# Assessment exemplars for Higher National Units

# D3BY 04 Network Technology (Microsoft)

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## Contents

## 1 Introduction

This pack supplements the original unit specification. It aims to provide examples of assessments that are valid, reliable and practicable.

The examples provided are intended for guidance only. They may be used in a variety of ways including, for example:

- to exemplify the standard expected of candidates achieving the unit ie as a benchmark
- to help you develop your own assessments for the unit
- to help you develop valid and practicable assessments for other units in the same curricular area
- to give you new ideas
- as a staff development tool.

It is very important that you note that using assessments based on these examples does not automatically guarantee successful external moderation. It is still your responsibility to make sure that all the appropriate internal quality assurance procedures are satisfactorily completed. For example, a valid, effective and approved internal moderation system must be in use at your centre.

Before using this material, you might find it useful to look at some other publications, in particular:

- Guide to Assessment and Quality Assurance for Colleges of Further Education (A0841)
- Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs and Candidates whose First Language is not English (A0645).

Details of these and other SQA publications are available in the SQA Information catalogue, updated and printed quarterly (tel 0141 242 2168 to obtain a copy). The SQA Information catalogue also lists all published HN Exemplar assessments. You could also visit our website at www.sqa.org.uk.

A free copy of this pack is available to all SQA centres. Additional copies can be obtained, price £15.00 from the Sales Section, Scottish Qualifications Authority, 24 Douglas Street, Glasgow G2 7NQ (tel: 0141 242 2168 or fax 0141 242 2123).

## 2 Summary of unit

Throughout this document the following type of abbreviations will be used:

| | |
|---|---|
| O2: | Outcome 2 |
| O4 PC (a): | Outcome 4 performance criterion (a) |
| O3 PCs (a) to (d): | Outcome 3 performance criteria (a) to (d) inclusive |
| O5 PCs (a), (c) and (d): | Outcome 5 performance criteria (a), (c) and (d) |
| A1: | Assessment task 1 |
| A4d: | Assessment task 4 part (d) |

This unit is designed as part of the Advanced Certificate in Networking (Microsoft) and should be read in conjunction with the notes for that group award. Note that although much of the material is taught using the MOC material this unit is assessed by traditional means.

#### Contextualisation

The unit is delivered in conjunction with D3C0 04 Stand Alone Computers Systems Support (Microsoft), D3BX 04 Multi User Network Systems Administration (Microsoft) and D3C1 04 Local Area Networks and Wide Area Networks in the Enterprise (Microsoft). As this unit is delivered partially using the MOC material and since this does not map directly to individual units a list of the topics covered in the Microsoft courses is provided in the course notes to allow cross referencing however the assessments for this unit are completely separate.

## Content

This unit covers all aspects of the hardware involved in computer networking. It is not concerned with network operating software except in the most general terms and references to particular operating systems should be avoided.

The outcomes and performance criteria have been constructed in a manner which does not assume that a centre has access to any particular hardware. Centres should, however, take every opportunity to introduce candidates to actual examples of the various technologies covered. A collection of samples of cables, connectors etc would be a useful resource.

Outcomes 1 to 3 build from the basic building blocks of networks, the transmission media, through the general principles of combining these into working networks to a specific Local Area Network (LAN) example. The final outcome introduces wide area networking.

Outcome 1: Deals with the physical features of networks including topologies and transmission media. Candidates should have as much opportunity as possible to see actual examples of network implementations.

Outcome 2: Covers, in generic terms, the operation of networks.

Outcome 3: Looks in detail at the hardware required by a LAN.

Outcome 4: Serves as an introduction to wide area networks (WAN).

## Approaches to generating evidence

### Assessment tasks

The table below shows how each exemplar assessment task relates to the unit outcomes and performance criteria. It also indicates the evidence that should be retained for external moderation.

| Outcome | PC | Suggested task | Suggested evidence to be retained |
|---|---|---|---|
| 1 | all | 1 | Candidate response |
| 2 | all | 2 | Candidate response |
| 3 | (a)<br>(b)<br>(c)(d) | 3(a)<br>3(b)<br>3(c) | Candidate response<br>Investigation report<br>Implementation proposal |
| 4 | all | 4 | Candidate response |

### Possible routes through the exemplar assessment tasks

Task 1a and Task 3a should be undertaken early in the delivery of the unit. Thereafter it is recommended that the remaining tasks are taken in order, although Task 3b could commence soon after completing Tasks 1a and 3a.

### Merit

The merit statement of this unit gives three alternative criteria for merit.

- Quality of response - depth of analysis and detail of response.

  The suggested responses to Task 1 are of merit standard.

- Selecting hardware for a wide range of networking requirements.

  This applies to O3 PCs (b), (c) and (d) and the requirements described in the sample scenario are of pass level. The scenario would need to be extended to provide merit opportunities. Where a real investigation is undertaken the actual requirements will determine whether or not merit should be awarded. The quality of the investigation may also be taken into account if carried out on an individual (not group) basis.

