Name ..... ID ..... Section ..... Seat No .....

Sirindhorn International Institute of Technology
Thammasat University

Midterm Exam Answers: Semester 2, 2010

Course Title: ITS413 Internet Technologies and Applications

Instructor: Steven Gordon

Date/Time: Wednesday 29 December 2010; 13:30–16:30

Instructions:

- This examination paper has 17 pages (including this page).
- Conditions of Examination: Closed book; No dictionary; Non-programmable calculator is allowed
- Students are not allowed to be out of the exam room during examination. Going to the restroom may result in score deduction.
- Students are not allowed to have communication devices (e.g. mobile phone) in their possession.
- Write your name, student ID, section, and seat number clearly on the front page of the exam, and on any separate sheets (if they exist).
- The space on the back of each page can be used if necessary.

Question 1 [18 marks]

For each question fill in the blank space with an appropriate word, acronym, name or phrase. To assist you some acronyms and technologies covered during the lectures are listed below. For each blank space you must give only one answer. However, there may be more than one correct answer. Each answer is worth 1.5 marks.

Acronyms and technologies: 3G, 802.3, 802.11, 802.15, 802.16, AS, ADSL, ATM, BGP, Bluetooth, CDMA, DCF, DSL, EDGE, FTTH, GPRS, GSM, HSPA, IANA, IEEE, IGP, IP, ISDN, ISP, IXP, LAN, LTE, MAN, MANET, Mobile IP, NEMO, PDH, POTS, PSTN, RTS/CTS, SDH, TCP, UMTS, WAN, WLAN, WiMax, X.25, ZigBee

(a) *LTE* is an advancement of 3G/UMTS mobile technologies that offers higher speeds, but requires significant hardware upgrades to the network base stations.

(b) Both *IEEE 802.16 (WiMax)* and *IEEE 802.11 (WLAN)* can be used for point-to-point wireless links over several kilometres.

(c) *IETF* is a standards organisation that has developed protocols such as IP, Mobile IP and NEMO.

(d) *SDH* uses optical fibre to connect cities and countries at data rates greater than 1Gb/s.

(e) An *IXP* is a facility where multiple ISPs connect via for peering with each other.

(f) *DSL* technologies can provide Internet access over copper telephone lines at identical upload/download speeds.

(g) *GPRS (or GSM)* and *EDGE* are considered 2G or 2.5G mobile technologies for data access.

(h) *IEEE 802.15 (ZigBee) (or Bluetooth)* is designed to offer low data rate wireless networking while consuming very little power.

(i) *ATM (or X.25 or FrameRelay)* is an example of a virtual circuit packet switching technology.

(j) One motivation for the design of *Mobile IP (or NEMO)* is that an application may perform poorly if an IP address on a host running that application changes during the application use.

Question 2 [6 marks]

NEMO supports network mobility as opposed to host mobility supported by Mobile IP. However, Mobile IP could be used to provide the same service as NEMO.

(a) Explain how Mobile IP could be used to support network mobility. [2 marks]

Answer. *All hosts within the mobile network must support Mobile IP, as well as the mobile router.*

(b) Explain two advantages of using NEMO (as opposed to Mobile IP) for network mobility. [4 marks]

Answer. *With NEMO, the hosts within the mobile network do not need to support Mobile IP; they are unaware of their mobility. The signalling overhead is reduced in NEMO: only the Mobile Router performs signalling during handover, whereas with an all Mobile IP solution, all hosts contribute to signalling overhead.*

Question 3 [6 marks]

Two key characteristics of Mobile Ad Hoc Networks are infrastructure-less and dynamic topology. Explain what each means, and for each characteristic describe an advantage and disadvantage. (For example, the advantage should indicate why this characteristic is beneficial in MANETs, and the disadvantage should indicate how this characteristic makes tasks difficult in MANETs).

