

## Module 25 Advanced Network Theory

<b>Module title</b>	Advanced Network Theory
<b>Module NFQ level (only if an NFQ level can be demonstrated)</b>	8
<b>Module number/reference</b>	BSCH-ANT
<b>Parent programme(s)</b>	Bachelor of Science (Honours) in Computing Science
<b>Stage of parent programme</b>	Award stage
<b>Semester (semester1/semester2 if applicable)</b>	Semester 1
<b>Module credit units (FET/HET/ECTS)</b>	ECTS
<b>Module credit number of units</b>	10
<b>List the teaching and learning modes</b>	Direct, Blended
<b>Entry requirements (statement of knowledge, skill and competence)</b>	Learners must have achieved programme entry requirements.
<b>Pre-requisite module titles</b>	BSCH-CH, BSCH-DNA
<b>Co-requisite module titles</b>	None
<b>Is this a capstone module? (Yes or No)</b>	No
<b>Specification of the qualifications (academic, pedagogical and professional/occupational) and experience required of staff (staff includes workplace personnel who are responsible for learners such as apprentices, trainees and learners in clinical placements)</b>	Qualified to as least a Bachelor of Science (Honours) level in Computer Science or equivalent and with a Certificate in Training and Education (30 ECTS at level 9 on the NFQ) or equivalent.
<b>Maximum number of learners per centre (or instance of the module)</b>	60
<b>Duration of the module</b>	One Academic Semester, 12 weeks teaching
<b>Average (over the duration of the module) of the contact hours per week</b>	4
<b>Module-specific physical resources and support required per centre (or instance of the module)</b>	One class room with capacity for 60 learners along with one computer lab with capacity for 25 learners for each group of 25 learners

Analysis of required learning effort		
	Minimum ratio teacher / learner	Hours
<b>Effort while in contact with staff</b>		
Classroom and demonstrations	1:60	30
Monitoring and small-group teaching	1:25	18
Other (specify)		
<b>Independent Learning</b>		
Directed e-learning		
Independent Learning		102
Other hours (worksheets and assignments)		100
Work-based learning – learning effort		
<b>Total Effort</b>		250

Allocation of marks (within the module)					
	Continuous assessment	Supervised project	Proctored practical examination	Proctored written examination	Total
<b>Percentage contribution</b>	50%			50%	100%

### Module aims and objectives

This module provides the learner with a detailed understanding and appreciation of the different networking standards and protocols with more emphasis above the physical level, but with some reference to the physical layer. The module covers the different protocols commonly found and focuses on available WAN technologies. This module also covers network management and security issues.

### Minimum intended module learning outcomes

On successful completion of this module, the learner will be able to:

1. Apply signal encoding and scrambling techniques
2. Discuss detailed error detection and correction techniques
3. Evaluate the detailed routing techniques for data through data networks
4. Discuss IP addressing and subnetting
5. Identify congestion problems and discuss congestion controls
6. Discuss transport level end to end communication
7. Discuss protocols related to wireless networks and concepts network security
8. Critically analyse a communication system functionality or protocol and present conclusion

## **Rationale for inclusion of the module in the programme and its contribution to the overall MIPLOs**

This module provides the learner with a detailed understanding and appreciation of communication networks standards and protocols. The module builds on the knowledge already obtained and brings it up to the next level. This module looks at advanced topics in signalling and error detection and introduces functionalities at higher layers. This module concentrates on the higher layer network protocols such as datalink layer, network layer and the transport layer.

Appendix 1 of the programme document maps MIPLOs to the modules through which they are delivered.

## **Information provided to learners about the module**

Learners receive a programme handbook to include module descriptor, module learning outcomes (MIMLO), class plan, assignment briefs, assessment strategy, and reading materials.

## **Module content, organisation and structure**

### **Introduction and Revision:**

- connection and connectionless oriented services
- acknowledged and unacknowledged services
- Network models, end-to-end & node-to-node, topologies, devices and media access.

### **Transmission and Error control:**

- Scrambling techniques.
- Error detection and correction.