- Providing evidence of further research or reading.

  Tasks 1, 2 and 4 all provide opportunities for this to be demonstrated, Task 4 is particularly suitable in this respect.

# 3 Exemplar assessments

## Introduction

The exemplar assessments which follow are intended to cover all performance criteria and range. Re-assessment may be required where initial responses do not meet the required standard.

## Assessment tasks - information for the candidate

## Assessment task 1

## Outcome 1 Describe the main physical features of computer networks

## Performance criteria

(a) Benefits of computer networking are correctly described.

(b) Limitations on the transfer of data are correctly described.

(c) Common network topologies are accurately described.

(d) Common data transmission media are correctly described and their data transmission limitations accurately identified.

(e) The physical characteristics of common data transmission media are correctly identified.

## Assessment task instructions

a) What are the principal benefits of linking computers to form networks? What limitations can apply to the transfer of data in a computer network and how do they affect the usefulness of networks?

b) Describe the main topologies used in the connection of networks of computers.

c) Describe, in general terms, common data transmission media and their advantages and disadvantages in terms of data transfer. Briefly outline their physical characteristics.

d) Describe in detail the physical implementation of a simple Ethernet network using thin co-axial cable.

Your responses should be approximately 500-800 words in length for each section and should include diagrams where appropriate.

## Assessment task 2

## Outcome 2 Describe the operation of computer networks

## Performance criteria

(a) Methods of sharing transmission media are correctly described.

(b) Data transfer protocols are correctly described.

(c) The principal features of each layer of the Open System Interconnection (OSI) model are accurately identified.

(d) Common network configurations are correctly described and their relative merits correctly evaluated.

## Assessment task instructions

a) Why is **transmission media sharing** important in the operation of computer networks? Describe common methods of achieving this sharing.

b) Identify the principal features of each layer of the **Open System Interconnection model**. Describe the data transfer protocols of the Network and Data Link layers.

c) Describe how **client-server** and **peer-to-peer** networks are configured. What are the relative merits of each configuration?

Your responses to Parts (a) and (c) should be around 1,500 words; a more restricted response is sufficient for Part (b).

## Assessment task 3

## Outcome 3 Select appropriate hardware for use in a local area network

## Performance criteria

(a) The hardware components of a LAN are correctly described

(b) Operational requirements of LAN are accurately established.

(c) An appropriate network topology is selected and justified.

(d) Appropriate hardware components are selected to meet requirements.

## Assessment task instructions

a) Briefly describe the following hardware components of a Local Area Network:

**Servers:**

**Nodes:**

**Output devices:**

**Storage devices:**

**Transmission medium:**

b) Investigate and report on the operational requirements which a LAN would need to satisfy in _____. Your report should include sections covering the following areas:

1 Data storage requirements - both shared and private.
2 The number of users including usage patterns.
3 The actual locations of servers and nodes within the organisation's premises.
4 Volume and type of required output.
5 Backup and security requirements.
6 Any plans of the organisation which might require future expansion of the LAN.

c) Based on the information gathered, select an appropriate network topology (or topologies) and the hardware components to be used in the implementation of the LAN. Include an explanation and justification of your choices.

## Assessment task 4

## Outcome 4 Describe the features and operation of wide area networks

## Performance criteria

(a) Application areas of wide area networks (WANs) are correctly identified and described.

(b) Hardware components which extend or connect network segments are correctly described.

(c) Factors affecting or contributing to the performance of a distributed network are correctly described.

(d) Switching systems and their uses are correctly described.

## Assessment task instructions

a) Identify three different sets of circumstances where wide area networking could be used. Describe, in general terms, how the WAN would be implemented in each case.

b) Describe the hardware components commonly used to extend or connect network segments. What factors determine the performance, in data transfer terms, of such distributed networks.

c) Describe **circuit**, **message** and **packet switching** as used in networking.

Your response to each section should be approximately 250 words.

## Assessment task 1 Information for the tutor/trainer

## Outcome 1 Describe the main physical features of computer networks

### Performance criteria

(a) Benefits of computer networking are correctly described.

(b) Limitations on the transfer of data are correctly described.

(c) Common network topologies are accurately described.

(d) Common data transmission media are correctly described and their data transmission limitations accurately identified.

(e) The physical characteristics of common data transmission media are correctly identified.

### Information for the tutor/trainer

It is suggested that Task 1a-c should be completed without reference to texts. For Task 1d reference materials may be used. The precise example network for Task 1d can be replaced by any other network type of which candidates have had actual experience.

Task 1a sample response treats data as a special type of shared resource. This is quite acceptable provided that the distinctive benefits are described.

## Assessment task 2

## Outcome 2 Describe the operation of computer networks

## Performance criteria

(a) Methods of sharing transmission media are correctly described.

(b) Data transfer protocols are correctly described.

