NATIONAL UNIVERSITY OF SINGAPORE

CS2105 – INTRODUCTION TO COMPUTER NETWORKS

(Semester 1: AY2020/21)

Date: 30 November 2020

Time Allowed: 100 Minutes

INSTRUCTIONS TO STUDENTS

Final Assessment is a Quiz on LumiNUS

Good luck!

Multiple Choice Questions

1. Which of the following statements about the network layer and the link layer are TRUE?

i) The network layer and its IP protocol provides communication service between any two end hosts, i.e., end-to-end.
ii) The link layer and its protocol(s) provide communication service between two adjacent nodes (host or router), i.e., over a single link.
iii) Both the network and the link layer use IP addresses to find the receiver node.

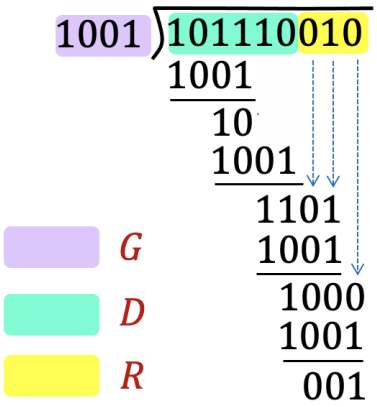
- [x] i) and ii).
- [ ] ii) only.
- [ ] iii) only.
- [ ] i) and iii).
- [ ] ii) and iii).

2. The link layer may use parity bits for error checking, i.e., to identify bits that may have been corrupted (i.e., flipped) during transmission. Which of the following statement is **FALSE** for **2-D parity**?

- [ ] It can detect **all** 1 bit errors.
- [ ] It can correct **all** 1 bit errors.
- [x] It can correct **all** 2 bit errors.
- [ ] It can detect **all** 2 bit errors.
- [ ] It adds more overhead (percentage wise) than 1 bit parity.

3. Cyclic Redundancy Check (CRC) is a powerful algorithm to detect errors in a sequence of bits that have been transmitted.

The example below is executed at the receiver side. G is the generator code, D is the data that has been received and R is the CRC code that was received. What does the computation below, executed at the receiver, tell the receiver? (Please select the most accurate answer.)



- There was a bit error in the data bits D. However, there was no error in the CRC bits R.
- There was/were some error(s) either in the data bits D and/or in the CRC bits R.
- There was no error in the transmission. Everything is fine.
- There was a bit error in the data bits D and the receiver can know which bit is wrong.
- There were two bit errors in the data bits D.

4. Each IP node (host, router) has an ARP table, which stores the mappings of IP to MAC addresses of the same subnet in the following format:

< IP address; MAC address; TTL >

What is the function of the TTL (time-to-live) field?

Assume this is the ARP table on host A and the entry shown above is for host B.

- The TTL value is a counter value that counts how many times host A has sent frames to host B.

- [x] The TTL value stores a counter that counts from certain value (say 120 seconds) down to zero. If the value reaches zero then the entry is deleted from the ARP table. This is to keep the table small and only remember IP/MAC pairs of nodes with which host A had recent communications.
- [ ] The TTL value is a counter that counts how many frames have been sent from host A to host B.
- [ ] The TTL value is a counter that stores the elapsed time since the host A was last turned on.
- [ ] The TTL value stores the average round-trip time between hosts A and B.

5. Hosts A and B are in the same subnet and use switched Ethernet. The subnet has other additional hosts and all of them are connected via a network switch.

Host A wants to send a frame to B, but it does not know B's MAC address. Therefore, A will do the following:

A → B

- [ ] Host A will need to know the MAC address of the switch interface and the switch will send out an ARP query only to host B.
- [ ] The switch will do Network Address Translation to forward the frame from host A to host B.
- [ ] Host A will need to know the MAC address of the switch interface and the switch will replace the destination MAC address of the frame with B's MAC address.
- [x] Host A broadcasts an ARP query to all the hosts in the subnet. The operation of the switch is transparent, i.e., A does not need to know that there is a switch (which will enable the broadcast and reply collection).
- [ ] Host A will need to know the MAC address of the switch interface and the switch will replace the destination MAC and IP address of the frame with B's MAC and IP address.

