THE UNIVERSITY OF MELBOURNE
DEPARTMENT OF COMPUTING AND INFORMATION SYSTEMS

Practice Examination – Semester 1, 2018

COMP90007: Internet Technologies

Exam Duration: 3 hours **Total marks for this Exam: 60**
Reading Time: 15 minutes
This exam has 6 pages.

Authorised materials:
The following items are authorized: writing materials (e.g. pens, pencils)
Calculators are *not* allowed.

Instructions to Invigilators:
Supply students with standard script book.

The exam paper must remain in the exam room and be returned to the subject coordinator.

Instructions to Students:

- This paper contains 20 questions, each question is worth 3 marks.
- Answer all questions in this exam booklet using pen only in the space provided after the questions. All even pages are intentionally left blank which you can use for rough work. Note that only your answers on odd numbered pages will be marked.
- As a guide, two or three sentences should be sufficient to answer each question.
- Marks may be deducted for overly long answers or irrelevant information.
- Any unreadable answers will be considered wrong.

Q1. Briefly explain the relative advantages and disadvantages of the OSI Reference Model versus the TCP/IP Reference Model. [3 marks]

Some suggested answers:
OSI Negatives:

- *Timing – TCP/IP adopted before OSI was even formalised. Vendors did not want to support 2nd standard.*
- *Although there are 7 layers, 2 of these (session, presentation) are 'almost empty' and 2 others (data link, network) are 'cramped'.*
- *Additionally some functions such as addressing, flow control and error control are recurring and duplicated at each OSI layer.*
- *OSI implementations were inefficient compared to TCP/IP.*
- *OSI was widely perceived as the product of quasi-government standards processes rather than driven by good design processes.*

TCP/IP Negatives:

- *Lack of distinction between concepts doesn't clearly distinguish between service, interface and protocol*
- *Not adaptable not a general model, and hence poorly adapted to other protocol stacks*
- *Ambiguous layers Host-to-Network is not really a layer, but an interface between network and data link layers*
- *Omitted the Physical and Data Link layers*
- *Early implementations were fragile*

Q2. The following data is the output of traceroute on a computer in a Alice Hoy laboratory.

traceroute to cis.unimelb.edu.au (128.250.37.164), 64 hops max, 52 byte packets
1 10.9.152.1 3.304 ms 3.304 ms 3.304 ms
2 172.18.68.81 1.146 ms 1.099 ms 1.076 ms
3 172.18.68.83 1.133 ms 1.144 ms 1.115 ms
4 172.18.68.33 2.175 ms 1.931 ms 2.149 ms
5 172.18.66.133 9.724 ms 1.688 ms 1.989 ms
6 128.250.37.130 1.246 ms 1.205 ms 1.381 ms
7 128.250.37.164 1.988 ms 2.035 ms 1.848 ms

a. What is the IP address of the router connected to the destination?

Suggested answer:
128.250.37.130

b. Explain how Traceroute uses ICMP (Internet Control Message Protocol) in its operation.

One suggested answer:
Traceroute sends packets to measure the RTT of each intermediate router in the path to reach the destination host.

It does this by sending packets with different TTL (hop limit) values to reach the intermediate routers. The packets Traceroute uses can be ICMP 'echo request' packets, UDP packets or TCP SYN packets. Upon reaching a router, the TTL value is decremented by one, and is dropped if the TTL value is zero. If the packet is dropped, an ICMP 'time exceeded' packet is sent back to the sender. Traceroute measures the timestamp of this packet to determine the RTT.

c. *Average of (**1.146 ms 1.099 ms 1.076 ms)***

Q3. Consider a client program that needs to run the following operations on a remote file server:

a. List the contents of a directory
b. Open a file
c. Read a text file
d. Display the attributes of a file.

For each of the above operations, indicate whether they are more likely to be delay sensitive or bandwidth sensitive. Justify your answer? [3 marks]

a. Delay-sensitive; directories are typically of modest size.
b. Delay-sensitive; the messages exchanged are short.
c. Bandwidth-sensitive, particularly for large files. (Technically this does presume that the underlying protocol uses a large message size or window size; stop-and-wait transmission with a small message size would be delay-sensitive.)
d. Delay-sensitive; a file's attributes are typically much smaller than the file itself (even on NT filesystems).

