

Easy Steps



Unit 2797 (v7)

Demonstrate knowledge of the principles of computer networks

- ☒ Easy to follow
- ☒ Step-by-step instructions
- ☒ Covers Unit Standard Criteria

A Cheryl Price Publication

Unit Standard 2797 (Version 7)

Demonstrate knowledge of the principles of computer networks

This book covers the course outline for the following New Zealand Qualifications Authority Unit Standard:

Unit Standard 2797 - GENERIC COMPUTING (Level 3, Credit 4)
Demonstrate knowledge of the principles of computer networks (Version 7).

All topics in this Unit Standard are included in this book.

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NZQA Outcomes and Evidence Requirements

Unit Standard 2797 (Version 7)

Title	Demonstrate knowledge of the principles of computer networks		
Level	3	Credits	4

Purpose	People credited with this unit standard are able to demonstrate knowledge of: data communications; the features of LANs; and the features of WANs.
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Classification	Computing > Generic Computing
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Available grade	Achieved
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Explanatory notes

- 1 Definitions
A *LAN* (local area network) refers to a network of computers and associated devices within a small geographical area (such as an office or building).
A *WAN* (wide area network) is a geographically dispersed telecommunications network and the term distinguishes a broader telecommunication structure from a LAN.
LANs and WANs can be wireless-based, wired, optical or a combination.
- 2 Legislation relevant to this unit standard includes but is not limited to the:
Copyright Act 1994;
Copyright (New Technologies) Amendment Act 2008;
Health and Safety in Employment Act 1992;
and any subsequent amendments.
- 3 An assessment resource to support computing unit standards (levels 1 to 4) can be found on the NZQA website at www.nzqa.govt.nz/asm.

Outcomes and evidence requirements

Outcome 1

Demonstrate knowledge of data communications.

Evidence requirements

- 1.1 The major elements in data communications are identified and described in terms of their role.
- Range computer, sender, receiver, transmission media, telecommunications provider.
- 1.2 The differences between WANs and LANs are identified and described in terms of their features.
- Range four differences.
- 1.3 The uses of LANs and WANs are described in terms of communications, sharing of data, programs, and peripherals.

Outcome 2

Demonstrate knowledge of the features of LANs.

Evidence requirements

- 2.1 Three main types of LAN media are identified and described in terms of their common uses.
- 2.2 The main LANs topologies of ring, star and bus, or hybrid are identified in terms of their connection, data flow, advantages and disadvantages.
- 2.3 A range of LAN protocols are compared in terms their media access and transmission methods.
- Range a minimum of three protocols are compared.

Outcome 3

Demonstrate knowledge of the features of WANs.

Evidence requirements

- 3.1 The uses and hardware requirements of telecommunications WANs are identified and compared in terms of their advantages.
- Range any four of – voice, data, packet switch, Integrated Services Digital Network (ISDN), frame relay, Asynchronous Transfer Mode (ATM).
- 3.2 The principles of WANs are identified and described in terms of data compression and encryption.

Planned review date	31 December 2016
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Status information and last date for assessment for superseded versions

Process	Version	Date	Last Date for Assessment
Registration	1	30 September 1994	31 December 2013
Review	2	24 September 1997	31 December 2013
Revision	3	28 July 1998	31 December 2013
Review	4	30 July 2002	31 December 2013
Revision	5	16 July 2004	31 December 2013
Review	6	22 May 2009	31 December 2015
Rollover and Revision	7	19 September 2013	N/A

Consent and Moderation Requirements (CMR) reference	0226
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This CMR can be accessed at <http://www.nzqa.govt.nz/framework/search/index.do>.

Section

1

Data Communications Concepts

Learning Outcomes

At the end of this section you should be able to -

- ☐ Identify roles of the major elements in data communication
- ☐ Identify differences between WANs and LANs

Sample Document

Introduction

Computers have come to dominate many aspects of the world we live in. Practically every modern workplace involves the use of computers in some way or form. Even the home has computers embedded in many devices, such as home entertainment centres and modern motor vehicles.

While computers are extremely powerful and useful on their own, it is really when we join them together and let them „talk“ to each other that we start to harness their full power. We call this **data communication**, and we describe computers that are linked as being **networked**. There are many different ways that this can be done, and this work module will explain the concepts and technologies involved.

