

Unit 46: Access Network Techniques and Applications

Unit code:	L/602/4640
QCF Level 3:	BTEC Specialist
Credit value:	10
Guided learning hours:	60

Aim and purpose

This unit will introduce learners to the characteristics of digital subscriber lines, its limitations and the systems that have been developed to deliver new services over it.

Unit introduction

This unit is concerned with the so-called 'last mile' connection of telecommunications services to customers. With the deregulation of the telecommunications industry, many more organisations are now involved with delivering services to residential and business customers over the infrastructure formerly installed and maintained by the incumbent service provider.

Incumbent service providers have, over many years, made a large investment in the provision of telephone lines (the 'local loop') that originally just provided access to basic telephony services. To meet the demand for new services such as high-speed internet access, new technologies have been developed to exploit the existing infrastructure.

The systems discussed include the analogue telephony system that has been in use for decades, the digital systems introduced to offer enhanced telephony and data services, and the latest broadband services that provide high-speed internet access.

Apart from explaining the underlying technologies, the unit also introduces learners to typical applications of these various systems.

The last mile connection to a customer is a challenging environment. The unit discusses the physical components of the copper-based access network and the factors that limit the maximum distance over which particular types of service can be provided. Learners are introduced to the technologies that overcome some of these limitations and provide the broadband services that have increasing importance to both customers and service providers.

Apart from the copper-based access network, the principles and applications of newer access technologies, such as those using optical fibre or wireless techniques, are also introduced.

The unit also considers the various test techniques used to check whether a copper line is capable of carrying broadband services and to find faults on the line.

Learning outcomes and assessment criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria determine the standard required to achieve the unit.

On completion of this unit a learner should:

Learning outcomes	Assessment criteria
1 Understand the structure, physical components, and transmission media employed in access networks	1.1 describe the structure of a copper-based access network and the role of its main functional components 1.2 explain the principles and capabilities of an alternative transmission media in an access network
2 Understand the effects of line impairments on transmitted goals	2.1 calculate loss, signal level, and signal-to-noise ratios from the results of a loss and level measurement 2.2 explain the effects of impairments in the local loop on the provision of telephony and data services
3 Understand the operations, capabilities and applications of time division multiplexing (TDM) systems	3.1 explain the principles of operation, capabilities and applications of a TDM line system 3.2 describe the principles of operation and capabilities of basic rate and primary rate ISDN services
4 Understand the operations, capabilities and applications of digital subscriber lines (DSL) systems	4.1 explain the operation, components, capabilities and applications of the various types of ADSL system 4.2 describe the capabilities and features of an alternative DSL system 4.3 explain the relevance of the measurements that can be carried out by the various types of DSL test equipment

Unit content

1 Understand the structure, physical components, and transmission media employed in access networks

Copper-based access network: role of street cabinets (CABs), primary connect points (PCPs), secondary connect points (SCPs), drop points (DPs); relationship between PCPs, SCPs and DPs; multipair cable structure and types; role of remote line unit (RLU); role of equipment at the local exchange eg main distribution frame (MDF), switch equipment, line cards

Alternative transmission media: basic transmission principles and capabilities (data transfer rate, reach, quality of service) of alternative line access techniques eg fibre to the cabinet (FTTC), telephony over passive optical networks (TPON), wireless access techniques (Wi-Fi, WiMAX); relative installation and component costs of alternative media

2 Understand the effects of line impairments on transmitted signals

Loss, signal level and signal-to-noise ratios: definition of decibel (dB) unit of loss; definition of dBm unit of signal power; calculation of total loss of a system from individual losses in dB notation; calculation of total loss of a system from input and output signal levels in dBm; calculation of output signal level in dBm notation from total loss in dB notation and input signal level in dBm; definition of signal-to-noise ratio; calculation of signal-to-noise ratio using dB notation

Impairments in the local loop: noise, near end and far end cross talk (NEXT and FEXT); primary and secondary line coefficients; variation of loss with frequency; role of bridge taps and their effect on digital subscriber line (DSL) signals; distance (reach) constraints for analogue and DSL signals; role of loading coils and their effect on DSL signals

