Before the
**Federal Communications Commission**
Washington, D.C. 20554

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| In the Matter of | ) | |
| | ) | |
| Proposed Eligible Services List | ) | WC Docket No. 13-184 |
| For Schools and Libraries | ) | |
| Universal Service Program | ) | |
| | ) | |

To: The Commission

**Comments of AppliansSys LLC on the Proposed Eligible Services List**

**for Schools and Libraries Universal Service Program for Funding Year 2018**

AppliansSys LLC. ("AppliansSys"), pursuant to the Public Notice released June 21, 2017 (DA-17-602), respectfully submits its observations and comments on the proposed Eligible Services List ("ESL") for the schools and libraries universal support mechanism for funding year 2018.

# 1 Executive Summary

In 2015 the FCC added caching to the E-rate program, clearly recognizing the potential benefits and direct cost savings derived from its capacity to augment bandwidth. Since its inclusion caching has had a positive impact far beyond that which the Commission originally envisioned.

Caching:

- Is playing a key role in speeding up access to personalized, flexible digital learning
- Is enabling schools to do more with less bandwidth, effectively reducing broadband spend

However, widespread adoption of caching technology within the E-rate program has been slow. ApplianSys contends that the reasons for this are:

- The structure of the E-rate funding program compels schools to
  - Buy unnecessary bandwidth
  - Not evaluate cost-effectiveness of alternative bandwidth technologies
  - Fund uncorrelated solutions from the same restricted funding category
- In many cases, decision-makers are unaware of, or skeptical about, the benefits of caching

To date ApplianSys has the only fit-for-purpose solution dedicated to schools web caching to have figured in the E-rate program. It has been overwhelmingly the most selected option under the "caching" heading since this was added to the program.

With hundreds of our appliances installed across 40 states now accumulating anonymized performance data, we are uniquely positioned to report on the actual outcomes.

**Our Findings**

*Broadband Overspend*

Schools are buying unnecessary bandwidth and wasting substantial FCC funding. We contend that:

- Schools are buying more than is needed to cater for average Internet demand.
- Connectivity targets for schools focus on peak demand – which is only needed for a very small part of the school day.
- Many school districts cannot achieve their capacity per student targets without exceeding their affordability targets, making broadband overspend pervasive.

*Maximizing Access*

Bandwidth should not be the only goal or yardstick by which the FCC assesses Internet performance because:

- Bandwidth capacity alone does *not* guarantee speed of access in the classroom.
- Slow speed is a problem ingrained in the Internet and beyond a school's control.

Caching is key to serving up educational content substantially faster. **All schools can benefit from caching**, regardless of whether they meet, are below, or exceed the FCC's connectivity targets.

*Nationwide adoption*

Evidence indicates that many more K-12 schools across the US can benefit from caching. By our estimates:

- Only 8% of over 7,500 requests in the last E-Rate cycle for proposals for internal connection components specified caching.

Our observations, insight and real-world evidence advocate that the FCC can:

- Leverage more effective bandwidth per dollar
- Address cost-inefficiencies
- Ensure equitable access to digital learning under E-Rate

To that end we urge the FCC to:

- Consider:
  - Implementing a balanced approach of smaller increments of bandwidth upgrades with caching, or caching in lieu of bandwidth upgrades.
  - Adjusting actual bandwidth targets for schools by using caching to achieve the same classroom Internet performance with a smaller Internet connection.
  - Allowing schools to factor in the 'virtual capacity' increases afforded by caching when measuring and reporting on their overall progress towards capacity-per-student targets.
- Formally evaluate why adoption has lagged behind its promise. Slower uptake may stem from:
  - Funding Wi-Fi from the same category as caching. Both are essential in delivering speedy access, so it is counter-productive that schools can fund either but not both.
  - Out-of-date perceptions about caching technology
- Direct USAC to take concrete steps to maximize adoption:
  - Increase awareness that caching is eligible for funding
  - Help educate schools that caching belongs in an education technology portfolio
  - Help schools evaluate its efficacy and cost-effectiveness in relation to bandwidth

**Formal Recommendations**

*Funding caching from Category One*

We recommend amending the proposed FY2018 ESL:

- With regard to "On-premises equipment that connects to a Category Two-eligible LAN is eligible for Category One support if it is necessary to make a Category One broadband service functional", add language to clarify that this includes when it compensates for inadequate external link bandwidth capacity, or offers the same end result as increasing the capacity of the external link.
- On this basis, we believe that dedicated caching appliances like **CACHE**BOX should be eligible for Category One funding.

**In addition** we propose that the FCC:

- Introduce a more holistic measurement of affordability, going beyond bandwidth pricing to consider capacity delivered by caches
- Change bid evaluation methodology to help schools avoid buying more bandwidth than needed
- Direct USAC to research the cost-performance of the use of caching

We strongly urge the FCC to reform the E-Rate program consistent with these observations, comments and recommendations.

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# 2 Introduction

The case for annual increases in bandwidth capacity stems from an urgent need to 'bridge the digital divide' and ensure the nation's education benefits from the value performance technology promises. However, without a proper appreciation of the nature of modern K-12 web traffic, the K-12 technology funding structure - in some respects - prioritizes the acquisition of bandwidth above "affordability".

Extensive research across 40 states indicates that within the current climate there are unexpected consequences of that almost exclusive focus on bandwidth capacity, that if addressed could lead to far better bang for the E-rate buck. We aim with this submission to:

- demonstrate the (potentially surprising) effect that modern caching actually has in K12 schools
- draw attention to excessive bandwidth spend and poor ROI from bandwidth-only capacity management regimes
- put forward suggestions for how these unintended consequences could be addressed, including commenting on additional clarification that could be incorporated into the proposed FY2018 ESL as requested in relation to Category One support for network equipment that connects to a Category Two LAN

ApplianSys is a server appliance specialist that designs, builds and markets a range of network appliances. We have deep-rooted expertise in technology for education and have served schools for over 15 years, now helping deliver web-enabled learning in over 150 countries.

