

Computer Networks

Philip J Irving

Lexden Publishing Ltd
www.lexden-publishing.co.uk

Dedication

As always, this book is dedicated to the special people in my life who made this all possible: Elizabeth, Victoria Rose, Philip, Margaret, Frank, Ena, Pat and Keith. Thanks for your help and support. Special thanks to Dave Nelson and Dave Ho for their keen eye and willingness to help and to Jane Lewis from Cisco particularly for the use of diagrams and images.

Third Edition published in 2010 by Lexden Publishing Ltd.

Second Edition published in 2005 by Lexden Publishing Ltd.

Reprinted 2006

Reprinted 2008

First Edition published in 2003 by Crucial, a division of Learning Matters Ltd.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior permission in writing from Lexden Publishing.

© Philip J Irving 2010

British Library Cataloguing in Publication Data

A CIP record for this book is available from the British Library.

ISBN: 978 190499554 8 1

Printed by Lightning Source.

Lexden Publishing Ltd

Tel: 01206 533164

Email: info@lexden-publishing.co.uk

www.lexden-publishing.co.uk

KEY CONCEPT

MANs occupy the area between LANs and WANs (see below). They can be contained within an organisation's site or they may be a regional resource. They generally operate on lines leased from a communications provider and hence operate at a lower speed than a LAN.

Metropolitan Area Networks (MANs)

Metropolitan Area Networks (MANs) are defined by **IEEE 802-2001**; they are larger than LANs, yet they are contained within a defined geographical area. A good example of a MAN is a university's campus network where several buildings are connected together across a city or town or where several universities or colleges are connected across a region. The media used in a MAN may be within the jurisdiction of the organisation itself or may belong to one or more telecomms providers (in which case the speed may be restricted). The overriding factor in determining which company provides the media, however, is cost. Although UK law currently allows for any organisation to lay its own cables, the cost of doing so safely and without risk to the public is high. The longer the cable run, the more expensive this becomes, and so it is often cheaper to contract with a telecomms provider who can provide the link at a lower cost.

MANs frequently don't belong to a single organisation but are a city or regional resource. An example of this is the **NORthern Metropolitan Area Network (NORman)**, which is a network in the north east of England linking together the universities in the area and providing them with a very high-speed Internet connection. MANs usually run at a slower speed than LANs. However, they span a larger geographic area than LANs; usually use the services of a telecomms provider; and are usually managed and maintained jointly by both the organisation and the telecomms provider. Occasionally, they can be the sole responsibility of the organisation.

TIPS & ADVICE

One of the most common mistakes made by students is to forget that networks are measured in megabits per second (Mbps) and that data is measured in megabytes (MB). There are 8 bits in a byte and failure to work in bits rather than bytes puts your calculations out by a factor of 8. Thus 1 MB of data to be transferred is 8 Mb.

Wide Area Networks (WANs)

WANs cover a geographical area beyond that of a MAN – perhaps all an organisation's offices in a country or even beyond national boundaries (a good example would be a multinational organisation with offices in different countries). WANs are almost always dependent upon telecomms providers, as the length of the media runs are huge and prohibitively expensive.

As WANs are dependent upon telecomms providers, the speed of the link is likely to be limited compared with a MAN or a LAN and the costs significantly higher. In general, organisations lease a WAN connection from the telecoms provider for a fixed annual charge. This charge will vary depending upon factors such as the distance covered by the WAN link, the facilities at the telephone exchange etc. Normally there will also be an installation cost. This cost generally depends upon the distance from the end points of the link to the local telephone exchange and the facilities in that exchange. Due to these varying factors, a standard formula for pricing is not available and individual cases will require a quotation from the telecoms provider.

TIPS & ADVICE

Just as a chain is only as strong as its weakest link, so the speed of a network is usually only as fast as its slowest link – thoroughly research the areas where you wish to deploy a WAN.

Until 1998, the fastest link available externally was only about 2 Mbps, and this speed (or slower) can still be encountered in many parts of the world where a WAN may have to make a link. Maintenance of the WAN is shared between the organisation and the telecomms provider. When selecting a WAN link, it is important to ensure that the provider will correct any faults in a timely manner – especially if the organisation is critically dependent upon the link.

Tips and Advice

The five main categories of networking are an important topic in networking and lend themselves well to examination. Even if there is no direct question, they can be added into answers to other questions to demonstrate the breadth of your knowledge. They are also useful for defining the type of network in an assignment.

