Inter-site connectivity and last mile technologies guide

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Overview

This guide introduces the technologies available in the UK for the connection of computer networks between multiple sites to create WAN (Wide Area Networks). The size range of networks to be linked considered in this guide extends from single remote users and small workgroup sites requiring connectivity to a central main network or the Internet, to large LAN (Local Area Network) inter-connections requiring multi-megabit bandwidths. This reflects the potential needs of small to medium enterprises and the general network requirements of academic institutions. Solutions for the very high inter-site data transfer needs required by, for example, research organisations for special projects, are outside the scope of this paper.

The aim of this guide is to help in the decision making process as to which technology should be adopted or investigated for a particular application. The target audience is IT managers and technicians who have a good understanding of LANs and some knowledge of WANs and who have been tasked with establishing, upgrading or reviewing inter-site data communications. Such readers may benefit from the technology comparison and characteristics tables, presented in quick reference form, for the various solutions which could be considered. Other readers who may benefit are non-technical decision makers for whom this guide will provide an insight into the issues and options available in selecting inter-site data communications solutions.

Introduction

There are many decisions to be made in selecting a WAN (Wide Area Network) solution. The considerations include:

- Medium: cable (copper or optical); wireless (optical, radio or microwave).
- Provision: buy outright; lease circuits; opt for contended service.
- Management: self-procure and maintain; managed service.
- Bandwidth: what is needed; supported by chosen technology; affordability.
- Distance between sites.
- Reliability and service availability.
- Security.
- Availability of technology in required localities.
- Packaging and marketing of technologies; recognisable products.
- Use of technologies to build a suitable network to satisfy the organisation’s needs.

Factors in Selecting an Inter-site Connection Technology

What is the link to be used for? As is said, ‘You don’t buy a Ferrari if what you need is just something for the shopping’. More fundamental is the **need** the network is to satisfy. For example, it may be a stunning achievement to put in place a 10 or 100Mbit/s WAN which enables all users to communicate with each other and use a bandwidth-hungry system. But if the need is only for access to the Internet and college learning materials, then a much simpler Internet-only connection to access an Extranet may be a better solution than a high performance, meshed WAN.

Having decided the link’s purpose, the all-important question of the required bandwidth can be considered. This often leads to the chicken and egg situation of which applications can be supported over the affordable bandwidth. If more bandwidth was available, a greater range of more bandwidth hungry applications would be considered, e.g. videoconferencing. (A high quality H.323 IP videoconferencing session can consume more than 2Mbit/s.)

Factors influencing the required bandwidth are:

- numbers of users to be supported over the link
- intensity of usage
- applications
- Internet access requirements
- thin client systems
- operating system
- location of authentication and application servers

As an indication of bandwidth needs, 128kbit/s is suitable for a small group of up to say five users for e-mail, web access and online text based conferencing, and is just about usable for Voice over IP. Greater bandwidth becomes necessary when the number of users requiring simultaneous access increases, for example, for accessing a bandwidth-hungry database or videoconferencing over IP.

For linking LANs of any real size, e.g. a central office or campus to remote campuses or large offices, where a degree of real-time interaction is required, 2Mbit/s links are really the minimum. (Having said this, WAN connections to smaller offices can in many cases be satisfactorily be effected with sub-1Mbit/s links). These links are generally implemented in the form of terrestrial circuits. A 2Mbit/s link naturally complements an office/campus LAN operating at the old perfectly respectable 10Mbit/s (up to 100Mbit/s) standard which is fine for modest file and print networks. A 2Mbit/s bandwidth will of course always represent a bottleneck on today’s networks which generally operate at 100Mbit/s. In this scenario, bandwidth management has a role to play. Advice on aspects of bandwidth management can be found at www.ja.net/bmas [1].

Typically many organisations begin with a single 2Mbit/s circuit link between sites, increasing this to 2 x 2Mbit/s and beyond as needs grow. Where cost effective, 10Mbit/s fibre Ethernet is increasingly the defacto standard and where possible, up to 25Mbit/s wireless or 100Mbit/s laser is widely deployed.

In practice most organisations base their decision over the bandwidth required on their current

experience of the perceived performance of the links and performance indicators such as round trip times, packet loss figures and percentage bandwidth utilisation.