### **Flow control,**

- Sliding window protocols: Stop-and-wait, go-back-n & selective repeat -

### **Network layer:**

- Routing. Fixed, adaptive, distributed, centralised, random, flood.
- Distance vector routing algorithms
- Link state routing algorithms.
- Congestion control

### **Transport Layer TCP/IP protocols**

- TCP/IP Protocol architecture.
- End-to-end and link-to-link error detection
- IP addresses, classes or address class, masks.
- IP 4 packets, TTL fields, IP packet fragmentation and reassembly.
- ICMP protocol

- TCP protocol and reliable transmission.
- UDP protocol
- Wireless Networks and IEEE802.xxx

#### **Security of communications:**

- Security attacks, passive and active attacks.
- Types of attacks,
- Security services
- confidentiality, integrity, authentication, availability, Non-repudiation.
- Conventional encryption and public key encryption.

#### **IP addressing and Subnetting**

- IP addresses, address classes, and address
- IPv4 & IPv6 addresses
- Subnetting and masks.

#### **Module teaching and learning (including formative assessment) strategy**

The module is delivered through a combination of lectures, tutorials, and practical lab sessions. The tutorials and practical lab sessions reinforce the learning in lectures. The emphasis is on developing knowledge and understanding in context. Learners get practical experience through working with networks in the faculty hardware lab.

Assessment is divided into four elements. The continuous assessment consists of a series of tutorials, a take home assessment, and a mid-term class test. These assess the learner's competency in specific areas of the syllabus. Finally, there is an end of semester exam that tests the learners understanding of the theoretical material.

#### **Timetabling, learner effort and credit**

The module is timetabled as one 3-hour lecture and one 1-hour tutorial per week.

The number of 10 ECTS credits assigned to this module is our assessment of the amount of learner effort required. Continuous assessment spreads the learner effort to focus on the aspects of the course under discussion.

There are 48 contact hours made up of 12 lectures delivered over 12 weeks with classes taking place in a classroom. There are also 12 tutorial sessions delivered over 12 weeks taking place in a smaller class room. The learner will need 102 hours of independent effort to further develop the skills and knowledge gained through the contact hours. An additional 100 hours are set aside for learners to work on worksheets and assignments that must be completed for the module.

The team believes that 250 hours of learner effort are required by learners to achieve the MIMLOs and justify the award of 10 ECTS credits at this stage of the programme.

### **Work-based learning and practice-placement**

There is no work based learning or practice placement involved in the module.

### **E-learning**

The college VLE is used to disseminate notes, advice, and online resources to support the learners. The learners are also given access to Lynda.com as a resource for reference.

### **Module physical resource requirements**

Requirements are for a classroom for 60 learners equipped with a projector.

### **Reading lists and other information resources**

#### **Recommended Text**

Kurose, J. F. and Ross, K. W. (2017) *Computer Networking: a top-down approach*. Boston: Pearson.

#### **Secondary reading**

Stallings, W. (2013) *Data and Computer Communications*. Boston: Pearson Education.

Comer, D. E. (2014) *Computer Networks and Internets*. Boston: Pearson Education Limited.

### **Specifications for module staffing requirements**

For each instance of the module, one lecturer qualified to at least Bachelor of Science (Honours) in Computer Science or equivalent, and with a Certificate in Training and Education (30 ECTS at level 9 on the NFQ) or equivalent.. Industry experience would be a benefit but is not a requirement.

Learners also benefit from the support of the programme director, programme administrator, learner representative and the Student Union and Counselling Service.

### **Module Assessment Strategy**

The assignments constitute the overall grade achieved, and are based on each individual learner's work. The continuous assessments provide for ongoing feedback to the learner and relates to the module curriculum.

<b>No.</b>	<b>Description</b>	<b>MIMLOs</b>	<b>Weighting</b>
<b>1</b>	Tutorials: aims at enhancing the understanding of module material covered.	1, 2, 3, 5, 6, 7	15%
<b>2</b>	Assignment: a programming or a technical report writing on some topic of networks.	8	15%
<b>3</b>	A mid-term test.	1, 2, 3, 4	20%
<b>5</b>	Written exam that tests the theoretical aspects of the module	1-7	50%

All repeat work is capped at 40%.

### **Sample assessment materials**

Note: All assignment briefs are subject to change in order to maintain current content.

## Tutorial 01 – Switching techniques

**Module:** \_\_\_\_\_ **date:** \_\_\_\_\_  
**Student no.:** \_\_\_\_\_ **Family name:** \_\_\_\_\_  
**First name:** \_\_\_\_\_

Which of the following statements is correct when used to describe each of the three communication techniques: the Circuit Switching, the Datagram switching and the Virtual Circuit switching techniques.

