Homework #1, CS211, Winter 2024
Due Date: 9:00 pm, February 10 (Saturday), 2024

Note: each group must submit one copy only!

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Problem 1 (Multiple Choices; 60 points; 4 points each): For each question, please select the correct answer(s) out of the choices (there may be multiple correct choices in a question). If you are not sure which one is the correct answer, you can write down your thoughts. It will be graded based on your understanding of the question.

1. (1) Which network uses an ad hoc, but NOT the cell-based infrastructure? Your choice: _____

   (A) Wi-Fi AP operation mode; (B) Wireless sensor networks; (C) 2G/3G wireless networks; (D) Inter-satellite communication in Starlink of Space X.

Ans: (B) Wireless Sensor Networks.
Wireless sensor networks are infrastructure less, and communicate through sensors sending environmental data to each other in an ad hoc manner. It cannot be A as Wifi AP mode is interpreted as access points so nodes send info to access points instead of to each other directly. It cannot be 2G or 3G as those are based off the cell infrastructure.

2. Which is NOT true for wireless and mobile networks? Your choice: _____

   (A) A main challenge is the wireless link issue; (B) Another main challenge is the mobility issue; (C) A main driver for wireless networking design is new wireless communication technologies; (D) A main driver for wireless networking design is new applications and services; (E) Wireless networks can use the same protocols as the wired Internet.

Ans: (E)
We discussed in lecture how wireless research can be driven by a top down demand by the application layer. Thus, (D) can be true. (A) and (B) are obviously true as wireless channel nature and mobility are the two big challenges to wireless networking. (C) is true as the bottom up approach indicates that wireless technology development can drive research

3. Which design principle is used by the Internet but not the telecom-based telephone network? Your choice: _____

   (A) end to end argument; (B) both the network core and terminals are smart; (C) prioritize goals given a list of multiple goals; (D) circuit switching to provide guaranteed service

Ans: (A) End to end argument.
Telecom based networks use the idea of smart core, dumb terminals. However, the end to end argument and indeed the internet use smart terminals and dumb core, rationalizing that it is better to build functionality on the higher layers of the protocol stack. So it must be (A).
We thought about putting C but cell phone providers also prioritize services

4. Which is a case of applying the adaptation guideline over wireless mobile networks? Your choice: _____

   (A) opportunistic design approach; (B) protocol layering; (C) model-referenced adaptation; (D) end-to-end design argument

Ans: (A) and (C)
Adaptation guideline refers to allowing the system to account for changing time and space dynamics.

5. Which of the principle(s) does the Internet design NOT use? Your choice: _____

   (A) keep per- connection state at routers inside the network core; (B) "smart core, dumb terminal" approach; (C) Not to completely prevent failures but react to them properly; (D) multiplexing (but not integrating) of different networks; (E) Recover lost packets via link-by-link retransmissions.

Ans: (A), (B)
The internet operates off the end-end principle and so prefers a dumb core, smart terminal approach. Additionally, to ensure robustness of connectivity, it tries to avoid making routers stateful so it does not store the per connection state.

6. Which issues need to be addressed when applying adaptation guideline? Your choice: _____

   (A) when to invoke adaptation; (B) how many scenarios or cases to handle; (C) how to perform specific adaptive actions for each case; (D) no need to evaluate adaptation since adaptation is always good and helps to improve performance.

Ans: (A), (B), and (C)

7. Which statement is incorrect about the coordination guideline? Your choice: _____

(A) It is for better performance, deployment, or system operations; (B) Cross-layer feedback does not happen between PHY layer and Application layer; (C) Cross-layer feedback may hurt system performance; (D) Indirection via proxy generalized end-to-end argument.

Ans: (B)
The assumption is that we are talking about the cross layer guideline for coordination. The entire point of this guideline is to let non adjacent layers talk to each other, so it would involve also allowing PHy and application to communicate

8. which will be true for cross-layer design? Your choice: _____

(A) technology evolution can make the hourglass platform become the bottleneck in the long run; (B) application can always improve its performance with additional design work through the cross-layer design; (C) It allows for the application and the underlying technology can adapt to each other; (D) It can never lead to undesirable consequences on the overall system architecture and performance.

Ans (C) It allows for the application and underlying technology to adapt to each other
So (C) is obviously true. The entire point of cross layer design is to allow for non adjacent layers to talk to one another, and this would allow them to be more responsive to one another. (D) is obviously false as it makes you lose benefits of traditional layering.

