C.O.R.E.

Efficiency Strategies for Meaningful Connectivity and Recommended Standards

v1.1.2, 02/11/2023

This prospectus is a discussion document that will be updated periodically to incorporate and respond to the wider collaborative process. To access the latest version, go to:

https://nea.appliansys.com/core-strategy

Foreword (Adapted and abridged from "Digital Transformation and the Elephant in the Room")

Trina Angelone

We are entering the age of rapid systemic digital transformation. Fuelled by artificial intelligence and innovation, it's a time for bold initiatives and *edupreneurship* designed to provide the best experiences for all learners. BUT it is not a conversation worth having if we do not address the elephant in the room.

Without meaningful connectivity that provides equitable, sustainable access to the Internet for all learners, strategic priorities for meeting Global Goals and the Future Visioning 2030 for Sustainable Development will remain out of reach. Low-middle income countries and hard-to-connect regions will continue to be left behind, and at a rate whereby the gaps grow exponentially wider faster.

Covid-19 forced online and hybrid education into the mainstream. No longer a novelty, access to online opportunities became essential for every country, learning organization or training institution.

There's little doubt that technology needs to play a significant role if we are to have a truly modern education system. Access to, and understanding of, that technology is a key factor in bridging the gap between rich and poor throughout the world.

Many recent reports draw attention to the things that need to change. UNESCO's GEM23 Report on the progress of Future Visioning 2030 brought home the harsh reality of having failed to deliver on not just access, but education quality as well. It's yet another wake-up call to accelerate change - but NOT be blinded by the rush to do so.

As technological innovation is happening *outside* the classroom with increasing speed, we know that students are graduating without the new fundamental skills that careers in the modern economy need, skills clearly identified in the World Economic Forum (WEF) The Future of Jobs Report 2023.

To date, huge expenditure on classroom tech and connectivity has not improved learning for most; for some it has made things worse. Moving to digital for digital's sake has often delivered insufficient value and poor user experiences. There is of course evidence which points to pockets of excellence: the power and potential of ICTs and the Internet being harnessed, proven edtech, successful practices - on which we can build inclusive and sustainable transformation that genuinely moves the learning dial.

What's standing in the way?

As Chair of the Commission for Instructional Technology & Distance-learning at NCPSA and associated accrediting organizations globally, I repeatedly addressed questions raised both during and post pandemic, pointing to a globally shared problem: The respective ability of schools to effectively access the same e-learning or hybrid learning platforms differs widely depending on their location and available budget.

In US schools, efforts by the FCC (Federal Communications Commission) and local or federal government have provided considerable funding for ISPs to help alleviate the problem, for now at least. The FCC has been aware for some time that even for a relatively wealthy and well-connected nation, funding ever-increasing bandwidth is not sustainable over the long term. As a result, since 2015 a federally funded schools technology program has been funding efficiency technologies that help to get better value for money from network spending. Having to rely on bandwidth alone to deliver meaningful connectivity leads to inequities of access, and is not a model which can be replicated around the rest of the world at any kind of scale.

Can it be fixed?

To understand more about meaningful connectivity and provision of effective access to e-learning, I began to question WHAT "meaningful" really means. My research led me to Roger Clark, Executive Director of Education Technology at ApplianSys and his organization's unique global source of longitudinal data gathered over the past 20 years.

Let's be clear, I know I am not an expert in connectivity, but what I have learned during the past six months of research has been eye opening. I am grateful to the generosity of Clark and the ApplianSys network team for agreeing to answer my questions and provide me with access to the data they have, giving me six months of their time to analyse the data and to help with the interpretation of what the findings mean.

The collaborative research of ApplianSys eLearning specialists and technologists and the GlobalED team, has analysed network performance for billions of pieces of anonymized learning activity which shows how content, media, digital assets, software, and applications really perform on the internet in a learning environment. The data is from schools across 160 countries, using some of the world's leading digital content over the past 20 years.

The data shows that the scale of the problem goes far beyond not having an ISP or adequate bandwidth available. It's exacerbated by the heavy consumption of bandwidth by modern digital content. The real disaster unpacking before us, again the proverbial elephant in the room, is that a very large portion of the world's countries cannot access or utilize the rich content and multimedia resources that the majority of providers have created, because they don't have connectivity that is meaningful, they don't have connectivity that provides effective access to the transformative capabilities of internet-enabled ICTs.

The analysis reveals that there is not a single set of protocols being followed by technology providers, nor are content builders adhering to a standardized methodology for the development and delivery of their content. As a result, it is increasingly difficult for network managers supporting those low-bandwidth schools to tap into strategies and tactics for better network performance on narrower connections, many of which were originally conceived at the birth of the internet for exactly the purpose for which they are now needed.

The culmination of the project has been to develop a framework for the combined efficient use of bandwidth, content, and everything in between. Developed as a free research-based resource for all learning organizations, our C.O.R.E. Efficiency Strategies (Conserve, Optimize, Recycle and Extend) for Meaningful Connectivity are focused on supporting equitable access and getting more value out of networks and connections.

All countries, regions and learning organizations should have a direct interest in making better use of available bandwidth, in understanding those strategies which can be used to cut costs and increase opportunities for e-learning, even in the remotest locations.

Our goals should be to reduce barriers to entry and to increase awareness of the opportunities that are available. For inclusivity and expanded access, we need not reinvent the wheel; there is a wide variety of materials and connectivity sucessful practice available today that will allow developing nations to short circuit the way forward. We can learn from mistakes made, and in the context of our needs, we can identify what works for us specifically.

So just because it took 10 years for Western countries to reach point X in their digital journey, does not mean it should take a country embarking on new digital transformation initiatives any time at all to leapfrog gaps.

We are talking about upscaling nations if we can access opportunity in this manner. Meaningful Connectivity, delivering effective access to drive the transformation of Education, will increasingly become recognized as an essential resource as much as food and water for the economic future of many countries.

Trina Angelone

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Preface & Acknowledgements

This document introduces the **C.O.R.E. Efficiency Strategies for Meaningful Connectivity and Recommended Standards,** a framework that enables schools and educational institutions everywhere to make more efficient use of their internet connections, supporting their efforts to expand learning opportunities and achieve more with less: valuable cost-savings and content acceleration for well-connected urban schools; for schools in low-bandwidth areas, sustainable and equitable access to the most transformative digital transformation.

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Collaborating partner organizations:

- GlobalED Foundation
- Appliansys
- Geeks without Frontiers
- IDATA-Integraldata
- Little Bridge
- Whizz Education

The development of this framework constitutes key portions of the authors' contributions to:

- UN Partner-2-Connect program
- UNESCO, UNICEF, World Bank, other international organizations work towards SDG4
- The US FCC, National Education Authorities, striving to narrow the digital gap

During our collaborations, the team identified a series of directly adjoining topics which this discussion richly illuminated. These topics, referred to in the document's *Background* section, are explored in detail as associated papers listed in Appendix 2.

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Proposing an evidence-based paradigm for Meaningful Connectivity & Effective Access

"Meaningful school connectivity" has been defined as having fast, reliable, and affordable access to the Internet, allowing for skill development, use of 'smart' devices, and safe navigation. That definition depends on the combination of factors called "connectivity enablers": infrastructure, affordability, device, skills, and safety and security.

Some 2030 targets for universal and meaningful digital connectivity have set a minimum connection speed of 20 Mbps per school, or 50 kbps per student for schools larger than 400 students. Faced with the realities of remote rural schools in developing contexts, that's a high bar to clear. But it also risks perpetuating connectivity inequality, as well as network inflation und subsequently sustainability challenges, wrapped in a misunderstanding of how effective access is constituted in the Teaching & Learning (T&L) environment.

The first problem is that bandwidth isn't equitably available nor uniformly affordable. If Meaningful Connectivity were just about connection 'capacity', then both equity and sustainability would be forever in question.

But the inequitable distribution of bandwidth is not the only factor that constitutes The Connectivity Problem for Schools. For low-bandwidth schools looking to harness Internet-enabled ICTs, the remarkable inefficiency with which T&L utilizes networks and internet connections is actually an even more problematic challenge than the limited capacities of the connections themselves.

Anonymized network performance data provided by schools around the world shows that Meaningful Connectivity is not a number of Mbps, rather it is about what digital activities can be supported, or effectively accessed. As the pre-requisite for enabling *Effective Access* to advanced e-Learning platforms in a whole-class setting, *Meaningful Connectivity* itself needs a rethink.

This document proposes a Meaningful Connectivity paradigm that focuses on Effective Access, on what you can do with the connection - and it shows that more, much more, can be done with less.

If Meaningful Connectivity is available for less cost, budgets can go further. If edtech can make better use of narrower bandwidth, reach can be extended further and faster. The most transformative e-learning platforms will reach those in low-middle income countries and low-bandwidth environments much sooner – accelerating the acquisition of digital skills and competencies and enabling better learning outcomes for all.

Ultimately, connectivity strategies that rely on bandwidth targets are omitting a critical factor: how efficiently the connection is utilized.

