Connecting America's Students: Opportunities for Action

An Analysis of E-rate Spending Offers Key Insights for Expanding Educational Opportunity

April, 2014

Education SUPERHIGHWAY

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Introduction

Today, 99% of America's K-12 public schools and libraries are connected to the Internet. This is a testament to the success of the Federal Communications Commission's (FCC) Congressionally-mandated E-rate program, which has provided technology funding to schools and libraries since 1998. However, as a new generation of education technology and digital learning opportunities enter the classroom, basic Internet connectivity is no longer sufficient to educate and prepare America's children for the modern age. To ensure that all students receive a high quality education and are prepared to compete in today's global economy, our schools and libraries need high-speed broadband and ubiquitous Wi-Fi.[1]

Increasing adoption of one-device-per-student ("1:1") learning models, online classes, streaming video content, live video chat, and other online educational software has made technology essential to the 21st century classroom. In making these digital learning opportunities available to more students, schools' need for bandwidth is growing 30 - 50% per year.[2] Recognizing the importance of bringing schools up to speed in the Internet age, President Obama announced the ConnectED initiative in June 2013, establishing a goal to connect 99% of students to high-speed broadband within five years.

To meet the objectives of the ConnectED initiative, each component of a district network needs to be upgraded to minimum bandwidth standards that ensure the delivery of high-speed Internet to students' desks. Networks should also be designed to be future-proof to enable higher minimum standards in the future as bandwidth needs increase.[3]

ConnectED Connectivity Standards: Current Goals[4]

- Internet Access: 100 kbps per student
- Wide Area Network (WAN): 1 Gbps connection per school
- Local Area Network (LAN): 1 Gbps inside each school
- Wireless Network: High-speed Wi-Fi capable of supporting 1:1 learning in every classroom and learning area.

ConnectED Connectivity Standards: Five Year Goals

- Internet Access: 1 Mbps per student
- WAN: 1 Gbps connection per school[5]
- LAN: 1 Gbps inside each school
- Wireless Network: High-speed Wi-Fi capable of supporting 1:1 learning in every classroom and learning area.

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[1] See the State Educational Technology Directors Association's (SETDA) Broadband Imperative and the LEAD Commission's Digital Learning Blueprint.

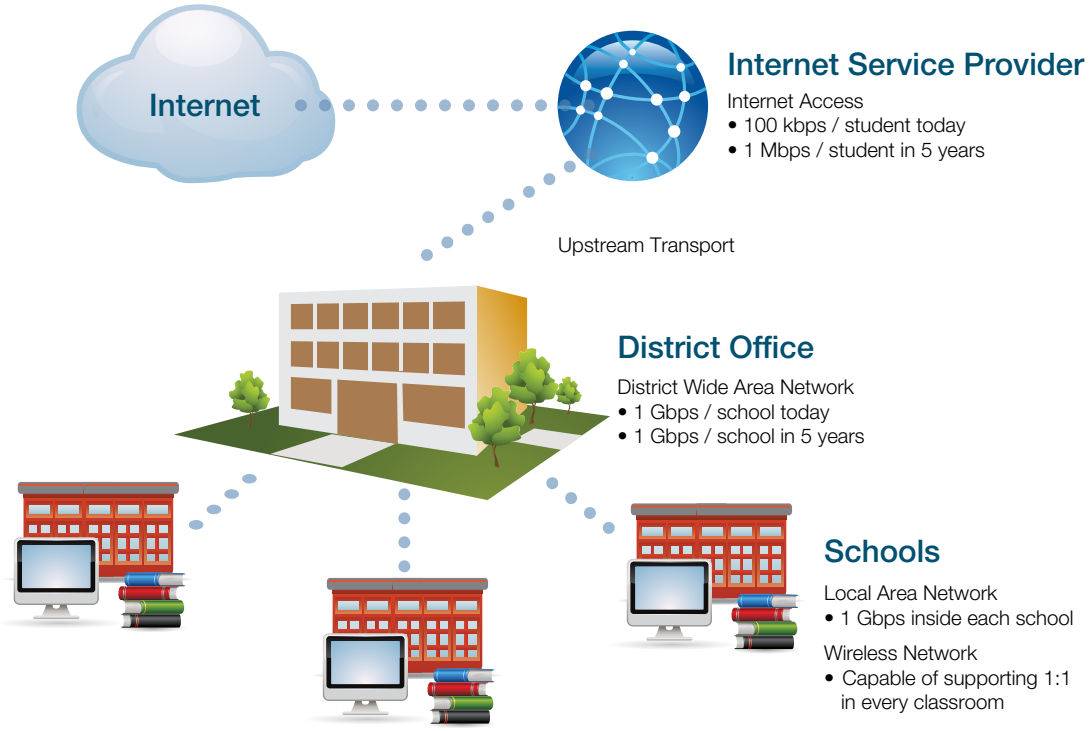
[2] Growth in education is consistent with growth in other sectors. According to the Visual Networking Index report from Cisco, IP traffic will grow at a compound annual rate of 23 percent from 2012 to 2017.

[3] In his ConnectED announcement, the president called for schools to be connected "at speeds no less than 100 Mbps with a target of 1 Gbps" and for wireless to every classroom within five years. The standards outlined here represent a synthesis of various interpretations of the infrastructure requirements necessary to meet these goals.

[4] This paper will refer to the Internet access and WAN components of the ConnectED connectivity standards as "Current Goals" and "Five Year Goals" throughout. These references do not include the LAN and Wi-Fi requirements to meet the ConnectED goals.

[5] SETDA recommends a WAN connection of at least 10 Gbps per school in five years although this is not required to meet the ConnectED goal.

Figure 1: District Network Schematic



Public Libraries and ConnectED

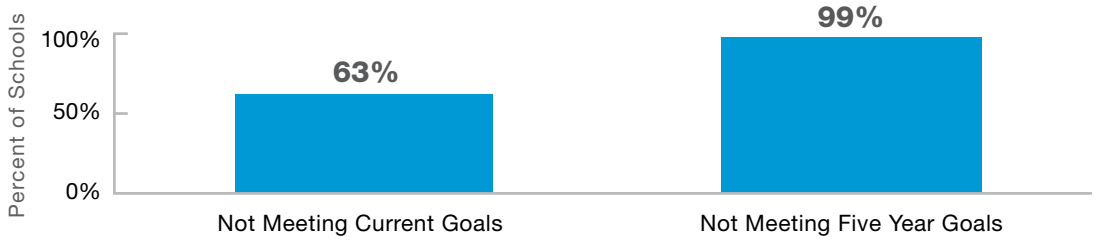
The goals of ConnectED also extend to libraries, which provide important educational resources and facilities in many communities, and are particularly important for families that do not have broadband at home. While this report focuses on connectivity in school districts, the pricing data and strategies for lowering the cost of bandwidth that are discussed below can also be used to help libraries meet the ConnectED goals and provide improved and needed services to their communities.

The Need For E-rate Modernization

According to the 2013 results of EducationSuperHighway's National SchoolSpeedTest, an online tool used to measure available bandwidth at school sites, the median bandwidth per school in the U.S. is 33 Mbps.[6] This leaves the median school in the U.S. almost 25% behind the Current Goals and over 90% below the Five Year Goals.[7] Moreover, many schools in areas that are hard-to-reach or where broadband is too expensive are significantly further behind. In fact, 50% of students[8] in America would have only the equivalent of dial-up speeds (up to 56 kbps per student) if their classrooms were to transition to a 1:1 digital learning environment.

Data from the SchoolSpeedTest indicates that 63% of U.S. schools do not meet the Current Goals for high-speed connectivity. Because schools with large student populations are more likely to have inadequate bandwidth, this connectivity gap impacts an estimated 75% of K-12 students, leaving nearly 40 million children without enough bandwidth for digital learning. Looking ahead to projected bandwidth needs in five years, 99% of schools will be behind the standard, impacting approximately 50 million public school students.

Chart 1: SchoolSpeedTest results show that 63% of U.S. schools are not meeting the Current Goals

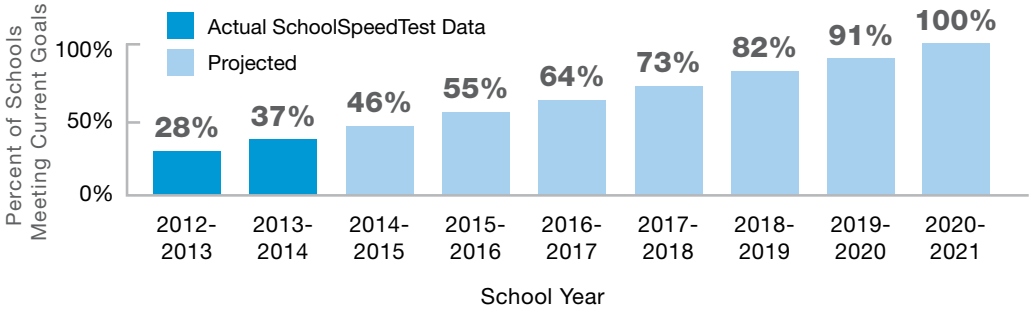


The SchoolSpeedTest results also show that the rate of improvement in the number of schools meeting the Current Goals is too slow and thus schools risk falling even further behind. The percentage of schools with at least 100 kbps per student of bandwidth increased from 28% to 37% from the spring of 2013 to the fall of 2013.[9] If schools continue to implement upgrades at this rate, it would take seven years for schools to reach 100 kbps per student of bandwidth, by which time schools' needs will already be ten times higher at 1 Mbps per student.

> **"The connectivity gap impacts an estimated 75% of K-12 students, leaving approximately 40 million children without enough bandwidth for digital learning."**

[6] EducationSuperHighway SchoolSpeedTest 2013 data
[7] The median school in the U.S. has 430 students.
[8] EducationSuperHighway SchoolSpeedTest 2013 data
[9] Most school network upgrades occur during the summer.

Chart 2: At the current rate of upgrades, it would take until 2021 for all schools to meet Current Goals



Over the last several years, numerous experts and studies have pointed to similar shortfalls. In light of those studies, many, including the president, have called on the FCC, the administrator of America's largest program for connecting schools and libraries, to update, modernize, and expand the E-rate program. To design effective changes to the 18-year-old program and assess the magnitude required for any expansion, it is critical for the FCC to know how the program's funds are being spent today. Specifically, in order to ensure that E-rate modernization can deliver on the president's promise to connect 99% of students in five years, the FCC needs data that address the following critical questions:10

- What percentage of schools are meeting ConnectED's Current Goals for WAN and Internet connectivity? What percent are meeting the Five Year Goals?
- What are the key issues that prevent schools from purchasing enough bandwidth to meet the ConnectED goals? Why do similarly situated schools often pay widely varying prices for bandwidth?
- Are E-rate's funds being allocated in the most effective way to meet the ConnectED goals? How can E-rate help schools get the most out of their broadband spending?
- How will different policy approaches advance the goal of connecting 99% of America's K-12 students in the next five years? What policy changes are needed to ensure E-rate can continue to meet its goals over the long term?

[10] Many of these questions were also raised by FCC Chairman Wheeler in a March 17, 2014 speech to the Council of Chief State School Officers: http://www.fcc.gov/document/chairman-wheeler-remarks-ccsso-legislative-conference

The E-rate Form 471 Item 21 Analysis

To answer these questions, EducationSuperHighway worked with school districts to collect data on schools' telecommunications and broadband spending from approximately 1,200 E-rate applicants, including school districts, schools, and consortia. The final dataset used for this analysis includes 1,044 applicants, representing over six million students in approximately 11,000 schools across 45 states. These applicants reported a total of $468 million in annual spending, corresponding to $363 million in funding requested from the E-rate program (approximately 15% of the total E-rate funding available for Funding Year 2013).[11]

Data was collected from school districts' Funding Year 2013 E-rate Form 471 submissions to the Universal Service Administrative Company (USAC), the administrative agency for the E-rate program.[12] Each year, districts submit a Form 471 to request funding for services. The Item 21 attachment to the Form 471 asks districts to provide detailed information on the specific services being submitted for reimbursement, including service type, service provider, quantity, and cost.

EducationSuperHighway systematically collected and coded every element of participating districts' Item 21 attachments to create the underlying dataset for the analysis in this paper ("Item 21 Sample"). Throughout the six-month collection and coding process, we worked closely with districts, state partners, and E-rate consultants to verify data accuracy and completeness, frequently engaging in multiple follow-up conversations to identify exact uses of services and detailed cost breakdowns of multiple services in a single contract.

EducationSuperHighway's rigorous coding and analysis of school and district Item 21 submissions provides an unprecedented view into how E-rate's funds are being used today and what the market for Internet and data network services looks like for school districts nationwide.

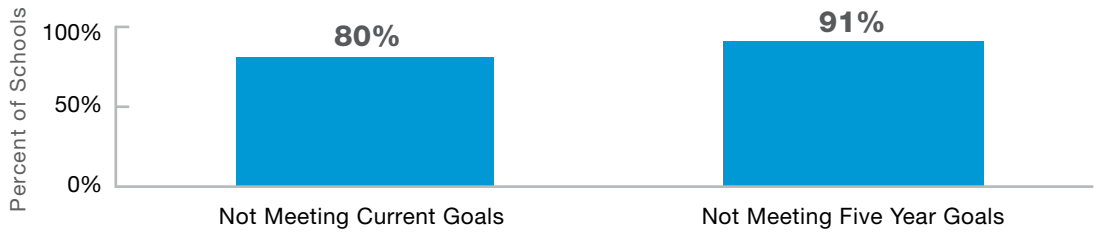
The analyses in this paper focus on "Priority 1" services categorized by the USAC as Telecommunications Services or Internet Access. These categories include the WAN and Internet access services required to meet the ConnectED goals. LAN and Wi-Fi equipment, which are an equally critical element of meeting the ConnectED goals, are classified as "Priority 2" in USAC's Internal Connections category. In February, 2014 the FCC noted that there would be insufficient funds to fully support any requests for internal connections from Funding Year 2013 due to the growing demand for Priority 1 services.[13] As a result, in order to best reflect how E-rate funds are being spent today, the analysis in this paper is focused on Priority 1 services.

[11] See *Appendix A: Data Collection and Sampling* for detailed description of methodology
[12] USAC is responsible for administering the Universal Service Fund, of which E-rate is one component.
[13] FCC, "From the Wall to the Desk," http://www.fcc.gov/blog/wall-desk-facilitating-21st-century-digital-learning

Where Do We Stand Today Against the ConnectED Goals?

80% of schools in EducationSuperHighway's Item 21 Sample do not meet the Current Goals for Internet access and/or WAN connections established by ConnectED.[14]

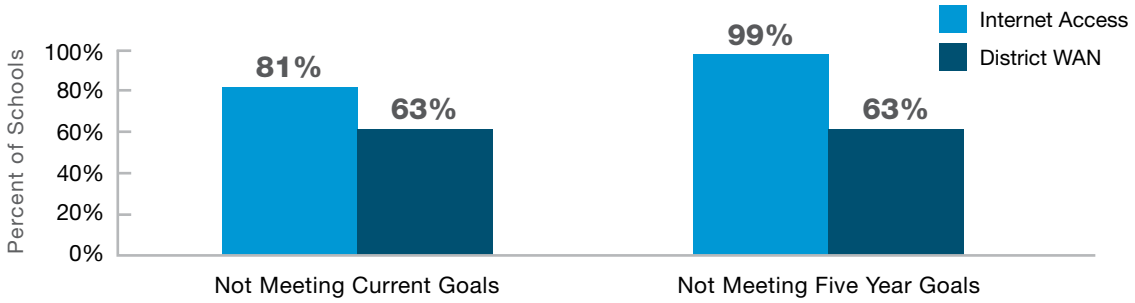
Chart 3: The vast majority of districts report that they are not purchasing enough bandwidth to meet Current Goals



To gain further insight into the underlying causes of the connectivity gap, we analyzed school districts' Internet access capacity separately from the speeds for the WAN connection between school buildings. This analysis allows a more detailed view into what part of the district network is more likely to be the bottleneck to high-speed connectivity.