Having selected the ideal bandwidth, the technologies available in the particular area can be considered. The capabilities of the telecommunications providers operating in the locality will have a major bearing on which technologies are available and at what cost. A further key consideration will be the geography of the land between the various sites and the distance between the sites to be connected.

Reliability and service availability will also be of vital importance. WAN links generally represent a considerable investment by an organisation and the ongoing annual rental costs can be significant. It is rare that an organisation can afford duplication, fault-tolerance and resilience. The paradox is that the main links of the WAN are usually absolutely mission critical, but are often installed at the limit of available funding. It is essential that the organisation recognises the importance of the communication links and allocates budget accordingly to ensure that >99.8% reliability is intrinsic in the technology selected. Otherwise fail-over systems must be put in place.

Selecting an Inter-site Connection Technology

The next two tables match available technology solutions to different bandwidth requirements and geographical distances. They are:

- General Guide to Inter-site Connection Technology
- Technology Suitability Table

The remaining tables give more detailed information about bandwidth ranges, installation and running costs, and applications supported by each technology.

- Local Building to Building Campus Solutions
- Small Office / Remote Outreach Centre / Single Power Home-user
- Short Distance 1km-4km, Medium – High Bandwidth Connections
- Medium Distance 4km-25km, Medium – High Bandwidth Connections
- Longer Range 25km+, Medium – High Bandwidth Connections

Table 1. General Guide to Inter-site Connection Technology

	B a n d w i d t h R e q u i r e m e n t s *			
GEOGRAPHY	**Low (0-2Mbit/s)**	**Medium (2-50Mbit/s)**	**High (up to 100Mbit/s)**	**Very high (100Mbit/s +)**

Local building to building	1. Analogue private wire 2. Analogue leased circuits (EPS 8)	1. Wireless 802.11 2. Private fibre optic cable	1. Infrared laser 2. Private fibre optic cable	Private fibre optic cable
Small office, home user, remote outreach centre	1. ISDN 2. ADSL Broadband VPN 3. Cable VPN 4. Satellite VPN	1. G.SHDSL Broadband 2. Broadband Fixed Wireless Access and Public Access 802.11 Wireless Hotzones	Not generally required	Not generally required
Short range: 1km to 4km	1. Analogue leased circuits (EPS 8) 2. Broadband (xDSL, fixed wireless, hotzone) VPN 3. Cable VPN	1. Wireless 802.11 2. Leased line digital circuits 3. Short Haul Data Services (LES 10/ p2p)	1. Infrared laser 2. Private fibre optic cable 3. Short Haul Data Services (LES 100/ p2p) 4. Leased line digital circuits	1. Private fibre optic cable 2. Short Haul Data Services (LES 100/ p2p)
Medium range: 4km to 25km	1. Broadband (xDSL, fixed wireless, hotzone) VPN 2. Cable VPN 3. Frame relay (rarely used)	1. Wireless 802.11 2. Leased line digital circuits 3. Short Haul Data Services (LES 10/ p2p)	1. Licensed microwave 2. Short Haul Data Services (LES 100/ p2p) 3. Leased line digital circuits	1. Leased Line Digital Circuits 2. Short Haul Data Services (LES 100/ p2p)

Long range: 25km+	1. Broadband (xDSL, fixed wireless, hotzone) VPN 2. Cable VPN 3. Frame relay (rarely used)	1. Leased line digital circuits 2. Wireless 802.11 3. Licensed microwave	1. Licensed microwave 2. Leased line digital circuits	1. Leased line digital circuits 2. ATM/SMDS

*Example users/uses of:

- Low bandwidth: e-mail, Internet access and thin client supported applications
- Medium bandwidth: e-mail, Internet access and network applications, including high bandwidth applications such as videoconferencing
- High bandwidth: large organisations and regional network operators, with high inter-site traffic, supporting most network applications

Note: This table is intended as a visual guide to the technology options and is not prescriptive. It is valid at the date of publication (May 2005).