This document sets out how to deliver adequate access not through sole dependency on unnecessarily high bandwidth capacities, but, instead, by leveraging the most effective factor - Connectivity Efficiency.

It brings together logical and proven strategies and presents them as a methodology with accompanying recommended Standards that will equip education stakeholders to deliver - equitably and sustainably - the Meaningful Connectivity needed for even the most transformative e-learning activities.

Background

A.1 The Learning Gap and Skills Gap have widened (further discussed in Appendix 2 – Linked Papers)

Prior to the pandemic, there was already a global learning crisis. UNESCO had reported 617 million children and adolescents worldwide were already not achieving minimum proficiency levels in reading and mathematics.

The 2022 UNICEF report, Are Children Really Learning, showed that even before the pandemic the majority of those not learning were nevertheless in school. Of the 387 million primary-age children unable to read proficiently, 262 million were in classrooms*. That data was a "wake-up call" for far greater investment in the quality of education. * (UNICEF Are Children Really Learning Report).

The pandemic only compounded the situation. Although learning loss was experienced globally, some well-resourced schools responded comparatively well to the global COVID-19 pandemic, having the resources to accelerate ICT-enabled remote learning. But for schools in developing contexts, the gap between what they are delivering now and what they need to deliver has been stretched in two directions:

- Students suffered massive learning loss - one in three of the world's schoolchildren – 463 million children globally – were unable to access remote learning during COVID-19
- The skills requirements for future jobs evolved at unprecedented rates. The fastest growing roles will include technology and digitalization, demanding skills such as analytical and creative thinking, communication, AI and big data, lifelong learning, technological literacy – skills which school leavers require today, not in 5 years.

To address the now much wider equity gap, we need to accelerate both learning recovery and future progress for students and teachers in under-resourced environments by urgently maximizing the benefits from established ICT-enabled learning.

A.2 The goal is to transform learning outcomes. How? (further discussed in Appendix 2 – Linked Papers)

Higher performing schools in developed contexts deliver measurably higher levels of learning progress. But that has taken the better part of 3 decades of digital innovation and more than a hundred years of continuous investment.

Thankfully, schools in developing contexts can leapfrog much of that development time by exploiting pockets of proven innovations that improve learning outcomes - and do it at scale.

That solution, however, is far from simply enabling digital content in the classroom. Digitization isn't an end-in itself. Nor is it the ultimate replacement of crafted teaching skills and experiential learning with nameless digital input/output.

For several decades, progressive education systems have been working to develop the pedagogical model, blending self-paced learning with group learning, including:

- upskilling teachers to deliver differentiated teaching that aims to engage and manage the learning process for students across the progress and ability range.
- assigning classroom assistants to small groups or individuals to individualize teaching aimed at overcoming specific learning hurdles

Applying those approaches at scale was always going to be challenging, even in well-funded highly resourced classroom contexts. In a post-pandemic large-class developing context, with a far wider ability-age range of students and a shortage of teachers and digital teaching skills, it would seem impossible.

In the ideal world, every student would have personal, instant access to the Teacher, who would respond in real time, personalizing the learning actions that needed to be taken. It is this exact frontier where the most advanced edtech and e-Learning practices can make a difference.

Teachers know what they want from technology – better support for them, better support for individual students, and inspiration for better learning.

At the top of the transformative hierarchy, and as part of a fully blended approach, adaptive platforms hold great promise, personalizing learning at scale, enabling both students to learn at the rate and method that best suits them, and teachers to efficiently guide and mediate that learning to successful outcome.

A.3 Connectivity is key (further discussed in Appendix 2 – Linked Papers)

As nations progress along the digital journey, having adequate connectivity in place for each step is critical.

Online functionality that supports transformative learning is not simply providing access to the internet, nor is it hosting curricula online: ultimately, it is about ensuring the entire national education system can interconnect holistically to not just deliver learning, but to learn from that delivery and continuously improve implementation.

Thus, schools' connectivity underpins everything. When connectivity fails or is inadequate, teachers are forced to fall back to traditional teacher-centered methods, and digital content becomes front-of-class show-&-tell; learning outcomes will be negatively impacted.

Meaningful Connectivity that provides Effective Access to advanced e-Learning in a whole-class or ICT-lab setting is vital.

SECTION 1

Why and how Efficiency Strategies fix the Connectivity Problem for schools

1 The Connectivity Problem for schools

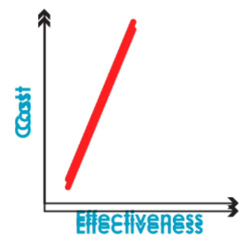
1.1 Defining 'The Connectivity Problem'

Sadly, the evidence tells us that existing connectivity strategy is systemically failing. Not just in rural and remote locations but in urban, well-connected environments too.

In developed environments, bandwidth has been invested-in to the tune of billions of dollars. The US is not alone in spending huge amounts of universal service funding to meet promoted bandwidth targets. Yet demand continually evolves to outstrip capacity in most schools. For less developed regions, the cost and availability of higher bandwidth is simply out of reach. Too many schools are being left behind, struggling on the narrowest of connections or resorting to offline solutions while awaiting adequate connection.

Rural/economic digital divide

Ever-increasing costs



Poor bandwidth ROI

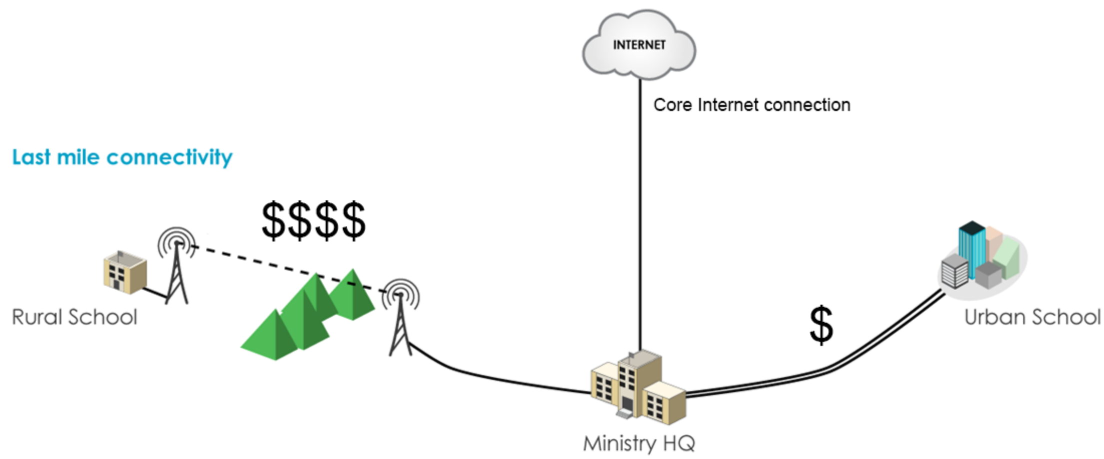
The connectivity problems for schools are systemic:

- bandwidth distribution is inequitable due to cost and availability
- as e-Learning develops, the need for more and more capacity creates network inflation, which is wholly unsustainable
- connectivity usage in schools is wastefully inefficient.

As a result, with content publishers designing content for high-bandwidth contexts, the best, most engaging, most transformative eLearning is inaccessible to remote schools.

1.1.1 Bandwidth is inequitably distributed and inequitably priced

Multilateral funders, national and international projects such as the UN's GIGA, are working hard to connect schools. The challenges in providing schools in the most remote communities with **sustainable Meaningful Connectivity** are huge and widely understood; bandwidth is more difficult and more costly to support for less densely populated and more remote regions. And it takes time, which we don't have.

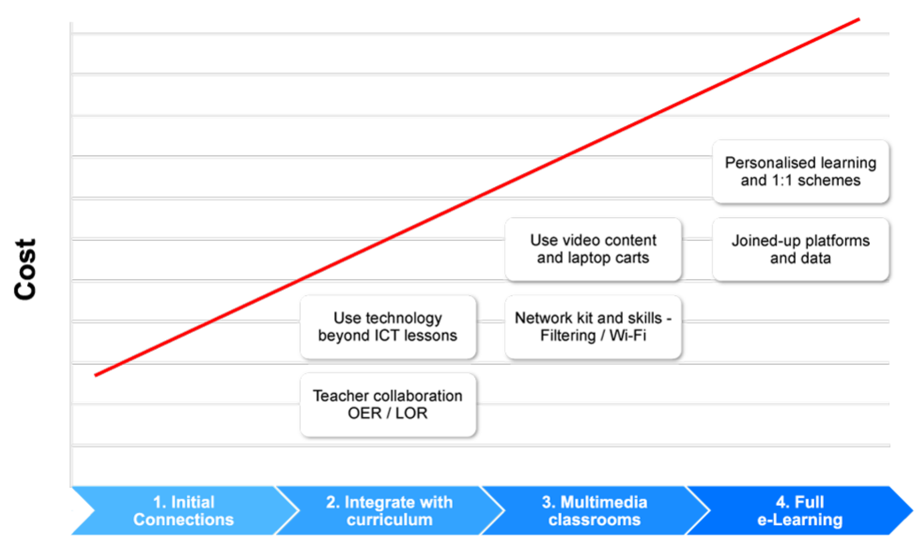


In addition, while a school's first 'connection' - such as 4G or satellite - is an important first step, on its own it doesn't deliver what is needed to close the learning gap. Remote and rural schools need more connectivity than an initial connection will deliver alone if they are to avoid being left further behind.

