

Enabling **Army Learning Transformation** through Infocomm Technology

ABSTRACT

The fast-changing operating landscape and undefined threat scenarios require Third Generation soldiers to adapt, learn and operate rapidly in a wide spectrum of operations. In recognition of this, the Army's Training Transformation Master Plan (T2MP) was developed with the vision of producing leaders and thinking soldiers. The transformation entails a fundamental pedagogical paradigm shift – from passive and one-dimensional instructor-led lessons to a more collaborative, immersive and self-directed learning environment. Under this masterplan, one of the key strategic thrusts is to leverage technology as a vehicle to enhance and innovate the way institutes teach and how soldiers learn.

The LEARNet programme, as part of T2MP, is the keystone to a Learning Army. It strives to deliver the holistic learning system in three ways: transformation of curriculum, deployment of immersive rich media content and mobilisation of knowledge through a learning network and portal. It enables the Singapore Armed Forces (SAF) to keep pace with revolutions in the use of social and rich media applications in learning. It also allows learners to tap familiar and effective pedagogies to quickly assimilate new knowledge and skills.

However, media-heavy applications are typically bandwidth-intensive. Existing networks can be easily stretched beyond their capacities. This emerged as one of the key challenges for the programme. This article describes how Content Distribution Network (CDN) technology was successfully deployed during the LEARNet Phase 1 implementation to overcome the bandwidth challenge. This is a major breakthrough as CDN implementation is a pioneer technology for the Ministry of Defence and the SAF.

Lee Hwee Ling
Darren Teo Wee Hong
Cindy Seah Ye Leng

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INTRODUCTION

The learning culture in the Third Generation (3rd Gen) Army must keep pace with increasingly challenging operational requirements, evolving technological landscape and changing user expectations

Generation Y (Gen Y) soldiers who are technologically savvy and comfortable with Infocomm Technology enabled training make up the demographic profile of the Army today. Thus, a fundamental change in learning pedagogical approaches and knowledge delivery methods is necessary for effective engagement of these digital age learners.

In line with the Ministry of Education's (MOE) 'Teach Less, Learn More' and Infocomm Development Authority of Singapore's (IDA) iN2015 initiatives, the current educational climate is conducive for the Army to transform its learning and training landscape as well.

THE LEARNET INITIATIVE – A HOLISTIC LEARNING SYSTEM

In 2008, the Army initiated a new wave of training transformation. LEARNet, as part of the larger Army Training Transformation Master Plan (T2MP), was identified as the keystone to a Learning Army. DSTA, as the enterprise architect and programme management office, was entrusted with the task of ensuring the successful delivery of the LEARNet programme.

A rapid pilot implementation of the LEARNet initiative was carried out at the Basic Military Training Centre (BMTc), Officer Cadet School, Specialist Cadet School and Signal Institute in Phase 1. The first phase was completed successfully, while the remaining Singapore Armed Forces (SAF) training institutes and units will be covered in Phases 2 and 3.

One critical success factor is the ability to infuse technology possibilities into the SAF's core learning process and training curriculum. To support this transformation initiative, one of the strategic approaches is to harness technology, engineering and learning science resources to foster a learning environment of creativity and innovation. In this technology-enabled world of learning, instructors and trainees are able to collaborate and co-create knowledge, to produce bigger and better ideas as a collective whole.

The LEARNet learning system can be conceptualised as an end-to-end continuum that spans across front, middle and back office operations, with key components as shown in Figure 1.

Front Office

Enhanced Learning Space and Knowledge Mobility

The LEARNet strategy is to tap rapid innovations in consumer technologies such as 'iPAD-like' mobile devices to offer familiar and intuitive front-end interfaces to the learners. The initiative equips each trainee and instructor with a personal mobile computing device. Having such a device not only exposes the trainee to lessons beyond classroom settings, it also provides a window to the entire system. The trainee gains access to the repertoire of content as well as learning and training administration activities. Trainees are able to carry out self-directed learning activities, conduct personal reflections and peer appraisals, perform self-evaluation, and retrieve checklists for different types of operations during training.