Among districts that reported information on Internet connectivity ("Internet Access Sample"), 81% of schools do not meet the Current Goals. Looking ahead, 99% of schools do not meet the Five Year Goals for Internet access. Among districts that reported information on WAN connections ("District WAN Sample"), 63% of schools do not meet the Current Goals.[15]

Chart 4: Network deficiencies exist in both the Internet access and district WAN connections



[14] 20% includes districts that reported only Internet Access, only WAN, and both Internet Access and WAN. See *Appendix B, Section 2: Nationwide Readiness Assessment* for detailed methodology. Lower readiness assessment from the Item 21 Sample, as compared to the SchoolSpeedTest results may be attributed to oversubscription of Internet services in districts, resulting in schools being able to measure speeds higher than what would be available to them assuming conditions of simultaneous usage.

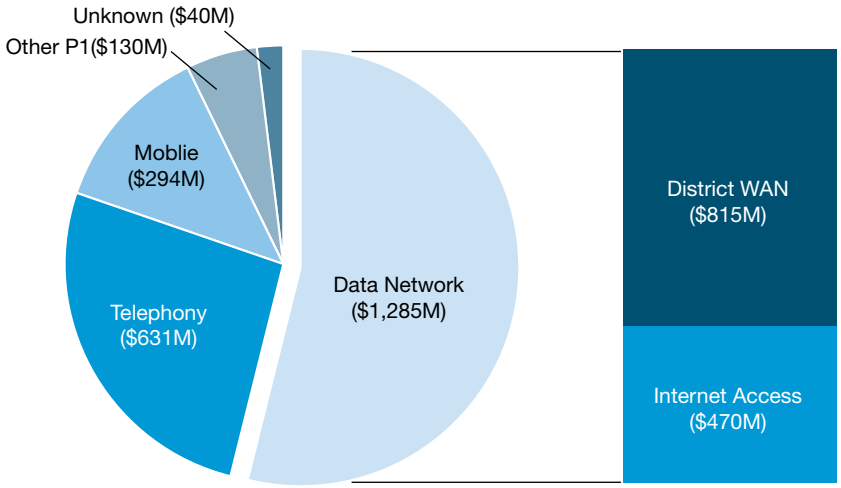
[15] The same percentage of schools (63%) does not meet the Five Year Goals as the WAN standard remains 1 Gbps.

Among districts that reported both Internet access and district WAN information, 69% of schools not meeting the Current Goals were constrained in both parts of the network, 25% of schools were constrained only in Internet access, and 6% of schools were constrained only in the district WAN. In order to ensure high-speed connectivity for 99% of students, it is important that all components of a district's end-to-end network infrastructure are upgraded to support the bandwidth needs of a digital learning environment.

How Are E-rate Funds Being Spent Today?

Based on the Item 21 Sample, only 54% of E-rate reimbursements are going towards Data Networks ($1.3 billion), of which 77% is spent on services for districts that do not meet Current Goals (approximately $989 million). Within reported Data Network spending, approximately 37% ($470 million) is spent on Internet access and 63% ($815 million) is spent on district WAN connections.[16]

Chart 5: Data Network services represents only 54% of annual E-rate spending



At the same time, $1.1 billion per year (46% of the total E-rate program) is being spent on non-broadband services. Specifically, 27% of the E-rate fund is spent on telephony ($631 million), 12% is spent on mobile ($294 million), and 5% is spent on other services such as email and web hosting ($130 million). Uses for the remaining 2% of funds were not identified.

[16] See *Appendix A, Section 1* for taxonomy of E-rate spending categories. See *Appendix B, Section 6: E-rate Spend Allocation* for methodology and key assumptions in calculating E-rate spend allocation across categories.

The $294 million spent on mobile services is divided between voice and data packages for mobile phones and other wireless devices, including mobile data cards and hot spots. Outside of telephony and mobile services, another $130 million annually goes toward other non-broadband services. Email and web hosting make up over 90% of spending in this category, with web hosting accounting for about five times as much as email.

Chart 6: Approximately half of E-rate mobile spending goes toward data services for mobile devices (including tablets), wireless cards, and Wi-Fi hot spots

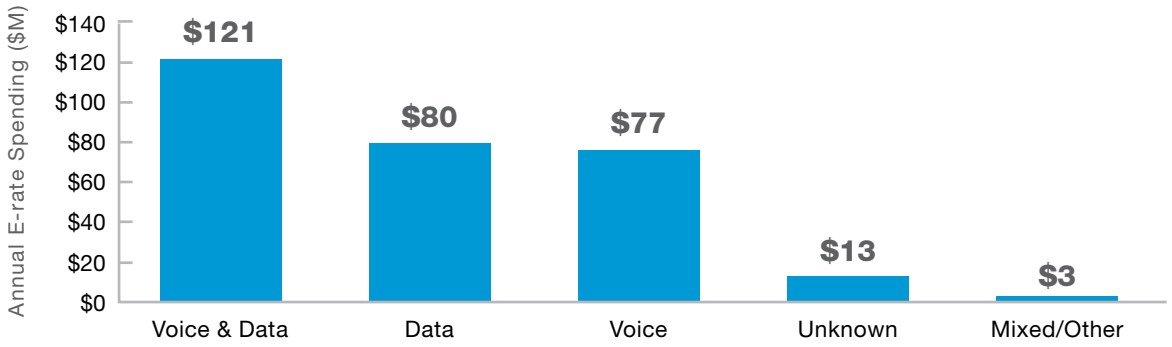
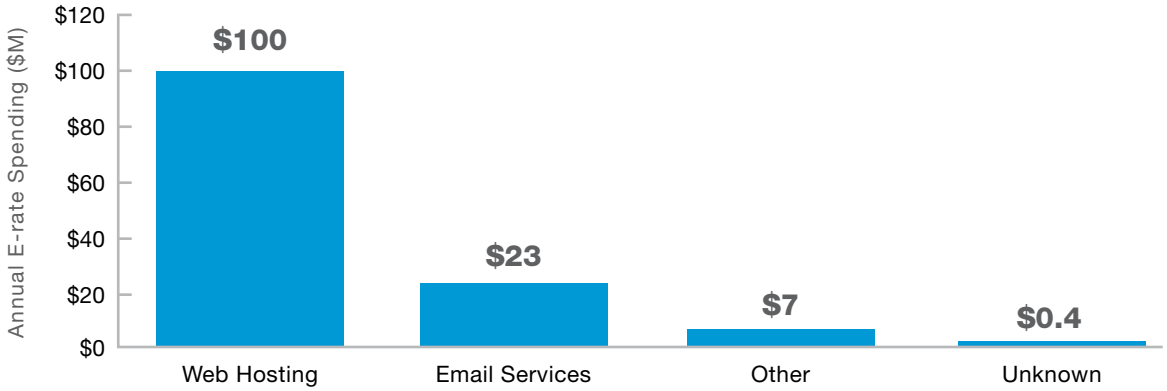


Chart 7: Approximately $124M of annual E-rate spending is on web hosting and email



In summary, a large percentage of today's E-rate funding is being spent on legacy technologies that do not directly support student learning in the classroom. Consequently, a significant opportunity exists to provide schools and libraries with more broadband funding by transitioning the E-rate program's resources to focus on broadband in a timely and thoughtful way. This will enable the greatest number of schools and libraries to meet the ConnectED goals.

> **"$1.1 billion of today's E-rate funding is being spent on legacy technologies that do not directly support student learning in the classroom."**

What Drives the Connectivity Gap?

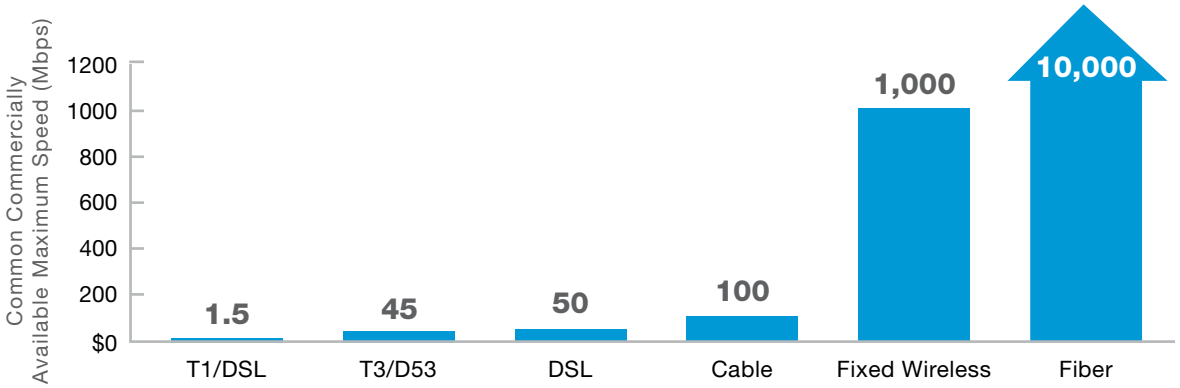
Issue 1: Access to fiber

The data show that not only is the technological capacity of fiber superior for high-quality digital learning, but that fiber is more cost-effective as compared to other services. Overall, districts in the Item 21 Sample that reported the use of fiber had approximately nine times more bandwidth and 75% lower cost per Mbps compared to districts that did not use fiber.

> **"Districts that reported the use of fiber had approximately nine times more bandwidth and 75% lower cost per Mbps compared to districts that did not use fiber."**

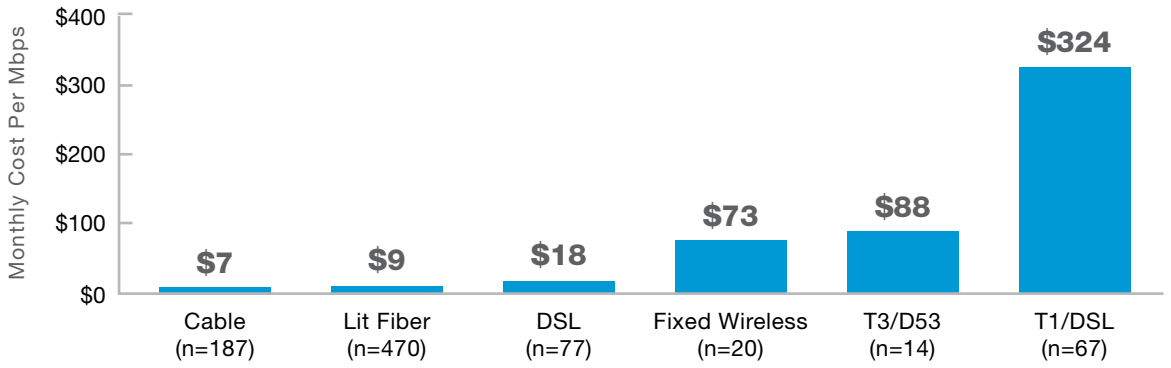
Fiber is the highest capacity broadband technology available today and the only commercially available technology that is scalable enough to support the projected bandwidth needs for the vast majority of school districts. According to the Five Year Goals, the typical school district (which averages 3,000 students) will require 3 Gbps of Internet access. Legacy technologies, such as copper T3s, DSL, or cable modem, are currently limited to speeds of 100 Mbps or less and could only support 45 - 100 students under the Five Year Goals. In contrast, 100 Gbps fiber connections are commercially available today and affordable 10 Gbps connections are already in use in many school districts across the country.

Chart 8: Significantly higher speeds are available over fiber connections compared to other service types



Fiber not only allows for faster connections, but also is more cost-effective on a per Mbps basis compared to other service types. In the Item 21 Sample, Internet access over a T1 connection costs on average $324 per Mbps per month, compared to $9 per Mbps per month over a fiber connection.[17]

Chart 9: Fiber is more cost-effective than most service types and more scalable than cable



Districts that reported the use of fiber had an average cost of $11 per month for 344 Mbps of Internet access and 787 Mbps of WAN. Meanwhile, districts that did not report the use of fiber had an average cost of $41 per month for 37 Mbps of Internet access and 90 Mbps of WAN.[18] While some districts may be able to meet their bandwidth needs with other service types, in many cases, lack of fiber access is a significant obstacle that prevents districts from purchasing the bandwidth they need at a cost they can afford.

[17] For discussion of where commercially available cable modem services are a viable solution, see page 22.

[18] Almost all districts without fiber that report WAN connections of 100 Mbps or higher on average used fixed wireless. The average non-fiber WAN connection excluding fixed wireless was 56 Mbps. For description of weighted cost calculation, see *Appendix B, Section 4: Weighted Average Cost Methodology*

Chart 10a: Fiber connections result in bandwidth that is on average 9 times higher than other service types

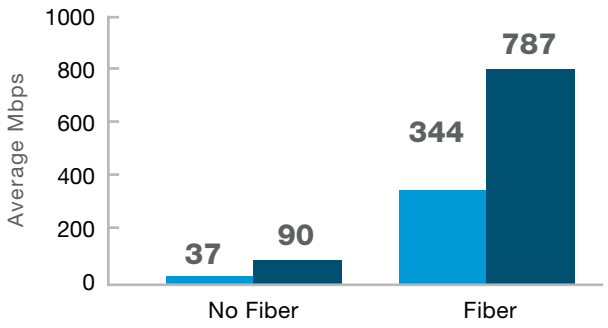
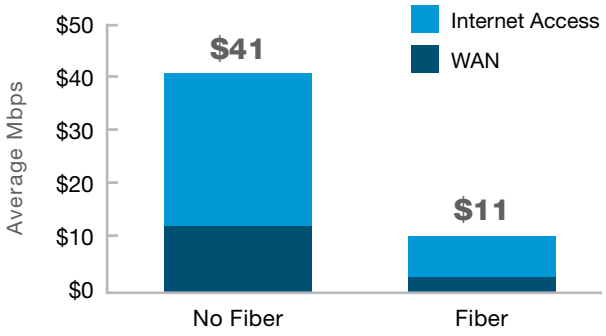


Chart 10b: Cost of connectivity using fiber is approximately 75% lower than other service types



Fiber is the only future-proof broadband technology that can scale to meet the speeds required and do so in a cost effective way.[19] Unfortunately, access to fiber is not universal, and schools without fiber are most at risk of being left behind without the broadband they need for high quality digital learning.[20] Not surprisingly, these gaps in fiber access disproportionately affect schools in more remote areas, where districts were three times more likely to report a non-fiber connection for both Internet access and WAN services.[21] When Congress launched the E-rate program in 1996, legacy copper technologies provided schools with sufficient Internet access for administrative and limited instructional purposes. Today, as schools strive for higher speeds and leverage the Internet to deliver equal educational opportunities for all students, access to fiber is critical.

Issue 2: District resources and affordability

While fiber has the physical capacity to meet districts' bandwidth needs, access to fiber, in and of itself, does not ensure that districts meet the ConnectED goals. Among schools that reported a fiber connection, the majority in both the Internet access and WAN Samples did not report sufficient capacity. 83% of districts using fiber for Internet access and 61% of districts with fiber WAN connections do not meet Current Goals. Looking ahead to the Five Year Goals, only 1% of schools meet the standard for Internet access.[22]

[19] As discussed further on page 22

[20] Fiber is generally available from at least one provider in areas where the overall demand for bandwidth economically justifies the up-front investment required to lay fiber. There are many rural and economically disadvantaged areas, though, where providers have not been able to economically justify the investment in fiber. Providing access to fiber in these locations typically requires government subsidies or some form of public/private partnership.