Summary

The five types of networking are important as they represent the key attributes of that particular type of network. For example, if we are talking about a LAN, we would expect it to be under the control of the organisation, be of high speed and be limited to the size of the building. Knowing these types of network greatly assists the learning of computer networks.

Quick test

Briefly compare and contrast the five main categories of networking.

Section 4: Intranets/Internet/Extranets

Networks are also classified according to their connection to the 'general public'. Categorised as intranets, the Internet and extranets, this classification can be used to determine whether access to the network is from a closed group or from all groups.

Intranet

Intranets are networks that provide the facilities we have come to expect from the World Wide Web, such as web pages, file transfer, form filling, etc., but they only provide these to a closed group. Access is normally controlled by a password. For example, the XYZ Widget Company may have several sales executives who travel to meet with customers. To support these executives, the company wants them to have access to production schedules, customer information and costing details. If they had been based in the company offices, the network would provide them with this information. As the information will constantly change, it isn't feasible to continuously send them disks containing the information. The dilemma is that they need the facilities of the network but they need them outside the building. Using the Internet would solve the physical problem, but the data is confidential.

This is an ideal candidate for an intranet – the executives can go to the company's website and then select the private area (or a more secure method is to have a separate URL that isn't advertised). The executives are authenticated in some way and then allowed access to the sensitive data contained in the site.

The name 'intranet' is sometimes used to describe an 'internal' Internet, based upon files that are only open to users of the company's LAN. Although this is not exactly what is meant by the term intranet – which is providing web facilities to a closed group – it can be regarded as an intranet.

Most colleges and universities have intranets to support learning.

The media needs to be connected to the computers that are being networked, which may require the use of networking devices such as a hub or switch (see Figure 2.4) (for further information, see Chapter 5). Our computers are then able to communicate and are physically connected together. The final requirement is the software itself. On a Microsoft Windows platform, two pieces of software are necessary:

KEY CONCEPT

Networking requires hardware, software and media. The hardware provides the electrical connection from the computer to the outside world, whilst the media connects the computers together. Networking 'kit' may be used to extend the media. The software uses this connection to carry bits of data. This data could be used to share or move anything that's digital.

- driver software for the NIC;
- Windows itself.

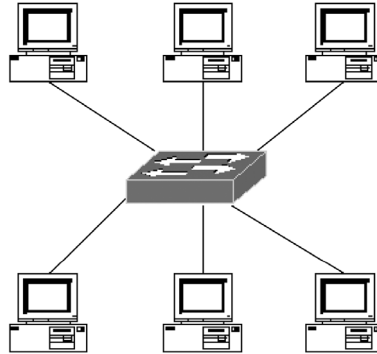


Figure 2.4: Computers networked using an Ethernet switch

As with most accessories purchased for a PC, NICs are shipped with a driver disk. The driver disk simply allows the computer to use (or 'drive') the hardware and needs to be installed before attempting to network the computer – otherwise the operating system won't be able to find the NIC. Since **Windows for Workgroups** was launched in the mid-1990s, the Windows operating system has had the ability to communicate through networks. The network settings can be found in the **Control Panel** (see Figure 2.5).

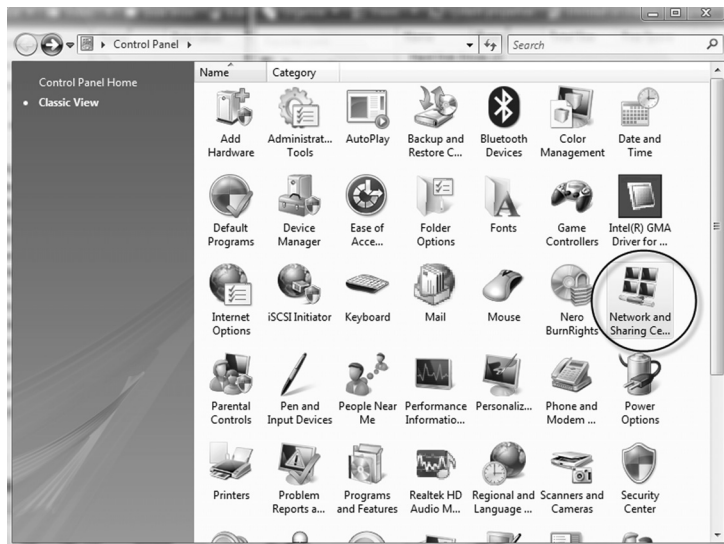


Figure 2.5: Control Panel settings; note the networking icon

Quick test

List the essential components of a networked operating system and briefly outline their purpose.