(a) Infrastructure-less [3 marks]

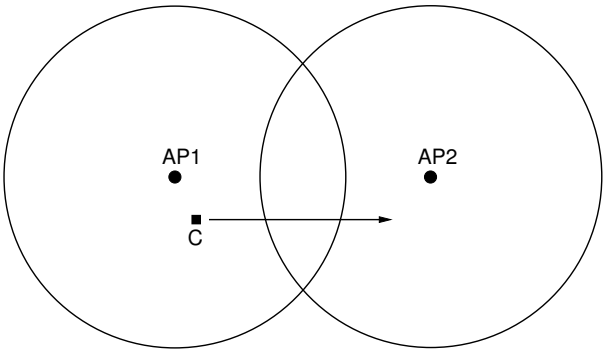
Answer. *The network does not rely on pre-existing infrastructure such as servers, base stations, wires. This is an advantage because the network can be deployed quickly, with low cost and in places where access is difficult. The disadvantage is that there are no central points of control to manage the network/security/performance.*

(b) Dynamic topology [3 marks]

Answer. *The topology of the network changes rapidly due to mobility of nodes. The advantage is that nodes can be mobile and still communicate via other nodes. The disadvantage is that routing protocols need to adapt quickly to learn of the new topology.*

Question 4 [20 marks]

Consider two wireless LAN access points, $AP1$ and $AP2$, that have overlapping coverage, and a client C moving between the coverage areas as shown in the figure below.



(a) If the client is initially powered off and within the coverage area of $AP1$ (but not $AP2$), explain two methods that the client, when powered on, can use to discover $AP1$. Refer to the specific types of frames. [3 marks]

Answer. *Passive discovery: client receives Beacon frames which were periodically broadcast by AP. Active discovery: client broadcasts a Probe Request frame, and an AP will respond with a Probe Response informing the client about the AP .*

Now assume the client is associated with $AP1$. Assume the client can only receive on one frequency at a time (and cannot change frequencies while associated with an AP).

(b) Assuming the APs use different frequencies, explain how the client may decide to initiate a handover to a new AP (e.g. $AP2$). [1.5 marks]

Answer. *Since they use different frequencies, while associated with AP1 the client cannot hear frames from AP2 (and therefore cannot determine its signal strength). Without knowing the presence of AP2 the client could only decide to initiate a handover when the signal strength of AP1 becomes too weak (or it doesn't recieve any more frames).*

(c) Assuming the APs use the same frequency, explain a better method than above for the client to decide to initiate a handover to $AP2$. [1.5 marks]

Answer. *In this case the client can also receive frames from AP2 and determine its signal strength. If the signal strength from AP2 is significantly greater than AP1 then it can decide to handover.*

(d) Explain why the 2nd approach (part(c)) is better than the 1st (part (b)). [2 marks]

Answer. *The 2nd approach is better because the client knows of a new AP before it disassociates from the old AP. In the 1st approach, the client must disassociate from AP*1 *before discovering AP*2*.*

Now consider that the client has decided to handover to *AP*2.

(e) Draw a diagram that shows the exchange of frames for the client to join AP2's network. Label each frame with its name. [2 marks]

Answer. *Authentication Request from Client to AP*
Authentication Response from AP to Client
Association Request from Client to AP
Association Response from AP to Client

Assume now that the client has associated with *AP*2. This AP is on a different IP subnet than the previous AP. Assume the client implements Mobile IP, and HAs/FAs exist in the relevant networks.

(f) Explain two methods that the client can use to discover a FA on the new IP subnet. Refer to the specific types of packets. [3 marks]

Answer. *Passive Discovery: the FA periodically broadcasts Router Advertisements; when the client receives an Router Advertisement it has discovered the FA. Active discovery: the client broadcasts a Router Solicitation; if a FA receives the packet it responds with a Router Advertisement.*

Now consider the client has discovered the FA.

