

# Lauder College – LearningStream Wide Area Network and IP Telephony Solution

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## Overview

This paper describes the implementation of a LearningStream-based WAN and an IP telephony system over 14 sites across a large part of southern Scotland. The technology employed is multiple 2Mbit/s SDH copper circuits connecting back to one central hub location together with Cisco routers and a Cisco Call Manager system. The system deployed also includes integration with legacy Siemens Realitis DX PBX systems. A key feature of the implementation was the use of QoS traffic prioritisation over the WAN to support VoIP together with compression of voice sessions to enable operation over limited bandwidth WAN links. This paper considers the motivation for the project, the planning, the equipment and its installation. Post installation issues such as the performance and benefits are also assessed. The project commenced in 2001 and the final stage is ongoing. It should be noted that costs quoted apply to that period of time.

## Executive Summary

Lauder College is highly dispersed with over 14 main sites covering more than 100 miles of southern Scotland. In 2000 the college adopted a strategy to link all its larger sites to the main campus using a uniform solution. Wireless technology was ruled out as distances were too great and line-of-sight did not exist to some campuses, and cable or ADSL were inapplicable as neither was available at all sites at the start of the project. The college therefore chose LearningStream from BT to link the sites. At the same time, in order to leverage value from the nascent WAN, a programme to roll out IP telephony across all the sites was begun.

The solution was to use Cisco equipment for the routers and IP telephony system. NTL were selected to undertake the implementation, having demonstrated that they had the ability to implement such solutions and to integrate the existing Siemens PBX.

The college now has 14 sites connected to the main Halbeath campus in a WAN using BT's LearningStream and over 120 IP telephones in use.

## Main Points:

- Lauder College needed to connect 14 of its larger sites to the main college campus

- Sites were geographically dispersed across southern Scotland, with the furthest approximately 40 miles (65 km) from the main campus
- A single solution was required for all 14 sites to simplify management
- Distances involved precluded a wireless solution
- ADSL and cable were not available at all sites
- There was a need to implement IP telephony initially at one of the sites
- LearningStream from BT provided the basis of the solution
- NTL was contracted to implement the solution
- Planning started in 2000
- Implementation began in the summer of 2001
- Rollout of broadband completed in early 2004
- IP telephony roll out is continuing, with over 120 IP telephones already installed

## Introduction

Lauder College is a medium sized Further Education college in Fife, providing education facilities at over 40 separate sites with 14 medium sized campuses around Fife, as shown on the map. Each site has around 15-20 PCs and at least two



[1]

*Figure 1: Lauder College Sites Locations*

The sites are widely distributed, with several of them a considerable distance from the main Halbeath campus. The furthest away is Galashiels which is 40 miles (65km) south east of Halbeath. A number of the sites are connected to different BT telephone exchanges to Halbeath.

Many of the campuses are small and have little in the way of IT infrastructure. As an example, at the start of the project in 2000, the Cowdenbeath Campus had two PCs in the reception area (one of which acted as the server) and two further PCs and a printer in the staff room. Prior to being upgraded the campus was connected to the main Halbeath site via a 33kbit/s dial-up modem. As such there was ample scope for improvement of IT facilities at many of the locations.

The Lauder College 2000-2003 Strategic Plan included the following aims:

- To continue to develop learning environments and learning and teaching methods, and to invest in a learning and learner support service infrastructure to support flexible and distributed lifelong learning
- To be a 'college without walls' extending the quality and accessibility of learning opportunities into community and workplace locations
- To acquire broadband network connectivity linking all Learning Centres to the main campus hub
- To extend the college's existing intranet services to all learners and staff
- To extend and improve network management services, desktop management services and e-mail systems in accordance with college ICT Strategy

At the time the college was also looking to support local schools in the area, but ultimately this connectivity was provided by other means.

To achieve these aims, an organisation-wide data communications network was therefore a key and urgent requirement. As the key resources on the network were located at the main central campus at Halbeath, a simple star topology was the obvious solution for the design of the WAN. To provide broadband connectivity, necessary to support access to learning materials and the Internet, a minimum bandwidth of 512kbit/s was deemed appropriate. The first step towards implementation of the network was therefore to provide high speed data connections for all 14 of the larger remote sites to link back to the main central campus at Halbeath.

As if the WAN implementation project was not a major enough project in itself, the roll out of broadband to the college campuses was part of a larger deployment of IT and upgrading of the facilities at many of the campuses such as Cowdenbeath, which had had very limited IT facilities before.

An additional issue was that the college wanted a single broadband technology to reach all of its learning centres and campuses. This was the key to the eventual solution choice.

One further requirement was that at the time of the installation the college needed to provide telephony services at a new campus that was to be opened in Rosyth – the Babcock Lauder Technology (BLT) campus (formerly the Babcock Dockyard Modern Apprentice Training Centre). This was to have far reaching consequences, not least of which was the implementation of an enterprise-wide IP telephony system.

## **Identification of Possible Solutions**

### **WAN to Link 14 Remote Sites**

A number of technologies were considered and investigated for inter-connecting the remote sites.

The technologies investigated were:

- ADSL
- Cable

- Wireless (licenced and unlicenced microwave / 802.11)
- Leased Line (BT LearningStream)

An important service requirement was that the college networks were based on the NetWare network operating system. To provide seamless integration of the remote sites, these had ideally to run this operating system too and be supported over the WAN.

