans helps ensure long-term sustainability and success. Administrators supported by digital learning leaders play an essential role in strategic planning and vision setting; understanding teacher and student needs for instructional materials and devices; determining internet and Wi-Fi connectivity needs; identifying key systems for data collection and assessment; and budgeting for technology. Adapted from the National Education Technology Plan 2017, the key components of collaborative leadership are:

DEVELOP A SHARED VISION
for how technology can support teaching and learning for all students

SEEK INPUT
from a diverse team of stakeholders to adopt and communicate clear goals for teaching facilitated by technology

COMMUNICATE
with all stakeholders by using appropriate media and technology tools and establish effective feedback loops

UNDERSTAND RESEARCH
Ensure that practitioners at the school and district level use and understand research

> ***We need technology in every classroom and in every student and teacher's hand, because it is the pen and paper of our time, and it is the lens through which we experience much of our world.***
>
> **–David Warlick,**
> The Landmark Project (retired)

TECHNOLOGY INFLUENCES PEDAGOGICAL APPROACHES

Pedagogical approaches that utilize the power of technology to personalize learning include blended and virtual learning. According to the U.S. Department of Education's Office of Educational Technology, "In a blended learning environment, learning occurs online and in person, augmenting and supporting teacher practice. This approach often allows students to have some control over time, place, path, or pace of learning. In many blended learning models, students spend some of their face-to-face time with the teacher in a large group, some face-to-face time with a teacher or tutor in a small group and some time learning with and from peers. Blended learning often benefits from a reconfiguration of the physical learning space to facilitate learning activities, providing a variety of technology-enabled learning zones optimized for collaboration, informal learning, and individual-focused study." Virtual learning is the opportunity to take courses where the curriculum is provided exclusively online.

70% of bandwidth is driven by **video streaming** and is expected to grow.

–AT&T

> ***Education will take place in continuous and context-aware mobile learning channels blending digital and physical experiences.***
>
> [A Faster Smarter Future, Emerging Applications for 5G and Edge Computing]

Although virtual and blended learning environments are widely thought of as effective instructional approaches, they are not available in all schools for all students. Without access to high-speed bandwidth and devices both at school and at home, teachers and students cannot realize the potential of these approaches. Further, newer approaches to provide project-based and hands-on activities are the reality for some schools and on the horizon for more. Such tools require even more bandwidth, such as augmented reality, virtual reality, mixed reality and game-based learning. The Franklin Institute, [What's the Differences Between AR, VR and MR?], describes the differences as follows:

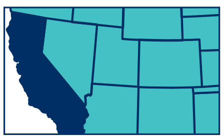
AUGMENTED REALITY (AR)
adds digital elements to a live view often by using the camera on a smartphone.

VIRTUAL REALITY (VR)
implies a complete immersion experience that shuts out the physical world.

A mixed reality (MR) experience combines elements of both AR and VR, where real-world and digital objects interact.

Examples of AR, VR and MR to enhance education include: virtual field trips using AR and VR, allowing students to explore areas without ever leaving the classroom; virtual 3D models for science; and lab experiences that allow students to virtually alter time to move more quickly or go back and correct mistakes. Game-based learning focuses on engaging students in learning through game-based approaches, such as choose your own adventure or student quests. Game-based learning is also expanding to Esports, a competitive video game play that is emerging in K-12 education to further engage students. According to the article, Gamers Are the New High School Athletes: The Rise of Esports, most leagues provide instructional resources for educators managing the team, explaining the game and offering suggestions for promoting good sportsmanship.

> ***The Near Future films inspire innovators to create technologies and experiences supported by the broadband network.***
>
> **CableLabs**, https://www.cablelabs.com/thenearfuture



California: California's Chaffey Joint Union High School District serves 23,894 students in grades 9-12 via ten schools. Sixty-one percent of students qualify for free or reduced school lunch. The district office is connected at 100 Gbps via fiber-optic cable and shares that bandwidth with several other school districts. Schools connect over nine 10 Gbps fiber-optic connections. The district has 4.19 Mbps per student. Career and Technical Education (CTE) pathways are provided via schools preparing students for future careers including Information & Support Services, Media Support Services, and Residential & Commercial Instruction.

Indiana: Through partnerships with the local community, South Ripley Community School Corporation is committed to educating students today to become responsible citizens of tomorrow. South Ripley's Integration of STEM instruction is instrumental in developing the soft skills of collaboration, teamwork, critical thinking and communication necessary to adapt to the ever-changing demands of the work environment. Beginning at the elementary school level, students are immersed into the world of STEM through collaborative spaces and personalized learning approaches that allow students to engage, create and apply their learning. New makerspaces are currently being created at the secondary level that will allow students to continue STEM-infused learning, fostering science and math literacy and problem-based STEM curricula.

Ohio: Cincinnati Public Schools developed the AP Blended Learning program to improve students access to rigorous learning opportunities and improve equity of learning. The blended learning program consists of face-to-face instruction and individualized student learning. The district provides every student with a device and wireless internet access via a Kajeet SmartSpot®. Teachers visit the physical classroom a minimum of two to three times a week. Since the students do not have a teacher in the classroom each day, they must learn to manage time and collaborate and communicate regularly with the teacher and other students. Technology enables many more students access to AP courses, improving their educational experience.

Impact of Technology Disruption

As access to innovative pedagogical approaches that utilize digital tools and resources increases, the reliability and speed of the network are critical. In the article, Pursue Digital Equity Through Access and Opportunity – All Means All, the challenges facing many schools include the capacity of the network. “When there is not enough bandwidth to accommodate access and applications don’t load or crash, the frustration and waste of instructional opportunities mount.” According to the Parana River group, a learning disruption occurs when there is inadequate bandwidth for a teacher to effectively utilize technology in the classroom causing the teacher to modify his/her pedagogy to NOT use the technology. For example, when a teacher plans a lesson using online digital content and the students can’t access the internet, the teacher is less likely to plan technology integrated lessons again. Typically, a learning disruption occurs when the 95th percentile bandwidth usage exceeds 75% of the available bandwidth. Further, if the disruption occurs repeatedly, then the learning disruptions may impact the future use of technology for teaching and learning. Long term data suggests that usage growth slows in districts that have experienced multiple disruptions in a school year. Inadequate bandwidth is a contributor to technology-based learning disruptions, but it is not the only factor. Lack of adequate bandwidth, however, is one of the easiest causes of learning disruptions to identify. It is essential to point out that inadequate bandwidth, even when corrected, appears to have a long-term impact on use of technology-based pedagogy. Proactively providing adequate bandwidth, provisioning a scalable underlying architecture, and having the information necessary to increase bandwidth in time to meet needs in the future is critical.