(g) Draw a diagram showing the exchange of packets for the Mobile IP registration procedure. Indicate the types of packets, the ordering of packets (e.g. which one is sent 1st) and the nodes involved. [3 marks]

Answer. *Registration Request from Client to FA Registration Request from FA to HA Registration Reply from HA to FA Registration Reply from FA to Client*

(h) Which node in the network stores the Visitors List? [1 mark]

Answer. *FA*

(i) After the registration procedure is complete, what values are stored in the Visitors List? [1 mark]

Answer. *MAC address of the client; HA of client; Home IP of client*

(j) Which node in the network stores the Mobility Binding Table? [1 mark]

Answer. *HA*

(k) After the registration procedure is complete, what values are stored in the Mobility Binding Table? [1 mark]

Answer. *CoA for Client; Home IP of Client*

Question 5 [11 marks]

(a) Explain what is meant by a collision in a wireless network. Give the conditions when a collision may occur. [2 marks]

Answer. *A collision occurs at a receiver, when two (or more) transmitting stations, both within range of the receiver, transmit at the same time. The transmissions will overlap in time and therefore interfere with each other at the receiver. This assumes all transmissions with are with the same frequency.*

(b) The hidden terminal problem is one reason that collisions may occur in IEEE 802.11 wireless LANs. Explain what the hidden terminal problem is. [2 marks]

Answer. *The hidden terminal problem is the situation where two stations outside of each others range transmit at the same time, resulting in a collision at a receiver which is within the range of both transmitting stations.*

(c) What IEEE 802.11 technique can be used to reduce the impact of the hidden terminal problem? [1 mark]

Answer. *RTS/CTS in DCF*

(d) For a IEEE 802.11 wireless LAN that does not contain hidden terminals, describe the set of conditions that may still result in a collision. [2 marks]

Answer. *If two stations, that end deference at the same time, choose the same backoff interval, they may transmit at the same time causing a collision.*

The DCF Contention Window (CW) is approximately doubled for each retransmission in IEEE802.11 DCF.

(e) What is an advantage of using a larger CW for retransmitted frames? Explain why it is an advantage. [2 marks]

Answer. *Reduces the chance of collisions, hence potentially increasing throughput. Collisions are reduced because the stations choose the random backoff from a larger interval, and hence lower probability that two stations choose the same backoff (and transmit at the same time).*

(f) What is a disadvantage of using a larger CW for retransmitted frames? Explain why it is a disadvantage. [2 marks]

Answer. *Increases the overhead (time spent waiting), hence potentially decreasing the throughput. On average a station will need to wait for a longer backoff before transmitting, hence inefficiently using the medium.*

Question 6 [8 marks]

(a) Consider the following four IP networks: Steve's home network (consisting of several PCs, laptops and routers); TOT's network; SIIT's network (including Bangkadi and Rangsit); Google's network. Select zero, one or multiple networks which are most likely considered *Autonomous Systems*. [1 mark]

Answer. *TOT's network; Google's network*

(b) Explain the difference between transit and peering agreements between ISPs. [3 marks]

Answer. *Transit agreements involves ISP A paying ISP B for traffic from ISP A to transit ISP B's network; peering agreements involve ISP A and B agreeing to exchange their traffic for free.*

(c) Explain the difference between an Interior Gateway Protocol and Exterior Gateway Protocol. [3 marks]

Answer. *IGP is used for routing within an Autonomous Systems; EGP is used for routing between AS's*

(d) Give the name (or acronym) of an Exterior Gateway Protocol. [1 mark]

Answer. *Border Gateway Protocol (BGP)*

Question 7 [18 marks]

Consider a wireless LAN with one AP and two clients (A and B) under the following conditions:

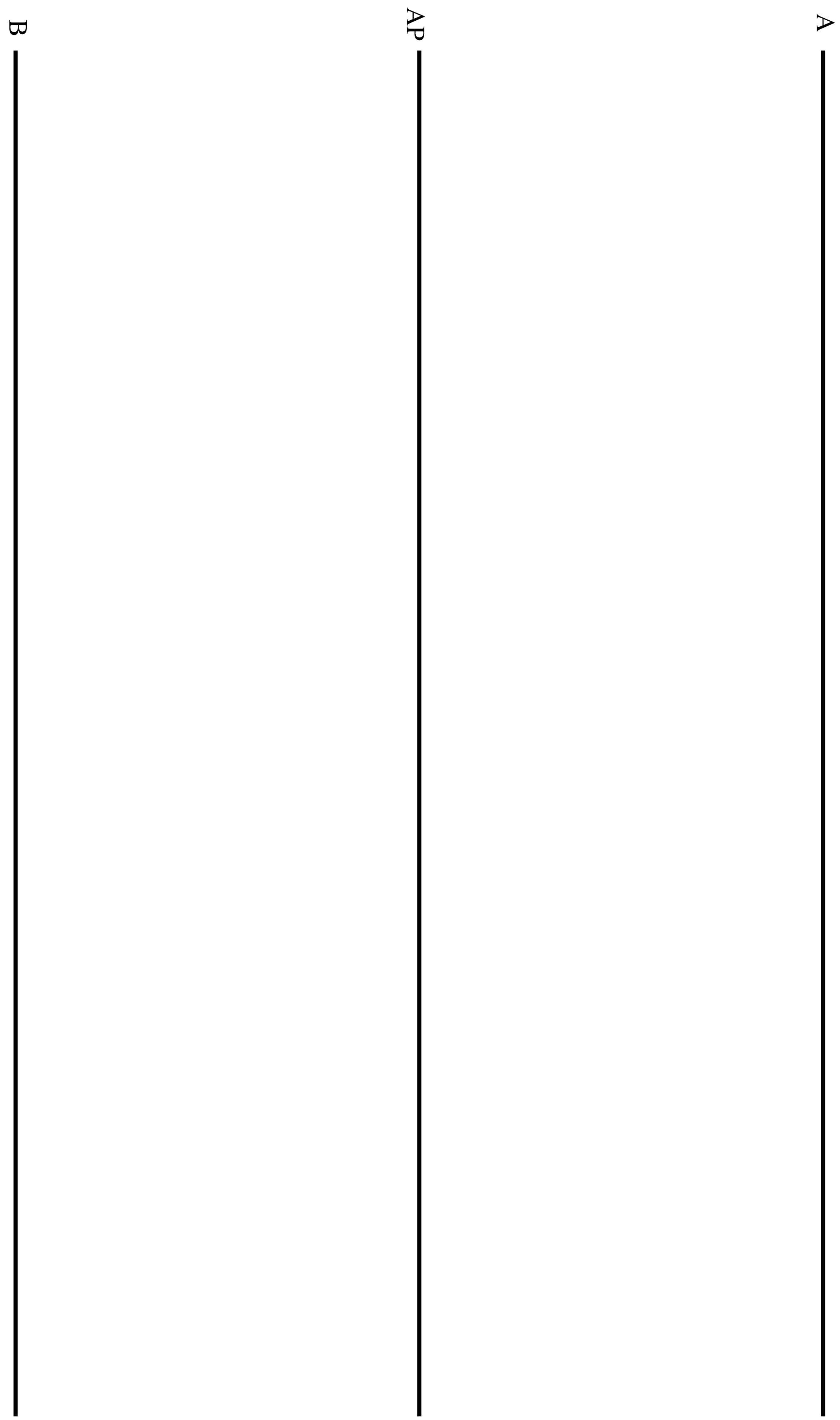
- Both clients are within range of the AP, however the clients are outside of range of each other (e.g. A cannot hear B).
- Fragmentation is not used.
- When choosing random numbers, the stations choose the following values in order:
  - Client A: 6, 19, 7
  - Client B: 20, 5, 23
  - AP: 1, 12, 3
- Stations have data with payload 875 Bytes ready to transmit at the following times:
  - Client A: time 0μs to AP
  - AP: time 10μs to B
  - Client B: time 150μs to AP

