E-rate Policy Options Analysis

Introduction

On October 17th, EducationSuperHighway and CoSN filed *Bringing Everyone Up To Speed: An Analysis of Costs to Upgrade and Maintain WAN and Internet Access Connections for all K-12 Public Schools.* The filing analyzed the anticipated cost of ensuring that every K-12 public school could meet the FCC's K-12 connectivity targets by 2018. As part of this analysis, ESH & CoSN estimated the annual recurring costs for Internet access and Wide Area Network (WAN) connectivity over the next five years as schools increased their connectivity to meet the Commission's targets.

In all scenarios considered by our analysis, we estimate that, by 2018, approximately $2.8 billion per year will be required to purchase the Internet access and WAN connectivity that public schools will need to meet the Commission's goals. This translates into approximately $2 billion in E-rate subsidies at an average discount rate of 70%. Without concerted action by the Commission to lower the cost of broadband, these costs are expected to grow significantly in subsequent years as the 50%+ annual growth in the demand for broadband significantly outpaces the 10% per annum decline in broadband prices.

This additional analysis assesses the potential of three policy actions to lower the ongoing operating cost of broadband for K-12 public schools. On their own, each of these policy levers has the potential to lower the annual cost of Internet access and / or WAN connectivity for an individual school district by 30% or more. Collectively, EducationSuperHighway believes that these measures can lower the annual cost of broadband by 10-25% for the E-rate program and significantly improve the financial sustainability of the program beyond 2018.

Overview of Measures

EducationSuperHighway analyzed the potential impact of three policy measures on reducing E-rate program costs in the context of the ESH / CoSN Connectivity Cost Model:

1. Increased use of cost effective consortia at the state, intermediate unit, and local level
2. Increased viability of leased and owned dark fiber as a competitive option to lit services
3. Enhanced transparency of prices paid by all E-rate participants during the buying process

It's important to note that these policy measures work together as a group much better than any does individually – for example, transparency will let you know that you are overpaying, but many districts will need self-provisioning as a potential lower cost option to drive price changes on the part of a monopoly carrier with no service provider competition.

Analysis

Increased Use of Cost-Effective Consortia

As the Commission recognized in its July E-rate Modernization Order, consortia present an opportunity to lower the cost of broadband by aggregating demand, particularly for Internet access connections.

The impact on costs is largely driven by the consortium buying one or two large Internet connections to be shared among the members, who connect to the consortia hub using lower cost WAN connections. This enables the consortia to take advantage of the inherent economies of scale in broadband purchases. For example, the ESH / CoSN Connectivity Cost Model estimates that the cost per Mbps for Internet access when purchasing 100 Mbps of Internet access is $15.41 / Mbps / Month, while the cost of Internet access falls to $4.37 / Mbps / Month at 1 Gbps and $2.32 / Mbps / Month at 10 Gbps. Such aggregation can take place at many levels, and in this analysis we examine three of the most common scenarios: local consortia, existing intermediate unit / educational service agency consortia, and statewide networks.

In addition to the savings on Internet access costs through aggregation, consortia are able to negotiate lower pricing for WAN connections due to the volume of circuits purchased. Our analysis shows savings of 22% when comparing transactions involving 20 or more circuits (consortia or large/mega districts) with those of smaller purchasers.

Overall, Our general field experience is that consortia have been highly effective at delivering network services, frequently in excess of commercially feasible speeds at the time the network was designed. We have also seen significant variation in the cost-effectiveness of consortium network approaches, as well as significant variation in the ability of individual consortia to evolve their networks enough to meet changing district needs. Because of these latter factors, we do not support policies that benefit consortia based on their institutional structure, but instead a focus on those that are able to successfully realize the savings inherent from their aggregation.

State Level Consortia / Research & Education Networks

The largest opportunity for cost-savings from consortia is also the one currently most widely adopted -- aggregation of districts on a statewide level, usually managed by a Research and Education network (REN) or state government agency. Because of the scale of statewide purchasing and operations, as well as the technical experience of the sponsoring agencies, these consortia are generally sophisticated network operators who are not only able to take advantage of scale economies and increased competition, but are able to expand the set of service options by buying discrete components such as long-haul transport services, internetwork transit, and peered connections to other networks directly. RENs are also able to take advantage of national buying programs for those high-aggregation products through organizations like internet2 and The Quilt. As seen in Appendix A, EducationSuperHighway estimates that cost-effective state level consortia can save up to 39% on the cost of Internet access for the districts they serve. These savings may be somewhat reduced by reasonable decisions to invest in above average network quality and network management as compared to commodity bandwidth at the lowest price.

Intermediate Unit Level Consortia

The next logical level of demand aggregation takes place at the Education Service Agency (ESA) or intermediate unit level. ESAs exist in 80% of states and the vast majority of school districts are already affiliated with an ESA, giving a natural structure for consortium governance and allowing an existing organization to be used for logistical and administrative support.

Indeed, many ESAs across the country already successfully act as demand aggregators for the purchase of Internet access and WAN connectivity for K-12 public schools, either in concert with a statewide network, or

independently. The E-rate cost savings opportunity is to replicate these consortia to cover a greater percentage of ESAs and districts, and to make ESAs more effective purchasers of bandwidth. The mechanisms for cost savings are the same as described for statewide networks above. As seen in Appendix A, EducationSuperHighway estimates that Intermediate Unit level consortia can save approximately 28% on the cost of Internet access and 22% on WAN connections.

Local Consortia

The third form of consortia will be those created by geographically adjacent school districts or by a small handful of geographically associated school districts and libraries. These are relatively easy consortia to implement, with one institution taking the lead based on technical ability or financial resources, and then offering to help nearby colleagues. Like the larger scale consortia, the primary objective will be to purchase Internet access at a higher demand category. This may be achieved by conducting a joint procurement, which offers the possibility of small cost savings with no technical interdependence. More often, we anticipate that libraries or other schools will connect to a school district's existing WAN and from there to the Internet. As seen in Appendix A, EducationSuperHighway estimates that local consortia can save 38% on their Internet access costs.

Sizing the Consortia Cost Savings Opportunity

In order to determine the potential impact of FCC policies designed to create incentives for consortia formation it is also important to estimate the number of school districts that could be impacted by the various types of consortia. EducationSuperHighway's research suggests that 19 states currently do not have a strong state government network or REN and thus are opportunities for new state level consortia. Similarly, the recent CoSN / AASA survey suggests that 60% of districts are currently participating in consortia to purchase Internet access.[1] Taken together, this implies a maximum annual savings opportunity of $80-$240 million depending on the type of consortia implemented with the highest savings resulting from the implementation of state level consortia.[2] In addition, FCC policy can further increase the potential savings from consortia by enhancing the purchasing effectiveness of existing consortia.