Our caching appliance has been the most widely selected caching solution by far in the E-rate program since 2015. It is the only schools-focused solution in the sector that handles 'whole school' traffic patterns including HTTPS, software updates, video and LMS password protected materials.

Traffic data from K-12 schools in over 40 states, from small rural schools to some of the largest school districts, demonstrates how bandwidth and caching should be combined to deliver best value for money.

We firmly believe that these insights will assist the Federal Communications Commission ("FCC" or "The Commission") in its efforts to bring 21st century technology to K-12, towards enabling a world-class education for every student regardless of local circumstance, transforming learning outcomes by helping '*schools take full advantage of feature-rich educational technologies that allow for individualized digital learning, access to interactive content, and online assessments*'[1]

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1 *Modernizing the E-rate Program for Schools and Libraries, WC Docket No. 13-184, Second Report and Order and Order on Reconsideration FCC 14-189 (2014), para 2.*
https://apps.fcc.gov/edocs_public/attachmatch/FCC-14-189A1.pdf

# 3 Caching Success in E-Rate

## 3.1 Caching helps secure effectiveness of digital learning

Since its addition to the Eligible Services List, caching has been proven to speed up access to, as well as enable, seamless and flexible digital learning environments in the nation's classrooms. This speed of access holds true across both urban and rural schools, and across districts with plentiful bandwidth as well as those operating well below the Commission's connectivity targets.

Caching technology enables schools to use significantly less bandwidth to serve a given volume of content repeatedly requested from the Internet. By implementing caching, schools have effectively multiplied the throughput of their existing Internet access enabling them to delay, or reduce, annual investment in connectivity upgrades.

Accordingly, ApplianSys believes that the impact of caching is inordinately more than the initial FCC premise that caching '*can serve to optimize network resources and potentially result in more efficient use of E-Rate funding*'[1] and that its success is measurable. By enabling schools to provide more capacity when they need it most and help maximize exposure to innovative digital curricula; caching is a lynchpin for realizing 21st century education goals.

Below are just some examples of the acknowledged - and measured - benefits afforded to K-12 schools and districts when caching traffic with our **CACHE**BOX appliances.

### Anaheim Union High School District

With a student population of approximately 31,000, **Anaheim** is one of the largest school districts in California, with Internet throughput to match. But as an urban district, **Anaheim** has access to comparably inexpensive bandwidth - they pay the same price for 10Gbps that a rural Texan district pays for 50Mbps.

This means that **Anaheim's** bandwidth capacity per student is actually much higher than average, so students shouldn't suffer the effects of network congestion.

However, even with a considerably higher than average 400Kbps of bandwidth capacity per student (four times the FCC's 2016 target for schools), **Anaheim's** students still find content that has to be fetched from the web arrives at sub-optimal speeds.

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1 *Modernizing the E-rate Program for Schools and Libraries, WC Docket No. 13-184, Report and Order and Order and Further Notice of Proposed Rulemaking FCC 14-99 (2014), para 130 https://apps.fcc.gov/edocs_public/attachmatch/FCC-14-99A1_Rcd.pdf*

We can see (table right) that classroom content arrives at a vast range of different speeds from the Internet, but all are significantly slower than content that is served from cache.

Even with a completely under-utilized 10Gbps link, it is caching that delivers the responsive browser that the classroom demands.

- Apex Learning is served 48x faster from cache
- SparkNotes is 35x faster
- PrimaryGames.com is 27x faster
- HistoryontheNet.com is 10x faster

| Domain | From Web (Mbps) | From CACHEBOX (Mbps) | Speed increase (times) |
|---|---|---|---|
| *.apexlearning.com | 0.97 | 47.05 | 48.5 |
| *.sparknotes.com | 0.16 | 5.78 | 35.8 |
| *.lkqd.net | 0.46 | 16.47 | 35.8 |
| *.rosettastone.com | 1.23 | 38.22 | 31.0 |
| *.primarygames.com | 1.01 | 28.18 | 27.9 |
| *.aeries.com | 3.32 | 51.41 | 15.5 |
| *.primarygames.com | 2.40 | 29.96 | 12.5 |
| *.unity3d.com | 0.21 | 2.50 | 12.1 |
| *.mcafee.com | 3.64 | 42.49 | 11.7 |
| study.com | 0.96 | 10.62 | 11.1 |
| *.historyonthenet.com | 2.12 | 22.85 | 10.8 |
| *.anaheim.net | 4.06 | 39.75 | 9.8 |
| *.googlevideo.com | 6.80 | 54.69 | 8.0 |
| *.autodesk.com | 6.72 | 45.53 | 6.8 |
| *.macromedia.com | 9.47 | 43.84 | 4.6 |
| *.mhpracticeplusap.com | 8.88 | 31.98 | 3.6 |
| *.revcontent.com | 4.30 | 8.94 | 2.1 |
| *.hbogo.com | 45.05 | 77.99 | 1.7 |
| *.narvii.com | 8.54 | 11.28 | 1.3 |

**CACHEBOX serves more than 50% of Internet requests locally which, in turn, frees up even more bandwidth and makes more content available.** ***In fact, of the district's 10Gbps capacity, with caching in place generally only a small proportion is utilized.*** **So caching simultaneously both accelerates what would otherwise be slow classroom access and slashes the bandwidth capacity needed to support e-learning.**

## St Johns County School District

**St Johns** is a large district of over 32,000 students spread across 39 schools in Florida. The district has reached the FCC's 2016 bandwidth target of 100Kbps per student, but the cost of this connectivity is huge. Reaching the 2018 target of 1Mbps per student will require an unrealistic budget, even with E-rate support. Fortunately, the district is able to deliver high speed content with a combination of existing capacity and caching appliances.