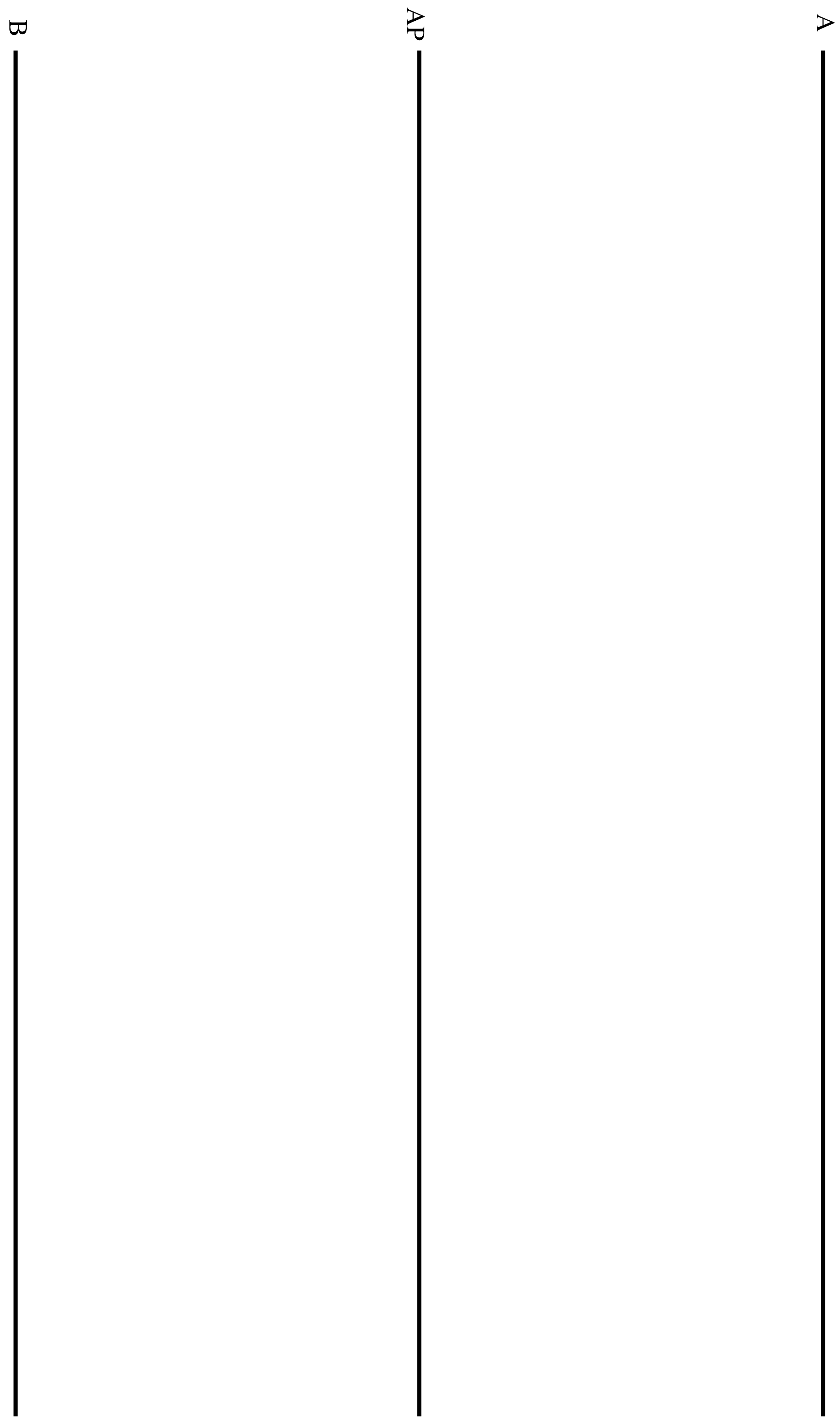
Parameter	Value
Data Rate	48 Mb/s
DATA Header	25 Bytes
ACK transmission time	20 μs
RTS transmission time	20 μs
CTS transmission time	20 μs
DIFS	30 μs
SIFS	10 μs
Slot Time	10 μs
CWmin	31
CWmax	1023
ACKTimeout	30 μs

On the following pages, draw a diagram that illustrates the DCF operation. You must clearly label all events/frames in the operation. Start at time 0, and finish when the last DATA frame is acknowledged. Your diagrams do not have to be to scale, however showing the timing of events will help with answering subsequent parts of this question.

