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

Sirindhorn International Institute of Technology
Thammasat University

Midterm Examination Answers: Semester 2/2009

Course Title : ITS413 Internet Technologies and Applications

Instructor : Dr Steven Gordon

Date/Time : Wednesday 23 December 2009, 13:30-16:30

Instructions:

- This examination paper has 19 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.
- Turn off all communication devices (mobile phone etc.) and leave them under your seat.
- Write your name, student ID, section, and seat number clearly on the answer sheet.
- The space on the back of each page can be used if necessary.

Short Questions [20 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 question is worth 1 mark.

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

1. **Mobile IP** is a protocol that enables host mobility in the Internet.
2. **IEEE 802.16 (WiMax)** is a technology designed to support long-distance point-to-point fixed wireless communications.
3. **ADSL** is used to provide Internet access via copper telephone lines.
4. **IEEE 802.11 (WLAN)** is a wireless technology that uses an unlicensed portion of spectrum to provide communications over distances of 10's to 100's of metres.
5. **BGP** is used to exchange routing information between autonomous systems.
6. **NEMO** is a protocol that could allow a single device on board a train to manage mobility on behalf of all passengers on the train.
7. **ATM** is an example virtual circuit packet switching technology used in core networks.
8. **SDH** uses optical fibre to connect cities and countries at data rates greater than 1Gb/s.
9. **HSPA/LTE** will allow mobile phone systems to provide data rates similar to or greater than current copper telephone based Internet access technologies.
10. **AS's** are networks normally operated by a single ISP, however sometimes large companies such as Google and Microsoft have their own.
11. **DCF** is the set of procedures/functions that are mandatory for IEEE 802.11 medium access control.
12. **MANET** is a network with multiple wireless hops, dynamic topology and no existing infrastructure.

Explain briefly (1-2 sentences) the important difference between the following concepts (e.g. A vs B). Each question is worth 2 marks. (Note that you need to give a brief definition of the differences, NOT the advantages/disadvantages).

13. Transit vs Peering agreements between ISPs

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.

14. Access vs Core networks

Answer

Access networks are used by end-users; Core networks normally carry only the traffic of other

access/core networks (end-users do not use core networks directly).

15. Host vs Network mobility

Answer

Host mobility involves a host changing its attachment to IP subnets; while Network mobility involves an IP subnet changing its attachment to IP subnets.

16. Routers vs Hosts in the Internet

Answer

Routers forward IP datagrams; Hosts do not for IP datagrams.

General Questions [80 marks]

Question 1 [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.

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

i. 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).

ii. 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 2 [19 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: 7, 10, 23, ...
  - Client B: 3, 20, 41, ...
  - AP: 8, 19, 33, ...

Parameter	Value
Data Rate	54 Mb/s
DATA Header	27 Bytes
ACK transmission time	20 µs
RTS transmission time	20 µs
CTS transmission time	20 µs
DIFS	28 µs
SIFS	10 µs
Slot Time	9 µs
CWmin	15
CWmax	1023
ACKTimeout	30