Increased Viability of Dark Fiber WANs as a Competitive Option

In *Connecting America's Students: Opportunities for Action*, EducationSuperHighway analyzed the cost effectiveness of leased and owned dark fiber WANs as compared to lit fiber WAN circuits. The analysis concluded that for a 1 Gbps WAN circuit the average cost of leased dark fiber was 67% less than lit fiber and the average cost of an owned dark fiber WAN circuit was 88% less than lit fiber.[3] In addition, because the monthly operating cost of leased and owned dark fiber does not vary with the speed of the circuit, these savings levels increase significantly when school districts move to 10 Gbps or larger WAN connections.

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[1] CoSN's Second Annual E-rate and Infrastructure Survey In Partnership with AASA (the School Superintendents Association) and MDR at 9. http://cosn.org/cosns-second-annual-e-rate-and-infrastructure-survey. By comparison, only 15% of districts are

[2] We assume that if a state consortium is implemented then the intermediate unit and local consortia opportunities are eliminated. Similarly, we assume that if an intermediate unit consortium is implemented the local consortia opportunity is eliminated.

[3] *See* EducationSuperHighway, *Connecting America's Students: Opportunities for Action* (April 2014), at 30. *Available at* http://www.educationsuperhighway.org/uploads/1/0/9/4/10946543/esh_k12_e-rate_spending_report_april_2014.pdf.

Unfortunately, the E-rate program makes it difficult for schools and libraries to take advantage of the cost savings opportunities dark fiber presents. Today, applicants are not allowed to use E-rate funds to self-provision dark fiber WAN networks and not all of the costs associated with deploying leased dark fiber networks are eligible for discounts. By adopting policies that remove these restrictions and equalize the treatment of dark and lit fiber, the Commission can make dark fiber WAN networks a viable competitive option for schools and libraries.

Owned Fiber Networks

Once the initial build is completed, districts in urban, suburban, town and distant rural locations that deploy an owned dark fiber WAN can save 75-80% per year on the cost of their WAN including electronics amortization while remote rural districts can see 33% savings over lit fiber services.

For comparison purposes, it is also helpful to evaluate the cost savings when the cost of building the fiber network is included by amortizing these costs over the 20 year life of the fiber. In this case, districts in urban, suburban, town and distant rural locations that deploy owned dark fiber WANs save 36-63% per year depending on their geographic location.

This savings explains why a significant number of districts are self-provisioning fiber networks, even with no E-rate support. Unfortunately, because the E-rate program has not equally supported these low cost, high capacity solutions, they have only been available to affluent districts with the ability to raise capital from their communities.

Because of the extreme distances involved, districts in remote rural locations are unlikely to reduce their costs by deploying dark fiber WANs IF lit fiber services are already available. However if the fiber construction is already being funded by E-rate as part of closing the fiber gap, then owned dark fiber WANs present an attractive long-term cost structure.

Leased Dark Fiber Networks

While districts who own their fiber networks generally see the greatest savings in operating expenses, many districts may prefer to avoid capital investment and outsource the responsibility for maintaining the network's physical plant by leasing rather than owning their WAN. In this case, a leased dark fiber network can still provide significant cost benefits.

In cases where the physical infrastructure for dark fiber service exists, EducationSuperHighway estimates that districts in urban, suburban, town and distant rural locations that deploy a leased dark fiber WAN can save 55-72% per year on the cost of their WAN including the amortized cost of the electronics required to light the dark fiber. When the amortized cost of fiber construction is included, leased dark fiber WANs can save 20-38%.[4]

Sizing the Dark Fiber WAN Cost Savings Opportunity

In order to determine the potential impact of FCC policies designed to increase the viability of dark fiber WANs as a competitive option, we estimated the number of additional school districts that could utilize dark fiber WANs. EducationSuperHighway's research suggests that approximately 25% of schools are either already using leased or owned dark fiber networks or are in single location districts. As a result, the projected maximum savings from

[4] For leased dark fiber we assume that the service provider pays 70% of the cost of construction and the school district / E-rate is responsible for paying the remaining 30% over a five year period.

policies that increase the viability of dark fiber WANs is $672 million assuming a mix of leased and owned dark fiber implementations.

Enhanced Transparency of Prices Paid

In its July E-rate Modernization Order the Commission took important action to increase the transparency of the E-rate program. Specifically, the Commission directed the Wireline Competition Bureau and USAC to more effectively collect data about what applicants were purchasing with their E-rate funds along with the cost of those purchases, and then make that data publicly available. Once implemented, this will provide the information required to transform the K-12 Internet access, WAN and LAN/Wi-Fi equipment markets from opaque markets where providers hold the upper hand in price negotiations into fully transparent markets where buyers can reference market prices as the starting point for pricing discussions.

In order to estimate the impact of transparency on the projected cost of Internet access and WAN connectivity, EducationSuperHighway analyzed data from the one fully transparent market that exists within the E-rate program today - broadband over cable modems, where prices are typically listed on providers' web sites. By calculating the ratio of the 90th percentile price to the 10th percentile price we are able to assess the appropriate range of prices in a fully transparent market.[5] When applied to the 100 Mbps cable modem market, this approach reveals that in a fully transparent market, the 90th percentile price for a service should not be greater than 2.2 times the 10th percentile price of that service. By comparison, the 90:10 ratio for lit fiber Internet access ranges from 4.1 times at 100 Mbps to 4.7 times at 1Gbps. Similarly, the 90:10 ratio for lit fiber WAN connections ranges from 3.3 times at 100 Mbps to 4.4 times at 1Gbps. Thus, it is clear that the markets for lit fiber Internet access and WAN connections are not fully transparent.

To determine the potential cost savings from increased transparency, we applied the fully transparent market 90:10 ratio to the cost of lit fiber Internet access and WAN services at 100 Mbps, 1 Gbps and 10 Gbps. First, we analyzed the impact of moving the 90:10 ratio for each service to the 2.2 times level seen in the 100 Mbps cable modem market. We then considered the impact of being able to lower the 90:10 ratio only 50% of the way to that seen in a fully transparent market[6]. Under these scenarios we project the savings from transparency to range from 28-43% for Internet access and from 18-41% for WAN connections.

Sizing the Transparency Cost Savings Opportunity

In order to determine the potential impact of FCC policies designed to increase transparency, we first estimated the number of school districts where transparency could be expected to meaningfully impact prices. For Internet access, we assumed that all districts currently in a consortium were unlikely to benefit from increased transparency.[7] For WAN connectivity, we assumed that districts currently using owned or leased dark fiber would

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[5] We used the 90th and 10th percentiles in order to eliminate any outliers at either end of the spectrum, which in our sample are generally representative of particularly good or bad deals not representative of (and unlikely to be moved by) the broader market. The savings described in this analysis do not assume any cost reductions in these transactions.

