Caching for Education Authorities

Accelerate the rollout of Connected Classrooms: overcome the limitations of small ‘last-mile’ connections to rural schools.

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ApplianSys has been working with schools for over 17 years to develop solutions that enable Education Authorities to deliver best value in connected classroom rollout.

With customers in over 150 countries, ApplianSys is well positioned to understand the specific dynamics of schools’ traffic profiles and the operational challenges at play.

We hope this document will help you analyse your own situation as you plan your bandwidth management strategy for the coming years.

Please feel free to reach out to us for help with any further explanation, or for a detailed analysis of your particular circumstances.

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Introduction

National Education Authorities face the task of rolling out connected classrooms

- to the whole nation
- within a minimum timeframe
- challenged by the considerable cost of providing appropriate bandwidth to remote and rural schools

The benefits of web-cache enabled connected classrooms cause a ripple-effect; it begins with the individual student learning future skills for future jobs, contributing to a globally competitive workforce. It results in national capabilities that lead towards an inclusive society where no young person is left behind.

In fact, the right infrastructure, cost-effectively provisioned nation-wide, can facilitate wider digital penetration to societal groups beyond school-age children. Community initiatives can tackle health and well-being, education for agriculture and empowerment of other groups who could otherwise be increasingly marginalised.

But if the cost of connectivity means that rollout is phased over many years, those at the end of the queue will be disadvantaged, sitting on the wrong side of a rural digital divide.

So, reducing the cost of connected classroom rollout has far reaching consequences, affecting the life-chances of many.

Few MoE’s have accumulated experience of large-scale school internet connectivity and e-Learning rollout, or would consider themselves as already having comprehensive expertise.

Meanwhile, systems integrators advising the MoE often have experience of large corporate environments, but are without the specialised domain knowledge of connectivity for distributed rural schools’ networks.

The situation can sometimes be exacerbated by providers from high-bandwidth nations, who don’t necessarily understand the impact on rural schools of failing to contextualise their products for a bandwidth constrained environment.

This paper introduces a technological approach that turns the tide in favour of MoEs.
The GOAL: Future Skills for Future Jobs

Internet rollout to schools is a strategic issue of national importance:

- e-Learning can be transformative for the life-chances of a whole generation

Connected Classrooms provide benefits which ripple outwards from the individual student to the opportunity for new national capabilities, which in turn impact on learning outcomes, creating a virtuous circle:

**Connected Classrooms**

- Devices
- Connectivity
- Content
- Pedagogy

**School Capabilities from Connected Classrooms**

- ICT Skills
- Digital Literacy
- Independent Learning
- In-School Teacher Training
- Collaboration
- Local Learning Object Repository
- Offline Schools Not Left Behind

**National Capabilities from Connected Classrooms**

- Central Learning Management
- Central Content Management
- National Datacentre

**Further National Capabilities**

- Effective Monitoring & Evaluation
- Targeted Interventions
- National E-Learning Curriculum
- State Online Testing
- Contextual Adoption of MOOCs, OERs, LORs, e-Learning Platforms

**National Outcomes**

- Future Skills for Future Jobs

Access to the internet and its wealth of information and e-learning content can provide any student, anywhere, the chance to acquire the skills they need to take part in the knowledge economy of the 21st Century. It gives teachers in underprivileged or remote areas the same opportunities as their peers for improving their teaching practices and instantly benefitting from the latest industry thinking. And, by its very nature, web-based learning gives students the means to flourish at self-guided informal learning.
The PROCESS: the journey to full, independent e-Learning

Today the value of autonomous e-learning with video and other media rich web-based resources is properly understood, its benefits measured by national and international research programs and is seen to be delivering better learning outcomes at lower cost.

In traditional classrooms a teacher would say to the class “sit up straight, fold your arms, face the front – I’m going to play you a video on the screen and then we’re going to do some creative writing”. But in 1:1, if pupils can study at their own pace – stop the video, make some notes, play that bit again – with that independent learning you get better – optimal - learning outcomes.

Few countries would attempt to transition in one single move from traditional classrooms to fully independent internet-enabled teaching & learning right across the curriculum. It is more of a process, with e-learning capacity-building over time. Once available, schools rapidly evolve the use of ICT in teaching:

Phase One – Initial Connection
- Teach in a dedicated room, separate curriculum item
  Computer Lab | ICT Skills | Data Reporting | Low Bandwidth

Phase Two – Integrate with Curriculum
- Integrate into curriculum, carts, teacher devices
- Teach from the front of the class
- Avoid bandwidth intensive content
  Teach from the front | Teacher Training | Lesson Content | Expensive Bandwidth

Phase Three – Multimedia in the Classroom
- Especially video – engaging content
- Keeping the attention of younger children
  Lessons need web access | Engaging Content | Learning Object Repository (OER) | Digital Literacy

Phase Four – Full e-Learning
- Independent learning and independent browsing
  Personalised/Autonomous Learning | Student Devices | Need for Browser Speed | Huge Spikes in Demand

At each stage through that development, the demand for content - and consequently the connectivity requirement also - will grow and grow.
The PROBLEM: ‘last mile’ connectivity

Adequate bandwidth provision is essential to deliver these benefits - BUT it’s not always possible...