For each of the techniques or in each column, answer “Yes” or “✓” if the statement applies to the techniques correctly or describes it. Or answer “No” or “X” if the statement is wrong or if it does not apply to the particular switching technique.

No.	Statement	Circuit Switching	Datagram	Virtual Circuit
1	A physical connection between calling and called stations is established for exclusive use of the call session until the connection is terminated			
2	Larger headers are not required. Either smaller or no headers for data transfer.			
3	A call may be blocked if resources required for it to start and continue are not available even before the call starts			
4	A route is established during call set up in the network between sender and receiver by making appropriate entries in special tables in each router.			
5	All data between two users must follow the same route			
6	Each packet contains all info needed, and is individually and independently treated from other packets on the same call.			
7	Each packet must contain sender’s and receiver’s addresses and some other information			
8	A message is broken into packets by sender. Packets are hopefully re-assembled into the same message by receiver.			
9	Routers will find the best rout for each data packet passing through them even if they heading for the same receiver.			
10	This techniques is directly suited for implementation of the Internet Protocol.			
11	No physical connection in any form is needed between the source and destination in order for communication to happen.			
12	Suitable for remote live video and sound music over the net.			
13	Successive packets in a call from same sender to same receiver MAY follow different routes through the network			
14	Successive packets in a call from same sender to same receiver MUST follow different routes through the network			
15	Successive packets in a call from same sender to same receiver MUST follow the same route through the network			
16	Before data can be sent, a call set up must be performed			
17	If a link along the route of a call fails, then this communication call will fail.			

<b>18</b>	Ideal for short-lived bursts of traffic; less suitable for long-lived bursts of traffic			
<b>19</b>	Each packet monopolises a link during its transmission only from one node to the next, after which the link is available for transmissions of other packets for other calls.			
<b>20</b>	Each packet must carry the VC number identifier			
<b>21</b>	The best route to follow is determined separately for each data packet on each and every call			
<b>22</b>	Routing is so flexible, as in routing may quickly change as traffic loads in the network changes.			
<b>23</b>	Quality of service (QoS) (Or at least a minimum level of QoS) is guaranteed for a single call.			
<b>24</b>	The fastest sure way to transmit large amounts of data of those three techniques.			
<b>25</b>	Consists of 3 phases: call setup, data transfer and call clearing			
<b>26</b>	The most inefficient of the three at utilizing the network			
<b>27</b>	A call setup is required and a dedicated physical path is reserved for the call			
<b>28</b>	It is likely that packets may arrive out of sequence			
<b>29</b>	Data packets don't need to carry source and destination addresses			
<b>30</b>	Acknowledgment of packets received is an integral part of this technique.			
<b>31</b>	End-to-end acknowledgment is possible to have or implement at end user's machines as additional functionality			
<b>32</b>	A user wanting to commence communication may be denied.			
<b>33</b>	Provides a confidential and secure way of message exchange.			
<b>34</b>	More suited for sending messages for broadcasting or advertising purposes			
<b>35</b>	Easier to implement accounting and charging			
<b>36</b>	If a data unit has an error it is dropped with no further action in this technique			
<b>37</b>	Before data can be sent, the receiver's machine must be live on the network and attended by some user or application.			
<b>38</b>	A receiver always has the right to accept or refuse a call			
<b>39</b>	Lowest cost for users to subscribe to.			
<b>40</b>	Will be more profitable to a network service provider.			



## Tutorial 02 – Encoding and Scrambling

- (1) Draw four graphs of the NRZ-I scheme using each of following data streams. Assume that the last signal level has been positive.
  - i) 00000000
  - ii) 11111111
  - iii) 01010101
  - iv) 00110011
- (2) What are the differences between Asynchronous and synchronous serial transmission?
- (3) The following diagram shows a signal representing the data string: 1100001000000000. Use the B8ZS scrambling technique and redraw the diagrams with the signal pattern generated for transmission.
- (4) Why is scrambling used in digital data encoding? Give four reasons.
- (5) Draw the Bipolar-AMI line code for the bit sequence 1100000000110000010, then draw the line code for the B8ZS and the HDB3 scrambling techniques on the same sequence.