A brief analysis of the suitability of each of the above follows.

### **ADSL**

ADSL is now a well established technology and coverage extends to most of the UK. However in 2000 it was relatively new to the UK and the limited number of ADSL enabled exchanges severely limited its availability. At that time BT was not rolling out the technology to its exchanges rapidly and it seemed that many exchanges were not going to be enabled in the foreseeable future. Furthermore, some of the Lauder College sites are a considerable distance from the exchanges, particularly in terms of cable run length, so it was far from certain that all the sites could be connected by ADSL even if the exchanges were enabled within the timescales of the project.

There were also doubts about the technical merit of an ADSL-based WAN. ADSL suffers from some technical limitations. Of particular concern are the following:

- ADSL provides asymmetric data rates; the upload speed being limited to 256kbit/s compared to the minimum download speed of 512kbit/s.
- ADSL is a contended medium: that is, the link between the local exchange and the Internet is shared, with typical contention ratios at the time of 50:1 for 'home' users and 20:1 for 'business' services. (Now it is possible to find some commercial ISPs offering up to 1:1 contention – for a price.)
- Extended data path. ADSL encoded network traffic passes over the copper phone lines to the BT exchange DSLAM. From there BT's ATM network passes the traffic to the ISP ATM/IP gateway router. At this point the user traffic is exposed to the Internet. For users in Rosyth requiring a VPN WAN link to another ADSL-served site, the data traffic would then be passed back across the ATM network to the local exchange and then to the remote site. For users wishing to access Halbeath, which is connected to the Internet via JANET, the data traffic would cross the Internet to the JANET network and then be routed to the college main network. ADSL is not a local solution, which means that people in remote centres would not have the same experience, or speed and security of access to college resources, as those in Halbeath.
- Security. Because traffic crosses the Internet there is a security issue, which makes management of the network more complex.

Due to the above issues, ADSL was not adopted as the basis of the main WAN to link the 14 sites to Halbeath. (However there are a number of smaller sites at which education facilities are provided by the college where ADSL is being used. These smaller sites cannot justify the cost of the solution that was finally adopted – LearningStream – as they only have a very small number of PCs.)

### **Cable**

In 2000 cable suffered from many of the same problems as ADSL and in particular coverage was incomplete. It was expected to cover only 60% of homes by the end of 2001.

Cable also suffered from market fragmentation, in that there were a large number of companies offering to install and manage cable. There was also considerable instability in the market and in the product offerings available. A process of consolidation of suppliers was taking place and it was clear that there would be only a handful of companies in a short time. However, the uncertainties, limited availability and technical concerns meant that this solution was ruled out for the Lauder College WAN.

### **Wireless**

In 2000 this was still an immature market, with few products available for developing a large scale network between the campuses. The college could not identify suppliers with sufficient experience in designing and building such a network to draw upon.

The distances involved in establishing links to some of the remote sites would not have been possible with a single wireless hop. Lack of line of sight between many of the campuses was also a problem. This would have meant that wireless could not have been deployed as a general solution unless intermediate relay stations were established – which would have significantly added to the cost and difficulty of management.

The college was therefore concerned that a wireless network would prove expensive to deploy in the short term and unreliable in operation. It was therefore not adopted.

### **Leased Line – BT LearningStream**

The merits of traditional digital leased line circuits between sites to build a WAN are well known – reliability, performance, full-duplex symmetrical bandwidth, fault monitoring and rapid fix time. But the minus points are also significant – installation and annual line rental cost, which is both distance and bandwidth dependent. Due to the problems with the alternative technologies considered for the Lauder College WAN, it seemed that the only solution was to deploy these traditional expensive leased lines.

BT LearningStream is not as well known as it could be in the education community. It is nevertheless a very worthy option to consider when deploying a WAN encompassing three or more locations. It is a badged version of BT's Megastream product, packaged specifically for the education market and offered at appropriate pricing.

LearningStream provides 2Mbit/s Megastream type digital circuits over copper cabling to a central hub site, forming a star topology network. Installation charges are a fraction of commercial Megastream costs and line rental charges are also relatively low. It is packaged in such a way that one site must act as a hub for a number of others and hub sites are available as 4 port or 16 port installations. Line rental for the hub site is significant, but overall, as the number of remote sites connected into the network increases, the solution becomes increasingly cost effective. Connecting to the circuits is identical to connecting to any other digital circuit – X21 interfaces can be specified on the NTUs to facilitate connection to standard IP routers.

When designing the product, BT had in mind a secondary school acting as hub for a number of feeder primary schools, or a library acting as a hub for citizen's advice bureaux. LearningStream only provides connectivity between sites; it does not offer connectivity to the Internet. However, for Further and Higher Education this of course is not a problem as colleges have their access to the Internet provided through JANET.

Although highly cost-effective, LearningStream is still partly priced by distance which was the only potential problem for the college given its dispersed nature, with several of the campuses at a considerable distance from the centre. Nevertheless LearningStream was selected as the basis for the Lauder College WAN.

## **Telephony Solution**

A solution was required for the provision of telephony services at the new campus that was to be opened in Rosyth. Initial investigations took place to establish whether replicating the Siemens Realitis DX systems used in both the main college building and the conference centre was viable. The findings showed that whilst this would be relatively easy to do, the solution was limited in terms of flexibility and could prove costly as dedicated telephone lines would have to be installed.

