UNIVERSITY OF DUBLIN

TRINITY COLLEGE

FACULTY OF ENGINEERING, MATHEMATICS & SCIENCE

SCHOOL OF ENGINEERING

Electronic & Electrical Engineering

Senior Sophister Engineering Annual Examinations

Trinity Term, 2013

WIRELESS COMMUNICATIONS (4C4)

Date: 11th May 2013 **Venue: Regent House (136)** **Time: 09:30 – 11:30**

Prof. Linda Doyle
Prof. Luiz DaSilva

Answer ALL FOUR questions

All questions carry equal marks

Permitted Materials (Complete List):

Graph paper
Calculator
Any book
Any personal notes (on paper)
Laptop (all network connectivity must be disabled)

Q.1

A Digital TV transmitter is operating on channel 46 in the USA. The table below shows the Height Above Average Terrain (HAAT) readings for the antenna at the transmitter site. You can assume that the readings have been generated from the FCC online database.

0.0°	50 meters
30.0°	150 meters
60.0°	120 meters
90.0°	200 meters
120.0°	300 meters
150.0°	400 meters
180.0°	450 meters
210.0°	500 meters
240.0°	450 meters
270.0°	400 meters
300.0°	100 meters
330.0°	200 meters

Fig. Q.1. HAAT at the TV transmitter site

(a) On the graph paper provided, make a plot of the service contour for this transmitter. The transmission power is 500 kW.

[10 marks]

(b) How far away from the transmitter must a white space device operating on channel 45, 46 and 47 be? To carry out this analysis, use the protection ratios recommended by the FCC and select a simple propagation model of your choice to determine what kinds of distance restrictions apply. Assume that the white space device is a fixed white space device at 30 m height and 4 W.

[10 marks]

(c) What other considerations does the white space device need to take into account when operating in the TV bands?

[5 marks]

Q.2

The 2011 IEEE INFOCOM paper on '*Understanding Traffic Dynamics in Cellular Data Networks*' by Utpal Paul, Anand Prabhu Subramanian, Milind Madhav Buddhikot, Samir R. Das is on the reading list for this course and is the focus of this question.

(a) What kinds of cellular networks have been used to collect the data for the paper?

[2 marks]

(b) What are some key characteristics of an LTE network that would be different from the networks used in this paper?

[2 marks]

(c) What are the key conclusions drawn by the authors about the <u>temporal</u> behaviour of traffic in cellular networks?

[6 marks]

(d) What are the key conclusions drawn by the authors about the spatial behaviour of traffic in cellular networks?

[6 marks]

(e) Do you think the analysis is valid given that the data has been collected in 2007 and using a specific cellular technology? Explain your answer.

[4 marks]

(f) How do you think this kind of analysis can influence the design of future networks?

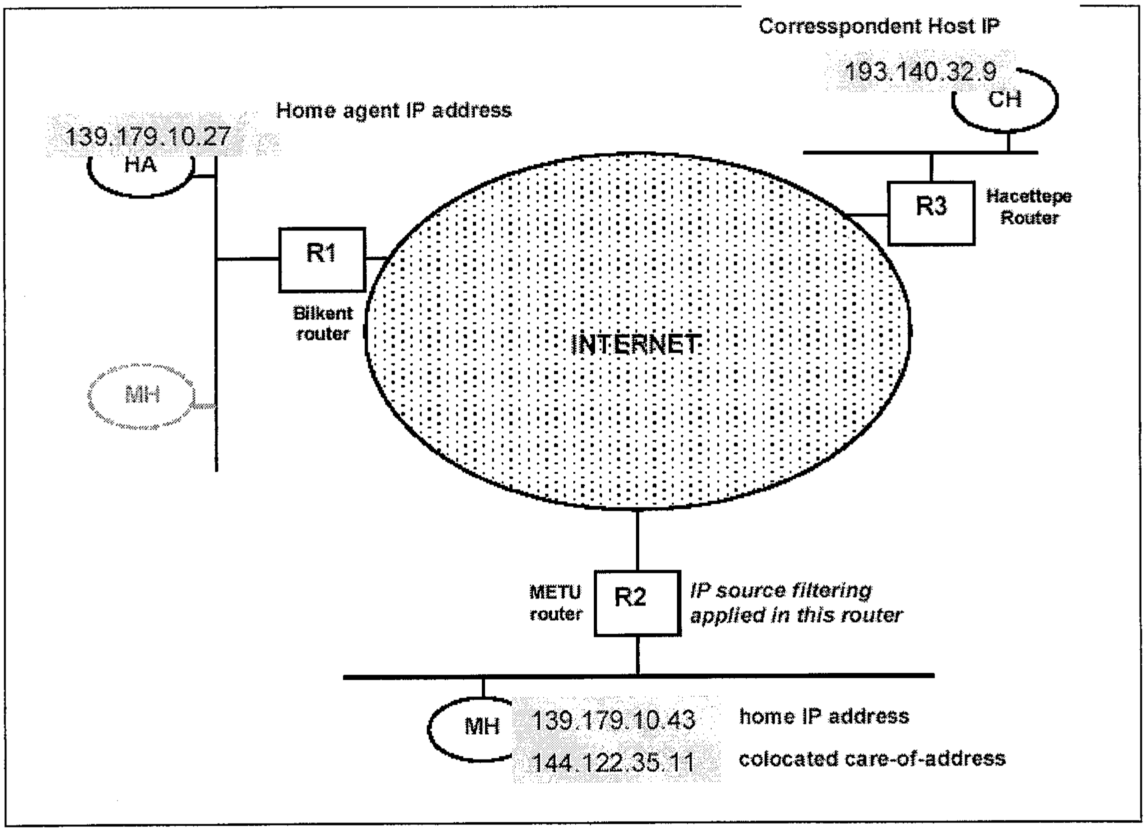
[5 marks]