3 Understand the operations, capabilities and applications of time division multiplexing (TDM) systems

TDM line system: principles of TDM; frame structure of 2 Mbit/s TDM E1 signal; role of frame alignment word (FAW); role of multiframing structure; transport of signalling in timeslot (TS) 16; role of primary multiplexers; G.703 network interface standard; high density bipolar 3 (HDB3) line code; applications of E1 systems eg inter-exchange transmission, inter-connection of private automatic branch exchanges (PABXs)

Basic rate and primary rate integrated services digital network (ISDN) services: time division multiplexing of B and D channels in a basic rate access (BRA) ISDN service; role of B and D channels; BRA ISDN customer's equipment (terminal equipment, terminal adaptor, network termination); definition of the user-network interface (UNI); use of BRA for telephony and data transfer; aggregation of B channels ('channel bonding') to provide higher data transfer rates; time division multiplexing of up to 30 B channels to form a 2 Mbit/s aggregate for a primary rate access (PRA) ISDN service

4 Understand the operations, capabilities and applications of digital subscriber lines (DSL) systems

Asymmetric digital subscriber line (ADSL) systems: principles eg quadrature amplitude modulation (QAM), discrete multi tone (DMT), forward error correction (FEC), interleaving; functions of the ADSL termination units (ATU-R and ATU-C); principles and advantages of rate adaptive ADSL; role of splitters at customers' premises and at the local exchange; splitterless ADSL services; role of microfilters at customers' premises; role of the asynchronous transfer mode (ATM) in ADSL connections; role of a digital subscriber line access multiplexer (DSLAM); role of broadband remote access server (B-RAS); definition and significance of contention ratio

Alternative digital subscriber line (DSL) services: role and capabilities of a single-pair high-speed DSL (SHDSL) service; role and capabilities of other DSL services eg high-speed DSL (HDSL), very-high-bit-rate DSL (VDSL); effects of transmitting different DSL and TDM services over the same multipair cable; applications of DSL services eg internet access, voice over internet protocol (VoIP), virtual private network (VPN) connections, access to television programmes

DSL testing: relevance and role of direct current (DC) and alternating current (AC) line tests on local loop using a digital multimeter; relevance and role of the various tests carried out using a time domain reflectometer (TDR) eg line length measurement, location of line break, location of bridged tap; relevance and role of the various tests carried out by a DSL tester eg insertion loss, bits per tone, error performance, internet protocol (IP) and ATM ping test; definition and relevance of noise margin

Essential guidance for tutors

Delivery

This unit takes into account the rapid technological changes occurring in telecommunications service access networks. It also acknowledges that older systems and infrastructure are likely to remain in use for some years to come. Tutors should ensure that learners appreciate this while they gaining an insight into how access networks may evolve.

The unit could be delivered as a stand-alone unit or it could be integrated with other telecommunication systems units in order to enhance learning across the qualification. Tutors should try to use as wide a range of delivery techniques as possible. For example, lectures, discussions, use of e-learning courses, learner presentations, site visits, research projects and library resources would all be suitable. These techniques can assist in the achievement of all of the learning outcomes and maintain interest in a predominantly theory-based unit.

Learning outcome 2 provides an opportunity for practical work and centres should consider providing suitable equipment (eg audio signal generator, level meter and calibrated attenuator). This would allow loss and level measurements and calculations to be carried out by learners as part of a practical activity. It would also be useful if access to reels of multi-pair cable were available so that learners could make more advanced measurements, including crosstalk measurements.

It is appreciated that, because of its high cost, many centres will not be able to provide access to more advanced test equipment. However, centres should consider obtaining access to DSL line test equipment so that learners can carry out practical activities relating to learning outcome 4. This would ensure that learners have some knowledge of the capabilities and operation of modern test equipment.