The average speed of web content served by **CACHE**BOX is consistently several times faster than content served directly from the web. That average includes sizeable software update files, but in the classroom it's what's happening to the important content that matters most.

**St John's** caching report for May 2017 (right) highlights the impact of caching on core learning content from Pearson, Discovery Education, PBS Kids, abcya.com and more.

Most classroom content is served between 5 and 30 times faster from cache.

The result is a significantly more 'snappy' browser experience, with less waiting for pages to load and more time to answer questions. Student engagement is optimized, saving accumulated browser wait that can amount to days of lost teaching and learning time over a school year.

| Domain | From web (Mbps) | From CACHEBOX (Mbps) | Speed increase (times) |
|---|---|---|---|
| sjkace-01.stjohns.k12.fl.us | 0.88 | 131.94 | 149.8 |
| www-pes.stjohns.k12.fl.us | 0.85 | 28.23 | 33.1 |
| www.primarygames.com | 1.57 | 45.74 | 29.2 |
| www.bing.com | 1.35 | 34.15 | 25.3 |
| app.discoveryeducation.com | 2.05 | 41.45 | 20.2 |
| www.incredibox.com | 0.72 | 14.46 | 20.1 |
| swcdn.apple.com | 3.38 | 49.70 | 14.7 |
| fonts.gstatic.com | 2.16 | 30.54 | 14.1 |
| www.pearsonsuccessnet.com | 3.16 | 44.54 | 14.1 |
| external.abcya.com | 4.02 | 51.81 | 12.9 |
| www.discoveryeducation.com | 1.89 | 24.21 | 12.8 |
| cdn01.symbaloo.com | 2.49 | 27.43 | 11.0 |
| www.mobymax.com | 2.09 | 20.17 | 9.6 |
| media.abcya.com | 2.48 | 23.76 | 9.6 |
| view.etext.home2.pearsoncmg.com | 2.58 | 24.10 | 9.3 |
| webcdn.abcya.com | 2.84 | 25.17 | 8.9 |
| lib.myilibrary.com | 0.37 | 3.28 | 8.8 |
| appldnld.apple.com | 4.01 | 26.63 | 6.6 |
| iosapps.itunes.apple.com | 2.38 | 15.26 | 6.4 |
| tvokids.com | 7.50 | 43.54 | 5.8 |
| lookkool.ca | 7.94 | 45.78 | 5.8 |
| hls-jr.brainpop.com | 21.61 | 78.52 | 3.6 |

## Miami-Dade County Public Schools District

Results at **Miami-Dade**, Florida show how caching can help provide equitable access to accelerated e-learning in remote schools. Because of its huge geographic span, 220 of the district's schools are remote with small Internet connections. Students experienced very slow access to the online learning platform, waiting as long as 30 seconds for a page to load. Lost learning time was rapidly reaching many minutes in just a single lesson due to the constant traffic congestion and latency.

After installing **CACHE**BOXes, **Miami-Dade** found 97% of content from the learning application was being served from cache. With content being served locally at LAN speed, load times were drastically slashed.

A classroom of 30 students waiting 30 seconds for a page to load saw that drop to 2.45 seconds.

Serving the content from cache also freed up precious bandwidth, making the 3% of dynamic content not served from cache also much faster to load.


| | Requests | Total Load time |
|---|---|---|
| Without Caching | 30 requests @ 1 sec each | 30 seconds |
| With CACHEBOX | 1 original file @ 1 sec + 29 requests @ 0.05 sec | 2.45 seconds |

# 4 Observations on caching's potential to help surpass E-rate goals

## 4.1 Achieve more by combining bandwidth with caching

### *4.1.1 The challenge is that schools are buying or being urged to buy more & expensive bandwidth in excess of their average needs in order to cater to 'peak congestion'*

The organizations reporting on the state of K-12 connectivity predict that much steeper growth in capacity is needed to deliver a personalized, equitable learning experience anytime, anywhere.

> EducationSuperHighway reports that *bandwidth demand is growing in K-12 public schools at a rate of over 50% per year and predicts that*, *to meet 2018 demand, the typical school district will need to triple its bandwidth and ensure ubiquitous Wi-Fi to support digital learning needs.*[1] And throughput continues to be seen as the key to access in the classroom.
>
> The September 2016 Broadband Imperative II Report by SETDA takes the position that *Robust broadband is essential for equitable access in schools for all students, as bandwidth capacity determines which digital instructional materials and educational applications students and educators can effectively leverage in the classroom.*[2]

From the evidence accumulated over the last 3 E-rate rounds, AppliansSys contends that many schools are buying more bandwidth than they actually need and even prioritizing excessive bandwidth upgrades over caching options that would be more affordable and be more effective.

To put this in perspective, the FCC must first consider that Internet traffic demands in the K-12 environment are unique. Unlike any other sector, K-12 Internet is characterized by large peaks occurring at the start of lessons, as classrooms of students simultaneously attempt to access the same material, en masse.

This results in spikes well above average demand – typically 6 to 7 times that of the sustained demand required for the rest of the lesson and indeed, over the school day. These bursts of demand ultimately cause short periods of network congestion – long periods if capacity is wholly inadequate.

We have observed that schools tend to purchase bandwidth to cater to peak congestion, or are being given unnecessary capacity goals that significantly outpace true average need.

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1 *2016 State of the States,* EducationSuperHighway's second annual report on the state of broadband connectivity in America's public schools, https://www.educationsuperhighway.org/challenge/

2 Fox, C., Jones, R. (2016). *The Broadband Imperative II: Equitable Access for Learning.* Washington, DC: State Educational Technology Directors Association (SETDA).