For remote and rural schools, reliance on bandwidth alone to provide the Effective Access that they need simply doesn't work.

1.1.2 Year-on-year demand for increasing connectivity

Sustainably meeting the demand for bandwidth is an uphill challenge. As digital learning develops from early connections, demand increases from having more users, from increasing use of engaging media-rich content, from utilizing the internet across a wider curriculum.



Often doubling every 2 years, Western nations have taken more than 20 years to reach current capacities, while in developing contexts, some national education authorities expect it to take a decade to get to just ¼ of US 2020 levels.

1.1.3 The most transformative online platforms are inaccessible to rural schools

With rural learning environments typically restricted to narrower bandwidths, digital learning is confined to the bottom of the SAMR model where digital content is presented from the front of class. The more transformational approaches - from independent learning, through the addition of metrics for monitoring and targeted intervention, through to adaptive platforms with personalized learning pathways for each individual student – without a rethink these approaches remain inaccessible for years. Sole reliance on bandwidth to deliver connectivity condemns rural schools to the slow lane in terms of transforming learning outcomes.

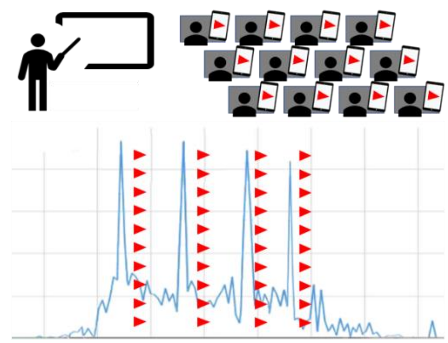
1.1.4 T&L utilizes networks and internet connections inefficiently

How the teaching & learning (T&L) process uses the internet is remarkably inefficient. With a traffic profile unique to education & training activities, T&L traffic is made up of peaks in demand that reoccur at the start of every lesson throughout the day.

Other Industries

Typical daily traffic – hour by hour
Constant average demand

Schools

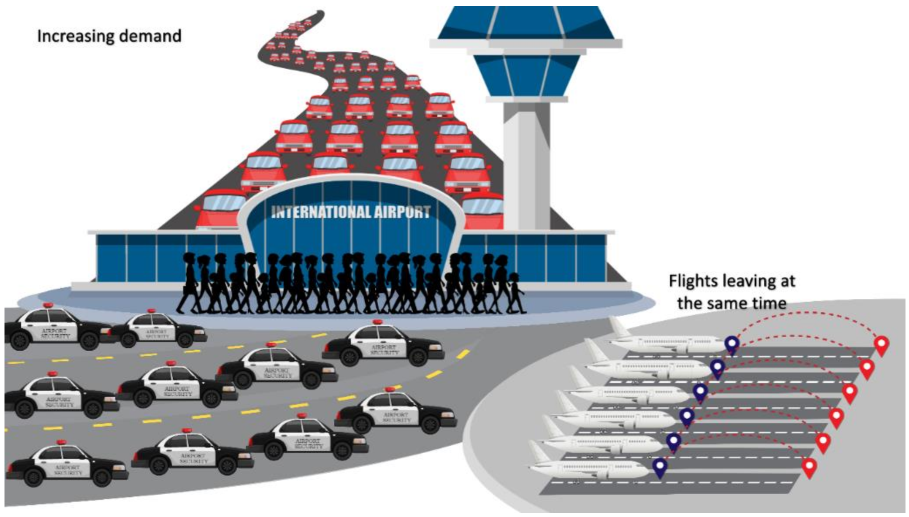


Typical daily traffic – hour by hour
Frequent excessive peaks

When Teachers instruct whole classes to access the same content, they do so at the same time causing huge spikes in demand. The act of fetching duplicate content, over and over, instantly causes excessive traffic peaks. These quickly overwhelm capacity, causing congestion that prevents further access. It is this uniquely compressed but time-sensitive demand, completely unlike the demand in other industries, which determines the capacity needed to avoid congestion, and for lessons to run smoothly, efficiently, and effectively.

But it is exactly this usage inefficiency which gives scope for dramatic efficiency improvements - by simply paying attention to 'how the internet is used'.

If an airport operated as inefficiently, with the whole day's flights leaving all at once, the scale of resources needed to accommodate passengers, cars, and security at the terminal – plus the number of gates, planes, and runways - would be mind-boggling. But of course, airports don't operate like that, in fact they are designed for efficient use throughout.



The evidence shows that most nations rely on bandwidth alone, so The Connectivity Problem for schools remains unaddressed, poorly understood, even accepted.

1.2 Efficiency addresses all aspects of The Problem

Inclusive internet delivery mechanisms already exist - they are merely being ignored. Devised at the birth of the internet, some of these mechanisms are widely in use by large CDN and hosting platforms, who, like Internet Service Providers, already reap efficiency benefits for themselves for example from millions of caching servers around the world.

When content is designed and configured with efficiency in mind, those same delivery efficiencies can bring the most powerful, fully inclusive learning transformation within reach of every school.

1.2.1 Connectivity Efficiency practices are as old as the internet

Technologies and approaches for countering the inefficient use that T&L exerts on the internet and networks were widely understood and utilized in advanced schools-systems at one time. ISPs based their commercial operating model on their implementation when the internet was founded, and by-and-large still do.

In the early 2000s in both the US and the UK, it was common practice in a school to optimize what connectivity you had. US and UK school district network managers routinely undertook husbandry measures to ensure smooth internet access. In the UK, the government provided funding to schools to deploy caching appliances, and network managers were adept at controlling and 'shaping' traffic use to prioritize key applications.

But within a generation of Education network managers, a culture developed that sought to *build-out infrastructure* as the only priority. In the US, internet bandwidth was even labelled 'Priority One' in Federally funded schools technology grant schemes. Bigger budgets pumped funds into higher capacity connections. Strategies evolved to focus connectivity growth on bandwidth capacity targets. In the US these targets mistakenly became the method for evaluating successful connectivity implementation, and advisory bodies evolved targets down to Mbps per student. Making careful use of whatever bandwidth was available became a forgotten art.

With remarkably high bandwidth capacity targets soon a mainstream fixture, content providers developed their curricula and platforms for high bandwidth environments. If a school didn't have sufficient connectivity to support the latest media-rich content, they were advised to upgrade their bandwidth. If the only way to deliver Effective Access for a whole class or lab of students is solely to build out bandwidth, that same content now can seem to be simply inaccessible for remote schools, or for those where Effective Access would come at too high a price.

Even the US concluded in 2014 that simply doubling bandwidth every year was unsustainable. Network inflation didn't stop with the internet connection itself; the entire network infrastructure in schools was on an inflated upgrade path: the faster you grew your bandwidth consumption, the more rapidly you needed to upgrade to larger filters, firewall, routers and switches. In a belated attempt to drive better value for money, from 2015 onwards the US FCC opted to encourage schools to make more efficient use of the bandwidth they had, with funding made available for all schools to implement caching technologies that would re-use and recycle web content.

1.2.2 Efficient use defines a path that is more equitable and more sustainable

Today, harder-to-connect communities in developing environments setting out on their e-Learning journey have to take a different path from the start. If we treat connectivity as a precious resource, with the good husbandry with which we conserve other precious resources like power and water, we can make a little bandwidth deliver 10 or 20 times the Effective Access that it otherwise would,

Overall, incorporating efficiency strategies into connectivity management does not COST anything. On the contrary, it saves money, enabling in low bandwidth environments whole classrooms together to access advanced online learning platforms, at bandwidth capacities that would otherwise only support one or two simultaneous users.

The **C.O.R.E.** framework is simple, logical, proven:

- Don't use the internet unless you have to – save it for the things you really need the internet for
- If you are going to use it, make it as lite as possible. And protect your key start-of-lesson minutes from unnecessary online activity
- Wherever possible, fetch re-usable internet objects once and then share them with whoever needs them
- Find ways to utilize the infrastructure outside of school hours to take the pressure off the network during the daytime, and better leverage the investment
- The adoption of C.O.R.E. strategies and Standards mean the most transformational e-Learning doesn't have to be out of reach, including for the most remote users relying on the narrowest of connections.

In Senegal, many schools have few connectivity options. The MoE project examining 4G ICT lab connectivity found 3.5Mbps insufficient for all the smart classroom devices to be online at the same time. Videos would buffer, students would lose concentration, leaving teachers reluctant to use the lab. When a **C.O.R.E.**-efficient approach was adopted, Effective Access to the Education Ministry's online content was unlocked for the whole class.

In Ecuador, the Ministry of Education project to connect remote schools on just 1Mbps of low-cost satellite connectivity, through efficiencies and efficiency technology, whole-class online activity was enabled. All the devices in the lab streamed online video concurrently, despite the limited bandwidth capacity.