It was estimated that the site to site telephone traffic between Rosyth and Halbeath would be fairly high. The use of ISDN-2 or ISDN-30 PSTN access for inter-site traffic for Rosyth would result in high call charges, but not to the extent of justifying a dedicated digital circuit between the sites. It was at this point that the possibility of sharing the proposed LearningStream digital data circuit for voice was considered.

Investigations revealed that an upgrade to the Siemens systems was available that would provide VoIP capability through the use of an add-on card to one of the existing PBX switches. This VoIP card would have connected to the network cabling and would have permitted voice traffic to be routed down the LearningStream links. However, detailed examination showed that bandwidth use of this solution would have been high, limiting the number of concurrent calls so that many of the potential advantages of VoIP were unlikely to be achieved using this system.

A number of pure VoIP IP telephony systems were then looked at for Rosyth. With these systems traditional PBX units are replaced with software systems running on server hardware. Voice and data share the same Ethernet LAN and digital WAN links using VoIP. Although in many cases it is best to deploy a Call Manager system on each site as a replacement for a hardware PBX, in some instances a central Call Manager system can control all phone-phone IP connections and can provide a gateway to the PSTN (through a router with e.g. an ISDN-30 interface). This can negate the need for a remote site PBX as all telephones just connect straight to the Ethernet cabling and one central off-site call management server can be employed.

This was the solution model identified for Lauder College and is described in more detail in the 'Multi-site WAN with Centralized Call Processing' section at the following link:

<http://www.cisco.com/en/US/products/sw/voicesw/ps556/> [2]

With any implementation of VoIP, the reliability, quality and performance of the inter-site digital links are very important. This is why 'traditional' leased line digital circuits are often recommended. Voice communication over IP over the Internet often has poor quality results as packet delay (latency), jitter and restricted bandwidth cannot be controlled. On a private network where such parameters can be controlled to an extent, the bandwidth provided for voice traffic must be adequate and voice traffic should also have priority over other network traffic. QoS can be provided on some private networks to ensure prioritisation of voice traffic.

For Lauder College, the aim was to install such an IP telephony system for Rosyth and for this to inter-operate with the existing Siemens PBXs at the other sites. Due to the tight implementation timescales, the college needed a proven solution. Cisco was selected as they were able to present reference sites at which successful interoperability between Siemens systems and the Cisco Call Manager had been implemented.

Cisco proved to be of great assistance in the planning of the solution and helped in producing a statement of requirements.

## **Cost/Technical Information**

### **WAN to Link 14 Remote Sites**

#### **Circuits**

BT LearningStream was the only realistic option for the WAN circuits.

LANs at the sites are connected to the circuits in an identical way to connecting to any other digital circuit. X21 interfaces can be specified on the NTUs to facilitate connection to standard IP routers. At the central hub site, a high performance multi-port router can be installed to connect to the multiple X21 interfaces of the LearningStream circuits to the remote sites.

The following section details the approximate costs of the solution.

The table below shows the circuit costs as at September 2003:

| <b>Circuit</b>                      | <b>Status</b> | <b>Inception Date</b> | <b>Circuit<br/>Installation (£)</b> |
|-------------------------------------|---------------|-----------------------|-------------------------------------|
| Central Hub Site – Halbeath College | Completed     | September 2001        | 600                                 |
| BLT                                 | Completed     | August 2001           | 600                                 |
| New Row                             | Completed     | September 2001        | 600                                 |

|                        |             |                |              |
|------------------------|-------------|----------------|--------------|
| Lochgelly              | Completed   | March 2002     | 600          |
| High Valleyfield       | Completed   | April 2002     | 600          |
| Falkirk                | Completed   | July 2002      | 600          |
| Levenmouth             | Completed   | July 2002      | 600          |
| Polmont                | Completed   | January 2003   | 600          |
| Alloa                  | Completed   | January 2003   | 600          |
| Kirkaldy               | Completed   | February 2003  | 600          |
| WFE (Low Valleyfield)  | Completed   | February 2003  | 600          |
| Cowdenbeath            | Completed   | August 2003    | 600          |
| Parkgate               | Completed   | August 2003    | 600          |
| Galashiels             | Completed   | September 2003 | 600          |
| Abbeyview              | In progress | -              | 600          |
| <b>Total (ex-VAT):</b> |             |                | <b>9,000</b> |

\* It is worth noting that the annual costs for New Row and Abbeyview are only £1,420 which is an attractively low figure for a Megastream quality 2Mbit/s circuit. These sites share the same exchange as Halbeath and so there is no main link cost element.

