LearnCanada
Infrastructure Workpackage

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Final Report, plus Appendices as follows:

A) LC NTN

B) Network & Application Characterization Plan

C) FTP Tests Analysis

D) XBone

E) Video Conferencing Platform

- ISABEL
- H.323

F) Video Streaming

- H.263
- MPEG-2

G) ISABEL/Linux Training Material

H) Steps for securing Linux

I) Bandwidth Management.

The broad objectives of the Infrastructure Work Package were to,

1. Establish the National Test Network (NTN) which featured an advanced set of Protocols, Services and Technologies (PSTs) to provide a suitable testbed environment for the LearnCanada program
2. Implement the NTN in a two phase process
   - Phase I – Limited deployment with basic PSTs
   - Phase II – Evolving NTN with advanced PSTs
3. Establish a Controlled Experimental Testbed (CET) to provide,
   - A "Proof-of-Concept" environment for new PSTs which were to be migrated to the NTN upon successful "Validation & Test"
   - "Hands-On" training to the technical leads from participating sites
4. Provide technical support to the participating sites by,
   - Establishing a technical web site
   - Running a Network Operations Centre (NOC)
   - Supporting testing, scheduled events and training.

The NTN was successfully implemented and extended to each participating site via CA*net 3 and (O)RANs as shown in Figure 1.

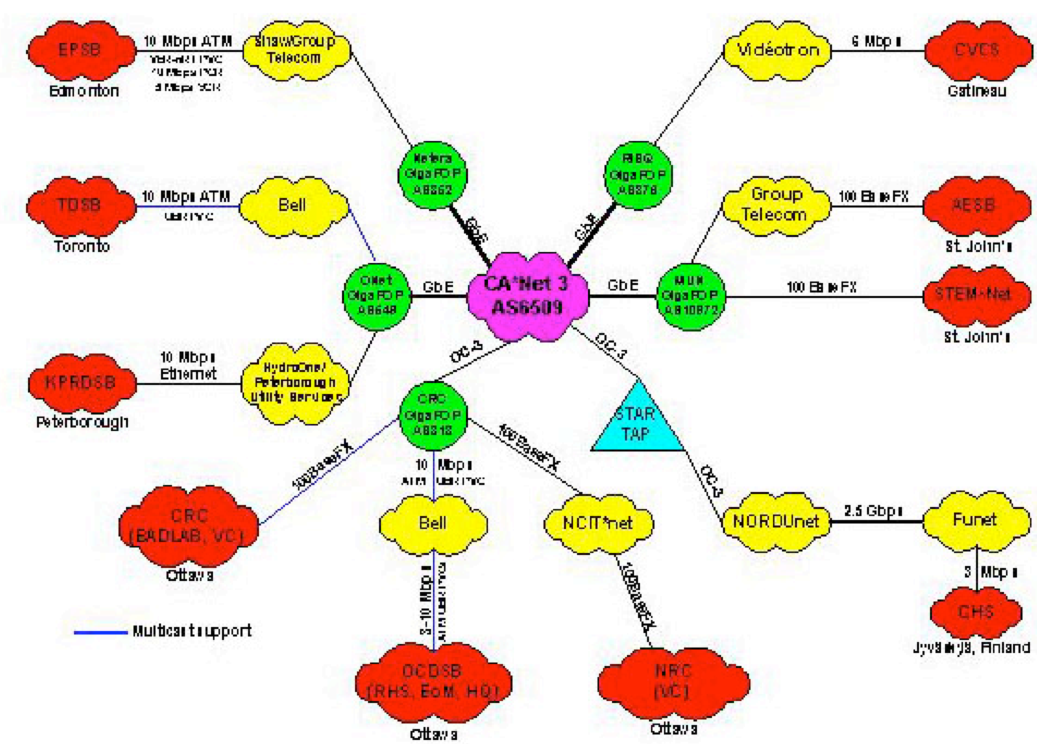

Figure 1.0 LearnCanada NTN

The participating sites were,

1. STEM~Net
2. Avalon East School Board (AESB)
   - Holy Heart
3. Commision Scolaire au Coeur-des-Vallées (CSCV)
4. National Research Council (NRC)
   - Virtual Classroom (VC)
5. Ottawa Carleton District Schoolboard (OCDSB)
   - Rideau High School (RHS)
   - Earl of March (EoM)
   - Headquarters (HQ)
6. Communications Research Centre (CRC)
   - BADLAB
   - Virtual Classroom (VC)
7. Kawartha Pine Ridge District School Board (KPRDSB)
8. Toronto District School Board (TDSB)
   - J. Percy Page
9. Edmonton Public School Board (EPSB)
10. Cygnaeus High School (CHS)

In Phase I, the network features consisted of the following basic PSTs,

- Broadband connectivity at ≥ 10 Mbps
- Multicasting protocols such as PIM, MBGP and MSDP where available, Flow Servers (equivalent to MCUs) to reach sites without multicast support
- ISABEL Computer Supported Collaborative Work (CSWC) application for collaboration
- QuickTime (Sorenson) application for streaming A/V.

In Phase II, the following advanced PSTs were validated and tested in the CET,

- VPN implementation based on the XBone tools capable of supporting IP Sec and QoS
- Bandwidth management
- Streaming A/V based on MPEG 2.

The CET consisted of core components local to Ottawa. They were,

- BADLAB
- CRC VC
- NRC VC
- OCDSB.

The CET was instrumental in providing "Hands-On" training to the technical leads from the participating sites. Training sessions were held at the start of the program using the CET. On-going training was performed over the NTN.