1.2.3 Efficiency Strategy needs widespread, collaborative, stakeholder buy-in

The Senegal and Ecuador examples and thousands like them show that Meaningful Connectivity is not about the # of Mbps available. What matters is what you can and can't do in any given connectivity situation. And that is affected by both the bandwidth that you have and by how efficiently you use it.

In fact, what **C.O.R.E.** and successful practices have shown is that bandwidth is NOT king. Some schools achieve a lot with very little, while others find they achieve little despite having a lot. Efficiency is the senior partner in the equation.

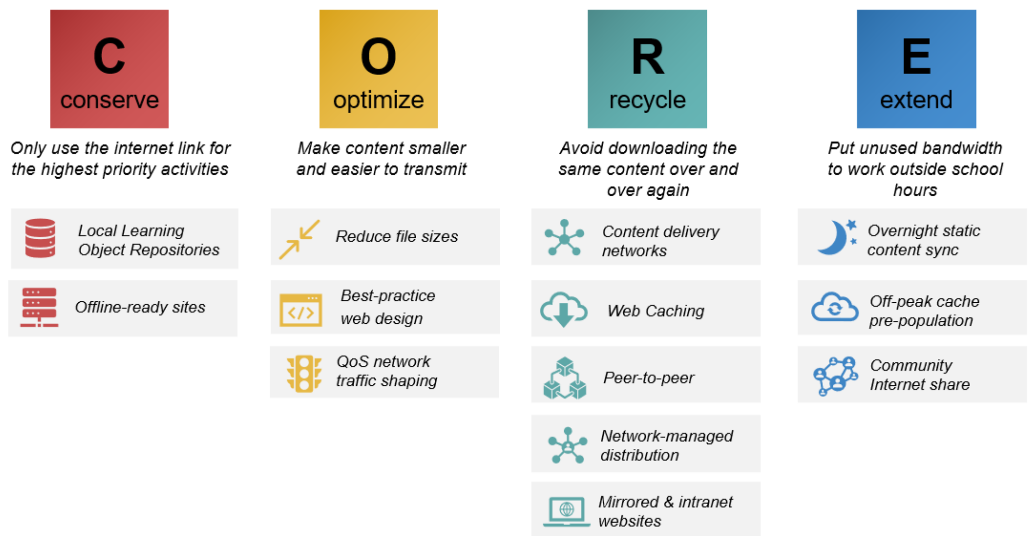
But connectivity efficiency requires a rules-based order. It is only through shared and open standards that all respective education stakeholders will participate, help shape, and ultimately compel adherence to a framework that benefits everyone.

The development of the **C.O.R.E.** strategies and accompanying Standards is a step towards that, and towards the equity and sustainability that can follow.

2 Connectivity Efficiency Strategies

2.1 C.O.R.E. Efficiency Strategies for Meaningful Connectivity

Connectivity efficiency can be defined by four **C.O.R.E.** Efficiency Strategies for Meaningful Connectivity:



Conserve – Bandwidth is a precious resource; we need only to use it for priority activities, and instead leverage offline capabilities, and off-peak content syncing.

Optimize – Consideration for reducing the weight of unnecessarily large content, without affecting quality, can minimize bandwidth use. Minimizing transmission cost can also help optimize local network performance and improve user experience. In addition, the precious start-of-lesson window can be protected with low-cost traffic shaping.

Recycle – Configured correctly, the vast majority of traffic fetched from the internet into a learning environment can be recycled and re-used. Various technological approaches can help with recycling content and software updates, de-duplicating repeat-requests, storing re-usable page elements including video and updates, as well as copies of whole websites, locally.

Extend – Getting more from a connection means making use of it off-peak, day and night. Content can be downloaded ahead of time, ready for school use. When schools are closed the same connectivity and internet access can be extended to the local community – supporting local needs for basic communication or adult learning schemes.

C.O.R.E. Efficiency Strategies for Meaningful Connectivity enable education authorities and ed-technologists to be fiscally responsible, executing towards planned internet capacity, building for Future Visioning 2030. The same **C.O.R.E. Efficiency Strategies for Meaningful Connectivity** and the **Standards** that emanate will provide content providers with a framework to guide how they configure content, delivering equitable and sustainable access for hard-to-connect learning environments around the world, resulting in:

- the most efficient use of whatever bandwidth is available
- equity of opportunity to access the most transformative e-Learning
- radical reduction in costs and improved sustainability
- better network & content performance
- ultimately - better learning outcomes.

2.2 C.O.R.E. in Context

The **C.O.R.E. Efficiency Strategies for Meaningful Connectivity** will ensure that all learning environments, including those yet to be connected or struggling to build capacity, and their respective e-learning method – be that hybrid, blended, online in brick-and-mortar classrooms – will benefit from the most effective connectivity solutions.

Meaningful Connectivity is at least in some part contextual; the connectivity requirements of a school's system, a TVET college, a university, or a corporate training center, are dictated by a series of inter-relating factors, such as the number of learner devices that could use the internet at any one time, and the range and scope of digital activities and/or ambition.

In terms of the connectivity needed, there is no single numerical that can be applied to all individual learning environments – there is no one-size-fits all. Understanding respective connectivity contexts is critical to the adoption of these Standards and the maximizing of corresponding outcomes.

As a result, there are two key areas for leadership to address:

- understanding the strategy – impact on:
    - classroom engagement, learning outcome support, transformational ambition
    - return on investment, fiscal responsibility, access to funding
- ensuring effective implementation:
    - content selection, design, management
    - network management, technology selection

C.O.R.E. in Context is a three-step process that aligns the efforts and capabilities of all stakeholders to deliver a coordinated approach to Meaningful Connectivity and bring about the improved learning outcomes that this underpins.

The process will determine which elements of each of the **C.O.R.E.** strategies require the greatest attention for each respective situation. It will provide a customized schedule of specific tactical actions by which leadership, educators, & technologists can:

1. Evaluate access requirements

- Self-assessment – C.O.R.E. Efficiency Strategies for Meaningful Connectivity model

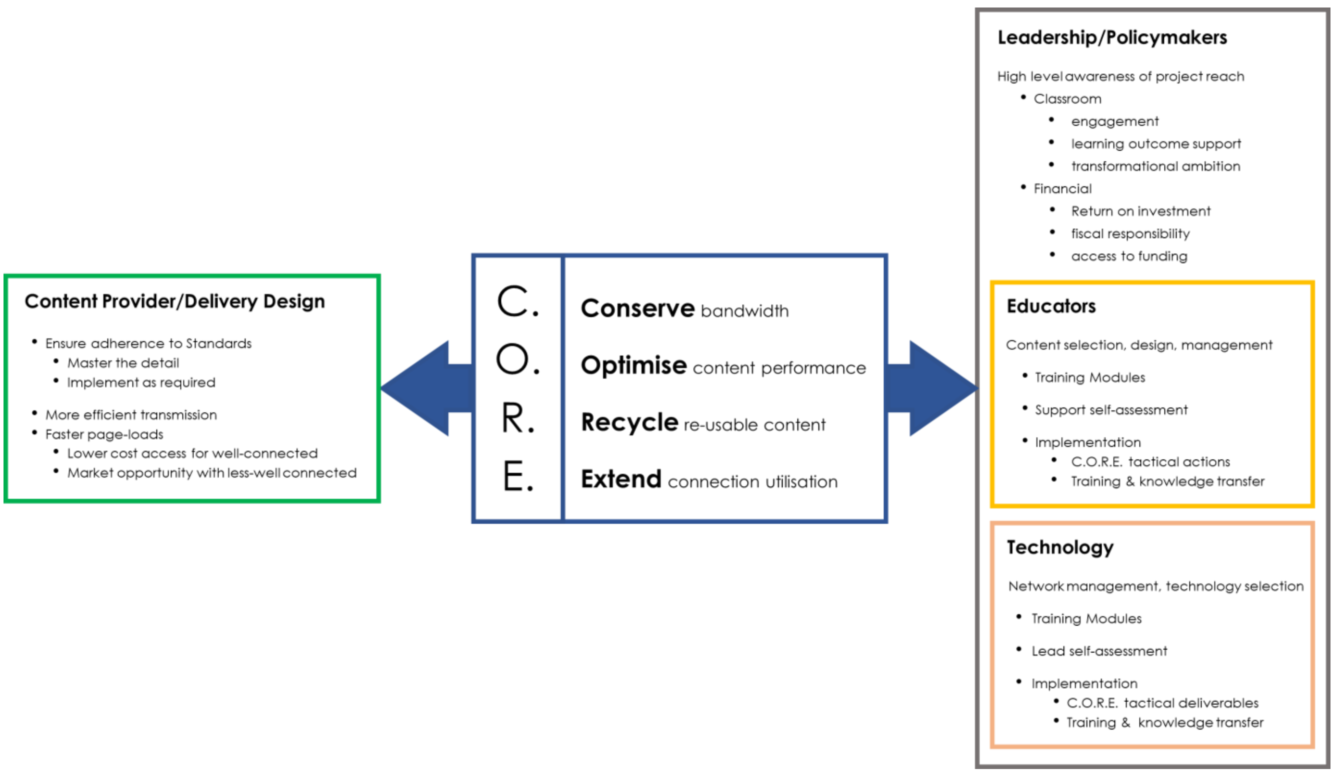
2 Establish management strategies

3 Deliver ongoing assessment, training & management

The new Recommended Standards that apply to this contextual application of the **C.O.R.E.** strategies specify the responsibilities at different levels within a school, or other learning environment, at the institution level, as well as within instructional & technology departments:

- an institution leadership responsibility: acquire a high-level understanding of the task and its implications across both learning outcomes and financial probity, and delegate appropriately
- an instructional leadership responsibility: understand and manage the process, training/ knowledge transfer
- a technology leadership responsibility: lead implementation, training/ knowledge transfer
- a technology team responsibility: master the detail and implement as appropriate.