**We contend that the excess capacity that is unused outside of those momentary peaks comes at too high a cost – as school districts, states and indeed, the FCC, are in effect paying for more than they need.** We turn again to data on bandwidth affordability from EducationSuperHighway to put this potential waste in context.

> They report that although 27 states already have more than half of their school districts paying at or below price benchmarks and the median cost per Mbps of Internet access to school districts declined 40% from $11.73 to $7 due to broadband infrastructure technology improvements, *affordability still remains a challenge for almost half of school districts as there continues to be significant variation in what districts pay for Internet access, especially for higher-bandwidth circuits*.[1] Specifically, they found that price can vary by more than 10 times when comparing the 10th and 90th percentile prices for the same circuit sizes.

Thus, under these conditions of high cost circuits, relying solely on bandwidth upgrades to cater for momentary peak demand of 6-7x average demand is not a cost effective nor prudent use of E-Rate funds.

**And alongside this, the FCC must factor in the additional costs that they will help to fund through E-Rate as some schools need to upgrade network infrastructure or licenses when they upgrade bandwidth.**

> For example, when institutions go above 100Mbps, 500Mbps or 1Gbps thresholds for the first time, other network equipment like firewalls, filters and access points may need to be upgraded. These cater for a given maximum throughput and so directing more traffic through them may cause equipment failure or flag a new bottleneck and the need for a larger, more expensive model.
>
> With the trend towards virtualization, it is now not even necessary for hardware to falter because pricing is designed on a per-Mbps/per-connection license basis and once exceeded, additional charges result or performance is artificially limited.

An accelerated upgrade path for associated network equipment and software constitutes a hidden cost of over-reliance on bandwidth capacity to cater for peak classroom-generated data demand.

#### *4.1.2 Caching is both more effective and more cost-effective for the unique K-12 traffic spikes in demand*

With caching, schools can easily handle the sharp bursts in traffic volume that occur during a typical school day at a fraction of the cost of a bandwidth upgrade. Because peaks in network traffic are generated by repeat requests for web and rich media content, including video, educational content from providers like Pearson, Compass Learning and Khan Academy are served at LAN speeds, eliminating wasted lesson time.

In addition, software updates that normally swamp a school's Internet connection when multiple devices update concurrently, can be downloaded just once and then served from memory for all subsequent requests.

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*1 Price Benchmarks for Affordable Broadband, January 2017, EducationSuperHighway, compareandconnectk12.org*

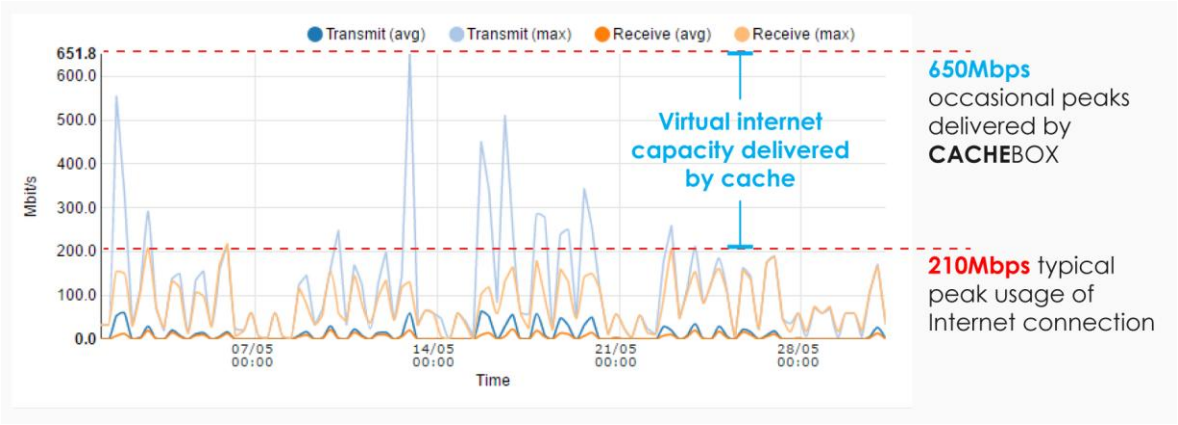
While removing this extremely bandwidth-heavy update traffic from the upstream Internet connection and/or WAN link, caching **also** delivers those updates at LAN speeds, meaning that – instead of clogging up the Wi-Fi for hours – they clear the LAN in seconds.

So clearly there is a distinction being drawn here between a 'partial cache' for a discrete segment of the district's traffic – e.g. Apple software updates, or online testing – and a schools-focused 'whole school' cache that handles **all** the district's web activity, including HTTPS and software updates. The ROI from different types of caching solution needs to be considered in the school's E-rate procurement process; while 'partial' solutions will have an affect only on a very limited proportion of the district's traffic, 'whole school' solutions will deliver a really substantial reduction in required bandwidth and have a comparable impact on Teaching and Learning via optimal browser responsiveness. Value for money will therefore be decidedly different in each case.

### Woodland Community Consolidated School District

Consider the illustrative example of **Woodland Community** in Illinois. With 6,100 students sharing an Internet connection of just 250Mbps, the district falls well short of the FCC's 100Kbps per student target set for 2016. To reach this, the school would need to add a further 360Mbps, but with their current supplier that could cost an additional $2,600 per month, more than doubling their current payment.

However, as shown in the graph below, for the majority of the time 250Mbps is actually sufficient to handle demand. But, every now and then, traffic spikes considerably and can be seen peaking at 650Mbps - which works out at 110Kbps per student, just over the FCC target.




If the District did nothing, then requests from those peaks would back up and could take a substantial part of the lesson to clear. But **CACHE**BOX, by its 'virtual capacity', bridges that gap, providing seamless service to every classroom - and does so at a fraction of the cost of bandwidth.