Table 1: WLAN Parameters

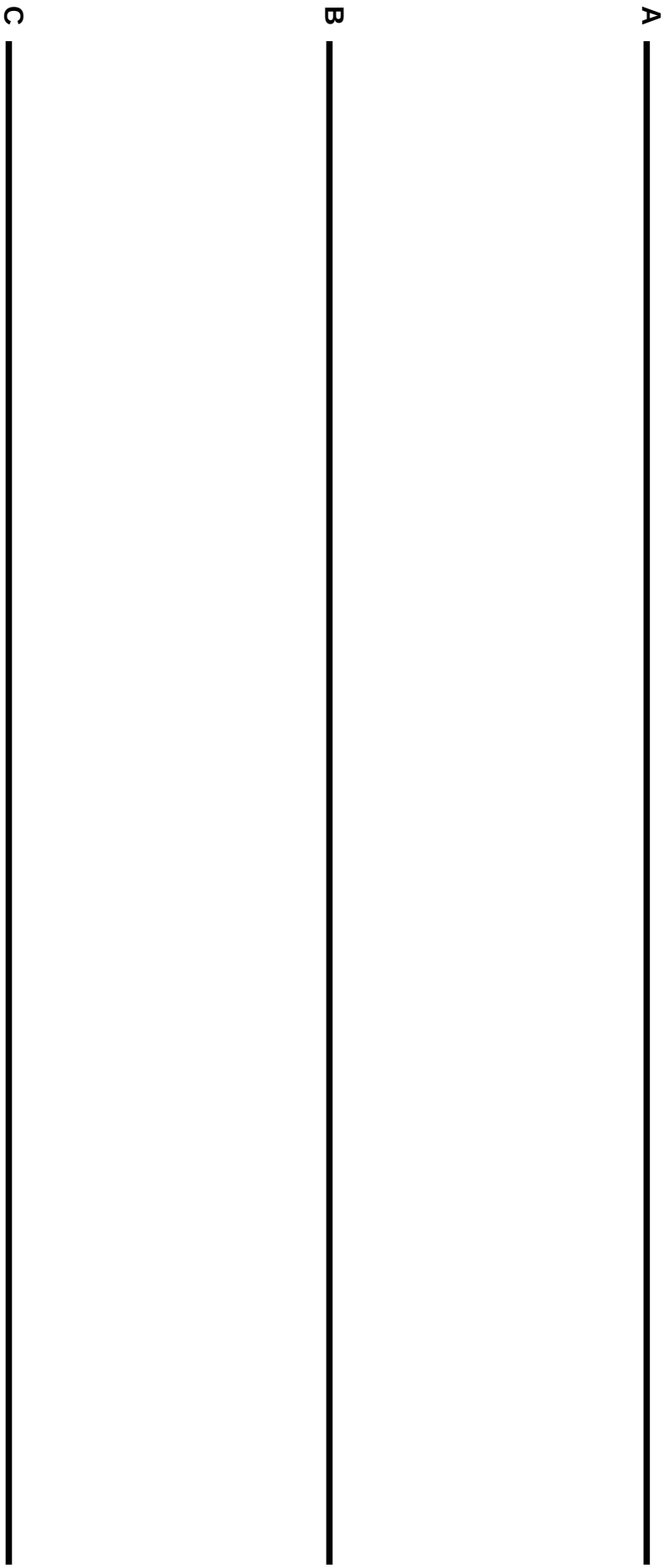
Assume client A has data with payload of 1080 Bytes ready to transmit to the AP at time 0µs, and client B has data with payload of 1080 Bytes ready to transmit to the AP at time 160µs.

a) For the following two cases, 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. Use the following pages for the diagrams. Your diagrams do not have to be to scale, however showing the timing of events will help with answering subsequent parts of this question.

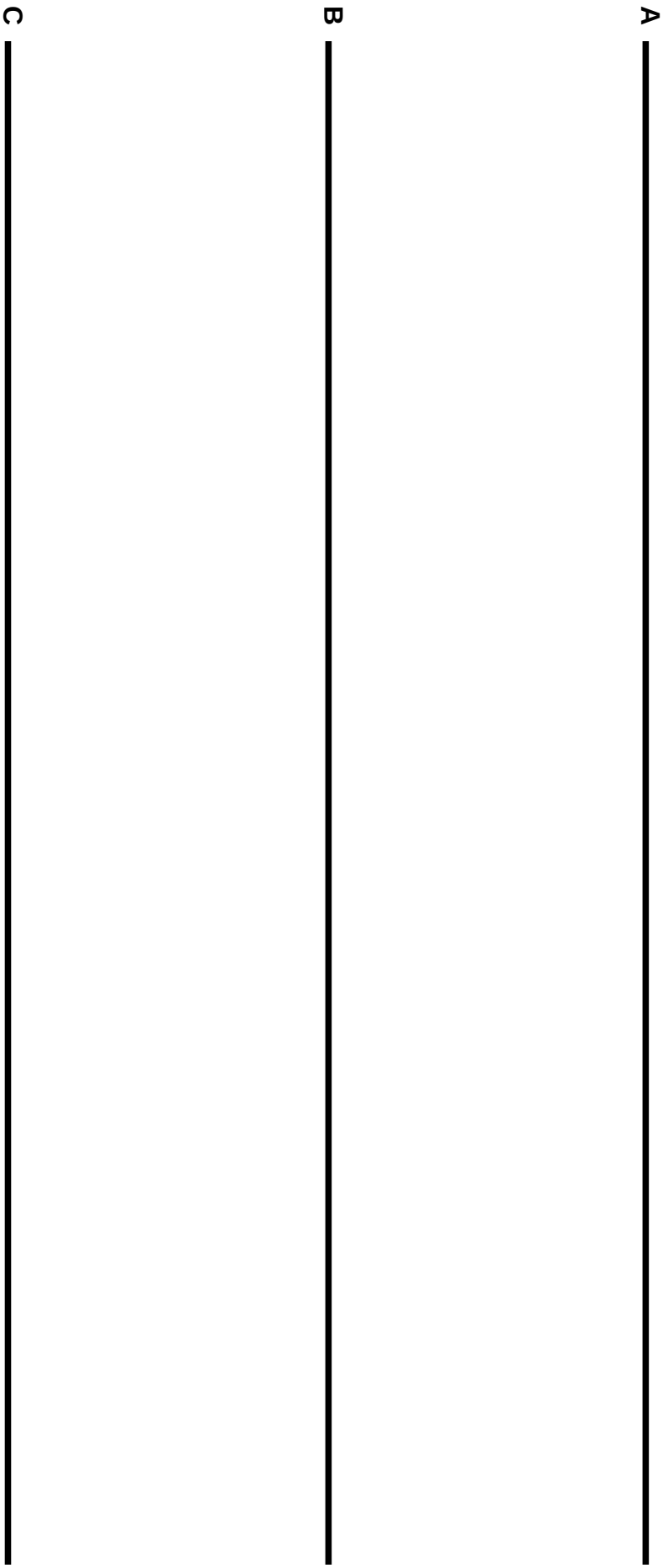
   i. RTS threshold is 1500 Bytes [5 marks]