> ***“Actual usage per student data indicates that preventing learning disruptions is critical for the continued integration of technology in education.”***
>
> **Parana River Group**

Recommendation

Districts and schools are in different stages when considering access to and the utilization of digital tools. The integration of technology for learning is a journey and schools and districts launch and implement these transitions differently. Leaders must focus on their academic goals and leverage technology to support student learning experiences in preparation for college and/or careers in the digital age.

DIGITAL ACCESS AND EQUITY

Virtually all our nation's schools have access to the internet, but the quality and type of connectivity vary greatly across the country. Equitable access to high-speed broadband is the foundation upon which today's schools create enhanced and empowering digital learning experiences.

> ***"Digital Equity is a condition in which all individuals and communities have the information technology capacity needed for full participation in our society, democracy and economy. Digital Equity is necessary for civic and cultural participation, employment, lifelong learning, and access to essential services."***
>
> –National Digital Inclusion Alliance

With reliable high-speed broadband access, teachers can utilize digital tools and applications to cultivate student-centered, personalized learning. In the recent blog post from Education Elements, How Can Personalized Learning Support Educational Equity, Noah Dougherty states that "personalized learning can be a powerful tool for educators seeking to provide equitable outcomes for students" and that "the equity lens can become a driving purpose behind personalized learning." Personalized learning experiences enable students to collaborate with their teachers and take ownership of their learning opportunities through flexibility and choice. Further, as discussed in the article, Pursue Digital Equity Through Access and Opportunity – All Means All, access to high speed broadband and devices does not necessarily ensure engaging interactions with technology and changes in pedagogy. In many schools, teachers are still using technology to simply replace paper documents for drill and practice. The article points out that this is more prevalent for low-income, nonwhite students.

DIGITAL EQUITY

NCDE
National Collaborative for Digital Equity

National Collaborative for Digital Equity (NCDE) works to eliminate the digital divide as a barrier to economic and educational opportunity. Specifically, they work to assist learners to develop the skills for lifelong learning and living wage career opportunity.

SETDA's website shares the importance of digital equity and highlights a variety of national programs; state programs; and resources supporting digital equity.

Helping families obtain off campus access to devices and the internet can be an unfunded requirement for districts and schools.

Off Campus Device Access

Off campus access is not just limited to access to the internet, it also includes access to a device. The High School Students' Access to and Use of Technology at Home and in School survey conducted by the ACT Center for Equity in Learning reveals that the percentage of students with access to only one device at home is substantially higher for underserved populations, such as those students with the lowest annual family income. Additionally, nearly one-quarter of traditionally minority populations, American Indian and African American students, reported having access to only one device compared to 8% for White and Asian students. Lastly, the Pew Research Center Fact Tank reports that 17% of teens can't always finish their homework because they do not have reliable access to a device.

17% of teens don't have reliable access to a device and as a result can't always finish homework.

–Pew Research Center

Off Campus Internet Access

Additionally, off campus internet access for educators and students is essential for ensuring equitable access to digital tools and resources for all students. As instructional materials continue to shift to digital, where content may be exclusively available online, students must have access to broadband and devices outside of school, particularly at home, to be successful. Unfortunately, many students still do not have adequate access to the internet at home—often referred to as the "homework gap," the gap between students whose internet connections at home are slow or non-existent—and those who have home connections with adequate speed. In June 2019, the Associated Press reported that nearly 3 million students across the country do not have home internet access.

According to the recent GAO study, students that lack home internet access and rely on mobile devices for homework may face challenges, such as slower speeds and device limitations. Further students that access the internet outside of the home at libraries and community centers may face additional challenges, including limited hours, device availability or lack of transportation. The Institute of Education Sciences (IES) Student Access to Digital Learning Resources Outside the Classroom report states that the primary barrier to internet access at home is affordability, especially for children from low-income

OFF CAMPUS

kajeet
More than just Internet™

Kajeet Success Stories highlight over a dozen internet access solutions utilizing school bus Wi-Fi and filtered Wi-Fi hotspots, among other solutions.

mobilebeacon
4G Internet Access. 4 Nonprofits. 4 Less.

Mobile Beacon uses its Educational Broadband Service (EBS) spectrum to provide schools, libraries, and nonprofits with uncapped mobile data plans for $10/month. In addition, Mobile Beacon offers device donation programs and Connect for Success grants to further lower the cost of broadband access for schools.

families. SETDA's K-12 Broadband Leadership 2019 publication further substantiates this assertion with more than 50% of states reporting that affordability in urban and rural areas impacts student internet access off campus. Statistics gathered in 2017 from the US Department of Education also found that 14 percent of households in metropolitan areas and 18 percent in nonmetropolitan areas cited expense as the primary reason they lacked home internet.

Impact on Rural Communities

Rural communities continue to suffer from lack of highspeed, reliable, broadband access which impacts student learning opportunities. CoSN's 2018-19 Infrastructure Survey reports that many rural school districts lack affordable broadband access due to lack of broadband competition. Of those respondents who had one provider (or no provider) for E-rate Category 1 telecom services, 50% are rural districts. Compared to urban and suburban districts, rural districts continue to be more impacted by a lack of internet service provider options. Millions of federal and state dollars have been spent to subsidize new network infrastructure in rural communities, yet these funding initiatives don't address affordability in these communities.

Home internet access is exacerbated in rural areas. The Institute of Education Sciences (IES) Student Access to Digital Learning Resources Outside the Classroom reports that 18% of students with either no internet access or only dial-up access at home was higher for those living in remote rural areas than for those living in all other locale types. Both availability and affordability affect both on and off campus internet access in rural areas. Lack of home internet access and device access impacts student achievement. The IES data shows a consistent pattern of higher performance scores in reading, mathematics and science for students with home internet access compared to their peers without home internet access.

RURAL

ATT Air Gig
Currently, ATT is testing Air Gig, a technology to help address the rural broadband gap at home. Air Gig delivers high speed broadband over power lines between the ISP and a neighborhood utility pole. From there, homes and offices are close enough to connect wirelessly.

