SQA Advanced Unit specification

General information

Unit title: Network Technology and Data Communications

Unit code: HP2X 48

Superclass: XM

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Version: 01

Unit purpose

This Unit is designed to introduce the candidate to the basic concepts and principles of data communications, and to provide the candidate with a wide knowledge of the technologies and standards involved in the construction of modern networks. It is intended for candidates undertaking a Computing or Information Technology related qualification who require an understanding of modern networking concepts and practice.

On completion of the Unit the candidate should be able to:

1 Define the principles of Data Communications.
2 Describe the characteristics of Network Media.
3 Describe the characteristics and construction of Wide Area Networks.

Recommended prior knowledge and skills

Access to this Unit will be at the discretion of the Centre. There are no specific requirements but candidates would benefit from knowledge of binary numbers, digital data representation and digital electronic operation.

Credit points and level

2 SQA Credits at SCQF level 8: (16 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the Support Notes of this Unit specification.

There is no automatic certification of Core Skills or Core Skill components in this Unit.

Context for delivery

This Unit is included in the framework of a number of SQA Advanced Certificate and SQA Advanced Diploma Group Awards. It is recommended that it should be taught and assessed within the context of the particular Group Award to which it contributes.

The assessment exemplar for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable instrument of assessment. Centres wishing to develop their own assessments should refer to the assessment exemplar to ensure a comparable standard. Assessment exemplars are available on SQA's secure website.

Unit specification: statement of standards

Unit title: Network Technology and Data Communications

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The sections of the Unit stating the Outcomes, Knowledge and/or Skills, and Evidence Requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Define the principles of Data Communications.

Knowledge and/or Skills

- Shannon–Weaver model
- Basic concepts and terminology of data communications
- Analogue modulation techniques
- Digital line coding techniques
- Multiplexing techniques

Evidence Requirements

The candidate will need evidence to demonstrate his/her Knowledge and/or Skills by showing that they can answer questions on a sample of all of the following:

- **Shannon–Weaver model**

  Shannon and Weaver's model is widely accepted as the basis of all communication studies. Claude Shannon and Warren Weaver were engineers working for Bell Telephone Labs in the United States. Their goal was to ensure the maximum efficiency of telephone cables and radio waves. The advantages of Shannon and Weaver's model are that it is in a simple, easily understood form and that it is a general model that can be applied to most types of communication.

- **Basic concepts and terminology of data communications**

  Basic concepts and terminology described must include Data Communication Equipment, Data Terminal Equipment; simplex, half-duplex, full duplex communication; baud and data rates; the OSI model; digital and analogue signalling; asynchronous and synchronous communications must be described and compared. The Internet Protocol (IP) is the principal communications protocol currently in use by networks. The candidate should describe the difference between Internet Protocol Version 4 (IPv4) and its successor, Internet Protocol Version 6 (IPv6).

Analogue modulation techniques

Amplitude Modulation and Frequency Modulation; Amplitude Shift Keying, Frequency Shift Keying, Phase Shift Keying, Quadrature Amplitude Modulation must be described in the contexts of analogue broadcast media and analogue modems respectively.

- **Digital line coding techniques**

  Non Return to Zero, Manchester and Alternate Mark Inversion line coding must be described in the context of their applications at the physical layer of LANs and telecommunications systems.

- **Multiplexing techniques**

  Frequency Division Multiplexing, Time Division Multiplexing (synchronous and asynchronous), Wavelength Division Multiplexing and Code Division Multiplexing must be described in the context of their respective uses.

Outcome 2

Describe the characteristics of Network Media.

Knowledge and/or Skills

- Basic LAN topologies
- Types of medium
- Attenuation
- Bandwidth
- Propagation time
- Cabling practice and standards

Evidence Requirements

The candidate will need evidence to demonstrate his/her Knowledge and/or Skills by showing that s/he can answer questions on a sample of all the following:

- **Basic topologies**

  Current industry-standard LAN topologies and technologies including bus, star, token-ring, wireless, etc.

- **Types of medium**

  Any medium commonly in use to transmit data, examples include coaxial, twisted pair, unshielded twisted pair, optical fibre and radio waves. The candidate should have knowledge of standard use, costs and advantages and disadvantages.