   ii. RTS threshold is 500 Bytes [5 marks]

Part (i)



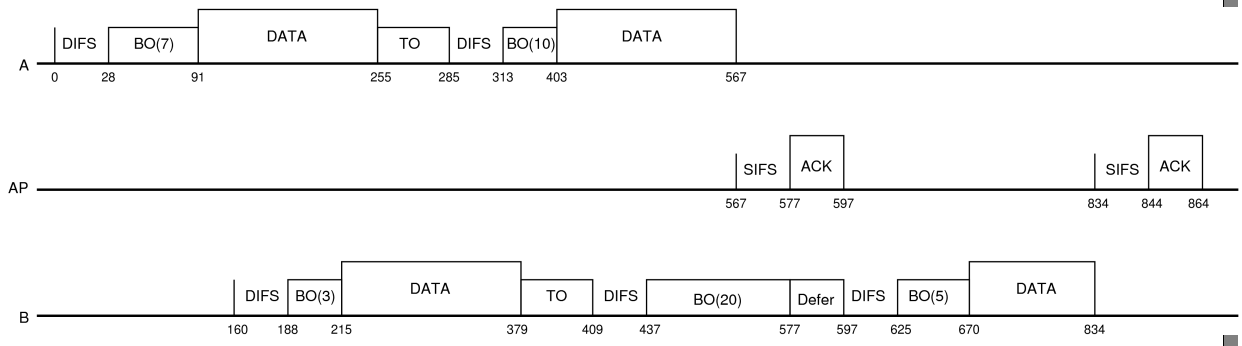
Part (ii)



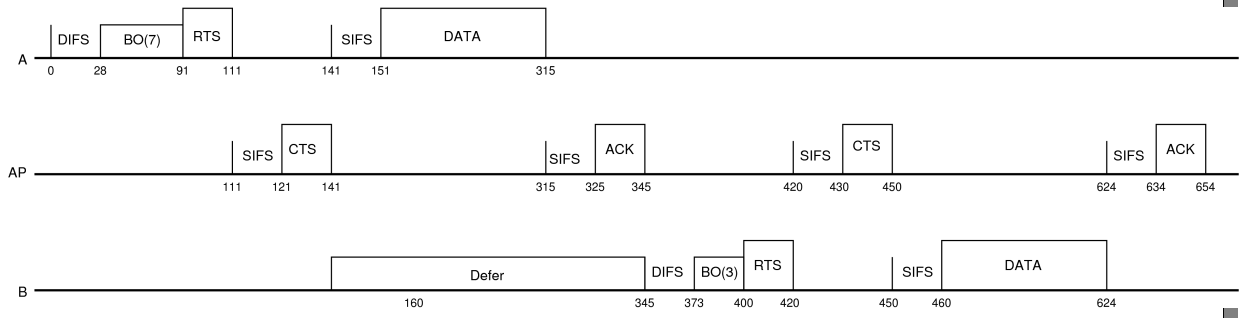
Answer

The DATA frame size is 1080 bytes of payload plus 27 bytes of header. Total transmission time is: 164μs.