**Table 1: LearningStream Circuit Costs**



## Routers

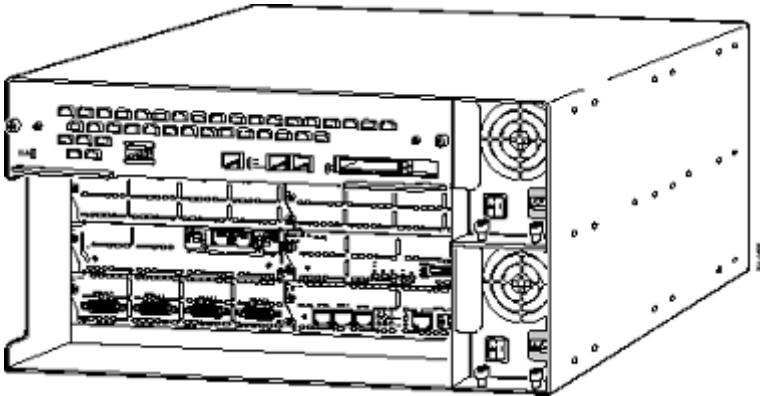
The router equipment necessary to drive the WAN was to comprise the following:

- Cisco 3662 to act as the central site multi-port central router:  
<http://www.cisco.com/en/US/products/hw/routers/ps274/index.html> [3]. This provides a cost effective and easily managed solution, although representing a single point of failure.



BT LearningStream circuit NTUs, 4 x modules insert into the router.

[4]



[5]

*Figure 2: Cisco 3600 Series Routers*

- At each remote site, a Cisco 1751 router provides data connectivity and support for VoIP: <http://www.cisco.com/en/US/products/hw/routers/ps221/> [6]. These connect to the LearningStream NTUs using standard X21 cables.



[7]

*Figure 3: Cisco 1751 Router*

The Cisco 1751 router provides support for:

- Multi service voice/fax/data integration
- Secure Internet, intranet and extranet access with VPN and firewall
- Integrated broadband DSL connectivity
- VLAN support (IEEE 802.1Q)

For full details of the router see the Cisco data sheet at:

[http://www.cisco.com/warp/public/cc/pd/rt/1700/prodlit/c1751\\_ds.pdf](http://www.cisco.com/warp/public/cc/pd/rt/1700/prodlit/c1751_ds.pdf) [8]

## **Telephony System**

The IP telephony system selected for Rosyth was based on Cisco Call Manager. IP telephones connect to the LAN and a networked gateway device is installed, connected to a PSTN telephone line(s) and ISDN-2 or ISDN-30 trunk line to enable calls to outside phones via the PSTN. With IP these systems' traditional PBX units are replaced with software systems running on server hardware. The Call Manager server(s) controls IP phone-IP phone connections and provides all the traditional PBX functionality and more. Both voice and data share the same Ethernet LAN and digital WAN links, with voice packetised via VoIP. Although in many cases it is best to deploy a Call Manager system on each site as a replacement for a hardware PBX, in some instances one central Call Manager cluster system can control all phone-phone IP conversations across an entire WAN-connected organisation.

As budget was limited it was decided that a fault tolerant set-up, which would have comprised two Call Manager servers, was not affordable and that the risk of downtime due to a single Call Manager failing was acceptable. To provide a measure of resilience, arrangements were made for a small number of emergency telephone lines to be made available for use if the main system went down.

The provision of a voicemail system was problematic. At the time of procurement, a native Call Manager voicemail solution was not affordable, but NTL and Kingston Communications

provided assistance in providing a method for utilising the voicemail system that was embedded in the Realitis system. This provided an acceptable solution until the college was able to install an IP based voicemail system.

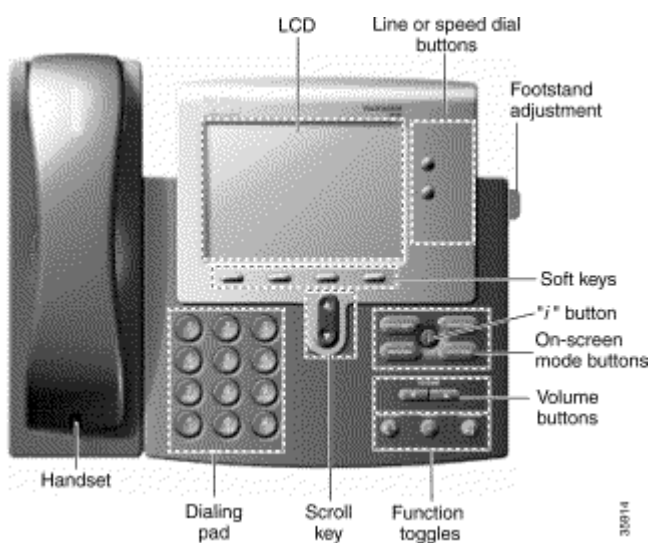
The equipment to be installed comprised:

- Cisco Call Manager ([http://www.cisco.com/en/US/products/sw/voicesw/ps556/products\\_data\\_sheets\\_list.html](http://www.cisco.com/en/US/products/sw/voicesw/ps556/products_data_sheets_list.html)<sup>[9]</sup>) – this is a single server running an optimised version of Windows 2000 that is capable of supporting up to 500 phones
- Cisco 4224 PSTN Gateway ([http://www.cisco.com/en/US/products/hw/switches/ps669/products\\_data\\_sheet09186a00800922a](http://www.cisco.com/en/US/products/hw/switches/ps669/products_data_sheet09186a00800922a)<sup>[10]</sup>) – a combined switch/router/voice gateway. This was to be located at the Rosyth site to provide some advance telephony capability that would not be required at other sites, including eight analogue lines for faxes and the potential to utilise telephone lines that could be used should the LearningStream WAN link become unavailable



[s/ps379/index.html](http://www.cisco.com/en/US/products/sw/voicesw/ps379/index.html)<sup>[11]</sup>)

[12]



35914

[13]

*Figure 4: Cisco 7940G IP Phone*

- QSig card to be installed in one of the Siemens Realitis DX PBX switches to provide connectivity between the legacy phones systems and the IP telephony network. This would permit the Cisco IP telephony system to utilise the telephone lines already connected to the Realitis for outgoing calls.