Learners would benefit from access to businesses involved in operating access networks, as this would enable them to put the subjects studied into context. This could be achieved through the centre's links with their learners' employer(s). However, work placement opportunities could be used if the course is full time with learners not yet employed. As a minimum, centres should consider supervised visits to industrial sites where learners can see the relevant equipment areas in operation. Areas that would be applicable to supervised visits include local exchanges and visits to outside plant such as street cabinets. Ideally, the engineer or technician with technical responsibility for the visited area would be available to answer questions.

If work placements are possible, it would be useful if learners could have supervised access to view, for example, the testing of a line at a customer's premises or local exchange. Learners could also be asked to use their workplace or placement as the context for their assessment activities (with permission from the employer/work placement). For example, they could research and write a report describing the architecture of the access network maintained by the learner's employer. Learners could also assist an engineer or technician in their normal duties, although health and safety issues must be taken into account with suitable training and supervision provided.

Learning outcomes 1 and 2 could be delivered before learning outcomes 3 and 4. This will enable learners to appreciate the effects that the limitations of copper-based access networks have on the operation of the systems covered in learning outcomes 3 and 4.

The internet can be used to give learners access to company-specific websites and other sites that give explanations of technical and service aspects of access networks.

Many company websites provide access to technical 'white papers' that can develop learners' understanding of the technologies used in access networks and an appreciation of their capabilities. Descriptions of the types of technology used by a network operator may also be found to ensure learners are exposed to current practice rather than an out-of-date view.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments. The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
<p>Introduction to the unit</p>
<p>Understand the structure, physical components, and transmission media employed in access networks: whole-class exercise – tutor presentation on copper-based access networks, followed by directed research into hardware whole-class exercise – tutor presentation on alternatives to copper-based access networks, followed by directed research.</p>
<p>Assignment 1 - What is an Access Network</p>
<p>Understand the effects of line impairments on transmitted goals: whole-class exercise – tutor presentation on decibels, followed by directed research whole-class exercise – tutor presentation on signal to noise ratio and signal loss calculations, followed by individual exercises whole-class exercise – tutor presentation on Impairments in the local loop, followed by directed research.</p>
<p>Assignment 2 - Sending a clear message Assignment 3 - What's going wrong?</p>

Topic and suggested assignments/activities and/assessment
<p>Understand the operations, capabilities and applications of time division multiplexing (TDM) systems:</p> <p>whole-class exercise – tutor presentation on the principles of TDM, followed by directed research</p> <p>whole-class exercise – tutor presentation on standards, HDB3, G.703, E-carriers, followed by directed research</p> <p>whole-class exercise – tutor presentation on ISDN services, to include multiplexing of basic rate channels for primary rate service, followed by directed research.</p>
<p>Assignment 4 - This what we do</p>
<p>Understand the operations, capabilities and applications of digital subscriber lines (DSL) systems:</p> <p>whole-class exercise – tutor presentation on ADSL systems, followed by directed research into hardware</p> <p>group exercise –directed research into the role and operation of selected hardware items, followed by group presentations to the whole class</p> <p>whole-class exercise – tutor presentation on alternative digital subscriber line systems, followed by directed research</p> <p>whole-class exercise – tutor presentation on <i>DSL testing</i>, followed by individual exercises / practical exercises.</p>
<p>Assignment 5 - What to use where</p> <p>Assignment 6 - What's going wrong, part 2</p>

Assessment

It is suggested that the assessment strategy for this unit should consist of a mix of report writing, practical assignments and formal, time-constrained examinations.

Criteria 1.1 to 2.2 are pre-requisites for the other pass criteria and should be assessed in sequence and before criteria 3.1 to 4.3.

Practical work could aid the assessment of pass criteria 2.1 and 4.3, subject to the availability of suitable equipment. However, 4.3 could also be assessed by providing learners with 'screenshot' displays of test results provided by a test equipment manufacturer or supplier.

Care must be taken with respect to the integrated nature of the pass criteria in this unit. For example, 1.1 asks learners to describe the structure of a copper-based network, while 1.2 asks them to explain the principles and capabilities of alternative transmission media. These criteria could be assessed together, for example by asking learners to describe the structure of a modern access network with reference to the use of copper and alternative transmission media.