6. A client requests to download an object from a Web server. The header of the corresponding HTTP response message is shown below.

```
HTTP/1.1 301 Moved Permanently
Location: https://www.comp.nus.edu.sg/
Content-Length: 0
Connection: close
```

Which of the following statements is TRUE?

- DNS resolution of the Web server has failed.
- The object requested by the client is appended to the back of the HTTP response message.
- None of the other.
- The Web server is too busy to handle the HTTP request of the client.
- The Web server is unreachable.

7. Ethernet uses the CSMA/CD algorithm with a binary backoff to access the media. In the binary backoff algorithm, each time when there is a collision the NIC waits *K**512 bit times until it tries again. *K* is chosen differently after each collision. A NIC encounters 4 collisions in a row. Which of the following sequence of values of *K* is **NOT** possible for the 4 collisions?

1 2 3 4
1 3 7 15

- 1,2,5,7
- 1,1,9,6
- 1,2,4,8
- 0,1,2,3
- 0,0,0,0

8. We have two devices: a more expensive switch A and a cheap switch B. Switch A has full-duplex interfaces (i.e., it can send and receive on each interface concurrently) and it can learn which computer is connected to which interface. Switch B is very cheap and can do neither (it always sends out frames on all interfaces, except on the one it received the frame). Both switches have *n* interfaces and each interface has a max. bandwidth of 1 Gb/s in either send or receive direction. Throughput means the total number of frames that a switch can process (send and receive) per second.

Which are the properties of switch A versus switch B?

i) Switch A achieves higher total throughput because of full-duplex interfaces.
ii) Switch A achieves higher total throughput because it can learn on which interface a computer is reachable.
iii) Switch A needs more internal memory (e.g., space for the learned forwarding table).

- i) and ii).
- ii) only.
- i), ii) and iii).
- i) and iii).
- ii) and iii).

9. Digital audio is characterized by two numbers:

i) the number of samples per second, and
ii) the number of bits with which each sample is represented.

Assume that we have an analog audio signal whose highest frequency component is 10,000 Hz. According to the Shannon and Nyquist theorem, the number of samples per second to represent this signal digitally would need to be at least how many (the theoretical lower limit)?

- 10,000 samples per second.
- 5,000 samples per second.
- 20,000 samples per second.
- 22,050 samples per second.
- 11,025 samples per second.

10. We have learned that images can be described with spatial coding: instead of using *N* values of the same color (e.g., *purple, purple, purple, ...*), we use only 2 values: color value (*purple*) and a count, i.e., the number of repeated values (*N*). Whenever the color changes we'll use a new color value and a new count. So the whole image would be described like this: [color1; count1][color2; count2][color3; count3]... . This is also called *run-length encoding*.

Let us assume that we have an image with a resolution of (width) 720 x (height) 480 pixels. The top 1/3 of the image is black and the bottom 2/3 is white. We index the pixels from left to right, and top to bottom (row by row). Then the run-length encoding of this image is:

(If you don't have a calculator, here are some useful numbers:
230,400 = 720 x 320
172,800 = 720 x 240
115,200 = 720 x 160)

- [ ] [black; 172,800] [white; 172,800]
- [ ] [black; 230,400] [white; 230,400]
- [ ] [black; 115,200] [white; 230,400]
- [ ] [black; 115,200] [white; 115,200]
- [ ] [black; 230,400] [white; 115,200]

11. The client side playout buffer is very important in a media player to provide a smooth playback experience for the user. Which of the following statements are TRUE:

i) If the average fill rate ($\bar{x}$) into the buffer is smaller than the playout rate (r) out of the buffer, then the playback will stall (freeze) at some point.
ii) If the average fill rate ($\bar{x}$) into the buffer is larger than the playout rate (r) out of the buffer, but x(t) fluctuates considerably and sometimes drops below (r), then we may stall if the buffer is small, and we may not stall if the buffer is large.
iii) It is always better to have a large playout buffer with a lot of data in it.

- [ ] i) and ii).
- [ ] ii) and iii).
- [ ] i) only.

- i), ii) and iii).
- i) and iii).

12. You are working for a company that makes a web-based document sharing product (something similar to Google Docs). Several users can work together by just using their browser. Now your boss would like you to add audio/video conferencing capabilities to this product, but she is not giving you much time to finish the task. Which of the following technologies would be the best fit for this development task in this scenario?

