

Foxes Academy Multi-Link EPS 9 / SHDSL WAN Case Study

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Project Date: July 2005 – December 2005

Overview

This case study describes the planning and implementation of an innovative approach to connecting a number of outlying buildings in Minehead, Somerset, to JANET via a central site. The solution is based on DSL (Digital Subscriber Line) technology and employs an IP DSLAM (Digital Subscriber Line Access Multiplexer) at the central site and SHDSL (Symmetric High-speed Digital Subscriber Line) modems for each building. BT EPS 9 private circuits are used for low cost inter-site connections. The result is a cost-effective alternative to commercial leased line services when connecting buildings sharing the same BT exchange. The motivation behind this project and its planning, equipment and installation are considered in this case study. Post-installation performance, benefits and reliability are also assessed.

Executive Summary

- Cost-effective solution was required to connect seven residential student houses to the main college network
- Implemented using two wire private circuits and SHDSL hardware
- Achieved leased line quality connectivity between seven sites for a fraction of the cost compared with other commercial solutions
- Total first year cost for connection of all seven buildings and supporting hardware was £13,037.18 (ex VAT)
- Annual line rental for the 7 circuit 2.3Mbit/s WAN is £ 3,123.40 pa (ex VAT)
- Network resources and Internet access are now available in every residential building.

Introduction

Foxes Academy is a specialist training college for young adults with learning disabilities. It operates a 24-hour curriculum focused on the catering industry, with learners working in the main Hotel building and living in residential houses located near the town centre. The college is connected to JANET via a 2Mbit/s link in the Hotel building.

In order to provide access to network resources based at the Hotel, including in particular the impending deployment of a new management information system, and to provide access to the Internet via JANET for both staff and learners, it was decided to connect up the residential houses and integrate them into a WAN (wide area network).

Service Requirements and Constraints

The college required a cost-effective, secure and reliable solution to connect seven residential buildings to the main network. The links had to provide sufficient bandwidth to support the current need for access to network resources and the Internet via the 2Mbit/s JANET connection and also allow spare capacity for future expansion.

With many users working with laptops, it was hoped that every building would be connected to permit roaming access to the Foxes domain from wherever a user happened to be working. This meant that whichever solution was selected had to be flexible enough and have sufficient bandwidth available to support peaks in usage at any particular site.

Research into Possible Solutions

Foxes Academy considered using microwave wireless links, BT MegaStream / LearningStream and BT EPS 8/9 Baseband private circuits as potential technologies to achieve connectivity between the sites.

Wireless

The college had previously implemented a point-to-point 802.11b wireless link between the Hotel and one of the larger residential buildings and therefore had experience of the capabilities and limitations of such systems. Unfortunately, one of the problems with the wireless link had been its unpredictable performance.

The geographical dispersion of the buildings throughout the centre of Minehead was not favourable to the implementation of a wireless WAN. In total, only three of the buildings have line-of-sight to the Hotel, including the one already connected via wireless. In order to connect the remaining buildings not having line-of-sight, it would have been necessary to establish 'hop' links via the buildings that did have line-of-sight.

Taking into account the unpredictable performance of the existing wireless link and the likely time-consuming nature of trying to set up a wireless WAN comprising at least four multi-hop links, with no guaranteed success, it was decided that wireless would not be a suitable technology to connect all seven buildings.

BT MegaStream / LearningStream

Foxes Academy then considered the possibility of using either BT MegaStream or BT LearningStream services. Traditional PDH (Plesiochronous Digital Hierarchy) leased line services have the benefit of being a tried and tested method of inter-connecting sites over short and long distances. They offer guaranteed bandwidth services and being subject to a service level agreement are fully supported by the provider in the event of faults. The disadvantage of such solutions is the high installation costs and annual rentals involved.

BT MegaStream provides a base bandwidth of 2Mbit/s over digital circuits using copper or fibre-optic cabling. Higher bandwidths are available to 155 or even 622Mbit/s. Circuits can be installed from any point to any other point in the country, but most private WANs are designed

around a hub and spoke topology with remote site circuits running to a central hub site. The circuits can be connected to the network via interfaces provided on the MegaStream circuit NTUs (Network Terminating Units). The interface usually specified is X21 although G703 can be used. The connection to the network is generally completed using routers or alternatively X21 to Ethernet bridges, which are cheaper but offer less functionality.