## Tutorial 3 – Error Detection & Correction

- (1) Show the new message to be sent by a sender after performing the CRC calculation using the generator  $X^3+1$  on the message: 101110110.
- 2) CRC error detecting code: Given the message  $M = 1010001101$ , determine the CRC using the generator polynomial  $P=x^5+x^4+x^2 +1$ .
  - a) Show the polynomial key; calculate the CRC and the message to be transmitted.
  - b) How does the receiver check whether the message T was transmitted without any errors? Show that a transmission error (a bit change in the message) shall be discovered.
- (3) This is a received message: 101110110101 which includes the frame check sequence calculated by CRC using the generator:  $X^3+1$ . As a receiver find out whether the message contains any errors.
- (4) What are the advantages and disadvantages of Hamming code.

- (5) This message 11001100 needs to be sent after applying 4 parity even Hamming code. Show the full message to be sent.
- (6) How much redundant information does the basic parity bit error check carries?
- (7) The message 11001101 10101000 10111010 was received. For each of the methods below, show whether the message contains any errors.
  - (i) Using Odd Parity Bit error detection.
  - (ii) Using the Block Parity check with odd rows and columns, and the last byte considered a parity byte.

### **Tutorial 04 – Flow control**

- (1) Compare the memory requirement imposed on sender and receiver nodes by Go-Back-N protocol. Give examples to support your answers.
- (2) Explain Piggyback acknowledgements.
- (3) What are the benefits of using the sliding window protocol?
- (4) With reference to a go-back-n sliding window protocol:
  - a) Would the use of sequence numbers be necessary? Justify your answer.
  - b) Is a timer necessary or advisable in this protocol at the sender? Is a timer necessary or advisable at the receiver? Justify your answers.
  - c) Describe how the receiver would know when a data packet sent by the sender is lost.
  - d) Describe two situations where the receiver will not know when a data packet sent by the sender is lost.
  - e) Consider the selective repeat protocol and the go-back-n protocol. In the case of errors, which of these protocols requires the sender to send fewer packets? Explain your answer.
- (5) For each of the following frame errors, describe how can it happen and how it can be fixed:
  - a) Out of sequence frame,
  - b) Duplicate frame
  - c) Damaged frame
  - d) Lost frame
  - e) Frame number outside the expected range

## Tutorial 5 - Routing

- 1) Describe flood routing; and give three of its advantages.
- 2) Show, using a diagram, whether or not an optimal routing algorithm is always fair.
- 3) Show how the Count-to-infinity problem occurs if a node fails. Select a node to fail for your explanation.
- 4) Explain each of the following with reference to routing algorithms:
  - (i) Adaptive and Non-adaptive
  - (ii) Centralized and Distributed
  - (iii) Robustness and Conversions
  - (iv) Routing and Forwarding
- 5) Explain problems which are associated with Centralized routing.
- 6) Explain differences between Distance vector and Link state routing algorithms.

## Tutorial 06 - Congestion

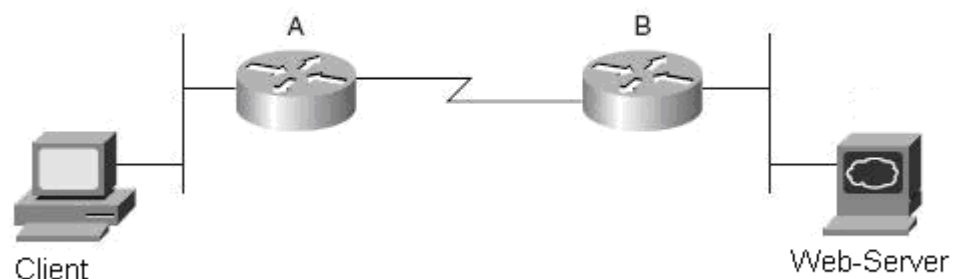
- (1) What is congestion in communication networks?
- (2) Give two causes of congestion.
- (3) Name three methods whose aim is to prevent congestion.
- (4) Differentiate between the Leaky bucket and the Token bucket algorithms?
- (5) Describe “choke packet” approach in dealing with congestion and explain its disadvantages.
- (6) Are the objectives of flow control and congestion control the same? Explain your answer.
- (7) Explain how each of the following can be used to achieve good quality of service:
  - a. Buffering
  - b. Resource reservationWhat are the drawbacks of each technique?

- (8) Is there a relationship between QoS and congestion control? Discuss.