ApplianSys calculated that when factoring in the costs for **Woodlands' CACHE**BOX**230** - $7450, with an expected lifecycle of 5 years – the appliance offers a drastically cheaper alternative to a bandwidth upgrade. The additional 360Mbps that would be needed to reach the FCC target would equate to an extra $31,000 per annum (based on current EducationSuperHighway data).

On these figures **CACHE**BOX will:

- have paid for itself in 3 months
- over its expected lifetime, save the district (together with FCC funding) over $150k.

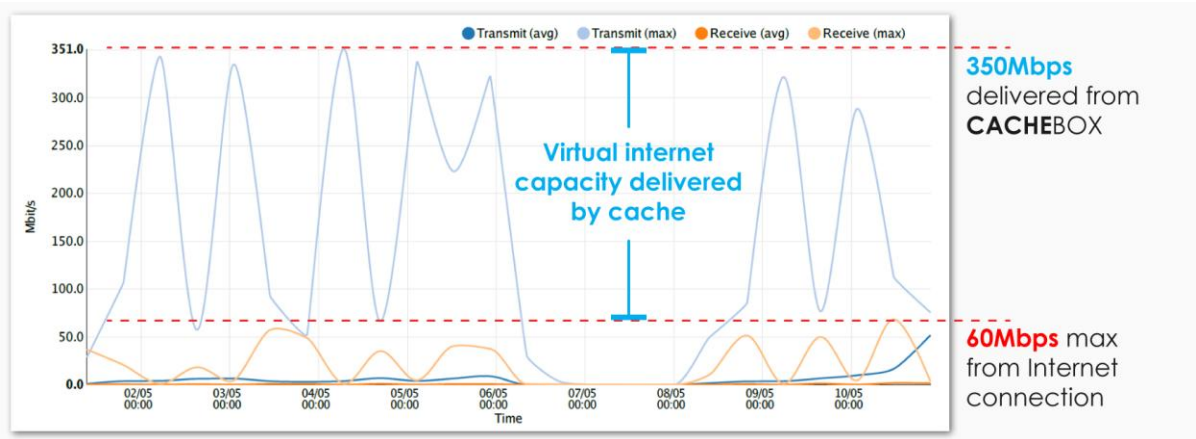
**Caching can also mitigate the impact of congestion in the classroom for schools <u>meeting or exceeding</u> the FCC targets for connectivity.**

## Trinity School

**Trinity School,** an independent private school in Maryland with 382 students at a single campus has a 50Mbps Internet connection that provides 130kbps per student - above the recommended FCC target of 100kbps. However, peak traffic sees requests spike to 6 and 7 times higher than average – reaching 350Mbps.

This means, without **CACHE**BOX in place, 6 out of 7 requests would be queued before delivery. In the classroom this queuing would have left students waiting, with some requests taking so long the requester would have received a 'timeout' response rather than the content needed.

As shown in the graph below, **Trinity's CACHE**BOX is actually delivering the content students need up to 350Mbps, despite the school only operating - and paying for - a 50Mbps connection. 300 Mbps of additional virtual Internet capacity is being delivered by the cache.



#### *4.1.3 Speedy access to modern Internet content is what matters most in educational outcomes - and it is caching that can deliver this edge to schools.*

We have also observed that a large number of schools suffer under the misapprehension that upgrades are more effective than caching in delivering digital, personalized learning at speed in the classroom. The reality is actually more nuanced.

ApplianSys is not minimizing the importance of bandwidth upgrades in meeting the connectivity and, ultimately, the learning goals of the E-Rate Modernization Order. Adding bandwidth is indeed one method of reducing the congestion that leads to web requests queuing, addressing that particular cause of slow classroom access. On its own however, it doesn't address the other main culprit – which is slow delivery speeds from further upstream, beyond the reach of the District technology department.

**It is important for the FCC to understand that speed of access to digital content in the classroom, irrespective of bandwidth capacity, depends on several factors upstream and out of the school's control.** Slow speed is a problem ingrained in the Internet with the causes ranging from underpowered web servers to congestion at international, regional and local nodes and additional latency and deceleration generated by upstream routing, filtering and monitoring.

Not all traffic is equal and objects arrive at the edge of the K-12 network at a variety of different speeds, many of them sub-optimal in terms of browser responsiveness to support e-learning and timed assessments.

Over the years, ApplianSys has acquired significant insight into the nature of evolving modern Internet traffic and the wide scope of educational content that schools use daily. Today, a typical school's web traffic spans HTTPS content and video, to modern content delivery networks (CDN), to learning management systems (LMS) and login-protected content - to bandwidth-intensive software updates that increase in size every year.

So, for example, a multi-gigabyte software update file delivered at Internet speeds of typically a few Mbps might trickle down the Internet for hours, clogging up both the WAN link and the local area networks; that same update, served locally from cache, could be delivered in less than a minute – at LAN speeds approaching 1Gbps.

**These slow Internet delivery speeds are also seen in educational content, but, for online learning to be effective, that content needs to be served quickly—the moment it is needed. An average page load of 3 seconds can equate to 5% less time to answer questions in an online arithmetic test than a student would have with lightning fast page loads.**

##### Laurens County School District

The data from **Laurens County** in South Carolina illustrates the order of magnitude of speed at which a cache can serve up content quicker than the Internet. It also shows that, even in upgrading to multi-Gigabit links, schools cannot accelerate content that is inherently slow at the server source or is delayed by latency.

When Laurens decided to roll out 1:1 learning to each of its 10 schools it chose to upgrade bandwidth to 1Gbps to ensure capacity. That equated to 175kbps, nearly double the FCC target. However, in daily use, they still found content was too slow in the classroom. One particular favourite - CoolMath – was just not responsive enough.