To enable the exchange of knowledge between trainees and instructors, a wireless network infrastructure links up the entire training institute so that learners can have access to the knowledge network regardless

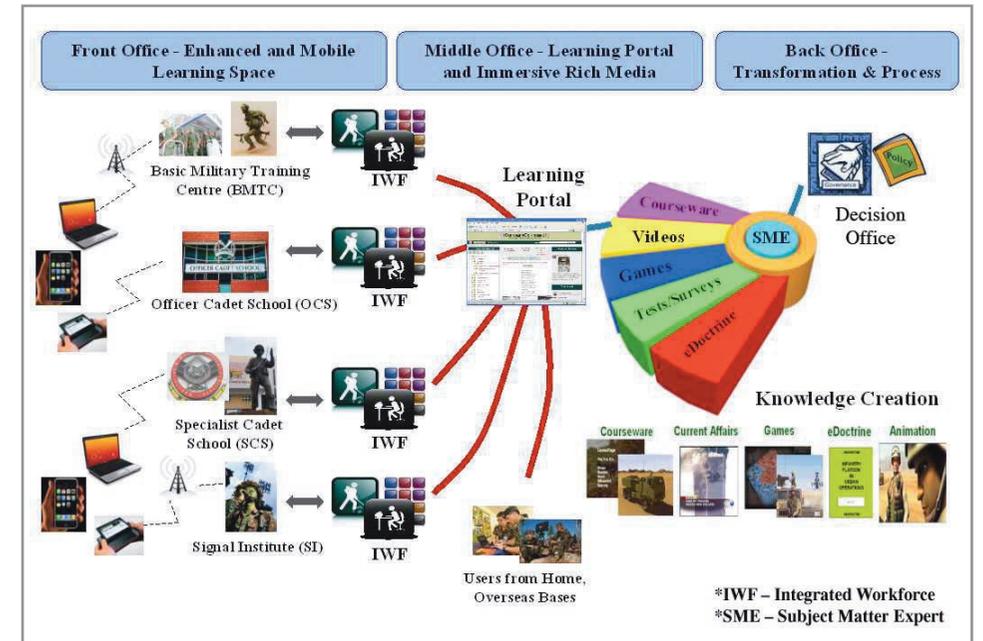


Figure 1. Holistic LEARNet learning system

of time and location. The network capability enables trainees to read content and engage in collaborative learning while instructors can deliver content on a just-in-time basis as they take on the role of online coaches and subject matter experts.

Middle Office

Personal Learning Portal

The portal aims to create a 3rd Gen Professional Learning Space for individuals and teams to come together virtually to learn and build knowledge at their preferred pace and convenience. Social media and Web 2.0 technologies connect people, knowledge networks and expert systems, allowing the efficient harnessing of intellectual capital and collective knowledge. Through the portal, the learner gains better control of his self-development by building his own learning process according to his personal aspirations and competency gaps. This helps to improve

the learning experience of the trainees and enhance their ability to accomplish assigned missions for the organisation.

Lifelong Learning

LEARNet engenders a spirit of lifelong learning as learners are provided with a personal Learning Account to track their professional learning experience throughout their service terms. This Learning Account also allows learners to consolidate their competency records, journals and reflections. Thus, the SAF can assess the learning progress of its personnel and identify any competency gaps within the institute.

Immersive Rich Media and Rapid Content Creation

Unlike traditional teaching methods, rich media resources enable better engagement, visualisation and deeper understanding of the

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Figure 2. Wide range of interactive rich media in LEARNet

subject matter (see Figure 2). It also increases training realism. To meet the operational tempo, just-in-time learning has to be supported by rapid content development capability. Rapid content development technology, augmented by additional manpower from an integrated workforce, allows instructors to deliver and deploy high impact learning content that can be shared across all Services within three to four hours, as compared to four to six weeks in the past.

Back Office

Curriculum Transformation and Pedagogical Paradigm Shifts

The instructional mode will shift away from passive, uni-directional and instructor-led lectures to a more immersive and collaborative self-directed learning environment. There is an ongoing comprehensive curriculum review to identify and restructure courses to the new mode of delivery and engagement.

Change Management

It is critical that commanders, instructors and trainees understand the strategic intent of the learning transformation and are familiar with the new technological tools. The project team introduced a customised change management programme to encourage trainers and learners to be receptive to the system. The programme also ensures a smooth operationalisation of the learning system.

Governance

The central governing agency sets directions, formulates policies, manages risks and ensures a consistent implementation of training policies and syllabi in the various training institutes.

THE CHALLENGE

The delivery of rich media over a bandwidth-limited network that connects the front, middle and back offices is challenging as such content is usually bandwidth-intensive and

can take a long time to download. This affects the system's performance and the users' experience. During Phase 1 implementation, the project team realised that the constant pressure and speed of expanding the network bandwidth can never catch up with the fast-growing demand and proliferation of rich media and high-bandwidth applications.

