2019 EXAMINATIONS

Lancaster University

Part II

COMPUTING AND COMMUNICATIONS [2.5 Hours]

SCC.203 Computer Networks

Candidates are asked to answer THREE questions from FOUR; each question is worth a total of 25 marks.

Use a separate answer book for each question.

Simple calculators permitted

Question 1

1.a Communication is organised in multiple layers.

i. Explain how the layered architecture of the Internet facilitates development of applications.

[2 marks]

ii. Describe two drawbacks of protocol layering.

[4 marks]

iii. Explain the difference between services and protocols.

[2 marks]

1.b Consider the following hypothetical DNS record for an organization:

Name	Type	Value	TTL (seconds)
dithen.co.uk	A	52.1.126.117	3600
dithen.co.uk	NS	oberon.dithen.co.uk	3600
dithen.co.uk	NS	thor.dithen.co.uk	3600
dithen.co.uk	MX	hangzhou.dithen.co.uk	60
oberon.dithen.co.uk	A	52.1.126.110	3600
thor.dithen.co.uk	A	52.1.126.111	3600
hangzhou.dithen.co.uk	A	52.1.126.112	3600
zeus.dithen.co.uk	A	52.1.126.113	3600
www.dithen.co.uk	CNAME	zeus.dithen.co.uk	3600

i. If you send email to support@dithen.co.uk, explain which IP address the message will be delivered to?

[2 marks]

ii. The TTL (Time To Live) field indicates how long a DNS resolver can cache the record. A TTL of of 3600 seconds corresponds to 1 hour, while a TTL of 86400 seconds corresponds to 1 day. What is the trade-off between choosing a shorter or a longer TTL? Why was the MX record specifically chosen to have a much shorter TTL?

[3 marks]

Question 1 continues on next page…

Question 1 continued.

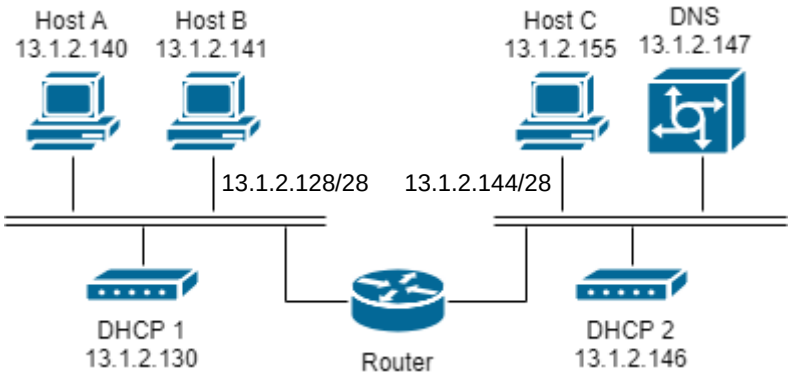
iii. The host linux utility is used for performing DNS lookups. Below is the output of the command `host bbc.co.uk`, which returns the 4 IP addresses for bbc.com:

```
$ host bbc.co.uk
bbc.co.uk has address 151.101.128.81
bbc.co.uk has address 151.101.192.81
bbc.co.uk has address 151.101.0.81
bbc.co.uk has address 151.101.64.81
```

Can you explain why the BBC uses multiple IP addresses for its domain name? What is this technique called?

[3 marks]

1.c. Consider the following network at a small company. The company has been allocated the IP prefix 13.1.2.128/27 and has split this prefix over two subnets, 13.1.2.128/28 and 13.1.2.144/28, as shown in the diagram. The DHCP and DNS servers have been manually configured with their IP addresses and default router, while the hosts A, B, and C obtain their IP addresses, subnet masks, default router and DNS server from their respective DHCP server.



i. Suppose that Host A wants to send an IP datagram to Host B and knows B's IP address. Must A also know B's MAC address to send the datagram to B? If so, how does A get B's MAC address? If not, explain why not.

[2 Marks]

ii. Suppose that Host A wants to send an IP datagram to Host C and knows C's IP address. Must A also know C's MAC address to send the datagram to C? If so, how does A get C's MAC address? If not, explain why not.

[2 Marks]

Question 1 continues on next page…

Question 1 continued.

iii. The network operator accidentally configured both servers with an error when converting prefix lengths to netmask:

- DHCP 1: subnet 13.1.2.128 netmask 255.255.255.224
- DHCP 2: subnet 13.1.2.144 netmask 255.255.255.224

What did she get wrong in both cases and what should the correct value be?