[21] See *Appendix B, Section 3: Fiber Access Assessment*

[22] See *Appendix B, Section 3: Fiber Access Assessment*

Chart 11a: 83% of schools with Internet access over fiber still are not meeting Current Goals

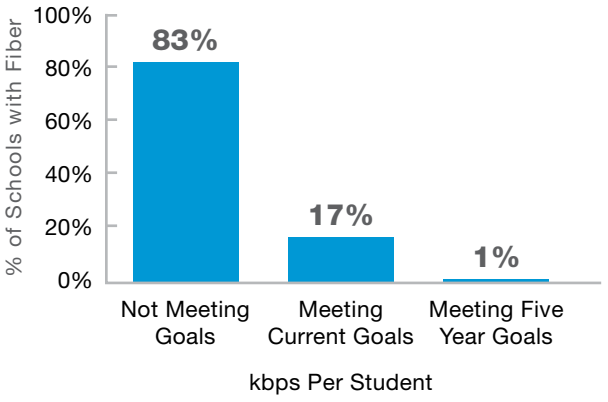
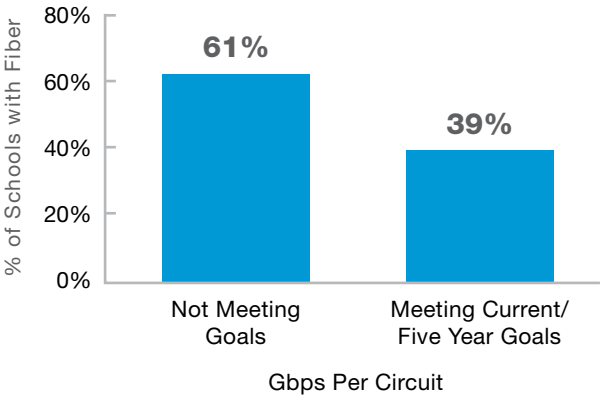
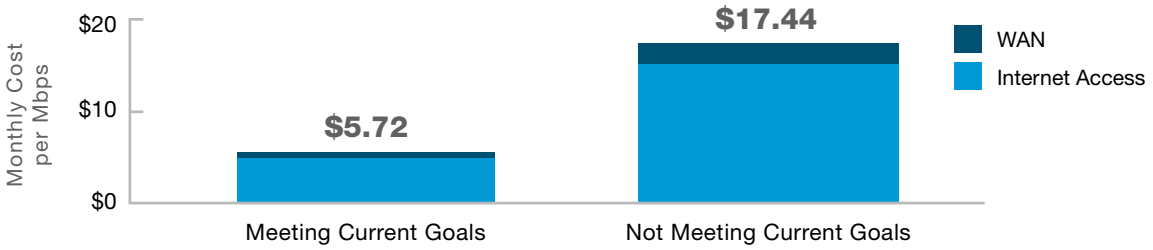


Chart 11b: 61% of schools with fiber WAN connections are not meeting Current Goals



The key factor that prevents some districts from purchasing enough bandwidth to meet the ConnectED goals is the *affordability* of high-speed connections. Districts that do not meet Current Goals reported connectivity costs that were three times higher on average than those reported by districts that do meet Current Goals.[23] When the price of connectivity is too high, districts are unable to purchase the level of bandwidth that they need.

Chart 12: Districts not meeting Current Goals face a price for connectivity that is too high to buy sufficient bandwidth

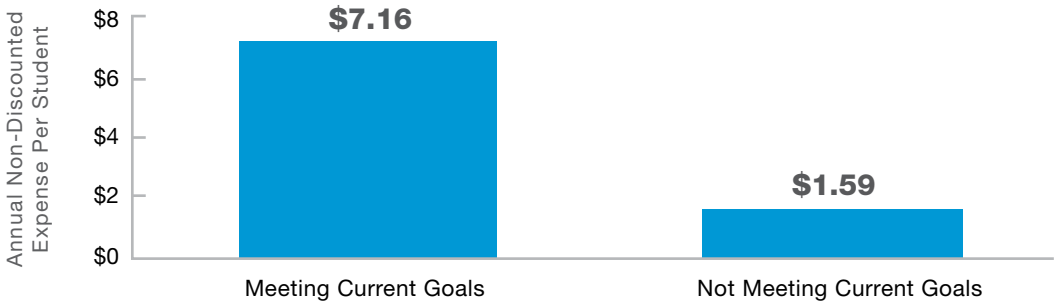


The affordability challenge is also evident when one looks at the district's share of the annual cost of Internet access (i.e., the non-discounted portion of the annual cost that is not reimbursed by E-rate). Districts meeting the Current Goals are spending over $7 per student per year from their budgets for Internet access. This is over 450% more than the $1.59 per student per year of district funds being spent on average by districts that are not meeting

> **"The key factor that prevents some districts from purchasing enough bandwidth to meet the ConnectED goals is the *affordability* of high-speed connections."**

[23] See *Appendix B, Section 4: Weighted Average Cost Methodology*

Chart 13: Districts that are meeting the Current Goals pay approximately 4.5 times more from their budgets for Internet access

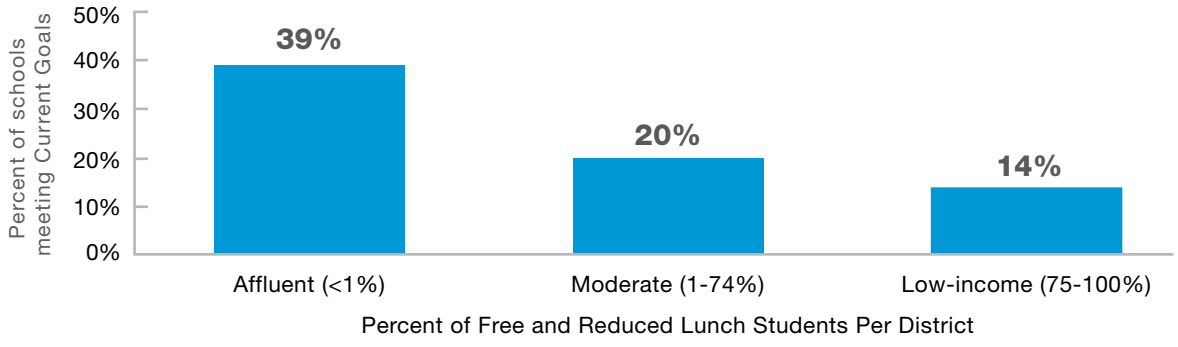


the Current Goals.[24] In other words, many districts may be unable to meet the ConnectED goals because they do not have the resources to purchase Internet access at higher speeds.[25]

The ability of districts to fund the non-discounted portion of high-speed Internet access purchases is reflected in the readiness of districts for digital learning. Specifically, the 2% of schools in America's wealthiest districts (with less than 1% free and reduced lunch (FRL) populations) are approximately twice as likely to meet Current Goals compared to the national average. Meanwhile, the 15% of schools in the most financially challenged districts (with 75% or higher FRL populations) are

> **"The current design of the E-rate program, which provides the steepest discounts to the most financially challenged schools, has not been effective at achieving the goal of ensuring that every student has access to the bandwidth they need for equal educational opportunity."**

Chart 14: Wealthier schools are more likely to be meeting the Current Goals than poorer schools



[24] See *Appendix B, Section 5: District Non-Discounted Portion*

[25] In some cases, districts not meeting the Current Goals have chosen not to invest scarce resources in Internet access because they do not perceive the need for additional bandwidth given a lack of devices or demand from teachers and students. However, districts are increasingly realizing that reliable connectivity must be in place before teachers and students will attempt to integrate digital learning into the classroom.

30% less likely to meet Current Goals compared to the national average. This outcome suggests that the current design of the E-rate program, which provides the steepest discounts to the most financially challenged schools, has not been effective at achieving the goal of ensuring that every student has access to the bandwidth they need for equal educational opportunity.

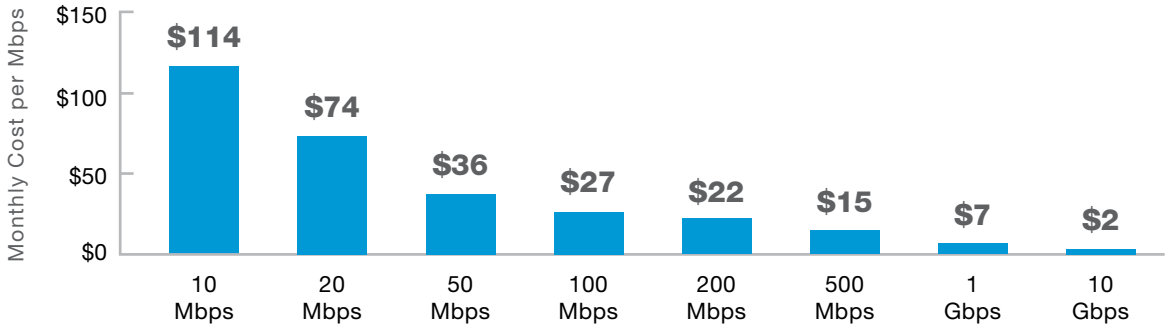
While E-rate achieved its original mission of establishing basic connectivity for virtually every school and library, it needs to be modernized to meet the new and urgent challenge of overcoming an emerging and potentially more consequential connectivity gap. E-rate's current design does not effectively address the affordability issue in obtaining high-speed connections and the program has insufficient resources to ensure that every school and library can meet the ConnectED goals in the face of these affordability challenges.

Consequently, this lack of affordability and resources is creating a significant roadblock to establishing the broadband infrastructure that is a critical pre-requisite to the implementation of digital learning. Wealthier districts with more local funding can overcome this issue by allocating a larger budget for Internet connectivity and WAN. On the other hand, districts that are more budget-constrained, particularly those with a high percentage of FRL students, are more likely to respond to high connectivity costs by buying less bandwidth, leaving their students on the wrong side of the digital divide.

Issue 3: Scale of procurement

In many cases, high prices per Mbps reflect schools purchasing too little bandwidth to take advantage of economies of scale. For both Internet access and WAN services, districts and other purchasing entities can access better pricing per Mbps by purchasing in greater quantity. For example, the average reported cost per Mbps of Internet access over a fiber network owned and operated by a commercial service provider ("lit fiber") is $27 at 100 Mbps, but reduces to just over half that much ($15 per Mbps) at 500 Mbps and one quarter ($7 per Mbps) at 1 Gbps.[26]

Chart 15: Internet access costs decrease significantly as more bandwidth is purchased

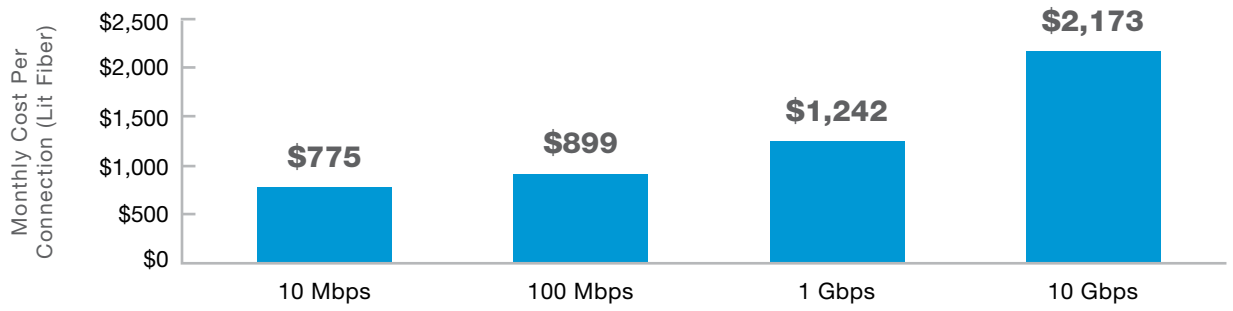


[26] See *Appendix B, Section 4: Weighted Average Cost Methodology*

The average district has approximately 3,000 students and would need roughly 300 Mbps of Internet access today and 3 Gbps in five years. This implies that the average district should be able to lower its cost per Mbps from $15-22 today to less than $7 in five years. Capturing these economies of scale will be critical to meeting the Five Year Goals and also suggests that districts can reduce costs today by forming consortia to aggregate demand and purchase at higher volume.

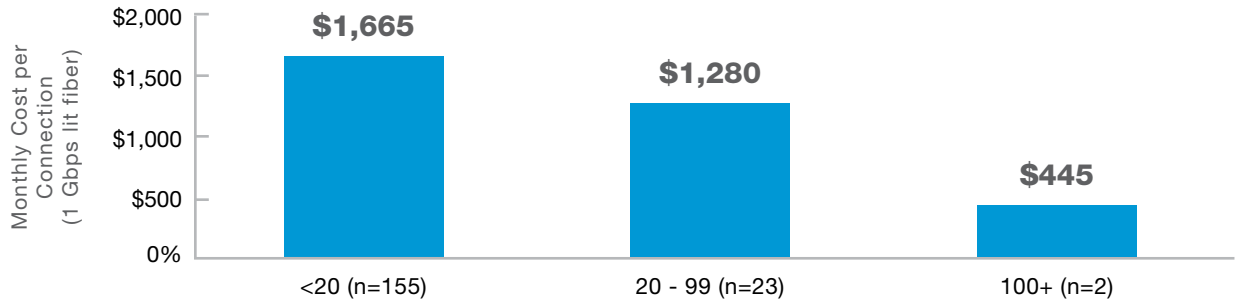
Purchasing at scale is also highly beneficial for district WAN connections, where scale benefits are seen in both the capacity of the connection and the number of connections purchased. One way to capture economies of scale is to purchase connections with higher bandwidth. The average reported cost of a 100 Mbps WAN circuit is $899. Meanwhile, a 1 Gbps circuit, which is ten times faster, is only 40% more expensive. This suggests that dramatic increases in WAN capacity can be achieved with moderate increases in cost.

Chart 16: District WAN capacity can be significantly increased with moderate increases in cost



Another aspect of WAN economies of scale is captured in the total number of connections purchased. For example, for a 1 Gbps lit fiber WAN connection, the average cost per circuit is more than 20% lower if 20 or more connections are purchased and over 70% lower if more than 100 connections are purchased. Thus, purchasing consortia can also be an effective lever to drive down the cost of WAN in certain market areas.

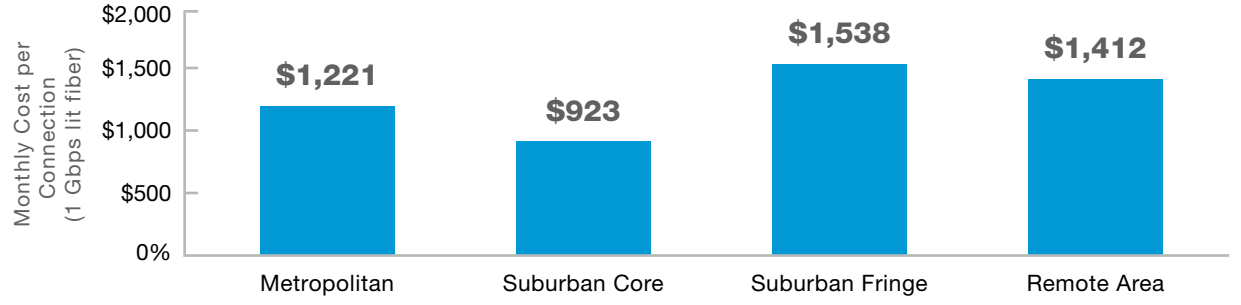
Chart 17: District WAN cost per connection decreases with a higher number of connections purchased



The Item 21 Sample also shows that these scale benefits are not limited only to metropolitan areas. Because the WAN market is relatively localized, smaller scale local and regional providers can offer effective solutions at competitive prices across all locales. For a 1 Gbps circuit, the average reported cost per month in suburban fringe and remote areas is not dramatically higher than the average reported cost in metropolitan and suburban core areas.