18% of students with no internet access or only dial-up access at home was **higher in rural areas**

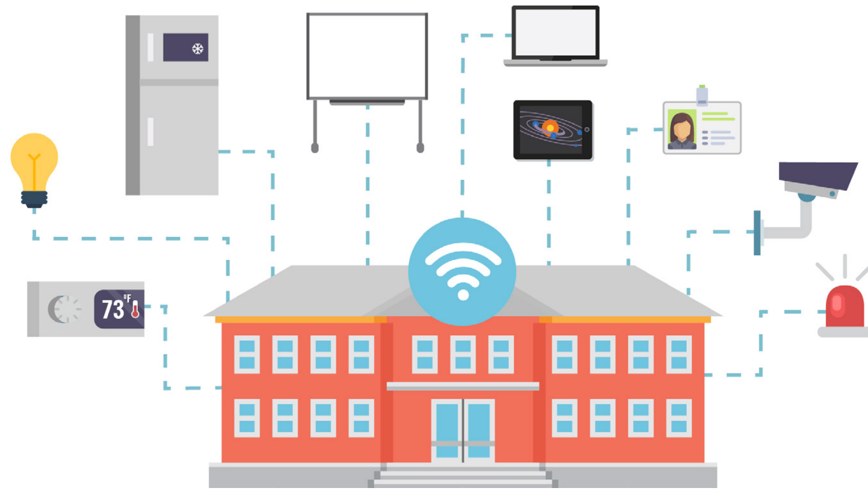
Colorado: The Northeast Colorado Board of Cooperative Educational Services (BOCES) is comprised of twelve members that collectively serve 4,600 students. Three years ago, nine of the districts selected ENA to provide a fully-managed Internet access service to its schools. The rural members depend on robust and reliable Internet connectivity to facilitate and deliver many of its programs providing 1Gbps district connection speeds, translating to approximately 2 Mbps per student. They are leveraging this connectivity to transform and enhance the learning opportunities including using video conferencing to deliver courses when local teachers are not available, collaborating with a local junior college to provide and deliver distance learning courses and to expand its gifted and talented program enabling students to participate in a variety of enrichment courses.

Michigan: The Michigan Moonshot project addresses the lack of broadband access in rural Michigan and seeks to create an accurate picture of Michigan's connectivity to reduce barriers to broadband network deployment in rural communities. The project includes three phases: access and availability data collection; investigation and community education regarding infrastructure investment and societal impact studies.

Recommendation

Addressing digital equity for all students continues to be a challenge and stakeholders must work to ensure equitable student access to broadband and devices both on and off campus. Every child, regardless of background, race or economic status deserves equitable access to personalized, student-centered learning experiences to prepare for living and working in the digital age.

PLANNING INFRASTRUCTURE FOR THE FUTURE



Source: Kajeet Internet of Things

In addition to the academic and instructional needs identified earlier in the Technology Influences Pedagogy section, district and school leaders must consider the bandwidth requirements for administrative applications, for both internet access service and wide area network (WAN) service. Administrative tools such as student information systems, learning management systems, assessment tools, transportation resources, data collection and human resource tools each require access to the internet.

Additionally, districts are particularly focused on the Internet of Things (IoT)--everyday objects that are connected to the internet that can collect and share data. In 2017, CDW surveyed 300 K-12 administrators about how they are approaching IoT and found that the top use cases generally fall into one of three categories: interactive devices; security-focused technology; and energy-saving resources. In practice, districts are implementing modern applications that auto-connect utilities and tools for heating and cooling to increase efficiency and reduce costs and installing intelligent video systems to ensure a safe and secure environment with surveillance security and emergency management reliable emergency notification services and failsafe communications with police.

> ***The key moving forward is for district leaders to understand how their schools use the internet and what is driving capacity increases.***
>
> –Closing the Connectivity Gap, Center for Digital Education and Cox Business

INTERNET ACCESS

There is not a one size fits all for digital learning implementation and districts and schools should determine their digital learning pedagogical goals and administrative bandwidth needs, and then design the capacity of their network to anticipate future growth and utilization, ensuring that schools are not under-provisioning bandwidth that is necessary for digital learning approaches. Under-provisioning bandwidth may result in a learning disruption causing the teacher to modify his/her pedagogy to NOT use the technology. Learning disruptions appear to have a long-term negative impact on the use of technology-based pedagogy, even when corrected. Proactively providing adequate bandwidth, provisioning a scalable underlying architecture, and having the information necessary to increase bandwidth in time to meet needs in the future is critical.

Important Considerations

It is important to point out that many factors affect usage data including the school leadership and culture; level of digital learning implementation; and the number of devices accessing the network. The number of devices per user accessing the network varies greatly among districts and the target projections do not account for users with multiple devices. Bandwidth demands are also increasing from the administrative side, including the use of student information systems; learning management systems; transportation; real-time school security video; and VOIP. These targets are presented as guidelines and technology leaders should consider all factors when determining their bandwidth needs.

KEY QUESTIONS

- **Are you using the bandwidth you have?**
- **Is bandwidth available when you need it?**
- **Are your bandwidth needs scalable?**

In addition, district, regional and state network leads most closely monitor networks to ensure efficiency and to avoid disruption. Included in this monitoring should be considerations regarding customer satisfaction, uptime data (the reliability and availability of internet connects to the district hubs and to the school sites), security and network matrix. Depending on the structure of the networks, some of this monitoring is conducted by the regional or state consortia network and by the school sites. All network leaders should also look to the future with anticipation that schools and districts will ultimately function with innovative, seamless digital learning similar to the corporate structure.

Launched in 2012 and updated in 2016, SETDA's Broadband Imperative reports have consistently provided bandwidth capacity recommendations to support leaders interested in providing dynamic, seamless digital learning opportunities for all students. In addition to student access, teacher and administrator access and the implementation of administrative tools are taken into consideration when considering the number of users. In 2016, SETDA provided broadband capacity recommendations for internet access connectivity based on the size of the district (number of students). This method allows education stakeholders to better understand some of the nuances between very small districts (under 1,000 students) compared to large districts (over 10,000 students).

Peak Utilization Broadband Capacity

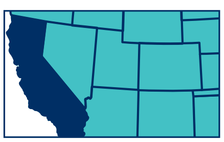
In considering future projections, experts analyzed four years of internet usage data, identified by school size and rurality for over 300 districts serving 1.8 million students. Appendix A provides detailed information about the methodology and calculations used for this analysis. Based on this in-depth analysis, for the 2023-24 school year, SETDA encourages districts to have the ability to implement the architecture and to provision enough bandwidth to ensure adequate user experiences during peak utilization. It is important to note that there are many variables that affect bandwidth needs, including administrative applications; the Internet of Things (IoT); implementation of smart technologies; and the number of devices per user accessing the network. Additionally, the amount of actual bandwidth provisioned will vary depending on the types of technological approaches implemented. Participation in state or regional networks may affect the amount of actual bandwidth provisioned. State and regional networks often have the benefit of more robust and rich internet access contracts and access to peering networks, which is a major benefit to districts as it provides higher quality and faster direct (non-internet) access to services that other districts must connect to over the public internet. Data centers can also allow districts to receive hosted educational and administrative services (i.e. student information systems, learning management systems, etc.) that otherwise might be in the cloud. These options can reduce the amount of internet that is required to support students, teachers, staff and other education users.