[1 mark]

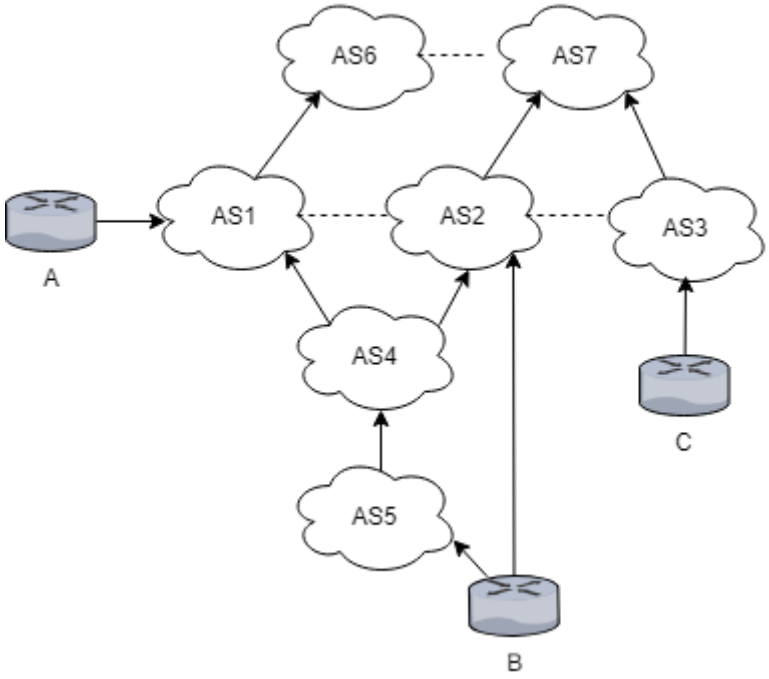
iv. Due to the configuration error the network doesn't behave correctly. Host C can connect to the Internet and browse the web without problem. But Hosts A and B cannot access the web. To debug the problem, the network operator uses ping. She types `ping google.com` on each host and discovers that Host C can successfully ping google.com, but ping fails on A and B with the error message: *"ping: cannot resolve google.com: Unknown host"*. However, when she types `ping 216.58.210.78` (one of Google's IP addresses), this works as expected from all three hosts. Explain in detail how the DHCP misconfiguration gives rise to these symptoms.

[4 Marks]

Total 25 marks

Question 2

2.a Consider the topology below that forms part of the Internet map. Clouds represent Autonomous Systems (ASes) that connect to other networks using the Border Gateway Protocol (BGP), which provides connectivity to BGP-speaking edge networks (A, B and C). A single-ended arrow indicates a "customer-to-provider" relationship, while dashed lines indicate "peer-to-peer" relationships. For example, network B is a customer of ASes 5 and 2, while AS1 and AS2 are peers. Paths are selected at each AS based on the normal customer/provider/peer policies, and no other policy is applied.



i. Suppose AS1 receives a route to network B from AS6, and it has not yet learned another path to B from any other AS. Which neighbours will AS1 export that route to, and which not? Explain your answer.

[2 marks]

ii. Suppose AS1 now also receives a route to network B from AS2. Will AS1 prefer the route via AS2 or the route via AS6? Which BGP attribute determines the route in this case?

[2 marks]

iii. Explain how the valley-free BGP policy can lead to path inflation. Provide an example based on the above topology.

[3 marks]

Question 2 continues on next page…

Question 2 continued.

2.b BT and Deutsche Telecom (DT) both have international networks and they peer with each other via two local links, one in London and one in Frankfurt. Consider the case where traffic flows from a bank in Frankfurt that is a DT customer, to a bank in London that is a BT customer. Describe how the BGP routing policy determines whether BT or DT will carry the traffic from Frankfurt to London.

[3 marks]

2.c Error detecting codes

i. Two-dimensional parity can catch all 3-bit errors, but not all 4-bit errors. In the following diagram change four of the bits in a way that 2D-parity will not detect the change.

		Parity bits
Data	0101001	1
	1101001	0
	1011110	1
	0001110	1
	0110100	1
	1011111	0
Parity Byte	1111011	0

[3 Marks]

ii. You want to transmit the message 11001001 using the Cyclic Redundancy Check (CRC) polynomial x^3 + 1 to protect it from errors. Calculate the message to be transmitted and show the process.

[4 Marks]

iii. TCP and UDP use checksums for error detection, while Ethernet uses CRC. Can you explain why?