Q.3

Consider the network in Fig. Q.3. A mobile host (MH) has a permanent home address of 139.179.10.43. It moves to a foreign network, where it uses DHCP to obtain a co-located care-of address of 144.122.35.11. The MH implements Mobile IP functionality and will serve as the start/end point for tunnels.

Now, let us assume the MH wants to send some data to a correspondent host (CH) whose IP address is 193.140.32.9. The egress router **R2** performs *source address filtering* and drops any IP packet that is going out of that network and that has a source IP address field set to an IP address that is not from the local address pool. In this case, all IP packets sent directly from the MH to the CH using the MH's home address as the source address will be dropped at the **R2** router.

A solution to this problem is to *encapsulate* all the IP packets that originate from mobile host MH at MH using *IP-in-IP encapsulation* and then tunnel them to the home agent (HA), which in turn will forward them towards the correspondent host CH. Assume this solution is applied.



. **Fig. Q.3**

Q.3 (Cont'd)

(a) For a packet traveling from the MH towards the HA, how many IP headers will be present? Explain.

[5 marks]

(b) For a packet traveling from the MH towards the HA, provide the source and destination IP addresses for each of the IP headers. Start with the outermost header, and provide the source/destination IP addresses for as many inner headers as needed in this case, consistently with part (a).

[5 marks]

(c) For a packet traveling from the HA to the CH, how many IP headers will be present? Explain.

[5 marks]

(d) For a packet traveling from the HA towards the CH, provide the source and destination IP addresses for each of the IP headers. Start with the outermost header, and provide the source/destination IP addresses for as many inner headers as needed in this case, consistently with part (c).

[5 marks]

(e) What is the most likely reason for the egress router R2 to perform source address filtering as described in this question? Explain.

[5 marks]

Q.4

Consider the transmission of data packets between two wireless sensors u_1 and u_{k+1}, separated by a distance $d(u_1, u_{k+1}) = m$, as depicted in Fig. Q.4. There are other sensors placed at regular intervals between u_1 and u_{k+1}, all of which can potentially relay packets for one another.

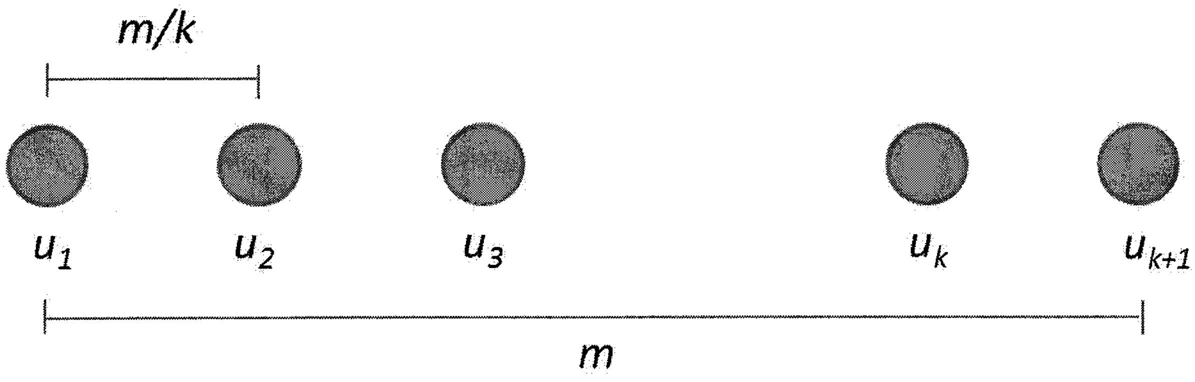


Fig. Q.4

On transmission, each sensor can select a power level so that it reaches only as far as its desired destination. Consider that all transmissions of a packet last one time unit. We model the energy spent during transmission of a packet between any two sensors u_i and u_j, as $t(d(u_i, u_j))^\alpha$, where: t is a constant and α is the exponent for the wireless propagation model ($\alpha \geq 2$). We model the energy necessary for reception as a constant c.

(a) How large must m be for it to be more efficient to relay data through all intermediate sensors $u_2, u_3, \ldots, u_k$, rather than transmit directly from u_1 to u_{k+1}? Your answer must be a function of t, c, and α. Note that you are only to consider two alternatives: communicate directly between u_1 and u_{k+1}; and relay the packet through all intermediate sensors.

[10 marks]

(b) All other parameters staying constant, as α increases is it more energy-efficient to use more or fewer intermediate sensors to relay the data? Provide some intuition for your answer.

[5 marks]

(c) All other parameters staying constant, as m increases is it more energy-efficient to use more or fewer intermediate sensors to relay the data? Provide some intuition for your answer.

[5 marks]

(d) All other parameters staying constant, as c increases is it more energy-efficient to use more or fewer intermediate sensors to relay the data? Provide some intuition for your answer.

[5 marks]