What is a network? Why do we need networks?

A computer network is a way of connecting two or more computers and other devices so that they can communicate with each other. The important part of the definition is that a network allows them to **communicate** with each other. The way they are connected can take many forms – cables, telephone lines, radio signals, infra-red and even microwaves.

Why would we want to network computers together?

Computers connected together can:

- send and receive files, letters, emails, photos, spreadsheets, etc.
- connect to a printer.
- use a common Internet connection.
- share input from other devices such as DVD players, webcams or scanners.
- play multiple player games.
- access data from a single database.

You don't need a network to share this data, of course. You could just copy everything onto floppy disks or burn some CDs and pass them between computers. This is very cheap (and is sometimes jokingly referred to as a "Sneakernet" network) but extremely slow and may have other implications such as copyright issues.

A better way is to link your computers together more permanently. It would be useful if we could just plug a wire into our computer and be connected to all the other computers we want but it is not quite as easy as that. Later we shall see how the **Internet** has made our task almost as easy.

Elements of Data Communications

In this section you will learn about the language of networking and will look at descriptions of some of the components that will be covered in later chapters. The glossary at the end of this book provides an alphabetical explanation of networking terms.

Data

Computers are usually linked together in order to share data. (Note that the word “data” is plural. A single bit of information is a “datum”). Data are simply pieces of information – text, numbers, pictures and sound are forms of data. You may want to keep copies or make more copies of data, send it to friends, or change it somehow. Frequently you will want to have a printed copy. You may need to look up something that is stored in a shared database. All of these actions require that two or more computer devices share data between them.

Computer

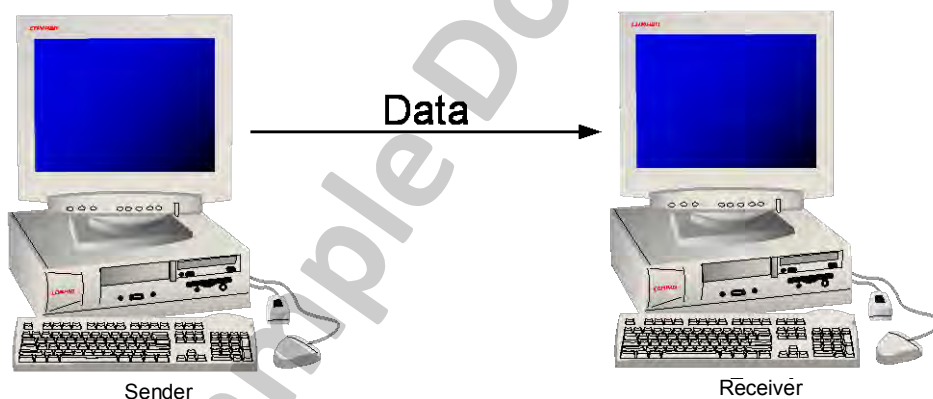
A computer is a device that processes the data. We generally think of the computer as an actual computer (ie with screen, keyboard and mouse) but in networking terms, it is a **computer device**. A computer device could be a computer, a printer, a smart controller that controls machines, or even a communications device such as a cellphone.

Sender

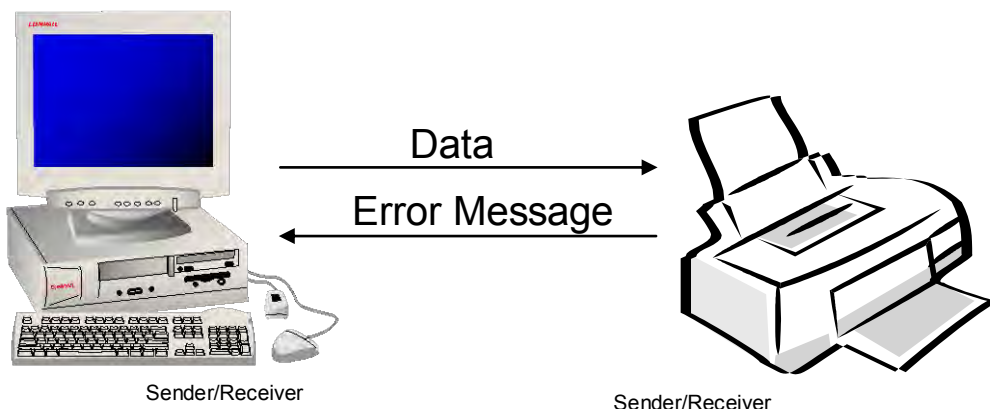
In any communication between computer devices, one device always acts as the **sender**. This device is the one that initially has the data, and wishes to send or transmit it to another device.