While LearningStream and MegaStream are technically the same, they are marketed differently. The former is packaged and attractively priced as a hub and spoke solution and is targeted towards educational establishments, which must meet certain criteria in order to be eligible for the service. As an illustration of the cost effectiveness of the package; the installation cost for a remote spoke circuit is only £600 and the annual rental charge a manageable £1,420 (if no main link element is involved). Hub location rental costs are however somewhat greater at between £5,443 and £9,566pa.

Unfortunately, due to the fact that Foxes Academy is a private college and a limited company, the BT Local Business adviser doubted that the college would be eligible for the service. Therefore the college was limited to the option of the fully priced BT MegaStream service which is available to businesses and does not qualify for an educational discount.

[Note: It was considered that fibre-optic circuits between the sites would be just as expensive as MegaStream. These can be provided by BT as LAN Extension Service, LES10LR. Installation cost where fibre is not already running to a building is £7,000 per end].

BT Baseband Private Circuits (EPS 8/9)

Originally marketed and used for voice traffic between sites, BT "Baseband" private circuits can also support digital traffic between two site LANs (Local Area Networks) by using DSL modem-routers at each end.

By using SHDSL units, "upstream" and "downstream" data rates are the same, so a link driven by such units would most closely resemble a traditional PDH circuit (like MegaStream) supported by conventional routers. The limitations on using a Baseband circuit as a digital traffic pathway are that the buildings to be connected must share the same BT exchange and ideally the same MDF (Main Distribution Frame) at the exchange and also that the total circuit length must be below certain maxima. This is because digital traffic is sensitive to signal attenuation and line noise.

Baseband circuits can either be four wire (EPS 8) or two wire (EPS 9). The four wire circuit can support speeds of up to 4.6Mbit/s while the two wire circuit can support up to 2.3Mbit/s, both dependant on distance and the quality of the copper wire circuit. Although quality of service is not guaranteed by BT and there is no contractual commitment to fix problems within a certain time limit, the cost of these circuits makes them an attractive possibility. As detailed below, installation and rental charges are a fraction of those of the MegaStream service.

Private circuits appeared to offer a very attractive solution to meet the requirements of Foxes Academy, because all sites that needed to be connected did indeed share a single BT exchange and furthermore they were within a two km radius.

Circuit Cost/Technical Information

BT MegaStream Circuits (*per circuit prices based on a three year contract term*)

Service	Connection Cost	Annual Rental	Total First Year
BT MegaStream 2Mbit/s	£9,750.00	£3,610.00	£13,360.00
		Quantity	7
		Total (ex VAT)	£ 93,520.00

Table 1: Circuit costs for a BT MegaStream based solution

BT Private Circuits**EPS 8 Baseband Private Circuits** (*per circuit prices based on a three year contract term*)

Service	Connection Cost	Annual Rental	Total First Year
BT EPS 8 - Four Wire Private Circuit	£1,080.00	£740.00	£1,820.00
		Quantity	7
		Total (ex VAT)	£ 12,740.00

Table 2: Circuit costs for a BT Baseband EPS 8 based solution

EPS 9 Baseband Private Circuits (*per circuit prices based on a three year contract term*)

Service	Connection Cost	Annual Rental	Total First Year
BT EPS 9 - Two Wire Private Circuit	£890.00	£446.20	£1,336.20

		Quantity	7
		Total (ex VAT)	£ 9,353.40

Table 3: Circuit costs for a BT Baseband EPS 9 based solution

Analysis of Available Options

Based on the circuit installation and annual rental costs, it was considered that while providing a proven solution to connecting multiple sites, the cost of BT MegaStream would be prohibitive.

Over the distances required, BT EPS 8 private circuits could provide up to 4.6Mbit/s to each site far more cost-effectively than MegaStream. However, it was decided that the extra bandwidth provided compared to that available with the EPS 9 solution would not be required and therefore the extra cost could not be justified.

The EPS 9 service seemed to offer the best solution for achieving connectivity between the sites given the bandwidth required and cost constraints. Therefore, more research was done into potential geographical limitations and to find the most suitable and cost-effective hardware solution to support the connections.