C.O.R.E. in Context responsibilities:



SECTION 2

Recommended Standards supporting **C.O.R.E.**

1 Conserve

The **CONSERVE Efficiency Strategy** considers that while the most transformative e-Learning may require online whole-class access to media rich and engaging content with learning metrics and adaptive capabilities, there are other routine digital activities that do not need to utilize the internet connection to be effective.

By designing content and content delivery mechanisms with that in mind, it's possible to relieve internet connections of traffic which doesn't strictly need internet access, particularly at times of peak demand, making space for priority activities that do require real-time internet access.

Mechanisms which can be used to achieve that include making static content available offline as well as off-peak content synchronization to on-premise repositories.

1.1 RECOMMENDED STANDARD: Static content & resources that don't require real-time access to central web servers are configured to enable the use of local, offline, and offline-synchronized access.

1.1.1 Provide offline/local delivery for content that does not need real-time online access

Offline-ready sites: rather than the linear page organization of a pdf, offline-ready sites are designed to simulate a browsable website structure – but, unlike a website, they are hosted within the local area network.

These sites are entirely read-only and have no dynamic content – that is they return the same content for every user. They contain content that is rarely updated, and which can be delivered without the need for a persistent internet connection.

Industry examples include Wikimedia, PhET, Rachel Offline and Khan Academy's KA Lite.

The same mechanism can be used for an Education Authority's own static content and resources.

1.1.1.1 INDICATOR: Learning Content Managers and Content Providers make Static content available as 'offline-ready' & 'mirror-ready' sites

Technical considerations for offline-ready sites:

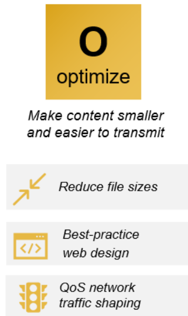
- Use an index.html home page to enter the site
- A structured HTML collection of linked files can include any static media type:
  - Images, JavaScript, videos, and audio content can all be included but should be suitably compressed
- Server-side generated pages (PHP, node.js, Python, JSP etc.) cannot be included as there is no interpreter available
- Any interactivity must be contained on the client side (e.g., local storage in the web browser) using JavaScript to remember user preferences
- Cookies are not recommended
- Once the content has been organized correctly locally it can be turned into a ZIM file - various tools such as zimwriterfs are available to do this

Learning Object Repositories (LORs): LORs are set up not as publicly accessible websites but as a central (datacenter) or a local (last mile) repository of static, read-only teaching and learning resources.

Authorized users (e.g., content curation teams, teachers) upload content such as videos, e-books, learning resources and lesson plans, that can be viewed in read-only mode by other network users (e.g., students). As such, LORs are a great tool for collaboration and the accumulation of successful practice from a wider network of contributors.

1.1.1.2 INDICATOR: Learning Content Managers and Content Providers make available Static Teaching & Learning materials in a Learning Object Repository or other synchronization-capable File Structure

2 Optimize



There are cost and speed-of-access implications for all content; the 'heavier the content, the higher the cost'. This applies to all learning environments, not just in bandwidth-constrained areas.

2.1 RECOMMENDED STANDARD: Web-based learning content is 'optimized' to minimize bandwidth consumption

2.1.1 Minimize overall page weight & complexity

Overall pages (consisting of HTML structure, scripts, stylesheets, and multimedia content) should be minimized, reducing bandwidth consumption and improving content rendering on user devices.

2.1.1.1 INDICATOR: Content Providers minimize overall page size, the use of scripts, and the loading of scripts from external domains

2.1.2 Media optimization – compress videos & images

Multimedia content included in webpages should be compressed to reduce the file size.

Indexing video which is delivered in smaller chunks (via HLS, Range Requests, or similar) enables a user to jump straight to the relevant part of a video without downloading the entire video file.

2.1.2.1 INDICATOR: Content providers resize images and compress video content using modern codecs with a high compression ratio

2.1.2.2 INDICATOR: Video content providers use tags, indexing, to permit users to access a point in the video directly without the need to download the entire video

2.1.3 Minimize bandwidth consumption of PDFs and other document media

As a mechanism for distributing content to low bandwidth areas for on-screen use, HTML pages are preferable to the distribution of PDFs over HTTP. With HTML, content will start to load immediately and pull in external images later, optimizing content responsiveness. With PDFs, the entire document must be transferred before it can be displayed, which can be problematic on narrow connections.

Where PDFs are unavoidable, images should be suitably compressed, and graphics should utilize vector images to allow for bandwidth-efficient scaling.

2.1.3.1 INDICATOR: Content Providers use HTML instead of PDFs

2.1.3.2 INDICATOR: Content Providers reduce and compress PDF images

2.1.3.3 INDICATOR: Content Providers use vector images for bandwidth-efficient scaling

2.1.4 Minimize refresh rates

Content providers should ensure that content is 'refreshed' only when necessary. For example, for a static page no refresh is needed. For content that updates either by refreshing the page or performing background XHR/AJAX requests, such as a live scoreboard for a quiz, an assessment should be made to minimize the refresh frequency in order to minimize bandwidth consumption.

2.1.4.1 INDICATOR: Content Providers configure static web pages with low/zero refresh rates

2.1.4.2 INDICATOR: Content Providers configure pages with both static and dynamic content so that only the dynamic components are refreshed, rather than the entire page

2.1.5 Responsive design

Web content is accessed on both mobile devices and desktop/laptop computers, so designing for both is essential. Having separate websites for different-sized screens increases bandwidth consumption. Modern web frameworks allow for implementing 'responsive' designs, i.e., a single site that adapts to the device-type accessing it.

If there is a mixture of devices in a school, such as BYOD (Bring Your Own Device) environments, a responsive design will mean that the same assets can get loaded by different device-types, with browsers adjusting content layout. This allows shared network caches to reduce bandwidth consumption and will simplify content development and management.

Such design can also respond to accessibility considerations ensuring content is fully optimized for screen readers and other third-party tools. Those accessibility design principles can also be optimized for bandwidth efficiency.

2.1.5.1 INDICATOR: Content Providers build sites with a single responsive design

2.1.6 'Lazy loading' of images

On pages with heavy media content, for example a topic in a course containing images, 'lazy loading' reduces bandwidth consumption and can smooth demand spikes.

With this design technique, content is not loaded until the user scrolls near to it, so that unseen/unused content is never loaded, only that which is displayed to the user.

2.1.6.1 INDICATOR: Content Providers configure long scrollable pages with 'lazy loading'

2.1.7 Content hierarchy

Organize content to minimize the chances of users navigating to the wrong content, resulting in unnecessary bandwidth consumption.

For example, at the end of a topic in a course you could have clear 'Next topic' buttons. If offering a choice of next topics, consider limiting to say 3 available topics rather than 15.

2.1.7.1 INDICATOR: Content Providers design web content with a hierarchical structure and/or with thoughtful sequencing

2.1.7.2 INDICATOR: Content Providers design course materials to include 'Next' and 'Previous' navigation

2.2 RECOMMENDED STANDARD: Learning content and software updates are configured to support network QoS optimization

2.2.1 Preserve peak-time internet capacity for the highest priority e-Learning traffic

Quality of Service (QoS) is used in networks to optimize or guarantee performance, decrease latency, or otherwise increase usable bandwidth by limiting the performance of selected traffic to make space for priority traffic.

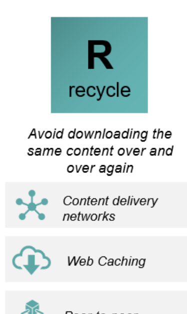
An example is Traffic Shaping, which limits the amount of bandwidth a specified application can use, in some cases applying these limits to specific time-periods with peak/off-peak rules.

2.2.1.1 INDICATOR: Content Providers and Software Vendors use standard ports to facilitate QoS optimization

2.2.1.2 INDICATOR: Network Managers apply QoS policies to prioritize peak-time access for content that must be accessed online, and for live video or calls

2.2.1.3 INDICATOR: Network Managers have the ability to shape traffic to support off-peak downloads of software updates

3 Recycle



Internet traffic in schools and other learning environments includes learning content as well as software updates for learning devices. But it is the way in which the process of Teaching & Learning accesses this content which exerts an unusual pressure on the internet connection:

- Multiple users fetching the very same identical content simultaneously, create start-of-lesson spikes in demand, often compounded by demand from user devices for software updates.