(B) is tricky, but I would still say false as you cant *always* improve performance with additional design. Heavy coupling can lead to performance downgrades as the non adjacent layers will have to spend effort talking to each other with irrelevant details that don't help them make better decisions.

(A) is controversial, but we disagree. That is an assumption that the proponents of it support, but the hourglass system actually helps the interoperability of the internet

9. What will be the justifications on using the thin-AP architecture for Wi-Fi? Your choice: ____

(A) It does not reduce the cost and has the same degree of reliability for each AP; (B) The control plane of the Wi-Fi network remains to be decentralized; (C) It is easier to monitor the network status at the AP controller rather than at each individual AP; (D) The AP controller can readily regular the traffic (say, filter out spams) sent to each mobile device.

Ans: (C) and (D)

The AP Controller can be more responsive to the changing network settings instead of having to manually update each AP. Additionally, we can collect statistics at the controller for traffic engineering purposes.
We don't think it is (B) as there is centralized control and management at the Access Controller.

We don't think it is (A) as something *not* reducing cost doesn't serve as a justification.

10. What is NOT an effective PHY technique that can significantly boost the data rate in WiFi? Your choice: _____

(A) OFDM; (B) MIMO; (C) frame aggregation and block Acknowledgment; (D) Multiuser MIMO (MU-MIMO).

Ans: (C) frame aggregation and block acknowledgement
It is MAC layer not link layer.

11. What have not been adopted by 802.11ax to improve its performance? Your choice: _____

(A) more flexible channel use through allocating resource units rather than subcarriers; (B) the guard interval is still preceded before every DATA symbol; (C)increased guard interval to extend the outdoor coverage; (D) uses more sophisticated modulation/demodulation such as QAM 1024.

Ans: (B) the guard interval is still preceded before every data symbol

So 802.11ax introduced resource units through OFDMA to create more flexible channel use. Additionally, 802.11ax supports improved outdoor operation with larger guard intervals as the base spread is bigger.

I chose (B) as every four data symbols you have 1 guard interval instead of before every data symbol.

12. Which statement(s) about mobility support will be true? Your choice:_____

(A) In TCP/IP, host IP address acts as an end-point identifier for TCP connections and a packet destination for IP routing/forwarding at the same time. It breaks the layer-based design and requires extra mobility support. (B) The mobile IP solution addresses both host mobility and the triangle routing issue without making any changes at the correspondent host. (C) Mobile IP is not needed if the mobile host switches between different Wi-Fi APs in the same subnet. (D) The mobile IP solution is still needed when the mobile host sends IP packets to the static correspondent host on the Internet.

Ans: (A) and (B) and (C)

If we read host IP as including destination IP, then A is true. The destination IP is part of the n-tuple that identifies a tcp connection and it is one of the entries in the routing table. When you have mobile users and the dest IP changes there can be conflicting ideas on how to handle it. If

you change the dest IP then the TCP Connection is broken but if you don't then routing is inaccurate.

13. What design guidelines does mobile IP apply to address network-layer mobility? Your choice:_____

(A) opportunistic design; (B) indirection; (C) cross-layer design; (D) model-referenced adaptation.

Ans: (B) Indirection
Mobile IP creates new proxy agents which act as middle men between mobile hosts and communicating hosts.

14. What can eliminate duplicate data forwarding in opportunistic routing over multihop wireless networks? Your choice:_____

(A) local scheduler only; (B) random linear combinations of packets; (C) wireless broadcast; (D) aggregate multiple data packets into a super-large packet.

Ans: (B)
B is also called random net coding, and by each router forwarding random combinations of packets duplicates are prevented. It can't be A because you need an idea of the global state of the system in order to schedule nodes to send packets to dest. It can't be C because wireless broadcasting is what causes duplicate forwarding

15. What are NOT the new challenges faced by wireless TCP design? Your choice: ____

(A) diversified packet losses; (B) Internet congestion control rule of additive increase, multiplicative decrease is too slow to respond to fast wireless link rate fluctuation; (C) Internet congestion control should not apply for certain cases of packet losses; (D) TCP congestion control does not ensure secure transport of TCP segments.

Ans: (D) TCP Congestion control does not ensure secure transport of TCp segments

I'm interpreting A as meaning there are multiple reasons for packet loss outside of just congestion control, which is definitely true in a wireless system due to the nature of the channel.

Problem 2 (Short answer; 40 points; 5 points each): Please briefly answer each question.