Q4. The bandwidth and latency are the main characteristics of the networks affecting the performance of applications on networks. Define bandwidth and latency as discussed in lectures. Give an example of a network that exhibits high bandwidth but also high latency. Then give an example of a network that has both low bandwidth and low latency. [3 marks]

One suggested answer:
Bandwidth: the rate of data transferred across two hosts
Latency: the delay experienced by each communicated bit
A network with high bandwidth and high latency: transcontinental fibre link

A network with low bandwidth and low latency: telephone modem

Q5. How can you increase the bit rate of a 1200 baud line from 1200 bit/s to 3600 bit/s? [3 marks]

One suggested answer:
Increase the number of bits encoded per symbol from 1 bit/symbol to 3 bits/symbol. For example, by increasing from a two-level (BPSK) code to an 8-level code (8-PSK).

Q6. Consider a telephone signal that is bandwidth limited to 4 kHz. (a) At what rate should you sample the signal so that you can completely reconstruct the signal? (b) If each sample of the signal is to be encoded at 256 levels, how many bits/symbol are required for each sample? (c) What is the minimum bit rate required to transmit this signal? [3 marks]

a. One suggested answer:
By Nyquist's theorem: min sampling rate = 2 × 4×103
= 8×10^3 samples/s
= 8 kHz
b. One suggested answer:
256 possible values per sample requires:
$log_2(256)$ = 8 bits/sample
c. One suggested answer:
$8×10^3$ samples/s × 8 bits/sample
= $64×10^3$ bits/s

Q7. a. The following binary data fragment occurs in the middle of a data stream for which the bit-stuffing algorithm described in the lectures is to be applied:

00011111101111111111001

Show the output binary data stream after the bit-stuffing algorithm has been applied. (Note that you do **not** need to add any flag bytes)

One suggested answer:
*00011111**0**01111**0**11111**0**001*

b. The following data fragment occurs in the middle of a data stream for which the byte-stuffing algorithm described in the lectures is to be applied:

A B ESC D FLAG FLAG ESC C

Show the output data stream after the byte-stuffing algorithm has been applied.

One suggested answer:
A B ESC ESC D ESC FLAG ESC FLAG ESC ESC C

c. What is the maximum overhead in the byte-stuffing algorithm in general? [3 marks]

One suggested answer:
100% when the payload consists of only ESC and FLAG bytes.

Q8. Briefly explain the difference in operation and philosophy of two approaches to error handling on the data link layer; error-correcting and error-detecting. [3 marks]

One suggested answer:
Error detection includes adding extra information (e.g. a checksum) to the information to allow the receiver to determine if an error has occurred and subsequently request a re-transmission.

Error correction goes one step further and adds extra redundancy to the information so that even in the presence of errors, some of the information can be re-constructed/deduced to what was transmitted.

Q9. Data link protocols almost always put the CRC in a trailer rather than in a header. Why? [3 marks]

One suggested answer:
The CRC is computed during transmission and appended to the output stream as soon as the last bit goes out onto the wire. If the CRC were in the header, it would be necessary to make a pass over the frame to compute the CRC before transmitting. This would require each byte to be handled twice – once for checksumming and once for transmitting. Using the trailer cuts the work in half.

Q10. If a LAN is under high load, would it be more efficient to use a contention protocol or a collision free protocol in the MAC Sub-layer? Briefly explain your answer. [3 marks]

One suggested answer:
Under high load a contention protocol would cause many collisions and not be effective, whereas a collision free protocol allows each source to use the network in turn, with no collisions. Therefore, a collision free

protocol should be used at the cost of a higher overhead compared to contention protocols.

Q11. Briefly explain how the Binary Countdown Protocol works and describe the relative advantages over the Bit Map Protocol. [3 marks]

Some suggested answers:
In the Binary Countdown Protocol, each station has a binary address, and from the high order bit, the highest number "wins" bidding and right to send. Bidding then starts again. Potential disadvantage is high numbers have priority.

Advantages over Bit Map protocol is that it avoids the scalability problem (1-bit per station) and avoids collisions by using the station binary number to arbitrate between stations wanting to send.

Q12. A router has built the following routing table. The router can directly deliver packets over Interface 0 and Interface 1 or it can forward to routers R2, R3 and R4.

Subnet Number	Subnet Mask	Next Hop
148.96.39.0	255.255.255.0	Interface 0
148.96.39.128	255.255.255.128	interface 1
148.96.40.0	255.255.255.128	R2
196.4.153.0	255.255.255.192	R3
Default		R4

Describe what the router does if a packet addressed to each of the following destinations is received.

(a) 148.96.40.12
One suggested answer:
Router 2

(b) 148.96.39.193

One suggested answer:
Interface 1 (also matches Interface 0, but longest-prefix matching)

(e) 196.4.153.90 [3 marks]

One suggested answer:
Router 4 (no matches, so packets gets forwarded to Default interface)

Q13. A router has built the following CIDR entries in its routing table. The router can directly deliver packets over Interface 0 or it can forward to routers R2 and R3.