Fortunately, since the formation of the internet, mechanisms have evolved which slash the network impact of those spikes. Together they form a formidable toolbox.

3.1 RECOMMENDED STANDARD: Web-based learning content and software downloads are configured to support single-download/recycling technologies, including for access by user-owned devices

3.1.1 Content Delivery Networks

Content Delivery Networks (CDNs) allow high-bandwidth content to be recycled closer to end users through a network of physical nodes, often globally. CDNs are typically controlled by third parties. For schools, last-mile CDNs (at the school level) overcome the limitations of last-mile connectivity and are a significant aid in low bandwidth environments to making specific online content available, including on student-owned BYOD devices.

Technical considerations:

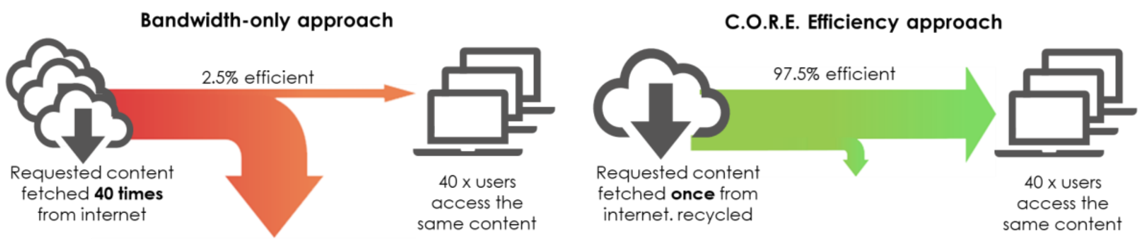
- Content must be delivered using predictable URLs
- URLs must not be specific to the user that requested it
- Content providers should consider the use of HTTPS carefully. Securing only elements which need to be secure (authentication, private user-data) will make it easier for remote schools to re-cycle re-usable elements.
- The public certificate and private key pair may need to be shared in reverse proxy scenarios, which means that appropriate subdomains and organization of certificates may be needed to mitigate the risks appropriately.

3.1.1.1 INDICATOR: Content Providers configure content to enable last-mile CDN access in remote schools, with consideration for BYOD use.

3.1.1.2 INDICATOR: Network Managers utilize last-mile CDN access in remote schools.

3.1.2 Last-mile web-caching

Web-caching is a low-cost technology, and because of the high proportion of 'repeat requests' it works particularly well in Teaching & Learning where content providers adhere to internet standards.



Web-caching has been in use since the birth of the internet itself. In effect, web-caching de-duplicates internet requests. It fetches re-useable content elements and software updates just once, then shares them to users locally, from cached memory. It is a cornerstone of ISP operational models.

3.1.2.1 INDICATOR: Network Managers utilize web-caching in the last mile

3.1.3 Adherence to HTTP Standards

By reminding Content Providers of the internationally accepted Standards for content transmission configuration, this same mechanism can be made available to learning environments in the last mile - in the school building itself.

Without adherence to Standards, media-rich web-based content can remain inaccessible to schools in low-bandwidth areas. But if content can be downloaded once and then shared dozens, hundreds or even thousands of times, it slashes any bandwidth requirement.

These Standards are incorporated in the HTTP protocol that the internet uses.

Technical considerations:

- Websites should incorporate appropriate headers, avoiding headers which are unnecessarily restrictive, such as:
- Cache-control: private
  - Max-age: 0
  - No-cache

        - No-store
    - A good example of a correct header might be:
        - Cache-control: public

3.1.3.1 INDICATOR: Content Providers and Software Vendors configure both static and dynamic content/traffic elements to support interoperation with last-mile caches

3.1.4 Tailored transmission of re-useable content and user-specific data

In modern interactive content delivery, the data transmitted from the upstream webservers is commonly a mix of:

- user-specific data such as authentication (user-login) data, learning progress data & metrics
- re-usable elements utilized by all users such as videos, images, page assets

with both of those data-types working together in a single application or content platform.

Some of the most common and important e-Learning activities will contain this mix of unique and re-usable data in combination:

- interactive live video broadcast teaching with teacher video and student chat
- online assessments
- online content platforms that track user progress
- adaptive platforms which personalize learning pathways for individual students

To be amenable to connectivity efficiency approaches, these two data-types must be treated appropriately, and that treatment differs depending on whether an object is re-usable or unique.

If the unique (personalized) elements are separated/marked differently from the reusable (generic) elements, then network managers can selectively apply bandwidth-saving tactics to the re-usable portion.

In low-bandwidth schools, any rich-media content needs this consideration. But this is particularly important with content that contains video because video is such a heavy consumer of bandwidth.

For example, where multiple students in a school all access a remote interactive live-broadcast lesson, some applications may download the entire live-stream for each student. Where there is insufficient bandwidth available to support that level of activity, video quality will be reduced, or the stream will be intermittent/broken.

Interactive remote-broadcast teaching applications designed specifically for this remote-classroom situation have a fundamentally different architecture, which enables the separation of the broadcast stream from the interactive elements such as chat windows. This means that in low-bandwidth schools, connectivity efficiency strategies can be applied to the reusable element – the video stream – fetching it just once into the school network and then sharing it from there to each individual user.

Technical considerations for separating/marking data types:

- Separating the reusable content onto its own domain or subdomain enables network managers to target re-usable efficiency strategies and tactics such as traffic shaping. For caching and filtering of content transmitted over HTTPS, an appropriate interception regime would be required.
- Alternatively, HTTP headers can be used to indicate to network devices whether each object is reusable or unique. With HTTPS, this approach requires an appropriate interception regime for traffic-shaping as well as for caching and filtering.

3.1.4.1 INDICATOR: Network Managers selectively apply bandwidth-efficiency strategies to interactive live broadcast, online assessment, and platforms enabled with metrics and adaptive capabilities

3.1.4.2 INDICATOR: Content Providers separate/mark differently re-usable from unique elements

3.1.5 Integration with caches in BYOD environments

Website providers should set up re-usable content elements to be highly cacheable and preferably served over HTTP for 'unmanaged' student devices.

Network managers should set up the network so that the BYOD devices are intercepted.

Technical considerations:

- Content being served should have the appropriate headers and be served over HTTP to enhance classroom performance.
- If content needs to be private and/or encrypted using the HTTPS protocol, site content should be organized appropriately to ensure certificates can be distributed to Cache and CDN owners for reverse proxy capabilities.

3.1.5.1 INDICATOR: Content Providers configure sites to support last-mile caching of static/ re-usable page elements for access by user-owned/ unmanaged/ BYOD devices

3.1.6 File-validated Peer-to-Peer software update mechanisms

Peer-to-Peer update mechanisms typically enable a software update or application to be downloaded once to a user device, then distributed to other devices locally.

Technical considerations:

- Peer to peer software update mechanisms typically use a checksum to validate that the payload is intact and has not been modified in transit, either maliciously or through corruption. Inbuilt checking of the integrity of the update file provides the freedom to securely access the file from a source different from the origin server, such as a neighbouring user-device.
- Given the decentralized nature of this approach, the configuration of boundaries is often recommended to define the scope of peering, along with options to help ensure that the performance of the source device is not impacted by the additional load placed on it by peers.
- Encourage the use through appropriate design of technologies like AirDrop or Wi-Fi Direct to support local transfers.

3.1.6.1 INDICATOR: Content Providers design their solutions to search for other devices on the local network that have already downloaded the required content or updates and request it from them

3.1.6.2 INDICATOR: Network Managers configure the delivery mechanism to prefer downloads over the local network

3.1.7 Network-managed distribution

Network-managed distribution mechanisms can also be used to facilitate the deployment of software updates to multiple user devices from an internal source. This approach typically provides greater control and reporting over the peer-to-peer model, albeit with a higher management overhead.

Technical considerations:

- This should be a local mechanism to minimize load on WAN/Internet Links

3.1.7.1 INDICATOR: Network Managers administer the distribution of content from local network servers such as an MDM solution

3.1.8 Mirroring

Mirroring can be used to create copies of websites that are located closer to user devices with the aim of serving content faster. An on-premise mirror site will also provide last-mile bandwidth savings; however, some only host static content.

Technical considerations:

- Mostly static or can be used to create an 'offline site'; that which is dynamic should be client side rather than server side, and provisions in place to regularly synchronize new content between the origin and mirror.
- Content should be served over HTTP where possible
- If HTTPS is used, then the requirement for a certificate needs to be considered appropriately.
- If caches are to be utilized downstream of the hosted site, files must have sensible cache headers. Modern web servers such as nginx will do most of this automatically for static files, for example, adding ETag headers.
- Content should be accessed without needing to login first.