> **"Because the district WAN market is relatively localized, smaller scale local and regional providers can offer effective solutions at competitive prices across all types of locales."**

Chart 18: District WAN economies of scale can be achieved in all types of locales



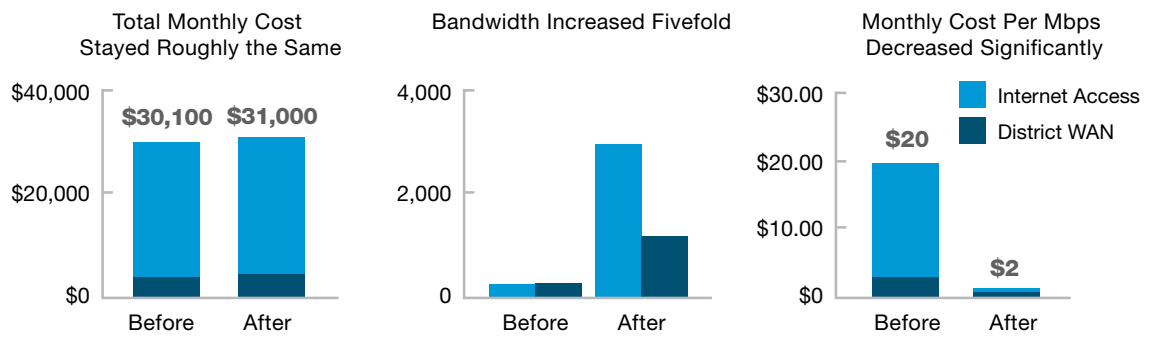
Indian Prairie School District, Illinois

The experience of Indian Prairie School District in Illinois illustrates the tremendous cost benefits possible through improving the procurement process and purchasing at scale. In 2013, the school district determined a pressing need to increase their bandwidth in preparation for online assessments and digital learning. Unfortunately, if they were to upgrade based on the current rates offered by their incumbent service provider ($17 per Mbps for Internet access and $3 per Mbps for WAN each month), significant upgrades would have been financially infeasible.

In order to procure increased bandwidth while managing costs, Indian Prairie issued a request-for-proposal for higher bandwidth services. An efficient procurement process, which included obtaining bids from numerous service providers and negotiating favorable terms and conditions, resulted in a final contract that delivered twelve times more Internet access bandwidth and five times more WAN capacity at roughly the same total monthly cost. As a result, the district saw a 90% reduction in total cost per Mbps.

The increased bandwidth effectively supports the district's bring-your-own-technology initiative and will continue to result in higher levels of engagement from students, while allowing teachers to accommodate different learning styles and comprehension levels.

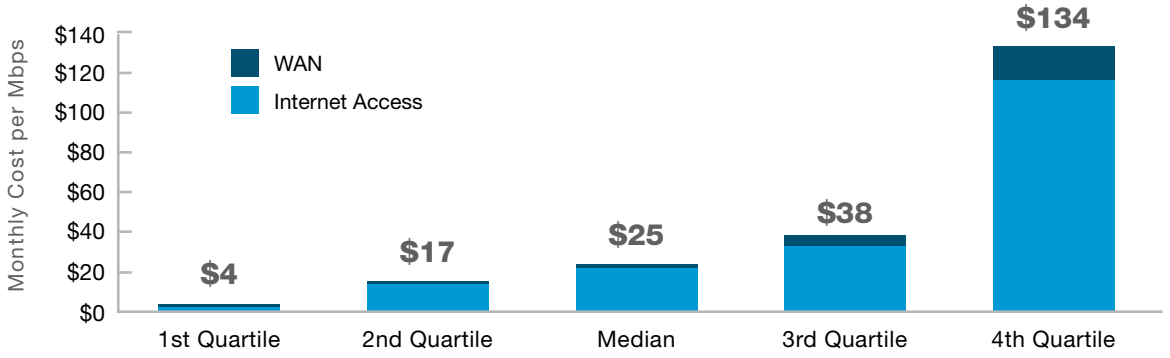
Figure 2: **Indian Prairie School District dramatically increased bandwidth without increasing costs**



Issue 4: Effectiveness of procurement

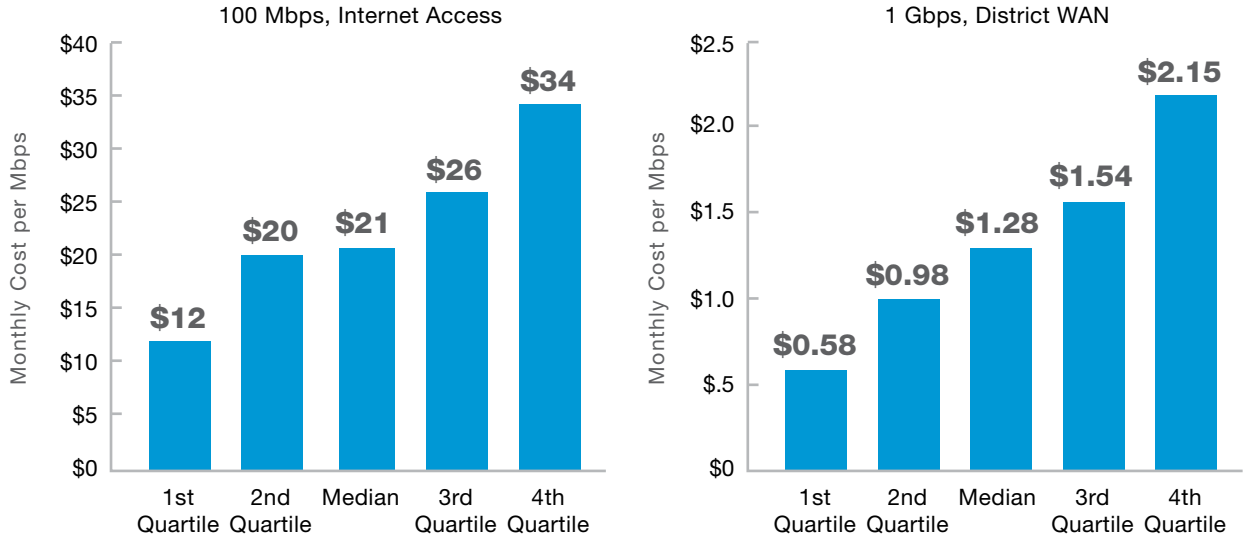
Procurement practices and market dynamics can play a significant role in achieving prices that enable districts to meet the ConnectED goals. In the Item 21 Sample, the median price of broadband connectivity (WAN + Internet access) for a single district is $25 per Mbps. In contrast, the quartile of districts with the lowest per-Mbps rates pay just $4 per Mbps — one-sixth the median cost. Meanwhile, the quartile of districts with the highest per-Mbps rates pay over $133 per Mbps — more than five times the median district.

Chart 19: The quartile of districts with the lowest per-Mbps rates pay 1/6th the median cost



While scale and geography account for some of the observed variation in cost per Mbps, there is a still a wide range of prices across districts when bandwidth and locale are held constant. In major metropolitan areas, for example, the bottom quartile of prices for 100 Mbps of Internet access is nearly three times as expensive as the top quartile. For a 1 Gbps WAN connection, the bottom quartile is nearly four times as expensive as the top quartile, as shown in charts 20a and 20b.[27]

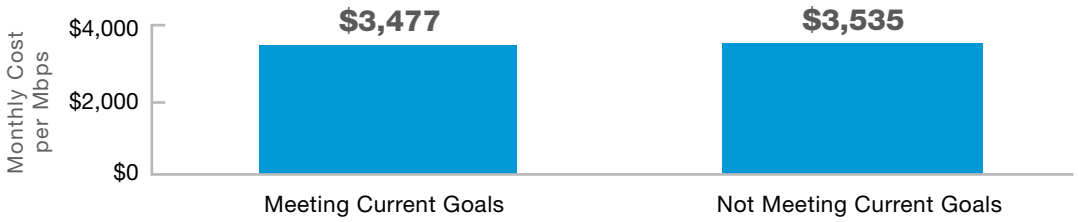
Chart 20a and 20b: Wide cost variations for Internet access and district WAN exist even within metropolitan areas



[27] This is a particularly puzzling situation given that the E-rate's Lowest Corresponding Price rules require that similarly situated customers (in this case customers buying the same amount of bandwidth in the same geographic category) receive the lowest prices available for a service.

The importance of effective purchasing is also seen when analyzing the non-reimbursed district expenses for WAN purchases. In the Item 21 Sample, districts meeting the ConnectED goals for WAN capacity actually contributed slightly less per WAN connection in district funds than those not meeting the ConnectED goals. In other words, effective procurement can make a significant difference in whether districts with similar budgets are able to meet the ConnectED goals.[28]

Chart 21: District contributions to WAN costs are roughly equal regardless of whether districts are meeting Current Goals



One reason that some districts are unable to purchase WAN cost-effectively may be due to a lack of options. In market areas where there are few service providers, the lack of competition keeps prices high. Alternatively, some districts may have limited knowledge of the options available due to a lack of price transparency from service providers. Either way, inefficient procurement is limiting the ability of some districts to purchase WAN connections of sufficient capacity to meet their needs and may significantly add to the funding needed to meet the ConnectED goals.

How Do We Connect 99% of Students in 5 Years?

Data from the National SchoolSpeedTest shows that the U.S. needs to accelerate K -12 network upgrades in order to meet the president's goal of connecting 99% of students to high-speed broadband in five years. While the E-rate program has been successful in delivering on its initial mission of basic connectivity for schools and libraries, fundamental issues of access to high-speed infrastructure, scale, affordability and resources now need to be addressed. By addressing these issues as part of its E-rate modernization process, the FCC can ensure that the program will continue to serve the evolving needs of schools and libraries and provide every student with access to the bandwidth they need. Specifically, the FCC can accelerate bandwidth upgrades by increasing E-rate's investment in broadband, ensuring that schools have access to the essential inputs of fiber and internal connections, empowering schools with price transparency, and maximizing the choices available to schools, so they can obtain the most cost-effective and scalable solutions both today and in the future.

[28] See *Appendix B, Section 5: District Non-Discounted Portion*

The analyses that follow demonstrate that there are significant opportunities to increase the number of schools meeting the Current and Five Year Goals within the current budget of the E-rate program. The data also shows that it will not be possible to meet the Five Year Goals without significantly improving the affordability of broadband for schools and libraries. This analysis does not directly address the question of whether, and by how much, the E-Rate cap would need to be increased to meet the high-speed goals at hand. Only after modernizing the program to take advantage of the opportunities to focus spending on data networks and make broadband more affordable can we effectively analyze the amount of a cap increase that will be required.

Accelerator 1: Connect schools to fiber

Given the cost and capacity limitations of other technologies, 98% of schools, serving over 99% of students, will require a fiber connection in order to meet the Five Year Goals.[29] As mentioned above, fiber is the most scalable and cost-effective broadband technology available in the market today. Once fiber is installed, the capacity of a school's broadband connection can be easily increased through low-cost upgrades to the optical electronics at each end of the circuit.[30]

Other technologies, such as cable modem and fixed wireless can be effective solutions for small or hard-to-reach schools and libraries but are less attractive in the vast majority of cases due to either capacity limitations or high costs. Similarly, as explained below, the current cost of LTE wireless solutions make them impractical for the E-rate program.

Cable Modem

Smaller districts with fewer schools and small student populations may be able to address their bandwidth needs using cable modem connections. On average, cable modem connections reported in the Item 21 Sample are cheaper than fiber ($7 vs. $9 per Mbps per month). However, the current commercially available capacity of a cable modem connection is limited to approximately 100 Mbps, and this bandwidth is shared with the surrounding community.[31] For this reason, most schools receiving their Internet access and WAN from cable providers do so over a fiber connection.

In the Item 21 Sample, cable modem connections were a viable solution only for smaller districts. Districts in the Item 21 Sample that were able to meet Current Goals on cable modem have a median size of three schools and approximately 500 students.

[29] Calculated based on the number of students in each school. According to the NCES database, 2% of schools (9% of districts) have 100 students or fewer. These districts should be able to meet their connectivity needs with technologies other than fiber.

[30] Capacity upgrades are simplest when districts have dedicated fiber networks. When districts utilize shared fiber networks provided by telecommunications or cable companies, upgrading the capacity of a school's broadband connection can be significantly more costly and complex because it may require upgrades throughout the provider's network as opposed to simply upgrading the optical electronics at the district's locations.

[31] Cable companies are currently working on increasing capacity beyond 100 Mbps/second, but these speeds are not widely commercially available.

Chart 22a: Districts using cable and meeting Current Goals have a median three schools

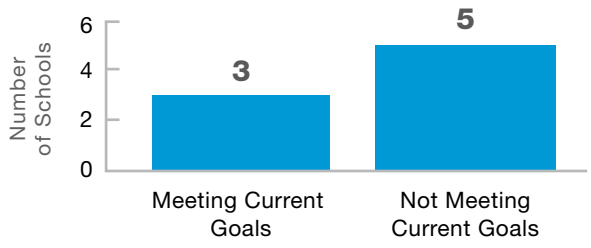
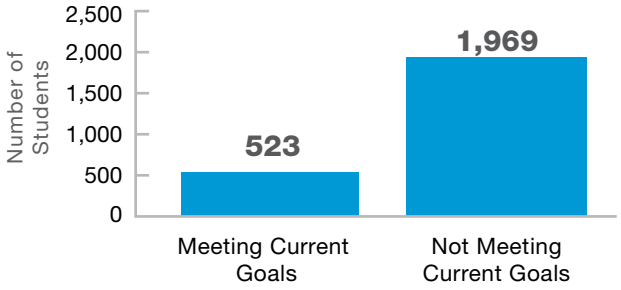


Chart 22b: Districts using cable and meeting Current Goals have approximately 500 students



Fixed Wireless

Another high-speed alternative to fiber are fixed wireless connections, which can be as fast as 1 Gbps and thus are a viable solution in hard to reach areas that are far from existing fiber. In the Item 21 Sample, districts reported fixed wireless connections of up to 200 Mbps for Internet access and up to 1 Gbps for WAN.

Although fixed wireless connections are capable of reaching high speeds, the Item 21 Sample suggests that they are over twice as expensive as lit fiber alternatives at equivalent speeds. For Internet access, fixed wireless connections in the Sample ranged from 10 - 200 Mbps and had an average cost of $73 per Mbps per month. Prices for lit fiber connections in that same bandwidth range averaged $29 per Mbps per month. For district WAN, fixed wireless connections in the Sample had up to 1 Gbps per circuit and cost on average $2,283 per month. The average cost for lit fiber circuits of equivalent capacity is $1,099 per month.

Fixed wireless connections also require a direct line-of-sight between the provider's transmission towers and transceiver equipment at school sites, which makes them better suited to more flat, rural geographies. For example, the presence of large mountains or tall towers obstructing the line-of-sight would present significant challenges. Nevertheless, in the case of a rural district where fiber construction costs are prohibitively high, fixed wireless may be the best solution to achieve high-speed connections.

Chart 23a: Fixed wireless Internet access is over two times more expensive than lit fiber

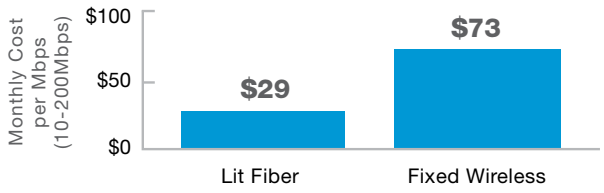
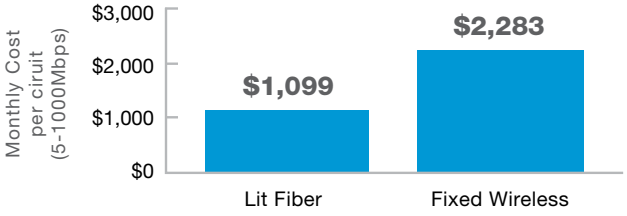


Chart 23b: Fixed wireless WAN connections are over two times more expensive than lit fiber



LTE

Another fiber alternative that some districts have implemented uses mobile LTE data subscriptions for individual devices as an alternative to the traditional network architecture described in *Figure 1*. This solution allows districts to address the lack of funding for Priority 2 equipment and services. Whereas LAN and Wi-Fi equipment are only eligible for E-rate Priority 2 funding, mobile data contracts are included in Priority 1 services and therefore provide districts with an opportunity to receive E-rate support for an end-to-end Internet solution that goes directly to students' devices.

