

Broadband Technologies for Learning and Teaching Off-Campus

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Summary

At a time when widening participation to non-traditional learners and enhancing student retention rates are high up the agenda, new broadband technologies could possibly remove access barriers to e-learning in the wider community, by reducing the differences between on-campus and off-campus learning experiences. They may also offer institutions a cheaper alternative to current on-campus infrastructure provision. The off-campus broadband picture is confused by hype. Not all the options currently available have sufficient bandwidth to justify the term "broadband" and some technologies are unlikely to be available at an affordable cost for mass application to learning in the near future

In the UK there are currently seven major options that could be considered by institutions seeking to determine the best way of supporting off-campus learners.

1. Public Wireless LANs
2. Broadband fixed wireless
3. Mobile telecommunications
4. ADSL
5. Cable networks
6. Satellite
7. Digital TV (not really a separate technology, but widely available)

This briefing identifies important issues that might affect institutions' choice of current broadband media, summarises the key differences between the different technologies and comments on their significance for off-campus situations within the next three years. Many of the options reviewed here have to be ruled out for reasons of cost, availability, speed or other performance characteristics. The most feasible and likely contenders for supporting off campus study are ADSL and cable networks. Other services that

are likely to have limited niche potential are Broadband Fixed Wireless (for mainly urban areas) and satellite services (for mainly rural areas).

Introduction

This briefing has been prepared for senior managers in tertiary, further and higher education with responsibility for curriculum development and delivery strategies. It will be useful for Assistant / ViceDeputy / Deputy Principals, Pro Vice Chancellors and Heads / Directors of Teaching and Learning. It aims to inform senior decision makers regarding the potential capability of a range of so called "broadband" technologies to support off campus learning and teaching within the next three years (2003-2006). The briefing considers the following questions: What is broadband? What are the options? What are the issues and how might it affect off campus delivery and support of further and higher education in the UK?

What is Broadband?

"Broadband" refers to the bandwidth of communications networks such as Local Area Networks (LANs), ie. their capability to transmit large amounts of data rapidly, measured in bits per second (bit/s).

The definition of broadband depends on context. There is a difference in perception depending on whether one is looking at on-campus networks, owned and paid for the institution, and off-campus networks, owned by third party service providers and paid for by individual users. Domestic users are typically offered "broadband" services up to a maximum of 1Mbit/s. Not many network managers would call 10Mbit/s Ethernet a broadband technology. They would reserve that phrase (if they used it at all) for 100Mbit/s technologies.

The definition of broadband also changes as technological capability increases. Until recently

ISDN2 at 128kbit/s was regarded as broadband, compared with the 64kbit/s bandwidth of an ordinary telephone line. The DTI's current definition of broadband is 2Mbit/s and above and next generation broadband will likely be 10Mbit/s and above (http://www.e-envoy.gov.uk/publications/reports/broadband/1_1.htm). To put this in context, full-screen broadcast quality video requires in excess of 2Mbit/s although with good compression technology such as MPEG-4, VHS-quality video is feasible at 384kbit/s and DVD-quality video within 1.5Mbit/s (although high quality DVD may require 2Mbit/s).

However, despite being promoted as "broadband", most service offerings cannot yet achieve 2Mbit/s, certainly not at a cost affordable by the mass market. For the purposes of this report, broadband is defined as anything in excess of 128kbit/s, while recognising that this is likely to change as technology develops and the market matures.

Why is broadband important?

HE and FE institutions are investing significant sums to implement virtual learning environments on campuses. Off campus these developments have been held back by bandwidth and cost restrictions, thus limiting the scope for maximising the return on investment in new systems and approaches and for allowing learners to access these resources more flexibly.

Recent rapid growth in the availability and take up of new broadband technologies in the wider community potentially removes access barriers to e-learning at a time when widening participation to non traditional learners and enhancing student retention rates are high up the agenda. It may also offer institutions a cheaper alternative to current on-campus infrastructure provision.

What are the benefits?

The main characteristics of broadband delivery are:

- Always- on connections.

- Fixed price/unlimited access to the Internet (although some broadband tariffs are based on data volume)"The Net".
- Faster, more reliable data transmission rates.

These characteristics widen the range of possible uses and affect the way users respond to the medium. For example, "always- on" means that users can read emails as soon as they are received and send messages at any time instead of having to wait until they are logged on. It also speeds up the response time of the machine, so users do not have to wait while their modem dials in and makes a connection. Fixed price access means that home based learners can spend time online interacting with sophisticated course materials such as simulations; with each other in collaborative exercises; and with their tutors in tutorials without having to worry about call time charges. Faster, more reliable data transmission rates create opportunities to provide data rich learning environments such as video, audio, multimedia simulations, videoconference communications. The net effect of both factors is to reduce the potential differences between on-campus and off-campus learning experiences, allowing institutions to plan for a level of off-campus delivery and support comparable with on-campus. This could be significant if the institution is seeking to open up access for non-traditional learners at home, in the workplace, in outreach centres, or even in some public spaces.

What are the options?

In the UK there are currently seven major options which could be considered by institutions seeking to determine the best way of supporting off-campus learners.

1. Public Wireless LANs
2. Broadband fixed wireless
3. Mobile telecommunications

4. ADSL
5. Cable networks
6. Satellite
7. Digital TV

The first six are network technologies. Digital TV is different in that it is an application that can be deployed via different technologies (eg. cable, satellite). However, as the fastest growing broadband medium in the UK, Digital TV deserves consideration in its own right. In the following sections each of these seven options is reviewed to assess the extent to which it is worth considering as a vehicle for delivering and supporting off campus learning.

What are the issues?

The important issues that might affect institutions' choice of current broadband media are:

1. Bandwidth
2. The effect of multiple users
3. Distance
4. Security
5. Integration into existing network infrastructure
6. Availability
7. Cost
8. Educational effectiveness.

Bandwidth

Some technologies are faster than others. In many cases the technology offers a range of speeds depending on a variety of other factors such as cost, number of users, distance.

The amount of bandwidth available defines the limits of potential use. For example, 128kbit/s is suitable for email, surfing the web and online text based conferencing. It is just about usable for voice over IP, but inadequate for IP based videoconferencing. Note that sometimes the

speed of incoming information is not the same as outgoing information, as in the case of Asymmetric Digital Subscriber Line (ADSL), where download speeds greatly exceed upload speeds.