Section 2: Facilities of a networked operating system

Quite simply, networked operating systems (or NOSs) enable almost any make of computer to communicate with almost any other make of computer. Although this sounds relatively simple, it is not – and the power such simple communication provides to an organisation is tremendous. As the digital revolution continues more and more can be transported by a computer network, for example, low cost telephone calls, video, music, etc.

Why are computer networks so popular?

Networking has, throughout its history, brought huge benefits to organisations. For example, the ability of early programmers to work online was immeasurable in terms of efficiency and effectiveness. Before the advent of PCs in the 1980s, computing was undertaken on either mini or mainframe computers. As these were hugely expensive, organisations with such machines needed to ensure maximum use was being made of them whilst the machines themselves were kept secure. The most effective way of achieving this was via remote access through the network. Thus, in local authorities and large companies throughout the world, the resources of the computer – processing power, disk storage, printing, etc. – were shared, providing maximum benefits for the cost.

In the early 1980s, IBM introduced the first PC, which was an instant success with organisations across the world. Processing power was brought to the desktop, as were files and printing devices. Having the files and printers local to a machine was, at first, a novelty – users were in charge of their own data, printing and processing power. Organisations very quickly realised that, although there were benefits to this approach, there were also drawbacks. Files, which needed to be shared, had to be swapped physically (sometimes referred to as **sneakernet** – a term which comes from walking around with a disk); expensive printing resources had to be duplicated; and the organisation's data was decentralised, difficult to locate, access and back-up. In the example of the booking office, taking bookings for a popular gig which we looked at briefly in *Chapter 1*, the seating area (file) needs to be shared amongst everyone taking the bookings, otherwise over- or under-booking may occur. This cannot be efficiently undertaken by sharing a floppy disk! As this example illustrates, the sharing of information in an organisation is critical. To most organisations, communication and the sharing of information are critical. A sales department may ask: 'Can production handle this extra order if we take it?' If production keep their data local, this will be a difficult question to answer and the order might be lost.

Soon PCs were added to the LAN providing a means whereby the users could have their processing power locally, but could share information and other resources such as expensive printers. The first LANs introduced to the PC environment were client/server LANs and, today, the majority still follow this pattern. However, such are the benefits provided by LANs that smaller organisations have introduced peer-to-peer LANs to emulate these similar benefits. As LANs have evolved, so have the benefits they provide. Early LANs provided facilities for file and printer sharing. Today, LANs provide many more benefits to the organisation, for example:

- distributed processing (where the server can process, for example, a database query before returning the results to the client);
- email facilities and file transfer;
- remote backup;
- video conferencing;
- fax;
- shared applications, such as accounting and payroll systems (subject to licence terms);
- shared data;
- telephony services;
- instant messaging;
- wireless access.

To emphasize the importance of these benefits, most people would argue that email has revolutionised communication. For example, in 2002, a fire at a chemical plant sent a toxic cloud over the north east. The university, in which I work, had one call from the police advising everyone to stay inside. Relaying this life-threatening information to 1500 employees and thousands of students was achieved in seconds using email.

Sharing information (such as working documents) with colleagues is difficult and time-consuming without email (the file would have to be copied to one disk per colleague and put in the internal post). It is much more efficient to use email and simply attach the file. The network, therefore, also has to provide the translation between different machine types. Thus a Mac computer can send and receive emails to and from a PC, which is easier than sharing floppy disks (due to the different formats between MACs and PCs). The phrase 'information is power' is certainly true – the organisation that can share and access the information the quickest is likely to be the one that progresses the fastest. In every sense, networks provide an organisation with many ways of communicating more effectively. The fact that the cost of providing these facilities is relatively low means that the networks are providing low-cost/high-benefit solutions to an organisation – hence their popularity and continued growth.

KEY CONCEPT

Networking has brought many benefits to organisations, allowing them to realise huge savings. Such a positive cost-benefit has fuelled the development of networks. Organisations can almost always benefit from enhancing their networks.



Figure 3.5: Point-to-point network

Bus network

The bus network (see Figure 3.6) used to be very common and was used by a number of technologies – most notably, Ethernet. In this topology, a central ‘backbone’ cable spans the area and computers ‘tap’ into this backbone for their connection. In a bus network, the communications medium is shared between the computers attached to it. The standard connector used in this type of network was the **British Naval Connector (BNC)** (see Figure 3.8). The cable used was coaxial cable (similar to that used by TV aerials and cable TV) (see Figure 3.9).