Site Survey and Geographical Constraints

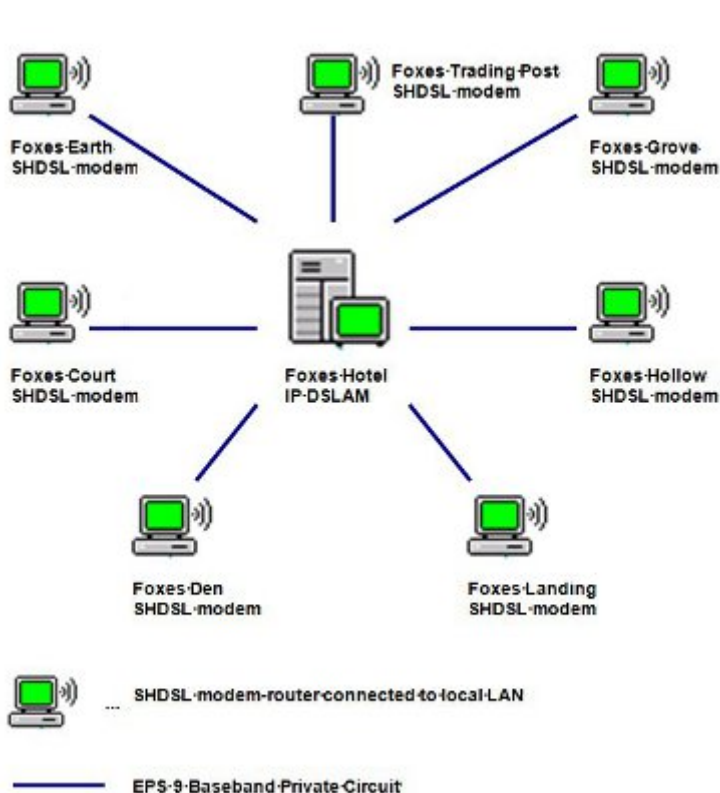
The use of EPS 9 circuits with DSL equipment requires each end of the link to be connected to the same BT exchange. An enquiry was made to BT Local Business to verify that each of the seven residential houses was connected to the same BT exchange as the Hotel. With this confirmed, estimates of the total circuit distances between the Hotel, the telephone exchange and each residential building were required to give an idea of the potential connection speeds which could be expected.

By using online mapping tools such as <http://www.multimap.com> [1] and driving between the sites it was estimated that the maximum distance between the Hotel, exchange and a residential building should be no more than two km. Foxes Academy was hopeful that the full capacity of 2.3Mbit/s would be achievable over this distance, although it was recognised that this could be hindered by poor quality connections along the copper wires. Nevertheless, it seemed highly likely that a minimum connection speed of at least 1Mbit/s would be possible, which would be acceptable.

Feasibility Study

Two companies, Network Extender Technologies Ltd and Lanode Ltd, were contacted in order to obtain more information about the DSL hardware required. Both companies offered similar solutions, with Lanode recommending equipment manufactured by CTC Union and Network Extender recommending Net-to-Net equipment. Both companies advised that when connecting several buildings to a common 'A end' i.e. the Hotel, an IP DSLAM can be used at the hub site.

The DSLAM would be located at the Hotel and form the termination point for all seven circuits to the remote buildings. This would avoid having to use a separate SHDSL modem-router at the Hotel for each connection and would also provide a central point for administration. Each residential house would have its own SHDSL modem/router to complete the link. This is illustrated on the next page.



s and operate as Ethernet bridges. The location through DHCP from the JANET

[2]

Figure 1: Schematic of EPS 9 based WAN with SDHSL routers and IP DSLAM

Procurement

The two companies that had been approached for information were invited to submit quotations.

Lanode offered the most cost-effective solution to Foxes Academy's hardware requirements and also provided excellent pre-sales support and technical advice. A contract was therefore

placed with Lanode to supply the required equipment.

BT was the only supplier of the EPS 9 private circuits, therefore an order was placed directly with BT Local Business.

BT Services:

Service	Connection Cost	Annual Rental	Total First
BT EPS 9 - 2 Wire Private Circuit	£890.00	£446.20	£1,336.20
		Quantity	7
		Total (ex VAT)	£ 9,353.40

Hardware:

Item	Cost	Quantity	Total
CTC 16 Port IP DSLAM	£1,588.91	1	£1,588.91
SHDSL Modem / Router	£279.00	7	£1,953.00
24 Port Cat 5 patch panel	£42.87	1	£42.87
Telco Cable for IP DSLAM	£50.00	1	£50.00

RJ45 to BT Cables	£7.00	7	£49.00
		Total (ex VAT)	£ 3,683.78

Total project costs:

BT Services	£ 9,353.40
Hardware	£ 3,683.78
Total Project Cost (excluding VAT)	£ 13,037.18

Table 4: Project costs

Hardware Specification

SHDSL Modem

The CTC Union SHDSL router family enables users to create high speed links over two wire circuits such as those meeting the BT EPS 9 standard.