- **Small Districts** – At least 2.8 Mbps per user with a minimum of 300 Mbps per district
- **Medium Districts** – At least 2 Mbps per user
- **Large Districts** – At least 1.4 Mbps per user

With the continued impact of "all things internet" on education, SETDA encourages districts to use these numbers as guidelines and implement solutions to ensure sustainable scalability as future internet access requirements change. Further, SETDA encourages districts to monitor and track their individual requirements to allow them to anticipate, prepare for and provision internet levels to support the integration of technology to support the teaching, learning and administrative requirements in their district

State Data on Bandwidth Capacity

States provide leadership to districts and schools to support robust high-speed broadband access to all students to best prepare them for college and careers. Several states are collecting data from districts on bandwidth capacity and usage to help with network planning and design, as well as advocacy efforts to support the importance of equitable digital learning opportunities for all students.

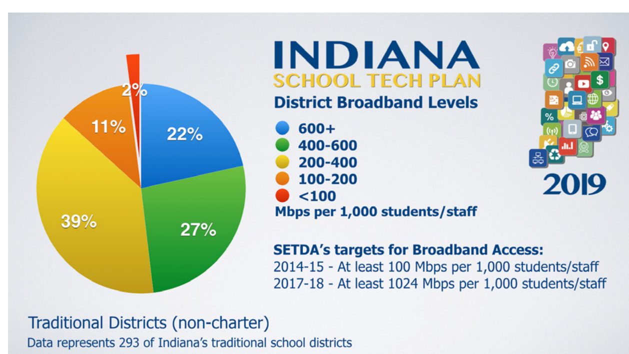


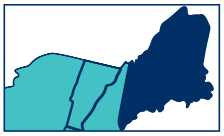
California: In 2019, California's K12 High Speed Network completed a 2019 School District Bandwidth Utilization Study which includes a series of Case Studies highlighting school's academic activities, device access, bandwidth access and bandwidth usage.

Indiana: Annually, Indiana's Department of Education's Office of eLearning surveys all Indiana school districts for the annual Indiana School Tech Plan. The report includes district data on broadband capacity. Indiana reports that 98% of districts have broadband levels of at least 100 Mbps per 1,000 students/staff, SETDA's 2014-15 recommendation. Nearly one-half of districts have broadband levels higher than 400 Mbps per 1,000 students/staff.

LARGE NETWORK CONSIDERATIONS

Schools and districts that are members of regional or statewide broadband consortia often have the benefit of more robust and rich internet access contracts. These contracts often include stronger Service Level Agreements (SLAs), guaranteed service levels and access to peering networks for education centric services. Access to peering networks is a major benefit to districts as it provides higher quality and faster direct (non-internet) access to services that other districts must connect to over the public internet. In addition, data centers can allow districts to receive hosted educational and administrative services (i.e. student information systems, learning management systems, etc.) that otherwise might be in the cloud. These options can reduce the amount of internet that is required to support students, teachers, staff and other education users.

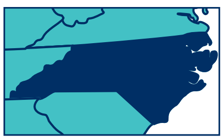




Maine: Maine provides broadband connections to K12 schools through a cooperative consortium, Networkmaine, formed by the Maine Department of Education, the Maine State Library, the University of Maine System, and the Maine Office of Information Technology. Maine works to size circuits to be at least twice the measured sustained rate (1Mbps/student) to provide sufficient headroom above the sustained rates to avoid congestion during peak times. Doing so avoids congestion and minimizes latency while also accommodating usage growth during the funding year. Each year Networkmaine reviews sustained usage vs provided bandwidth and makes adjustments as needed. This practice often results in K12 schools being provided connections that deliver 1Mbps/student or greater. **Please note Maine does not have larger school districts with more than 10,000 students.

BANDWIDTH UNKNOWNS

There are many variables that affect bandwidth needs, including administrative applications; the Internet of Things (IoT); implementation of smart technologies; and the number of devices per user accessing the network.



North Carolina: Through the School Connectivity Program, all districts in North Carolina now have a high speed direct connection to a robust education networking infrastructure. Recurring funding has been allocated from the General Assembly to support this effort. These funds are used for broadband access, equipment and support services that create, improve and sustain equity of access for instructional opportunities for public school students and educators. The state monitors all district charter schools bandwidth each month. By observing the bandwidth, the state can upgrade circuits to the next level of service as needed.

Utah: Utah Education and Telehealth Network (UETN) connects Utah's K-12 schools, technical colleges, institutions of higher education and public libraries, as well as patients and healthcare providers throughout the state. Whether you're a teacher in Tooele or a physician in Fillmore; a patient in Parowan or a student in San Juan County, UETN provides robust infrastructure, applications, and support for education and healthcare. K-12 schools are connected with at least 1 Gbps per 1,000 students and share over 220 Gbps in internet bandwidth through an effective, efficient and state of the art statewide network.

WIDE AREA NETWORK (WAN)

SETDA acknowledges that as more digital content and applications move to the cloud, the per user bandwidth requirements for WAN and internet access will move closer to convergence; however, WAN plays a critical role and measurements of WAN efficacy and utility should include more than bandwidth alone. In addition to simply being an extension of a district's internet access, high quality WANs serve the following critical functions in multi-campus digital learning environments:

CHANGING USES OF WAN

With many digital applications moving to the cloud, some districts are increasing their use of WANs for administrative applications such as phone and safety services.

- **Reduction of overall networking costs** of providing high quality access to internet-based resources versus the cost of providing internet access directly to each campus
- In general, **WAN circuits are less expensive** than Direct Internet Access (DIA) per Mbps

- WANs allow districts to **reduce per student bandwidth requirements** for DIA because they allow all students to share the same DIA bandwidth in the absence of a WAN, aggregate per user DIA bandwidth requirements would need to increase
- Ability to **provide consistent quality of service** to each campus independent of the availability of high quality DIA at each campus location
    - Many school systems do not have options for high quality DIA at certain school or campus locations, but do have the ability to procure and/or build out WAN connections to each site
- Limitation of overall network attack surface for **improved cybersecurity**
- **Improved control of QoS (quality of service),** network segmentation and encryption for enhanced content delivery and security of student and district data
- **Delivery of critical, latency-sensitive district-based services** such as VoIP and unified communications, teacher sharing and distance learning between sites and between organizations, video surveillance and other critical security services and operations

SOFTWARE DEFINED WIDE AREA NETWORK (SD-WAN)

A Software Defined Network (SD-WAN) is a next evolution networking technology that may help districts address multiple needs in increasingly complex environments and reduce networking costs. SD-WANs are cloud based, dynamic and more suitable for networking a digital campus. Application and network visibility analytics allow SD-WAN to react to changing network topology, link load and circuit performance in real time by providing web-based dashboards to view application behavior. Key factors include: pervasiveness; faster deployment; service continuity; and holistic view on network performance.