The effect of multiple users

In some cases speed is also affected by the number of simultaneous users, known as the 'contention ratio'. Contention based services share the available bandwidth between the total number of simultaneous users, so the more users on-line the slower the service. Services which do not guarantee contention ratios are likely to perform less well at busy times.

Distance

The strength of signals declines with distance. For some technologies the effect is more acute than for others, for example there is a physical limit to how far ADSL and wireless LAN signals can travel and the available bandwidth drops off with distance. Another effect of distance is latency: the delay between a signal being sent and received. Over short distances latency is negligible, but over longer distances it can cause problems. For example, two-way satellite systems are subject to delays caused by the time taken for signals to pass between the satellite and the receiver through the atmosphere.

Security

"Always on" means that individual machines are more vulnerable to attack. This has serious implications not only for the owners of those machines, but for institutional network managers because unprotected off campus machines can provide a relatively easy means of entry into campus networks for unscrupulous third parties. Also, technologies such as cable networks, which are a shared medium, provide further opportunities for hackers to illegally gain entry to the institutional network by "snooping" information packets and their contents. Wireless LANs and Cable modems can also be "snooped". Security concerns need not rule out use of broadband but appropriate data encryption and virus and firewall protection are highly recommended.

Integration into existing network infrastructure

Integration of network access products such as ADSL with existing LANs is likely to require significant effort in terms of upgrading the network to meet the minimum requirements for network access services (in terms of hardware, software versions and software patches). Other issues may be limited availability of skilled network engineers and insufficient information to support off campus learning centres.

Availability

Some technologies are only just becoming available as trials, eg. Third generation (3G) telecoms, and cannot be expected to be widely available in the foreseeable future. Others are well established but limited in their coverage and likely to remain so indefinitely, eg. Cable TV networks. The planning time frame for this report is taken assumed to be as three years so technologies that fall outside this frame are disregarded.

Cost

Many of the technologies reviewed here are new. They require massive investment in infrastructure and in some cases have also cost their operators billions of pounds in licence fees. Operators need to recover their costs as rapidly as possible and so, not surprisingly, many of these technologies will be priced at a premium to begin with. Thus although services such as two-way satellite broadband are already available, they are unlikely to be taken up by the mass market to the extent that they can be relied upon for educational use in the foreseeable future because of their high cost. Costs generally increase in proportion to speed.

Educational effectiveness

The amount of available bandwidth constrains the range of possibilities open to institutions. Ordinary telephone lines are fine for simple text email and just about usable for web surfing, but unsuitable for any kind of multimedia application or for moving around large data files. The difference between one way systems (eg.

TV broadcasts) and two way systems (eg. Cable modems) is significant also. One way systems are essentially content distribution media. The greater the bandwidth of the return channel from the learner, the more possibilities there are for meaningful interaction.

Broadband Technologies in the UK

In this section each of the seven technology options introduced in the previous section is reviewed in terms of the issues identified there. While there are one or two other technology options, such as broadband over power lines, or NTT's DoCoMo (i-mode) wireless internet service, these are considered to be so unlikely to become mainstream options in the UK within the next three years that they have not been considered in any depth. Although tremendously successful in Japan, there are major doubts about the roll-out of i-mode in other markets and at this stage powerline transmission in the US and UK is more oriented to transmitting data over the electric power cables within a home rather than to the home.

Public Wireless LANs

Wireless LANs are usually thought of as proprietary networks belonging to a particular organisation and closed to outsiders. However, the technology can also be deployed outside buildings into public areas for access via Personal Digital Assistants (PDAs) and laptops. This could be beneficial in public locations (both open-air and covered) such as shopping malls and cafes, thus allowing users to mix education and leisure. For example, in March 2002 a wireless 'HotZone' in Palo Alto, California, USA, was announced. The HotZone is designed to provide 802.11b coverage to an area that spans six city blocks. Gatespeed and WiFi Metro plan to jointly market the new service, with an additional 20 HotZones scheduled for rollout by the end of 2002. In April 2002 BT

announced a similar UK public WLAN service. They plan to have installed 400 public access WLAN points – “hotspots” – around the UK by June of 2003, increasing to around 4,000 by 2005. Users would have secure fast access to the Internet and their own networks and would be billed via subscription or by buying vouchers at shops. The service will use the IEEE Wireless LAN 802.11b (WiFi) standard which gives a bandwidth of 11Mbit/s using Ethernet-type protocols over a range of up to 50 metres. Since Ethernet is a contention-based protocol and all devices within a zone share the same service, the effective throughput is likely to be much less, and depends on the number of devices within range and what they are doing. This shared nature means that there are potential security risks that should be addressed through appropriate data encryption, anti virus and firewall protection measures. For a more detailed explanation of wireless technologies and standards and their implications for on-campus delivery see the TechLearn website:

<http://www.techlearn.ac.uk/Themes/wireless.htm>.

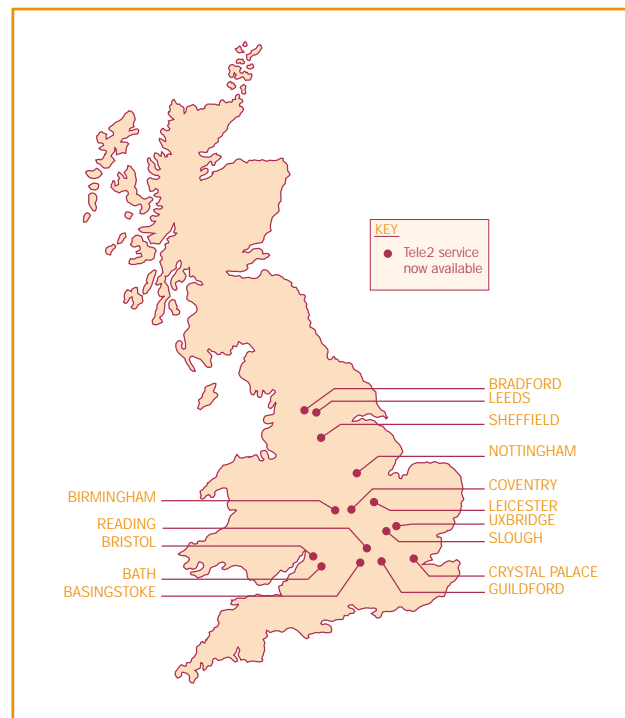
Conclusion

WLANS have the potential to deliver significant bandwidth to public local areas, allowing learners to tap into emails, web based learning resources and even videoconferencing communications. However there are too many uncertainties at present to make this option worth considering. The costs are unknown, the accessibility is too limited and because they are shared, if they do become popular, bandwidth may be rapidly absorbed by users at times, resulting in unpredictable service levels.

