18

Computer Networks in Higher Education. A Case Study: Staffordshire University

Paul D. Bossons and D. E. Ord
Staffordshire University

18.1 Introduction

This paper is a resume of the presentation given by the author to the CAA96. The aim of the presentation was to take a critical look at the network infrastructure implemented at Staffordshire University, UK. This evaluation covered all major aspects of the infrastructure from the physical cabling to the software running on the network, including hardware, maintenance and support issues. It also covered the reasoning behind the decisions that were taken, and how the infrastructure evolved over a 10 year period. Finally, there is an examination of the potential future technologies that will be required to meet future business and academic needs. The methodology used for the final planning of the infrastructure could be used for any institution that comprises several linked buildings, as are most higher educational facilities and Universities.

The founding colleges of Staffordshire University developed in response to the training and education needs of the people of Staffordshire, encompassing ceramic technology, art and design, engineering, archaeology and geology. The merger of the colleges in the 1970s to form the North Staffordshire Polytechnic was the first step towards the modern Staffordshire University which gained university status in June 1992. Teaching and research is focused in nine academic schools — Arts, Business, Computing, Design and Ceramics, Engineering, Health, Law, Sciences and Social Sciences. The university is based on two main campuses, in Stoke-on-Trent and Stafford, and has a presence at Cannock, Telford, Oswestry and Shrewsbury. Some of its award programmes are also offered at partner colleges throughout Staffordshire, Shropshire and Cheshire, as well as much further afield, for example in Cyprus and China. The combined sites make up Staffordshire University, the home of one of Europe's largest educational computing facilities. Stoke-on-Trent and Stafford are 27km apart. It was a requirement that all sites were to be linked by a single logical network. This network was intended to be used by both academic and administrative functions. Schematic maps of the networks at Stafford and Stoke on Trent sites are included in Figures 18.2 and 18.1. These schematics also show some of the outreach centres of the university.

18.2 Information Technology services

18.2.1 User population and needs

IT services provide a wide range of computing facilities and support services for staff, students and external organisations. The current user population catered for by the IT infrastructure consists of:

- 11,000 UK and EU Students
- 500 Overseas Students
- 3,500 Part Time Students
- Over 1,000 staff

The needs of this user population include the following services:

- Word-processing and spreadsheets
- Printing and plotting
- Image scanning
- Internet access and file transfers
- Remote access via dial-in modems
- Electronic mail
- Programming — *e.g.*, C++, Visual Basic
- Databases — *e.g.*, Oracle, MS Access
- Data acquisition and processing
- Graphical Information Systems, GIS, ARCINFO, Satellite Imaging System
- Help and advice