- **Attenuation and Noise**

  Signals lose power based on the distance they travel. Signal to Noise ratio relates to the Shannon–Weaver model covered in Outcome 1. The candidate should demonstrate knowledge of how different mediums are affected by a range of factors including interference, crosstalk, distortion, thermal noise etc...

- **Bandwidth**

  Network bandwidth is the channel capacity or the maximum throughput of a logical or physical communication path in a digital communication system.

- **Propagation time**

  Propagation time is the time for a signal to travel from one device to another across a medium. The candidates should understand that speed of propagation and bandwidth or channel capacity are not always linked.

- **Cabling practice and standards**

  Structured cabling advantages and costs must be described; accepted cabling standards, including current cable categories and testing requirements.

Outcome 3

Describe the characteristics and construction of Wide Area Networks.

Knowledge and/or Skills

- Basic concepts
- PTO switched services
- Mobile and broadband services

Evidence Requirements

Evidence for the Knowledge and/or Skills in this Outcome will be provided by an extended response report requiring additional independent research, analysis and evaluation by candidates. This report must include:

- **Basic concepts**

  Types and characteristics of WANs including circuit, packet and cell-switched technologies must be described. General routing and congestion control algorithms must be described, and routing must be described within the context of Internet Protocol. The candidates should discuss both IP4 and IP6 technologies.

- **PTO switched services**

  A representative range of current public switched PTO services must be described. This must include circuit-switched and packet-switched services.

- **Mobile and broadband services**

  Current and developing high-speed broadband and/or mobile data communication technologies must be described.

  Relevant standards and applications must be described.

Unit specification: support notes

Unit title: Network Technology and Data Communications

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 80 hours.

Guidance on the content and context for this Unit

This Unit requires the candidate to complete independent research, analysis and evaluation. Whenever possible the candidate should be introduced to real-world examples. There are opportunities for whole-class and group discussion and practical demonstrations. Concepts and terminology should be presented in context throughout the Unit. Video presentations should be used where appropriate for providing an alternative explanation of a difficult topic, or as a focus for class discussion or group work.

Given the theoretical nature of this Unit, it is intended that a significant amount of time will be made available as a central part of the course for research, tutorials and formative assessment exercises. Candidates should be strongly encouraged to undertake further reading and opportunities for individual or group research should be provided.

The most important overall emphasis should be on the relevance and currency of content in such a rapidly-evolving field.

This Unit assumes no previous experience of communications theory and so requires a general introduction to communications concepts — processes, everyday examples (speech, phone call, lecture), binary numbers, simple digital signalling, (eg TTL NRZ) and the representation of information as digital data, (eg ASCII, graphics). It will also be necessary to introduce at an early stage a range of communications terminology and concepts which will be required throughout the course, (eg simplex, half and full duplex; DTE and DCE; synchronous and asynchronous communications).

Outcome 1

The candidate should then be introduced to the basic physical principles of signalling using electromagnetism and electricity, covering the electromagnetic spectrum in terms of its applications (Shannon–Weaver model can be used to simplify these terms), however concepts of voltage and current in electrical signalling should be covered briefly. The important differences between analogue and digital signalling should also be described, and the characteristics of serial and parallel communication discussed. Using this as a basis, it will then be possible to introduce in more detail important concepts such as data rate, bandwidth, attenuation and interference and noise.

The Open Systems Interconnection model (OSI model) illustrates the functions of a communications system. The candidate should understand the functions of each layer, and how information is passed from layer to layer.

Different network media should then be examined individually and in some depth; emphasis should be placed on practical experience, applications, characteristics, advantages and limitations rather than abstract or mathematical theory. It is extremely important that the media and implementations discussed should cover the whole range of current communications, and care should be taken to ensure that information presented to candidates is accurate, comprehensive and up-to-date.

Both guided (copper, optical fibre, etc) and unguided (radio such as Wi-Fi, satellite, microwave, etc) needs to be covered however specific technologies are not defined in this document. All media should then be reviewed to address issues of noise and signal degradation (including EMI, crosstalk, skew and attenuation), and security.