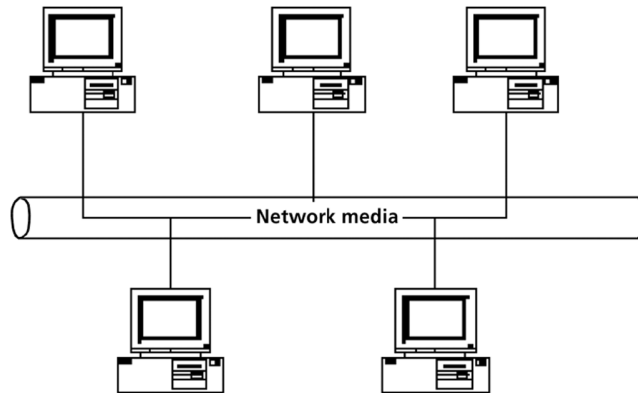


Figure 3.6: Bus network

The advantages of a bus network include the following:

- it was easy and inexpensive to install;
- it was easy to add further devices by tapping into the wire (avoiding the costs of expensive recabling);
- bandwidth was higher than in early star networks;
- facilitates communication with the interconnected device without going through the central computer.

The disadvantages include the following:

- the media was shared – therefore there was contention for access that required an algorithm to ensure fairness;
- data was sent in a broadcast fashion, meaning that all computers could ‘see’ the information – a security weakness;
- a cable break on the main bus cable took down the entire network;
- although the cable had higher capacity, it was shared among

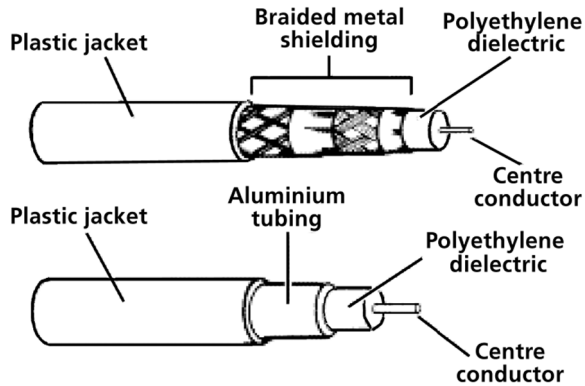


Figure 3.9: Coaxial cable
(diagram courtesy of Professor Peter Hodson,
University of Glamorgan)

Ring network

In the ring topology (see Figure 3.10), computers are connected to one another in a circular fashion and therefore form a ring. Although several companies and several implementations were involved, the two most notable were the Cambridge Ring (developed in Cambridge University and used extensively by Acorn in the BBC microcomputer series) and the Token Ring (developed and used extensively by IBM). The dominant network in this topology was IBM's Token Ring network.

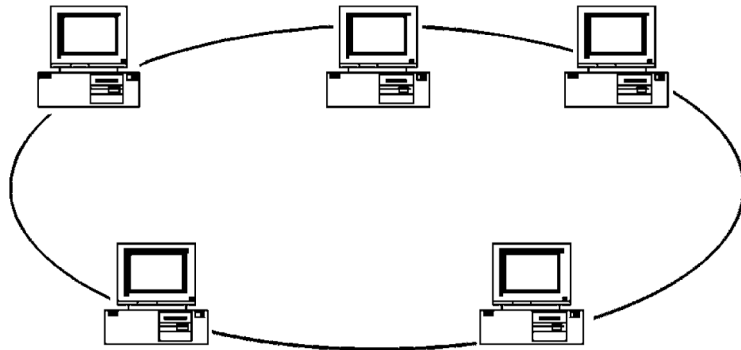


Figure 3.10: Ring network

The advantages of the ring topology are as follows:

- robustness – there are two links to each PC;
- in the case of Token Ring, higher capacity than 10Base2, 10Base5 (usually bus or tree networks) or 10BaseT Ethernet (modern star);
- a fairer method of access than standard Ethernet (see Chapter 5).

The major disadvantage was cost. As the equipment used in the Token Ring topology was IBM proprietary technology (which had a royalty fee

TIPS & ADVICE

All 56 K modems provide an upload speed of only 33.6 K. This is because this speed is the fastest at which digital-to-analogue conversion can reliably operate (Nyquist Theorem). The reason the download speed is quicker is because the V.90 standard treats the incoming signal as digital (even though it is analogue) and, therefore, the conversion rule doesn't apply.