Table 2: Technology Suitability

Local building – building campus solutions Private Fibre Optic Cable Connections Wireless 802.11 Infrared Laser Analogue Leased Circuits	**Small office/remote outreach centre** **Single power home-user** Digital Subscriber Line – Broadband Public Access 802.11 Wireless Hotzones Broadband Fixed Wireless Access ISDN (Integrated Services Digital Network) Cable Satellite Broadband

Short Distance 0km – 4km, medium – high bandwidth connections Private Fibre Optic Cable Connections Analogue Leased Circuits – EPS (Engineering Performance Specifications) 8 Wireless 802.11 Infrared Laser	**Medium distance 4km – 25km, medium - bandwidth connections** Short Haul Data Services – LES (Local Are Extension Service) or p2p (peer-to-peer) Leased Line Digital Circuits Wireless 802.11 (up to 14km)
Longer range 25km+ medium – high bandwidth connections Leased Line Digital Circuits Frame Relay SMDS (Switched Multi-megabit Data Service) Licensed Microwave	**Technologies for the future** Free Space Optics – AirFibre IP over Powerlines 802.16 Wireless – WiMAX UMTS (Universal Mobile Telecommunicatio

Table 3: Building – building campus solutions

Technology	Bandwidth	Range	Cost	
			Install	**Annual**

Private Fibre Optic Cable Connections	Very high Limited only by equipment connected Full duplex	Limited by connecting equipment and protocol Physical barrier and rights of way may be an issue	High £25/metre	Low
Wireless 802.11 802.11 802.11b 2.4GHz (WiFi) 802.11g 2.4GHz 802.11a 5GHz (WiFi5)	Medium Half duplex Nominal - 2Mbit/s Realistic - 1Mbit/s Nominal - 11Mbit/s Realistic - 5.5Mbit/s Nominal - 54Mbit/s Realistic - 25Mbit/s Nominal - 54Mbit/s Realistic - 25Mbit/s	< 12km direct single hop, greater distances possible with multiple hops Increasingly widespread use of 802.11b 2.4GHz channels is resulting in higher levels of interference in some locations, necessitating reduction in bandwidth	Medium £3k - £5k depending upon bandwidth	Low

Infrared Laser	High < 100 Mbit/s Full duplex	< 4km direct Affected by fog/adverse weather	High c.£10k - £20k	Low
Analogue Leased Circuits (EPS8)	Medium < 2Mbit/s Line quality/distance dependent Full duplex	4km circuit Sites must share same BT exchange	Low £1,120	Low £770pa

Table 4: Remote outreach centre / single remote user solutions

Technology	Bandwidth	Range	Cost	
			Install	Annual

Digital Subscriber Line 'Broadband'	Moderate, generally 2Mbit/s down, 256kbit/s up Subject to contention Full duplex Fast service 8Mbit/s down, 400kbit/s up	Limited by Internet boundary and availability of DSL enabled exchange Reach is 3.5km from exchange for full bandwidth or 5.5km for 250K Fast broadband reach up to 2km. Limited availability	Low £0 - £260 £50	Low As increasing upload and download performance is provided, costs increase 1Mbit/s/256kbit £780pa (**1)** 2Mbit/s/256kbit £1200pa 8Mbit/s £480pa
PAWH (Public Access 802.11 Wireless Hotzones) AND BFWA (Broadband Fixed Wireless Access)	Moderate Subject to contention Half duplex	Limited only by Internet boundary and availability of WISP (wireless ISP) coverage	Low	Low
ISDN	Moderate 2 x 64kbit/s 30 x 64kbit/s Full duplex	Limited only by availability of ISDN at A and B ends	Low	Relatively high Charged on ca time basis

Cable	Moderate Subject to contention Full duplex	Limited only by Internet boundary and availability of fibre cable in street	Low	Low As increasing upload and download bandwidth is provided, costs increase
Satellite	Moderate Typically 1Mbit/s down 384kbits/s up 2Mbit/s down 1Mbit/s up available Subject to contention Full duplex	Limited only by Internet boundary and line of sight to satellite	Moderate £300 -£1000 If kit must be purchased cost can be up to £1050	Low - moderate 512kbit/s/128k £708pa 1Mbit/s/256kbi £1668 - £4260 2Mbit/s/384kbi £6120pa (2) 2Mbit/s/1Mbit/s £12600pa

(1) Prices quoted are generally those for 'business-type' multi-user suitable services.