Broadband fixed wireless access

Broadband fixed wireless access (BFWA) uses local “nodes” or “base stations” to transmit/ receive data to your PC via radio, using the IEEE 802.16 standard for Wireless Metropolitan Area Networks. Current systems use Line of Sight (LoS), but non-LoS systems are being developed which plan to increase the bandwidth

to 100 Mbit/s. Upload and download speeds can be the same (although uploading is usually more expensive). Bandwidth is shared between users, so performance declines as the number of simultaneous users increases. This shared nature means that there are potential security risks that should be addressed through appropriate data encryption, anti virus and firewall protection measures. In the UK, probably the best known is Tele2 (www.tele2.co.uk). Tele2 operates a BFWA service in 15 cities as shown in the map below. Tele2's wireless network is based on the IEEE WLAN standard 802.11a, which in turn is the foundation of the Metropolitan Wireless Area Network 802.16 standard.



Their domestic service is charged at £39.99 per month. For this a user gets:

- Download Speed up to 512kbit/s
- Upload Speed of up to 256kbit/s
- 30:1 Contention Ratio

Higher bandwidth speeds up to 2Mbit/s are available at greater cost.

In Wales, where ADSL coverage is very limited, the Wales Digital College (<http://www.learn.cd/>) is promoting the use of BFWA, see <http://www.e-fro.cd/en/>.

Conclusion

Fixed wireless is broadband. In bandwidth terms it is comparable with cable modems and, like cable, performance may vary depending on the number of users on-line at any one time. It has the advantage of offering access to users not on existing copper loop/fibre networks. On the other hand, availability is still relatively limited and there are potential problems with interference between competing networks. At present tariffs are higher than for cable or ADSL so roll out is probably not going to be very rapid. BFWA therefore does not offer a feasible mass market solution for broadband connectivity at present. However, in areas where it is available, it could be used to support institutional outreach centres. The high bandwidth and bi-directional capability of business offerings make it suitable for a wide range of educational applications, including simulations, video, multimedia and videoconferencing, as well as high volume data transmission.

Mobile telecommunications

There has been a lot of hype in the mobile telecoms market with terms such as '2G', '3G' and 'broadband' bandied about fairly loosely. In this section we review a range of mobile telecommunications network standards, distinguishing between those which could be described as "broadband" and those which cannot. We then go on to discuss the relative merits of each of the contenders.

GSM

GSM is not broadband. The standard GSM offering is basically for voice telephony. It supports only narrowband data transmission (9600bit/s). There is a Short Message Service (SMS), restricted to 160 text characters and a cut-down version

of the Web protocol suite called WAP (Wireless Application Protocol) which after months of major hype, has largely faded away. However, the success of the GSM standard, launched around 10 years ago, gives some indication of the potential reach of succeeding generations. Unusually for a non-US technology, it has become the world's leading and fastest growing mobile standard, spanning over 174 countries, in use by more than 10% of the world's population and the number of subscribers worldwide is expected to surpass one billion by the end of 2003.

Conclusion

GSM is available now and relatively cheap, but only useful for voice telephony and (limited) text messaging) because it is not broadband. Text messaging may be useful for sending off campus (and on campus) students' short messages about assignment due dates, changes to lecture schedules etc. The tortuous nature of the interface make it unlikely to be used for large volumes of data or sophisticated academic debate.

GPRS

GPRS, the General Packet Radio Service or so-called 2.5G, is a new non-voice value added service that allows information to be sent and received across a mobile telephone network. A theoretical maximum speed of around 170kbit/s is achievable. However, the GPRS maximum speed is uneven less likely to be achieved. In the real world than, getting 10 Mbit/s flat out from one's 10 Mbit/s Ethernet link. There are many factors that conspire against this, and initial service offerings are mostly at the 28kbit/s level. In practice speeds in excess of 40kbit/s are unlikely. Thus it is nowhere near broadband in reality.

Conclusion

GPRS is available now. However it is not broadband. It may be useful to the lecturer and student on the move, wanting access to email and the Web from a laptop, but for the next few years it will be priced at a premium and so is

not likely to become ubiquitous in the time frame we have set for this report. It may also be overtaken by 3G (see below) although the indications are that 3G is still some considerable way off.

3G

3G, the so-called 3rd Generation GSM standard, otherwise known as UMTS (Universal Mobile Telecoms System) is designed to overcome the bandwidth problems of current GSM technology, and in particular to offer broadband services comparable with those available to fixed users. ITU recommendations for minimum bandwidth for 3GSM networks are:

- High Mobility: 144kbit/s for rural, outdoor, high-speed mobile use.
- Full Mobility: 384kbit/s for pedestrian or slow-moving users in urban, outdoor environments.
- Limited Mobility: 2Mbit/s with low mobility in stationary indoor and short-range outdoor environments.

The technology on which 3GSM services will be delivered is built around an open standard aimed at ensuring its widespread adoption. It is estimated that over 85% of the world's network operators have chosen 3GSM's underlying technology platform to deliver their third generation services.

3G is available in the UK only as a test network in the Isle of Man. A press release from Manx Telecom – www.manx-telecom.com – in December 2001 stated that it has switched on its Third Generation (3G) network. This is the first 3G network in Europe to go live. Hutchison Whampoa has one of the 3GSM licenses in the UK. It said in March 2002 that it has a target of one million third-generation mobile phone users in the UK in 2003 and will launch a 3GSM network in Britain in the fourth quarter of 2002. Many commentators are sceptical of these timescales.

8 3G needs a completely new technology base, so

will be very expensive to set up. (It will cost around \$5bn to network the UK). Tariffs are likely to be very high and roll-out of 3G across the UK is therefore likely to be slow. It is unlikely to overtake GPRS in market penetration before 2006 and not likely to cover even all UK cities until at least the second half of this decade. Reasonable national coverage is unlikely before 2010.