(c) The principal features of each layer of the Open System Interconnection (OSI) model are accurately identified.

(d) Common network configurations are correctly described and their relative merits correctly evaluated.

## Information for the tutor/trainer

Task 2c should elicit a generic response - references to facilities provided by particular operating systems should be avoided.

Use of appropriate reference materials should be encouraged for Task 2a-b however Task 2c should be undertaken without reference to texts.

## Assessment task 3

## Outcome 3 Select appropriate hardware for use in a local area network

### Performance criteria

(a) The hardware components of a LAN are correctly described.

(b) Operational requirements of LAN are accurately established.

(c) An appropriate network topology is selected and justified.

(d) Appropriate hardware components are selected to meet requirements.

### Information for the tutor/trainer

a) It is suggested that this task is undertaken early in the delivery of the unit. If Task 1 and 2 have previously been completed then responses to those may already cover the performance criteria and range.

b) Wherever possible this task should be based on the investigation of real requirements, as a group activity with each candidate producing an individual report. Where this is not possible you should provide the candidates with suitable scenarios. An example of a suitable scenario is shown below.

### LAN Operational requirements scenario

Pan Universal Widgets Inc. currently operate a number of personal computers spread over three main departments: accounts, sales and personnel. A number of other personal computers are used: three for secretarial and one for scheduling purposes. The company has decided to move to an integrated accounting system linking sales and payroll information directly to accounts. This system requires that the personal computers be networked.

It is estimated that five users will be required in accounts, eight in sales and three in personnel and it has been decided to include the remaining personal computers in the network. Two of the sales staff (on a rota basis) will be engaged in answering general enquiries; not requiring constant access to the computer system. Only two of the personnel department require access to the computer system immediately, although it is anticipated that this will rise to three in the near future.

The company would like to site a printer in the warehouse office to print sales orders taken by the sales department for use as picking lists and delivery notes. The integrated package includes a stock control module and it is intended to introduce this and two further stations in the warehouse as a second phase.

The company uses, and will continue to use, multi-part stationery for sales orders and invoices (sales department); customer statements and supplier remittance advices and cheques (accounts department) and wage slips and pay cheques (personnel). Two of the current secretarial systems share a laser printer while the other has exclusive access to another laser printer for confidential material. None of the laser printers is currently used to capacity. The scheduling system has no printer at present although access to a laser printer is desirable. All departments will produce various reports for internal circulation and the flexibility to use either continuous stationery or single sheets would be of benefit.

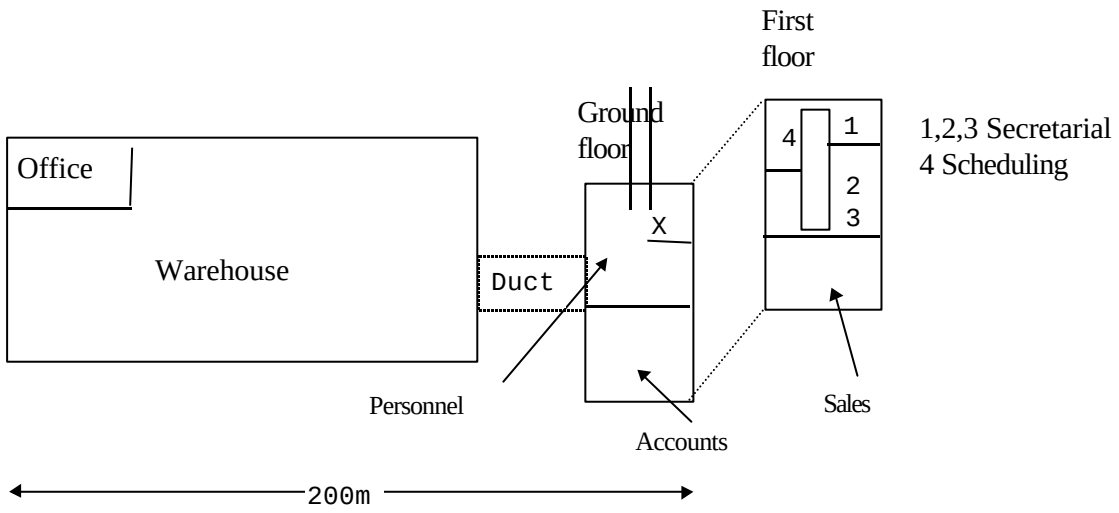
The accounts department needs to produce confidential monthly accounts for the board and external circulation and these need to be of a high standard of presentation. Statements, remittances and payslips are printed monthly; invoices are produced daily and sales orders immediately.

Several hundred phoned sales orders are processed each day between 9 am and 5 pm in addition to mail and fax orders. Each sales order averages 10 items with a single line description and cost information and each sales order generates an individual invoice.