Address / mask	Next Hop
128.16.64.0 / 21	Interface 0
128.16.80.0 / 21	R2
128.16.72.0 / 21	R2
128.16.88.0 / 21	R2
Default	R3

Can you simplify the routing table by aggregating addresses having the same outgoing lines? Briefly explain your answer. If you can simplify, give the simplified routing table. [3 marks]

suggested answer

128.16.72.0 / 21 R2
128.16.80.0 / 21 R2
128.16.88.0 / 21 R2

72= 01001000
80= 01010000
88= 01011000
Agrregatredadd 128.16.64.0/19

The new table is

Address / mask	*Next Hop*
128.16.64.0 / 21	*Interface 0*
128.16.64.0/19	*R2*
Default	*R3*

Think why the table is correct? In particular, recognize that the first entry has a longest matching prefix than the second; this guarantees the aggregated addresses covered by the second entry do not match with the first.

Q14. Explain the purpose of subnetting and Classless Inter-Domain Routing (CIDR) for logically partitioning the IP Address space. [3 marks]

One suggested answer:
Subnetting allows networks to be split into several parts for internal uses whilst acting like a single network for external use. Subnet masks can be written using:

- *"dotted decimal"(e.g. 255.255.255.128 indicates 2 internal networks)*
- *"slash" notation (e.g. /25)*

Historically, classful addressing required allocation of complete classes (became very inefficient). Currently CIDR (RFC 1519) allows allocation of variable sized blocks of IP address space regardless of classes.

Q15. With respect to routing packets in the Network Layer, explain the difference between a connectionless and connection-oriented service?

One suggested answer:
Connection-less: Each packet independently routed without the setup of a prearranged route, move packets in a potentially unreliable subnet, QoS is not easily implemented, e.g. the internet
Connection-oriented: Packets travelling between destinations all use the same route. Telco view: guarantee reliability of subnet – QoS is important

Q16. Give three types of policy choices at the Transport layer that can affect network congestion. In each case, briefly explain why the policy choice affects network congestion. [3 marks]

Some suggested answers:

- *Retransmission policy - increases congestion if packets retransmitted too soon.*
- *Out-of-order caching policy - increases congestion if packets that arrive out of order cannot be buffered, and hence need to be retransmitted*
- *Acknowledgement policy – negative acknowledgements can be used to avoid timeouts*
- *Flow control policy – small congestion windows reduce the data rate, and avoid congestion.*
- *Timeout determination – if too short, unnecessary retransmissions may result.*

Q17. A common approach to removing jitter in streaming audio is to buffer incoming packets at the receiver. Briefly explain the main problem with using this approach for video conferencing. [3 marks]

One suggested answer:
Videoconferencing is a 2-way interactive service. Buffering introduces delay into the service, which is a nuisance for interactive services.

Q18. Briefly explain the architecture of the email system by describing key components and services. What are the basic steps of SMTP protocol? [3 marks]

One suggested answer:

- *User agents: fetch email from MTAs with POP3 or IMAP (delivery protocols) and allows users to read emails*

- *Mail transfer agents: transports emails to destination via SMTP (transfer protocols)*
- *SMTP uses ASCII human-readable commands to communicate with MTAs. Typical message transfer:*
  - *HELO [server name]*
  - *MAIL FROM [sender]*
  - *RCPT TO [recipient]*
  - *DATA*
  - *QUIT*

Q19. Give 3 reasons for the emergence of Voice-over-IP telephony as an alternative to the PSTN. [3 marks]

Some suggested answers:

- *Data has overtaken voice as the primary traffic on many networks originally built for voice*
- *PSTN infrastructure is not flexible enough for the rapid deployment of new features*
- *PSTN technologies are largely incompatible with the convergence of data/voice/video*
- *The architecture built primarily for voice is not flexible enough to carry data Network providers are increasingly looking to leverage investment in network infrastructure by bring new services to data networks*

Q20. a. Is a DNS server a client, a server, or both? Briefly justify your answer.
b. Give three important properties of a message digest. [3 marks]

a. *One suggested answer:*
Both, since it can act as a server if the requested domain name is in its database, or as a client if it needs to ask another server to resolve the name.
b. *Some suggested answers:*

- *Easy to compute MD(P), given P*
- *Impractical to compute P, given MD(P)*
- *Given P, impractical to find P' such that MD(P') = MD(P)*
- *A single bit change in P creates a very different message digest.*

End of exam