## **Procurement**

Following assistance from Cisco in drawing up a statement of requirement, three vendors were invited to tender.

NTL were selected because of their competitive pricing and the fact that they were the only one of the three vendors who tendered with the ability to meet the key experience criteria:

- Good track record in implementing Cisco Call Manager systems
- Had worked with both Siemens Realitis and Cisco Call Manager systems
- Could support running NetWare over the routers
- Able to manage the VoIP telephony issues

## **Implementation**

### **Background Theory – IP Telephony over WAN**

Cisco routers support a variety of means for protecting quality of voice services. RSVP (Resource Reservation Protocol) enables routers to reserve enough bandwidth on an interface for reliability and quality performance; weighted fair queuing and custom queuing; and RTP header compression. Not all mechanisms are supported on all routers and the best mix of systems implemented will vary depending on individual circumstances. For more information on QoS for VoIP on Cisco routers see:

<http://www.cisco.com/en/US/products/sw/iosswrel/ps1835/> <sup>[14]</sup>

In addition to router-level control of bandwidth, the Call Manager system can control the amount of bandwidth consumed by VoIP calls through call admission control. This limits the amount of bandwidth that is available for audio and video calls over links between locations. For further details see:

<http://www.cisco.com/en/US/products/sw/voicesw/ps556/> <sup>[2]</sup>

As well as establishing the best possible WAN infrastructure configuration, a key component in ensuring optimum voice quality in an IP telephony system is the voice signal digital encoding system employed. In order to convey voice traffic over a network, analogue voice signals are sampled 8,000 times per second and converted into digital form. The voice stream is then segmented and inserted into packets for transmission. The encoding process can include compression to reduce the bandwidth needed. The encoding methods or CODECs used are standardised by ITU-T recommendations. Standards commonly employed are: G.711, G.723, G.726, G.729(a) and code voice into 8-64 kbit/s streams. After packetisation, Ethernet bandwidth required varies from 12-80 kbit/s per voice stream and there are two voice streams per two-way phone conversation.

Whilst the lowest possible bandwidth per conversation is desirable for WANs comprising relatively low bandwidth links e.g. 2Mbit/s or less, there is a trade off in terms of quality and CODEC induced delay, which is not desirable, as the compression increases.

| CODEC           | Bit Rate (kbit/s) | Compression Delay (ms) |
|-----------------|-------------------|------------------------|
| G.711 PCM       | 64.0              | 5                      |
| G.723.1 MP-MLQ  | 6.3               | 30                     |
| G.723.1 ACELP   | 5.3               | 30                     |
| G.726 ADPCM     | 32.0              | 1                      |
| G.729 CS-ACELP  | 8.0               | 15                     |
| G.729a CS-ACELP | 8.0               | 15                     |

Table 2: CODEC Induced Delays and Perceived Quality

| CODEC | Bandwidth (kbit/s) | Description                             |
|-------|--------------------|-----------------------------------------|
| G.711 | 80                 | Default CODEC for all calls in Cisco Ca |

|          |     |                                                                                                                    |
|----------|-----|--------------------------------------------------------------------------------------------------------------------|
| G.722    | 80  | Video endpoints typically prefer this CO                                                                           |
| G.723    | 24  | Low-bit-rate CODEC supported for use<br>Phone model 12 SP Series and Cisco I<br>VIP.                               |
| G.728    | 16  | Video endpoints support this low-bit-rat                                                                           |
| G.729    | 24  | Low bit-rate CODEC supported for Cise<br>family models.                                                            |
| Wideband | 272 | High-quality, high-bandwidth audio CO<br>to IP-phone calls supported by Cisco IP<br>family models.                 |
| GSM      | 29  | GSM (Global System for Mobile Comm<br>CODEC that enables the MNET system<br>handsets to interoperate with Cisco Ca |

The bandwidth figures shown apply for 30ms data packets and include IP headers. Each call comprises two call streams.

**Table 3: Bandwidth Requirements for Different CODECs**

### **Initial Implementation at Lauder College**

Planning for the implementation of the LearningStream WAN began in autumn 2000, triggered in part by the development of the new BLT campus at Rosyth Dock Yard.

Initial infrastructure was installed in August 2001, the circuits being provided by BT and NTL providing the support and integration services.

It had always been recognised that the 2Mbit/s bandwidth of the link to Rosyth would be in heavy demand for supporting 60 PCs requiring access to resources on the Halbeath campus LAN and the Internet as well as supporting a large number of VoIP phones. NTL was mindful in setting up the WAN to balance the demands on bandwidth and to ensure that VoIP traffic, which is highly sensitive to packet delay (latency), jitter and packet loss, received priority over data packets.

The set-up of the WAN link / VoIP compression configuration to maximise quality of IP telephony for the initial Rosyth-Halbeath link at Lauder College comprised the following:

- 1Mbit/s of bandwidth always available to be called on for voice when required
- Priority for voice traffic over data
- Voice set to use minimum amount of bandwidth (approx. 14 kbit/s per stream) using G729a CODEC

This ensured that voice call quality would be assured to the extent that there would have to be in excess of 40 concurrent calls active for bandwidth related problems to occur.