ISABEL which stands for Infrastructure for Supporting Advanced Broadband Experiments and Labs, was developed by a team of students led by Juan Quemada at the University Polytechnic de Madrid in Spain under a number of European initiatives (such as RACE, ACTS). Over the years, this CSCW application has been used to run large distributed events which in turn provided a fertile environment for testing and improving the features of ISABEL. The ISABEL application runs under the Linux operating system and supports many unique features,

- Multicasting
- Integrated Flow Server
- Traffic regulation
- Supports large multipoint collaboration sessions over heterogeneous networks
- Supports various modes
  - Telemeeting
  - Teleconference
  - Telelearning.

A commercial version of ISABEL is now available through Agora Systems.

For the operations and maintenance of the NTN a technical web site was established that contained the following,

- Configuration information
- Guidance & advice
- FAQs
- Event information
- ISABEL builds.

A Networks Operations Centre (NOC) was also established for,

- Coordinating NTN operations
- Troubleshooting network problems
- Providing technical support.

Another facet of "Operations & Maintenance" was the,

- Testing of the NTN to obtain performance measurements to characterize the network and applications
- Training of technical leads and teachers using the CET and on-going over the NTN
- Support for scheduled events (planning, testing, rehearsals and running the event).

Several problems were encountered throughout the program. They are,

1. Connectivity to CA*net 3 was a major challenge due to,
   - High local loop costs
   - Difficult and costly to establish service outside of (O)RAN coverage
   - Service provisioning date is a moving target
   - Troubleshooting network problems is challenging
     - Finger pointing syndrome
     - Requires coordination of several technical people
2. Services to participating sites varied
   - LAN Extensions over ATM PVCs (UBR, VBR) @ 10 Mbps
   - Dedicated Ethernet (10 Mbps) or Fast Ethernet (100 Mbps)
   - Very few providers supported Multicasting
   - What you paid for wasn't necessarily what you got
   - Interoperability issue between NICs and Switches
     - Degraded performance when 10/100 BaseTx port was set to 10 & FD
   - Required careful planning of ISABEL network
3. PC platform for ISABEL terminal
   - Variety of hardware implementations
     - Sound card
     - Video capture card
     - Frame buffer/display card
     - Motherboard with single or dual CPU
     - NIC

- Difficulty in achieving optimal configuration for Linux OS
    - Need to match drivers with hardware
    - Incorrect driver settings result in poor performance
    - Requires high competency with Linux

4. Annotation Video Server
    - Suboptimal file transfer speeds
        - Initial implementation based on clhttp
        - Pathchar used to identify bottlenecks
        - Need to implement RFC-1323 extensions to increase throughput
    - Migrated to streaming technology
        - Insensitive to BW-Delay product associated with Long Fat Networks

Because the ISABEL application used dynamic port assignments, it was required to place the PCs running ISABEL at participating sites on separate or external networks in order to be reachable without going through a firewall. Although this provided the necessary environment to run advanced applications, it presented a high security risk.

Steps to hardened the Linux platforms against security threats were defined and included in the configuration guidelines for the installation of Linux and ISABEL. Over the course of the program, a few sites had their Linux platforms compromised due to not having followed the hardening steps after having upgraded the OS in conjunction with an ISABEL upgrade. The ideal solution would be to locate the PCs behind a firewall and use proxy servers to deal with the dynamic port assignments. Unfortunately, we were unable to test this solution under this program and it is being recommended as future work to verify that it would be able to achieve the desired level of security while maintaining an acceptable level of performance.

Another option to address security issues is the use of VPN technology. A VPN was implemented within the CET using the XBone tools. The VPN enabled controlled access to the network using certificates, supported IP Sec for encryption and lent itself well to implementing QoS features. The performance penalty in using ISABEL within a VPN environment was found to be negligible. The VPN however, forces a star topology that is counter productive to the benefits of using multicast protocols. By carefully choosing the location of Flow Servers and integrating them with the VPN node at a participating site, an ISABEL network can be realized that can reap the benefits of both VPN and multicasting technologies.

Scaling this technology for wide deployment within schoolboards across the country isn't a simple matter. By making some assumptions, it is possible to derive some generic numbers for total bandwidth requirements. It is anticipated that the technology would be deployed in a progressive manner in that initially a dedicated facility within a school would be established to serve the needs of the teachers and students and that over time, the technology would be deployed to classrooms. Bandwidth requirements for one PC station are defined in Table 1.

Table 1.0 Bandwidth Requirements Per PC Station

Application	Bandwidth Utilization (Mbps)	
	Low End	High End
ISABEL	2	5
Streaming A/V		
MPEG 4	0.3	0.75
MPEG 1	0.6	1.5
MPEG 2	6	15

Typical bandwidth utilization would range from 0.3 to 8 Mbps at the low end and from 0.75 to 20 Mbps at the high end. Based on these figures, projected bandwidth requirements for schoolboards are listed in Table 2.

Table 2.0 Projected Bandwidth Requirements Per Schoolboard

Scope	Bandwidth (Mbps)	Technology Solution
Single Facility Per School		
School	10-20	Fast Ethernet
Board (10 schools)	100-200	Gigabit Ethernet
Every Classroom		
Classroom	10-20	Fast Ethernet
School (10 classroom)	100-200	Gigabit Ethernet
Board (10 schools)	1000-2000	10 Gigabit Ethernet

Since not all nodes would be accessing the network simultaneously, these numbers being conservative, would allow room for growth. Bandwidth management technology should be deployed at the WAN connections to minimize the cost for broadband services while guaranteeing bandwidth for applications sensitive to jitter and latency.