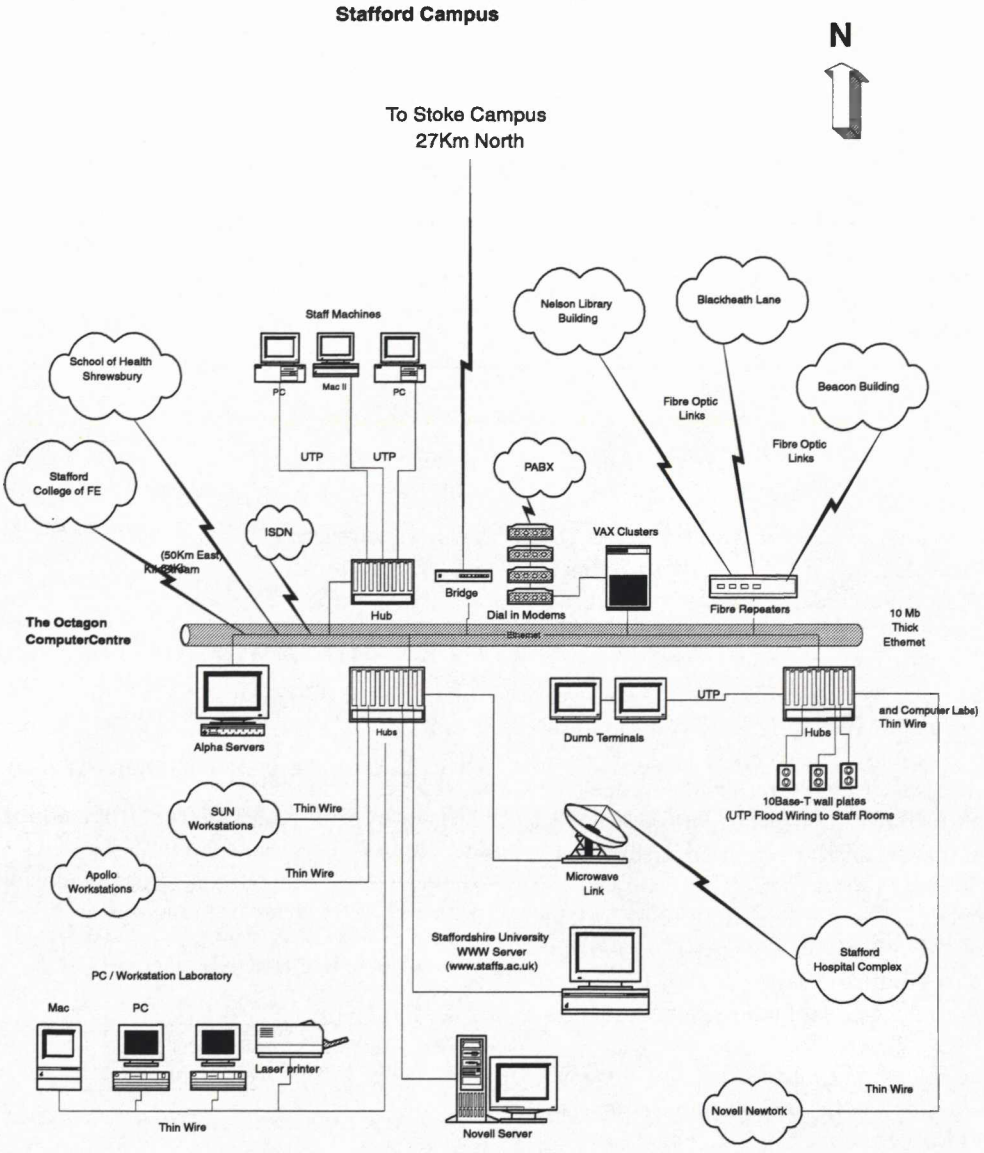

Figure 18.1: The Stafford Campus network.

18.2.2 Services provided

IT Services meets these requirements by providing:

- Networking on a large scale
- Provision of Help Desks backed up by specialist support staff
- Analysis, design and programming for Administrative and Management Information Systems
- Provision of relevant training courses
- Ongoing consultation with users

18.2.3 User benefits

These services provide the following identifiable benefits to the users:

- Easy access to a wide variety of resources *e.g.*, printers, plotters and storage devices
- The standard client software interface to the network services provide the same look and feel to the users
- Access to a wider range of application software
- Ability to share data
- Data stored on file servers is backed up by the system automatically
- Transparent access to data from any site or workstation within the university
- Electronic Mail
- Schedulers and Diary systems
- Time-Tabling
- Access to the Internet, *e.g.*, the World Wide Web