3.1.8.1 INDICATOR: Network Managers mirror websites on local file servers

3.1.8.2 INDICATOR: Content Providers design sites that are mirror-capable

3.1.9 Intranet sites

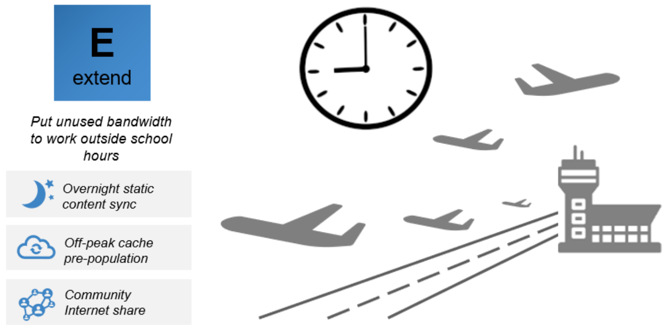
Intranet sites can be used to recycle specific, preloaded content to user devices. Although not transparent, these sites are often accessed by a significant proportion of users and therefore provide both speed and bandwidth savings.

Technical considerations:

- The intranet server should be local (true intranet as opposed to extranet) such that traffic does not have to pass on to the Internet

3.1.9.1 INDICATOR: Network Managers use internal sites to distribute content

4 Extend



Where bandwidth is expensive or limited, extending downloads into off-peak times is a key strategy in delivering equitable access to the most transformative e-Learning.

Activities that can be automated to take place overnight are:

- synchronizing static file-structures of learning resources to local servers
- pre-populating cache servers with the static page elements of websites that will be accessed the next day

By fetching these items overnight:

- peak-time bandwidth is freed up, e.g. at the start of lessons
- content is then available at local network speeds, typically faster than internet speeds

4.1 RECOMMENDED STANDARD: Web-based learning content is configured to facilitate off-peak automated download to last-mile servers and caching servers

4.1.1 Local synchronization of static web-page assets via 'Indexing'

A Site Index lists static page assets, enabling last-mile caches to retrieve page assets as an off-peak automated synchronization activity

4.1.1.1 INDICATOR: Content Providers make available an automatically updated index of the site's assets, each URL representing an individual object

4.1.1.2 INDICATOR: Network Managers configure web-caches to perform periodic synchronization of websites via site index files to keep last-mile content current

4.1.2 Local synchronization of video and audio files

Video and audio files consume particularly large amounts of bandwidth and can be slow to download on narrow connections. Local off-peak synchronization can be particularly helpful.

4.1.2.1 INDICATOR: Content Providers configure web-based video content to be available for automated off-peak synchronization

4.1.3 Local synchronization of File Structures

4.1.3.1 INDICATOR: Content Providers and Network Managers configure Learning Object Repositories and materials housed in File Structures to be available for automated off-peak synchronization

4.1.4 Extending access to the local Community

Schools can make their connectivity available to the local community to access the internet at off-peak times, evenings, weekends, and holidays. The scope of that access can be controlled and would need to be tightly controlled where connections are narrow.

Appropriate access to online and offline areas and applications could be configured for different stakeholders and organizations in the community.

Technical considerations

- Regulation and control
  - Traffic shaping (ideally last-mile and, if required, with central/remote control) can be configured to limit access times and define what can be accessed
  - Last-mile control could be achieved by, for example: Firewall, Content Filter, QoS e.g., Traffic Shaping
  - Consider the nature of those limits, e.g., specific websites, or include email or chat platforms, and whether there is sufficient bandwidth for specific options:
    - cached or local content would be low bandwidth, so preferred
    - use of attachments, video or voice, potentially heavy in social media
- Managed devices and BYOD
  - Access for BYOD – e.g., for government web sites – will have to be either HTTP, or, if HTTPS, then cached in a reverse proxy setup
  - Managed devices for adult training, enterprise, government offices, could have HTTPS caching enabled if installation of SSL certificates is possible
- Segmentation
  - Where individual authentication is impractical, user-groups that are to have their own access rules will need to be identifiable as a segmented user-group via an appropriate mechanism such as subnet or SSID

4.1.4.1 INDICATOR: Network Manager to provide suitably regulated access to the internet for the community

5 C.O.R.E. in CONTEXT

It is Schools, and other organizations with learning environments, that will take responsibility for implementing C.O.R.E. Efficiency Strategies for Meaningful Connectivity.

This is particularly so because the concept of 'Meaningful' is entirely contextual, requiring collaboration between leadership, pedagogy, instructional IT and technology.

Because that context will change over time, sometimes rapidly, the establishment of an ongoing process is needed, which the C.O.R.E. Strategies & Standards are designed to support.

5.1 RECOMMENDED STANDARD: Organizations, Learning Environments, establish & maintain effective connectivity provisions, appropriate to their context, which take into consideration C.O.R.E. Efficiency Strategies to maximize support for e-Learning and to minimize cost

5.1.1 The role of leadership

5.1.1.1 INDICATOR: Institutional leaders adopt elements of the C.O.R.E. Efficiency Strategies for Meaningful Connectivity to minimize financial impact and maximize pedagogical delivery in context of own institution

5.1.1.2 INDICATOR: Institutional leaders manage strategic adoption and the training/ knowledge transfer process

5.1.2 The roles of technology and instructional teams

5.1.2.1 INDICATOR: Instructional & Technology teams evaluate internet access requirements, establish management strategies, and lead implementation

5.1.2.2 INDICATOR: Instructional & Technology teams deliver ongoing assessment, training, and management

FOOTNOTE

GlobalED is an accredited Learning Services Provider and will provide access to upskilling for Tech Administrators, Managers, and other interested leaders. Micro credentials and CEUs will be awarded for those who successfully complete programs leading to industry certifications. Request more information here: https://nea.appliansys.com/core-strategy

A universal rating system for certifying content as 'edge-capable' is under discussion.

Appendix 1: Evidence-based T&L connectivity insights

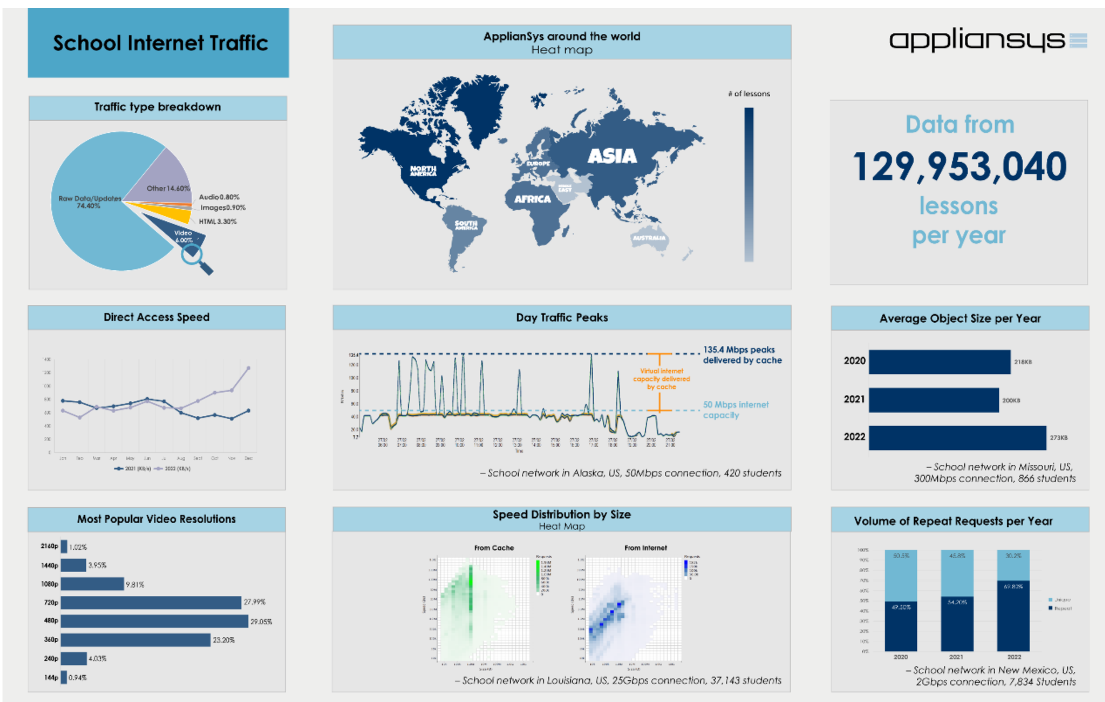
A unique evidence-base for schools' connectivity

Aggregated traffic data provided by schools in over 160 countries over 20 years builds unique insight into the size of internet objects and the speed that they are transferred to and within school networks, precisely measuring the impact of that activity on the school network. No other network devices generate this particular dataset and apply it to measure how efficiently teaching & learning is utilizing connections.

Individual user-content and individual user activity is not visible within the databank, though it is known to the schools themselves – they use it to enforce policies that protect students from harmful content.

But the underlying 'performance' data is not just unique, it is essential to our understanding of how schools' networks are dealing with e-Learning traffic now, and what they can do to radically improve performance and slash costs in the future.

These essential evidence-based insights can help us to unlock SDG4.