Receiver

The device that accepts the data is called the **receiver**. It receives the data and usually processes it in some way. In the case of a printer, for example, the receiver would print out the data onto paper.



Of course most computer devices act both as sender and receiver at various times. For example, a printer normally acts as a receiver. However, if it runs out of paper it will often send a message back to the computer, informing it of this problem. At that point the printer is the sender and the computer the receiver.



It is very rare these days to have devices that are purely senders or receivers. In the early days of computers some devices did just one or the other. Early printers were not able to communicate back to the computer, and if the paper jammed you only found out when you went to collect your print-out. Keyboards and computer mice are modern devices that act purely as senders – they only ever send information to a computer.

When two computer devices are connected together a decision must be made regarding which device should be sending, which should be receiving and which one's "turn" it is. If both machines decide to send at the same time there is a conflict and all the sent data is lost. A network must have some way of communicating all data from senders to receivers correctly and quickly.

Data transfer rate/bandwidth

A very important consideration when discussing any sort of network is the speed with which the sender can transmit information to the receiver. This is the **data transfer rate**, and is often called the **bandwidth**. Various technologies are able to achieve different data transfer rates. The exact speed will be discussed in later sections as each technology is covered, but the basic concepts need to be defined.

Firstly, in the digital world of computers an electrical wire can only have one of two states – a voltage is present, or it is not. This corresponds to a 0 or a 1, and is the basis of the Binary system on which all computers are built. This also forms the most basic unit of information that can be transmitted over a wire, namely a **bit**.

The bits get joined together and the speed at which they can be sent over a cable is the **data transmission speed**, or **bandwidth**. This is measured in thousands of bits per second (Kilobits per second or Kbps), millions of bits per second (Megabits per second or Mbps) and even billions of bits per second (Gigabits per second or Gbps).

There are other common measurement units used in computers, that are sometimes confused with bandwidth units. Two of these are:

Byte A byte is 8 bits, and is used to measure the size of data. Data storage such as hard disk capacities are measured in bytes, and units such as megabytes (MB) and gigabytes (GB) are used. Bytes and bandwidth are inter-related in time – for example, an 8 Mbps network can transmit 1 MB of data in one second.

Remember – the factor of 8 converts bits (as in bandwidth) to bytes (as in data size).

MHz The Megahertz is the clock frequency of a computer's processor and is often used as a gauge of its speed. The next unit up is Gigahertz (Ghz). One thousand Megahertz equals one Gigahertz. Typical speeds are 2.4 Ghz or 3.2 Ghz. The more megahertz or gigahertz, the faster your computer processes data. Note that clock speed is not related at all to data transmission speeds or data storage.

Exercise 1

- 1 A network is a way of connecting computers together. What else is often connected to a network?

.....

.....

.....

- 2 Which of the following is not a form of data? Numbers, keyboards, photos, letters, megahertz, sounds, databases.

.....

.....

.....

- 3 What's the difference between Mb and MB in computing terms?

.....

.....

.....

Transmission media

Computer devices need a way to move data between the sender and receiver. There must be some link between the devices, and the usual way of achieving this is by some form of **cable**, or a **wireless** (radio or infrared light) link.

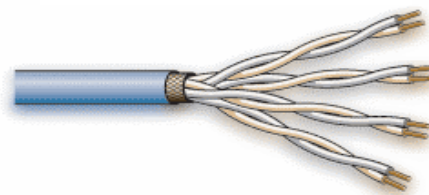
Cabling comes in many varieties. In the simplest form is it just a short cable that runs directly between the devices, such as when a printer is plugged into the computer. In that case the link between the devices is a **dedicated** link; ie, it is only used by those two devices to communicate, and is not shared by any other devices. This kind of dedicated cable is not usually regarded as a network. More often, there is a shared link that is used by many devices. In this case a range of network cabling types could be used.