Since initial installation, the numbers of PCs and IP phones has grown to around 100 PCs along with 50 phones. The link to the main campus is still only 2Mbit/s, but performance is tolerable although the link has now reached saturation point and is due for an upgrade.

### **Further reading**

A configuration guide for optimising the Cisco 1751 router for VoIP can be found at the following link:

<http://www.cisco.com/en/US/products/hw/routers/ps221/> [6]

The section of the Call Manager Administration Guide relating to implementing call admission control in a centralised call-processing system can be found at:

<http://www.cisco.com/en/US/products/sw/voicesw/ps556/> [2]

### **LearningStream / Call Manager Implementation Issues**

Installation went very smoothly. The only problems of note were:

- It took longer than expected to get the two telephone systems connected using the QSig card. Engineers from NTL and Kingston Communications, who support the Siemens systems, worked well together to resolve the problems which were related to required operating system upgrades and configuration.
- It was discovered that IPX was not supported by the Cisco 4224 access gateway switch. At the time IPX was still the network protocol of choice as the college ran the Netware 5 system. Although it would have been possible to change to TCP/IP by configuring the servers and clients, time was limited. This would also have introduced some risks as only limited testing had been carried out using IP. NTL agreed to work out a solution as the college had specified that IPX was a required protocol in the statement of requirements.
- NTL came up with the alternative of using an additional 1751 router which supports IPX and voice functions as the Rosyth site router instead of the 4224. (It turned out that Cisco had originally planned IPX support for the 4224 but eventually decided against this. The 4224 became a discontinued product in October 2002 as several newer platforms, including now the Cisco 2600XM and Cisco 3700 Series platforms, were capable of performing similar functions. The college still uses the 4224 switch, but not in its originally intended role as it continues to work faultlessly, although it will be replaced at some point with newer equipment.)

## **ADSL**

Some of the smaller sites are provided with connectivity by ADSL. They do not use a VPN for remote virtual secure connection to the main campus LAN. Instead there is an extranet, which provides staff with web access to some facilities such as their e-mail. Proxying is used to enable use of some of the facilities provided by the college.

## **Other**

The smallest sites link to the college via modems, either analogue or ISDN. Some staff are also allowed to use this facility for working from home. Calling numbers are validated for extra security.

## **Growth of LearningStream WAN and IP Telephony System**

Since the initial Rosyth link, a further 12 sites have been added to the LearningStream network and a thirteenth site is in the process of being connected as of summer 2005. Ten of these sites also have IP phones deployed. To support the LearningStream circuits, each new site has been supplied with a Cisco 1751 router and at the central 3662 router site, four port serial cards (NM-4Ts) were purchased as required. In this way the costs were spread over a number of financial years.

In February 2004, because dependence on the Cisco Call Manager system had increased over time, a second server was purchased to provide resilience by way of automatic system failover.

Further functionality was added to the IP telephony system in August 2004 in the form of the Cisco Unity voicemail system to provide native voicemail capability.

The price of IP handsets has come down considerably over the last three years, but remains high compared to standard analogue phones. Therefore, although the college still continues to add to the numbers of IP handsets that are use, in order to save costs in many cases the college now uses the Cisco ATA (Asynchronous Terminal Adaptor) together with re-use of old analogue handsets. The asynchronous terminal adaptor is a unit that plugs into the network and provides two analogue ports for the connection of phones/faxes etc. It costs around £100. The college uses existing phones or faxes with these units and this has proved a very cost effective way of extending the VoIP network.

Recently tests have been carried out with the Cisco Softphone application which allows a PC or laptop with a simple USB connected telephony device to act as a standard telephone extension. These tests included using wirelessly connected laptops to make calls. A pilot of this system is planned for 2005/2006.

## **Project Timescales**



The project has evolved and developed over time. Initial implementation started in the summer of 2001, and still continues, as shown in the following table.

| Date                   | Action                                                                                                                                                                                                                                                                                                                        |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| July 2001              | Installation of initial LearningStream end link at Rosyth Babcock Lauder Tech hub site link at Halbeath campus.                                                                                                                                                                                                               |
| July/August 2001       | Installation of a single Cisco Call Manager system and 40 phones, the majority at Rosyth to support the Engineering faculties who were moving to the new site.                                                                                                                                                                |
| End 2001 to early 2004 | Added a further 12 sites to LearningStream network, 10 of which also have IP cards (4 port) for the 3662 and routers for each new site were purchased as network costs were spread over a number of financial years.                                                                                                          |
| August 2003            | New estates development called Advantech on the main Halbeath Campus. IP throughout.                                                                                                                                                                                                                                          |
| November 2003          | New estates development called MediaSpace on the main Halbeath Campus. IP throughout.                                                                                                                                                                                                                                         |
| February 2004          | Installed a second Cisco Call Manager to provide resilience in the form of automatic failover.                                                                                                                                                                                                                                |
| August 2004            | Installed the Cisco Unity voicemail system to provide native voicemail capabilities on all phones.                                                                                                                                                                                                                            |
| October 2004           | Upgraded our Eclipse billing system to provide support for the VoIP system. This allowed us with seamless billing and usage reporting over all calls made using the SIP and ISDN phone systems.                                                                                                                               |
| November 2004          | Carried out tests using the Cisco Softphone application that allows a PC or Laptop with a USB connected telephony device to act as a standard telephone extension. This allowed using wirelessly connected laptops to make calls. There are plans to pilot this for staff communication with academic staff during 2005/2006. |

## **Table 4: Project Timeline**

### **Operational Performance and Reliability**

The systems have been extremely reliable.