The software suppliers estimate that the accounts package will require the following data storage:

| | |
|---|---|
| Programs: | 35Mb |
| Sales orders: | 50Mb |
| Sales accounts: | 70Mb |
| Purchase accounts: | 40Mb |
| Nominal accounts: | 40Mb |
| Payroll | 100Mb |
| Stock control: | 250Mb |

The layout of the company's premises is as follows:




The room marked 'X' currently houses the impact printers used for multi-part printing and also houses the service duct between the two floors.

## Assessment task 4

## Outcome 4 Describe the features and operation of wide area networks

## Performance criteria

(a) Application areas of WANs are correctly identified and described.

(b) Hardware components which extend or connect network segments are correctly described.

(c) Factors affecting or contributing to the performance of a distributed network are correctly described.

(d) Switching systems and their uses are correctly described.

## Information for the tutor/trainer

This task provides an opportunity for candidate research. This approach would be particularly useful where centres have limited access to real WANs.

## Exemplar assessments - suggested solutions

## Assessment task 1

## Outcome 1 Describe the main physical features of computer networks

## Performance criteria

(a) Benefits of computer networking are correctly described.

(b) Limitations on the transfer of data are correctly described.

(c) Common network topologies are accurately described.

(d) Common data transmission media are correctly described and their data transmission limitations accurately identified.

(e) The physical characteristics of common data transmission media are correctly identified.

## Suggested solution

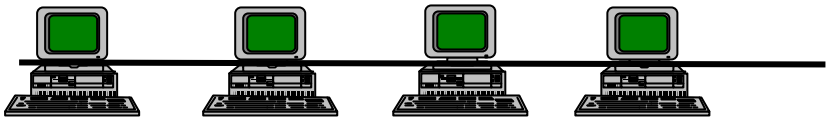
a) The principal benefits of networking computers are the ability to share physical resources and data.

Resource sharing reduces equipment costs by allowing controlled access by any computer on the network to any of the shared resources. Thus the number and type of, for example, output devices such as printers and plotters can be determined by factors such as the required throughput rather than the number of users. In addition the effects of equipment failures can be minimised by redirecting output to alternative devices or by a user switching to another workstation.

Working with a single data set ensures that all users access current information. Administration and version control are simplified by having single sets of software and data. A single backup procedure can be implemented leading to enhanced data security. The general availability of data provides the opportunity of making use of it in new ways.

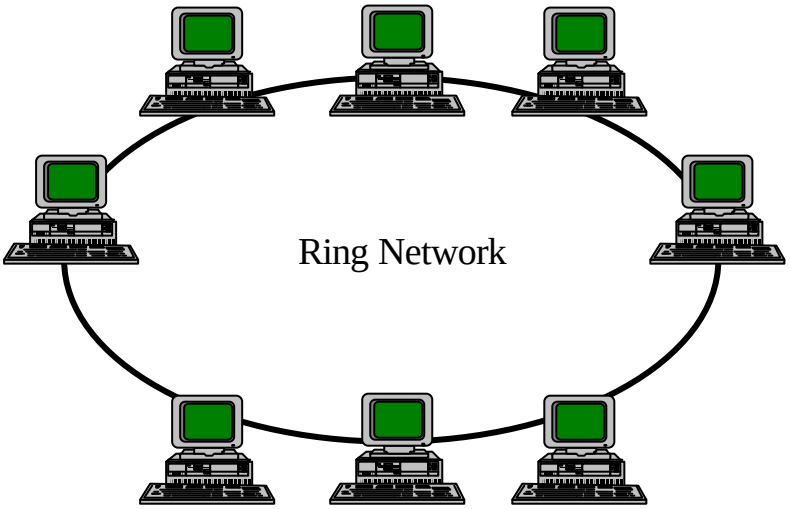
These benefits depend on the transfer of data between the component parts of the network which is, however, subject to limitations. It is essential that the network can transfer sufficient amounts of data quickly enough to provide an acceptable level of response to the user. The distance over which data can be transmitted is limited by the physical characteristics of the transmission media employed. Additionally, the data transfer process may be unreliable, inaccurate or insecure, any of which would negate the benefits of networking.

b) The three main type of network topology in common use are ring, star and bus. The layout of nodes in each of these is shown below:

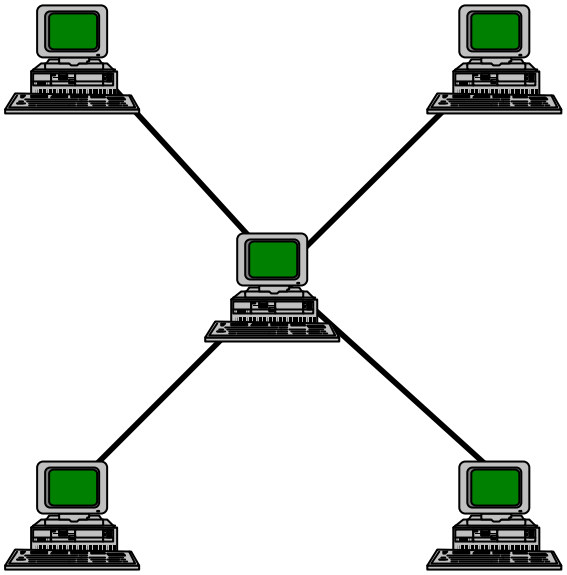


Bus Network

In a bus network each device is connected, either directly or via a spur, to a main communications line (the bus) along which signals are sent.