[6] While we believe there will be significant benefits to purchasers in a more transparent market, we also recognize the non-cost factors such as customer service experience, quality and reliability issues associated with a provider, and incumbancy advantages will still affect customer choices even with full price transparency.

[7] In fact, it is likely that many consortia can benefit from transparency but the magnitude of the benefit is likely to be significantly lower than it is for districts that are not part of consortia.

not benefit from increased transparency. As a result, as seen in Appendix A, the projected maximum savings from transparency is $170-260 million for Internet access and $200-450 million per year for WAN connections. Together, these represent an opportunity to save nearly 25% of the annual cost of bandwidth for K-12 schools simply by ensuring that the lit fiber market functions in a fully transparent manner.

Interactions Amongst Policy Measures

In the preceding sections we have estimated the cost savings potential of each policy action the Commission might take to lower the cost of broadband for K-12 public schools. In order to maximize the potential cost savings for the E-rate program, the Commission should enact policies that encourage schools and libraries to take advantage of all of these measures. Indeed, EducationSuperHighway believes that the policy actions are complementary to each other, with consortia primarily being used to lower the cost of Internet access, dark fiber impacting WAN costs and transparency providing a simple approach to reducing expenses for all districts.

Policy Implications

In order to dramatically lower the cost of broadband for schools and ensure the sustainability of the E-rate program by leveraging consortia, dark fiber and transparency, the Commission must implement changes to both the rules of the E-rate program and the way it is managed by the Wireline Bureau and USAC. In this section we discuss rule and program management changes to enable these cost savings measures as well as those that are needed to close the fiber access gap.

Closing the Fiber Access Gap

Closing the fiber access gap requires the Commission to address two critical roadblocks that prevent districts from obtaining access to the fiber they need at a price they can afford. First, the Commission needs to dramatically reduce the need for districts to fund up-front, non-recurring costs (NRC). Second, the Commission must either require service providers to provide affordable fiber connections to schools and libraries or allow them to self-provision fiber networks when they are unable to obtain affordable fiber connections from a service provider.

Reducing Up-Front Non-Recurring Costs Paid by Districts

As was explained in *Bringing Everyone Up to Speed*, subsidizing up-front, non-recurring construction charges is the most cost effective way to pay for fiber construction. Indeed, the E-rate program already allows applicants to obtain discounts for these non-recurring costs. However, two rules significantly limit the number of schools that take advantage of these subsidies.

First, NRC greater than $500,000 must be amortized over the life of a contract. This is a problem because it means that fiber construction companies cannot be paid for their work when it is completed, an arrangement very few are willing to accept. As a result, applicants only take advantage of NRC when it is less than $500,000 which, given the cost of fiber construction, means that urban districts with more than 14 schools, towns with more than seven schools, rural districts with more than three schools and all remote schools, are effectively unable to use E-rate NRC subsidies to fund their fiber builds. Second, E-rate program rules currently require applicants to pay for the non-discounted portion of NRC in the year those costs are paid by E-rate. For a typical school district this can

amount to hundreds of thousands of dollars. Very few districts have the capital reserves or the ability to raise funds to cover these costs and thus few districts take advantage of NRC discounts.

In order to address these two issues and dramatically reduce the need for districts to fund up-front NRC, EducationSuperHighway recommends that the Commission make the following changes to the E-rate program:

1. For a period of five years, beginning with funding year 2015, suspend the rule requiring NRC greater than $500,000 to be amortized over the life of the contract for new fiber construction.[8] This will allow all schools to take advantage of the most efficient and cost effective funding for their fiber construction needs.
2. For the same five year period, increase the discount rate to 90% for all new fiber construction. As an alternative, provide matching funds for new fiber construction whereby the E-rate program matches any contributions from states, counties, municipalities, foundations or other donors for the un-discounted portion of the NRC.
3. Allow schools to amortize the un-discounted portion of the NRC for new fiber construction over the life of the contract while having E-rate pay the discounted portion of the NRC when the expense is incurred. This will greatly reduce the annual cost of the un-discounted portion of the NRC and will make vendor and bank financing a more realistic option by greatly reducing the overall amount needed to be financed.

Ensure All School Districts Can Obtain an Affordable Fiber Connection

During the course of the E-rate proceeding, ample evidence has been submitted indicating that many schools and libraries are still unable to obtain affordable fiber connections from service providers. This is not surprising as many of these applicants are located in areas where it is difficult or impossible for service providers to make a sufficient return on their investment to justify extending their fiber networks to these locations. If the Commission truly wants to ensure that every student has equal access to educational opportunity, it has no choice but to address this issue by either requiring existing service providers to provide affordable fiber connections to schools and libraries or allowing schools and libraries to use E-rate funds to self-provision fiber networks.[9]

In order to ensure that all schools have access to affordable fiber connections, EducationSuperHighway recommends that the Commission make the following changes to the E-rate program:

1. Add self-provisioned fiber networks to the Category 1 Eligible Services List. Restrict eligibility to cases where no service providers have responded to an RFP for lit or dark fiber connectivity or when applicants can demonstrate that self-provisioning is the most cost effective solution using a 20 year amortization for construction costs and a seven year amortization for optical equipment.
2. Add optical equipment required to light dark fiber to the Category 1 Eligible Services List. Limit the capacity of the equipment that a district can buy to the greater of i) 10 Gbps per connection or ii) the capacity required to meet the Commission's Internet access and WAN targets for the applicant plus a reasonable 5 year growth projection.

[8] A five year period is recommended in order to allow sufficient time for network design and to ensure that procurements are run effectively. In addition, it is anticipated that if a shorter time period is used, many districts will have trouble finding sufficient fiber construction capacity. By comparison, the BTOP program, which focused on easier to build middle mile fiber, took four years to build approximately 110,000 miles of fiber. EducationSuperHighway projects that over 70,000 miles of fiber will need to be built to close the fiber access gap.

[9] Adding self-provisioning to the eligible services list in limited situations has received widespread support from applicants, state educations agencies, RENs and even some service providers such as AT&T.

3. Add fiber maintenance contracts to the Category 1 Eligible Services List to ensure that self-provisioned networks are properly maintained.

In addition, EducationSuperHighway recommends that the Commission adopt the following changes to the Connect America Fund to minimize the number of schools and libraries that are required to self-provision in order to obtain access to fiber connections:

1. Mandate that community anchor institutions eligible for the E-rate program are included in the service obligations of CAF recipients.
2. Require that CAF recipients meet the connectivity targets for Internet access and Wide Area Network connections set out in its E-rate 2.0 Order.[10]
3. Consistent with this requirement, require all CAF recipients to provide all schools with greater than 50 students and all libraries with fiber optic broadband connections unless it can be demonstrated that an alternative technology can more cost effectively meet the connectivity targets set out in the Commission's E-Rate 2.0 Order.
4. Require CAF recipients to provide the required connectivity at prices that reflect those available to schools and libraries in urban areas and reflecting the fact that the capital costs of these connections are being subsidized by the CAF.