## Tutorial 07 - IP addressing and sub-netting

- (1) IP address allocated is 130.16.0.0 with a mask: 255.255.0.0. Thirteen subnets are required. Devise an IP subnet plan, giving the network, first host, last host and broadcast IP addresses for the first two subnets. Also specify the subnet mask you would use.
- (2) IP addresses are classified based on the number of host and network addresses permitted in each class;
- (i) *How many bits are assigned for the network in class A, B and C addresses?*
  - (ii) *clearly state how each class of address, can be determined,*
- (3) RFC 1918 details a set of unregistered IP network-numbers and the range of addresses for each: list these network numbers for use in *private* networks?
- (4) Referring to the figure below, the network address is: 200.1.1.0 with a mask: 255.255.255.224. The host named Web-Server has been configured with the IP Address 200.1.1.70, Router B's Ethernet interface has been configured with 200.1.1.60 and Router B's serial interface (out the WAN link to Router A) has been configured with 200.1.1.115. Router A's serial interface has 200.1.1.99, and its Ethernet interface is configured with 200.1.1.159. The host named Client has been configured with a 200.1.1.130.

What is wrong with this network? If so, what is the easiest thing that can be done to fix it?



## Tutorial 08 – Introduction to Security - Encryption

- (1) What is a session key?
- (2) Recommend five ways through which a conventional encryption system can be made more difficult to break.
- (3) Write the definition of each of the following:
  - (i) Data Integrity,                      (ii) Authenticity,                      (iii) Non-Repudiation.
  - (iv) Data confidentiality              (v) Denial of Service Attack (DoS)
- (4) What is the difference between substitution encryption and transposition encryption?
- (5) With the help of a diagram explain the basic operation of a Conventional encryption system.
- (6) Briefly, what is the difference between passive and active attacks?
- (7) How can symmetric encryption systems be attacked? and how could such attacks be resisted?
- (8) With reference to asymmetric (public key) encryption systems:

Draw a diagram and describe how the public key encryption and decryption system works, showing the six elements of the system.
- (9) Give two characteristics of the keys used in public key encryption systems.
- (10) Name three methods of how keys are distributed.

(11) Explain the difference between using public key encryption system for confidentiality or authentication?

(12) State three functions (or services) that asymmetric encryption systems provide.

## **Tutorial 09 – End-to-End communication & Wireless Networks**

Q1) How do Wireless LAN differ from wired LANs?

Q2) Explain roaming in wireless networks.

Q3) What are the advantages of 802.11g over previous versions (802.11e, 802.11a)

Q4) Comment on the following statement: “End-to-End error detection is better than link-to-link error detection”.

Q5) In data networks, is better to use large packet sizes of smaller packet sizes? Explain your idea.

**GRIFFITH COLLEGE DUBLIN**

**ADVANCED NETWORK THEORY**

## **Class test**

**Lecturer:**

**Date: XXXXX**

**Time: xXXX**

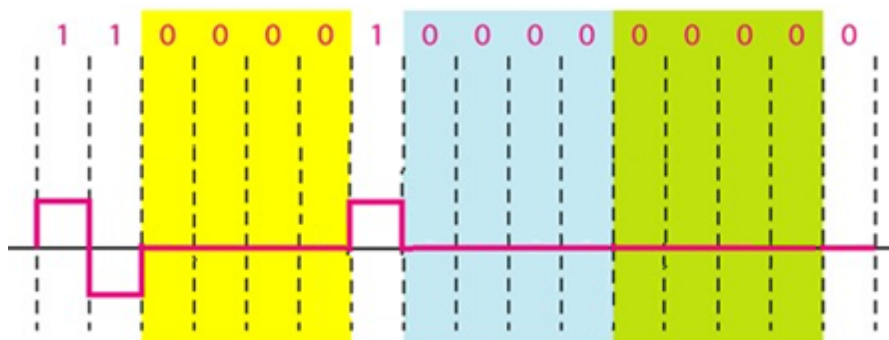
**This is a closed book, 80 minute test**

**This Class Test is worth 20% of the overall marks for the module.**

**ALL QUESTIONS TO BE ATTEMPTED.**

**ALL QUESTIONS CARRY EQUAL MARKS.**

- (1) The following diagram shows a signal representing the data string: 1100001000000000. Use the B8ZS scrambling technique and redraw the diagrams with the signal pattern generated for transmission.