Section 1: Types of Internet connections

There are many ways to connect to the Internet: dialup; DSL; cable; etc. This section discusses the major current ways of connecting.

Dial-up connection

Most people are familiar with this method of connecting to the Internet and it is still a common connection. Dial-up connection involves the use of a pair of modems and a telephone line. The modems convert the digital computer signals into analogue signals that are suitable for transmission over the telephone network. Another modem at the other end converts them back. This is known as a point-to-point (PPP) serial link and is available through virtually all ISPs. Once at the ISP's premises, the data is transferred on to its LAN and begins its journey to the Internet. Dial-up connection is also known as plain old telephone service or POTS for short. Typically, modems provide 33.6 K upload speed and 56.6 K download speed.

Digital Subscriber Line (DSL)

DSL is a method by which a permanent connection to the Internet can be provided to an end-subscriber using existing telephone lines. Quite simply, this is achieved by dividing the bandwidth of the conventional telephone line into channels, in a similar way that the bandwidth of TV/radio broadcasts is divided into channels (BBC1, BBC2, ITV1, etc.) (see Figure 11.1). Technically, this is known as **Frequency Division Multiplexing (FDM)**. Frequency ranges are allocated to particular services.

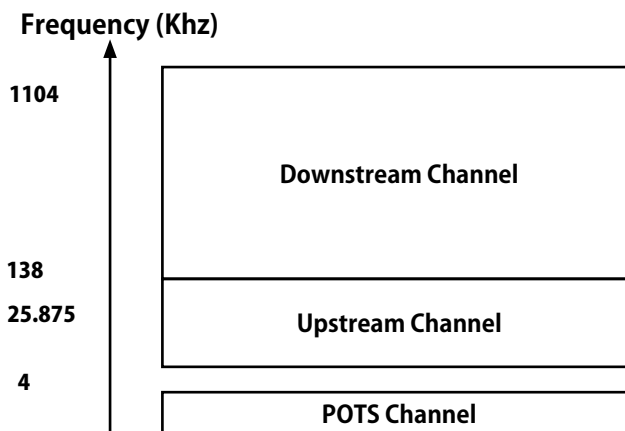


Figure 11.1: ADSL channels

There are generally two groups of DSL available:

- **ADSL** – Asymmetric DSL; and
- **SDSL** – Symmetric DSL.

'Asymmetric' means the line is imbalanced in favour of receiving data. In the case of ADSL, a small frequency range is allocated to the telephone service, a second, larger frequency range to the upstream connection to the Internet and the third and largest channel to the downstream connection to the Internet.

With ADSL it is possible to receive at up to 8 Mbps, but outbound transmission is limited to around 512 Kbps. As most home connections surf the web and download files, video and music, ADSL is ideally suited for this purpose. However, if a web server was connected or an organisation made large and frequent transmissions, ADSL would not be so suitable. There would be a considerable difference in speed when downloading a file compared to uploading.

In 2008, ADSL2 (known as ITU G.992.3) was launched in the UK. This is basically an improved version of ADSL providing up to 12 Mbps. ADSL2+ was also launched providing a theoretical 24 Mbps and over 2 Mbps upload speed. In 2009, ISPs were beginning to offer 20 Mbps download and up to 2.5 Mbps upload.

'Symmetric' means the line is balanced being able to send and receive data at the same rate. In the case of SDSL, a small frequency range is allocated to the telephone service, and two larger equal-sized frequencies are allocated to the upstream and downstream connections to the Internet.

With SDSL it is possible to send and receive at up to 2 Mbps making it ideal for small businesses who upload as much data as they receive. As SDSL is a business solution, it is more expensive than ADSL (£170 per month at 2009 prices) but comes with guaranteed service and a lower contention ratio than standard broadband (see *Chapter 9*).

Whichever type of DSL is deployed, connection requires a device to split the channels (often called a **microfilter** – see *Figure 11.2*) and a broadband modem or ADSL router. The computer is attached to the modem or router which, in turn, connects with the telephone to the microfilter.



Figure 11.2: A typical ADSL microfilter

Although the theory sounds straightforward, the cable and legacy telephony equipment that carry ADSL were never meant for this purpose, and so the technology that makes this possible is nothing short of a miracle!