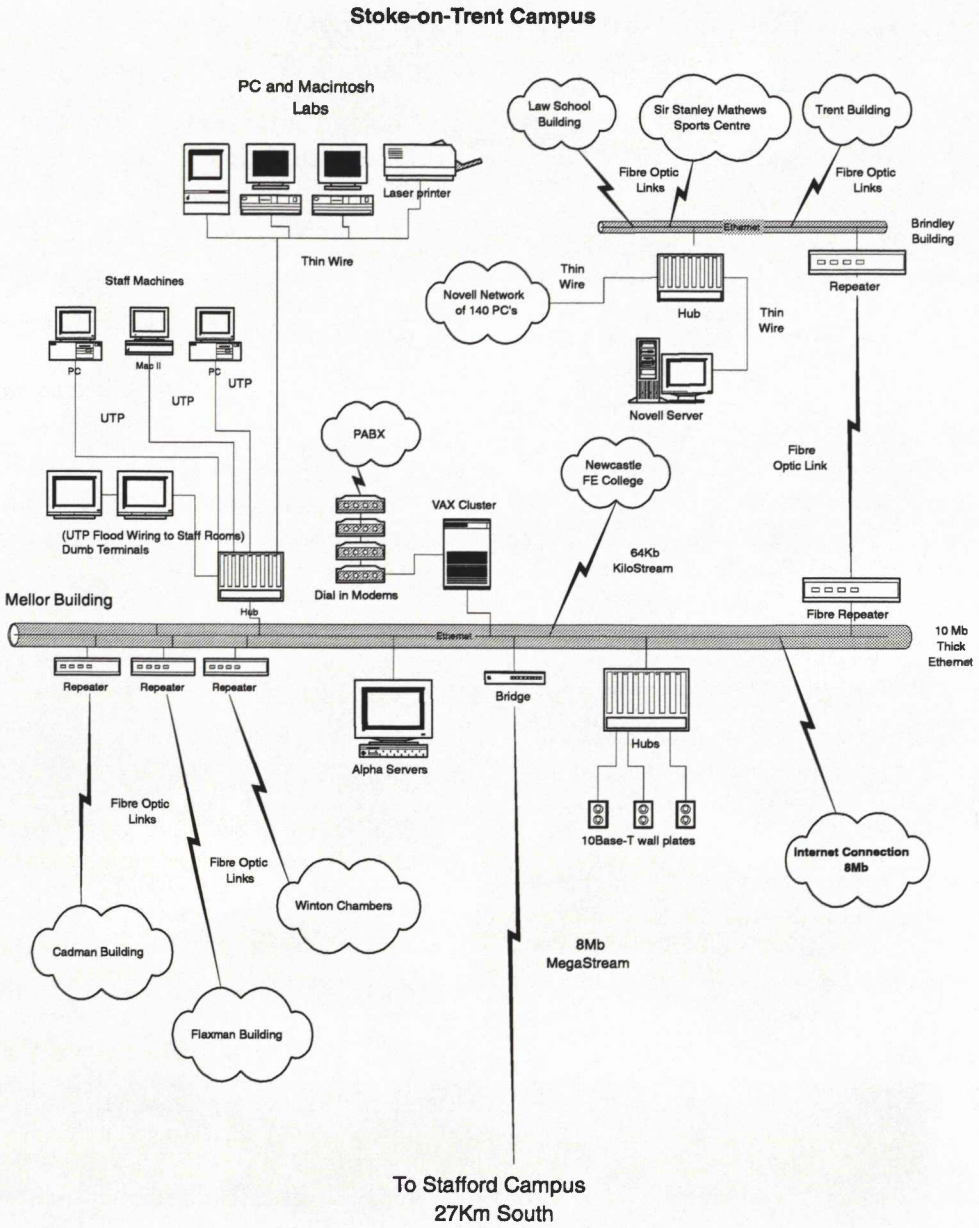

Figure 18.2: The Stoke-on-Trent Campus.