Support provided by Cox Communication & Nokia

Districts should also consider the number of users and number of devices in schools and the level of digital learning implementation, especially for smaller schools. SETDA recommends that districts have the capability to support WANs with 10 GB capacity per 1,000 users, where users are administrators, teachers, students, staff and guests. SETDA recommends that districts consider the number of users and number of devices in schools and the level of digital learning implementation, especially for smaller schools.

Additionally, given the importance of being able to deliver low latency, high quality content and collaboration services and solutions in today's digital learning environments, SETDA recommends the following specifications for high quality WANs:

- **Symmetric bandwidth**
  - Real-time, multi-user collaboration technologies such as unified communications, VoIP and video conferencing do not function as well over asymmetric network services
- **Multicast support**
  - A WAN that supports and enables multicast is critical to the cost-effective delivery of data-rich streaming content to multiple, simultaneous users and campuses. It is also critical for the deployment of district-wide IP-based paging and alerting systems
- **Low Latency, Jitter and Packet Loss**
  - < 5ms latency
  - < 0.1% packet loss
  - < 2ms jitter

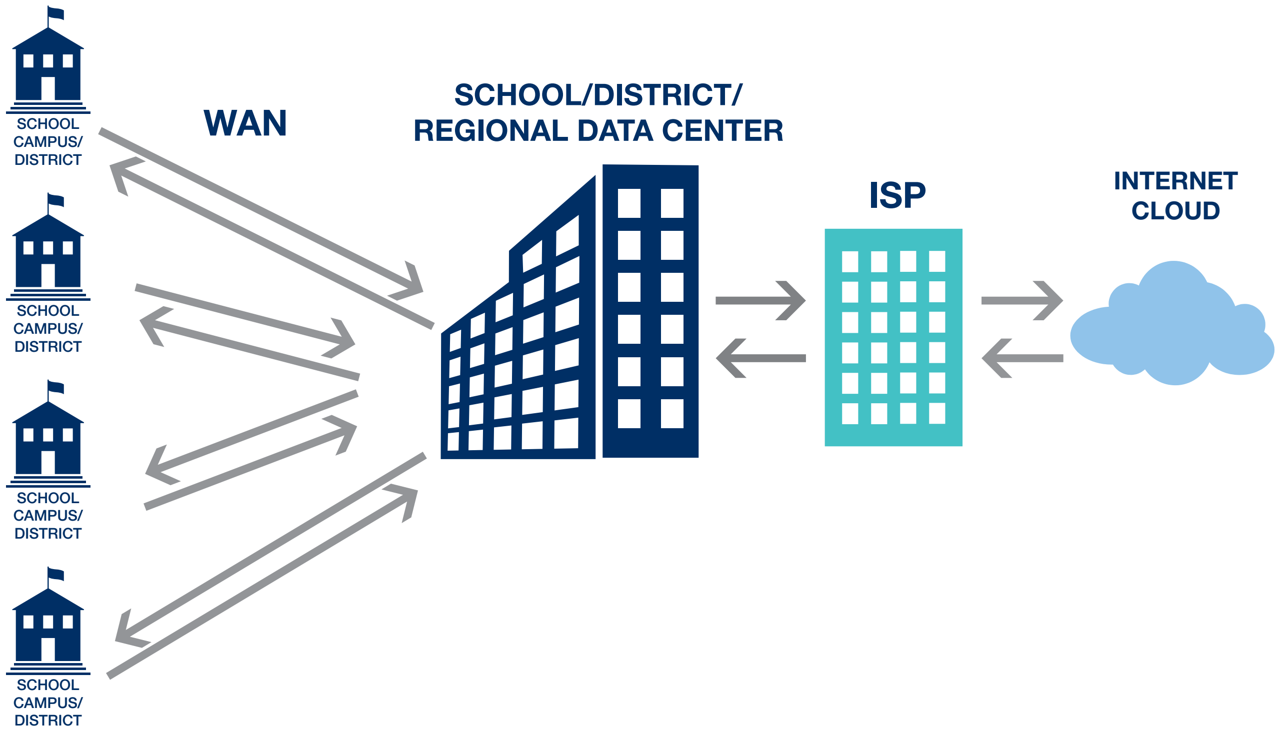
Recommendation

Schools and districts should strategically plan for reliable, high speed networks to support sustained, seamless access to the internet for the implementation of administrative tools, the Internet of things and teaching and learning activities, without disruption. Districts should consider the recommended peak utilization bandwidth capacity goals and WAN implementation considerations as a guide and then plan accordingly for current and future needs as they move to digital age teaching and learning environments.

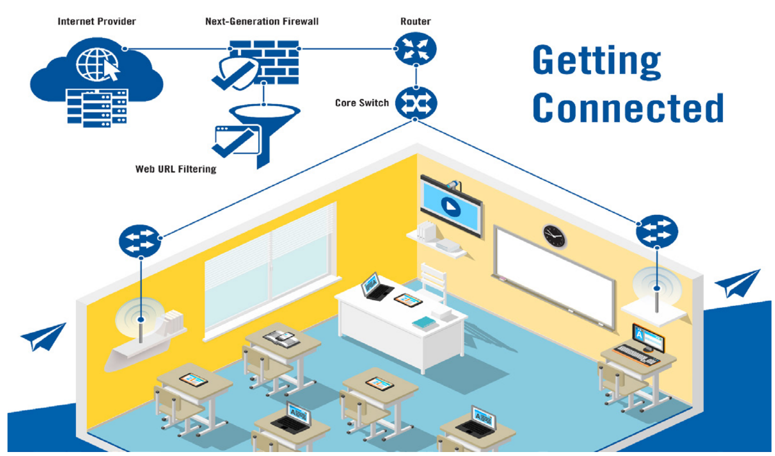
BUILDING NETWORKS FOR THE FUTURE

Network Design

With the changing pedagogical approaches to personalized learning for all students and the advent of more powerful technologies, wired and wireless, the importance of forward-looking network design is evolving at a rapid pace. Historically network design focused on the connection between school campuses, the regional/district data center and the internet service provider. Bottlenecks



often occurred at the WAN between the school campus and the district data center. With the advent of cloud-based services and applications, less data is physically stored at the district data center. Instead data is stored in the cloud and can be accessed as needed through the internet. Districts must now carefully monitor traffic through their entire network from the local building level, through any district or regional WAN and on to the internet service provider. Technology leaders should allocate adequate bandwidth at the state, regional and building level, as needed, to mitigate disruptions. As discussed in CoSN's Smart Network by Design, decisions about data storage and software hosting significantly impact network design and capacity. Cloud computing won't solve the bottleneck of inefficient networking. The importance of understanding network design and the stresses on the network as the requirements continue to change and