- (2) Using Hamming code find out whether the following received message contains any errors, and if it does then identify which bit: 1000110000000. Finally, identify the original user message. The message was coded using even hamming code. Assume there can only be error in one bit or no error. Show your work.
- (3) Write at least ten statements describing the virtual circuit switching technique.
- (4) What complication arises when many bridges or switches are connected in parallel in an Ethernet network? And how it can be solved?
- (5) If frames 1 to 5 are sent, but frame 1 becomes lost. How is the problem of this lost data frame handled in go-back-n sliding window protocol? Draw a detail diagram for total recovery.
- (6) Why is the “time-to-live” approach required in flood routing?



**BSc4 Advanced Network Theory  
Literature Survey and Report  
Assignment (15%)**

Investigate and study the topic allocated to you from the list below. A different topic may be suggested and may be used **if and only if approved** by your lecturer. Then write a comprehensive report about your investigation. Your study should not be general in nature but must concentrate on a specific aspect of the topic area. In relation to the topic and according to the relevance many aspects like performance, efficiency, design, implementations, algorithms, comparisons and operations may be covered. Your report should not exceed 7 pages and must not be less than 5 pages when printed using standard A4 papers and fonts no larger than 14 and no smaller than 10 points. But don't print it on paper.

The report must be submitted electronically as an MS DOC Word Document file. If you cannot make submission in this format then talk to the lecturer. The file must be uploaded into the module page on Moodle.

The first page of the report must include the following:

1. A suitable title for the report,
2. Your Student no.
3. Clearly and separately indicating your first name and family name
4. The course: in this case it should be (BSc4-ANT Advanced Networks Theory).
5. Please have the pages of your report numbered.

Please refer to recommended text books for the course. References can also be made from any books, journals, papers or reputable Websites.

The report must include the following 5 parts:

- 1) A brief abstract at the start. The abstract outlines what the report is about and the motivation for the study
- 2) An introduction providing a general discussion of the topic area describing the topic area and its relevance to the area of networks and communications.
- 3) A detailed discussion of the relevant area of the topic.
- 4) A report summary at the end.
- 5) A list of references to sources of materials used. The reference list must be clearly indicated and can be from papers, books, technical reports, journals or reputable Internet websites.

The report must also include some drawings, or charts, or diagrams or case studies or examples in order to help clarify the ideas discussed.

**Marks will be assigned as follows:**

- 1) A brief abstract of the report outlining what the report is about and the motivation for the study. **(10 marks)**
- 2) Introduction. A general describing of the topic area and its relevance to networks and communication systems. **(10 marks)**
- 3) A detailed discussion of the area of relevance in the topic. **(30 marks)**
- 4) Use of examples, cases, drawings, charts and/or diagrams where and when relevant to help clarify ideas. **(20 marks)**
- 5) A brief summary of the report **(10 marks)**
- 6) List of references. References to sources of materials must be clearly indicated i.e. papers, books, technical reports, journals and Internet websites. At least five references are required **(10 marks)**
- 7) The lecturer's overall evaluation of the report based on clarity and substance. **(10 marks)**

**List of suggested topics or areas**

01) Error detection	02) Spanning Tree Protocol
03) Flow control	04) Banyan or Delta switches
05) Routing	06) Congestion in data networks
07) Wireless Networks	08) Shortest Route algorithm
09) Any of the Internet Protocols	10) Network Security
11) Encryption	12) Firewalls
13) Virtual Private Networks VPN	14) Traffic balancing
15) TCP	16) IP Addressing
17) Routers	18) Hamming Code
19) Security protocols	20) Token passing media access protocol
21) Mobile Phone networks	22) Local Area networks.
23) Sub-networking	24) Wireless Protocols
25) Virtual circuits	26) Addressing
27) Chocking packet algorithms	28) Digital signatures.
29) Routing Information Pro. (RIP)	30) Datagram switching.
31) Open Shortest Path First (OSPF)	32) Leaky bucket algorithms

Please note that a signed assignment submission sheet is required.

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**GRIFFITH COLLEGE DUBLIN**

**QUALITY AND QUALIFICATIONS IRELAND  
EXAMINATION**

**ADVANCED NETWORK THEORY**

**Lecturer(s):**

**External Examiner(s):**

**Date:           XXXXXXXX**

**Time: XXXXXXXX**

**THIS PAPER CONSISTS OF FIVE QUESTIONS  
FOUR QUESTIONS TO BE ATTEMPTED  
ALL QUESTIONS CARRY EQUAL MARKS**

**THE USE OF NON-PROGRAMMABLE CALCULATORS IS PERMITTED DURING THIS  
EXAMINATION  
APPENDIX AT BACK OF EXAMINATION PAPER**

### QUESTION 1

- (a) State three advantages of CSMA and three disadvantages when compared with Token Ring as a Media Access Control method.