With RTS threshold of 1500, Basic Access will be used for all transmissions (1080 is less than threshold). The resulting operation is shown below:



With RTS threshold of 500, RTS/CTS will be used for all transmissions (1080 is greater than threshold):



b) For each case, at what time does each client know that the data has been successfully delivered:

i. RTS threshold 1500, Client A? [1.5 mark]

ii. RTS threshold 1500, Client B? [1.5 mark]

iii. RTS threshold 500, Client A? [1.5 mark]

iv. RTS threshold 500, Client B? [1.5 mark]

Answer

RTS Threshold 1500: Client A receives the ack at time 567μs and Client B receives the ack at time 864μs.

RTS Threshold 500: Client A receives the ack at time 345μs and Client B receives the ack at time 654μs.

c) Which value of RTS threshold (1500 or 500) leads to better performance for this scenario? Explain why it leads to better performance. [3 marks]

Answer

RTS threshold of 500 (using RTS/CTS) leads to better performance, i.e. shorter time to transmit same amount of payload, and hence higher throughput. The reason is that A and B are hidden from each other, resulting in a collision using Basic Access. By using RTS/CTS the RTS from A and B do not collide, as a result the CTS from the AP informs B of an upcoming transmission, thereby avoiding a collision.

Question 3 [25 marks]

a) A Home Agent (HA) in Mobile IP maintains a Mobility Binding Table. What is the purpose of this table and what is the important information in the table? [2 marks]

Answer

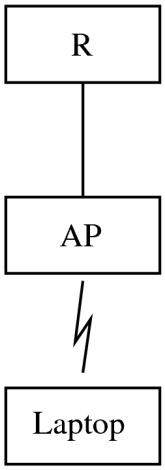
The Mobility Binding Table keeps track of the nodes from the home network that are currently visiting other foreign networks. It should store at least the Home IP and CoA of the MN.

b) A Foreign Agent (FA) in Mobile IP maintains a Visitors List. What is the purpose of this list and what is the important information in the list? [2 marks]

Answer

The Visitors List keeps track of the foreign nodes currently visiting this network. It should store at least the Home IP, CoA, and Home Agent of the visiting Mobile Nodes.

Consider an IEEE802.11 based laptop running Mobile IP that has just turned on in a foreign network (see figure below). The Foreign Agent is router R. (In parts (c) to (f) you may give a written description or use a diagram showing the message exchange. In either case, make sure you clearly state the type of messages being sent, and the source/destination.)



c) Describe two methods for the laptop to discover the access point using IEEE 802.11. [4 marks]

Answer

Method 1: Active discovery, Probe Requests

Laptop broadcasts a Probe Request frame when powered on; if an AP receives this Probe Request it may respond with a Probe Response informing the laptop of the AP.

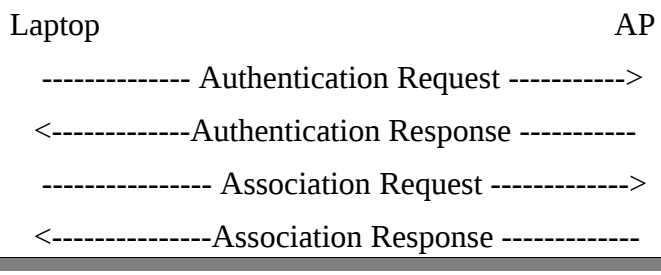
Method 2: Passive discovery, Beacons

AP's periodically broadcast Beacon frames. When the laptop receives a Beacon it has discovered the AP.

d) Once the AP is discovered, describe the procedure for the laptop to join the wireless LAN. [2 marks]

Answer

Authentication and Association



e) Describe two methods for the laptop to discover the Mobile IP Foreign Agent. [4 marks]

Answer

Method 1: Active discovery, Router solicitation

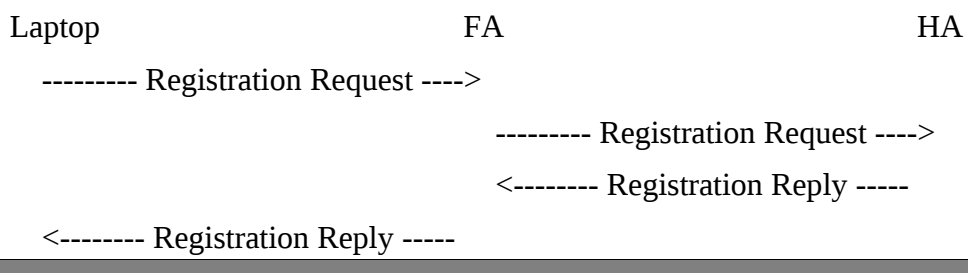
Laptop broadcasts a Router Solicitation message on the IP subnet. If a FA receives the solicitation then it may response with a Agent (Router) Advertisement.