Source: The Digital Classroom, ENA

grow have become more vital. Additionally, with many schools relying on wireless technology to supplement wired technology, the building infrastructure and layout of the classroom impacts the performance of the network. All wireless networks are not created equal and each building or facility has its own unique physical challenges, limitations and user demands that need to be taken into consideration when deploying a Wi-Fi service. Often wireless networks, which are becoming ubiquitous, are underperforming for the number of devices connected to them. Bottleneck problems are no longer occurring at just the WAN or ISP connections, but also in the wireless network. The utilization of WANs, cloud-based services and wireless networks all impact network design and capacity. In order to create sustainable, robust and reliable networks, administrators and technology leaders must look at the level of digital learning implementation and the administrative and security services relying on the network. These decisions will determine the amount of WAN capacity and ISP connection capacity required to meet those needs.

BROADBAND USAGE REQUIRED AS PART OF RFP

To support smart network design, schools and districts need to consider language in Request for Proposals (RFPs) that support current and future network considerations. One important consideration is the request for broadband usage datasets for at least two years. For example, in Alabama, the state advised districts to include language in the RFP around bandwidth usage reports. The suggested language is "the awarded service provider will provide detailed quarterly activity reports displaying usage of the contracted bandwidth/ Internet." The state reserves the right to request such reports at any time. Interested service providers bidding on this service must include examples of the detailed reports that will be provided.

■ Network Security

Network security monitoring, management and communication are fundamental components of network design. Network security design should address both external threats of unauthorized access and internal threats of inappropriate use. Whether intentional or unintentional, a breach of the network may result in data loss, the release of confidential information or a network outage. In a digital learning environment, any time the network is compromised results in a disruption of teaching and learning. As more schools move towards the utilization of digital instructional materials and applications, it is critical to maintain a reliable, robust network. Although all threats cannot be foreseen, implementation of preventative network security design and configuration measures can help prevent and mitigate many common threats.

With threats to network security and private data increasing and evolving, education organizations must implement the most effective security practices to protect their communities. Common policies include acceptable use, remote access and digital communication policies. Districts need to communicate to stakeholders the importance of good security practices and the potential impacts of breaches in network security. Further, key prevention measures to consider include infrastructure design and systems configuration, access control and authentication and network monitoring. Lastly, incident response and mitigation are critical because no network is 100 percent secure. The most important components of the incident and mitigation plan are preparation, communications and restoration. ENA developed the Network Security Recommendations Checklist as a resource for districts to diagnose their defenses and preparedness in the following key area: cybersecurity, risk management and data privacy.

Impact of Future Technologies

As more districts use cloud-based and advanced wireless technologies, it is expected the 5G networks on the horizon will be dramatically faster than today's wireless infrastructure and they'll also break the barriers of network latency--the period between when your device requests data from the cloud and the time the network sends that data to your device. With 5G, edge computing, the massive amount of near real-time data crunching necessary for your smartphone to render a convincing virtual world or for a robot to learn how to clean your house, is a reality. Essentially, with the edge computing model, it is possible for any connected device to have the power of a supercomputer. While it is not likely that districts will have the bandwidth and pedagogy in place to utilize this technology in the near future, it is important to remember that no one technology solution is going to be the only option for every district and/or geographic location. Future technologies can offer new pedagogical options. For example, game-based learning or virtual reality, for districts to provide personalized learning experiences for students were not thought possible several years ago but are being successfully implemented today. Additionally, there are other technologies on the horizon, including fixed wireless, laser wireless and low earth satellite internet access. As these technologies develop, there will be more opportunities for districts, especially in traditionally underserved rural areas, to implement digital resources to enhance teaching and learning.

Recommendation

In order to create sustainable, robust and reliable networks, administrators and technology leaders must look at the level of digital learning implementation and the administrative and security services relying on the network. Additionally, education organizations must implement the most effective security practices to protect their communities.

POLICIES AND FUNDING

In education, access and opportunities to utilize digital resources for learning provide students with the necessary skills and connections to be successful learners and contribute to their own futures. Both state and federal policies can support the implementation of digital learning to ensure that all students are prepared for college and a career.

State Leadership, Policies and Funding

SETDA and its state member leaders play a pivotal role in driving high-speed broadband access to all students to best prepare them for college and careers. No one state has the same policies or practices, yet all states are providing leadership. Many states and districts are utilizing a hybrid approach of state, regional and local networks using wired, wireless and cloud-based technologies to meet the bandwidth needs of their schools.

SETDA's website highlights state, regional and district approaches to broadband implementation.

SETDA's State K-12 Broadband Leadership publication highlights the importance of state leadership and the various ways states strive to support districts and schools to achieve equitable digital learning opportunities for all students both on campus and outside of school.

SETDA Broadband Map provides real time details regarding state broadband leadership. The story map includes the following details: state leadership, state network details, regional network details, alternative model details, state strategies and state broadband funding.

Connecticut Case Study

Minnesota Case Study

Kentucky Case Study

Federal Policies and Funding

The goal of the Federal Communication Commission's E-rate program is to ensure that all schools and libraries have ample bandwidth to meet the educational needs of students and library patrons. Funding categories include Category 1 (broadband) and Category 2 (internal connections/managed internal broadband services). Category 1 services include internet access and data transport between school facilities. Category 2 services include internal connections (Wi-Fi) within a school. Discount maximums are determined by school enrollment and poverty level.

SETDA's Federal Policies & Funding website highlights current and pending policies and funding around equitable access to the internet and devices.

In February 2019, the FCC Category 2 Funding Report recommended that the FCC retain the Category 2 budget approach based on the Category 2 flexibility originally provided in the 2015 E-rate Modernization order. The FCC established five-year Category 2 budgets to make funding for internal connections more equitable, predictable and more broadly available. This occurred in recognition of the importance of internal connections, particularly robust Wi-Fi networks, the role they play in enhancing educational opportunities for students and library patrons and the potential for these networks to close the digital divide. The Bureau's review of the data from the first five-year Category 2 budget cycle showed that the Commission's goals in creating these budgets have largely been met. Policy adjustments are still pending. SETDA advocates for a continuation of the new Category 2 budget approach.