Conclusion

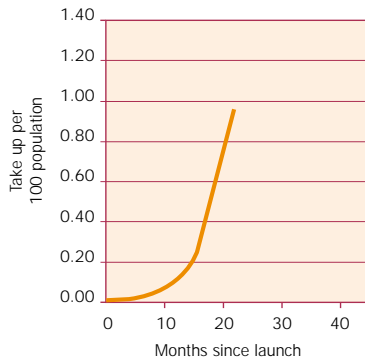
3G is broadband. In addition to voice calls over the network, 3G also offers video telephony and high speed access to the Internet over a mobile device. Possible educational uses include videoconferencing, accessing video clips, or large data files such as CAD/CAM drawings and virtual reality simulations as well as email and web browsing. However limited availability and expected high tariffs rule out 3G as a feasible option for mass deployment in tertiary and higher education.

ADSL

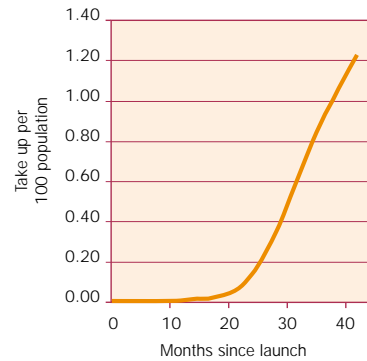
The analogue telephone network, built upon thousands of miles of twisted-pair copper wiring, is the most pervasive two-way communications network in the UK. Recent developments under the general title of "Digital Subscriber Line" (DSL), mean that it can be used to transmit high speed digital data, although DSL is only effective when used over relatively short distances compared with conventional telephone services. In the UK the main offering is Asymmetric DSL (ADSL), i.e. ADSL stands for Asynchronous DSL, which means that the rate at which data are received by users is different from speed at which users can transmit data.

DSL is being rolled out to replace the ISDN technologies that are now available, but little used, in most countries. Europe is lagging behind the US and Far East by about 18 months, and the UK still lags behind several other European countries, as the following graphs show.

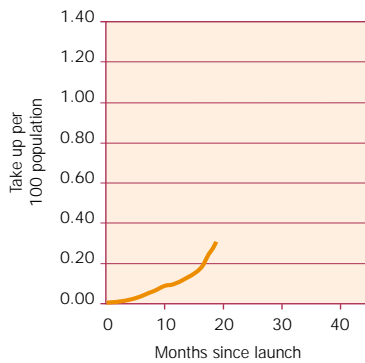
Germany



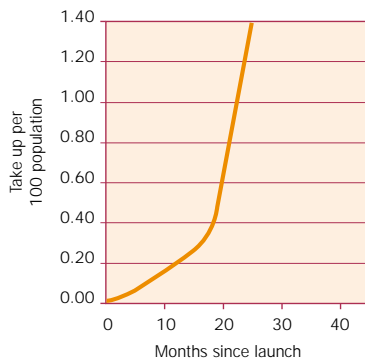
US



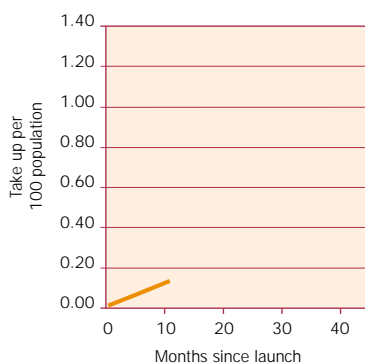
France



Sweden



UK



(Source: Oftel)

Nevertheless the take up in the UK is following the same pattern as elsewhere, indicating that penetration will be significant in due course.

BT is the main ADSL provider in the UK. BT's coverage was reported as 60% of all household lines, across over 1000 exchanges, in November 2001, with plans for 75% by the end of 2003 – but plans are fluid in the ADSL world. BT's current plans are to have one million ADSL connections by summer 2003. Most cities and major towns are now covered in whole or part. There are still some problems in areas where the signal is affected by noise, the lines are degraded aluminium, or the exchange lines are long. But there is a variant (RADSL) being deployed soon which should increase the range to 5.5 km and coverage in theory to around 90% of households (if the exchange is enabled).

At present ADSL in the UK is expensive compared both with cable modems and with similar services in other European countries. For this reason market penetration is low, despite the relatively high availability. However, BT made recent moves to correct that situation. The price of BT's retail offering, 'BT Openworld', was reduced in April 2002 from £39.99 to £29.99. BT Openworld Home500, has a downstream speed of 512kbit/s and an upstream speed of 256kbit/s. This means that, while it is quite feasible to use basic ADSL for delivering video and other large files such as CAD/CAM data, simulations and

virtual reality; high bandwidth two way exchanges such as videoconferencing are not feasible. Higher bandwidth services are available but at a higher cost. ADSL has the capability to run at around 8Mbit/s downloading and 1Mbit/s uploading. It is however affected by the number of users. BT offer a contention ration of 50:1 for their home service and 20:1 for their business offering. This shared nature means that there are potential security risks that should be addressed through appropriate data encryption, anti virus and firewall protection measures.

One new system worth watching is the SDSL (Symmetric DSL) service launched in the Leeds area in April 2002 by Star Internet, an ISP specialising in the business market. This is a consumer version of the business SDSL service offered by Fibernet in several UK cities over the last year. Star plans to roll out its SDSL service to other large cities in the UK during 2002/3. SDSL lines offer equal upload and download bandwidth, so uploading is just as quick as downloading.

Conclusion

ADSL is broadband and it is available now to the majority of households in the UK and could be made available to most. It is a shared medium so bandwidth is affected by the number of users. Upload speeds are significantly lower than download speeds, which limits its educational use to some degree as it means that users will not be able to return as much data to the centre (or each other) as they receive. Although ADSL is largely unavailable in rural areas and still expensive compared with a conventional telephone line or cable modems, its combination of increased bandwidth at an affordable price means that it is likely to become increasingly available in homes, public locations and workplaces.

Cable Networks

In addition to Multi-Channel TV, digital TV and telephone services, cable TV companies offer broadband data services using what is normally

called "cable modem" technology. The term is slightly misleading as the device is not really a modem as such but rather a kind of digital network interface card (NIC). This is a descendant of broadband Ethernet technology and is now widely used in the US. The shared nature of the medium means that there are potential security risks that must be addressed by network managers through appropriate data encryption, anti virus and firewall protection measures.