The typical price of a wireless data contract is $40 per device per month. Under this model, if each device serves one student, the entirety of the E-rate program would only be able to support 7 million students per year (14% of all students vs. the roughly 95% of students that E-rate serves today). Therefore, while a device-specific LTE solution may be financially sensible for an individual school district, it is impractical for E-rate to support on a national level given current prices and the size of the E-rate program.[32] Additionally, since mobile LTE data is a shared resource, latency and capacity in the network could present risks to successful implementation.[33]

[32] To be affordable on a national scale, the cost of LTE data would have to be under $3 per student per month.

[33] If mobile carriers were to offer affordable, uncapped LTE solutions at the school level (where the LTE connection replaced legacy copper connections and tied into a school's LAN / Wi-Fi network instead of going directly to the device), LTE could be an attractive solution for schools that lack access to fiber as it would provide superior bandwidth capacity to many legacy services. Latency and network capacity issues would still need to be considered to determine if this is the best solution for a school without access to fiber.

Chart 24a: It would cost E-rate $16B per year to support all students on mobile LTE

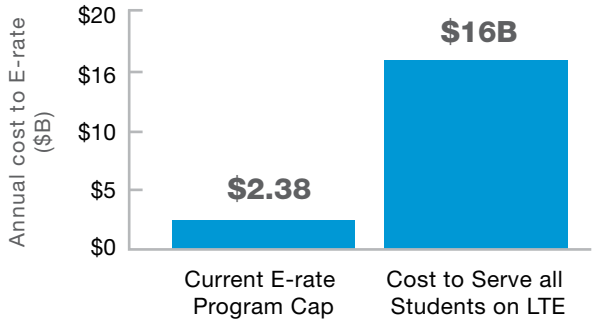
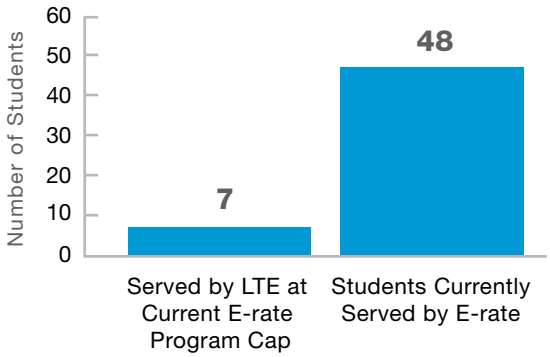


Chart 24b: At the current cap, E-rate could support only 7 million students on mobile LTE



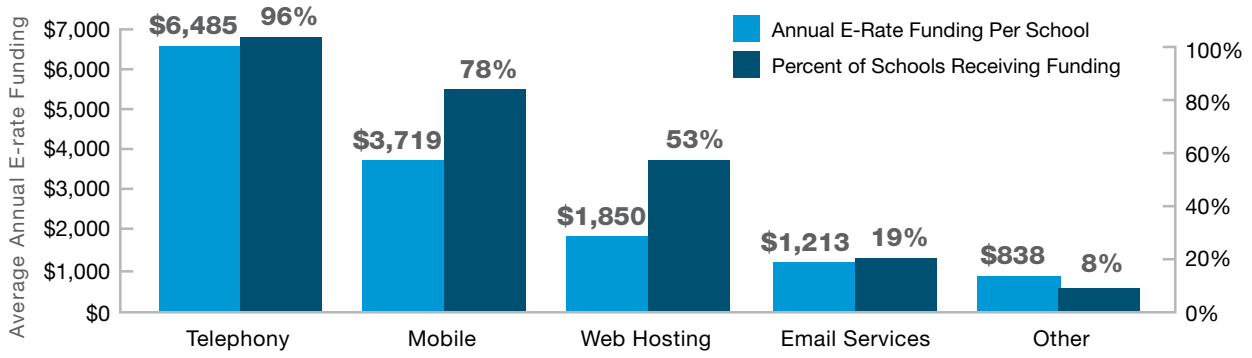
In summary, while there are alternatives to fiber that may be appropriate for some districts, fiber remains the most cost-effective and scalable solution for the majority of schools. Cable modem can serve the needs of smaller districts today, but, unless cable dramatically increases its commercially available capacity, most of those districts will outgrow the service capacity of cable modems in five years' time. Fixed wireless is a good solution to achieve gigabit speeds where it is economically infeasible to invest in fiber, but it is more costly to operate and its use is limited to certain geographies. Finally, mobile LTE may currently be an attractive option for some districts, but it is not sustainable for E-rate to support nationally.

Accelerator 2: Focus E-rate on broadband

One way to address the broadband affordability challenge is to increase the funding available to districts for data networks. Today, approximately $1.1 billion annually, or 46% of E-rate funding, currently goes toward services unrelated to broadband, such as telephony, mobile voice and data, email, and web hosting. Across all districts, the average amount of non-broadband funding that schools receive from E-rate is approximately $11,000 per year.[34]

[34] Not every district applies for E-rate reimbursement for every type of non-broadband service. Chart 25 shows the average E-rate subsidy per school in each category of service for those who do apply for funding.

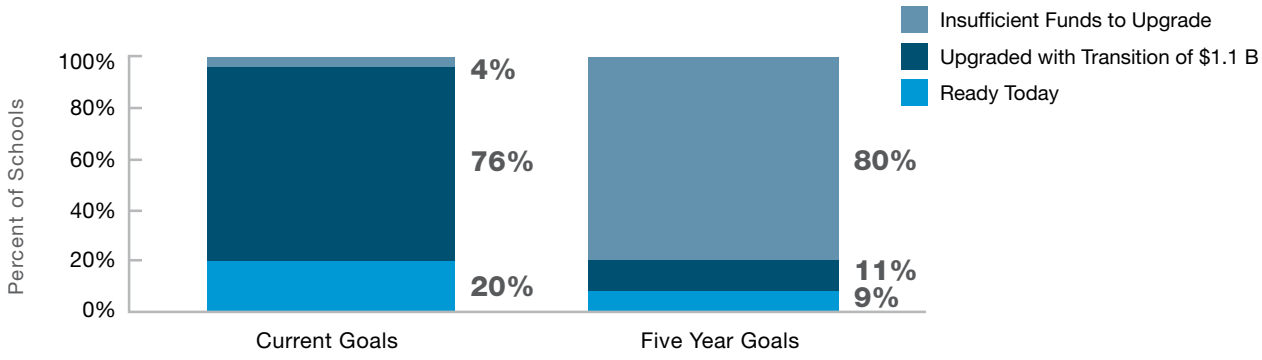
Chart 25: Schools receive an average of $11,000 per year for non-broadband services



The evolution of technology and markets over the last 18 years raises the question of whether E-rate should continue subsidizing non-broadband services. While subsidizing telephony as a way to enable classrooms to have access to dial-up Internet made good sense at the start of the E-rate program, telephony is no longer being used to advance learning in the classroom. Similarly, as Chairman Wheeler said in his speech to the Council of Chief State School Officers, "Mobile phones are now ubiquitous in our nation. E-rate support does not mean the difference between teachers having mobile phones and not having them." Lastly, widespread availability of free, feature-rich, cloud-based services for email and web hosting make the need for E-rate support for these services obsolete.[35]

Thoughtfully phasing out support for non-broadband services and re-investing the $1.1 billion of funding into broadband would provide sufficient annual subsidies to allow an additional 76% of schools to purchase enough connectivity to meet the Current Goals, leaving just 4% of schools with too little bandwidth. Unfortunately, because the annual cost of meeting the Five Year Goals is seven times higher, a $1.1 billion increase in funding for broadband will still leave 80% of schools with too little bandwidth in five years.[36, 37]

Chart 26: Transitioning $1.1B of E-rate funding to broadband services significantly advances Current Goals but leaves a large gap against Five Year Goals

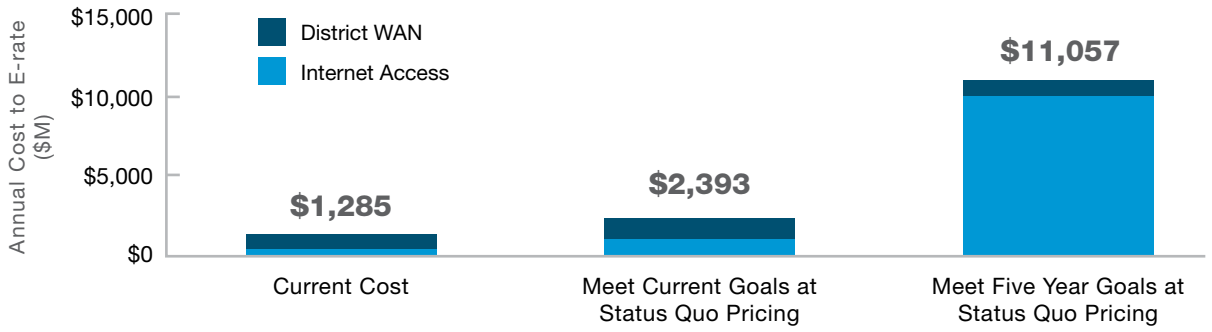


[35] For example, Google Apps for Education and Microsoft Office 365 Education A2
[36] See *Appendix B, Section 7: Estimated Status Quo Cost*
[37] The average annual cost to upgrade a school's bandwidth to the Current Goals is $14,000 while the cost to upgrade a school to the Five Year Goals is $97,000 per year. This is only for Internet access and WAN and does not include LAN / Wi-Fi upgrades.

Accelerator 3: Lower the cost of bandwidth

While increasing E-rate's investment in broadband can enable most schools to meet the Current Goals, meeting the Five Year Goals requires that the FCC empower schools to dramatically lower the cost of Internet access and WAN connectivity. Using current status quo pricing for Internet access and district WAN, it is projected to cost E-rate $2.4 billion annually to ensure all schools meet the Current Goals. With no changes to the program, meeting the Five Year Goals would cost E-rate $11 billion annually. Thus, even if the E-rate funding cap is increased, in order for E-rate to be sustainable in the long term, we need to reduce the cost of connectivity and improve choices so schools can affordably scale their bandwidth to address future needs.[38]

Chart 27: It would cost E-rate $11B per year to meet the Five Year Goals, assuming status quo pricing



There are a number of strategies that the Item 21 analysis demonstrates can help reduce the cost of bandwidth.

- **Purchasing at scale** by aggregating demand within and across school districts will reduce costs by taking advantage of the scale economies evident in bandwidth pricing.
- **Increasing price transparency** by providing districts with information on what their peers are paying for bandwidth can enable districts to become more effective purchasers and thereby decrease the average prices paid.
- **Increasing competition** by making all Internet access and WAN options available to districts can reduce costs by enabling districts to choose the most cost-effective solution to meet their needs.

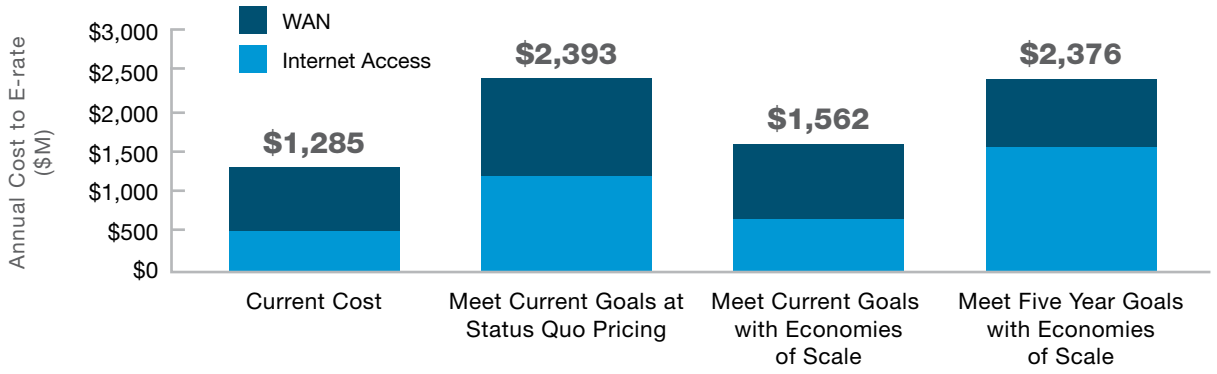
[38] *Appendix B, Section 7: Estimated Status Quo Cost*

Each of these strategies can dramatically reduce the total annual cost to E-rate of meeting the Current and Five Year Goals. However, while the analyses that follow show that any one of these strategies would allow all schools to meet the Five Year Goals within the current E-rate budget, it is unlikely that any one strategy will be effective for all schools. Thus, it is critical that the FCC modernize the E-rate program in a manner that supports all of these approaches with the goal of achieving average costs of $750 per 1 Gigabit WAN connection and $3 per Mbps for Internet access. If schools and libraries are unable to achieve these average prices, the FCC will likely need to increase the size of the E-rate fund to meet the Five Year Goals.

Strategy 1: Purchase at scale

As districts implement network upgrades, it is essential to ensure that they are capturing economies of scale in their service contracts. Pricing trends in the Item 21 Sample suggest that if districts can upgrade at prices that reflect economies of scale, Internet access and WAN for all schools could be upgraded to meet Current Goals at a total cost of $1.6 billion annually — only 20% higher than current data network subsidies. In five years, if districts can upgrade at prices that reflect economies of scale, supporting these schools would cost $2.4 billion annually.[39] Smaller districts, that may not be able to achieve optimal economies of scale on their own, can leverage economies of scale through purchasing consortia with other districts to aggregate demand and secure better pricing.[40]

Chart 28: Leveraging economies of scale in purchasing could save up to 79% over the status quo



Internet access and WAN only. Does not include LAN / Wi-Fi costs to meet ConnectED Goals

[39] Economies of scale are observed in the Item 21 data, which show that cost per Mbps decreases as higher bandwidth is purchased. Many districts today purchase low bandwidth at a high cost per Mbps. Maintaining the current cost per Mbps of each district, wide-scale upgrades to meet Five Year Goals would cost E-rate $11 billion annually. This cost decreases to $2.4 billion if upgrades can be achieved at low cost per Mbps that should be available with higher bandwidth. See *Appendix B, Section 8: Estimated Cost with Economies of Scale*

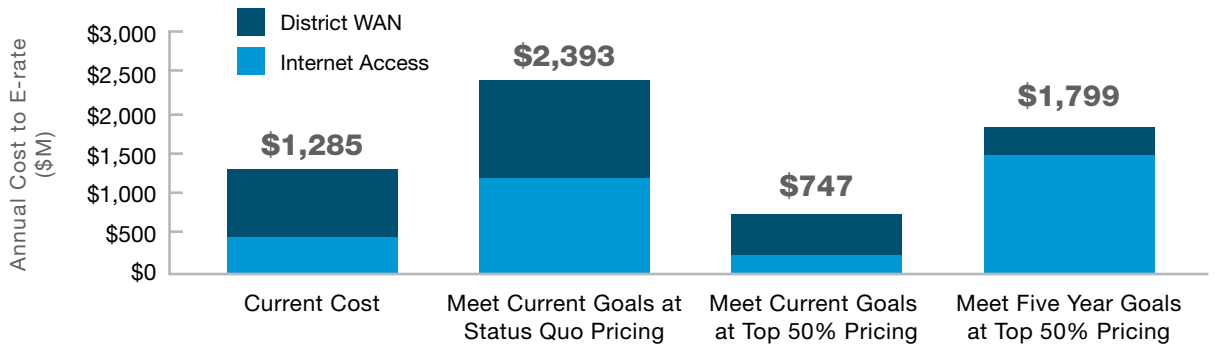
[40] Some districts, particularly those in rural areas, may have trouble leveraging purchasing at scale and thus will require other strategies to reduce their costs or additional support in order to meet the ConnectED goals.