Turning to caching to help, they found **CACHE**BOX was caching and serving content more than 10 times faster on average, than content from the Internet. CoolMath is accelerated almost 14x faster.

| Volume of Data | | | |
|---|---|---|---|
| **Status** | **Transfer** | **% of total** | **Mbps** |
| TCP_HIT | 302.7 GB | 25.0 % | 7.56 |
| TCP_MISS | 554.8 GB | 45.8 % | 0.69 |

**So even schools that the Commission would consider as having sufficient capacity have reaped the benefits of caching: increasing speed of access in the classroom without needing to further upgrade bandwidth capacity.**

## Westwood Community School District

Also consider the experience of **Westwood Community**, a small district located in the small rural town of Sloan, Iowa, serving 520 students on one campus. Westwood pay $3,111 per month to maintain a 1Gbps connection. This equates to an extremely high 1,923kbps per student, almost 20 times the 100kbps target - meaning they have more than enough capacity to avoid congestion.

However, despite that capacity, speed of delivery at Westwood is not guaranteed. Educational content that comes directly from the Internet still arrives slowly – as low as 50-80Mbps (see table below). These Internet delivery speeds are beyond the control of the school.

| Domain | Volume (GB) | From web (Mbps) | From CACHEBOX (Mbps) | Speed increase (times) |
|---|---|---|---|---|
| more.starfall.com:80 | 1,439.86 | 0.08 | 6.97 | 89.0 |
| www.fun4thebrain.com:80 | 1,478.85 | 0.06 | 3.35 | 59.4 |
| media.abcya.com:80 | 5,623.38 | 0.21 | 6.18 | 29.9 |
| www.roomrecess.com:80 | 1,451.24 | 0.08 | 1.79 | 23.4 |
| pbskids.org:80 | 2,718.00 | 0.50 | 4.33 | 8.6 |
| external.abcya.com:80 | 517.96 | 0.77 | 4.95 | 6.5 |
| imagescdn.memoryebooks.com:80 | 529.97 | 2.84 | 14.13 | 5.0 |
| hls-jr.brainpop.com:80 | 265.18 | 23.17 | 114.90 | 5.0 |
| roomrecess.com:80 | 881.03 | 0.30 | 1.08 | 3.6 |
| m.coolmath-games.com:80 | 721.66 | 3.24 | 11.01 | 3.4 |

But with **CACHE**BOX, that same vital content is being served locally at sometimes exponentially faster speeds. Gigabytes of data are being delivered in to the classroom at 5, 8, 20+ and even 80+ times faster (see table above). Even relatively quick content is multiple times faster, but it is the particularly slow content – content that causes wait times in the classroom – that is significantly faster, ensuring a better learning experience in the classroom.

**ApplianSys contends that speed in the classroom is fast becoming a pre-requisite for equality of learning pace and online assessment. Speed will ultimately drive improvements to learning outcomes. Thus, the FCC should not view broadband capacity as the only goal or yardstick for assessing Internet performance as we seek to improve learning outcomes in the nation's schools.**

#### *4.1.4 We need to shift the focus on "affordable" access to broadband towards "best value performance from broadband with caching" to enable web-based classroom learning*

In reality, broadband is not affordable to many schools and indeed, EducationSuperHighway reports that *Affordability is the number one barrier to schools acquiring the speeds necessary for digital learning.*[1] ApplianSys considers two additional sobering facts that they shared:

> *The typical school district pays $25 per Mbps for bandwidth — more than six times the approximately $4 per Mbps paid by best practice districts. This is despite the fact that funding for connectivity is subsidized by the federal E-Rate program and that collectively schools are one of the world's largest purchasers of Internet access and equipment.*[2]
>
> Also, *Schools with enough bandwidth for digital learning pay 1/3 the cost per megabit of those without sufficient connectivity. These schools also have Internet access budgets that are 4.5x larger per student than those on the wrong side of the digital divide*.[1]

**As a result, ApplianSys sees the potential for substantial waste of E-Rate funding by simply having schools try to hit the connectivity targets in place today without considering the role of caching technology in extending existing connectivity and speeding up content – in particular but not exclusively where connectivity comes at a high cost.**

It is wasteful to congratulate ourselves on having large swathes of schools hitting the bandwidth targets when they are, at the same time, achieving middling to low scores on maximizing their bandwidth for the budget spent. As we've shown, caching:

- Delivers faster speed at lower cost
- Enables 'burstable capacity' at low cost, enabling schools to easily handle periodic surges in demand (typically 6 to 7 times higher than sustained traffic) while only paying for average throughput
- Offers real value to rural schools and libraries struggling with the connectivity gap by making 21st century learning equally accessible at a fraction of the cost of fiber

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1 *https://www.educationsuperhighway.org/about-school-networks*

2 *https://www.educationsuperhighway.org/the-connectivity-gap*

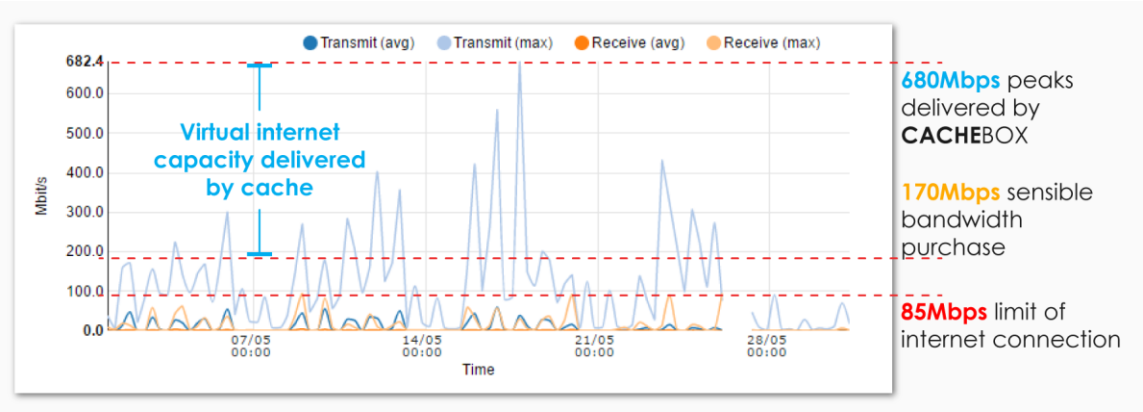
**Therefore, we urge the Commission to evaluate the potential to hit the education and spending goals of its E-Rate Modernization Orders by balancing the push for bandwidth with wider deployment of caching technology. And to think 'outside the box' when it comes to capacity: for example, the FCC should allow schools to factor in the 'virtual capacity' increases afforded by caching when measuring and reporting on their overall progress towards capacity-per-student targets.**

We offer two examples in closing: Durant Community School District in rural Idaho and Oak Grove R-VI School District in Missouri.