1. If we use the plain (RTS-CTS)-DATA-ACK sequence to transfer data over the high-rate 801.22 n/ac/ax, what is the main limitation of using this scheme? Explain why frame aggregation and block ACK can effectively exploit the high data rate from the PHY layer.

Ans: The main limitation of using this scheme would be the amout of overhead in latency, datasize, and available subchannels while sending this sequence over high rate wireless protocols.

Frame aggregation allows multiple frames to be gathered and sent in a single transmission cycle, and block ACKs allows device to ACK parts or all of the frames in a single response, which would take advantage of the higher data rate capability of the PHY layer.

2. Briefly explain how 802.11ax supports MU-MIMO (i.e., multi-user MIMO) in its both (devices to AP) uplink and (AP to devices) downlink transfer.

Ans: For downlink, 802.11AX DL MU-MIMO allows AP to send data streams to multiple devices simultaneously via multiple antennas. It can assign more or less antennas for each devices' transmission on a per-round basis.

For uplink, 802.11AX UL MU-MIMO allows multiple devices to send at the same time to the AP, and the AP will use spatial processing to distinguish the various streams. This can be used to parallelize device-to-AP ACK packet transmissions, lowering latency.

3. Identify at least two main functions of home agent in the mobile IP proposal.

If the mobile host is away and connected to a guest network, mobile host will give Home Agent its care-of address, and Home Agent will receive from the mobile agent its care-of address and remember it. Then, Home Agent will intercept any packet addressed to the mobile host and forward it via IP encapsulation to the mobile host's care-of address.

4. Identify a merit and a limitation of the DNS based solution to device mobility compared with the mobile IP proposal.

It is easier to implement because it reuses some existing DNS infrastructure to redirect traffic. Avoiding the need for changes in the mobile device or network infrastructure. However, it can have higher latency due to DNS update and propagation delays.

5. explain the detailed steps to apply random network coding in opportunistic routing over multi-hop wireless networks.

Encode at Source: The source node encodes packets using random linear combinations of data packets.
Broadcast Encoded Packets: Encoded packets are broadcasted to neighboring nodes.
Opportunistic Forwarding: Upon receiving packets, intermediate nodes decide whether to forward them based on the network coding algorithm and network conditions.
Decode at Destination: The destination node decodes the original data from received encoded packets, requiring enough linearly independent packets for successful decoding. It does this by effectively solving a system of linear equations.

6. According to the design guideline for the Internet, when do we implement a functionality at lower layers? Explain it using an example.

If it can significantly increase the performance or efficiency of the network. This benefit should be universal to all applications using the network. For example, error correction should be implemented at a lower layer because it can efficiently correct errors close to their source, and other applications don't need to handle error correction individually.

7. Does 802.11 handle all cases of hidden/exposed terminals? Briefly explain your answer.

Ans: The four cases in consideration are hidden sender, hidden receiver, exposed sender, and exposed receiver.
802.11 uses RTS and CTS (request to send and clear to send) signalling. These allow some organization in which node to defer based on which RTS is accepted and thus the resulting CTS sent out by the receiver. CTS silences nodes in range of the receiver, and RTS silences nodes in range of sender, and with the NAV they can figure out how long to shut up after RTS and CTS. However, RTS/CTS don’t solve hidden receiver. There can be a collision of a CTS and an RTS at the hidden receiver.

8. Can you compare TCP snoop and the Wi-Fi link-layer solution to TCP? Identify two differences and one common feature in their design.

Ans: Let us describe the problem first. Because of the nature of the wireless channel, there can be reasons for packet losses besides congestion. However, there is a uniform reaction to these different losses which is congestion avoidance that can hurt performance.
The Link Layer retransmission aims to hide losses from TCP to some extent to avoid duplicate ACKs. If a packet is sent and doesn’t go through, it gets retransmitted from link layer immediately.
TCP Snoop on the other hand involves creating a TCP aware link layer while maintaining the TCP end to end semantics. The base station buffers data packets, and if it receives duplicate

ACKs, retransmit the packets on the wireless link if in buffer to avoid congestion avoidance at sender.

Common Feature: Both employ link layer retransmission. TCP Snoop does it at the base station whereas link layer retransmission does it at every link layer.

Two differences:

1) TCP Snoop violates layering principle as link layer at base station must be TCP Aware
2) In Link Layer retransmission, the delivery is out of order which can trigger fast retransmit. In TCP Snoop, fast retransmit at the TCP Sender is avoided.