Twisted pair

Twisted pair cabling is perhaps the most commonly used because it is very cheap. It has plain copper wires wrapped in insulation and twisted together in pairs. Bundles of pairs are then wrapped in a further plastic coating to form the cable. The insulation may be simply rubber or plastic (Unshielded Twisted Pair) or it may be made of foil to shield the wires from outside interference (Shielded Twisted Pair).



Unshielded twisted pair cable



Shielded twisted pair cable

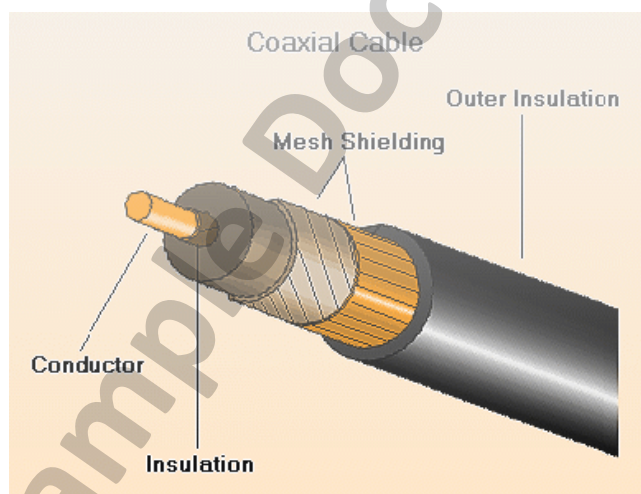
Almost all telephone wiring is twisted pair because it is very cheap and because voice transmission does not need to be very high quality. One disadvantage of twisted pair cabling is that it cannot carry data very far before resistance (a sort of electrical “friction”) is too great. The maximum distance is about five to six kilometres for voice, but only two to three kilometres for digital data before some sort of signal boost is needed. That makes it suitable for small or close networks but not for widely spaced networks.

Another disadvantage is that unshielded cable picks up interference very easily. On a telephone, it may just be annoying crackling or static, but digital data is completely ruined by interference. Even shielded twisted pair cable can pick up static, although less easily. Finally twisted pair cabling cannot carry very large volumes of data at any time. This is not a problem for voice or simple email but is hopeless for running large programmes or video.

Coaxial cable

To overcome the problems of distance and volume a different arrangement of cabling is used. Instead of a pair of wires twisted together, a single copper wire is covered in insulating material then wrapped in a woven metal sheath. This is then covered in a tough plastic outer coating. Each wire is shielded from outside and from each other. In this arrangement the copper wire is inside the metal sheath which acts as the other “wire”. In effect the two wires share a common axis, hence the name **coaxial**.

Coaxial or “coax” cable can carry much greater volumes of data than twisted pair. For example, cable television with over 100 channels is possible. Coax can also transmit data over greater distances than twisted pair. It is, however, more expensive to buy and more difficult to install than twisted pair.



Coaxial cabling

Fibre optic cable

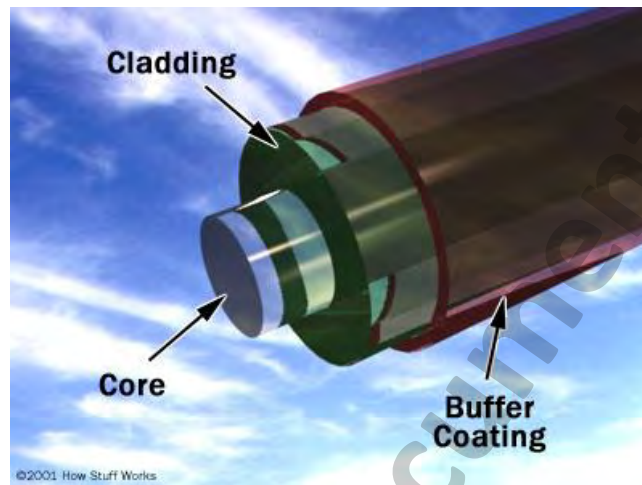
Fibre optic cable is made of very thin strands of glass or plastic. Instead of electrical pulses along a wire, pulses of light are shone down the fibre optic cable.

The advantages of fibre optics are huge.