OVERCOMING THE CHALLENGE

To overcome the bandwidth limitation, the project team evaluated several alternatives and also studied similar initiatives implemented elsewhere, such as in MOE, IDA and academic institutions. Eventually, a content distribution network (CDN) was assessed to be the best solution.

A CDN is a network of systems in which multiple copies of data are placed at various hubs to reduce bandwidth requirements and maximise speed of access to the data within the Wide Area Network (WAN). Future requests for a particular content will be served from the closest hub, without the need to gain access to the source at the central site. This mechanism leads to a more direct, and hence faster, delivery. Figure 3

depicts the CDN architecture design in the iNET environment of the Ministry of Defence (MINDEF) and the SAF.

The new CDN system had to be integrated within the iNET environment as part of a larger complex system. The team considered the following key design principles:

Scalability

The system needs to cater for future growth in user population. The approach was to ensure scalability in managing the infrastructure instead of having to expand the network bandwidth constantly. Phase 1 of the implementation was targeted at four training institutes serving 10,500 learners in total. The next phase will reach out to another 240,000 active National Servicemen (NSmen). Thus, the architectural design must be modular and extendable while being easy to configure, maintain and deploy.

Performance

The system response time determines the quality of videos streamed to viewers. After benchmarking best practices, the team targeted a response time of not more than

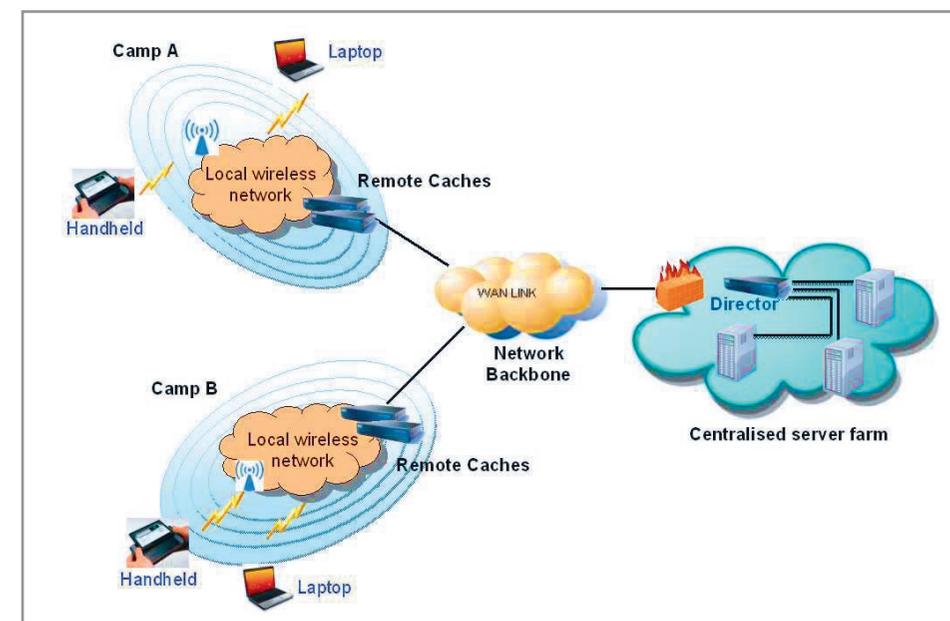


Figure 3. System architecture of the CDN in MINDEF

eight seconds for 90% of the hits during peak periods. The quality of the videos had to be maintained at a resolution of at least 640 by 480 pixels at 512 kilobits per second (kbps), which is better than the quality of typical YouTube videos.

Improved System Reliability

LEARNet shares the WAN with many systems. The LEARNet implementation should not result in any degradation of the operations and performance of other systems such as email and other business applications. Hence, LEARNet's design should reduce dependence on the WAN.

Security

Due to security and operational requirements, all transmissions across the network must be encrypted. Secure Sockets Layer (SSL) encryption is the de facto standard for encrypted and authenticated communication between end users and application servers. The caching technology selected must thus have the ability to optimise encryption algorithms and reduce SSL handshakes over the WAN.

Interoperability and Open Standards

Any technology introduced within the environment of MINDEF and the SAF has to be integrated with existing legacy systems and across multiple networks. It also has to be flexible enough to cater for interoperability with future systems.

To support interoperability, the system was designed based on industry standards for file formats, external protocols and interfaces. The technologies are also platform independent to prevent reliance on a single vendor or service provider.