RECOMMENDATION

Federal: The federal government should continue to expand federal funding options to support: (a) state, regional and district broadband networks, (b) districts and schools increasing bandwidth capacity to and throughout each campus, (c) communities in providing access points at anchor institutions, such as libraries and community centers.

State: As schools increase digital learning opportunities, states need to demonstrate leadership to support high-speed broadband connectivity by leveraging policies, networks and purchasing options to support increased broadband access in schools.

CONCLUSION

Reliable, robust access to the internet is an essential part of the global economy. The equitable implementation of digital learning affords educators the opportunity to customize pedagogical approaches, including project-based, blended, virtual, game-based and collaborative-based learning to personalize education for students and best prepare them for the ever-changing workforce. Proactively providing adequate bandwidth today, provisioning a scalable underlying architecture and collecting the information necessary to increase bandwidth in time to meet needs in the future is critical.

Recommendations

Technology and Pedagogical Approaches

Districts and schools are in different stages when considering access to and the utilization of digital tools. The integration of technology for learning is a unique journey that each school or district may embark upon differently. Leaders must focus on academic goals and leverage technology to support student learning experiences in preparation for college and/or careers in the digital age.

Digital Access and Equity

Addressing digital equity for all students continues to be a challenge and stakeholders must ensure that we consider equitable student access to broadband and devices both on and off campus. Every child, regardless of background, race or economic status deserves equitable access to personalized, student-centered learning experiences to prepare for life and work in the global economy.

Planning Infrastructure for the Future

Schools and districts should strategically plan for reliable, high speed networks to support sustained, seamless access to the internet for the implementation of administrative tools, the Internet of things and teaching and learning activities, without disruption. Districts should consider the recommended peak utilization bandwidth capacity goals and WAN implementation considerations as a guide and then plan according to their current and future needs as they move to teaching and learning environments that mimic the corporate structure.

Building Networks for the Future

In order to create sustainable, robust and reliable networks, administrators and technology leaders must look at the level of digital learning implementation and the administrative and security services relying on the network. Additionally, education organizations must implement the most effective security practices to protect their communities.

Policies and Funding

Federal: The federal government should continue to expand federal funding options to support: (a) state, regional and district broadband networks, (b) districts and schools increasing bandwidth capacity to and throughout each campus, (c) communities in providing access points at anchor institutions, such as libraries and community centers.

State: As schools increase digital learning opportunities, states need to demonstrate leadership to support high-speed broadband connectivity by leveraging policies, networks and purchasing options to support increased broadband access in schools.

Appendix A: Methodology

2016 Methodology and Conclusions

SETDA asked multiple states to provide information regarding connectivity and utilization across the entire K-12 school base in order to build recommendations for ISP connectivity in this updated report. Eight states provided detailed, per district utilization data and a number of additional states also provided both aggregated statewide data and anecdotal feedback.

For the states where detailed per district utilization information was provided, we analyzed that data using a combination of 95th percentile traffic data on the downstream (towards the district) portion of the circuit as well as peak and average utilization data for March, April and May 2016. Peak, average and 95th percentile utilization data was then grouped by district enrollment and analyzed across states to understand the relative variances in actual utilization between various populations. While there were minor variances between states, a pattern showing roughly 45% more utilization per student at peak times for a district with 50 to 999 students as compared to a district with 2,000- 2,999 students. Similarly, districts with 10,000 or more students utilized between 24% and 33% less utilization per student at peak than the same 2,000-2,999 student district.

Students (up to)	Observed Size Factor Peak
50	5.62
1,000	1.45
2,000	1.09
3,000	1.00
4,000	0.73
5,000	0.70
10,000	0.76
more	0.67

The team reviewed the actual peak utilization per student across the entire data set and found that the peak district currently utilizes about 500 Kbps at the end of the 2015-2016 school year. This observation fits with SETDA's previous recommendation of 1 Mbps per student or 1 Gbps per 1,000 students in the 2017-18 school year. Projecting utilization forward using a mix of annual growth projections ranging from 35% per annum to 65% per annum, we were able to come up with the recommendations we publish in this paper of 3 Gbps per 1,000 students at a district with 2,000- 2,999 students. The recommendations for the lower and higher population districts were calculated using the observed size factor provided above.

Students (up to)	Size Factor (Peak)	2015-2016	2017-2018	2020-2021
1,000	1.45		1.49	4.35
3,000	1.00	0.50	1.02	2.99
more	0.67		0.68	2.00

2019 Broadband Imperative III Methodology

Students (up to) Size Factor (Peak) Validation

An independent data analyst replicated the 2016 Broadband Imperative II methodology using actual 95th percentile usage and peak data from four states for the months of March, April and May 2016. In this recreation of the methodology it was observed that the same ratios between Small, Medium and Large districts were statistically the same as those used in the Broadband Imperative II calculations.

	Broadband Imperative II: Max Peak Usage Mar, Apr & May 2016	Broadband Imperative III: Actual Max Peak Usage Ratios Mar, Apr & May 2016
Small	**1.45**	**1.45**
Medium	**1.00**	**1.01**
Large	**0.67**	**0.75**

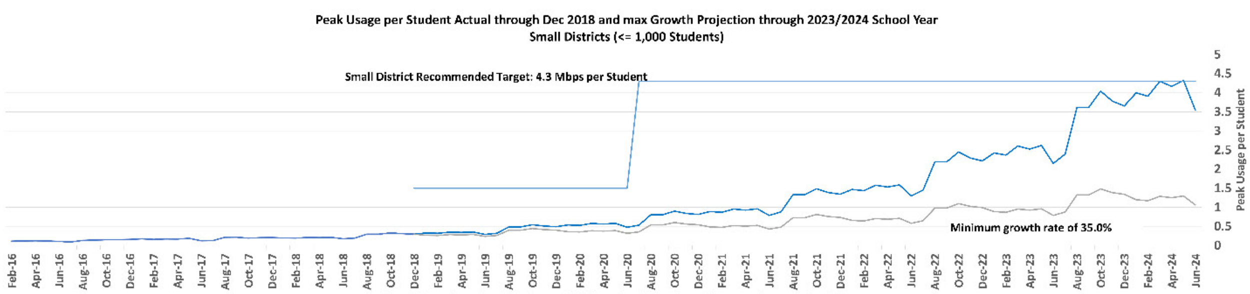
Calculation of 2023/24 Recommended Targets