18.2.4 Organisation benefits

The networking methodology provides additional benefits to IT Services:

- Ease of management of PCs on a large scale
- Ease of software provision and administration
- Cost effectiveness of computing provision on a mass scale

18.3 Network infrastructure

18.3.1 Physical transport media

The university uses a wide variety of physical communications media. There is a single Local Area Network (LAN) in place at all the main sites of the university. This network is essentially a multi segment Ethernet network. The network consists of Unshielded Twisted Pair or 10BaseT (UTP) within each building running on a thick Ethernet backbone. UTP was chosen because it provides the most effective and flexible network cabling architecture that can be used for both data and voice traffic. Thin Ethernet is also used within the PC Laboratories. It is more cost effective to use thin Ethernet in this type of environment where there are a great number of networked devices within the same proximity, see Figure 18.3. UTP cabling can become very expensive if enough data ports were to be provided for the network configuration used in the PC Labs. Buildings within each site are connected using Fibre Optics. The Fibre is used to connect the thick Ethernet building backbone LANs to-

gether via repeaters. So, in essence, there is a single backbone network for each site. The sites are connected using Megastream links provided by BT. Each site is 'Bridged' so that the non-routable protocols (NETBEUI and IPX) can be used. It is recognised that routers would be more effective and reduce the amount of traffic over the Wide Area Links, but that would only let TCP/IP operated effectively. Routers or bridge/routers are used wherever possible to contain local traffic, thus reducing the network load. Kilostream, Microwave, ISDN, DOVE (Data Over Voice Equipment), and conventional telephone lines are all used to provide communications to the smaller outposts of the university. ISDN is the favoured connection medium for new outposts, but it is not cost effective yet to convert the existing outposts.

18.3.2 Infrastructure hardware components

There are a great many discrete hardware components that make up Staffordshire University's network. They include:

- Transceivers — used to physically connect to the thick Ethernet that makes up the building backbone
- Communications racks — that contain the hubs, supplied by DEC. They also contain all modems, bridges, routers, physical cable connections and diagnostic equipment used by the network
- Communications hubs — also supplied by DEC, are used to provide the connectivity for both the thin Ethernet and UTP LANs. They also include:
  - Terminal servers
  - Repeaters
  - Patch panels
  - Dial-in modems
- Bridges and routers — used to connect the sites of the university and provide internet access and link into the Joint Academic Network (JANET).

In many cases, it is sensible to standardise on a single supplier for the communications racks and hubs, and their associated equipment, *e.g.,* bridges and routers, as this makes the constructions of the complete network much easier, and is also cost effective due to economies of scale. There are many potential problems in making equipment from different suppliers interact. However, this does not suggest that the university's supplier, DEC, is the best. It happens that they best met the needs of the university at the time. Other major vendors, such as 3Com, UB, Cisco, all have features and qualities that should be considered when implementing any new network.

18.3.3 Servers

The university uses a variety of servers including:

- DEC Alpha — running OpenVMS used for Administrative systems, File and Print services for PC workstations (Pathworks) and a general VMS computing environment, *e.g.,* VMS email.
- DEC VAX — used for a mixture of administrative and academic systems, *e.g.,* statistical analysis.
- Pentium and 486 PCs — used to provide Novell Netware and Windows NT platforms for basic file and print services.
- Apple Macintosh — used only to provide file and print services for the Macintosh workstations.
- Sun Sparc and other Unix Workstations — used for a wide range of academic systems.

18.3.4 Clients

The university uses the following main groups of client workstations:

- Pentium, 486, 386 and 286 — running Windows for Workgroups and Windows 95. This is the standard client workstation for the university.
- Apollo and Sun SPARC Workstations.
- Silicon Graphics Stations.
- Macintosh, 68x00 and PowerPC versions.

At least 80% of the workstations used by the university are connected to the network. This is achieved by installing a Network Interface Card (NIC) and the relevant network software drivers into the workstations. The Unix workstations generally have them already fitted when purchased. It is now more usual for PC suppliers to provide full hardware and some pre-installed software on delivery. Many of the non-networked units are now old and do not have the power to run the more modern operating systems and applications. These older units are relegated to simple word processing and spreadsheets.