In theory, cable modems can run at speeds of up to 30Mbit/s. In reality, cable companies cap the speed at, typically, 512kbit/s (download) and 128kbit/s (upload). Also, cable modems are a contention technology, so performance tends to degrade the more people are using the network in a particular area.

Cable networks piggyback data traffic on the cable TV feed to individual locations, so availability is restricted to those areas that have a participating cable supplier. There are two main cable operators in the UK: NTL and Telewest. NTL's broadband service for home internet use is called 'ntl:home Broadband Internet' and they claim up to 1Mbit/s speed in both directions. Telewest's Blue Yonder service offers speeds of 512kbit/s and above. Now that ADSL prices have been reduced, the costs of cable broadband are only slightly lower than ADSL. For example, Blue Yonder is priced at £33 a month or £25 a month for subscribers to another Telewest Broadband service.

Conclusion

Cable networks offer high bandwidth, in both directions, at prices sustainable by a mass market. Their main limitation is restricted access. The networks of the two main UK providers are concentrated in urban areas. Cable companies are under pressure from a variety of quarters and neither company is likely to change its investment strategy in the foreseeable future. Cable networks offer good value for those who can access them, but limited coverage means they will not become

universal in the foreseeable future, if ever. For individuals in the areas covered by cable, this is an effective, low cost option for accessing a full range of educational resources and services, including video, multimedia, videoconferencing and web browsing as well as voice telephony, although it is affected by the number of simultaneous users.

Satellite

Satellite is commonly used to provide one-way transmissions (e.g. for television broadcasts).

Data downloads are possible at up to several Mbit/s. One UK example of a one-way educational data service is Espresso Education (www.espresso.co.uk) which delivers a mix of video and multimedia material to schools. Over 40 Local Education Authorities are now using the service.

One-way services are useful for distributing content but they do not allow interaction. A solution to this is to provide a return loop of some kind for sending commands or data back to the service provider. The commonest methods employed are dial up modems or ISDN lines. This adds to the cost and slows down the overall rate of interaction compared with a full two-way service. One interesting UK example is the mrcs TV medical training programme run by the University of Plymouth (<http://www.mrcs.tv>). A series of 30 live TV programmes, each of 90 minutes duration, is delivered via the Eutelsat W2 satellite to 26 subscribing hospitals in the UK and Ireland. Interaction during live transmissions for questions or comment is possible using text messaging, telephone, fax or e-mail. Another UK example is at the University of Derby. They have recently installed a satellite-driven teaching link between Derby and five centres in Israel. The operation involves two-way video conferencing between five studios in Derby and 25 classrooms in Israel, delivering lessons to over 5,000 students on a daily basis.

The core technology, from Gilat, is readily available, although it is more commonly used by highly distributed companies to deliver training courses cost-effectively to multiple sites. The return loop from the Israeli classrooms is via ISDN lines to an uplink in Israel and from there via satellite back to Derby. For more details see the TechLearn web site at <http://www.techlearn.ac.uk/newdocs/ohagan160701.doc>.

There are several satellite operators now offering two-way Internet services in the UK, to homes, schools and small businesses, via two-way satellite dishes. The major players are BT, Astra, Gilat and Hughes, but there are also less well-known commercial operators such as Fantastic and Tachyon (via Satweb) and also a number of start-ups and university spin-offs.

Fantastic (www.fantastic.com) made much noise in the education world over the last few years but now seem to be focussing purely on the commercial sector. Satweb are a newer arrival (<http://www.satweb.co.uk/>), supporting the roll out of satellite broadband in Scotland. BT Openworld have entered the market, in partnership with Gilat, to offer satellite services, initially to the Highlands and Islands, but now to the whole of the UK. This is likely to be of interest to rural schools as well as end-users and SMEs.

Data download speeds are impressive in theory, up to several Mbit/s, but depend crucially on the loading of the network (satellite is another shared medium). Upload speeds via a satellite link are typically around 64 to 256 kbit/s. The shared nature of satellite means that there are potential security risks that should be addressed through appropriate data encryption, anti virus and firewall protection measures. Satellite prices are high compared with other technologies, as the following BT figures illustrate.

Satellite product	Equipment + installation = one-off set up fee	Monthly fee
Business Satellite 500/1	£649.00 + £250 = £899.00	£59.99
Business Satellite 500/4	£1,049.00 + £250 = £1,299.00	£109.99

These are clearly too expensive for home users, but perhaps appropriate for schools or learning centres.

A number of service providers have already started to test high speed Internet access using the ASTRA satellites. However, if it is considered desirable to have a fast return path this will not be provided by current geo-stationary satellite technology. ALCATEL and others have ambitious plans to launch constellations of low earth orbiting (LEO) satellites with services commencing in 2002. These satellites would be used to offer higher bandwidth and broadband services to consumers' worldwide including the UK.

Conclusion

Satellite is broadband and, providing a full two-way satellite service is employed, is capable of equal download and upload speeds (although a premium is payable for high upload bandwidth). Satellite services have the advantage of reaching remote or rural areas unlikely to be covered by other networks, but two-way broadband services are too expensive for individual users in general. Where subsidies are available, as in the Scottish Highlands and Islands, there is potential for using satellite for delivery to individual homes. Elsewhere educational uses are likely to be restricted to supporting remote access centres. Although satellite bandwidth is impressive, latency, or signal delay, is a problem particularly where rapid responses are required. Content which is designed around single click responses and

minimal data uploads will get a perfectly acceptable performance. FE and HE study programmes where there is a lot more two way traffic, especially for instance in videoconferencing and computer based simulations, is unlikely to be satisfactory.

Digital TV

Digital TV is the single fastest growing broadband application in the UK. As of June 2000, about 14% of British homes had digital TV connections of some kind; this figure rose to 37% of households in early 2002. It was predicted to be 47% by the end of 2003 (that now looks optimistic) and 76% by 2008 (or could be higher). Digital TV can be delivered via satellite, cable systems or over the air. In terms of absolute numbers in the UK:

- BSKyB (satellite) is in over 5 million homes
- ITV and BBC (terrestrial) is in over 1 million homes
- Cable (all suppliers) is in around 1.5 million homes

All of these can be made to some extent interactive, in a variety of ways. The BBC Web site has an excellent description of the options at www.bbc.co.uk/digital/howtoget.shtml. Optionally, but increasingly, there is a return channel from the TV to the station; in the case of satellite or terrestrial broadcast, this is a telephone line; in the case of a cable system this is a return channel on the cable system.