In a ring (also referred to as a loop) network the devices are connected, either directly or via a spur, to a ring communications line around which signals are sent.



Star Network

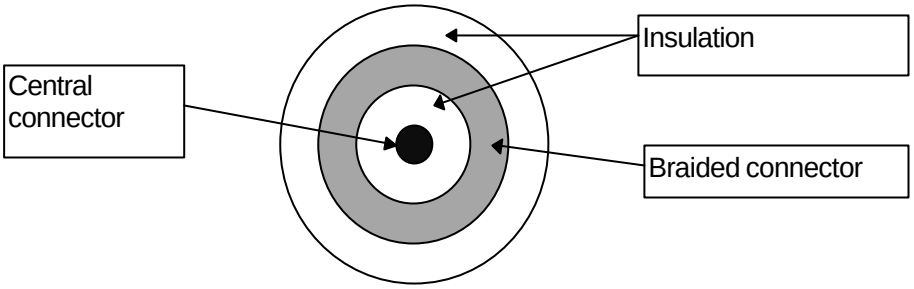
In a star network all devices are connected individually to a central hub which can be a computer (usually the network server) or a dedicated device.

Large networks can be formed by combining these topologies eg a bus backbone can be used to connect a number of rings or stars. One particular type of layout, referred to as "structured cabling", is being increasingly used in medium and large sized buildings. All data outlets (including telecommunications) within an area of the building (often a floor) are routed to a central location. These connections are generally based on a star configuration utilising UTP cable. Each of these nodes is then connected with a backbone (often fibre optic). This arrangement allows for flexibility in configuration and allows for multiple networks within a single building.

c) The main data transmission media are copper cable (including co-axial and twisted pair); fibre optic cable and wireless (such as infra-red and microwave).

Copper cable has the advantages of being relatively inexpensive and simple to install. However it does impose limitations in terms of the overall length of segments (generally limited to hundreds of metres) and provides limited bandwidth. Cable can also be subject to interference and is relatively insecure. Cable does, however, remain the most widely used medium for network data transmission.

Cables used in networking consist of one or more pairs of conductors. In a co-axial cable these are arranged as shown:




In the simplest form of Twisted Pair (TP) cable, a pair of insulated copper wires are twisted together, surrounded by a copper braid and external insulation. In more complex forms, a number of pairs can be combined within a single braid and external insulation. In an alternative form the pair of wires in twisted with an earth wire. When the shielding (braid or earth wire) is omitted, this is known as Unshielded Twisted Pair (UTP).

Each physical type of cable can support different bandwidths dependant on the quality of the actual cable. Ethernet cable, for example, constructed to the Category 3 (CAT-3) standard can support transmission rates of 10 MHz Higher speed networks (based on Fast Ethernet) operating at 100 MHz require higher specification CAT-5 cable.

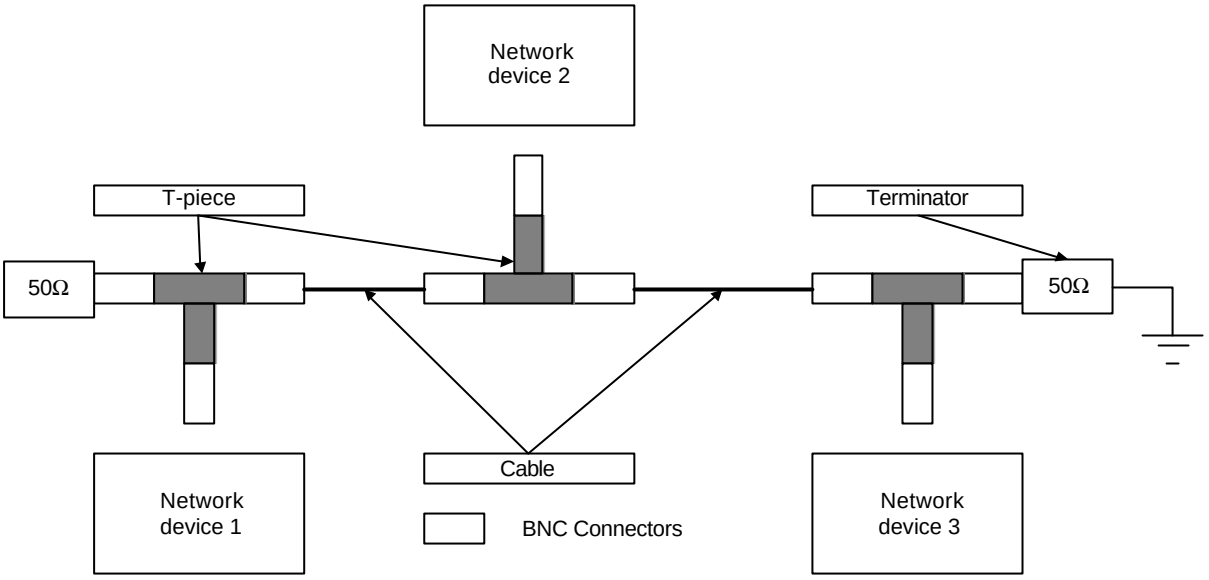
Optical fibre is becoming more widely used in situations which require data transmission over long distances (kilometres) or large bandwidths. It also provides interference-free, secure data transmission. Disadvantages are higher cost and difficulty of installation. The advent of cable TV networks will continue to increase the usage of fibre cable in networking since many of the operators are making spare capacity available to other organisations.