Increasing the Use Of Cost-Competitive Consortia

In order to encourage the formation of cost-competitive consortia, EducationSuperHighway recommends the Commission adopt the following changes to the E-rate program:

1. Provide an incentive for the formation of additional cost-effective consortia by providing a 5% additional discount for consortia that achieve 30% lower cost as compared to the market price for bandwidth that would otherwise be incurred if their members purchased Internet access independently.[11]
2. Make aggregation and long-haul transmission equipment used to connect consortia members eligible for E-rate discounts.
3. Adopt simplified rules that allow public, co-operative or non-profit networks to provide fiber connections and / or Internet access to schools and libraries without requiring a competitive bidding process if the connectivity is provided at a below-market rates.

Increase the Viability of Dark Fiber WANs as a Competitive Option

In order to increase the viability of dark fiber WANs as a competitive option, EducationSuperHighway recommends the Commission adopt the following changes to the E-rate program:

1. Equalize the treatment of dark and lit fiber in all respects including, but not limited to:
    a. Add optical transceivers to light dark fiber to the Category 1 Eligible Services List.

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[10] *See* Modernizing the E-rate Program for Schools and Libraries, FCC 14-99, WC Docket No. 13-184, Report and Order and Further Notice of Proposed Rulemaking, Order Released July 23, 2014 at ¶¶ 26-44

[11] In general, EducationSuperHighway supports the idea of providing incentives for *new* consortia formation when a consortium can demonstrate savings over what the individual consortia members would otherwise pay.

    b. Make all special construction charges related to the construction of dark fiber networks eligible for Category 1 E-rate reimbursement.
    c. Allow service providers to use ring designs when deploying dark fiber networks for schools and libraries in order to match the redundancy characteristics of lit fiber networks.
2. Allow 20 year contracts for leased dark fiber and IRUs when such contracts meet national benchmark prices for monthly operating costs.

Enhanced Transparency

In order to maximize the impact of enhanced transparency, EducationSuperHighway recommends the Commission adopt the following management approaches to the E-rate program:

1. Require USAC to publish updates to the Item 21 data as it clarifies purchases as part of the PIA process or approves changes to the submitted information based on applicants' requests.
2. Direct USAC to use the total cost of services and the cost of each service relative to the average price paid by E-rate applicants as the primary determinants of where to focus its PIA reviews.
3. Increase enforcement of the LCP rule and define what constitutes a similarly situated customer so that pricing data can be used to identify violations of the rule.
4. Standardize the collection of pricing data for Category 2 equipment.

Finally, as digital learning becomes an integral part of K-12 education and schools and libraries grow their Internet access and WAN purchases to meet the Commission's long term targets, the Commission should revisit its rules on redundancy. While the E-rate should not support fully redundant connections, the Commission should proactively clarify the program's support for fault tolerant networks, including designs that split a district's Internet access between two providers or two locations so long as they are not exceeding the bandwidth target set by the Commission. If districts are purchasing more than their 1 Mbps / student or staff of Internet access, they should be required to get a waiver from USAC or the Wireline Competition Bureau to split their traffic.

Appendix A: 2018 E-rate Cost Connectivity Model Policy Scenarios

Note: Total costs and savings shown are as of Funding Year 2018 and pre-E-rate discount

Internet Access Scenarios

State Networks	**Est. opportunity (# states)**	**% savings per state**	**Total opportunity**	**% of 2018 baseline**
New Network	19	39%	$236,744,194	16%
Consortia	**Est. opportunity (# districts)**	**% savings per consortium**	**Total opportunity**	**% of 2018 baseline**
Intermediate Unit Consortia	6,433	28%	$124,989,867	8%
Local Consortia	3,512	38%	$79,342,463	5%
Enhanced Transparency	**Est. opportunity (# connections)**	**% savings per connection**	**Total opportunity**	**% of 2018 baseline**
Partial (halfway to full transparency)	7,236	28%	$174,454,544	12%
Full Transparency	7,236	43%	$262,097,344	18%

WAN Scenarios

Enhanced Transparency	**Est. opportunity (# connections)**	**% savings per connection**	**Total opportunity**	**% of 2018 baseline**
Partial (halfway to full transparency)	75,599	18%	$197,659,544	15%
Full Transparency	75,599	41%	$450,258,172	33%
Consortia	**Est. opportunity (# connections)**	**% savings per connection**	**Total opportunity**	**% of 2018 baseline**
Volume Purchasing	21,538	22%	$40,782,561	3%
Dark Fiber (60% Leased + 40% Owned)	**Est. opportunity (# connections)**	**% savings per connection**	**Total opportunity**	**% of 2018 baseline**
Opex + Electronics	75,599	63%	$671,829,768	50%
Opex + Electronics + Construction	71,305	43%	$414,967,803	31%
Dark Fiber (100% Leased)	***Est. opportunity (# connections)***	***% savings per connection***	***Total opportunity***	***% of 2018 baseline***
Opex + Electronics	*75,599*	*56%*	*$608,515,801*	*45%*
Opex + Electronics + Construction	*71,305*	*34%*	*$328,891,469*	*24%*
Dark Fiber (100% Owned)	***Est. opportunity (# connections)***	***% savings per connection***	***Total opportunity***	***% of 2018 baseline***
Opex + Electronics	*75,599*	*75%*	*$794,096,996*	*59%*
Opex + Electronics + Construction	*71,305*	*58%*	*$557,927,972*	*41%*

Scenario: Consortia (Local / Intermediate Unit / State)

% of all districts currently in consortia	60%

Local Consortia

Potential number of participating districts	3,512					
	Tiny	Small	Medium	Large	Mega	Total
# of Districts	1	1	0	0	0	2
IA need (Mbps)	1,464					
Baseline Annual Cost	$49,893	$69,759	$0	$0	$0	**$119,652**
New Annual Cost	**$74,469**					
Internet Access	$52,445					
Transport to districts	$22,024					
Savings per consortium	**$45,184**	**38%**				
Total opportunity	**$79,342,463**					

Intermediate Unit Consortia

Potential number of participating districts	6,433					
District Categories	Tiny	Small	Medium	Large	Mega	Total
# of Districts	4	6	2	0	0	12
IA need (Mbps)	12,619					
Baseline Annual Cost	$199,572	$418,556	$215,522	$0	$0	**$833,650**
New Annual Cost	**$600,503**					
Additional staff (likely partial FTE)	$50,000					
Aggregated Internet access	$263,181					
Transport to districts	$107,322					
Aggregation equipment	$180,000					
Savings per consortium (annual)	**$233,147**	**28%**				
- Savings per consortium to E-rate	$198,203	34%				
Total opportunity	**$124,989,867**					
#NAME?	$106,256,407					