Total Cost of Ownership

The amount of hardware, rack space and power requirements were key considerations

for deployment. The ability to optimise these factors reduces the need for expansion in remote server rooms and the re-equipping of power and cooling systems. This leads to cost efficiency with lower upfront investment and less recurrent maintenance.

IMPLEMENTING THE CONTENT DISTRIBUTION NETWORK IN MINDEF AND THE SAF

For successful operations-technology (ops-tech) integration, a good understanding of the customer's business is of utmost importance. In implementing the CDN, the team analysed user content, usage and traffic patterns before designing a system with adequate scalability and performance-tuning to support the anticipated load. The original proliferation strategy was also tweaked to allow a more customised rollout to each training institute to better meet its needs.

Stretching Beyond Design Limits

Through a paper design exercise, the team assessed that the current network can neither support the desired load nor meet the performance objective. Expanding the network would incur significant time and hefty monetary investments.

Further analysis of the anticipated usage pattern offered a better understanding of dealing with the challenge. It was noted that the surge in traffic was due to two factors: (a) trainees logging on to follow the course content during lecture-style lessons and (b) learners from the BMTC using the system in allocated time slots. It was observed that instructors on the ground had allocated fixed time slots for trainees to be engaged in a self-directed mode for some of the courses, to better control the progress of the overall curriculum. This case illustrated that time and effort are required to achieve the desired learning transformation which involves mindset and behavioural changes.

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Building the Right Model of User Behaviour – Utilisation and Traffic Modelling

While the issue of scalability was being managed, the traffic patterns were further analysed. Understanding the traffic patterns was critical for fine-grained system performance tuning.

The initial implementation strategy was to deploy LEARNet to the training institutes one at a time. However, with further analysis, it was noted that the curriculum and usage behaviour varies across different training institutes. Hence, the implementation strategy was reviewed and revised subsequently. The new approach called for progressive deployment in all training institutes. A subset of military units i.e. companies within each training institute was chosen for each phase of rollout (see Figure 4). This offered the team opportunities to better understand the training institute so as to develop more accurate profiles, models of utilisation and user traffic.

A good understanding of the usage pattern and content resulted in a combination of solutions. The team adopted the same principle of CDN but differed slightly in the approach for institutes with a large population (i.e. more than 5,000 personnel) such as BMTC. For such institutes, selected content was pre-loaded in the computing devices instead of the remote cache. This changed the system usage traffic pattern and demand. Through this implementation, the team realised that rich media content varies and can be handled in the following ways:

- Pre-loading of content in devices through the use of content push down via system management tools
- Pre-loading the latest copy of content in the remote cache at pre-defined times of the day (i.e. pre-positioning)
- Releasing the latest copy of the content to the remote cache only upon request by the 'first user' (i.e. dynamic caching)

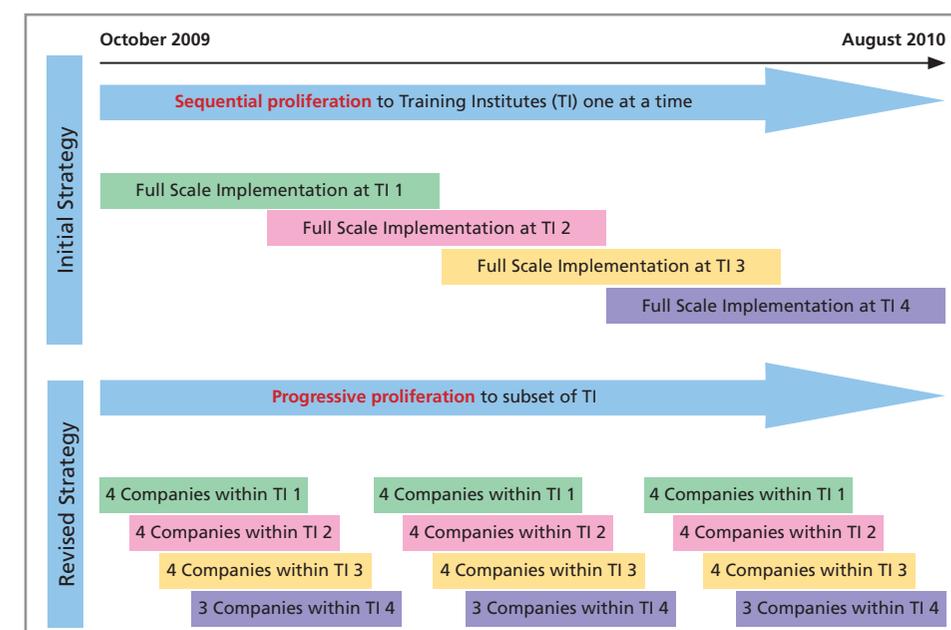


Figure 4. Implementation strategy

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Assurance and Confidence

It was important to validate the paper design and tests in a real world environment to ensure that performance specifications can be met. User confidence in the system was critical in managing the change in the LEARNet project.