Optical fibre is a very fine glass strand that allows rapid transmission of data using modulated light beams.

Wireless local networking is still relatively uncommon. However microwave links are extensively used by public telephone systems and can also be used in private installations to link different sites. Since a highly directional signal is used, a direct line-of-sight is required between transmitters. Cost of these installations is very high, although in the appropriate circumstances where large volumes of data are involved, it can be less than the cost of, say, laying fibre cable under city centre streets.

d) Ethernet is a popular general-purpose local area network standard which can be implemented in a number of ways. The most popular method of implementing small Ethernet systems has been to use thin co-axial cable, conforming to the RG58C/U specification which has an impedance of 50Ù.

The network takes the form of bus which requires to be terminated by a 50Ù resistor at each end, one of which should be earthed (these serve to prevent signal reflections at the cable ends). Cable sections have BNC connectors at each end and the network interface of each device also has a BNC connector. Connection of devices to the network is made using BNC T-pieces. A simple three device network is illustrated as follows:




Additional network devices can be added by disconnecting a cable or terminator, adding a new section of cable with a T-piece and reconnecting.

Using this method it is very quick and easy to construct a network. However it does have some limitations: a single cable segment can not exceed 185m in length or have more than 30 connected devices. Devices should be separated by at least 1m of cable. In addition, any break in the connection from terminator to terminator will disable the *whole* network. Alternative connection systems have been developed which protect against inadvertent disconnection, although these add considerably to the cost of installation.

## Assessment task 2

## Outcome 2 Describe the operation of computer networks

## Performance criteria

(a) Methods of sharing transmission media are correctly described.

(b) Data transfer protocols are correctly described.

(c) The principal features of each layer of the Open System Interconnection (OSI) model are accurately identified.

(d) Common network configurations are correctly described and their relative merits correctly evaluated.

## Suggested solution

a) The operation of a network is dependent on the ability of connected devices to transmit messages to each other and these messages will generally include the address of the sending and intended receiving devices. Each message must share the transmission medium. However most media can only accommodate a single message at any point on the network. If messages from two separate devices meet, the resultant collision will result in corruption of one or both messages. A method of dealing with these potential collisions is necessary to enable the network to function. However the speed at which these messages can be transmitted determines the overall rate at which data can be transferred across the network and therefore the collision handling cannot impose too many limitations on message transmission.

Two broad strategies have been adopted to deal with this problem: collision avoidance and collision detection.

A common form of collision avoidance is **token passing** where messages can only be transmitted to the network by being attached to a token. A token is a special signal which continually circulates round the network and which carries one message at a time. The message is carried round the network until it reaches its intended destination, or returns to the sending device, when it is removed from the token. The token then becomes available to carry a further message. This method is restricted to ring networks and means that only one message can travel on the network at any given time. (A development of the token system known as the Cambridge ring involves multiple tokens moving round the network at a fixed rate. This improves the data transfer rate by enabling multiple messages to travel on the network - a message can be attached to the first available token.)

Another method of managing network traffic depends on the network interface being able to detect when a message is being transmitted by another device. Transmission of its own message is deferred until no traffic is detected. However it is likely that more than one device will be waiting to transmit at any given time and simultaneous transmissions, resulting in collisions, can occur. Most commonly this is handled by the network interface detecting the collision and re-transmitting after a short delay. This process is known as Carrier Sense Multiple Access/Collision Detection (CSMA/CD).