WAN volume purchasing savings opportunity

	Tiny	Small	Medium	Large	Mega	Total
# schools per district	1	3	9	26	113	
Total # schools	4	19	17	0	0	40
Baseline WAN cost per circuit	$0	$700	$902	$943	$943	
Est. WAN savings per connection	22%					
Est. WAN savings per consortium	$0	$154	$198	$207	$207	**$76,073**
Potential number of schools to benefit	21,538					
Total opportunity	**$40,782,561**					

State Network / REN

Potential new state networks	19					
District Categories	Tiny	Small	Medium	Large	Mega	Total
# of Districts	103	148	17	58	0	326
Avg Students/District	244	1,020	16,863	4,230	59,741	
Aggregated Concurency Ratio	4	4	2	1	1	
Bandwidth need (Mbps) - with concurrency	8,387	42,125	19,062	321,345	0	390,920
Bandwidth need (Mbps) - no concurrency	33,549	168,501	38,125	321,345	0	561,519
Baseline Annual Cost	$5,138,980	$10,324,379	$1,831,934	$14,759,103	$0	**$32,054,395**
New Annual Cost	**$19,594,175**					
Management	$2,500,000					
Aggregated Internet access	$9,243,001					
- Total bandwidth needed (Mbps)	332,282					
- blended IP transit cost (cost per Mbps)	$2.32					
Within-state backbone costs	$1,344,448					
- number of connections	14					
- cost per connection	$8,003					
Peered network connections	$200,000					
Transport to districts	$2,981,725					
Aggregation equipment	$3,325,000					
Savings per consortium (annual)	**$12,460,221**	**39%**				
Total opportunity	**$236,744,194**					

Assumptions

	Tiny	Small	Medium	Large	Mega			
Bandwidth need per district (Mbps)	326	1,139	2,243	5,540	18,146			
							Concurrency-adjusted load (Mbps)	
Bandwidth mix						IA pricing	Local consortia	Intermediate units
% 100Mbps	18%	10%	0%	0%	0%	$1,238	150	200
% 1Gbps	80%	80%	75%	30%	0%	$4,370	1,500	2,000
% 10Gbps	2%	10%	24%	55%	35%	$21,932	15,000	20,000
% 20Gbps	0%	0%	1%	13%	50%	$43,863	30,000	40,000
% 100Gbps	0%	0%	0%	2%	15%	$106,489	150,000	200,000
Transport pricing	$880	$956	$1,107	$1,625	$2,267			
Aggregation equipment per location, e.g.:	$237,500							
- Aggregation Router								
- L3 switch								
- Firewall / Security Appliance								

Scenario: Dark Fiber WAN

Cost Analysis

Reference Costs

	CapEx - build	CapEx - electronics	Lit Fiber Monthly Cost
Urban / Suburban	$35,400	$ 5,000	$1,055
Town	$68,500	$ 5,000	$1,176
Rural Distant	$176,800	$ 5,000	$1,713
Rural Remote	$642,720	$ 5,000	$1,713

Leased Dark Fiber - Monthly Opex + Electronics

	Monthly Cost	Monthly Savings ($)	Monthly Savings (%)
Urban / Suburban	$477	$578	54.82%
Town	$477	$700	59.48%
Rural Distant	$477	$1,236	72.18%
Rural Remote	$1,115	$598	34.91%

Leased Dark Fiber - Monthly Opex + Electronics + Amortized Construction

	Monthly Cost	Monthly Savings ($)	Monthly Savings (%)
Urban / Suburban	$654	$401	38.04%
Town	$819	$357	30.36%
Rural Distant	$1,361	$352	20.57%
Rural Remote	$4,329	-$2,616	-152.69%

Owned Fiber - Monthly Opex + Electronics

	Monthly Cost	Monthly Savings ($)	Monthly Savings (%)
Urban / Suburban	$247	$808	76.63%
Town	$247	$930	79.04%
Rural Distant	$360	$1,353	79.01%
Rural Remote	$1,154	$559	32.66%

Owned Fiber - Monthly Opex + Electronics + Construction

	Monthly Cost	Monthly Savings ($)	Monthly Savings (%)
Urban / Suburban	$394	$661	62.65%
Town	$532	$644	54.77%
Rural Distant	$1,096	$617	36.01%
Rural Remote	$3,832	-$2,119	-123.67%

Size of Opportunity

Est. schools using lit fiber	75,599

Total Schools and Districts (NCES 2011)

	Total number of schools	Schools not Applicable	Available Market by Locale
Urban / Suburban	56,796	12,095	44,701
Town	25,801	6,048	19,753
Rural Distant	10,480	3,629	6,851
Rural Remote	6,713	2,419	4,294

Estimated Leased / Owned Mix

Locale	Leased Dark	Owned
Urban / Suburban	35,760	8,940
Town	7,901	11,852
Rural Distant	1,370	5,481
Rural Remote	429	3,865

Savings Summary

Leased Dark Fiber

	Opex + Electronics	Opex + Electronics + Construction
Urban / Suburban	$310,216,921	$215,272,982
Town	$165,830,493	$84,644,561
Rural Distant	$101,653,162	$28,973,926
Rural Remote	$30,815,225	
Total	$608,515,801	$328,891,469
# schools	75,599	71,305
Avg Savings per School	56%	34%
Savings vs. Baseline	45%	24%

Owned Fiber

	Opex + Electronics	Opex + Electronics + Construction
Urban / Suburban	$433,625,825	$354,505,876
Town	$220,365,167	$152,710,224

Rural Distant	$111,277,902	$50,711,872
Rural Remote	$28,828,102	
Total	$794,096,996	$557,927,972
# schools	75,599	71,305
Avg Savings per School	75%	58%
Savings vs. Baseline	59%	41%

Leased Dark / Owned Mix

	Opex + Electronics	Opex + Electronics + Construction
Urban / Suburban	$334,898,702	$243,119,561
Town	$198,551,298	$125,483,959
Rural Distant	$109,352,954	$46,364,283
Rural Remote	$29,026,814	
Total	$671,829,768	$414,967,803
# schools	75,599	71,305
Avg Savings per School	63%	43%
Savings vs. Baseline	50%	31%