- Developing your own custom streaming protocol would be best because you could customize it to your needs.
- DASH would be a good fit to develop interactive video conferencing because much of the DASH support is already built into modern web browsers.
- Using SIP (the Session Initiation Protocol) would be the best fit because it is a standard.
- WebRTC would be a good fit to develop interactive video conferencing because it has low latency and much of the support libraries are already built into modern web browsers.
- Developing your own RTSP/RTP/RTCP-based interactive video conferencing would be a good fit because it has low latency.

13. The Secure Socket Layer (SSL) is used to encrypt the traffic between a web browser and a web server. SSL uses RSA public key cryptography. However, SSL uses RSA only to exchange a symmetric session key between the client and the server. Afterwards the traffic is encrypted with the symmetric session key. The most important reason for this is:

- Symmetric key cryptography is more secure than public-key cryptography.
- It is easier to keep a symmetric key secret than a private key.
- Public key cryptography, e.g., RSA, is computationally very expensive. Using RSA for the whole session duration would result in poor throughput and performance.

- Public-private key pairs are longer than symmetric keys, so they require more storage, which is expensive.
- RSA technology is protected by a patent and so it is more expensive to use.

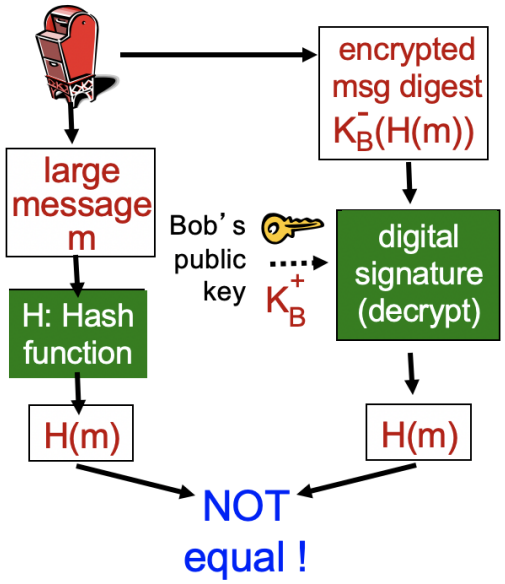
14. When generating a 256-bit long symmetric key, i.e., a 256-bit number, to be used for encryption, which of the following provides the most security?

- We can take the number of seconds (in binary format) since the computer booted as part of the key.
- We can take the MAC address (in binary format) of the computer as part of the key.
- We can take the current time (in binary format) and use it as part of the key.
- We can take the computer name and IP address (in binary format) as a part of the key.
- A key should be completely random and not be derived from any known value that an attacker can guess in order to provide the highest security.

15. The workflow in the figure below shows the process at the receiver side (Alice) of verifying the digital signature of a message *m* that was sent by Bob and where he digitally signed the message digest H(*m*).

The result, shown in blue at the bottom, shows that the message digests H(*m*) are not equal. This means the following:

i) We definitely know that Bob did not sign the message digest.
ii) We definitely know that the message *m* was tampered with.
iii) We only know that either Bob did not sign the message digest, or *m* was tampered with, or both.



- i) only.
- ii) only.
- i) and ii).
- iii) only.
- i), ii) and iii).

16. Certification Authorities (CA) such as DigiCert, Symantec, Thawte, etc., provide digital certificates that bind an entity E (a person, a website such as Amazon) to its public key. The main function of the CAs is:

- To provide a safe storage space for entities' public keys.
- To make money charging people for generating SSL certificates.
- To help an entity to generate their public-private key pairs.
- To ensure that an entity's public key can be verified by anybody. This is to avoid that an attacker could replace the public (and thus also the private) key of somebody else and impersonate them.

- ○ To ensure that an entity's private key is safe.

17. We are given a channel C which has an analog channel bandwidth of B = 1 MHz and a signal-to-noise ratio (SNR) of 15. Now we would like to double the theoretical channel capacity C' = 2*C of the channel by using a better cable and thus improving the SNR. What SNR would the cable need to have to double the channel capacity?