(2) Some providers offer special deals for schools and educational organisations.

Table 5. **Short Distance 0km – 4km, Medium – High Bandwidth Connections**

Technology	**Bandwidth**	**Range**	**Cost**	
			Install	**Annual**

Private Fibre Optic Cable Connections	Very high Limited only by equipment connected Full duplex	Limited by equipment and protocol	High £25/metre	Low Medium £8-10/m
Analogue Leased Circuits (EPS8)	Medium < 2Mbit/s Line quality/distance dependent Full duplex	4km Sites must share same BT exchange	Low £1,120	Low £770pa

Wireless 802.11 802.11 802.11b 2.4GHz (WiFi) 802.11g 2.4GHz 802.11a 5GHz (WiFi5)	Medium Half duplex Nominal - 2Mbit/s Realistic - 1Mbit/s Nominal - 11Mbit/s Realistic - 5.5Mbit/s Nominal - 54Mbit/s Realistic - 25Mbit/s Nominal - 54Mbit/s Realistic - 25Mbit/s	< 12km direct single hop, greater distances possible with multiple hops Increasingly widespread use of 802.11b 2.4GHz channels is resulting in higher levels of interference in some locations, necessitating reduction in bandwidth	Medium £3k - £5k depending upon bandwidth	Low

Infrared Laser	High < 100 Mbit/s Full duplex	< 4km direct Affected by fog/adverse weather	High c.£10k - £20k	Low

Table 6. **Medium Distance 4km – 25km, Medium – High Bandwidth Connections**

Technology	**Bandwidth**	**Range**	**Cost**	
			Install	**Annual**
Short Haul Data Services (LES/p2p)	10, 100, 1000Mbit/s	< 25km	High - very high	Moderate Good value

Leased Line Digital Circuits	‘Kilostream’ 64kbit/s upwards in 64K steps to 2Mbit/s ‘Megastream’ 2,4,6,8,10 upto 155 and 622Mbit/s ‘Megastream Ethernet’ 10 - 1000Mbit/s	No limit	High	High

Wireless 802.11 802.11 802.11b 2.4GHz (WiFi) 802.11g 2.4GHz 802.11a 5GHz (WiFi5)	Medium Half duplex Nominal - 2Mbit/s Realistic - 1Mbit/s Nominal - 11Mbit/s Realistic - 5.5Mbit/s Nominal - 54Mbit/s Realistic - 25Mbit/s Nominal - 54Mbit/s Realistic - 25Mbit/s	< 12km direct single hop, greater distances possible with multiple hops Increasingly widespread use of 802.11b 2.4GHz channels is resulting in higher levels of interference in some locations, necessitating reduction in bandwidth Limited range at higher bandwidths	Medium £3k - £5k depending upon bandwidth	Low

Table 7. **Longer Range 25km+, Medium – High Bandwidth Connections**

Technology	**Bandwidth**	**Range**	**Cost**	
			Install	**Annual**

Leased Line Digital Circuits	‘Kilostream’ 64kbit/s upwards in 64K steps to 2Mbit/s ‘Megastream’ 2,4,6,8,10 upto 155 and 622Mbit/s ‘Megastream Ethernet’ 10 - 1000Mbit/s ‘LearningStream’ 2Mbit/s ‘LearningStream Ethernet’ 10Mbit/s	No limit No limit No limit No limit	High Distance dependent £4250 - £9000 for 2Mbit/s £600/site	High Local ends plu fixed main link charge, so lon length circuits become better eg. £8000pa Less than Megastream
Frame Relay	< 2Mbit/s	No limit	High	Moderate Distance independent

ATM / SMDS (Switched Multi-megabit Data Service)	Medium - high 2Mbit/s (E1) 34Mbit/s (E3) 155Mbit/s (STM-1) 622Mbit/s (STM-4)	No limit	High	High
Licenced Microwave	High 100Mbit/s	No limit	£14-16,000 hardware for single hop 100Mbit/s	£600 for 38GH licence

Links
[1] http://www.ja.net/bmas