Satellite is the most popular way of delivering digital TV. After a bitter battle some years ago, there is only one provider, Sky – www.sky.com.

Cable is a well established but limited market. After some years of consolidation there are two main providers, Telewest – www.telewest.co.uk – and NTL – www.ntl.com – and also a local provider, Kingston Communications, in Hull (www.kitv.co.uk) which has a tradition of innovative services.

There is only one terrestrial provider: BBC digital (www.bbc.co.uk/digital/howtoget.shtml). ITV Digital (www.itv-digital.co.uk), formerly called On Digital, finally lost the battle with Sky in May 2002 and went into administration. There have been new bids for the licences but no new service provider has yet been established as of June 2002.

The pricing of digital TV services is a complex subject. The BBC offer 8 free digital channels, but to access them a user needs either a set top adapter, a digital TV or a subscription to either cable or Sky TV. As a typical example, Sky charges range normally from £10 for the "Basic Tier" of around 12 channels, to £37 for the full range of standard offerings; but to over £60 if you wish to have additional specialist channels.

Digital TV can offer:

- A large number of TV channels, quite a lot larger than the 4 or 5 available on terrestrial TV – one could pretend that 12 or 24 is enough (ITV Digital) but in reality users expect a hundred or more as on Sky
- Video on Demand: access via one's TV to many of the videos in the world, sometimes immediately one wants them; more commonly, within 30 minutes or so (Near Video on Demand)
- The ability to interact with each video, not just in terms of the usual video recorder features (stop, freeze, rewind, etc – if the video is being recorded onto a local storage device) but also perhaps the ability to change sound track language, camera angles, etc to a limited extent (in reality, one is merely switching to an alternate track)
- The ability to interact with surrounding material.

Although digital TV is potentially an interactive environment, the range of interactions is

predetermined by the content provider. Web access and limited information pages are currently offered from which users can choose between options that are provided, but they cannot use the medium creatively to create their own content. In the way that a PC can be used. One of the keys to effective learning is believed to be the level of learner engagement with the material. In theory digital TV has the potential to encourage high levels of interactivity. In practice there are as yet no convincing examples of interactive educational television. The BBC have recently made great play with their interaction capabilities for TV-related educational material. A BBC Press Release from November 2001 gives details of BBC digital programmes (see www.bbc.co.uk/hi/english/entertainment/tv_and_radio/newsid_1658000/1658575.stm) but these are essentially choices of alternative presentations rather than genuine interactions. It is still not feasible for viewers (note the term) to contribute to programmes on the fly.

There is a lobby to make educational videos available "on demand". (The technology to do this, satellite, cable or SuperJANET, does not matter to the user. UKERNA are investigating the technology (with the JISC and MAAS) and the traffic engineering options for the efficient delivery of content over the JANET network. The benefits of multi-access digitised video clips available on-demand are potentially enormous although it will be very expensive to deliver.

Conclusion

Digital TV is likely, very rapidly, to become the most pervasive and affordable broadband access medium in the home. However at present it is essentially a (high quality) one way broadcast medium and the low levels of interactivity on offer its educational usefulness. The Open University has broadcast on BBC2 since its beginnings in 1970, but it has never significantly extended its transmission hours (rather the reverse) or moved on to satellite channels (despite several studies of this aspect

over the years), or been joined by other universities (as has again often been rumoured). The high cost of making and transmitting television material rule it out as a serious contender for off campus study for most individual institutions. On demand video distribution via JANET is a possibility but, as with other broadcast services, this would be essentially a one way distribution system rather than a vehicle for interactive dialogue.

Conclusions

The off-campus broadband picture is confused by hype. Not all the options currently available have sufficient bandwidth to justify the term "broadband", even at the conservative level adopted here, and some technologies, such as 3G or two way satellite, are unlikely to be available

at an affordable cost for mass application to learning within the next three years. Although TVs may provide a familiar interface and more acceptable social context than PCs for certain categories of users, from an educational perspective two-way interactivity, as well as affordability, are important. So the most ubiquitous broadband application of all, digital TV, is largely irrelevant. The limited (central) interactivity of Sky or similar systems is much poorer (in interaction terms), and the exemplars much weaker, than those from a broadband Web connection even using current broadband offerings. Table 1. summarises the key differences between the different technologies and comments on their likely overall significance in off-campus situations. This latter judgement is a summation of the technical, cost and availability factors, combined with an assessment of the level of interactivity they offer off-campus users.

	Typical bandwidth	Affected by Multiple users	Affected by Distance	Availability 2003 - 2006	Cost: Install/Running	Overall significance
Public WANs	11-54mbit/s bi-directional	Yes	Yes	Low	Not Known	Low
BFWA	512kbit/s down 256kbit/s up	Yes	Yes	Low	£150/£40 per month	Medium
3G	144kbit/s- 2Mbit/s bi-directional	No	No	Very Low	Not known but expected to be very high	Low
ADSL	512kbit/s down 200kbit/s up	Yes	Yes	Medium to high	£140/£28 per month	High
Cable	512kbit/s-1Mbit/s bi-directional	Yes	No	Medium	£40/£25 -33 per month	High
Satellite	512kbit/s down 128kbit/s up	Yes	Yes	High	£900/£60 per month	One-way:Low One-way: High
Digital TV	2Mbit/s down	No	No	High	£350/£10-37 per month	Very low

14 Table 1. Comparison of technologies

From table 1 it can be seen that, in terms of speed, availability, cost and characteristics, many of the options reviewed here have to be ruled out. 3G mobile telecoms have the potential to support broadband based learning but they are unlikely to be widely available or affordable within the next three years. All other available mobile services are not broadband. Public wireless LANs may be of some use but are not likely to be widely available over the next three years and likely to be rapidly overwhelmed when they do catch on. Digital TV, although massively popular is not currently being used for more than content transmission, and is too costly for institutions to use as a distribution vehicle (the post is cheaper). The most feasible and likely contenders for supporting off campus study are ADSL and cable networks. Other services that are likely to have limited niche potential are Broadband Fixed Wireless (for mainly urban areas) and satellite services (for mainly rural areas).