**(6 marks)**

- (b) Draw diagrams showing five topologies used in networking. In addition, state the numbers of cable segments (cable pieces) used in each topology.

**(7 marks)**

- (c) With the aid of a diagram explain these terms in relation to the OSI model.

- (i) Peer processes
- (ii) Encapsulation
- (iii) End-to-end communication

**(6 marks)**

- (d) Many devices exist on a network to facilitate data transfer. Discuss six differences between the switch and the router devices on a network.

**(6 marks)**

**Total (25 marks)**

### QUESTION 2

- (a) In relation to framing explain what a frame delimiter is and the purpose it serves. State an example of same in your answer.

**(3 marks)**

- (b) Perform the two following operations:

- (i) BIT STRIPPING on this received bit pattern **011111010111110010**
- (ii) BIT STUFFING on the following bit pattern:  
**01111101111110101111110001** that is being prepared for transmission.

**(4 marks)**

- (c) Generate the Hamming Codeword for the following data bit pattern: 111010110 using even code.

**(8 marks)**

- (d) The following bit pattern 1001001111 is being prepared for transmission. If the known divisor is  $X^3 + 1$ , calculate the CRC to be appended to the data prior to transmission. And show the full message with the CRC to be transmitted.

**(10 marks)**

**Total (25 marks)**

### QUESTION 3

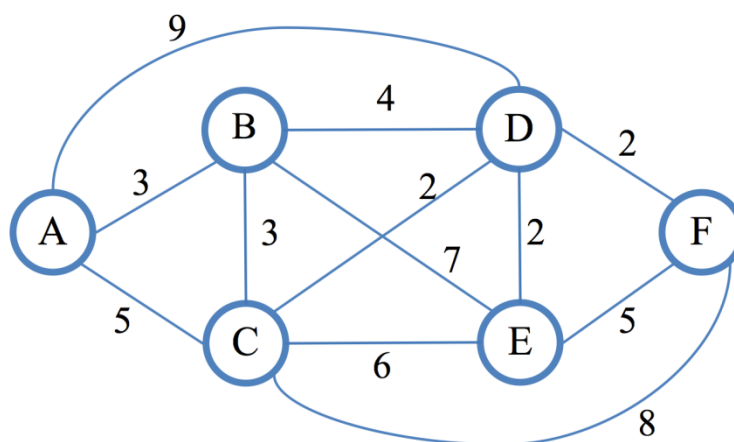
- (a) Explain what a static route is and how it would be implemented. Give an example of when it would be appropriate to create such a route.

**(4 marks)**

- (b) The two main classifications of routing protocol are distance vector and link state routing protocol. Compare the two classifications using five appropriate headings.

**(5 marks)**

- (c) Generate Router E's routing table using Dijkstra's shortest path algorithm.



**(6 marks)**

- (d) "Fibre optic cabling should be used in local area networks". Discuss this statement using five different arguments in support of your position.

**(10 marks)**

**Total (25 marks)**

### QUESTION 4

- (a) Explain the normal operation only of the Go-back-n sliding window flow control protocol. Diagrams must be used in your answer showing a total of 10 frames only sent using window size of 4 with sequence number 0 to 7.

**(6 marks)**

- (b) If frames 1 to 5 are sent, but frame 1 becomes lost. How is the problem of this lost data frame handled in each of the two following protocols?

- (i) Go-back-n sliding window Wait protocol

**(5 marks)**

(ii) Selective repeat (or reject) sliding window protocol

**(5 marks)**

(c)

(i) What is congestion in communication networks?

**(3 marks)**

(ii) Explain the Token Leaky bucket algorithm and how it helps prevent congestion.

**(6 marks)**

**Total (25 marks)**

### **QUESTION 5**

(a) If a host on a network has the address 172.16.45.14/30, what is the subnetwork this host belongs to?

**(10 marks)**

(b) An interface on a router has the IP address of 192.168.192.10/29. Give all other IP address, which can be allocated, to hosts on the LAN attached to the router interface. What is the subnetwork address and its broadcast address?

**(10 marks)**

(c) Write at least ten statements describing datagram switching techniques.

**(5 marks)**

**Total (25 marks)**