Features

- IP Routing – Static or RIP v1 / v2
- Bridging – IEEE 802.1 D Transparent Bridging
- NAT and PAT
- DHCP Server
- DNS Relay and Caching



[3]

Figure 2: CT-2300A G.SHDSL router

CTC Union provides versions of the SHDTU03 family supplied with either a single 100Mbit/s Ethernet port or an integrated four-port switch.

For more details see:

<http://www.lanode.com/tier2/ct2300a.htm>

IP DSLAM

The CTC Union IP DSLAM-G16 can provide connectivity for up to 16 two wire EPS 9 circuits.

Features

- IP based DSLAM with administrative layer 2 concentrator
- 16 Ports G.SHDSL Subscriber Interface
- 10/100 Base-T/TX Uplink Interface
- Rack mountable

For more details see:

<http://www.lanode.com/tier2/am3000.htm>



[4]

Figure 3: CTC IP DSLAM

This unit was ideal for Foxes Academy as it met the requirement perfectly for a small capacity DSLAM, presenting 16 G.SHDSL ports. Initially only seven of these ports would be used, allowing room for expansion should new buildings need connecting to the network.

Implementation

Trial Phase

It was decided that initially, as a trial, only two remote buildings would be connected to the main Hotel network. The aim was to assess fully the suitability of using EPS 9 circuits before the college went ahead with full scale implementation. The trial links would be set up by connecting SHDSL modem-routers at each site to the EPS 9 circuits. This enabled Foxes Academy to create test connections while postponing the purchase of the IP DSLAM for the Hotel until after the test phase if the trial was successful.

Two EPS 9 circuits were ordered from BT in July 2005 on a lead time of 30 days and four SHDSL modem-routers to support the two connections were ordered from Lanode at the same time. Two routers were for the Hotel and one each for the two residential buildings. The plan was to redeploy the two routers initially used at the Hotel as subscriber units at the other residential houses when these were connected after the trial.

The first circuit was installed by BT twenty-two days after ordering. Unfortunately the second circuit was delayed due to unforeseen problems which occurred when BT tried to add more incoming lines to the Hotel.

Connection of SHDSL Modem-routers

With one circuit handed over by BT, two routers were configured to create a connection from the LAN switch of one remote building to the Hotel's network switch stack. Both modems were assigned with static IP addresses. The modem at the Hotel was set to 'Provider' mode. The modem at the residential house was set as a 'Subscriber' unit in exactly the same way as if it were connecting to a DSLAM. To permit the modems to automatically connect to each other on startup, the VCI (virtual channel identifier) on each of the units has to be set to the same (i.e. 32).

This worked extremely well, achieving the maximum line connection speed of 2.3Mbit/s. The connection was then left active and several tests were done to assess how the link would perform in a working environment. Access speeds to network shares, the management information system and JANET were found to be more than satisfactory. The second circuit came into operation at the end of August 2005 with identical results to the first. The full line speed of 2.3Mbit/s was achieved and connection performance to the Hotel network was excellent.

BT Circuit Termination at Hotel

After the encouraging performance of the two test links, approval was given to connect all remaining residential buildings. In September 2005, five more orders were placed with BT for EPS 9 circuits. The first two circuits had been terminated onto wall mounted LTUs (Line Terminating Units) next to the network cabinet. Had the five additional circuits been terminated in similar LTUs an unnecessary amount of space would have been taken up. Therefore an "LTU shelf", which is in fact a free standing termination unit capable of supporting upto six circuits, as shown below in fig. 4, was requested via BT Local Business. The LTU shelf was positioned on top of a network cabinet. From the rear of the unit two leads were run to inside the network cabinet where they were terminated in standard BT sockets in