The challenge was to be able to generate system loads in the actual infrastructure so that bottlenecks could be identified and eliminated. The system could also be fine-tuned for better performance before trainees use it. An end-to-end performance testing exercise was conducted. This involved the use of load generation software to simulate actual trainee behaviour and the deployment of multiple monitoring agents at all network traffic routes. Expertise and resources from various teams were employed in the set-up and configuration of components ranging from network, firewall, caching database, application server and proxies.

The exercise was completed after a month of intense and thorough testing and fine-tuning. The team had a much deeper understanding of the system and could react quickly to unexpected problems when the system was rolled out. A summary of the test results in Table 1 demonstrates significant improvements with the CDN strategy.

WAY AHEAD

The next phase of LEARNet programme will continue to develop the close ops-tech integration and strong working relationship with the SAF. Future demands will continue to pose challenges and create opportunities in new areas such as:

- **Application to other domains** – The implementation has shown that in spite of limited network bandwidth, effective delivery of rich media over the network can still be achieved through innovative technology and proper content governance. The CDN concept and technology can also be extended to our secure network to meet the operational demands of other business domain areas such as those of intelligence and medicine.
- **Extending the Reach** – It is also intended that the next phase reach out to all training institutes, schools and possibly all units within the SAF. In addition, access will also be extended to home users by tapping on the Next Generation National Broadband Network to connect NSmen and other external educational institutions and armed forces.
- **Emerging Technologies** – New technologies for delivering high-definition videos such as adaptive bit rate streaming

are emerging and constantly improving in the consumer domain. With these developments, it would be possible to detect a user's available bandwidth and central processing unit capacity in real time – this allows an automatic adjustment of the quality of a

video stream and achieves a faster response time. The consumer domain also tends to see shorter product cycles and rapid innovations. Thus, constant monitoring and importing of such innovations will remain critical.

BIOGRAPHY



Lee Hwee Ling is a Principal Engineer (Enterprise IT). She is instrumental in conceptualising and developing the master plan for the Learning Management programme of the Singapore Armed Forces (SAF). She is overseeing the development and implementation of the LEARNet programme to enable self-directed learning in the SAF. She was also actively involved in the SAF's Knowledge Management and Leadership Competency Development initiatives. She was a member of the Knowledge Management project team that won the Platinum Knowledge Management Excellence Awards in 2010. Hwee Ling obtained a Bachelor of Computing (Information Systems) degree with Honours from the National University of Singapore (NUS) under the Defence Technology Training Award. She also obtained the Senior IT Project Management certification in 2010.

Darren Teo Wee Hong is a Senior Engineer (Enterprise IT). He is the Technical Architect for the LEARNet programme and manages the implementation of LEARNet for SAF training institutes and units. He leads the front-end planning exercise and develops the enterprise system architecture, working on aspects that include content distribution network deployment, last mile infrastructure implementation, integrated workforce and computing devices proliferation, and content development. He was also involved in knowledge management projects where he conceptualised and implemented common applications for the DSTA intranet. He was a member of the Knowledge Management project team which won the Knowledge Management Excellence Awards in 2010. Darren graduated from NUS with a Bachelor of Computing degree in 2001.



Cindy Seah Ye Leng is a Senior Engineer (Enterprise IT). She is with the Learning Management Systems team managing eLearning projects for the SAF. Previously with the DSTA Business Management Information System team, Cindy worked on several business system projects including the blueprinting and implementation of the Procurement System which won the SAP Overall Best Implementation Award. Cindy graduated with a Master of Commerce (eCommerce) degree from the University of Queensland, Australia.

	Response Time (90% percentile)	Performance Improvement
Login to typical portal web page		
Without going through cache	5.87s	38%
Going through cache	3.63s	
Streaming an 11 megabyte video content through the video streaming application		
Without going through cache appliance	30.20s	86%
Going through cache appliance	4.00s	

Table 1. Test results