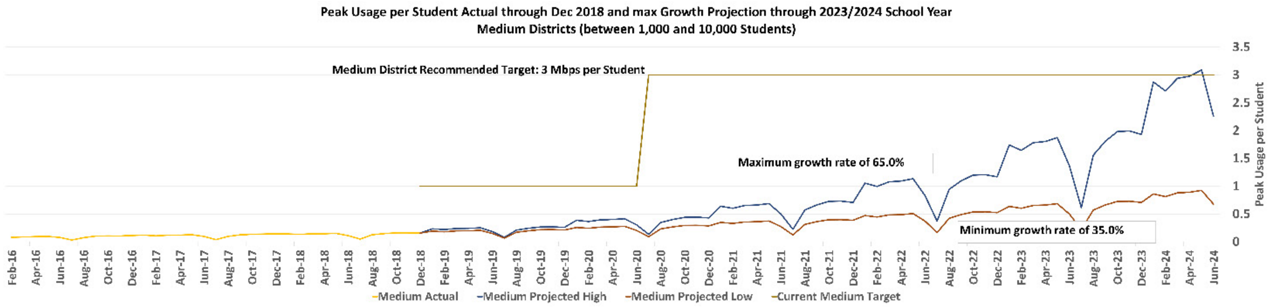
Using actual 95th Percentile usage and Peak data from February 2016 through December 2018, projected Peak usage was calculated using a maximum growth rate of 54% and a minimum growth rate of 25%. These growth rates were selected because 1) they were within the growth rate range used in the Broadband Imperative II projections and 2) while some districts were growing at a lower rate, multiple individual districts in the updates analysis were continuing to grow at 50%+ per year. Setting the target to meet the needs of the districts with the larger growth rates was essential to ensure that the maximum number of districts would be included.

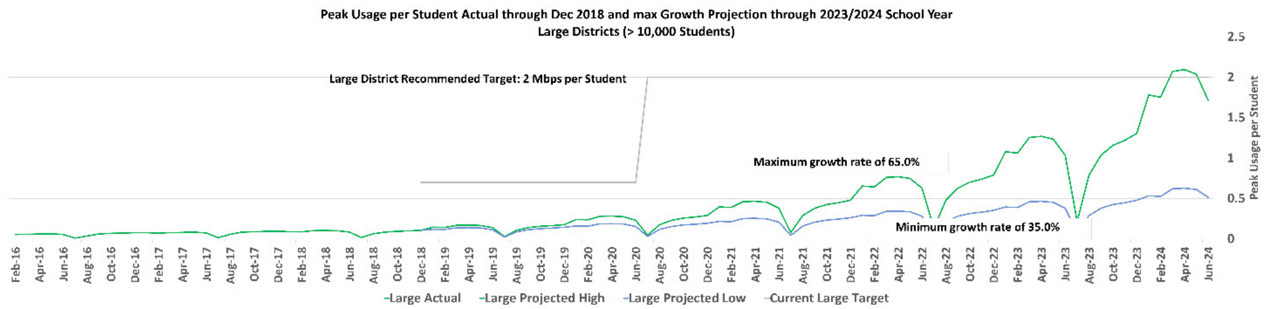
As the growth charts below demonstrate, the projected 2023/24 Mbps per Student targets are:

	2023-24 Targets
Small Districts	At Least 2.8 per User (Min 300 Mbps per District)
Medium Districts	At least 2 Mbps per User
Large Districts	At least 1.4 Mbps per User

As the growth charts below demonstrate, the projected 2023/24 Mbps per Student targets are:




Peak Usage per Student Actual through Dec 2018 and max Growth Projection through 2023/2024 School Year
Medium Districts (between 1,000 and 10,000 Students)
Medium District Recommended Target: 3 Mbps per Student
Maximum growth rate of 65.0%
Minimum growth rate of 35.0%
Peak Usage per Student
Medium Actual
Medium Projected High
Medium Projected Low
Current Medium Target


Peak Usage per Student Actual through Dec 2018 and max Growth Projection through 2023/2024 School Year
Large Districts (> 10,000 Students)
Large District Recommended Target: 2 Mbps per Student
Maximum growth rate of 65.0%
Minimum growth rate of 35.0%
Peak Usage per Student
Large Actual
Large Projected High
Large Projected Low
Current Large Target

APPENDIX B: GLOSSARY

Bits and Bytes

Bits and bytes are both units of digital information. A bit is the basic element; a byte is equal to eight bits. The terms kilobyte (KB), megabyte (MB), and gigabyte (GB) are typically used to indicate the size of a file or a program. The terms kilobit (Kb), megabit (Mb), and gigabit (Gb) are typically used to convey the rate at which data are transferred over a network, i.e., megabits per second, or Mbps.

Kilobit per second (Kbps) = 1,000 bits per second Megabit per second (Mbps) = 1,000 Kbps

Gigabit per second (Gbps) = 1,000 Mbps

Internet of Things

IoT is simply the network of interconnected things/devices which are embedded with sensors, software, network connectivity and necessary electronics that enables them to collect and exchange data making them responsive.

Cloud Computing

The term “cloud computing” refers to a computing model in which data, applications, and other computing resources are available on the Internet from just about any connected device. Another way to think of it: It’s computing delivered as a service.

Personalized Learning

Personalized learning refers to instruction in which the pace of learning and the instructional approach are optimized for the needs of each learner. Learning objectives, instructional approaches, and instructional content (and its sequencing) all may vary based on learner needs. In addition, learning activities are meaningful and relevant to learners, driven by their interests, and often self-initiated. http://tech.ed.gov/netp/learning/

Speed vs. Capacity

When we say that a 1 Mbps broadband connection is “faster” than a 1 Kbps connection, what we’re really saying is that it has a greater capacity to carry data. The 1 Kbps connection can deliver a maximum of 1,024 bits of information to your computer from the Internet in a second; a 1 Mbps connection can deliver 1,024 KB in a second. Although the bits are moving at the same speed (more or less), one connection delivers more in the same amount of time, so it feels faster to the end user. This capacity is referred to as bandwidth.

Throughput

The actual amount of data that gets transmitted from a PC, through the collection of networks known as the Internet, to the web server—per second—is what is known as throughput. Throughput rates vary, depending on traffic and other factors, but it will always be lower than the speed quoted by the ISP providing the connection. Think of that number as the fastest possible speed under ideal circumstances.

Virtualization

The next generation network, emulates the functions of hardware with software. The network is powered by technologies that include software-defined networking (SDN) and network functions virtualization (NFV). With this approach, administrators can add capacity faster to meet demand.

APPENDIX C: ENDNOTES

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