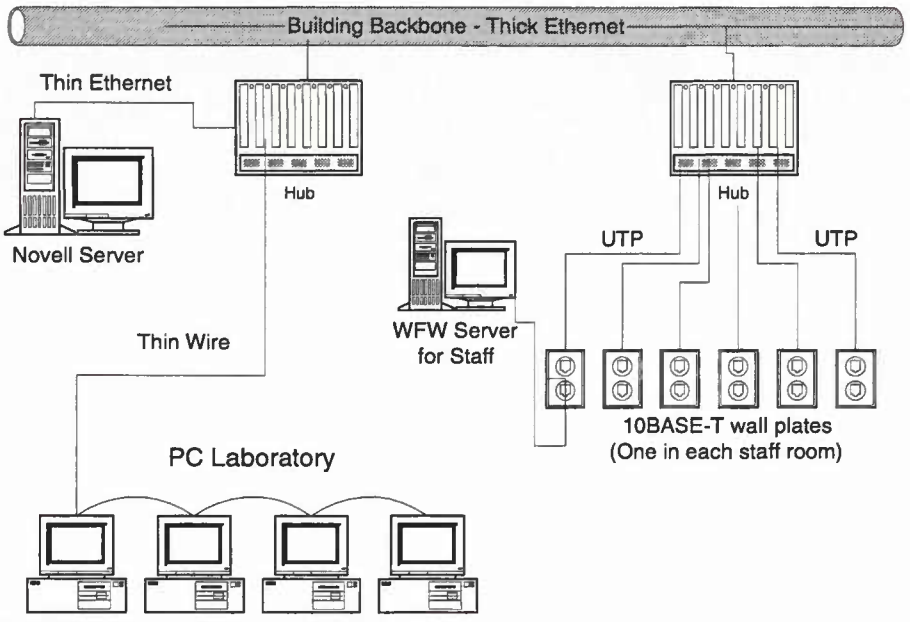

Figure 18.3: The network infrastructure.

18.3.5 Operating systems

There are several client and server operating systems in use within Staffordshire University. They were implemented to meet different user needs. These operating systems include:

- VMS — on a variety of clustered DEC VAX computers providing conventional mainframe type applications and databases.
- OpenVMS — on DEC Alpha hardware providing administration services. Primarily running Oracle database applications.
- Unix — on a variety of platforms. These are used for educational and technical applications.
- Novell Netware 3.12 — on Intel PC based hardware providing file and print services.
- Pathworks 4.1 — used to provide file, print, and data sharing capabilities between PCs and the VAX and Alpha systems.
- SUN and Maestro NFS — used to provide data sharing capabilities between PCs and the Unix systems.
- MS Windows for Workgroups — the current standard PC operating system.
- MS Windows 95 — under evaluation as the next standard client operating system.
- MS Windows NT — under evaluation, both for high end PC workstations and to provide file, print, and application services.
- OS/2 Warp — used mainly for the Library system, a relatively small number of users.
- Macintosh — used for secretarial services and specialist DTP.

18.3.6 Network protocols

The network is, of necessity, multi-protocol in nature. The primary protocols in use are:

- TCP/IP — for communications between PC and the Unix systems, and access to the Internet. This is the only routable protocol in use, and is likely to become the standard. It is likely that Windows NT services will also use TCP/IP.
- NetBeui — used by the Windows for Workgroups peer to peer networks, Windows 95 and NT, and Pathworks (DECNET).
- IPX/SPX — used by the Novell services.

18.3.7 Internet access

The external link is provided via the Stoke on Trent campus as shown in Figure 18.4. This is used to provide general Internet access to all users on the network across the university's LAN.

18.4 Strengths and weaknesses

As with most complex systems, the university's network has strengths and weaknesses.