[2 Marks]

Question 2 continues on next page…

Question 2 continued.

2.d Multiple access protocols

i. In a slotted aloha system, suppose each host always has data to send and transmits with probability p = 0.2 in every slot. There is no backoff and one frame can be transmitted in one slot. If more than one host transmits in the same slot, then the transmissions are unsuccessful due to collision. What is the maximum number of hosts which this protocol can support, if each host has to be provided a minimum through put of 0.16 frames per time slot?

[4 marks]

ii. Explain why CSMA outperforms Aloha.

[2 marks]

Total 25 marks

Question 3

3.a Almost all communication protocols used in the modern Internet are standardised in some way. Explain why standardisation is an important process, using an example to illustrate what would happen *without* this in place?

[2 marks]

3.b The Internet is composed of core and edge networks, built in a hierarchical fashion.

i. Using your knowledge of the Internet hierarchy, state the purpose and composition of an edge network, contrasting this with a core network.

[3 marks]

ii. Peering is often used between two or more ISPs operating at the same level of the Internet hierarchy. Why is peering beneficial to these parties, and what would happen if they did not peer? **[2 marks]**

iii. What is the role of an IXP and how do they earn money? **[2 marks]**

3.c An application transmits data at a steady rate, generating fixed-sized units of data over a small and static interval. When started, the application also runs continuously.

i. Would a packet-switched or circuit-switched network be more appropriate to use for this application? Explain why, and justify your answer.

[4 marks]

ii. Consider a packet-switched network, with the only traffic on the network originating from multiple hosts running the same application as described at the beginning of question 3.c. In addition, assume that the total data rate (combined between all hosts) is less than the capacity of every link in the network. Explain whether congestion control is needed, justifying why this is the case.

[3 marks]

Question 3 continues on next page…

Question 3 continued.

3.d Two hosts, A and B, are connected by a single link with a rate of R bps. The hosts are m meters apart, with a propagation speed s along the link measured in meters/sec. Host A sends a packet to Host B of size L bits.

i. State the propagation delay, d_{prop}, in terms of m and s. **[1 mark]**

ii. State the transmission time of the packet, d_{trans}, in terms of L and R. **[1 mark]**

iii. Form an expression for the end-to-end delay, ignoring processing and queuing delays. **[1 mark]**

iv. Suppose Host A begins to transmit a packet at time $t = 0$. At time $t = d_{trans}$, where is the last bit of the packet? **[1 mark]**

v. Suppose d_{prop} is greater than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet? **[1 mark]**

vi. Suppose d_{prop} is less than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet? **[1 mark]**

vii. Suppose $s = 3.2 \cdot 10^8$, $L = 240$ bits, and $R = 128$ kbps. Find the distance m such that d_{prop} equals d_{trans}. Show your working. **[3 marks]**

Total 25 marks

Question 4

4.a The Domain Name System (DNS) is used to resolve between human readable addresses and IP addresses.

i. DNS resolution relies on a hierarchical configuration of DNS servers. Describe the three *main* types of DNS server, and briefly explain the purpose of each. Use a diagram to illustrate how these are arranged.

[4 marks]

ii. Explain how DNS caching is used in conjunction with a local DNS server. Drawing diagrams to aid you, show how a request is resolved *before* caching is implemented, and *after* caching is implemented.

[3 marks]

iii. Compare recursive DNS queries to iterative DNS queries, making clear reference to when each would normally be used.

[3 marks]

4.b HTTP is the primary method through which files and objects are delivered over the Internet.

i. Describe the shortcomings of non-persistent HTTP connections, referring to how persistent HTTP connections resolve these issues.

[4 marks]

ii. The HTTP/1.1 standard contains 5 different methods. Describe which of these are used to retrieve content from a remote server, and include the additional fields within the request line.

[2 marks]

iii. A university network connects to the wider Internet using a single 15 Mbps access link. Using your knowledge of web caches, describe *where* a web cache should be deployed to improve the performance of hosts attached to this network, justifying your answer. Be clear about *all* of the advantages.

[4 marks]

Question 4 continues on next page…

Question 4 continued.

4.c SMTP, POP3, IMAP and HTTP are all used in the process of sending and receiving email over the Internet.

i. Using an illustration to aid your answer, explain how a message (sent by User A), is delivered to User B. Be clear what protocols are used at each step, justifying the best choice where multiple options are available.

[4 marks]

ii. Using the same scenario as above, state what happens when a message is sent, but User B's mail server is full.

[1 mark]

Total 25 marks

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