Scenario: Enhanced Transparency

Internet Access		2014 Average Cost per Month			2018 Average Cost per Month			Price Decrease	
Pricing	Service Type and Bandwidth	Baseline	Partial Transparency	Full Transparency	Baseline	Partial Transparency	Full Transparency	Partial Transparency	Full Transparency
	100 Mbps Lit Fiber	$2,522	$1,900	$1,475	$1,550	$1,168	$907	25%	42%
	100 Mbps Cable	$328	$328	$328	$194	$194	$194	0%	0%
	100Mbps Fixed Wireless	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	0%	0%
	1Gbps Lit Fiber	$8,323	$5,838	$4,511	$4,915	$3,447	$2,664	30%	46%
	10Gbps Lit Fiber	$41,061	$28,800	$22,256	$23,181	$16,259	$12,564	30%	46%
	10Gbps Transport to POP + ISP	$30,000	$24,441	$24,441	$16,936	$13,798	$13,798	19%	19%
	2x10Gbps Lit Fiber DIA	$82,123	$57,600	$44,512	$46,361	$32,517	$25,129	30%	46%
	2x10Gbps Transport to POP + ISP	$60,000	$48,882	$48,882	$33,872	$27,596	$27,596	19%	19%
	100Gbps Transport to POP + ISP	$240,000	$195,528	$195,528	$106,489	$86,757	$86,757	19%	19%

Annual Opex	# connections	Baseline	Partial Transparency	Full Transparency
100 Mbps Lit Fiber	1,631	$30,338,101	$22,862,053	$17,744,251
100 Mbps Cable	815	$1,895,239	$1,895,239	$1,895,239
100Mbps Fixed Wireless	272	$8,154,480	$8,154,480	$8,154,480
1 Gbps Lit Fiber	4,849	$285,988,327	$200,588,873	$155,011,974
10 Gbps Lit Fiber	678	$188,554,794	$132,250,130	$102,200,852
10 Gbps Transport to POP + ISP	169	$34,440,280	$28,058,538	$28,058,538
2x10 Gbps Lit Fiber DIA	78	$43,289,084	$30,362,458	$23,463,637
2x10 Gbps Transport to POP + ISP	19	$7,906,923	$6,441,779	$6,441,779
100 Gbps Transport to POP + ISP	19	$24,289,778	$19,788,911	$19,788,911
Total	**8,531**	**$624,857,005**	**$450,402,461**	**$362,759,661**
Total savings			$174,454,544	$262,097,344
Percent of savings from baseline			12%	18%
Avg savings per connection			28%	43%

District WAN		2014 Average Cost per Month			2018 Average Cost per Month			Price Decrease	
Pricing	Service Type and Bandwidth	Baseline	Partial Transparency	Full Transparency	Baseline	Partial Transparency	Full Transparency	Partial Transparency	Full Transparency
	100 Mbps Leased Lit Fiber WAN	$958	$840	$717	$687	$602	$514	12%	25%
	100 Mbps Fixed Wireless	$1,784	$1,784	$1,784	$1,784	$1,784	$1,784	0%	0%
	1 Gbps Leased Lit Fiber WAN	$1,408	$1,147	$882	$832	$678	$521	19%	37%
	1 Gbps Fixed Wireless	$1,784	$1,784	$1,784	$1,784	$1,784	$1,784	0%	0%
	10 Gbps Leased Lit Fiber WAN	$4,509	$3,673	$2,435	$2,001	$1,630	$1,080	19%	46%
	2x10 Gbps Leased Lit Fiber WAN	$9,018	$7,347	$4,869	$4,001	$3,260	$2,161	19%	46%
	100Gbps Leased Lit Fiber WAN	$54,000	$43,994	$29,158	$23,960	$19,520	$12,938	19%	46%
	Leased Dark Fiber WAN	$767	$767	$767	$619	$619	$619	0%	0%
	Owned Dark Fiber WAN	$200	$200	$200	$200	$200	$200	0%	0%
	Site-to-site VPN	$0	$0	$0	$0	$0	$0	-	-

Annual Opex	# connections	Baseline	Partial Transparency	Full Transparency
100 Mbps Leased Lit Fiber WAN	15,264	$125,910,276	$110,322,110	$94,179,430
100 Mbps Fixed Wireless	954	$20,427,682	$20,427,682	$20,427,682
1 Gbps Leased Lit Fiber WAN	38,926	$388,452,933	$316,473,072	$243,243,715
1 Gbps Fixed Wireless	2,595	$55,567,739	$55,567,739	$55,567,739
10 Gbps Leased Lit Fiber WAN	19,725	$473,553,137	$385,804,311	$255,703,991
2x10 Gbps Leased Lit Fiber WAN	1,518	$72,894,071	$59,386,888	$39,360,535
100Gbps Leased Lit Fiber WAN	166	$47,682,490	$38,846,982	$25,747,064
Leased Dark Fiber WAN	0	$0	$0	$0
Owned Dark Fiber WAN	0	$0	$0	$0
Site-to-site VPN	7,297	$0	$0	$0
Total	**86,446**	**$1,184,488,328**	**$986,828,784**	**$734,230,155**
Total savings			$197,659,544	$450,258,172
Percent savings from baseline			15%	33%
Avg savings per connection			18%	41%

Backup: Enhanced Transparency Price Ratios

Service	Purpose	90th percentile price	10th percentile price	Current 90:10 ratio	Partial transparency ratio
100 Mbps (	Internet Acc	$418	$188	2.22	
100 Mbps L	Internet Acc	$3,950	$954	4.14	3.2
1 Gbps Lit F	Internet Acc	$15,069	$3,230	4.67	3.4
100 Mbps L	WAN	$1,500	$454	3.30	2.8
1 Gbps Lit F	WAN	$2,665	$600	4.44	3.3

Backup: Enhanced Transparency Sample Calculation

	Current Cost/Month	Relative Price Distribution	Partial Transparency Pricing	Full Transparency Pricing
Line item 1	$500			
Line item 2	$662			
Line item 3	$754		$754	$754
Line item 4	$1,200	0.11	$1,028	$856
Line item 5	$1,200	0.00	$1,028	$856
Line item 6	$1,600	0.10	$1,274	$948
Line item 7	$1,990	0.10	$1,514	$1,037
Line item 8	$2,000	0.00	$1,520	$1,040
Line item 9	$2,093	0.02	$1,577	$1,061
Line item 10	$2,248	0.04	$1,672	$1,097
Line item 11	$2,400	0.04	$1,766	$1,131
Line item 12	$2,500	0.03	$1,827	$1,154
Line item 13	$2,542	0.01	$1,853	$1,164
Line item 14	$2,678	0.03	$1,937	$1,195
Line item 15	$3,278	0.15	$2,305	$1,333
Line item 16	$3,700	0.11	$2,565	$1,430
Line item 17	$4,275	0.15	$2,918	$1,561
Line item 18	$4,700		$3,179	$1,659
Line item 19	$5,550			
Line item 20	$15,000			
90th percentile	$4,700			
10th percentile	$754			
Current Ratio	6.2			
Partial Transparency Ratio	4.2			
Full Transparency	2.2			
Average Cost/Month	$2,447		$1,795	$1,142

Appendix B: Model Explanation and Methodology

This appendix details the structure and methodology of the model that informs our recommendations for each policy scenario discussed in the preceding comments: increased use of cost-effective consortia, increased viability of leased and owned dark fiber WANs as a competitive option, and enhanced transparency of prices.