Assessment of 2.2 and 4.1 could also be linked. For example, learners could be asked to explain the techniques used in an ADSL system to reduce the impact of the limitations of the local loop on the capabilities of the system.

3.1 and 4.2 could be assessed together by asking learners to explain the capabilities of an E1 2 Mbit/s service and describe the DSL services which could provide an alternative solution for typical applications of E1 systems.

Assessment of 3.2 could be carried out alongside that for 4.1 and 4.2. Learners could be asked to explain the principles of operation and capabilities of the various methods of providing access to the internet and other digital services.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass criteria in the outcomes and assessment grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment methods
1.1, 1.2	What is an Access Network	A telecommunications company asks you to produce some training material for their recruiting team. The material must describe what an access network consists of and explain the similarities differences between a copper-based network and one that uses an alternative transmission media. Potential recruits to the company will have good Science and ICT GCSEs but will be unfamiliar with telecommunications equipment.	Web pages. Presentation. Posters. Booklet.
2.1	Sending a clear message	Your supervisor asks you to demonstrate your understanding of signal loss. You are asked to prepare a short report on signal loss and complete a set of signal loss calculations based on figures given to you.	Brief report. Mathematical calculations.

Criteria covered	Assignment title	Scenario	Assessment methods
2.2	What's going wrong?	Your supervisor asks you to prepare a fault finding chart / check list for the Local Loop. The chart should identify: common problems causes of each problem a means of reducing or eliminating the effect of each problem.	Poster. Booklet.
3.1	This what we do	The company asks you to prepare a presentation for a 'Roadshow' explaining the capabilities of their E1 2 Mbit/s service. The presentation should suitable for a non-technical audience. You may assume the company runs a typical TDM system that complies with the standards that you have learned.	Presentation. Web pages.
3.2 4.1, 4.2	What to use where	The company asks you to prepare training material for new employees. The material should compare and contrast the principles of operation and capabilities of: ISDN base rate ISDN primary rate ADSL Alternative DSL. In the context of providing Internet access and other digital services.	Web pages. Presentation. Posters. Booklet.

Criteria covered	Assignment title	Scenario	Assessment methods
4.3	What's going wrong, part 2	Your supervisor asks you to demonstrate your fault finding abilities. Using the chart that you produced for criteria 2.2, you are asked to use test equipment and / or screenshots of test results, to diagnose a set of problems. You must produce a short report of your findings.	Observation. Short report.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC in IT sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
	Telecoms Principles	Telecoms Principles
	Telecommunications Technology	Communication Technologies
		Core Network Techniques
		Telephony Voice Systems Operation
		Telecommunication Systems

This unit maps to some of the underpinning knowledge from the following areas of competence in the Level 3 National Occupational Standards for IT (ProCom):

- 4.7 Systems Design
- 5.1 Systems Development
- 5.3 IT/Technology Solution Testing.

Essential resources

If a practical activity is used to facilitate the achievement of 2.1 then centres should provide learners with access to an audio signal generator, audio level meter and calibrated attenuators.

Indicative reading for learners

Textbooks

Freeman, R — *Fundamentals of Telecommunications, 2nd Edition* (John Wiley and Sons, 2005) ISBN 0471710458

Gagnaire M — *Broadband Local Loops for High-Speed Internet Access* (Artech House, 2003) ISBN 1580530893

Griffiths J — *ISDN Explained* (John Wiley and Sons , 1998) ISBN 0471979058

Functional Skills – Level 2

Skill	When learners are ...
ICT - Finding and selecting information	
Use appropriate search techniques to locate and select relevant information	describing the capabilities and features of alternative DSL systems
ICT - Developing, presenting and communicating information	
Combine and present information in ways that are fit for purpose and audience	describing the structure of a copper-based access network explaining the principles and capabilities of alternative transmission media explaining the effects of impairments in the local loop.