Method 2: Passive discovery, Agent (Router) advertisements

FA periodically broadcasts Agent (Router) Advertisements. If the laptop receives one it has discovered the FA.

f) Once the FA is discovered, describe the procedure that the laptop takes to join the foreign network and inform its HA of the new location. [2 marks]

Answer



Considering your answers from parts (c) to (f), assume the delay for sending a single message (WLAN frame or Mobile IP packet) from laptop to AP is 2ms, from AP to FA is 1ms, and from FA to HA is 10ms. The same delays occur in the opposite direction.

g) Ignoring all other delays (processing, queuing, collisions, etc.) what is the minimum delay from when the laptop turns on, until when the laptop can send data in the foreign network? State which discovery methods you assume, and state any assumptions about the rate at which messages are sent. [4 marks]

Answer

Laptop AP FA HA

X [beacon received]

------ Auth Req.------>

<----- Auth Reply-----

----- Assoc Req.------>

<---- Assoc Reply-----

X [Router Advertisement received]

---------- Registration Request ---------->

------- Registration Request ----->

<------ Registration Reply --------

<---------- Registration Reply ----------

Assuming the use of passive discovery (for both wireless LAN and Mobile IP), in the best case the beacon will be received as soon as the laptop is turned on (i..e no delay). Then there is an exchange of 4 messages with the AP: total delay of 8ms. Assuming once the WLAN association is complete the laptop immediately receives a Router Advertisement, then the Registration procedure can start. Messages from Laptop to FA take 3ms, and from FA to HA 10ms. Therefore the total time for the entire procedure is 34ms.

Once the laptop has successfully joined the foreign network, consider the IP datagrams being sent/forwarded along the path between between the laptop and a correspondent node. Assume the following IP addresses (with subnet mask 255.255.255.0 in all networks):

- Mobile Node Home IP: 63.14.23.94
- CoA: 103.3.22.46
- Home Agent: 63.14.23.13
- Foreign Agent: 103.3.22.1
- Correspondent Node: 102.16.100.4

h) For the data being sent from correspondent node to laptop, indicate the source and destination addresses in the IP header:

i. IP datagram sent by correspondent node [1 mark]

Source: _____ Dest.: _____

ii. IP datagram sent/forwarded by Home Agent [1 mark]

Source: _____ Dest.: _____

iii. IP datagram sent/forwarded by Foreign Agent [1 mark]

Source: _____ Dest.: _____

Answers

i.	Source = 102.16.100.4	Dest = 63.14.23.94
ii.	Source = 63.14.23.13	Dest = 103.3.22.46
iii.	Source = 102.16.100.4	Dest = 63.14.23.94

i) For the data being sent from laptop to correspondent node, indicate the source and destination addresses in the IP header:

   i. IP datagram sent by laptop [1 mark]

      Source: _____ Dest.: _____

   ii. IP datagram sent/forwarded by Foreign Agent [1 mark]

      Source: _____ Dest.: _____

Answers

i.	Source = 63.14.23.94	Dest = 102.16.100.4
ii.	Source = 63.14.23.94	Dest = 102.16.100.4