The model includes a summary tab that outlines the total potential impact of each scenario, one tab for each scenario detailing the underlying analysis and mechanisms, two tabs of supporting analysis for the enhanced transparency scenario, and the ESH & CoSN Connectivity Cost Model (referred to throughout this appendix as the "Connectivity Cost Model"), which provides the baseline for analyzing the impact of each scenario and also includes many key scenario inputs such as bandwidth need and pricing.

Scenarios Summary

The scenarios summary section shows total impact of each policy option and is organized into scenarios that impact Internet access costs and scenarios that impact WAN costs. For example, the formation of new consortia primarily results in Internet access cost savings, while adoption of leased dark or owned fiber results in WAN savings. Increased transparency can provide savings for both Internet access and WAN.

For each scenario, this tab summarizes the estimated opportunity (the total number of entities that could potentially benefit from the scenario[1]), percent savings per unit of analysis, total annual savings, and savings as a percent of the 2018 total baseline cost published in the Connectivity Cost Model.

It is important to note that in practice, the implementation of certain scenarios supersedes the modeled impact of other scenarios. Specifically:

- We assume that districts in consortia perform efficiently and thus receive no additional benefit from transparency. However, given that a number of consortia are less cost efficient, transparency might be used to help create savings.[2]
- Formation of a state network would reduce the potential number of districts that could form intermediate unit and local consortia. Similarly, formation of new intermediate unit consortia would reduce the potential number of districts that could form local consortia.
- Districts that used leased or owned dark fiber for WAN have minimal additional benefit from price transparency, because they are likely already using the most cost-effective option in their area

[1] For example, the state network scenario can only provide benefits for those states that do not already have a functional state network; estimated to be 19 states in this model

[2] The potential effect of transparency on consortia that are not cost-effective has not been modeled

Scenario: Consortia

We estimated the impact of forming new consortia by modeling the economics of a single consortium at the local, intermediate unit, or state level. In all cases, there are three cost components driving the impact:

1. Internet access purchasing is aggregated at a single site, which lowers costs in two ways:
    a. Total bandwidth need is lower due to concurrency benefits
    b. Higher purchasing volume allows for better economies of scale
2. District connections that were previously direct Internet access are replaced by lower-cost WAN connections of the same bandwidth
3. Intermediate unit and state consortia incur additional overhead costs (e.g. management and aggregation equipment[3])

Local Consortia

We modeled the impact of a local consortium by considering the economics of one Tiny district (one school) and one Small district (2-5 schools) forming a consortium. The potential number of districts participating in new local consortia is based on the total number of Tiny districts (1 school), the percentage of districts not already participating in consortia today[4], and the total number of districts per consortium.

Based on the Connectivity Cost Model, the total 2018 Internet access need of a Tiny and Small school district is 1.5 Gbps, and the baseline annual cost for each districts to purchase Internet access separately is roughly $120,000. By aggregating Internet access purchasing, these districts can reduce their total Internet access cost to just $52,000 annually, and incur an added WAN cost of $22,000 to connect to the aggregation site. This results in total savings of $45,000 annually, or 38% of the original cost.

Intermediate Unit Consortia

This analysis assumes a consortium of 12 districts, composed of 4 Tiny districts, 6 Small districts, and 2 Medium districts. Both the consortium size and the distribution across size categories are based on the typical size of an intermediate unit and the natural distribution of districts by size in the states where we believe such consortia are most likely to be formed (those that do not already have strong state networks). The total potential number of districts participating in new consortia is based on the percentage of districts not already participating in consortia today applied to the total number of districts nationally.

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[3] While not always eligible for E-rate (depending on whether a consortium participates as a service provider or a beneficiary) we have included management costs in order to more accurately model the relative economics of operating consortia-sized networks. Though many combinations exist, we modeled only the most common cases, including the costs In the case of state networks to reflect the significant number who are considered service providers, and excluding them for intermediate units.

[4] The Consortium for School Networking's *2nd Annual E-rate and Infrastructure Survey* showed that 60% of districts today reported participating in consortia for purchasing Internet Access

The total 2018 Internet access need of the modeled consortium is 13 Gbps, with a baseline annual cost of $834,000 if districts purchase Internet access separately. Aggregated Internet purchasing, meanwhile, would cost only $263,000, plus an additional $107,000 in transport from each district to the aggregation site. For this scenario, we also assumed $50,000 annual cost for staff overhead and $180,000 annually for the amortized cost of aggregation equipment (router, switch, firewall). This results in total savings of $233,000, or 28% of the original cost. From an E-rate perspective, because the staff overhead is not eligible for reimbursement, savings are 34% per consortium.

Additionally, we researched the potential for WAN cost savings if a consortium at this level were to aggregate purchasing for school WAN connections. Analyses of the Item 21 data have shown that WAN circuits purchased in quantities between 20-50 have a 22% lower average cost per connection compared to those purchased in quantities lower than 20. Based on the total number of schools in a typical intermediate unit consortium and the WAN bandwidth need at each school, we estimate that a consortium at this level could save $76,000 annually through consolidated purchasing of school WANs.

State Network / REN

We estimated the potential for up to 19 new state networks to be created, based on an assessment of existing state networks that already have a strong K-12 customer base today. The number of districts per new state network is based on the average number of districts in these states today, subtracting Mega districts (51+ schools), because they already benefit from high purchasing volume today and their participation does not usually improve the economics of a consortium. The distribution of districts across the remaining size categories is based on the actual distribution of districts in the states where we believe there is a significant opportunity for a new state network to serve K-12.

Using the bandwidth needs and pricing analysis published in the Cost Connectivity Model, we estimate that the total 2018 Internet access need of districts in the average potential state network is 391 Gbps, which includes the impact of concurrency benefits. If districts were to purchase Internet access individually, the total demand would be 562 Gbps and cost $32 million annually.

In the “New Annual Cost” section of this analysis, we have modeled the economics of meeting the bandwidth needs of these districts via a state network:

- Management: Estimated $2.5 million in annual management and overhead cost
- Aggregated Internet Access: $9.2 million annually, based on 332 Gbps of bandwidth need at a cost of $2.32 per Mbps, having already factored out 15% of total need served by peered connections or in-state sources.
- Within-state backbone costs: $960,000 annually based on 14 backbone transport connections of 40Gb each.[5]

[5] Assuming 10 aggregation sites with additional circuits to mesh for fault tolerance. In practice, we would expect a mix of heterogenous circuit speeds based on the user load at each aggregation site.