- Physically delivering bandwidth nationwide is challenging
- Cost will always be a limiting factor
- For sufficient bandwidth to be available & affordable for all schools can take years
- In the meantime remote schools suffer from ‘rural disadvantage’
- It is the last mile connection to individual schools that determines the limitations of connected e-Learning in rural schools

In the worst-case scenario, this can mean rural students being left behind, with a lag between their development and that of their urban cousins, on the wrong side of a rural digital divide or connectivity gap.

As nations strive to achieve SDG4, last-mile rural connectivity emerges as a key challenge.

The REQUIREMENT: sustainable autonomous learning, for all

The goal is to accelerate roll-out plans in order to implement connected classrooms, for all, in the shortest possible timeframe.

The challenge then, is to provide the same life-chances to all, via rapid access to digital content across all schools, regardless of the size of the internet connection, and to harvest the benefits for other marginalised groups at the same time.

So Education Authorities around the world are searching for technologies that can help make the internet useable on smaller and less costly connections.

MoEs need technologies and processes that help ensure a nation’s schools’ IT budget goes further, with specific requirements on three fundamental levels:

- For Ministry officials grappling with policy, strategy and funding to address connectivity and make sure no schools are left behind
- For architects & delivery agencies planning the equipment and processes to deliver on the promise of connected classrooms, with strategies for optimising manageability, minimising long term total cost of ownership and guaranteeing the best Return on Investment
- For teachers & students who need a seamless responsive internet experience that matches their workflows and supports independent student-centred learning, keeping them safe
The SOLUTION: an online environment, with ‘re-cycling’…

To accelerate the rollout and development of e-Learning capabilities in rural and bandwidth constrained schools, there are two, key, and apparently opposing, connectivity objectives:

- harvest all the promised online benefits of connected classrooms,

and yet

- minimise the bandwidth needed to support internet-enabled autonomous learning.

Advanced, schools-focused network technologies hold the answer. These technologies are enabled by some unique traffic characteristics that all schools share.

In schools, most of the content that is accessed is ‘repeat requests’ for content that is used by large numbers of students. That means that storing a copy of the first request and re-using that content for other students can slash the last mile bandwidth requirement by 95% or more.

This is achieved by a hybrid technology which combines web-caching with offline capabilities – the best of both worlds:

- minimising the data that needs to travel over narrow connections to individual schools
- but providing ‘a real internet experience’ that properly supports digital literacy.

When combined with effective content delivery design, this hybrid can deliver from cached memory almost all classroom content (and software updates) requested during the school day, freeing up the internet connection for learning management data and other priority traffic.

As a result, web-cache enabled Connected Classrooms deliver additional benefits to the Education system and the nation:

**Web-cache enabled Connected Classrooms**

**National Outcomes**

- SIGNIFICANTLY LOWER COSTS
- EQUITABLE ACCESS
- EFFECTIVE NATIONAL TEACHING & LEARNING STANDARDS
- RISING LEARNING OUTCOMES
- FUTURE SKILLS FOR FUTURE JOBS

Reducing the cost of the bandwidth component of connected classrooms drives more rapid rollout, meaning that rural students can get the same opportunities as their urban cousins.

And with effective national programs now possible it is easier to drive best practice, to make timely and targeted interventions, and ultimately, via better learning outcomes, to improve life-chances for all.
Web-caching works particularly well in schools

Modern school internet traffic, is fundamentally ‘spiky’ in nature, with distinctive large ‘start-of-lesson’ peaks that regularly occur when students are all directed to the same content at the same time. For a class of 30 students, that’s 29 copies of the same content that was requested by the first student.

However, the good news is that these problematic peaks are actually highly responsive to caching. With the right caching solution, schools could save 90% or more of that bandwidth usage.

And if that same learning content was ‘pre-fetched’ before the lesson, it would not be unusual for 95-100% to be served locally from cache.

Modern e-Learning content is bandwidth intensive and can be very slow to load – particularly for the independent learning of a whole class.

So the answer is ‘last mile’ caching – with a caching appliance in each school – from which content is served at LAN speeds – often dozens if not hundreds of times faster than the Internet could deliver.

The widespread ‘last mile’ use of web cache appliances as part of internet delivery is therefore vital to ensuring sufficient bandwidth supply to all schools, while keeping costs under control:

- Caches dramatically improve the availability of web content in the classroom where the maximum possible bandwidth is either insufficient or doesn’t guarantee speed – this means particularly that rural and remote schools will be less disadvantaged because of their location if they have a cache.