Strategy 2: Increase transparency to reduce price variability

The lack of price transparency in many broadband markets results in districts paying more than necessary for bandwidth. Cost projections using the Item 21 Sample suggest that if all districts could purchase bandwidth at the average price of the half of districts that are paying the lowest rates in their market (based on district locale and total bandwidth purchased) schools could meet Current Goals at an annual cost to E-rate of roughly $750 million — over 40% less than current program costs.[41]

The impact of enabling all districts to purchase at the average price of the top 50% of rates becomes even more dramatic as bandwidth needs increase over time. Every school could meet the Five Year Goals for an annual cost of $1.8 billion — less than the current size of the E-rate program.[42]

Chart 29: More efficient procurement can increase the impact of economies of scale



Internet access and WAN only. Does not include LAN / Wi-Fi costs to meet ConnectED Goals

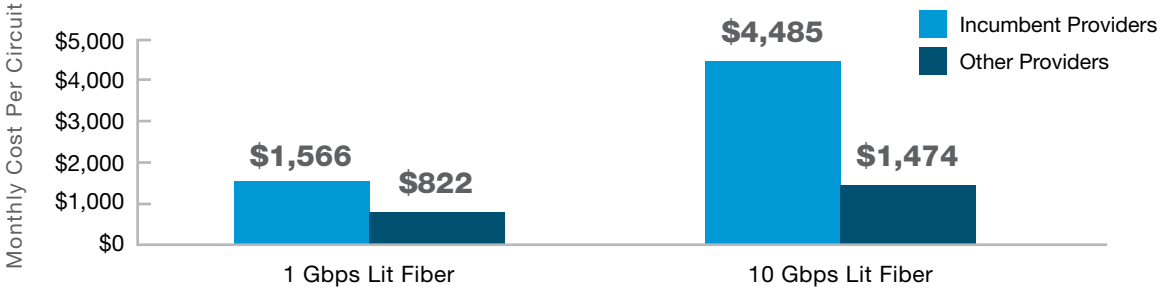
Strategy 3: Increase competition for district WAN

Districts in areas without competitive service providers are often left with few options for their WAN connectivity and end up paying significantly higher prices than their peers who are fortunate enough to be in competitive markets. The Item 21 data show that one of the major contributors to the variation in spending on bandwidth is the notable difference in prices between incumbent telephone and cable service providers and competitive service providers such as competitive local exchange carriers (CLECs), high-speed data network providers, public agencies (e.g., utility companies, county agencies, or municipalities), and other competitive entrants.

For a 1 Gbps district WAN connection, incumbent providers charge on average twice as much per circuit as other providers — $1,566 per month vs. $822 per month. At 10 Gbps, incumbent providers charge on average over three times as much — $4,485 per month vs. $1,474 per month per circuit. By encouraging market competition, better prices can be made available to schools, enabling faster and more efficient upgrades to 1 Gbps and 10 Gbps connections.[43]

[41] This factors in the effect of both scale purchasing and pricing transparency. We calculate the price based on the average of the top 50% prices at the quantity the district is purchasing.
[42] See *Appendix B, Section 9: Estimated Cost with Top 50% Pricing.* This factors in the effect of both scale purchasing and pricing transparency. Does not include LAN / Wi-Fi upgrades.
[43] See *Appendix B, Section 10: Incumbent and Non-Incumbent Providers*

Chart 30: Market competition results in significant cost reductions for district WAN



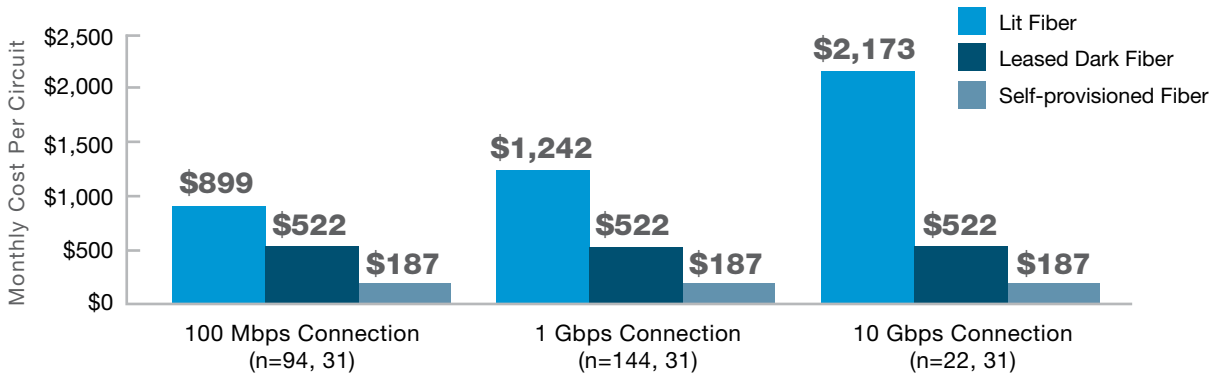
Another strategy for lowering district WAN prices is to provide districts with the option and resources to lease or self-provision dark fiber networks.

In a traditional commercial fiber service model, both the fiber and the optical equipment connecting the fiber at each end are leased from a service provider.[44] This is referred to as "lit fiber." In a "dark fiber" model, districts either lease or buy ("self-provision") the fiber from a service provider or fiber construction company and provide their own optical equipment.[45] This allows the districts to dramatically increase the capacity of their WAN through low cost upgrades to the optical equipment.[46] Notably, a recent survey reports that approximately 70% of districts already deploy and self-manage dark fiber networks for their on-campus connectivity needs.[47, 48]

In the Item 21 Sample, the average monthly cost of a leased dark fiber circuit, which can be configured for either 1 Gbps or 10 Gbps, is $522 per circuit, 58% lower than lit fiber at 1 Gbps and 76% lower than lit fiber at 10 Gbps. By comparison, the ongoing cost of maintaining a self-provisioned dark fiber connection, after the initial investment in infrastructure, is only $187 per month – 85% less than lit fiber at 1 Gbps and 91% less at 10 Gbps.[49]

[44] The optical equipment is what enables the fiber to transmit data.
[45] When dark fiber is leased, maintenance is typically provided by the service provider leasing the district the fiber. When fiber is owned, districts typically have a maintenance contract with a fiber construction and maintenance company.
[46] Today, the optical equipment required for a 1 Gbps WAN connection costs a few hundred dollars while the optical equipment required for a 10 Gbps WAN connection costs a few thousand dollars.
[47] Consortium for School Networking http://www.cosn.org/sites/default/files/2013EratebroadbandFinal.pdf?sid=289
[48] While self-provisioned dark fiber is currently an E-rate eligible service for on-campus internal connections use, self-provisioning dark fiber is not an E-rate eligible service for WAN connectivity.
[49] Magnolia Network Consulting, see Reply Comments of EducationSuperHighway to FCC's Notice of Proposed Rulemaking (Modernizing the E-rate Program for Schools and Libraries), filed November 8, 2013

Chart 31: Dark fiber WANs offer significant cost advantages over lit fiber



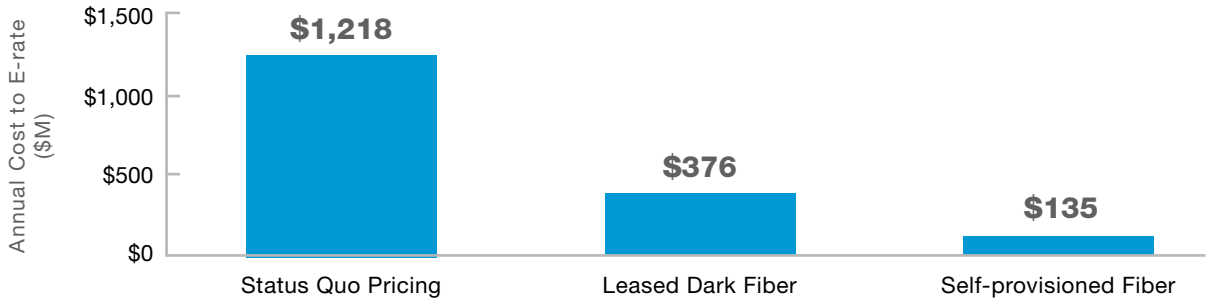
It should be noted that in order to take advantage of the long-term cost savings of self-provisioned fiber, a one-time up-front investment is needed to deploy the fiber infrastructure. However, because E-rate currently does not reimburse for self-provisioned fiber WANs, it is typically only the wealthiest districts that have the option to provide their own high-speed fiber. If the FCC wants to increase the WAN options available to every district, regardless of their financial resources, and reduce the cost of achieving the Current and Five Year Goals, providing districts with the funding they need for this one-time up-front investment appears to be one of the most cost-effective ways of doing so.[50]

Widespread deployment of leased and self-provisioned dark fiber networks would generate tremendous ongoing cost savings for E-rate. In the status quo environment, it would cost E-rate approximately $1.2 billion annually just to meet Current and Five Year Goals for WAN.[51] In contrast, if all districts had access to leased dark fiber networks, the annual cost to E-rate for WAN connections would be approximately $376 million, roughly 70% less than the status quo cost. Even more dramatically, if self-provisioned WAN connections were eligible for reimbursement, the annual WAN cost to E-rate would further decrease to just $135 million annually, roughly 90% less than the status quo cost.[52]

Despite the compelling nature of these estimates, there are many situations where dark fiber leases or self-provisioned WANs will not be the most effective choice for districts. Commercial providers with existing fiber networks who price their WAN services aggressively can actually offer superior costs while also reducing the need for districts to manage their own network. In many cases, simply making these options available to schools will incent commercial providers to be significantly more competitive with their prices. This is a strategy available to wealthy districts with the financial resources to fund their own fiber networks. In order to ensure that all districts, regardless of their financial resources, can utilize this strategy, the FCC can modernize the E-rate program to allow self-provisioning, just as it has allowed self-provisioning by healthcare providers eligible for Universal Service Fund Support.[53]

[50] Most service providers in low-competition markets are unwilling to lease dark fiber to customers. As a result, self-provisioning is typically the only competitive option that districts in these areas have.
[51] $1.2B is the WAN portion of the $11B status quo cost to meet the Five Year Goals. The remaining $9.8B is Internet access.
[52] See *Appendix B, Section 11: Estimated Cost (WAN) Using Dark Fiber.* $135 million = $187 per circuit x 90,000 schools needing WAN connections x 12 months x 66.5% (average E-rate discount across all schools)
[53] See FCC Rural Healthcare Connect Order: http://www.fcc.gov/document/fcc-releases-healthcare-connect-order

Chart 32: Widespread deployment of dark fiber would save E-rate 70 - 90% annually for district WAN

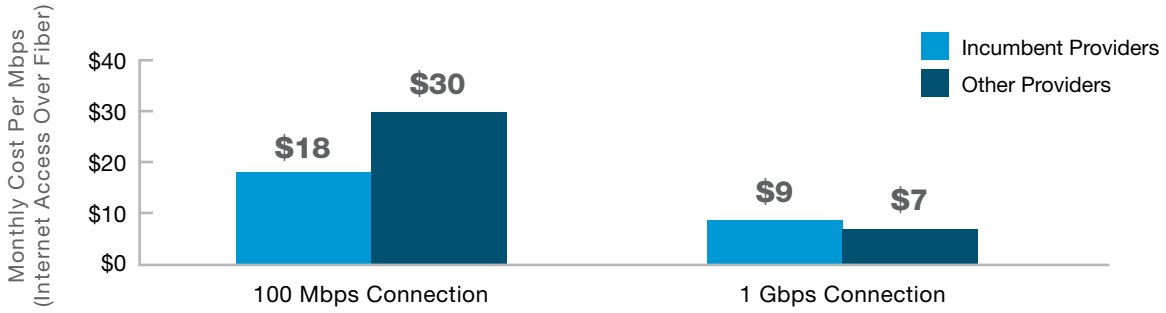


Does not include LAN / Wi-Fi costs to meet ConnectED Goals

Strategy 4: Increase competition for Internet access

For Internet access services reported in the Item 21 Sample, competitive service providers do not provide the same level of cost benefits over incumbent providers that we see for district WAN services. This may be due to a lack of operational scale, the high cost of backhaul to remote areas, or the likelihood that competitive providers must ultimately lease backhaul networks from incumbent providers.[54]

Chart 33: While effective for district WAN, market competition is not a reliable way to reduce costs for Internet access



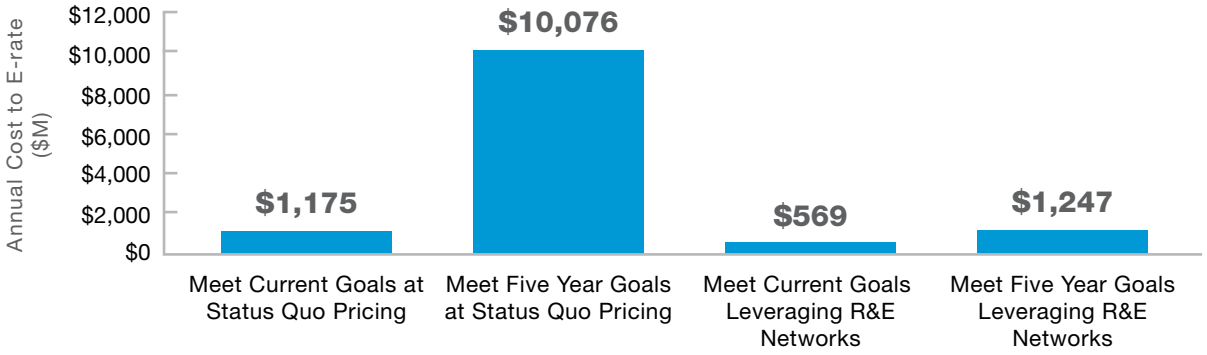
To solve the problem of high service costs for Internet access, districts in many states have been able to increase competitive options by leveraging the existing infrastructure of state research and education (R&E) networks. R&E networks have been established in 45 states by consortia of universities and state governments to provide member institutions with easily scalable and affordable bandwidth. In many cases, they provide the only cost effective option to incumbent providers for Internet access.[55]

[54] See *Appendix B, Section 10: Incumbent and Non-Incumbent Providers*
[55] Some states will need to make regulatory changes and/or additional investments in their R&E networks in order for their R&E networks to provide K-12 schools with the benefits described in this section.

R&E networks can achieve favorable economics by leasing or building a dark fiber backbone that connects directly to Internet exchange points where connectivity can be procured at a wholesale rates ranging from $0.50 to $3 per Mbps.[56] In order for K-12 schools to benefit from this low-cost, high-speed option, an initial investment must be made to connect K-12 districts to the existing backbone of R&E networks.

Once connected to the R&E network, the geographic location of a school no longer impacts its cost per Mbps for Internet access. As a result, schools in any location can buy Internet access at the same rates as school districts that are near Internet exchange points. This lowers the projected annual Internet access cost to E-rate for all schools to meet the Current Goals to $569 million per year. To meet the Five Year Goals, the projected annual cost is $1.2 billion — an 88% reduction from the cost under status quo pricing. In addition to delivering dramatic cost savings for Internet access, investing in transport to R&E networks may significantly increase a district's ability to scale its bandwidth for future needs by bringing a fiber connection to areas that currently lack access.[57, 58]

Chart 34: Investing in transport to state R&E networks for Internet access allows E-rate to meet Five Year Goals at an annual cost of $1.2B



Does not include LAN / Wi-Fi costs to meet ConnectED Goals

[56] For the purpose of this analysis we have used the $3 / Mbps pricing reported by QUILT (coalition of R&E networks across the U.S.). Serving K-12 districts would increase operational overhead for R&E networks, however at high volume this is a low percentage of total cost.