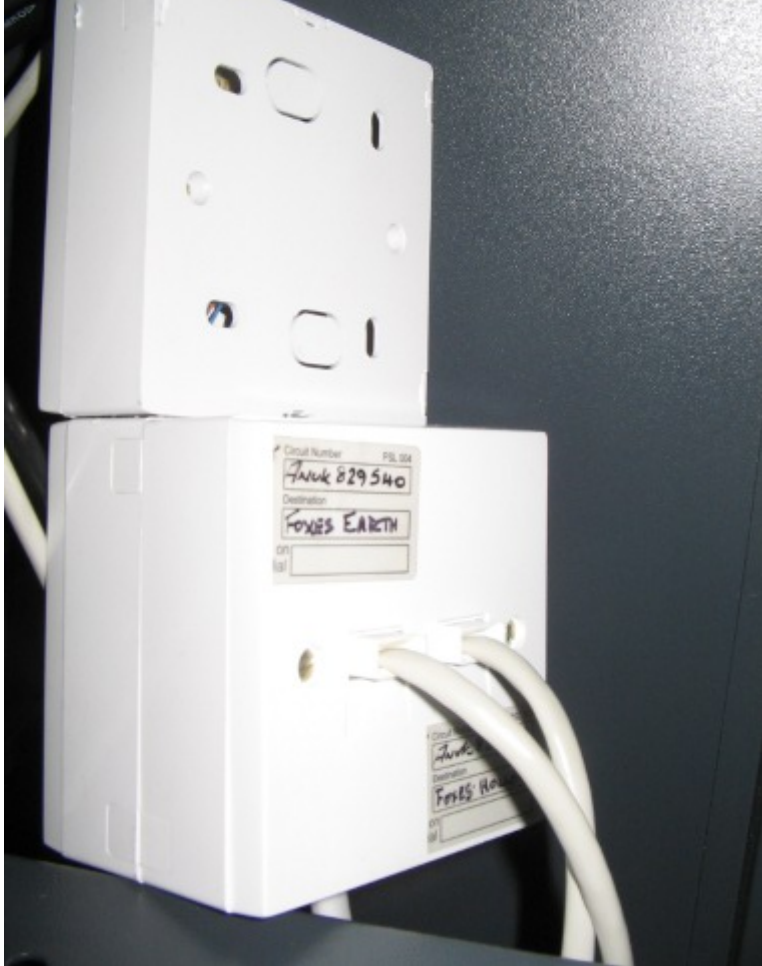
[5]



[6]

connections

Figure 5: Rear of Line Terminating Unit showing cables to cabinet sockets



[7]

Figure 6: BT socket terminations for EPS9 circuits within the network cabinet

Equipment Ordering and IP DSLAM Installation

As a total of seven modem-routers would be required, one for each remote building, three more CTC Union CT-2300A G.SHDSL units were ordered from Lanode, together with the IP DSLAM and all other items required for the project.

To permit patching of the BT EPS9 circuits, presented via the LTU at BT sockets within the network cabinet, see fig. 6, to the IP DSLAM, the latter needed to be connected to a patch panel via a 50-core cable. Since Lanode were supplying both the cable and the patch panel, they kindly 'punched in' the required connections to the patch panel prior to shipment. This cable was connected to the rear of the DSLAM as shown in fig. 7. The patch panel can be seen in fig.8.



[8]

Figure 7: Rear view of DSLAM showing 50-core cable which runs to patch panel

Between September and November 2005 the equipment arrived and the remaining circuits were installed by BT. The IP DSLAM arrived after the new modem-routers had been installed in the residential houses and it was then installed into the network cabinet with no difficulties. The 50-core cable from the patch panel connected directly into the back of the IP DSLAM (fig.7), allowing the circuits to be connected into the patch panel via BT - RJ45 cables (fig.8).

When the IP DSLAM was installed, its configuration was set to 'Provider' and the mode was set to bridging. A static IP address was assigned to the front panel 10/100BaseTx Ethernet uplink port and this was connected to the network switch stack (fig.8). The VCI for each circuit was set to 32 and the ports were enabled.

One final configuration detail was that SNMP was enabled on the modem-routers. The college uses Paessler PRTG Traffic Grapher <http://www.paessler.com/prtg> [9] to monitor the links. This has proved to be very useful in seeing which building uses the most bandwidth and it is hoped that it will be of further help when planning future network developments.



[10]

Figure 8: The IP DSLAM with patch panel below and JANET router above installed in equipment rack

Completion of WAN

With the IP DSLAM up and running, the two initial test circuits were transferred from the modem-router supported connections at the Hotel to the IP DSLAM. The configuration of the remote modem-routers remained the same. There were no problems or loss of performance.

The five new circuits were then connected to the IP DSLAM at the Hotel and the remaining modem-routers installed at the remote locations. All five of the new circuits performed identically to the test circuits, meaning that all seven circuits were now connected to the Hotel through the IP DSLAM at 2.3Mbit/s.

Each unit (including the DSLAM) has been configured with a static IP address and a VCI of 32. The units generally stay permanently powered on and connected to the DSLAM, but if they do reboot they automatically reconnect without any user intervention.