CSMA/Collision Avoidance (CSMA/CA) avoids collisions by ensuring that only one device can transmit at a time.

b) The Open Systems Interconnection Model describes a set of protocols which allow computers from different sources to be linked together. Equipment or software which conforms to the protocols for any one layer will interconnect with that designed for the level above or below.

| Level | Name | Features |
|---|---|---|
| 7 | Applications | Application and Operating System specific |
| 6 | Presentation | Data transformation (including device-specific formatting)<br>Encryption and compression |
| 5 | Session | Access control<br>Session dialogues |
| 4 | Transport | User communication<br>Enhanced flow control |
| 3 | Network | Routing/addressing between systems<br>Control of Inter-networking |
| 2 | Data Link | Creating and controlling messages (including error correction) |
| 1 | Physical | Transmission methods |

c) Client-server networks are based on the principle of the handling of shared resources by one or more dedicated computers (servers). In this organisation servers can not be used as client stations and vice versa. File servers provide central disk storage for network users and control access to these files both in terms of ownership (of private files) and data integrity (record and file locking of shared files). Print servers control access to shared printers by providing a spooling system. These server functions are generally provided by a single computer of a higher specification than the client stations in smaller networks with multiple, high specification, servers being used in larger networks.

Networks involving computers of similar specification which have equal status are known as Peer-to-peer networks. Each station can function as both a client and a server ie can use resources provided by other stations and also make its own resources available to other stations.

Peer-to-peer networks are simple to implement but may not provide the same level of facilities as a client-server network. In addition no computers beyond the number required as stations are needed, reducing costs. Acting as a server as well as a client imposes additional overheads on each station which can reduce performance. Failure of any station has only a limited effect on the network as a whole and individual stations can usefully operate in the absence of others. Expansion of the network will generally only be possible up to a point where conversion to a client-server configuration may be required.

Client-server networks can be more complex to install and require administration during operation. Stations are dependent on the operation of the server(s) with only limited functionality to unsupported stations. Expansion of the network is straightforward.

## Assessment task 3

## Outcome 3 Select appropriate hardware for use in a local area network

## Performance criteria

a) The hardware components of a LAN are correctly described.

b) Operational requirements of LAN are accurately established.

c) An appropriate network topology is selected and justified.

d) Appropriate hardware components are selected to meet requirements.

## Suggested responses

a)

| | |
|---|---|
| **Servers:** | Computers which control shared resources in order to provide services to client computers. |
| **Nodes:** | Devices attached directly to the network. Includes servers, client computers and others such as printers with built-in network interfaces and dedicated hubs. |
| **Output devices:** | Shared resources which can be used for output e.g. printers, plotters. |
| **Storage devices:** | Shared resources used for data storage including disk drives (fixed or removable), tape drives, CD-ROMs etc. |
| **Transmission medium:** | The medium connecting nodes on a network. Cable (thin/thick ethernet, UTP etc.) fibre optic cable or wireless. |

b) The candidate report should contain expanded versions of the following points when the provided scenario is used:

| Area | Operational requirements |
|---|---|
| 1 | Shared: Accounts (335 Mb)<br>Private: Limited amount required for Windows; Confidential documents |
| 2 | 18 stations required: 5 in accounts; 7 in sales (one shared); 2 in personnel and 4 others. |
| 3 | Main office area occupies two floors. Warehouse office remote (250m) but reachable via existing duct. Existing 'printer' room. |
| 4 | High volume of multi-part and report printing. Other printing requirements normal volume. |
| 5 | Volume of daily sales transactions imply daily backup of sales order and account data. Other data may only require weekly backup.<br>Security needed for payroll and cheque printing. Other confidential items. |
| 6 | Addition of stock control - 2 stations and 250 Mb of data.<br>Additional station in personnel. |

c) There is no one correct method of implementing any particular LAN. However the following **summarises** an acceptable approach to the given scenario. It is **not** comprehensive in that it omits the precise specification of the hardware components but these are relatively straightforward and of lesser importance than the networking aspects.

**Network topology**: Bus network with stars at appropriate points. The main bus would run from the warehouse office through the existing duct to personnel, accounts and the printer room then up to the 2nd floor in existing duct terminating at secretarial 1. Hubs supporting an appropriate number of terminals would be located in the warehouse office, personnel, accounts, sales and secretarial 1. Server to be located in 'printer room'with direct connection to existing printers. Other printers to be located in warehouse office, secretarial 1 and secretarial 2/3.

**Bus network**: thick Ethernet (or optical fibre); stars: UTP.

The proposal should also include a justification (including cost) of the options chosen.

## Assessment task 4

## Outcome 4 Describe the features and operation of wide area networks

## Performance criteria

(a) Application areas of WANs are correctly identified and described.

(b) Hardware components which extend or connect network segments are correctly described.

(c) Factors affecting or contributing to the performance of a distributed network are correctly described.

(d) Switching systems and their uses are correctly described.

## Suggested responses

a)

| | **Example** | **Implementation** |
|---|---|---|
| Linking geographically remote networks within an organisation | Company or government department with offices in different towns (or countries) | PSTN, leased lines, satellite links. |
| Linking separate networks or extending the size of a single network. | Large organisation previously operating separate networks in different depts. Or requiring large number of users | Physical link via bridge or router. |
| Allowing geographically remote stations to form a network | Internet | PSTN used to link to shared high speed lines. |

b) Repeaters: devices which link two cable segments, generally of the same type. Overcome segment length restrictions by amplifying the incoming signal from one segment before transmitting to the other segment. Can also be used to create a spur or spurs. Repeaters simply repeat the low-level information from one interface to another, and work at the physical layer of the OSI model.