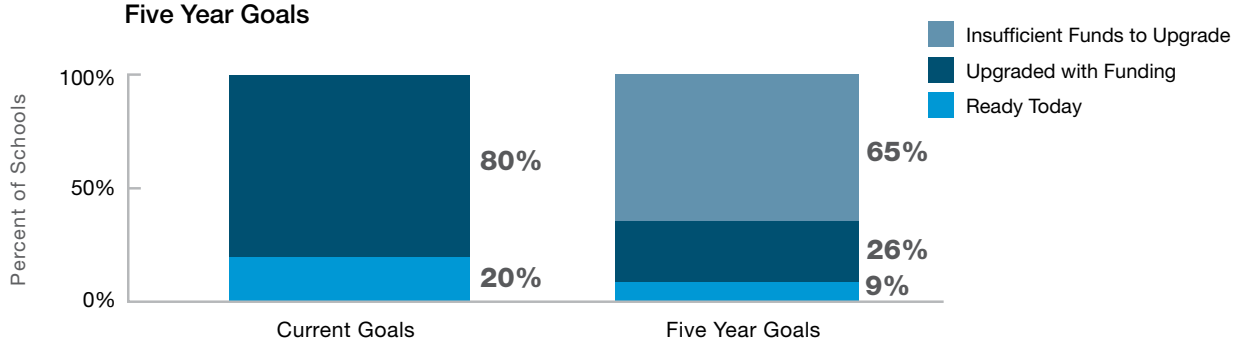
[57] See *Appendix B, Section 12: Estimated Cost (Internet Access) Leveraging R&E Networks*

[58] While connecting to R&E networks is one possible approach to lowering Internet access costs, the FCC should also consider options that significantly reduce the cost of middle mile transport for commercial carriers as this could have a similar impact on the cost of Internet access for schools and libraries.

Accelerator 4: Increase the funding cap

In order for every school to meet the Five Year Goals we must ensure that they have sufficient resources to purchase the broadband they need. Some participants in the E-rate modernization process have suggested that this can be accomplished by increasing the E-rate funding cap to $5 billion per year. This would add approximately $2.6 billion per year that could be used to subsidize broadband purchases and would enable every school to meet the Current Goals. However, in the absence of changes that improve the affordability of broadband, raising the cap to $5 billion would not be sufficient to meet the Five Year Goals, leaving 65% of schools with too little bandwidth.

Chart 35: Doubling the E-rate funding cap addresses Current Goals but leaves a large gap against Five Year Goals



Implications For E-rate

Based on the potential impact of each of the major accelerators identified herein for E-rate modernization – increasing access to fiber, focusing on broadband, optimizing costs and increasing funding – it is clear that no single lever will be sufficient to meet the president's ConnectED goals. Rather, E-rate modernization must be holistic and comprehensive in scope, addressing the core issues of access, scalability, market choice, and resources that prevent schools from obtaining the bandwidth they need.

EducationSuperHighway's analysis of Item 21 data suggests that three key changes to E-rate can help districts achieve the goals of a 1 Gbps district WAN connection and Internet access at 100 kbps per student today and 1 Mbps per student in five years:

1. Eliminate the capital investment barrier that precludes some districts from having the option of connecting their schools via fiber.
2. Focus on broadband by swiftly and thoughtfully phasing out support for non-broadband services in order to free up existing funds for connectivity upgrades.
3. Leverage all available options to lower the cost of bandwidth for schools and libraries including: capturing economies of scale through high-volume purchasing; increasing price transparency to reduce average prices; and increasing the competitive options available for Internet access and WAN services.

As K-12 school districts around the country plan for major upgrades to their connectivity, it is important to ensure that the investments made today pay off both now and in the future. With the right changes, the E-rate program has the potential to catalyze widespread upgrades in America's schools and ensure every child has equal access to educational opportunity.

Appendix A: Data Collection And Sampling

Section 1. Data Collection and Coding

Data collection process

From August 2013 to February 2014, EducationSuperHighway undertook an extensive outreach, collection, and coding process to build a representative database of national E-rate spending.

EducationSuperHighway initiated outreach efforts in August 2013 to every school district that filed a Form 470 for the 2013-2014 school year with the Universal Service Administrative Company (USAC), the administrative agency that oversees E-Rate. Form 470 allows districts to initiate a competitive bidding process for telecom and Internet access services. After a vendor has been selected, districts then file Form 471 to USAC for E-rate reimbursements. The purpose of EducationSuperHighway's outreach was to collect and analyze information from each district's Form 471 Item 21 attachment, which details the specific services for which funding was requested.

In the majority of states, EducationSuperHighway directly coordinated all data collection outreach efforts. In select states, EducationSuperHighway established partnerships with state contacts who coordinated data collection and outreach in their respective states.

In order to collect as much complete and representative E-Rate spending data as possible, EducationSuperHighway asked school districts to contribute all Priority 1 and Priority 2 Item 21 information from the 2013-2014 school year.

School districts submitted their Item 21 data through email attachments. As Item 21 data was received from districts and other E-rate applicants, it was checked for completion by referencing all Item 21 requests listed under each applicant's unique Billed Entity Number (BEN). For each incomplete Item 21 data submission, the missing information was identified, recorded, and requested from districts through follow-up communication.

EducationSuperHighway entered the information from complete Item 21 and Form 471 submissions into a database. Following this initial data entry, EducationSuperHighway further verified and coded the information according to an internal data taxonomy (defined below). Throughout this process, school districts were consulted with clarifying questions to ensure accurate coding of the reported data and obtain detailed breakdowns of the cost of services.

Coding and taxonomy

USAC categorizes E-rate requests into four categories of service: Telecommunications Services, Internet Access, Internal Connections, and Basic Maintenance. Of these four categories, Telecommunications Services and Internet Access are eligible for Priority 1 funding, and Internal Connections and Basic Maintenance are eligible for Priority 2 funding.

In order to establish a more detailed understanding of the uses and allocation of Priority 1 funding specifically, EducationSuperHighway developed an independent categorization of Priority 1 services according to the following taxonomy:

- **Data Network:** Services related to a district's broadband and data infrastructure, including Internet access and Wide Area Network services
- **Telephony:** Telephone services, including local and long distance phone service, trunk provisioning, voice over IP (VoIP) services, and exchange systems

- **Mobile:** Voice and data services for cell phones, wireless data services for tablets or laptops and other data services such as data or WiFi cards
- **Other Services:** Email services, web hosting, and any other services not belonging to the categories above

Data Network services were further sub-categorized as follows:

- **ISP (Internet Service Provider) Only:** Service offering direct access to the Internet from an ISP — does not include transport from the district to the ISP
- **Upstream:** Data transport from the district to the ISP — does not include Internet access service
- **Upstream & ISP:** Common bundled service offering data transport from the district to the ISP as well as Internet access through the ISP — this is the most common interpretation of "Internet access"
- **District WAN (Wide Area Network):** Data network connecting two or more separate buildings and/or campuses within a district
- **Upstream & WAN:** Bundled service offering data transport from the district to the ISP as well as within the district network — does not include Internet access
- **Upstream, ISP & WAN:** Bundled service offering data transport from the district to the ISP, data transport within the district network and Internet access through the ISP

In addition to service sub-categories, Data Network services were also classified according to service type, as defined by the technology transmitting the service. Data Network services were considered valid for pricing analysis if complete information was collected on the bandwidth capacity, quantity of connections, total cost, and contract duration. If any of these fields were incomplete, Data Network services were included only in analyses of total spend allocation and were not included in pricing analyses.

The following Data Network service types were represented in total spend allocation analyses but not in pricing analyses due to insufficient sample size or incomplete data:

- OC3
- OC12
- Other OC
- Satellite
- Frame Relay
- Broadband Over Powerlines

Mobile services were classified by the following sub-categories:

- **Voice:** Voice services for cellular phones
- **Data:** Data services for cellular phones or other mobile devices
- **Voice and Data:** Bundled voice and data services for cellular phones

Other non-broadband services were identified using the following service types:

- **Web Hosting:** Services for website hosting
- **Email Services:** Staff and/or student email services
- **Mixed:** Usually bundled web hosting and email services

EducationSuperHighway conducted extensive follow-up with participating school districts to ensure that Item 21 information received was coded as thoroughly and accurately as possible. If any given funding request (FRN) or contract submitted to EducationSuperHighway represented multiple services, those

services were entered as distinct line items and individually coded to allow more detailed analysis of the data. In these cases, total spending allocated to each service was based on follow-ups and clarification with each district.

In cases where services were uniquely bundled not according to the categories listed above and could not be unbundled through further clarification, the service was coded as "Mixed." (If a primary service was bundled with an ancillary service of much smaller size — e.g., 10 emails with 1 IP address — the service was coded as the primary service.) If services reported did not align with the categories identified, they were coded as "Other." In cases where categories, sub-categories, service types, or other service attributes could not be confidently identified, attributes were categorized as "Unknown."

Mapping to National Center for Education Statistics district and school data

Districts that submitted Item 21 attachments were mapped to their NCES IDs in order to cross-reference district size, locale, and FRL student percentage data from the NCES database. 41 of the 1,044 school districts in the final sample used for analysis could not be mapped to NCES IDs and 22 districts that were mapped had incomplete or missing NCES data (~1% of total sample spend). These districts were included in analyses of total program spending across categories of services, but were omitted from analyses requiring district demographic data (e.g., Internet access readiness, spend per student, etc.).

Section 2. Sampling and Distribution

EducationSuperHighway collected Item 21 data from approximately 1,200 districts. The final sample includes data from 1,044 school districts across 45 states, accounting for over 6 million students across approximately 11,000 schools; districts were excluded from the analysis if they submitted incomplete information. Total spending reported in the analysis sample was $468 million, corresponding to $363 million in E-rate funding requests (15% of the total E-rate fund). Of all reporting school districts, 1,039 reported Priority 1 spending totaling $263 million, or $188 million in funding requested. Within Priority 1, 897 districts reported spending that was categorized as Data Network spending, totaling $142 million, or $102 million in funding requested.

To ensure the sample was representative of the national population of K-12 public schools (about 100,000 total) of districts, an ideal distribution of funding and number of schools across locale and district size groupings was determined based on overall E-rate funding allocations within these segments and the total number of schools listed in the NCES database. Locale and district size were selected as the key dimensions for grouping districts because they were determined to be the most relevant factors impacting districts' broadband pricing and procurement.

Ideal Distribution by Funding Amount (P1)

	Size of Applicant		
Location Type	Small (<2,500 students)	Medium (2,500-9,999 students)	Large (10,000+ students)
Metropolitan	11%	9%	30%
Suburban Core	2%	4%	5%
Suburban Fringe	7%	9%	4%
Remote	12%	6%	1%

Ideal Distribution by Number of Schools			
	Size of Applicant		
Location Type	Small	Medium	Large
Metropolitan	5%	9%	32%
Suburban Core	1%	5%	6%
Suburban Fringe	8%	8%	4%
Remote	17%	5%	0%

Actual Distribution by Funding Amount (P1)				
	Size of Applicant			
Location Type	Small	Medium	Large	Unidentified
Metropolitan	3%	8%	43%	0.7%
Suburban Core	0.5%	5%	8%	0.1%
Suburban Fringe	4%	8%	5%	<0.1%
Remote	8%	5%	1%	0.2%
Unidentified	0%	0%	0%	0.6%

Actual Distribution by Number of Schools			
	Size of Applicant		
Location Type	Small	Medium	Large
Metropolitan	3%	8%	47%
Suburban Core	1%	4%	10%
Suburban Fringe	4%	5%	5%
Remote	9%	4%	1%

In order to minimize the impact of any biases in the sample relative to the ideal national distribution, the raw data sample was weighted by the ideal distribution in analyses where total program cost (actual and projections) and/or percentage of schools was a key metric. Examples of such analyses include: estimates of how E-rate funding is allocated today, estimates of the financial impact of certain policy levers, and estimates of the percentage of schools meeting a given connectivity metric. In these analyses, weighting the sample according to the ideal distribution helps to reduce bias caused by over- or under-representation of any particular district segment in the sample.

The raw data sample was not weighted in analyses of average pricing or bandwidth. Due to the granularity of the analysis, sample subgroups in these analyses were too small to detect meaningful differences between subgroups. An impact analysis revealed that average pricing calculations were not significantly impacted by using an unweighted rather than a weighted methodology.

Exclusions

Three districts that reported complete Item 21 information were excluded from the national analysis: Los Angeles Unified School District, Bering Strait Alaska, and Southwest Region Alaska. Los Angeles Unified School District is one of the largest districts in the United States; its Item 21 information represented $82

million in total spending ($69 million in funding requested), which would have constituted an overwhelming portion of the total sample and significantly skewed the analysis to be less representative of the national distribution of school districts. Bering Strait and Southwest Region in Alaska were excluded because their unique geographic situation creates pricing data that are outliers and would have heavily skewed the analysis.

Section 3. Representativeness

To ensure a representative sample of how E-rate funds are being spent today, the data collection process focused on obtaining complete and accurate Item 21 information from participating districts. It is important to note, however, that some districts may use broadband services that are not necessarily reflected in their Item 21 information.

For example, districts may use services that were purchased on their behalf by a state-level organization or other purchasing consortium. Some districts submitted Item 21 information for these services, while others did not, and as a result, those services would not always be reflected in the analysis. Or, a district may have a self-provisioned fiber network or other network components for which they do not apply for reimbursements from E-rate; as a result, these services would not be reflected in the Item 21 attachments submitted by the district to EducationSuperHighway.

Thus, estimates and analyses of district and school readiness are based on our best knowledge of the services districts use as reflected in the Item 21 Sample. While in some cases the Item 21 data do not capture the full range of services used by a district, the overall sample can still provide valuable insight on the national K-12 network landscape since the overwhelming majority of districts do request E-rate support for most of their telecommunications services and Internet spending.

Appendix B: Calculations and Assumptions

Section 1. District-Level and Line Item-Level Analysis

All analysis of the Item 21 data was conducted using either individual line items in the data sample or individual districts as the basic unit of analysis.

Each line item in the Item 21 data sample represents one distinct service reported in a district's Item 21 information. Districts may submit multiple funding requests and each funding request may be coded as multiple line items. For example, a district that reports one 1 Gbps WAN connection, two 100 Mbps WAN connections, and ten 50 Mbps WAN connections would have three line items associated with those services, one for each level of service.

The benefit of analyzing the data by line items is that it allows granular analysis of a certain type of product across the market. For example, a line item analysis can be used to determine the market rate for a 100 Mbps Internet connection over lit fiber in metropolitan areas sampled.

In other cases, however, it is beneficial to analyze the data by district, so that information collected from Item 21s on how much bandwidth is purchased in a district can be cross-referenced with information from the NCES database on the number of schools and students in a particular district, as well as the demographic profile of a district.

To enable a district-level analysis of the Item 21 data, the multiple line items associated with each district were aggregated into a single row for Internet access and a single row for district WAN.

Specifically, the district-level summary for Internet access included any line items that were coded as "Upstream & ISP," "ISP Only," and "Upstream only" services in districts that also reported "ISP Only" services. Of these sub-categories, "Upstream & ISP" constitutes 96% of total spend in the district-level Internet access sample.

The district-level summary for district WAN included any line items that were categorized as "District WAN," "Upstream & WAN," and "Upstream only" services in districts that did not also report separate "ISP Only" services. Of these sub-categories, "District WAN" constitutes 97% of total spend in the district-level WAN sample.

Throughout the paper, analyses done from the perspective of districts (e.g., percent of schools ready, total Internet access and WAN spend by district, district non-discounted portion expense, etc.) use the aggregated district summary of the data. Meanwhile, analyses on the cost of a specific type of service, whether fixed at a given speed, service type, or locale, use the individual line item view of the data.

Section 2. Nationwide Readiness (based on Item 21 Sample)

In the sample of 1,044 districts used for analysis, 897 districts reported information about Data Network spending. Of these, 138 districts were excluded from data network analysis due to one or more of the following reasons:

- Districts reported Data Network services that were not categorized as Internet Access or WAN (categorized as Other or Unknown)
- Districts were not mapped to NCES codes
- Districts had missing or incomplete NCES data on number of schools or students
- Districts reported Data Network services with missing information on bandwidth, quantity of connections, or sub-category of service

A total of 759 districts reported complete Data Network information on Internet access and/or district WAN services. The sample of Internet access information reported included 668 districts, and the sample of district WAN information reported included 336 districts. 245 districts submitted Item 21 information for both Internet access and district WAN. 423 districts submitted information for Internet access only, and 91 districts submitted information for district WAN only.