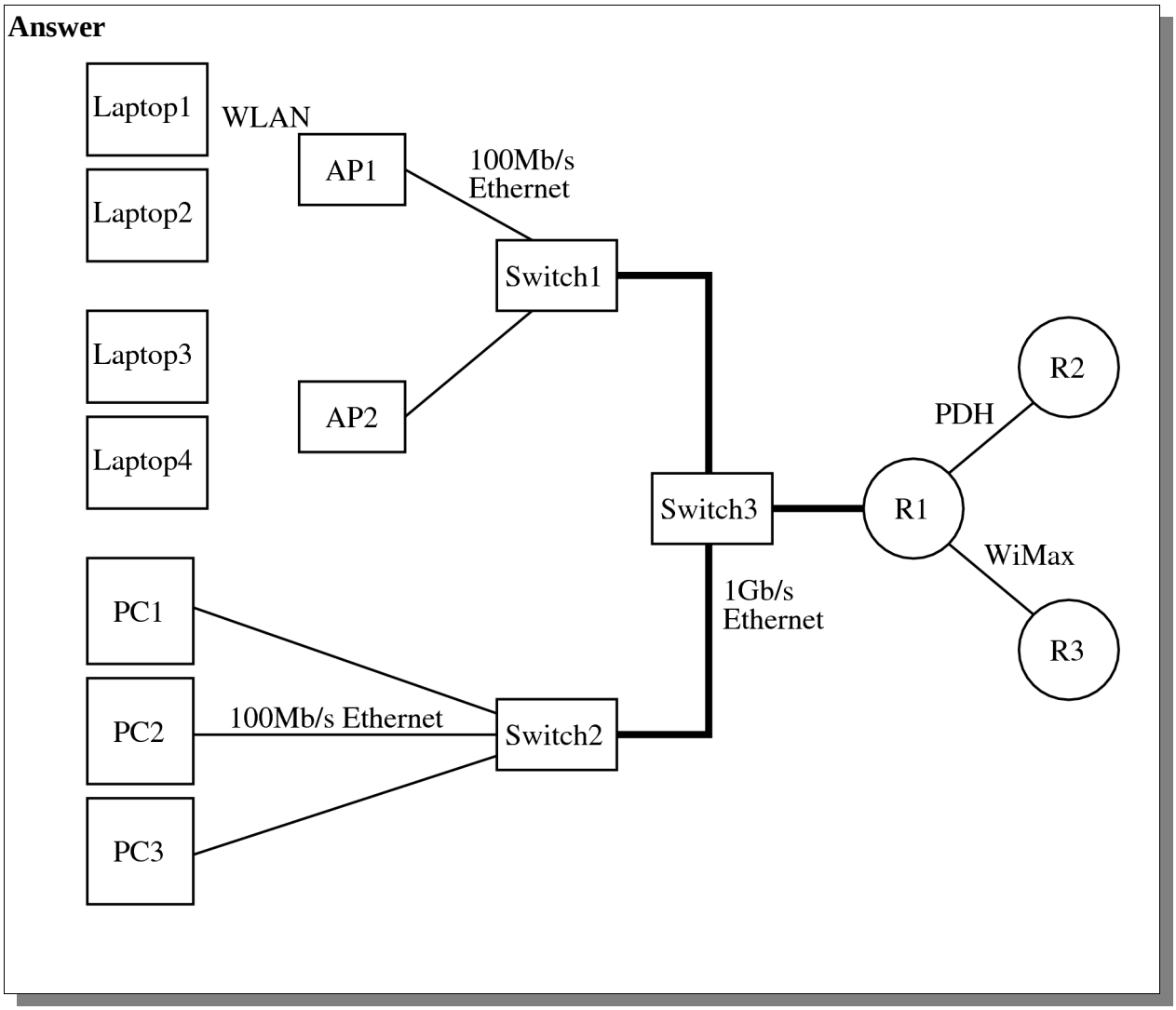
Question 5 [17 marks]

Consider a network with the following components:

- Two IEEE 802.11g wireless LAN basic service sets; each BSS containing two clients. Refer to the clients as Laptop1, Laptop2, Laptop3 and Laptop4.
- The BSS's are connected via a 100Mb/s Fast Ethernet switched LAN. The Fast Ethernet switch (Switch1) is also connected to a 1Gb/s Ethernet switch (Switch3).
- Three PC's (PC1, PC2, PC3) attached to a 100Mb/s Fast Ethernet switch (Switch2). The switch is also connected to the 1Gb/s Ethernet switch Switch3.
- Switch3 is connected to a router (R1) which has two additional interfaces: an 8Mb/s PDH E2 link to an ISP's router (R2); and a 34Mb/s WiMax link to a router at another campus (R3).
- Both routers R2 and R3 are part of separate core networks that connect to the Internet.

a) Draw the network topology, naming all network devices (using the names mentioned above and/or other meaningful names, such as AP1) and naming all links (based on the link technology). [5 marks]

Answer



In answering the following questions about addresses, use the following notation for your answers:

- MAC (or hardware) address of device: MAC(devicename) e.g. MAC(Laptop1)
- IP address of device: IP(devicename) e.g. IP(Laptop1)

b) If Laptop1 is downloading a file from PC1 using TCP, what addresses are inside the header of a IEEE 802.11 data frame received by Laptop1? [2 marks]

Answer

MAC(Laptop1)

MAC(PC1)

MAC(AP1)

c) If Laptop1 is downloading a file from PC1 using TCP, what addresses are inside the header of the IP datagram received by Laptop1? [2 marks]

Answer

IP(Laptop1)