- The volume of data capacity (bandwidth) is much larger; over 600 times more than coax cable and 32,000 times more than twisted pair.
- There is far less **attenuation** (loss of signal over distance) so data can be sent much further and faster than other cabling.
- Fibre optic is able to be used over extremely long distances. Most undersea cables are now fibre-optic, and distances of many thousands of kilometres are easily achieved.
- Optical fibres are physically much lighter and smaller than wiring and do not suffer from interference like metal wiring.

But the disadvantages are also greater.

- The fibre has to be made of very high quality pure glass or plastic without imperfections. This makes it very costly to manufacture.
- While it is very light and thin it is also much more fragile so that cabling has to have supports and stiffening built in.
- It is difficult to bend fibre optic cabling because it breaks easily and because light does not easily shine around corners.
- Fibre connections have to be extremely precise and special equipment has to be used, making installation costly and time consuming.



Fibre optic cabling

Wireless

There are occasions where the use of cable is impractical, impossible or prohibitively expensive. Data can be transmitted over a network using wireless connections. There are a variety of wireless methods that are used. These will be discussed in more detail later in this work module. In general wireless connections are used for local-area connections (ie connections directly between computer devices) or for connecting computers or entire networks to the Internet.

Infrared light is used over very short distances where the sender and the receiver are in line-of-sight. This makes it popular for:

- using a mouse and keyboard without cables;
- using handheld scanning devices such as light pens or bar code readers;
- connecting a laptop or palm pilot to a workstation.

Disadvantages are:

- the very short distances involved;
- the possibility of physical obstacles blocking the light;
- infrared signals can only be sent from one device to one other, not to many at once.

Ordinary broadcast radio can be used as a carrier signal for data transmission. It has the advantages of:

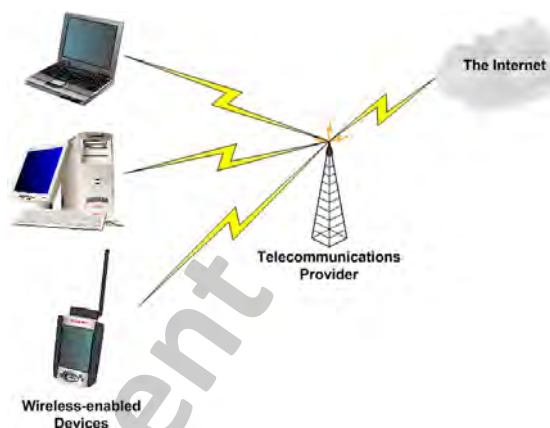
- Being able to communicate from within the home, or from country to country.
- Working well where the terrain makes cabling difficult, such as dense jungle or mountainous regions.
- Being relatively simple to set up and immediately ready to use.

It has some disadvantages, though.

- It is a relatively slow data transmitter.
- It can be easily disrupted by other broadcast signals on the same frequency.
- It is insecure, ie the data can be received by anyone with a receiver tuned to the right frequency.



Point-to-point wireless networking



Wide-area wireless networking

Refer to Chapter 4 for more details on wireless networking.

Telecommunications provider

(Also sometimes called the **service provider**)

Whenever a network has to extend beyond the immediate vicinity of the office, a company or individual has to make use of some form of public or shared transmission media. After all, if you wish to put a link between your office in Auckland and one in Christchurch, it would be astronomically expensive to run your own set of cabling for the entire distance!

The solution is to pay for access to a shared network, installed and maintained by a third party. This is usually a large telecommunications company, such as Telecom, but in the case of wireless networks may be smaller providers who have licensed a specific part of the radio spectrum for their use.

Exercise 2

1 What are the advantages of using twisted pair cabling?

.....

.....

.....

2 What are the disadvantages?

.....

.....

.....

- 3 For each of the following situations, suggest the most practical type of transmission media.
- a A small office network in three adjacent rooms.
.....
- b A network of scientists doing fieldwork on several small islands.
.....
- c A network designed to transmit video on demand.
.....
- d A network connecting thousands of subscribers over two continents.
.....
- 4 More data can be sent further and faster with fibre optic than any other transmission media. Why are other types still used?
.....
.....
.....