- Peered network connections: $200,000 annually for costs to connect to national networks (e.g. Internet2, CDNs, etc.) on a transit-free peering basis.
- Transport to districts: $3 million annually to connect each participating district to a backbone hub, including a 28% discount for WAN volume purchasing in quantities greater than 50
- Aggregation equipment: $2.4 million annually for amortized cost of equipment at each hub

This results in total cost of $20 million annually per state network, 39% lower than the baseline cost of $32 million. Multiplied by the 19 states where there is opportunity for a K-12 network, this results in a total savings opportunity of $237 million.[6]

Assumptions

This section details the key assumptions for the consortia scenario, including:

- Bandwidth need, bandwidth mix, and IA and WAN pricing: Based on the Connectivity Cost model
- Concurrency-adjusted load: Estimated benefit of aggregating multi-site networks; e.g. a local consortia in which districts need 1.5 Gbps could buy 1 Gbps Internet access to meet those needs
- Aggregation equipment per location: Cost of routers, switches, and firewall at each aggregation site (1 per intermediate unit consortium, 10 per state network)

Scenario: Dark Fiber WAN

This scenario estimates the cost savings if districts are encouraged to make the switch from a managed lit fiber WAN to a leased dark or owned fiber WAN.

Cost Analysis

In this section, we show the underlying cost assumptions for lit, leased dark, and owned fiber WANs. The cost analysis is broken out by locale to reflect the fact that the economics and savings potential vary widely by geography.

The cost for lit fiber is the monthly cost per connection charged to the district by the service provider. Monthly operating expense for lit fiber services was calculated based on Item 21 data from 2013 and annual price declines to 2018 detailed in the Connectivity Cost Model. Weighted average pricing by locale reflects both the natural trend of higher pricing in more remote areas and the greater bandwidth need in urban areas due to larger school sizes.

For leased dark and owned fiber, there are three cost components:

- Monthly operating expense (incl. provider overhead for leased dark fiber)

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[6] This analysis assumes that state networks will act as service providers and embed these costs into monthly service charges to districts, and that therefore all cost components, while modeled separately, are eligible for E-rate reimbursement.

- Capital expense for electronics
- Capital expense for fiber construction

Monthly operating expense for leased dark fiber in urban / suburban and town locales was calculated from Item 21 data, which we believe accurately reflects providers' costs and overhead in those areas. For leased dark fiber in rural locales and owned fiber in all locales, monthly operating expense was calculated based on estimated maintenance costs per mile plus 20% overhead/margin.

Capital expenses for leased dark and owned fiber are based on the Connectivity Cost Model and are incorporated into the model under two cases:

1. Cost of electronics is amortized over 7 years and added to the monthly operating expense
2. In addition to the cost of electronics, cost of fiber construction is factored into the monthly operating expense. For leased dark fiber, 30% of construction costs are charged to schools and amortized over 5 years. For owned fiber, the schools bear 100% of the construction cost, which is amortized over 20 years.

An estimated savings opportunity per connection is estimated in each locale by calculating the difference between lit fiber pricing and the estimated cost of leased dark and owned fiber, respectively. For example, the average monthly cost of a lit fiber WAN connection in an urban / suburban area is $1,055, while the average monthly cost of a leased dark fiber WAN, including the amortized cost of electronics, is $477. This results in monthly savings of $578 per connection.

Size of Opportunity & Savings Summary

The size of opportunity for increased use of dark WAN services includes all schools estimated to be using lit fiber WANs in 2018 according to the Connectivity Cost Model. Schools already using a leased dark or owned WAN, schools that do not require a WAN, and schools using a VPN for secure connections across the district are excluded from this scenario. This section of the analysis also shows our assumptions about the relative mix of districts using leased dark and owned WANs by locale.[7]

In the savings summary, the per-connection savings calculated for leased dark and owned fiber WANs is multiplied by the total number of eligible schools within each locale to calculate the total cost savings. We estimate that, factoring in the amortized electronics cost, leased dark fiber yields annual savings of up to $609 million (45%) and owned fiber yields annuals savings of up to $794 million (59%). Adding amortized construction costs, leased dark fiber yields an annual savings of up to $329 million (24%) and owned fiber yields annual savings of up to $558 million (41%).

[7] We assumed that 80% of schools in urban and suburban areas opt for leased dark fiber WANs, 40% in towns, 20% in rural distant, and 10% in rural remote areas; the remainder opt for owned fiber WANs

Enhanced Transparency

Our analysis of the impact of price transparency on total costs is based on studying the distribution of prices for various service types within our Item 21 pricing data. We believe the spread for 100 Mbps cable modem direct Internet access reflects the natural distribution of prices in a perfectly transparent market, because the prices of cable modem Internet access are typically posted publicly on providers' websites and other marketing materials. Therefore, this analysis estimates the total cost impact of reducing the pricing distribution of lit fiber services to more closely match the observed distribution for cable modem.

To conduct this analysis, we divided Item 21 pricing data into 4 discrete categories of lit fiber services: 100 Mbps lit fiber Internet access, 1 Gbps lit fiber Internet access, 100 Mbps lit fiber WAN, and 1 Gbps lit fiber WAN. Within each service category, the 10% of contracts with the highest prices and the 10% with the lowest prices were excluded from the distribution, because we believe those prices reflect unusual cases that are atypical in the market and not likely to be affected by price transparency.

We then calculated for each service the ratio of the 90th percentile price to the 10th percentile price as a metric for the level of transparency in that market (the "transparency ratio"). This metric applied to prices for 100 Mbps cable modem resulted in a ratio of 2.2, which we took as the measure of a fully transparent market. For each service type, we calculated two cases for pricing transparency:[8]

- Full Transparency: Assume the market achieves the spread for full transparency; multiply the 10th percentile price by 2.2 to calculate the 90th percentile price
- Partial Transparency: Assume the market moves halfway toward full transparency; multiply the 10th percentile price by the average of 2.2 and the current transparency ratio to calculate the 90th percentile price

Based on these new 90th percentile prices, we used the relative distribution of original prices to calculate the new distribution of prices between the 10th and 90th percentile price for each service, which was then used to calculate new average monthly costs reflecting the impact of enhanced transparency.[9]

The estimated opportunity for enhanced transparency includes, for Internet access, all districts not already participating in a consortia, and for WAN, all schools using leased lit fiber. The calculated new monthly costs for each service were applied to the relevant number of districts and schools to calculate total cost savings, estimated at $174-262 million for Internet access (12-18%) and $198-450 million for WAN (15-33%).

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[8] See the tab "Transparency - Ratios" for original and amended transparency ratios for each service type

[9] See the tab "Transparency - Example Calc" for an example of this calculation