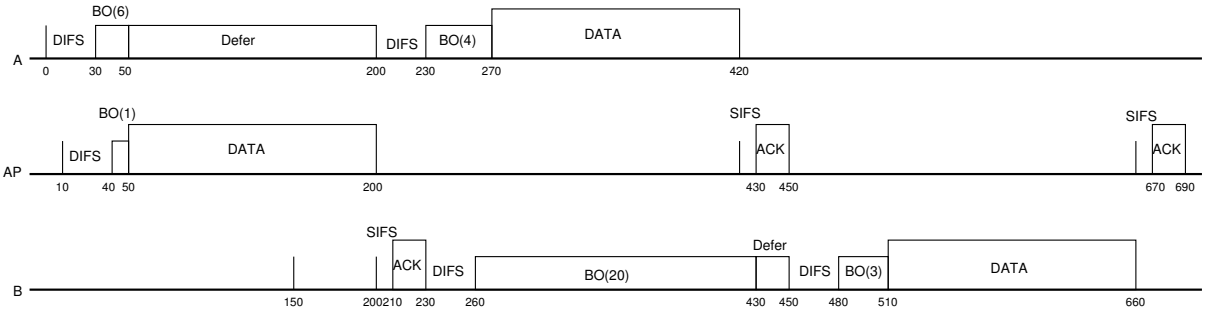
(a) Basic access is used [6 marks]

(b) RTS/CTS is used [6 marks]

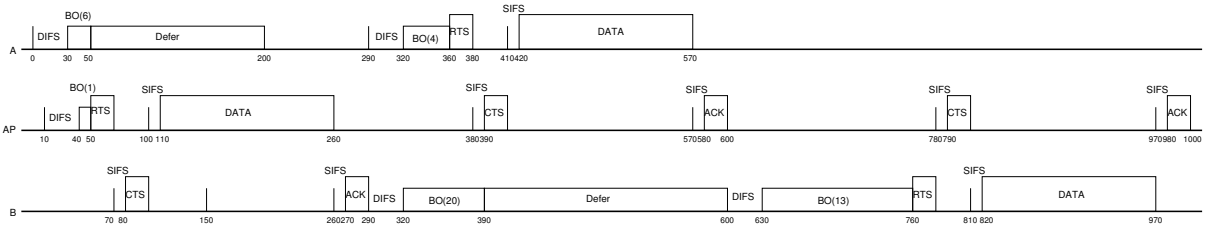

B
AP
A


B
AP
A

Answer. *Basic access:*



RTS/CTS:



(c) For the following cases, at what time does each station know the data has been successfully delivered to the destination? [6 marks]