- ○ 511
- ○ 31
- ○ 63
- ○ 255
- ○ 127

Multiple Response Questions

18. The information contained in an IP header includes: _____ .

- ☐ The congestion level detected.
- ☑ The version of the IP protocol of the IP datagram.
- ☐ The number of hops the IP datagram can further travel.
- ☑ Whether the IP datagram is a fragment.
- ☑ Sequence number of the IP datagram.

19. A DNS server can respond to a query with respect to:

- [x] Canonical name.
- [ ] MAC address.
- [ ] Port number.
- [x] Hostname.
- [x] IP address.

20. Host A sends a sequence of packets to host B using Go-back-N protocol. The following **partial** trace is captured at host A:

```
...
SEQ 3 →
SEQ 4 →
SEQ 5 →
...
SEQ 5 →
SEQ 6 →
...
```

3 4 5

Here, 'SEQ 3' indicates an outgoing packet with sequence number 3. So packet 3 is sent out, followed by packet 4, packet 5, etc.

Unfortunately, due to some corruption of the log files, **some** packets in the middle of the trace (i.e., between the two 'SEQ 5') were not properly recorded.

You are told that only **one** timeout has occurred at host A during the entire transmission, and can assume that no packet reordering has occurred and the sequence numbers are never reused.

Which of the following packets could have been sent during the missing portion of the trace?

- [x] A packet with SEQ 4 is part of the missing portion.
- [x] A packet with SEQ 3 is part of the missing portion.

- [ ] A packet with SEQ 7 is part of the missing portion.
- [ ] A packet with SEQ 5 is part of the missing portion.
- [ ] A packet with SEQ 6 is part of the missing portion.

21. The following shows a forwarding table in a router that uses longest prefix matching and 6-bit addressing. The prefix in each row is distinct.

Prefix Match	Output Interface
10	A
101	B
X	C
otherwise	D

Suppose a datagram with destination address 100100 is forwarded through interface C, what are the possible values of **X**?

- [x] 100
- [ ] 10
- [x] 1001
- [x] 10010
- [ ] 1

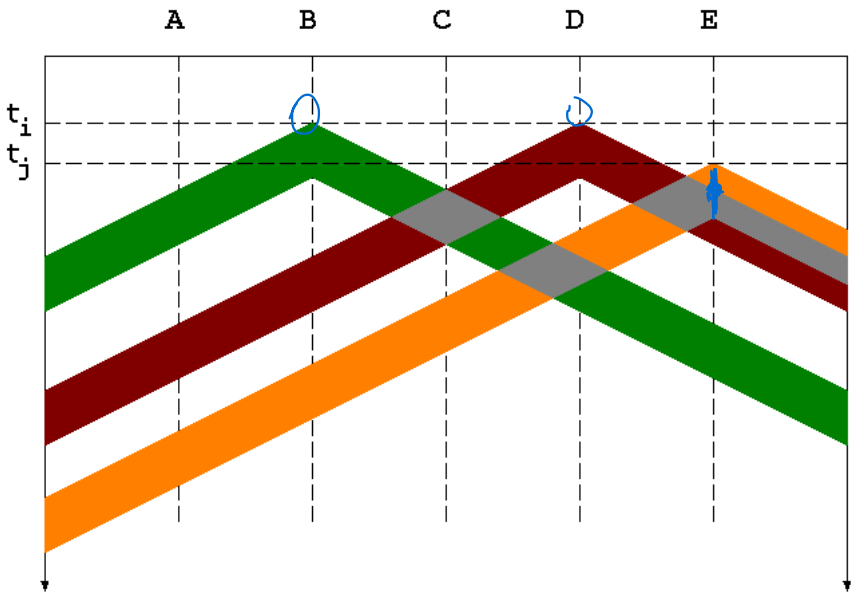
22. At the link layer there exist several link access protocols. In some of the protocols the access is deterministic, i.e., a node can calculate and guarantee when it will be able to access the channel and successfully transmit the next frame. Some other protocols are stochastic, i.e., a sender can not know beforehand exactly when it will be able to successfully send the next frame.

Which of the access protocols below are deterministic?

- [ ]

- [ ] CSMA/CD
- [ ] Pure ALOHA
- [x] TDMA (time division multiple access)
- [ ] CSMA
- [x] FDMA (frequency division multiple access)

23. The diagram below shows the propagation of 3 data packets sent from hosts B, D (at time t_i) and E (at time t_j) that are spatially arranged on a shared channel which is managed by the CSMA/CD protocol. The data frames transmitted are very short. Which of the hosts will detect a collision?