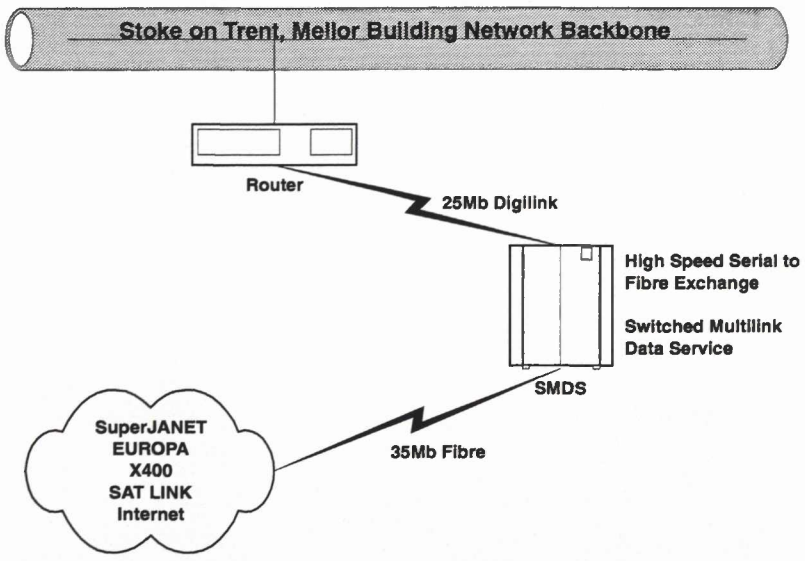

Figure 18.4: The external link for the network.

18.4.1 Strengths

Since the network has evolved over time, it has been very cost effective. Many components are re-used until they either fail or become obsolete. For the most part, the network meets all the current needs of the university. Industry standard components and software are used wherever possible. This keeps down the cost of maintenance and keeps the costs low. All components have proved to be very reliable with a low level of down time. The perceived performance of the network is fast enough that there are very few complaints about poor network related response times, *e.g.,* file transfers. The administrative systems have been partitioned so that they are only available to staff, making them very secure.

18.4.2 Weaknesses

Much of the computing equipment is now quite old, *e.g.,* some application response times from some of the VAX systems are perceived to be poor. Printing and file sharing across different computing platforms can be difficult and problematic. The actual management of the network is basic, as few commercially available network management systems have been implemented. The security of the network is not high due to the types of access required by so many different users. This does not apply to the administrative systems. There are many client operating systems in use (Macintosh, Unix, Windows *etc.*) making the desktops difficult to manage remotely. Also, this results in difficulties in establishing standards that could improve manageability.

18.5 How did the network evolve?

Ten years ago, the university did not exist in its current form. It was the North Staffordshire Polytechnic (*i.e.,*. not a university). The student population was only around two-thirds the level that it is now. Also, the computing needs of both academia and administration were far less complex. The primary computing centre was based at Stafford. This essentially consisted of an early VAX cluster running VMS. The only terminals in use were VT100 and VT52 dumb terminals connected serially. There were also a number of teleprinters in use. The VAX was used almost completely for academic work and student records. Few other administrative functions were computerised. In addition, a few specialist computers existed throughout the Polytechnic. They were not connected and used solely by the department owning them, *e.g.,* PDP11s used for engineering and computer science. There was also a small population of micro computers (approximately 250 BBC micro computers) that were used for teaching, and very basic word processing, along with terminal emulation to the VAX. These machines were all standalone, *i.e.,* not networked. Over the next few years, there was a growing demand for user level computing that could not be supplied solely by the existing VAX cluster or other mini computers, and for which the BBC micro computers were not powerful enough. This demand was met with the introduction of the PC and associated software. These early PCs were used on a standalone basis for the most part. However, the cost of peripherals for these early PCs was very high, and so a mechanism for sharing resources (*e.g.,* printers and disk space) was sought.