The 2Mbit/s capacity limit of the link to Rosyth has now been reached but apart from this there have been no performance or reliability issues.

The immediate experience of using the IP telephony system was:

- Voice call quality was good, including site to site calls
- The phones provided very advanced features normally only found in digital phone systems
- The web browser based administration tools compared very well to the command line administration required with the Realitis systems
- The reaction from all of the staff using the system was that it was an effective phone system.

### **Benefits of Project**

#### **Benefits of LearningStream Based WAN and IP Telephony System**

The key benefit of the project has been the successful, satisfactory and cost-effective provision of IT network access to the 14 dispersed sites of the college. This has resulted in remote users being able to access learning materials on the main campus network and the Internet, and to interchange information through e-mail. The project has enabled the IT aims of the college's 2000-2003 strategic plan to be achieved.

The key benefit of the IP telephony system has been the effective and efficient provision of telephony facilities across the college sites, at reasonable cost.

Telephony costs have not increased at the college substantially despite an increase in numbers of phone handsets of around 40% over three years. Similarly overall telecommunications costs have increased little despite the upgrade from modem/PSTN based communication to 2Mbit/s leased line LearningStream at 14 sites.

It is estimated that the payback for the investment in broadband/VoIP and IP telephony has been 2 to 3 years despite the increases in numbers of phones and usage.

Summary of main benefits:

- Successful, satisfactory and cost-effective provision of IT network access to the 14 dispersed sites of the college.
- Enabled the IT aims of the college's 2000-2003 strategic plan to be achieved.
- Effective and efficient provision of telephony facilities across the college sites, at reasonable cost.
- Telephone calls between college sites are free.

- Little increase in telephony and telecommunications costs despite dramatic increase in number of handsets in use, capability and features of phone system, and vastly improved performance and quality of IT network.

### **Particular Advantages of using IP Telephones**

The main advantage of VoIP is that calls between college sites are free. There is also the ability to transfer calls between sites and some additional features such as call forwarding between sites and missed calls recording.

A major advantage of the VoIP telephone system became clear quite quickly: it is extremely easy to relocate phones. It is as simple as moving PCs, because the phones use the same network cabling system as PCs and require no changes to the phone system configuration. The many relocations of staff within the Rosyth campus, which occurred early on in the occupancy of the site, were easily accommodated due to the simplicity of IP phone connection.

Another benefit is that IP phones can be re-configured remotely without the need for a site visit. This is an important feature for the college because despite the size of the Rosyth campus, there are no IT technicians based on site.

Some of the IP phones purchased (the 7940s and 7960s) feature dual port Ethernet switches. This allows a PC to be plugged into the phone which is then plugged into a single network data port. This has made life much easier on many occasions where insufficient data points were available. Typically IP phones will be used where there are cabling complications or where the requirements are temporary. As the number of IP phones has increased, this benefit has become increasingly clear.

Use of the Cisco ATA lets the college use existing phones or faxes to provide a very cost-effective way of extending the VoIP network and immediately get the benefits of the portability, flexibility of administration and cost savings. The college pays about £40-50 for IP phones or £80 for the ATA which supports two analogue units. For further information see:

<http://www.cisco.com/en/US/products/hw/gatecont/ps514/> <sup>[15]</sup>

### **Lessons Learned**

The main lessons learned are that the solution has been very successful for the college and that the payback period for the investment has been between two and three years.

### **Current Status**

#### **Current Status**

The 2Mbit/s BT LearningStream connectivity solution with a 16 port hub site installation at Halbeath has been implemented for 14 remote sites. The final site is in the process of being connected (summer 2005).

### **Solution Review**

As the LearningStream star topology WAN was nearing completion, it was considered sensible to review the project and to consider the future for the solution deployed. Part of this review was to reconsider other technologies. These were again rejected for the reasons that follow. The result of the review was to recommend the extension of the LearningStream contract for a further five years.

## **ADSL**

While ADSL annual costs (at around £1,000 per year) are considerably less than LearningStream (at around £3,000 per year) it has three basic problems: it offers only about one fifth the capacity of LearningStream, it provides different upstream and downstream bandwidths, and the bandwidth is subject to contention so that the actual bandwidth available may be effectively lower. Furthermore, because traffic passes over the Internet it is inherently insecure. However, as it is a small site, Musselburgh is connected using ADSL and ADSL is being considered for some of the other smaller sites such as Livingston and Harwich.

## **LAN Extension Circuits (LES)**

The annual circuit rental costs are slightly lower for LES10 (around £3,000 per site per year) compared to LearningStream (at an average of £3,320 per site per year). However, the capital costs (estimated to be around £9,000 per site, but with distance related costs applying after 5km of main link) make the total cost more expensive over the short to medium term. With the possible exception of Babcock Lauder Technology, the additional capacity it offers cannot currently be justified.

## **5-Year Term Contract Saving Option**

It is planned to extend the contract for a five year period in order to achieve a significant discount as shown in the table overleaf (prices exclude VAT).