Three nationwide readiness metrics were taken to build a robust picture of Internet access and district WAN readiness across the sample:

1) Internet Access Readiness

Assessed for the 668 districts that reported Internet access spend. Total bandwidth for the district was calculated as the sum of download speeds across all Internet access services reported by a district. Bandwidth per student was calculated as the total bandwidth divided by the total number of students in the district according to NCES 2010 data. Districts and their associated number of schools (according to NCES 2010 data) were assigned to readiness categories based on the following delineations:

- Meeting Current Goals: 100+ kbps per student
- Not Meeting Current Goals: <100 kbps per student
- Not Meeting Five Year Goals: <1 Mbps per student

2) District WAN Readiness

Assessed for the 336 districts that reported district WAN spend. Average bandwidth per circuit for the district was calculated as the average download speed (weighted by quantity of circuits at each bandwidth) across all WAN services reported by a district. Districts and their associated number of schools (according to NCES 2010 data) were assigned to readiness categories based on the following delineations:

- Meeting Current Goals: 1+ Gbps per circuit
- Not Meeting Current Goals: <1 Gbps per circuit
- Not Meeting Five Year Goals: <1 Gbps per circuit

3) Combined Internet Access and WAN Readiness

Assessed for all 759 districts that reported Internet access or district WAN spend, based on amount of data reported:

- Districts reporting both Internet Access and WAN spend were categorized as "Meeting Current Goals" only if both their Internet Access and WAN were categorized as "Meeting Current Goals." If either service was not considered ready, the district was categorized as not meeting goals in the combined metric. Similar logic was used to assess readiness in five years.
- Districts reporting only Internet Access spend were assigned the same readiness category as their Internet Access readiness.
- Districts reporting only WAN spend were assigned the same readiness category as their WAN readiness

Section 3. Fiber Access Assessment

The availability of fiber to a given district was estimated based on all service types reported in the Item 21 data submitted by that district. Specifically, a district that reported any fiber connection was categorized as having access to or using fiber. Districts that reported no fiber connections were assessed as not having access to or using fiber.

We recognize that because the Item 21 information does not necessarily reflect all of the services used by a district, this methodology may "underestimate" the access to fiber for some districts. For example, a district that has the option of a fiber connection may choose to purchase cable modem instead, and would appear in the data set as reporting no fiber connection. It is for this reason that the analysis focuses on districts that do report fiber, recognizing that those districts are a subset of all districts that have access to fiber.

Section 4. Weighted Average Cost Methodology

All average cost per Mbps and cost per circuit calculations in the report were calculated using a weighted average methodology. The average cost per Mbps across any given sample of districts or services was calculated as the sum of total annual spending in the sample divided by the sum of all Mbps purchased in the sample throughout the year. The maximum number of months was 12, representing a full year of service and corresponding to the total annual spend, although some contracts were reported as multi-year contracts.

$$\text{Weighted Avg Monthly Cost per Mbps} = \frac{\Sigma\ \text{Total Annual Spending}}{\Sigma\ (\text{Number of Connections x Mbps per Connection x Contract Months})}$$

Similarly, the average cost per circuit (used to assess district WAN pricing only) across any given sample of districts or services was calculated as the sum of total annual spending in the sample divided by the sum of all quantities purchased in the sample throughout the year.

$$\text{Weighted Avg Monthly Cost per Circuit} = \frac{\Sigma\ \text{Total Annual Spending}}{\Sigma\ (\text{Number of Connections x Contract Months})}$$

This methodology has two effects on the average cost calculation:

- The pricing of higher volume contracts is weighted more due to the pooling of spend and total bandwidth across the sample. In other words, the calculation reflects economies of scale available at higher volume (both higher bandwidth and higher quantity of connections).
- Potential biases resulting from contracts of irregular length (e.g., 6 months instead of 12) are avoided by taking the average over an entire year.

Section 5. District Non-Discounted Portion

For each service in the Item 21 Sample, the total funding requested was divided by the applicant discount rate to determine total spend for the service. Thus, district non-discounted portion expense (i.e., expenses not reimbursed by E-rate funding) can be calculated as the difference between the total spend and the total funding requested. For Internet Access spending, district non-discounted portion expense was evaluated on a per-student level to reflect the relationship between bandwidth needed and number of students. For WAN spending, district non-discounted portion expense was evaluated on a per-school level to reflect the relationship between quantity of WAN connections needed and number of schools (typically each located in separate building or campuses) in a district.

Section 6. E-rate Spend Allocation

The overall categories for E-rate spend allocation analysis are based on the service categories and sub-categories defined in the data collection taxonomy (Data Network, Telephony, Mobile, and Other – see Appendix A for details).

In order to ensure that estimates for overall allocation of E-rate funds were not skewed by any bias in the sample, funding allocation was first calculated for each district segment in the sample (based on the segments used to determine the ideal funding distribution described in Appendix A). Then, the funding represented in each sample segment was adjusted to reflect the ideal funding distribution. For example, if a certain district segment accounts for 10% of total E-rate funding requests but only 5% of funding requests in the sample, the amount of funding for that segment would be doubled in the sample in order to reflect its ideal weight of 10% of total E-Rate funds.

Using this weighted sample, spend allocation could be calculated across categories of service. This percentage was applied to the current E-rate program cap of $2.38 billion as a way to more accurately estimate the amount of total E-rate funding currently being spent on different categories of service.

In the analysis of total program spend allocation, 5% of Data Network spend which could not be confirmed as a defined sub-category within the data collection taxonomy was allocated proportionally to district WAN and Internet access.

Section 7. Estimated Status Quo Cost

The estimated program cost to meet connectivity standards in the status quo pricing environment was calculated using a bottom-up approach that estimated the cost to meet connectivity standards for each district in the Data Network sample.

Internet Access

Total bandwidth needed to meet goals was calculated for each participating district based on the number of students (100 kbps per student for today's connectivity goal and 1 Mbps per student for the five year connectivity goal). For districts already meeting their goals, total cost was assumed to be the same as current reported cost.

For districts not meeting their goals, if the district was identified as having access to fiber or if its current reported service type was calculated as being sufficient to fulfill their bandwidth needs, the total cost was estimated as the current cost per Mbps multiplied by the total bandwidth needed.

For districts both not meeting their goals and not reporting a service type that could meet their needs, the analysis assumed that these areas would be prioritized for a fiber investment and that the access issue could be overcome. The cost per Mbps in these districts was estimated as the current market rate for fiber at their current reported capacity, and the total cost was estimated as this number multiplied by the total bandwidth needed.

District WAN

Districts already meeting their goals had no change in cost. For districts not meeting their goals, a new cost per month was calculated based on reported number of circuits multiplied by a market price assigned using the table below. Rates in the pricing table are for a 1 Gbps WAN connection over fiber per month, and are intended to reflect a distribution of pricing variability and effectiveness across the market.

WAN Cost Quartile	1 Gbps Lit Fiber
1st quartile	$386
2nd quartile	$1,134
3rd quartile	$1,628
4th quartile	$3,254

For example, if a district not meeting the WAN connectivity standard is currently purchasing WAN at a cost per Mbps in the third quartile of the overall WAN cost distribution in the sample, their monthly cost for a 1 Gbps WAN was assigned as the average monthly cost of the third quartile of 1 Gbps WAN connections in the sample.

For both Internet access and WAN pricing to meet the Five Year Goals, a 33% decrease over current prices was incorporated to account for the natural decline in prices over time as technologies and competition improve.

Finally, for each district segment detailed in Appendix A, Section 2, the percent increase of estimated status quo cost over current cost in the sample was applied to the total estimated current E-rate spend in that district segment overall in order to calculate the estimated new status quo cost to E-rate overall.

Section 8. Estimated Cost with Economies of Scale

The estimated program cost to meet connectivity standards, assuming that districts can achieve economies of scale, was calculated with a similar bottom-up methodology as the Estimated Status Quo Cost (see Section 7).

Internet Access

Districts that already meet connectivity standards were assumed to maintain their current cost per Mbps. For districts that were not meeting Internet access standards, the cost per Mbps was estimated based on the district's locale and total bandwidth need.

The pricing table below shows the estimated market price, including cost savings from economies of scale, for a lit fiber service at the given bandwidth level across each locale group:

Bandwidth	District Locale	
	Metropolitan and Suburban Core	Suburban Fringe and Remote
20 Mbps	$89.08	$74.01
50 Mbps	$29.54	$40.74
100 Mbps	$21.97	$32.13
500 Mbps	$15.49	$22.65
1,000 Mbps	$8.02	$11.73
10,000 Mbps	$1.76	$2.57

These rates were calculated using the Item 21 sample for Internet access. Specifically, rates for the metropolitan and suburban core areas at all speeds and rates for the Suburban Fringe and Remote areas for speeds up to and including 100 Mbps were calculated using the weighted average cost per Mbps from the Item 21 data sample.

Rates in the Suburban Fringe and Remote areas at speeds higher than 100 Mbps were estimated as a multiple of the corresponding cost per Mbps in a Metropolitan or Suburban Core area due to low sample size. This multiplier (approximately 1.46) was calculated from the cost premium of the Suburban Fringe and Remote areas at 100 Mbps.

For each district, the cost per Mbps was selected by rounding up the total bandwidth needed to the closest bandwidth level in the pricing table. The total Internet Access cost was then estimated by multiplying the cost per Mbps by the total bandwidth needed to meet standards.

District WAN

Districts already meeting their goals were assumed to have no change in cost. For districts not meeting their goals, the total WAN cost was estimated as the cost per circuit per month for a 1 Gbps circuit (based on the pricing table below) multiplied by the number of circuits reported in each district's Item 21 information.

Rates in the pricing table below reflect the average price for a WAN connection over fiber at economies of scale and take into account expected price variation across locales.

Locale	1 Gbps
Metropolitan	$1,221
Suburban Core	$923
Suburban Fringe	$1,538
Remote Area	$1,412

For both Internet access and WAN pricing to meet the Five Year Goals, a 33% decrease over current prices was incorporated to account for the natural decline in prices over time as technologies and competition improve.

The total estimated cost to the E-rate program overall was calculated from the cost impact in each district segment, as described at the end of Section 7.

Section 9. Estimated Cost with Top 50% Pricing

The estimated program cost to meet connectivity standards, assuming that districts can achieve both economies of scale and lower prices reflecting cost-efficient procurement practices, was calculated with an identical bottom-up methodology as the Estimated Cost with Economies of Scale (see Section 8) but based on different pricing tables.

Internet Access

The pricing table used for Internet Access cost per Mbps reflects the estimated average cost of the top 50% of rates in each market (segmented by locale and amount of bandwidth purchased):

Bandwidth	District Locale	
	Metropolitan and Suburban Core	**Suburban Fringe and Remote**
20 Mbps	$49.64	$47.35
50 Mbps	$13.98	$24.42
100 Mbps	$14.08	$17.32
500 Mbps	$8.44	$10.38
1,000 Mbps	$4.49	$5.52
10,000 Mbps	$1.48	$1.82

Rates for the Metropolitan and Suburban Core areas at all speeds and rates for the Suburban Fringe and Remote areas at speeds up to and including 100 Mbps were calculated using the weighted average cost per Mbps for the top 50% of rates from the Item 21 Sample.

Rates in the Suburban Fringe and Remote areas at speeds higher than 100 Mbps were estimated as a multiple of the corresponding cost per Mbps in a Metropolitan or Suburban Core area due to low sample size. This multiplier (approximately 1.23) was calculated from the cost premium of the Suburban Fringe and Remote areas at 100 Mbps.

District WAN

The pricing table used for district WAN cost per Mbps reflects the estimated average cost of the top 50% of rates in each market. Rates in the pricing table take into account expected price variation across locales.

Locale	1 Gbps
Metropolitan	$768
Suburban Core	$569
Suburban Fringe	$589
Remote Area	$957

For both Internet access and WAN pricing to meet the Five Year Goals, a 33% decrease over current prices was incorporated to account for the natural decline in prices over time as technologies and competition improve.

The total estimated cost to the E-rate program overall was calculated from the cost impact in each district segment, as described at the end of Section 7.

Section 10. Incumbent and Non-Incumbent Providers

For analysis purposes, service providers classified as "incumbent" include national phone and cable companies, as well as regional or local phone and cable companies that are incumbent providers in the area of service.

Section 11. Estimated Cost (WAN) Using Dark Fiber

Estimates of ongoing cost for widespread deployment of leased and self-provisioned dark fiber WANs assume that 89% of schools use a district WAN connection. This estimate assumes that all districts with four or more schools use a WAN (84% of all schools) and that 40% of districts with two to three schools also use a WAN (5% of schools).

Leased dark fiber cost estimates were based on an average cost of $522 per connection per month, derived from the Item 21 data. Multiplied by the total number of connections needed and the average subsidy rate for E-rate (66.5%), this resulted in annual estimated costs of $376 million. The average E-rate subsidy of 66.5% was calculated assuming that the average discount across schools that receive E-rate funding is 70%, applicable to 95% of schools that receive E-rate funding.

Self-provisioned dark fiber estimates were based on an average ongoing maintenance cost of $187 per circuit according to research conducted by Magnolia Network Consulting.[59] This resulted in annual estimated costs to E-rate of $135 million.

[59] See Reply Comments of EducationSuperHighway to FCC's Notice of Proposed Rulemaking (Modernizing the E-rate Program for Schools and Libraries), filed November 8, 2013

Section 12. Estimated Cost (Internet Access) Leveraging R&E Networks

Cost estimates of Internet access through R&E networks are calculated with fixed and variable cost components. These costs exclude the cost of transport to the R&E network from each district.

The variable cost component assumed total bandwidth needed of approximately five million Mbps today (100 kbps per student) and 50 million Mbps in five years (1 Mbps per student). Cost per Mbps was estimated as $3, based on rates reported by the QUILT, a coalition of R&E networks across the U.S. For the estimate of costs to meet Five Year Goals, a 33% decrease over current prices was factored in to account for the natural decline in prices over time as technologies and competition improve.

The fixed cost component was based on an estimated incremental operating expense of $15 million annually for a state R&E network to serve K-12 districts on a wide scale. This estimated $15 million is intended to reflect an average, high-level approximation across the 45 states where R&E networks are present today. Actual costs will vary widely depending on each network's current scale of service and ability to handle added capacity.

Section 13. Target Cost Methodology

Calculations for target WAN and Internet access costs were based on a holistic assessment of the average costs that need to be achieved in order for E-rate to serve the needs of all schools and students within its current budget.

The total budget for E-rate in five years was estimated at approximately $2.6 billion (including a 1.5% annual increase over the current budget to account for inflation). Out of this, $500 million was allocated for LAN / Wi-Fi costs.

For WAN, the target average cost per circuit was estimated at $750 per month. This target cost was triangulated against two comparison estimates:

1. The average of the top 50% of pricing at 1 Gbps observed across locales today (see pricing table in Section 9), weighted by the percent of schools in each locale nationally, is approximately $750 per circuit per month
2. The average pricing at 1 Gbps today is $1,272 per circuit per month, which, assuming a natural decline in prices over time of 33%, approaches approximately $800 per circuit per month in five years

For Internet access, the target average cost per Mbps was estimated at $3 per month. This target cost was triangulated against two comparison estimates:

1. The QUILT, a coalition of state research and education networks across the U.S., reports an average cost of $3 per Mbps per month today
2. The average of the top 50% of pricing observed across locales today (see Section 9), accounting for variations in bandwidth need based on district size, is approximately $4 per Mbps per month

About EducationSuperHighway

EducationSuperHighway is the leading non-profit focused on upgrading the Internet infrastructure in America's K-12 public schools. We believe that digital learning represents an unprecedented opportunity to provide every student with equal access to educational opportunity and that every school requires high-speed broadband to make that opportunity a reality.

EducationSuperHighway's data-driven programs help accelerate upgrades in America's schools. We work to raise awareness of the school connectivity gap, provide technical and procurement expertise to states and districts, and advocate on behalf of students to influence policy decisions. Our work has helped shape President Obama's ConnectED initiative and served as a catalyst for modernization of the Federal Communications Commission's E-rate program.

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