The first Novell network was installed in 1987 to provide the peripheral sharing required. Over the next few years, there was an increase in the number of PCs and network operating systems. The management and control of these machines and systems was very basic. Expansion of the networks is still continuing, using more advanced technological solutions as they become available. Also during this period, the computing needs of the administration side of the polytechnic

expanded considerably. These requirements were met with the implementation of in-house administrative systems, running on the VAXes and Alphas and using dumb terminals initially. The next phase in the evolution process is to implement them in a client server environment. The IT Services department grew over the last ten years in line with the demands made upon the university's computing facilities. There were initially 60 staff in the early computing services department. There are now around 100, supporting a far higher level of computing activity.

18.6 The future

There are too many possible options likely to become available in the future to discuss them here. However, there are two areas that are of great interest to the university:

- Video Conferencing
- Virtual University

18.6.1 Video conferencing

The definition of video teleconferencing, or videoconferencing, is having a TV conference with one or several people at the same time. A videoconference allows users to communicate with others using video and audio software and hardware to see and hear each other. Audio can be provided through specialised videoconferencing equipment, through the telephone, or through the computer. Videoconferencing has traditionally been done with dedicated video equipment. But increasingly, personal computers communicating over switched digital lines are being used for videoconferencing. Full-screen, full-motion video at 30 frames per second requires a high-bandwidth network. However, due to improved compression techniques, it is expected that a videoconferencing window will become commonplace on desktop computers within the next five years.

Video and audio communication between two or more people via a videocodec (coder/decoder) at either end and linked by digital circuits will be the norm. Formerly needing at least T-1 speeds (1.54 megabits per second), systems are now available offering acceptable quality for general use at 128 Kbit/s and reasonable 7 KHz audio. Factors influencing the growth of videoconferencing are improved compression technology, reduced cost through VLSI chip technology, lower-cost switched digital networks — particularly T-1, fractional T-1, and ISDN — and the emergence of standards. At it's simplest, videoconferencing can be provided across an existing network by fitting a simple video capture and sound card, along with an inexpensive video camera, to a PC or Macintosh (estimated cost: £200 per machine) and using freeware software, such as CU-SeeMe. This option will give a mono image, providing a low cost, low tech and limited quality solution. This will allow a single user to communicate with another single user. However, it must be recognised that videoconferencing can have a significant impact on network load, therefore this must be taken into consideration in the planning stages. For more complicated arrangements, *e.g.,* a group of users talking to another group of users, more professional equipment is required. A full blown videoconferencing unit, with a large screen TV and ISDN connectivity will cost in the order of £25,000 per unit. However, by using this type of equipment along with commercial videoconferencing communications companies, like BT, Mercury, or MCI, it is possible to hold conferences between multiple groups simultaneously. A closely linked technology is computer teleconferencing, having a simultaneous conference with several people at the same time at their computers. It is provided by software in a host computer or BBS. This can be linked and integrated with the videoconferencing outlined above.

18.6.2 The Virtual University

The virtual university is far more a concept than a single technology. The concept of a virtual university is where the university buildings, location of students and staff, classrooms and teaching materials are all unimportant. The Open University in the UK, along with other distance learning institutions already go a long way to embodying the concept of the virtual university, however, they still have a long way to go. Ideally, the student at the virtual university would have access to exactly the same facilities as a student at any conventional university. This would necessitate face to face meetings with members of university staff, access to the library, participation in discussion groups, *etc.* It is clear that to enable this, videoconferencing and fast data communications will be essential. The videoconference element is required to enable the student to attend lectures, discussion groups and tutorials. A great deal of work is required in many other areas to make this a reality. For example, many courses offered by the university require laboratory work that must be redesigned to enable the student to carry out experiments at home. It is possible that other technologies, *e.g.,* virtual reality, could be used. There are many exciting possibilities ahead for the continued and enhanced support of the pursuit of excellence in all academic and scientific fields.

Paul D. Bossons
Senior Analyst Programmer, Information Technology Services
Staffordshire University
p.d.bossons@staffs.ac.uk

D. E. Ord
Director of IT Services
Staffordshire University
d.e.ord@staffs.ac.uk