- Caches allow teachers to use the Internet in lessons effectively, where otherwise it would be problematic, because they would have to wait too long for students to download material. With a cache deployed, only the first pupil downloads the page, with all subsequent requests served from the cached copy.

- Where schools are not yet connected to the Internet, a smart schools-focused cache can provide for offline working, and then transition to online use at a later date without any further investment being needed.
  - This avoids having to expend budgets on temporary offline alternatives like a separate fileserver which would be scrapped once the school is connected.
  - In addition, teachers and technical staff will not need to go through a whole new learning curve for online working when it is available.
A holistic approach: effective e-Learning on narrow connections

To be effective, web-caching and advanced synced-offline working capabilities need to work synergistically with the other elements of the e-Learning ecosystem:

- **Content** has to be delivered in a format that caches can interpret and that maximises the re-use of web-objects, while ensuring that learning management data can be appropriately directed to the internet
- **Student & teacher devices** must be able to interoperate with caches; a common pitfall here is weak SSL certificate management capabilities, which makes saving HTTPS bandwidth problematic – and has implications for student safety
- **Pedagogy** need to take into account what the new capabilities can deliver and be effective in extracting value out of them
- **Teacher training** needs also to be developed, as – with connected classrooms fully functional - training can now be facilitated in the workplace, without the expense of always having to travel to a teacher training centre

In many situations around the world, this interdependence is not properly understood.

Consequently, to ‘keep up’, decision-makers can feel pressured into incorporating **unsustainable bandwidth targets** into their plans.

Such an over-provision can consume budgets unnecessarily, slowing down rollouts, with rural schools inevitably the ones left behind.

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**National Outcomes**

- **Further National Capabilities**
  - National Capabilities from Connected Classrooms
  - School Capabilities from Connected Classrooms

**Connected Classrooms**

- **Devices**
  - Connectivity
  - Cache
  - Offline Working
  - Internet

- **Content**
- **Pedagogy**
In Conclusion

The digital economy of the future demands a teaching & learning environment that supports rapid, on-demand access to a digital curriculum and the digital world.

In that context, the key enabler for remote rural schools is narrow, cost-effective connectivity, in combination with performance web-caching and synced-offline capabilities.

These are Ed-Tech capabilities which were developed in what are now high bandwidth countries, but they were pioneered when those countries were first setting out on the e-Learning journey.

Since those early days over a decade ago, these technologies have been finely tuned in rural communities which are still, even today, bandwidth-constrained – at least they are in relation to what they aspire to achieve with 1:1 and autonomous learning.

Even the US - the most advanced Ed-Tech market in the world – is still grappling with 24% of schools on the wrong side of its own rural digital divide. In response, the US Federal Government is making funding available to every school for these advanced schools-focused web-caching technologies.

But the challenge is even greater for less wealthy nations. Projects across Latin America, Africa and South-East Asia all demonstrate the widespread belief in and will to deliver connected classrooms to support effective independent e-Learning. But almost all of those projects have to negotiate the same potholes along the way. While this schools-focused hybrid connectivity is at the heart of the e-Learning ecosystem for rural schools, consideration must be also given to Content, Student Devices and Pedagogy.

With a holistic approach that pulls all these threads together, rollout challenges can be overcome, with even the narrowest of VSAT connections providing effective support for advanced autonomous e-Learning, for all, in line with SDG4.

If MoEs can access the technological solutions that minimise connectivity costs, maximise opportunity for remote communities, and guarantee effective access on smaller connections, then there is no need to delay or phase because of bandwidth costs.

As a result, the whole nation’s school-age generation can begin preparation for joining the digital economy; rural communities need no longer be left to fend for themselves until the funding cycle eventually catches up with them.
Further Information

This paper introduces the key concepts of hybrid schools-focused web-caching with synced-offline working, to minimise bandwidth requirements and, at the same time, to leverage the life-opportunity-changing potential of properly supported internet-enabled independent learning.

This summary is an abridged excerpt from a live webinar and discussion delivered as a key note to MoEs, delivery agencies and advisors, which can be facilitated on request. The material covered includes a manifesto for a holistic approach to the e-Learning ecosystem – including Content, Connectivity, Student Devices and Pedagogy.

A comprehensive analysis of each of the individual elements is available through a series of ApplianSys technology education whitepapers:

- e-Learning traffic profiles, schools’ operational dynamics, caching solution design considerations – an introduction

- How the issues faced by Education Authorities with distributed rural schools’ networks informs a detailed design brief for caching solutions and their RFPs

- Determinants for web-cache topology selection: Core, Distributed, Hierarchies

- Effective SSL certificate management to minimise HTTPS bandwidth consumption and keeping students safe

- Delivery mechanism guidelines for content and hosting platforms to maximise content access and usability in rural schools