i. Basic Access, Client A: *450 μs*

ii. Basic Access, Client B: *690 μs*

iii. Basic Access, AP: *230 μs*

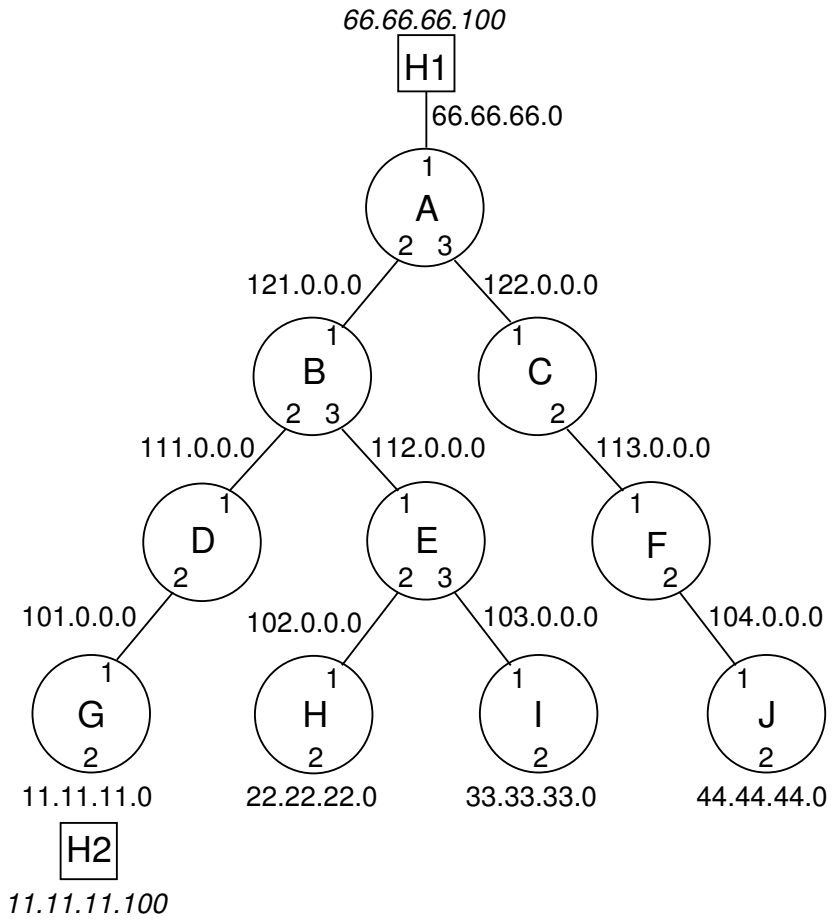
iv. RTS/CTS, Client A: *600 μs*

v. RTS/CTS, Client B: *1000 μs*

vi. RTS/CTS, AP: *290 μs*

Question 8 [13 marks]

Consider the network shown in the figure below. There are routers (circles) and hosts (squares). Routers are named with letters, and each interface is given a label (e.g. 1, 2 or 3). Network addresses are given. Router IP addresses are constructed from the network address and the interface number. For example, router A has three IP address: `66.66.66.1`, `121.0.0.2` and `122.0.0.3`. The home IP addresses of hosts H1 and H2 are given (`66.66.66.100` and `11.11.11.100`, respectively). The IP subnets `11.11.11.0`, `22.22.22.0`, `33.33.33.0` and `44.44.44.0` support host mobility (e.g. `11.11.11.2` is a FA/HA).



Assume hosts H1 and H2 are communicating (e.g. sending packets to each other in a video conference). Routing protocols have already been run such that shortest paths (in number of hops) will always be used. For example, the path from H1 to H2 is A-B-D-G.

Assume H2 is running Mobile IP and moves into subnet `22.22.22.0`. Answer the following questions, assuming Mobile IP registration has successfully completed.

(a) What is the path taken for the packets sent from H1 to H2? [2 marks]

Answer. *A-B-D-G-D-B-E-H*

(b) For the packets in this direction (H1 to H2), when the FA receives a packet, what is the source IP address in the packet header? [1.5 marks]

Answer. *11.11.11.2*

(c) For the packets in this direction (H1 to H2), when the FA receives a packet, what is the destination IP address in the packet header? [1.5 marks]

Answer. *22.22.22.2*

(d) For the packets in this direction (H1 to H2), when H2 receives a packet, what is the destination IP address in the packet header? [1.5 marks]

Answer. *11.11.11.100*

(e) What is the path taken for the packets sent from H2 to H1? [2 marks]

Answer. *H-E-B-A*

(f) For the packets in this direction (H2 to H1), when the FA sends a packet, what is the source IP address in the packet header? [1.5 marks]

Answer. *11.11.11.100*

(g) For the packets in this direction (H2 to H1), when the FA sends a packet, what is the destination IP address in the packet header? [1.5 marks]

Answer. *66.66.66.100*

Now assume H2 has moved into subnet `44.44.44.0` and the Mobile IP registration has successfully completed.

(h) Considering this case, state a problem with using Mobile IP and explain how that may impact on application performance. [1.5 marks]

Answer. *From correspondent node to mobile node, packets need to forwarded via the Home Agent. This adds extra delay to packets, which increase end-to-end delay.*