### Durant Community School District

**Durant Community** services 673 students in 3 schools on 1 campus in a rural region of Idaho. The bandwidth needed during peak demand periods is many times higher than average, however, due to its rural location, Durant faces extremely high costs for bandwidth, and is forced to pay well above the affordability targets set by SETDA.

The school maintains 85Mbps capacity but our analysis shows that it needs around 120Mbps on average during the school day – however, at peak times it needs almost 700Mbps. If that peak amount of bandwidth was costed at the rate it currently pays, Durant would need to spend over $33k per month.




With a **CACHE**BOX in place, the district has been able to serve up to 680Mbps virtual effective capacity from its 85Mbps connection. The light blue line on the chart above shows the performance of the cache, serving data to students at over 8 times actual capacity.

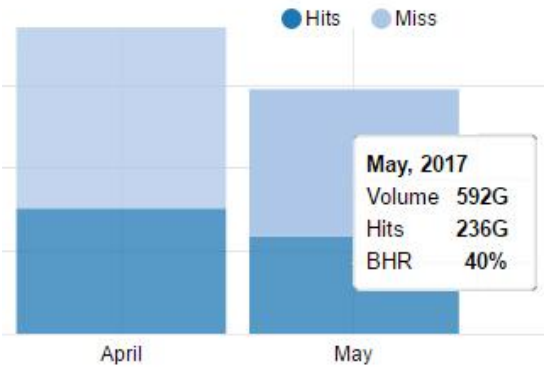
The total cost of the **CACHE**BOX solution purchased by Durant was $5,300 (appliance with a 3 year warranty), which, even over a 1 year period, equates to only $440 per month - that's around 1.3% of the cost of the equivalent bandwidth capacity. With a **CACHE**BOX in place the school is now able to make a far more cost-effective investment in less additional bandwidth.

**Conversely the FCC should consider how it could adjust the actual bandwidth requirements for schools and use caching to achieve the same classroom Internet performance with a smaller Internet connection. The potential to cut Category One spend significantly while delivering against E-Rate's digital education goals is surely an attractive proposition.**

### Oak Grove R-VI School District

**Oak Grove R-VI,** Missouri, manages 4 schools on 4 campuses with a total of almost 2,000 students. In 2016 they upgraded bandwidth to ensure high capacity per student, but in doing so exceeded affordability targets, with a $4 per Mbps monthly cost. This resulted in a monthly fee of over $4k.

However, Oak Grove's **CACHE**BOX serves 40% of Internet requests and higher (see right). The BHR (Byte Hit Ratio) is the percentage of duplicate Internet requests that could be served from cache. Taking our example month of May 2017 this meant that only 356GB of the 592GB of content accessed by the school came from the Internet.




This means that the district could achieve the same Internet performance in the classroom but with a smaller Internet connection. Based on their current monthly bandwidth bill of $4k Oak Grove could save around $20k per year and better.

| | Bandwidth | % | Cost /month | Cost /annum |
|---|---|---|---|---|
| Current Capacity | 1.0Gbps | 100 % | $4k | $48k |
| New Capacity | 0.6Gbps | 60 % | $2.4k | $28.8k |
| **Savings** | **0.4Gbps** | **40 %** | **$1.6k** | **$19.2k** |

**So we urge the FCC to assess whether, in pursuit of 'affordable' access for broadband, true cost effectiveness for the E-Rate program as a whole is being sacrificed. ApplianSys contends that the current approach does not deliver best value performance from E-Rate funding nor from the nation's limited educational budgets in the long term.**

## 4.2 Understanding and acting on other obstacles to wider adoption of caching across K-12

ApplianSys believes there is significant opportunity for more K-12 schools to benefit from caching and to fund it through E-Rate. Despite the evidence in Section 3 about the benefits of caching, our analysis of FY2017 E-Rate data reveals that a surprising number of schools are not following through on purchasing and implementing caching. We estimate that

- only about 8% of over 7,500 eligible entities filing Form 470s requested bids for caching
- only 37% of those actually selected a caching solution (as tracked on Form 471), at a projected value of nearly $9M.

We urge the FCC and the Universal Service Administrative Company ("USAC") to take steps to evaluate the data and better understand the factors contributing to this lag in uptake. Considering that caching had been ineligible for E-Rate funding until its addition to the Eligible Services List in Funding Year 2015, it may be necessary for FCC to take additional steps, for example, through a USAC seminar, to build awareness among schools that caching is now eligible for Category Two funding.

We believe that another reason for the lag in adoption relates to schools having to fund Wi-Fi from the same Category Two bucket as caching. Both are essential to delivering speedy access to digital learning.

EducationSuperHighway reports that[1]:

- 40% of schools have no Wi-Fi in their classrooms
- an additional 36% lack Wi-Fi capable of supporting 1:1 learning.

ApplianSys **endorses the need for robust Wi-Fi**. Without it, LAN speeds generated by caching are throttled by the Wi-Fi infrastructure and the potential for fast responsive browser performance is thwarted. Adequate Wi-Fi infrastructure is a key component of the modern network that enables rich digital learning that transforms education.