Comparing the two main contenders it is clear that they have two important differences. Unlike cable, ADSL download and upload speeds are not the same. So the range of functions that ADSL can support is slightly narrower than cable. In particular ADSL is unsuitable for two way exchanges that require equal bandwidth, such as videoconferencing and the kind of multi user gaming that could, perhaps, become the basis of educational role plays and simulations. The second difference concerns availability. The UK telephone network is essentially ubiquitous – copper wires run everywhere. Cable is limited in geographic and demographic penetration and tends to be limited to lower-income urban areas.

The main value of broadband is “merely” faster access to systems and resources. (A similar situation to the reality of ISDN.) But that apparently quantitative “merely” conceals important qualitative changes. Firstly vast amounts of time could be saved, or redeployed, by both learners and teachers, in the pursuit of

knowledge. Secondly, the (generally) fixed price of always on broadband means that users will be able to use it differently, opening the feasibility of studying online instead of downloading resources for offline study; online activities such as conferencing, simulations and group role plays; and access to high bandwidth applications such as video, audio, videoconferencing, CAD, etc. from the home and workplace. The effect of laptops, PDAs, and in particular wireless broadband, will be to widen the “locus of learning” and bring it back to the normal loci of learning of students across many years, i.e. almost anywhere.

Broadband access from the home and elsewhere reduces the difference between the home and campus. It makes many homes increasingly effective as places of study; and will increasingly raise the issue of the best use of the campus, school or learning centre. For example, will they become arenas for socialisation and for education of the underprivileged?

However, widening access to learning, in more places and to more sorts of people, especially those (still) not familiar with or antipathetic to PCs and formal learning situations – will remain an important goal. Achieving this goal becomes easier as broadband services spread and interfaces become more intuitive and consistent with those used in other parts of daily life (VCRs, games consoles, mobile phones).

Glossary

This is a short glossary of terms. There is a JISC glossary at www.jtap.ac.uk/techwatch/Sources/specific.htm. A glossary-cum-primer on similar topics can be found at www.wewantspeed.com/what.html. Other useful glossaries are at www.webopedia.com and www.auburn.edu/helpdesk/glossary/.

3G	3rd Generation Wireless Technologies.
4G	4th Generation Wireless Technologies.
802.11a	The new standard for 54 Mbit/s wireless LANs which will soon be available in the US and perhaps Europe.
802.11b	The standard for 11 Mbit/s Wireless LANs used in the majority of applications today.
ADSL	An asymmetric version of DSL (with lower upstream speed than downstream) available to those living within 3.5 km of a local exchange.
ATM	Asynchronous Transfer Mode.
BFWA	Broadband Fixed Wireless Access.
Broadband	A network which is rather faster than ISDN, ideally one which can carry broadcast-quality video.
Broadband Internet	Access to the Internet via a broadband connection, typically a home ADSL connection or a cable modem connection. Gives a connection which is fast enough to show low-quality moving video. Not covered in this report.
Convergence	In this context, the vision that any TV programme can be watched either on a TV or on a PC on the Internet. It is not a reality yet. Some even extend the notion to watching a TV programme on one's 3rd generation mobile phone.
DSL	Digital Subscriber Line: a range of technologies for transmitting high-speed data (128kbit/s up to many Mbit/s) over twisted copper pair as used in public telephone circuits.
e-learning	Learning via any kind of computer device, including PC, digital television, mobile phone, or PDA.
Etherloop	An Ethernet/DSL hybrid offering up to 6Mbit/s with a range of over 7000 meters, developed by Elastic Networks.
G.dmt	A version of ADSL with up to 8 Mbit/s downstream, 1.544Mbit/s upstream bandwidth; officially known as ITU-T Recommendation G.992.1.
G.lite	A lightweight version of G.dmt that offers up to 1.5Mbit/s downstream, 384kbit/s upstream; easier to install than other types of DSL; officially known as G.992.2.
16 GPRS	General Packet Radio Service.

GSM	Global System for Mobile Communications.
HDSL	High bit-rate Digital Subscriber Line: historically the first of the DSL technologies, and still used by telephone companies deploying 2Mbit/s links (requires two twisted pairs).
IDSL	A variant of ISDN oriented to data not voice; not really a broadband technology at all.
ISDN	Integrated Services Digital Network.
ISP	Internet Service Provider.
ITU	International Telecommunications Union.
ITV	Not what you think, but Interactive digital TeleVision. Sometimes also used, especially in the US, but not in this report, to mean Instructional Television (see video-conferencing).
LMDS	Local Multipoint Distribution Service.
Metatagging	The addition of descriptors to TV programmes which allow easier classification and searching by users.
RADSL	Rate Adaptive Digital Subscriber Line (sometimes called Remote ADSL): a version of ADSL oriented to longer distances, up to 5.5 km from the local exchange, by allowing modems dynamically to adjust their upstream transmission speeds, down to as low as 64kbit/s in extreme cases.
SDSL	Symmetric Digital Subscriber Line: a DSL version that provides the same bandwidth in both directions, upstream and downstream, over a single-pair copper wire (unlike HDSL); oriented to small businesses.
Snooping	The action of capturing data packets and storing them in a file for analysis and interpretation. Although extremely useful in debugging networking problems, the ability to capture packets and store them for later analysis allows unscrupulous parties to gain illegal access to data and systems.
UMTS	Universal Mobile Telecommunications System.
VDSL	Very High Speed Digital Subscriber Line: this transmits data at 13 – 55Mbit/s over copper pairs but is operative only over short distances (300 – 1500 meters) – the shorter the distance, the faster the connection rate. It is often used as the final link to the home in a Fibre to the Kerb system.
video-conferencing	Sometimes used to cover the use of television transmitted to a large number of sites with interaction via telephone or email.
VOD	Video On Demand: the ability to request one of a large number of videos when then plays more or less immediately.
VoIP	Voice over IP.

WAP	Wireless Application Protocol – a not very successful protocol suite designed to bring Web services to GSM phones.
xDSL	All the variants of Digital Subscriber Line: ADSL, HDSL, IDSL, MDSL, RADSL, SDSL, VDSL.