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| <b>Circuit</b>      | <b>Annual cost for 5 year contract (£)</b> | <b>1 year cost (£)</b> |
|---------------------|--------------------------------------------|------------------------|
| 1. New Row          | 1,278.00                                   | 1,420.00               |
| 2. BLT              | 2,993.40                                   | 3,351.00               |
| 3. Lochgelly        | 3,107.00                                   | 3,453.00               |
| 4. High Valleyfield | 3,040.20                                   | 3,378.00               |

|                      |                  |                  |
|----------------------|------------------|------------------|
| 5. Methill           | 3,557.70         | 3,953.00         |
| 6. Falkirk           | 3,332.70         | 3,703.00         |
| 7. Low Valleyfield   | 3,040.20         | 3,378.00         |
| 8. Polmont           | 3,265.20         | 3,628.00         |
| 9. Alloa             | 3,332.70         | 3,703.00         |
| 10. Kirkcaldy        | 3,287.70         | 3,628.00         |
| 11. Parkgate         | 2,972.70         | 3,303.00         |
| 12. Abbeyview        | 1,278.00         | 1,420.00         |
| 13. Cowdenbeath      | 3,040.20         | 3,378.00         |
| 14. Galashiels       | 4,300.20         | 4,778.00         |
| <b>Total</b>         | <b>41,825.90</b> | <b>46,474.00</b> |
| <b>Annual Saving</b> |                  | <b>4,648.10</b>  |

NB. Halbeath central hub site: £9,566 annual 1 year or £6,600.54 annually for a 5 year contract.

**Table 5: Cost Savings Achievable by Opting for 5-year Contract**

#### **Network Bandwidth Capacity**

The only part of the network which is currently experiencing occasional bandwidth saturation is the link to Babcock Lauder Technology at Rosyth. This link has therefore been partially optimised for voice.

The college is considering upgrading the bandwidth of this link by either using one of the remaining LearningStream ports on the 16 port hub to support an additional 2Mbit/s circuit – doubling the capacity to 4Mbit/s – or to upgrading to an 8Mbit/s circuit or 10Mbit/s LES10.

## **Dial-up**

It is planned that a small number of the sites which currently use dial-up modems will be upgraded to ADSL Internet connectivity. However, there is no justification for most of the remaining sites to move to broadband as they only have one or two PCs.

## **Telephony**

Internet telephony is being rolled out across the college and is seen as having real advantages for the college in terms of cost savings and additional telephony features.

Currently, of the 14 sites that are connected using LearningStream, 12 are using VoIP and have replaced their site exchanges with IP telephony. There are currently over 150 IP phones across the college, which are a mixture of IP phones and analogue phones connected using an ATA.

Sites which have switched over to VoIP also maintain some analogue lines for use in emergencies.

## **Connectivity within sites**

There is some use of wireless connectivity within sites, such as Cowdenbeath, where use is made of a 3com 802.11 wireless bridge.

There are also some trials underway of wireless within the college, which has installed three or four access points.

## **Summary**

BT LearningStream has proved to be a highly cost effective solution for the college by providing cheap and reliable broadband for a large number of local campuses and by enabling the rollout of IP telephony across the college.

The experience has been very beneficial for the college and NTL has been an excellent partner in installing the LearningStream equipment for the project. They handled the few problems that arose well.

Apart from the initial problems there has been little trouble and the costs of the project have been very affordable. Payback in the investment in IP telephony has been achieved within three years.

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**Source URL:** <https://community.jisc.ac.uk/library/advisory-services/lauder-college-%E2%80%93-learningstream-wide-area-network-and-ip-telephony>

### Links

- [1] <http://community.ja.net/system/files/images/lauder01.png>
- [2] <http://www.cisco.com/en/US/products/sw/voicesw/ps556/>
- [3] <http://www.cisco.com/en/US/products/hw/routers/ps274/index.html>
- [4] <http://community.ja.net/system/files/images/lauder02a.png>
- [5] <http://community.ja.net/system/files/images/lauder02b.png>
- [6] <http://www.cisco.com/en/US/products/hw/routers/ps221/>
- [7] <http://community.ja.net/system/files/images/lauder03.png>
- [8] [http://www.cisco.com/warp/public/cc/pd/rt/1700/prodlit/c1751\\_ds.pdf](http://www.cisco.com/warp/public/cc/pd/rt/1700/prodlit/c1751_ds.pdf)
- [9] [http://www.cisco.com/en/US/products/sw/voicesw/ps556/products\\_data\\_sheets\\_list.html](http://www.cisco.com/en/US/products/sw/voicesw/ps556/products_data_sheets_list.html)
- [10] [http://www.cisco.com/en/US/products/hw/switches/ps669/products\\_data\\_sheet09186a00800922a9.html](http://www.cisco.com/en/US/products/hw/switches/ps669/products_data_sheet09186a00800922a9.html)
- [11] <http://www.cisco.com/en/US/products/hw/phones/ps379/index.html>
- [12] <http://community.ja.net/system/files/images/lauder04a.png>
- [13] <http://community.ja.net/system/files/images/lauder04b.png>
- [14] <http://www.cisco.com/en/US/products/sw/iosswrel/ps1835/>
- [15] <http://www.cisco.com/en/US/products/hw/gatecont/ps514/>