IP(PC1)

d) If Laptop2 in one BSS is sending data to Laptop3 in the other BSS, what addresses are inside the header of the IEEE 802.11 data frame sent by Laptop2? [2 marks]

Answer

MAC(Laptop2)

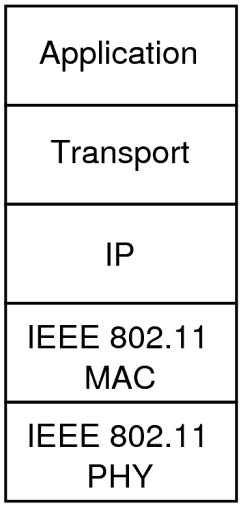
MAC(Laptop3)

MAC(AP1)

e) Draw the protocol stack of the following devices, clearly labelling the protocols/technologies used at each layer (assume hosts run a 5 layer Internet stack; if the question does not indicate a specific protocol, then give the layer name or example protocol):

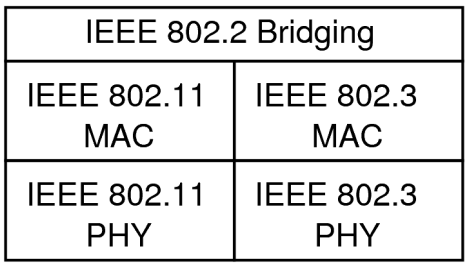
i. Laptop1 [2 marks]

Answer



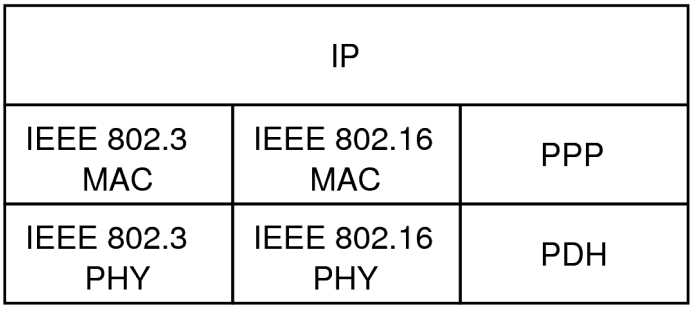
ii. A wireless LAN AP [2 marks]

Answer



iii. Router R1 [2 marks]

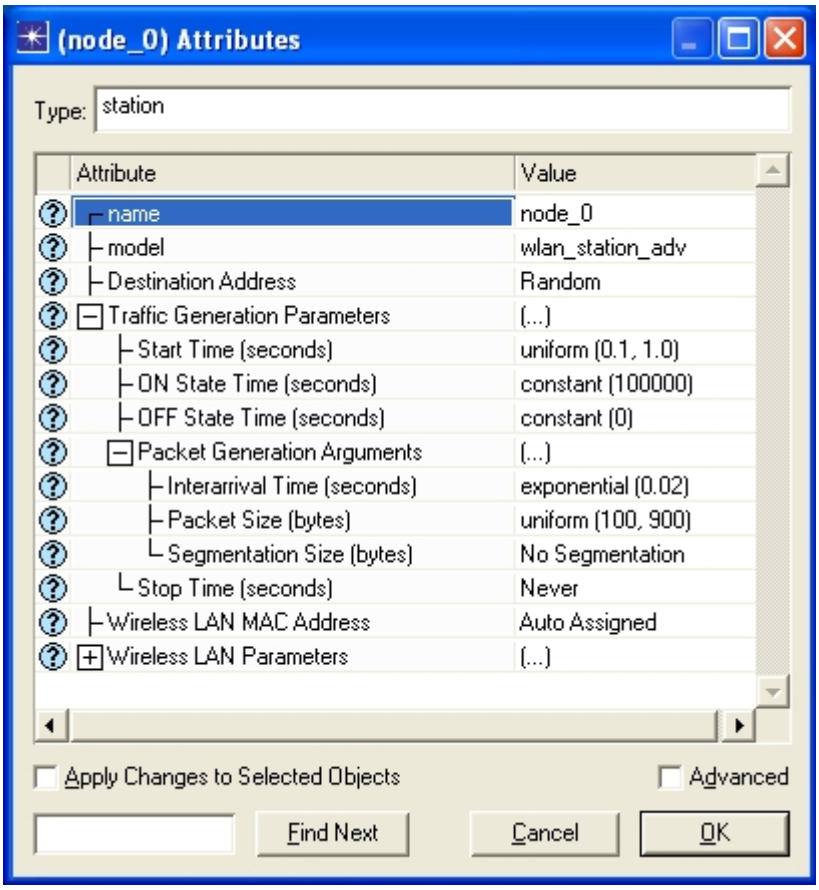
Answer



Question 6 [8 marks]

OPNET IT Guru allows you to simulate networks and applications to predict their performance before they are deployed. The steps involved in setting up a simulation include: defining the network topology; selecting values for node/protocol parameters; defining the traffic to be generated by applications/users in the network; and selecting statistics to measure.