Tracking e-Learning evolution, globally, and school-by-school

The data is generated by an appliance strategically placed in the network to respond to demands from the classroom, maximizing Effective Access to e-Learning content by minimizing the bandwidth consumption those activities generate. Teaching & Learning traffic passes through the appliance and key information about each request is logged, including the type of content schools' access and the web domains visited, the size and internet speed of each object in comparison to both internet capacity and local network speeds, how often it is requested and when.

Data is collated, categorized and graphed, anonymously aggregated, scaled, and tracked across years, illuminating trends for individual schools and from a global perspective over time.

As a result, the moment-by-moment impact on the network of whole-class e-Learning comes into focus, revealing the essential characteristics of schools' internet traffic, which educators and technologists must understand - and respond to - if they are to accelerate equitable and sustainable delivery of e-Learning.

The data reveals that all schools progress along a journey of peaks and valleys in e-Learning implementation. It shows the efficiency opportunities present in the T&L processes utilizing internet connections. This information illuminates a path to get far more out of whatever bandwidth capacity is available and creates a new way to measure the impact of employing efficiency strategies over time:

- It therefore matters for well-connected urban schools' systems, who can extend e-Learning with lower costs
- It matters even more for the barely connected and yet-to-be connected, who need no longer be left behind.

Appendix 2: Linked Reference Documents

Paper 1: URGENCY, the Learning Gap & Skills Gap

Brief Synopsis: UNICEF reported 617 million children worldwide not achieving minimum proficiency levels in reading and mathematics. But 68% of the primary-age children unable to read proficiently were in school. Other data showed average annual math skills progression was just half of an expected year.

During Covid one in three were unable to access remote learning, yet the need for 21st Century skills accelerated. Digital skills, technological literacy, analytic and creative thinking, skills which school leavers require now, not in 5 years. We need to close the gap sooner by urgently maximizing the benefits from established ICT-enabled learning.

(Final document pending - hyperlink to be confirmed)

Paper 2: Narrowing the learning gap with internet-enabled ICTs

Brief Synopsis: The traditional teacher-centered pedagogical model has been one-size-fits-all, but students learn at different speeds, leaving teachers unable to address individual learning needs consistently. The SAMR digital transformation model shows the pathway is facilitated by ICTs, helping teachers to achieve more and ultimately enabling personalized learning at scale,

By integrating the most advanced e-Learning practices to fully engage all students in a multi-ability class at the same time, all of these developments are made possible, scalable, and affordable, redefining what is possible in the classroom.

(Final document pending - hyperlink to be confirmed)

Paper 3: Connectivity is Pivotal

Brief Synopsis: The most transformative changes to education systems will come from the most transformative digital learning practices. Inadequate connectivity will hold back transformation at every step

Meaningful Connectivity is not a number. There is no single numerical that can be applied to all individual learning environments. Rather it is about what digital activities you can support, or effectively access. Online functionality that supports transformative learning is not simply providing access to the internet, nor is it hosting curricula online. Online capacity that supports the collection of continuous learning data is the game changer.

(Final document pending - hyperlink to be confirmed)

Appendix 3: Institutional Leadership - Standards Checklist

C.O.R.E. in CONTEXT

STANDARD: Organizations, Learning Environments, establish & maintain effective connectivity provisions, appropriate to their context, which take into consideration C.O.R.E. Efficiency Strategies to maximize support for e-Learning and to minimize cost

The role of leadership

- ☐ INDICATOR: Institutional leaders adopt elements of the C.O.R.E. Efficiency Strategies for Meaningful Connectivity to minimize financial impact and maximize pedagogical delivery in context of own institution
- ☐ INDICATOR: Institutional leaders manage strategic adoption and the training/ knowledge transfer process

The roles of technology and instructional teams

- ☐ INDICATOR: Instructional & Technology teams evaluate internet access requirements, establish management strategies, and lead implementation
- ☐ INDICATOR: Instructional & Technology teams deliver ongoing assessment, training, and management

Appendix 3: Network Managers -Standards Checklist

Optimize

STANDARD: Learning content and software updates are configured to support network QoS optimization

Preserve peak-time internet capacity for the highest priority e-Learning traffic

- ☐ INDICATOR: Apply QoS policies to prioritize peak-time access for content that must be accessed online, and for live video or calls
- ☐ INDICATOR: Shape traffic to support off-peak downloads of software updates

Recycle

STANDARD: Web-based learning content and software downloads are configured to support single-download/recycling technologies, including for access by user-owned devices

Content Delivery Networks

- ☐ INDICATOR: Utilize last-mile CDN access in remote schools.

Last-mile web-caching

- ☐ INDICATOR: Utilize web-caching in the last mile

Tailored transmission of re-useable content and user-specific data

- ☐ INDICATOR: Selectively apply bandwidth-efficiency strategies to interactive live broadcast, online assessment, and platforms enabled with metrics and adaptive capabilities

File-validated Peer-to-Peer software update mechanisms

- ☐ INDICATOR: Configure the delivery mechanism to prefer downloads over the local network.

Network-managed distribution

- ☐ INDICATOR: Administer the distribution of content from local network servers such as an MDM solution

Mirroring

- ☐ INDICATOR: Mirror websites on local file servers

Intranet sites

- ☐ INDICATOR: Use internal sites to distribute content

Extend

STANDARD: Web-based learning content is configured to facilitate off-peak automated download to last-mile servers and caching servers

Local synchronization of static web-page assets via 'Indexing'

- ☐ INDICATOR: Configure web-caches to perform periodic synchronization of websites via site index files to keep last-mile content current

Local synchronization of File Structures

- ☐ INDICATOR: Configure Learning Object Repositories and materials housed in File Structures to be available for automated off-peak synchronization

Extending access to the local Community

- ☐ INDICATOR: Provide suitably regulated access to the internet for the community

Appendix 4: Content Providers - Standards Checklist

Conserve

STANDARD: Static content & resources that don't require real-time access to central web servers are configured to enable the use of local, offline, and offline-synchronized access.

Provide offline/local delivery for content that does not need real-time online access

- ☐ INDICATOR: Make Static content available as 'offline-ready' & 'mirror-ready' sites
- ☐ INDICATOR: Make available Static Teaching & Learning materials in a Learning Object Repository or other synchronization-capable File Structure

Optimize

STANDARD: Web-based learning content is 'optimized' to minimize bandwidth consumption

Minimize overall page weight & complexity

- ☐ INDICATOR: Minimize overall page size, the use of scripts, and the loading of scripts from external domains

Media optimization – compress videos & images

- ☐ INDICATOR: Resize images and compress video content using modern codecs with a high compression ratio
- ☐ INDICATOR: Video content providers use tags, indexing, to permit users to access a point in the video directly without the need to download the entire video

Minimize bandwidth consumption of PDFs

- ☐ INDICATOR: Use HTML instead of PDFs
- ☐ INDICATOR: Reduce and compress PDF images
- ☐ INDICATOR: Use vector images for bandwidth-efficient scaling

Minimize refresh rates

- ☐ INDICATOR: Configure static web pages with low/zero refresh rates
- ☐ INDICATOR: Configure pages with both static and dynamic content so that only the dynamic components are refreshed, rather than the entire page

Responsive design

- ☐ INDICATOR: Build sites with a single responsive design

'Lazy loading' of images

- ☐ INDICATOR: Configure long scrollable pages with 'lazy loading'

Content hierarchy

- ☐ INDICATOR: Design web content with a hierarchical structure and/or with thoughtful sequencing
- ☐ INDICATOR: Design course materials to include 'Next' and 'Previous' navigation

STANDARD: Learning content and software updates are configured to support network QoS optimization

Preserve peak-time internet capacity for the highest priority e-Learning traffic

- ☐ INDICATOR: Use standard ports to facilitate QoS optimization

Recycle

STANDARD: Web-based learning content and software downloads are configured to support single-download/recycling technologies, including for access by user-owned devices

Content Delivery Networks

- ☐ INDICATOR: Configure content to enable last-mile CDN access in remote schools, with consideration for BYOD use.

Adherence to HTTP Standards

- ☐ INDICATOR: Configure both static and dynamic content/traffic elements to support interoperation with last-mile caches

Tailored transmission of re-useable content and user-specific data

- ☐ INDICATOR: Separate/mark differently re-usable from unique elements

Integration with caches in BYOD environments

- ☐ INDICATOR: Configure sites to support last-mile caching of static/ re-usable page elements for access by user-owned/ unmanaged/ BYOD devices

continued

File-validated Peer-to-Peer software update mechanisms

- ☐ INDICATOR: Design solutions to search for other devices on the local network that have already downloaded the required content or updates and request it from them

Mirroring

- ☐ INDICATOR: Design sites that are mirror-capable

Extend

STANDARD: Web-based learning content is configured to facilitate off-peak automated download to last-mile servers and caching servers

Local synchronization of static web-page assets via 'Indexing'

- ☐ INDICATOR: Make available an automatically updated index of the site's assets, each URL representing an individual object

Local synchronization of video and audio files

- ☐ INDICATOR: Configure web-based video content to be available for automated off-peak synchronization

Local synchronization of File Structures

- ☐ INDICATOR: Configure Learning Object Repositories and materials housed in File Structures to be available for automated off-peak synchronization