Multiplexing should be covered in some detail. FDM and WDM should be discussed within the context of long distance telephone, broadcasting and CATV, and used to introduce the concepts of modulation and carrier signals. Both synchronous and asynchronous TDM should be covered, including discussion of telecommunications. CDMA could be introduced conceptually and with a focus on applications such as Wi-Fi (802.11); a mathematical treatment would not generally be appropriate at this level.

The concept of asynchronous and synchronous transmission should be covered. The use of RS-232 V.24 standard has diminished however can be used as a simple example.

Synchronous signalling and digital modulation techniques should then be described with the focus on the strengths and weaknesses of different line codes; this allows a step-by-step progression from NRZ through bipolar, Manchester and AMI, candidates should understand the importance of these coding to remove DC bias.

Analogue signalling and modulation should be discussed in detail, including ASK, FSK, PSK, QAM and PCM. Applications of each in both unguided and guided transmission should be described to provide context, however complex mathematical representation are not required at this level. Current Domestic and commercial modulated data services should be described.

Outcome 2

The general advantages and limitations of LANs should be described, with specific focus on the relative characteristics and applications of peer-to-peer and client-server systems. Physical and logical topologies should be described, including bus, star, ring and wireless. The physical principles of operation of each should be explained, their components (media, connectors, transceivers, NICs, termination, switches, etc.) described and their subsequent advantages and limitations explained.

The candidate should describe transmission medium currently in use to carry data traffic; examples include coaxial, twisted pair, unshielded twisted pair, optical fibre and radio waves. The candidate should have knowledge of standard uses, costs and advantages and disadvantage.

The candidate should describe current transmission mediums in use within domestic and commercial networking, identifying their fault-tolerant characteristics, costs, attenuation, bandwidth, propagation time and typical applications.

The candidate should be introduced to the mathematical equations required to calculate attenuation, Signal to Noise Ratio (SNR), bandwidth capacity and Propagation time.

Current cabling practices such as structured and flood-wiring should be described along with details of cable categories, drop-cable and connector types. Current cabling standards such should be discussed. Where possible this should be illustrated by practical demonstrations of different cable types, connection systems and other components. If the teaching centre does not itself have a significant LAN installation, consideration should be given to a visit to a commercial site.

Outcome 3

The general characteristics of a WAN and examples of applications should be described. The concepts behind circuit and packet switching systems should be outlined, but a detailed treatment can be left until describing services where they are used. Theoretical aspects of network design such as routing algorithms and congestion control should be discussed. The concept of logical network addressing should be explored using a common protocol such as IP as a context, and the functions of routers at the network layer of the OSI model should be described.

Relevant standards for WANs should be discussed, with an emphasis on current or future developments such as Inter- and Intranets and networked multimedia delivery. It is suggested this range includes details and applications of at least current TCP, UDP and IP, IPv6 and H.32x.

The development of wired and mobile broadband provision should be discussed, with a focus on multimedia services and LAN/WAN integration. The candidate should be encouraged to investigate both existing and proposed future services.

Telecommunication companies offer a range of services to both commercial and domestic customers. The candidate must describe services currently available, care should be taken to ensure that information presented to the candidates, or research completed by the candidate is accurate, comprehensive and up-to-date.

The services offered by network providers is constantly evolving, and with each evolution the type of connection changes, and speeds increase. For this reason specific technologies are not listed but technologies that should be covered are as the following:

Circuit-switched services
Packet-switched services
Cell-switched services
Mobile and Broadband services

The candidate should describe the concept and typical application of the services above. Other factors to consider are bandwidth (up and down stream speeds), Quality of Service (QoS), cost, security, etc.

Guidance on the delivery of this Unit

This Unit has a large theoretical component, with all Outcomes requiring research and independent study.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 80 hours.