Types of Networks

Each network has its own special requirements and special problems to solve and are therefore set up in a wide variety of ways to address these issues. One way of looking at a network is in terms of its ordering or **hierarchy**.

Network Hierarchy

Peer-to-peer network

At the simplest level a network may be set up so that every device is the equal or “peer” of all the other devices. In a **peer-to-peer** network each device is connected to all the others by cabling. This is a very simple, cheap and easy-to-install type of network best suited to small home networks and situations where information sharing is useful but not critical.

The main disadvantages are that:

- sharing files slows down the network immediately;
- printers and other shared devices have to be manually switched (see page 16);
- if a computer is turned off, its files and applications are no longer available for use on the rest of the network.

Client/Server networks

In this type of network one computer is designated as a server and is normally left switched on at all times. Shared devices such as printers and modems are controlled by the server without manual switches and are always available. Commonly shared or time-critical files can be stored on the server, again, so that they are always available.

Thin-client computing

This is a special type of client/server network. The server is a powerful computer with hard drives and backup facilities. The other computing devices are extremely basic (and cheap). The server stores all the application programs, which are available to the clients on demand. The advantages are low cost, ease, accuracy and speed of updates and low maintenance. If the server fails, however, the entire network is forced to close for repairs.

*Another way to describe networks is in terms of their **physical layout**. This will be covered in Chapter 2.*

Network Coverage

A very common way to describe networks is by their coverage or spread. The following are the most often-used types of coverage.

Local-Area Network (LAN)

A **LAN** is a **Local Area Network**. This type of network connects a number of computers, printers, modems and other devices in a room or building, or even several buildings close together. Usually, devices can be separated up to several hundred metres. LANs are relatively cheap to set up, convenient to use and easy to manage.

LANs typically support very high data transfer rates. Since the cabling is short, high speed technology can be used. A typical office LAN would be 10 or 100 Mbps (Millions of bits per second, pronounced Megabits per second). Newer technology such as fibre optic supports 1 Gbps (Gigabits, or billions of bits per second).

LAN technology is cheap to use within a small area. Cabling costs only a few dollars per metre, and the network hardware required (network cards and associated devices) is also in the tens-to-hundreds of dollars range. The other important feature is that there is usually no cost to use a LAN – once it is set up it does not matter how much data is moved over it.

LAN technology is, however, very limited in the distance that can be covered. Due to the high speeds, performance drops off very rapidly as distance increases. The 100BaseT Ethernet standard stipulates that a maximum cable length of 100 metres is allowed, meaning that all devices have to be within a 200 metre diameter. The use of fibre optic cabling can increase this to 400 metres, but the network is still essentially restricted to one or two building that are close together.

Computer devices access the LAN by simply plugging into a suitable network point. There is no special device required, other than a Network Interface Card (NIC – defined later), and users are not authenticated by the network itself. Access to devices and resources on the network may be controlled by the devices, but access control is not a function of the network.

Wide-area network (WAN)

A **WAN** is a **Wide Area Network** that connects a number of devices spread over a wider area such as a city or perhaps cities close together. No single organisation owns the whole network, instead a number of organisations may share the facilities provided by a common provider, usually a **telecommunications provider**.

WANs usually have lower data transfer rates than a LAN. Typical WAN data speeds would be 2 Mbps for a business WAN, or as low as 56 Kbps for a dial up network access.

WAN technology is expensive to set up. Specialised hardware is required, ranging from routers and bridges for fixed-line LANs, through to wireless access points for wireless networks. Another important aspect is that most service providers have a usage charge for all data that moves through the WAN. They measure the total amount of data that is transferred and bill the customer accordingly.