Note: the entire LAN/WAN is configured as one IP subnet. Devices that haven't been set a static IP address are provided one by the JANET Cisco router through DHCP. This router is set as the default gateway for the network. It may be necessary in the future to reconfigure the IP address setup of the network and alter the basic Ethernet bridge mode configuration of the modem-routers, but at present the network is working very well and meeting the college's needs.

Project Timescales

July 2005	Orders placed for two EPS 9 circuits plus four SHDSL routers.
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	Circuit handover and connection of Foxes Grove using two SHDSL modems and an EPS 9 circuit.
August 2005	Circuit handover and connection of Foxes Court using two SHDSL modems and an EPS 9 circuit.
September 2005	Orders placed for 5 EPS 9 circuits and all supporting hardware.
October 2005	Circuit handover for Foxes Earth, Landing and Den.
November 2005	Circuit handover for Foxes Trading Post and Hollow.
	Installation of IP DSLAM. Shift of two test circuits from SHDSL modems to DSLAM.
	Installation of all subscriber SHDSL modems and final configuration for connection to the Hotel network.
December 2005	Full testing of all connections and installation of network services onto PCs and laptops.

Table 5: Project timescale

Operational Performance and Reliability

Foxes Academy was pleased that the full line speed of 2.3Mbit/s was reached on all seven circuits. Access to all network resources including the new management information system was more than satisfactory. The connections have performed flawlessly for over seven months since they became fully operational in December 2005.

Since December 2005, Foxes Academy has purchased a larger residential building, Foxes Halt, to replace a flat, Foxes Landing. BT was very helpful in arranging for the circuit to be moved to the new building at an acceptable cost. The new circuit was installed on time and is performing just as well as the others.

Benefits of Project

The benefits of having all seven residential buildings connected to the network were immediately noticeable. All members of staff now have access to the shared resource drive,

which is gradually growing. Instead of staff having to hold a supply of hard-copy documents and photocopy them, they can now print them directly from the 'Resources Area'. This also ensures that the latest revision is always used. All company policies and procedures are accessible (read only) in the same way.

Almost all members of staff now have e-mail accounts, which have greatly reduced the amount of paperwork being passed between buildings via the internal mail system. Plans are now in place to expand the e-mail system to allow students to have their own account.

Before the network was in place there was no JANET access from six of the seven residential houses. Now that Internet access via JANET is available for both staff and learners, it is being used more and more and has quickly become an indispensable resource.

The catalyst for implementing a solution to network connectivity between the residential buildings was the impending deployment of a new management information system. Initial tests have shown that the system will work well over the network from the residential buildings.

Lessons Learned

The project proved to be very successful and very few problems were encountered. The biggest setback experienced was when the second EPS 9 circuit was delayed. This was due to a problem with getting new lines to the BT pole at the Hotel. BT had to arrange for contractors to overcome this obstacle, and this delayed the installation of that circuit by almost a month. This may have been a one off problem, but a similar potential issue should be taken into account when ordering circuits for time-sensitive projects.

Summary

The connection of all seven residential houses using a secure, reliable and cost-effective method was successful. Compared to the cost of other solutions, Foxes Academy has made great savings while still meeting all the requirements initially set out.

Foxes Academy is now looking at other ways to take full advantage of any spare bandwidth between the sites. Once the management information system is fully in use in the residential houses, the college will have a better idea of how much spare capacity is available. After further testing it may be possible to connect the digital phone system based at the Hotel to the network. This could potentially allow all residential houses to have Voice over IP phones, with the benefit that calls between the buildings would be over the network, and therefore free at the point of use.

The technical and management staff at Foxes Academy would recommend using Baseband EPS circuits and SHDSL equipment when connecting buildings or remote sites within a limited radius which all share the same BT exchange.

Source URL: <https://community.jisc.ac.uk/library/advisory-services/foxes-academy-multi-link-eps-9-shdsl-wan-case-study>

Links

[1] <http://www.multimap.com/>

[2] <http://community.ja.net/system/files/images/foxes-academy-01.jpg>

[3] <http://community.ja.net/system/files/images/foxes-academy-02.jpg>

[4] <http://community.ja.net/system/files/images/foxes-academy-03.png>

- [5] <http://community.ja.net/system/files/images/foxes-academy-04.jpg>
- [6] <http://community.ja.net/system/files/images/foxes-academy-05.jpg>
- [7] <http://community.ja.net/system/files/images/foxes-academy-06.jpg>
- [8] <http://community.ja.net/system/files/images/foxes-academy-07.jpg>
- [9] <http://www.paessler.com/prtg>
- [10] <http://community.ja.net/system/files/images/foxes-academy-08.jpg>