Bridges: devices which link network segments of different cable types eg Ethernet and token ring to form an apparently single network from the user view. Can also be used to link a network segment to communications lines. Bridges operate within the data link layer within the OSI model, and need to be aware of MAC addresses. This allows bridges to selectively forwarded information depending on whether the MAC address in question is on the other side of the bridge or not, reducing network traffic.

Routers: enhanced repeater or bridge which routes messages according to destination address. Routers operate at the network layer within the OSI model, and need to be aware of the internal details of the network layer protocols (for example, IP addresses) in order to route packets. Routing can be adaptive or non-adaptive. In adaptive routing the router 'learns' the location of stations in the wide area network during normal operation and routes messages accordingly. Non-adaptive routers are programmed with information about station location.

In order to reduce costs of using those external communications links which are charged on a usage basis they can be activated only on demand. This reduces the availability of the link and imposes delays in data transmission until the link is established. General availability of communications links can be subject to interruption.

The efficiency of data transfer of wide area networks can be improved by managing the network to control congestion by re-routing messages to avoid bottlenecks and routing messages via the shortest available path.

c) Circuit switching: a link between two machines which is set up initially from one end to the other before data is exchanged, and remains available until the end of the transaction. A fixed bandwidth is available for the connection which may not be continuously used. An example of a circuit switched network is the public switched telephone network (PSTN).

Message switching: Involves the division of messages into sections which are transmitted separately. Each section can be sent by a entirely different route with the choice of onward route being made by each station on the route. The message is reassembled at the recipient station.

Packet switching: Involves sending messages as packets of data, often fixed length. Each packet occupies the communications link for only a short period of time leading to efficient use of the link. Packet switching systems use fixed routes.

## Recording checklists

### Outcome 1 Describe the main physical features of computer networks

| Performance criteria | | Range category and class | Pass |
|---|---|---|---|
| (a) | Benefits of computer networking are correctly described. | Benefits:<br>Resource sharing<br>Data distribution | |
| (b) | Limitations on the transfer of data are correctly described. | Data transfer limitations:<br>Bandwidth<br>Speed<br>Distance<br>Reliability<br>Quality<br>Security | |
| (c) | Common network topologies are accurately described. | Topologies:<br>Ring<br>Bus<br>Star | |
| (d) | Common data transmission media are correctly described and their data transfer limitations accurately identified. | Data transmission media:<br>Cable<br>Optical fibre<br>Wireless<br>Data transfer limitations:<br>Bandwidth<br>Speed<br>Distance<br>Reliability<br>Quality<br>Security | |
| (e) | The physical characteristics of common data transmission media are correctly identified. | Data transmission media:<br>Cable<br>Optical fibre<br>Wireless | |

## Outcome 2 Describe the operation of computer networks

| Performance criteria | Range category and class | Pass |
|---|---|---|
| (a) Methods of sharing transmission media are correctly described. | Sharing methods:<br>CSMA/CD<br>CSMA/CA<br>Token passing | |
| (b) Data transfer protocols are correctly described. | Protocols:<br>Network layer<br>Data link layer | |
| (c) The principal features of each layer of the OSI model are accurately identified. | | |
| (d) Common network configurations are correctly described and their relative merits correctly evaluated. | Configurations:<br>Client-server<br>Peer-to-peer | |

## Outcome 3 Select appropriate hardware for use in a local area network

| Performance criteria | Range category and class | Pass |
|---|---|---|
| (a) The hardware components of a LAN are correctly described. | Components of LAN:<br>Servers<br>Nodes<br>Output devices<br>Storage devices<br>Transmission medium | |
| (b) Operational requirements of LAN are accurately established. | Operational requirements:<br>Data storage (shared and private)<br>Number of users<br>Physical locations of server(s) and nodes<br>Volume and type of output<br>Backup and security<br>Future expansion | |
| (c) An appropriate network topology is selected and justified. | | |
| (d) Appropriate hardware components are selected to meet requirements. | | |

## Outcome 4 Describe the features and operation of wide area networks

| Performance criteria | Range category and class | Pass |
|---|---|---|
| (a) Application areas of WANs are correctly identified and described. | | |
| (b) Hardware components which extend or connect network segments are correctly described. | Hardware components:<br>Repeaters<br>Bridges<br>Routers | |
| (c) Factors affecting or contributing to the performance of a distributed network are correctly described. | Performance factors:<br>Availability<br>Adaptive and non-adaptive routing<br>Congestion control<br>Shortest path algorithms | |
| (d) Switching systems and their uses are correctly described. | Switching systems:<br>Circuit<br>Message<br>Packet | |