Thus ApplianSys suggests to the FCC that it is **counter-productive** to E-Rate Modernization goals to force some schools to have to choose to fund either caching or Wi-Fi and not be able to do both. The Category Two funding cap of $150 per student every 5 years is having this effect in many schools.

We have also seen that out-of-date perceptions about caching continue to limit uptake by schools because they mistakenly believe that:

- HTPPS content - a principal component of e-learning content - cannot be cached
- More complex modern traffic and dynamic content cannot be cached
- Functionality is so basic a cache might serve out-of-date content.

Vendors like ApplianSys play a key role in educating the market about the technology, but we also believe that the FCC and USAC should take steps to help schools understand the place for caching in the portfolio of educational technologies and in particular how to evaluate its more cost-effective benefits in relation to bandwidth.

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*1 https://www.educationsuperhighway.org/about-school-networks*

# 5 Specific ESL Comments and E-Rate Recommendations

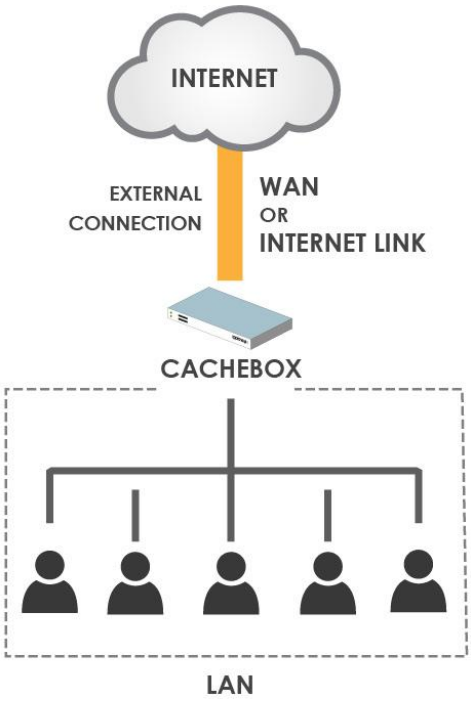
## 5.1 ESL Recommendations

ApplianSys submits the following comment and recommendations in response to the Wireline Competition Bureau's public notice of the proposed FY2018 ESL.

**ApplianSys believes that caching should qualify for Category One support because it fulfills the criteria of being 'necessary to make a Category One broadband service functional'.**

We have demonstrated that caching is a fundamental part of the provision of Internet services to schools or buildings with external connections. It is deployed in the same location as the termination of the external link, at the interface between external link and LAN. Its key functions are:

- to deliver a cost-effective 'virtual' increase in Internet capacity – particularly, but not exclusively, where bandwidth costs are high
- to accelerate content that would otherwise enter the LAN at speeds sub-optimal for teaching & learning




As a result, caching can overcome the impact of inadequate Internet access (due to high cost or unavailability) and deliver a media-rich technology model to every student, on-demand in the classroom. In this way, caching is necessary to make the Internet access fit for its educational purpose and thus, makes Category One broadband service 'functional'.

In addition, caching is an alternative to funding additional bandwidth capacity, serving

- to reduce the amount of broadband capacity required

With caching, schools can achieve the same throughput - and in almost all cases, speedier access - *with smaller bandwidth capacity connections*. This starkly contrasts with other Category Two LAN devices e.g., Wi-Fi access points, that solely function to make broadband available within the building.

**Therefore, ApplianSys recommends that the FCC add language to the draft FY2018 ESL for "On-premises equipment that connects to a Category Two-eligible LAN is eligible for Category One support if it is necessary to make a Category One broadband service functional" to clarify that this includes when it compensates for inadequate external link bandwidth capacity, or offers the same end result as increasing the capacity of the external link.**

## 5.2 General E-rate Recommendations

**Finally, further to the data on the benefits of caching and the observations presented Sections 3 and 4, we offer the Commission the following three recommendations to achieve its long-term goals for 21st digital learning whilst ensuring that E-Rate funds are used cost-effectively. We urge their speedy adoption.**

1) The Commission currently states, "*To measure affordability, the FCC will track pricing as a function of bandwidth*." We recommend that the Commission take a holistic approach to measuring affordability. They should track and consider capacity delivered via caches as described in Section 4.1, including 'burstable' caching capacity, when calculating whether the whole solution is affordable.

2) The Commission should require schools or libraries that propose to upgrade bandwidth to confirm that this is the most effective approach. The Commission should require schools or libraries to

   i. obtain bids to evaluate caching in lieu of a bandwidth upgrade to address its stated issues

   ii. obtain bids to evaluate a combination of caching and a smaller bandwidth upgrade to address its stated issues

   iii. compare the pricing of scenarios 1 and 2, as well as evaluate their relative impact on speeding up web access and progress towards state-wide connectivity targets, as well as their amelioration of any other stated issues.

   ApplianSys urges this path as a common-sense measure to avoid schools buying more connectivity than necessary, thus enforcing prudent spending of E-Rate funds over the long term as bandwidth demand continues its upward trajectory.

3) The FCC should direct the Wireline Competition Bureau to work with USAC to help schools understand the place for caching in the portfolio of technologies funded by the Commission - potentially through the basic education seminars held by USAC. The Bureau should also commission research on the return on investment from bandwidth, as well as bandwidth in combination with caching, to inform long-term policy planning and the setting of targets for connectivity (including 'virtual' capacity from caching) to, and within, schools.

# 6 Conclusion

ApplianSys urges the Commission to consider the data and adopt these changes to the ESL, as well as our recommendations for reforming the E-Rate program. They are essential in helping the FCC ensure provision of equitable access to a personalized, digital 21st century education, and, via a tight focus on cost efficiency and value, will extend the E-Rate program for many years.

Respectfully submitted,

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