LAN/WAN Comparison

LAN	WAN
Covers a relatively small area.	Covers a wide area.
Is usually owned completely by one organisation.	Is shared by various organisations.
Usually has a principal server and communicates with the outside world through this server.	There are many servers. Communication is through routers.
Normally has wiring or cabling shared by all devices in the LAN.	The transmission media is owned by a telecommunications provider and shared by all users on the WAN.
Often shares some resources eg printers, scanners, tape backup.	Shared resources are not usually shared by all devices.
Often stores frequently-used application programs on the “main” computer (or server). Users can then download a copy onto their computers to work from.	Due to the lower transmission speeds, applications are usually stored on the local machine, not on the WAN. However, data storage may be on the WAN, to enable many users to share the same central data.
Has an administrator who decides what can be shared and how to protect the LAN from viruses or misuse.	Different parts of the network require different administration.
May have two or three computers connected or may have hundreds connected. It is more usual to have less than one hundred.	Can have many devices attached to the network.
High data transfer rate.	Medium to low data transfer rate.
Cheap for short distances; gets progressively more expensive over longer distances.	Expensive to set up, but very little price differential for very long distances.
No costs for data transferred.	A charge is usually levied for actual data transferred.
Devices must be set up over a small area.	Unlimited distances can exist between devices.
No access control.	Computer cannot link to the network until it has been validated.

➤ Choose the best answer for each question.

- 1 Data rate transfers on a WAN are usually:
 - ☐ A: expensive for high priority items but cheaper for low priority.
 - ☐ B: very limited in the distance covered.
 - ☐ C: transmitted at medium to low rates.
 - ☐ D: limited to a single organisation.
- 2 Administration usually consists of:
 - ☐ A: a single administrator in a single organisation for a LAN.
 - ☐ B: many administrators over all the many organisations in a LAN.
 - ☐ C: a single administrator over all the many organisations in a WAN.
 - ☐ D: many administrators in both a LAN and a WAN.
- 3 Shared resources such as printers and modems:
 - ☐ A: are usually made available to all users in a WAN.
 - ☐ B: cannot be linked in a WAN.
 - ☐ C: should not be made available to all users in a LAN under any circumstances.
 - ☐ D: none of the above.
- 4 A thin client:
 - ☐ A: is usually extremely fit as well.
 - ☐ B: has a powerful server containing the application software and is networked to many basic devices.
 - ☐ C: is a small wireless computer linked to a WAN by a router.
 - ☐ D: is limited by the type of cabling used.
- 5 For a business, cabling:
 - ☐ A: is a limiting factor in LANs but not a great problem with a WAN.
 - ☐ B: problems have been solved by modern technology such as fibre optic cabling.
 - ☐ C: is expensive for small networks but gets cheaper the bigger the network.
 - ☐ D: can be used to protect both network types from virus attacks.

➤ Your office manager has proposed a web-based data storage system. All the company records could be converted to web pages so that branch offices could download their information from the Internet. It is relatively simple, easily accessible, cheap to run and extremely dangerous. In no more than three or four paragraphs explain why the company should NOT follow his advice and suggest simple alternative solutions.

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The Networking Model

Much has been theorised and written over the past 40 years about how best to build networks. Over time a theoretical model has evolved, and this has been approved by the International Standards Organisation (ISO). The ISO networking model (also called the OSI model, which stands for Open Systems Interconnect) is a theoretical model which is useful to understand.

Layer	Defines:
1 Physical	The cable or physical medium itself, eg coax, twisted pair, fibre, wireless.
2 Data Link	The format of data on the network. A network data frame, also known as a data packet, includes information about the source and destination of the data, plus some error checking information.
3 Network	Network protocol. The most widely used is the Internet Protocol. IP addresses are written as four dot-separated decimal numbers between 0 and 255, e.g., 129.79.16.40 There are other network protocols in common use, such as IPX and Netbeui.
4 Transport	Transport layer. This subdivides the data into packets that suit the network buffer. The most widely used on the Internet are Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).
5 Session	The format of the data sent over the connections.
6 Presentation	Converts local data into network data.
7 Application	Provides the actual application, eg Email, World Wide Web, etc.

It is **NOT** necessary to memorise this model, and it is included only for background information. Often the model is simplified into just four layers, with layers 1 and 2 combined into a **link layer**, and layers 5, 6 and 7 combined into an **application layer**.

The important thing to remember about the networking model is that the physical cables, including their electrical characteristics and mechanical connections, are totally separate from the protocols and other logical components of the network. The following table shows this in a simplified form.

Component	Definition	Examples
Physical	Transport Media.	Coax, twisted pair, fibre optic, wireless.
Data	Network type.	Ethernet, Arcnet, Token Ring.
Network	Protocol or „language“ used.	TCP/IP, IPX/SPX.
Application	The real reason for using the network.	Email, file sharing, WWW, printing.