Guidance on the assessment of this Unit

This Unit is likely to form part of a Group Award, which is primarily designed to provide candidates with technical or professional knowledge and skills related to a specific occupational area. It is highly technical in content and should not be adopted by Group Awards in other areas or delivered as a stand-alone Unit without careful consideration of its appropriateness. It is not a Unit which candidates are likely to find accessible at an introductory level; it is suggested that it be delivered only as part of a second-year SQA Advanced Diploma Computing award, after candidates have experience of basic background topics involved in digital electronic systems and data representation. It should be delivered in tandem with other networking Units rather than prior to them, and opportunities for teaching and assessment integration explored.

To minimise assessment overhead, sets of restricted response questions can provide evidence of the candidates' knowledge for Outcomes 1 and 2. It is suggested that multiple-choice questions can be used as the preferred assessment method. However it is conceivable that this evidence could be generated by a written report.

If the chosen method of assessment is multiple-choice questions then the number of questions which must be answered correctly in each assessment should correspond to 60% of those set in each case.

The theoretical component of Outcomes 1 and 2 are extensive, and should not be underestimated, however group work and individual research should be encouraged.

Outcome 3 is assessed by a report; this should require extensive independent research, analysis and evaluation by candidates. It is suggested that the basic concepts required for this Outcome be taught, but that the bulk of the information required for the other knowledge elements be developed by the candidate's own research.

Assessment Guidelines

Outcome 1

A representative range of questions must be set to reflect the five main Knowledge and/or Skills items described for this Outcome, and candidates must answer at least 60% of these correctly. In order that candidates will not be able to see what items they will be questioned on, a different sample of the items is required each time the Outcome is assessed.

It is suggested that 30 multiple-choice or restricted response questions would provide a convenient and appropriate method of producing the evidence required for this Outcome. The assessment should be carried out in supervised conditions and is closed-book. The candidate may not bring to the assessment event any notes, text books, handouts or other material.

Outcome 2

Evidence for the Knowledge and/or Skills in this Outcome could be produced using a set of 20 restricted response questions to assess the candidate's knowledge and understanding. Alternatively, it is suggested that multiple-choice questions would provide a convenient and appropriate method of producing the evidence required for this Outcome.

Outcome 3

It is important that teaching and assessment reflect current technologies. Where relevant however, historical technologies, should be included to provide context.

The candidate should discuss the most common form of connection for both domestic and commercial connectivity, giving details of advantages and disadvantages of each.

The candidate should demonstrate research of current and emerging technologies, evidencing relevant standards and applications of such technologies.

Online and Distance Learning

If this Unit is delivered by open or distance learning methods, additional planning and resources may be required for candidate support, assessment and quality assurance. A combination of new and traditional authentication tools may have to be devised for assessment and re-assessment purposes.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003).*

Opportunities for developing Core Skills

There may be opportunities to gather evidence towards Core Skills in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Equality and inclusion

This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

History of changes to Unit

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

General information for candidates

Unit title: Network Technology and Data Communications

This is a 2 credit Unit at SCQF Level 8 intended for candidates undertaking a Computing or IT-related qualification who require an understanding of modern networking concepts and practice. It is designed to introduce you to the basic concepts and principles of data communications, and to provide you with a wide knowledge of the technologies and standards involved in the construction of modern networks.

On completion of the Unit you should be able to:

1 Describe the principles of Data Communications.
2 Describe the characteristics of Network Media.
3 Describe the characteristics and construction of Wide Area Networks.

In this course, you will study basic communications principles and be introduced to essential concepts and terminology. This will include basic concepts and terminology of data communications; analogue modulation techniques; digital line coding techniques and multiplexing techniques. You will also cover the basics of Local Area Network topologies and equipment; media characteristics; cabling practice and standards.

The final section covers Wide Area Network concepts; Public Telecommunications Operator services; mobile and broadband services.

There will be two closed-book written assessments covering Outcomes 1 and 2, requiring short- or restricted responses. For each, the number of questions set and the number you must answer correctly are shown in the following table:

Outcome	Number of questions	Minimum current responses
1	30	18
2	20	12

Outcome 3 will be assessed by an extended response report describing WAN technologies and PTO services. This report will require you to undertake significant independent research, analysis and evaluation.

You must satisfy these requirements for all these assessment in order to achieve the Unit.

Assessment is at the discretion of the centre, and may vary from above.