- [ ] C
- [x] E
- [ ] B
- [ ] D
- [ ]

A

24. Host A with IP address 137.132.92.104 and net mask 255.255.255.0 wants to send datagrams to other hosts. The hosts that are in the same subnet can be reached directly without connecting through a router. Which of the hosts below are in the same subnet as host A?

- [ ] 137.145.92.192
- [ ] 187.132.92.104
- [x] 137.132.92.213
- [x] 137.132.92.154
- [ ] 137.132.82.112

25. In many VoIP applications, the audio data is sent in packets that contain 20 milliseconds worth of audio data. This is only about 160 bytes, i.e., much less than the MTU of Ethernet. The reasons for using 20 ms are as follows:

- [ ] The packet length is not important and we could just as well choose another value and it would not make any difference.
- [x] Packets that are much shorter than 20 ms would create a relatively high overhead (the header size i comparison to the payload data size) and also a high number of packets would be generated. Therefore, 20 ms is a good compromise.
- [ ] 20 millisecond is the average word length of a human being.
- [x] The data length (in milliseconds) directly and proportionally adds to the end-to-end delay. Therefore, for interactive VoIP applications we do want to use fairly short packets.
- [ ] 20 ms only works well for the English language.

26. Which of the following statements are TRUE about Dynamic Adaptive Streaming over HTTP (DASH)?

- [x] With DASH a client downloads a Media Presentation Description (MPD) file from the server and the MPD contains a description of the different media qualities available (and other details) for a video.
- [x] DASH can adapt the video quality to the available bandwidth between the server and the client.
- [ ] DASH requires a very specialized server.
- [ ] DASH can only adapt to three different video qualities: low, medium, and high.
- [x] Because DASH uses HTTP/TCP it works well with firewalls.

Fill-in-the-Blanks

27.

Fill in the blanks

In a UDP segment, the length of the payload is double of that of the UDP header. What is the decimal valu of the UDP header 'length' field?

1

Enter the correct answer below.

1 24 Please enter a number for this text box.

28.

Fill in the blanks

Suppose you are designing a pipeline reliable transmission protocol for a 1 Mbps point-to-point link, whicl has a one-way propagation delay of 10 milliseconds. Assuming that each packet carries 1,500 bits of app data, packet header and ACK packets are of negligible size, and transmission is always successful. What is the minimum sender window size to achieve a sender utilization of 100%?

1

Enter the correct answer below.

1 Please enter a number for this text box.

29.

Fill in the blanks

In the example given below data has been transmitted together with 2-D even parity bits. Which of the data bits has/have been corrupted during the transmission (assume that the parity bits have not been corrupted)?

Transmitted bits: 4 x 4
(with parity bits)

1	0	1	0	1
0	0	0	0	0
1	0	0	1	1
0	1	0	1	0
0	0	1	1	0

Answer key (for positions), i.e.,
the top-left bit is in position 'a'

a	b	c	d
e	f	g	h
i	j	k	l
m	n	o	p

Use the letters in the answer key on the right to provide your answer. For example, if you think that the bit in position 'a' was corrupted then enter the letter 'a' as your answer. If 2 bits have been corrupted then enter your solution with a comma, e.g., 'a,c'.

Corrupted bit(s): 1

Enter the correct answer below.

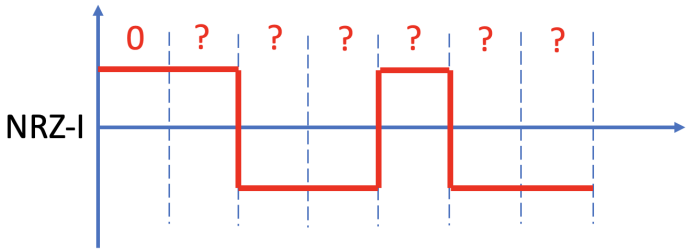
1

30.

Fill in the blanks

In the figure below a digital sequence *D* of binary bits has been encoded with the NRZ-I encoding method. The sequence starts with a 0. What is the bit sequence *D*?

D (6 bits of 0s and 1s) = 1



Enter the correct answer below.

1

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