Consider the Traffic Generation Parameters for a node in a network. The following screenshot shows selected parameter values from a node in OPNET.

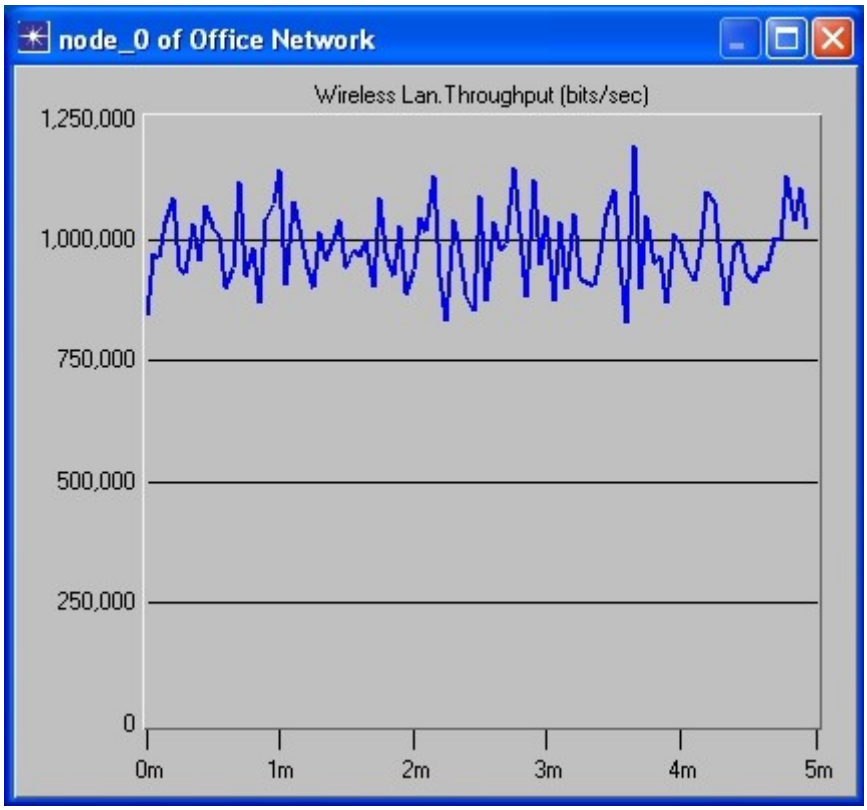


a) If there were 3 nodes in the network with the same attributes as above, then what is the average rate at which traffic is generated in the entire network? In other words, what is the *load* on the network due to the 3 nodes? [3 marks]

Answer

With an average interarrival time of 0.02 seconds and average packet size of 500 Bytes then the average amount rate at which one node generates traffic is: 25KB/s. Therefore 3 nodes generate 75KB/s or 600kb/s.

Consider the statistics obtained from a simulation. The following screenshot shows a result from an OPNET simulation. It is the throughput measured for a single node in a network. Assume the result was obtained when nodes in the network had the same traffic generation parameter values as shown above (except the interarrival time was changed from 0.02 to another value).



b) If you exclude wireless LAN specific factors (such as backoff and collisions), explain why the measured throughput varies over time. [3 marks]

Answer

The traffic generation parameters select interarrival time (and packet size) from a random distribution. That is the interarrival time changes over time: sometimes a node sends a lot; other times it sends a little. As a result the offered load varies over time, and hence so does the throughput.

c) The simulation above was run for a duration of 5 minutes. If instead the simulation was run for a duration of 5 seconds, do you think the results would be an accurate reflection of the network performance? Explain your answer. [2 marks]

Answer

No. Firstly, the start time of sending data is random between 0.1 and 1 second. Therefore some nodes may not start until 1 second, leaving only 4 seconds of sending packets. 20% of the simulation time all nodes are not sending, and therefore the results inaccurate.

Secondly, the number of packets sent in total may be a too small sample to obtain accurate statistics. As there is randomness in the interarrival time and packet size (as well as backoff) the exact conditions in a short duration may not reflect typical conditions.