Further information

This briefing was prepared by the TechLearn service of the JISC funded Technologies Centre. The Centre exists to encourage and support the investigation, development and proving of the applications of new technologies in support of the whole education process in the communities of those that fund the Joint Information Systems Committee. It can be contacted at www.technologiescentre.ac.uk. Further information on broadband topics is available as follows:

Suppliers of broadband services and equipment

Carriers – a selected list

Astra – www.ses-astra.com/market/british_isles/index.htm – satellite TV and data network operator

BT – www.bt.com/broadband/ – general service provider including ADSL

Fantastic – a satellite network provider – www.fantastic.com

Gilat – a satellite network provider – www.gilateurope.co.uk

Hughes Network Systems – www.hns.com/global/europe/europe.htm – satellite data network provider

ITV Digital (formerly OnDigital) – www.itv-digital.co.uk (www.ondigital.co.uk still works) – television service provider

Kingston Communications – www.kcltd.co.uk – telephony, data and television service provider in the Hull area

NTL – www.ntl.co.uk (or www.ntl.com) – cable TV, telephony and data service provider

Satweb – satellite network provider associated with Tachyon – www.satweb.co.uk

Sky – www.sky.com – satellite TV service provider

Tele2 – www.tele2.co.uk – wireless broadband service provider

Telewest – www.telewest.co.uk – cable TV, telephony and data service provider

Content providers

BBC – www.bbc.co.uk/digital/ – this is a very informative site

Cambridge Training and Development (CTAD) – www.ctad.co.uk – have worked on a pilot project for interactive DVD to be used for Basic Skills adult learners.

Discovery Channel – www.discovery.com – this is the gateway to a cluster of channels including TLC (formerly The Learning Channel); but note that the UK guide is at www.discoveryeurope.com/uk/home/index.html

Espresso Education Ltd – www.espresso.co.uk

Granada Media – www.granada.co.uk

Hardware providers

3Com – www.3com.com – a leading vendor of network equipment

Alcatel – www.alcatel.com/products/productsbysubfamily.jhtml?subCategory=ADSL+Modems

Cisco – www.cisco.com – the leading vendor of network equipment

Elastic Networks – www.elastic.com – the developers of Etherloop, and now part of Paradyne

Nortel – the leading Canadian networking company

Pace – www.pace.co.uk – a developer of set-top boxes, digital video disc recorders, and more integrated systems such as IPTV

TiVo – www.tivo.co.uk (and www.tivo.com) – the first and still perhaps the leading manufacturer of digital video disc recorders.

Industry organisations

3G Newsletter – www.3g.co.uk

3G Partnership Project – www.3gpp.org

Cable Labs (US) – www.cablelabs.com (and see also www.cablemodem.com); note that there is a UK site at www.cable-modems.co.uk

DSL Forum – www.adsl.com – the industry forum for DSL vendors

DSL Life – www.dsllife.com – a site oriented to end-users of DSL

GPRS Newsletter – www.gsmworld.com/technology/voiceless_gsm/newsletter.shtml

GSM Association – www.gsm.org (aliased to www.gsmworld.com) – the trade association of the GSM industry

Home Automation Site – www.homeautomationindex.com – not strictly an industry association site, but a site of an enthusiast on home automation and networking with a wealth of links to many networking topics

WLANA – www.wlana.org – the Wireless Industry Networking Association

Third party organisations

Institutions and related agencies

The Open University – www.open.ac.uk – has for many years been interested in the potential of interactive television.

LearnDirect (the University for Industry) – www.ufilttd.co.uk – is also getting interested. See in particular Appendix 4 of their Draft Strategic Plan at www.ufilttd.co.uk/strategic%20plan/plan/app4.htm

The Welsh Digital College (Coleg Digidol Cymru) – www.digitalcollege.co.uk or www.learn.cd is actively promoting and using broadband, in particular wireless broadband. See <http://www.e-fro.cd/en/>

Derby University -

<http://cedm.derby.ac.uk/BeyondText/cedm.HTM> - are running two-way satellite/ISDN based remote classrooms in Israel.

Plymouth University - <http://www.mrcs.tv/> - have for many years been running satellite based professional training courses for medics.

Government and related agencies

BECTa – the advisory body for ICT in schools and colleges – have a useful leaflet at www.becta.org.uk/technology/infosheets/html/broadband.html

Department for Education and Skills – www.dfes.gov.uk – is running many initiatives in this area; see in particular the material on UK Online Centres at www.dfes.gov.uk/ukonlinecentres/whatis/default.cfm

Department for Health – www.doh.gov.uk – and see in particular the material on NHS Digital at www.doh.gov.uk/ipu/strategy/update/ch3/3_2_3.htm

Digital Scotland – www.scotland.gov.uk/digitalscotland/ is a Scottish Executive initiative to develop a Scottish broadband infrastructure. See in particular the broadband strategy at <http://www.scotland.gov.uk/digitalscotland/csbc/csbc-00.asp>.

JISC – www.jisc.ac.uk - is the web site of the Joint Information Systems Committee. JISC promotes the innovative application and use of information systems and information technology in further and higher education across the UK and is responsible for the JANET network.

National Institute for Adult and Continuing Education (NIACE) – www.niace.org.uk/ – has been interested in this area for several years – see in particular the NAGCELL report at www.niace.org.uk/Organisation/advocacy/NAGCELL/NAGCELL_Technologies.htm

Oftel – www.oftel.gov.uk – the Office of Telecommunications, is the regulator for the UK

telecommunications industry. It was set up under the Telecommunications Act 1984.

Independent Television Commission – www.itc.org.uk

Technologies Centre – www.technologiescentre.ac.uk
– A service funded by JISC to maximise, through technology transfer, the value, impact and relevance of JISC's work in technologies supporting learning, teaching, research and administration. The Techlearn arm of the Technologies Centre commissioned this report.

Magazines, Webzines, etc

Broadband Satellite – www.broadbandsatellite.co.uk

Broadband Times – www.broadbandtimes.com

Business 2.0 – www.business2.co.uk – a gold-mine of information

Mobile Whitepapers – www.mobilewhitepapers.com

ViaSatellite – www.satellitetoday.com

WAP Analysis – www.wap-analysis.com – newsletter about WAP (note that www.wap.com has closed, and www.wap.org is not about WAP!)

ZDNet Broadband Guide – www.zdnet.co.uk/news/specials/2000/04/broadband/

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1 <http://www.manx-telecom.com/news/article.asp?id=134>

2 ADSL Fact Sheet, Oftel, March 2002, www.oftel.gov.uk/publications/local_loop/adslsheet/adsl0302.htm

TechLearn

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