

Home Work #1 (due June 3, 2002 by 5 PM)

Total = 65 points

Note: Please submit your solution on-line (PS or PDF or HTML or Word or Framemaker). Send an email to mbs@ee.ucla.edu with a URL from where I can download the file(s). *DO NOT SEND AS EMAIL FILE ATTACHMENTS. ALSO, PLEASE MAKE SURE THAT THE URL REMAINS VALID FOR THE REMAINDER OF THE QUARTER.*

Q 1. [10 points]

Consider a communication scheme with two protocol layers. The lower layer recovers packet errors by immediate retransmission (assume instantaneous and error-free feedback). The upper layer resets a connection if it does not receive correct packets for τ seconds. The idea is to counteract physical channel impairments (consider only Rayleigh fading here) through immediate retransmission, and to release a connection if something more persistent happens (e.g., congestion in the network). We want to avoid that the protocol resets a connection due to Rayleigh fading attenuation. Find an appropriate value of the timeout, τ , as a function of the fading margin F (consider the ranges 5, 10, 15, 20, and 25 dB) in the following cases: pedestrian environment (3 km/h mobile velocity and 1 Mbps channel speed) and vehicular environment (60 km/h mobile velocity and 200 kbps channel speed). Packet length is 1000 bits and carrier frequency is 900 MHz. Your design should be such that connection reset happens due to Rayleigh fading with small probability (consider 1% and 5% in your results). You may use engineering simplifications as appropriate, and may use software tools.

Q 2. [12.5 points]

Consider a set of 10 sensor nodes distributed on a square field of size 25 m by 25 m that has its lower left corner at the origin of the coordinate system. The coordinates of the sensor nodes are given in the table below. In addition to the sensor nodes, there is a gateway node at the center of the field to which all the sensors send their data. Each sensor node has a battery with initial energy of 4 units. The gateway has infinite energy.

Assume that the transmission range of each sensor node is 12.5 m when it is transmitting with maximum transmit power. The energy needed at the transmitter to send a packet to a node that is 12.5 m away is 1 unit. Assume $1/d^4$ path loss, and assume that it takes the same amount of energy to send a packet to a node that is closer than 12.5 cm as it does to send a packet to a node that is exactly 12.5 cm away. There is no energy consumed in receiving a packet.

There are a lot of events happening at nodes 1, 2, and 3, which are generating packets at the rate of 2 packets/second (i.e. packets are generated at $t = 0, 0.5 \text{ s}, 1.0 \text{ s}, \dots$). There are no events, and therefore no packets generated, at the other nodes.

a. Consider the case when the nodes have no transmit power control, and therefore always transmit at the maximum range. The routing policy is shortest # of hops. What is the system lifetime (the earliest time at which one of the ten nodes exhausts its battery energy)? Which node is the first one to die? Assume that it takes zero time to transmit a packet over a link.

b. Now consider that nodes have perfect transmit power control, and the routing policy is to use the path from each node to the gateway that would consume the minimum energy. Show the minimum energy paths from nodes 1, 2, and 3 to the gateway. What is the system lifetime? Which node is the first one to die?

Node	X	Y
1	11	12
2	22	15
3	22	1
4	9	20
5	0	2
6	1	10
7	23	2
8	19	13
9	6	20
10	5	9

Q 3. [25 points]

Consider the network of 10 sensor nodes that we had in Q3. Ignore the gateway and consider the network as a peer-to-peer network. Moreover, consider the case where there is no transmit power control, so that the nodes always transmit at maximum power.

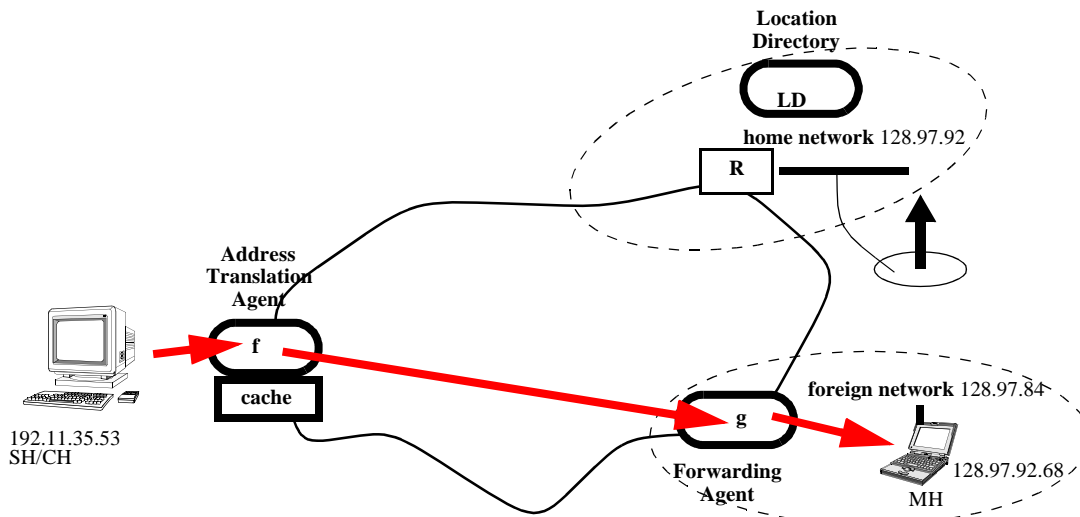
a. The nodes are all time synchronized, say through a GPS, so that a TDMA based medium access can be used. In particular, we wish to divide time into “Frames” consisting of N “Slots” each. Each node gets assigned to a slot number, and is allowed to transmit during that Slot in every Frame, and the transmission is heard by all of the neighbors who arrange to be in receive mode during that Slot. Describe a general algorithm (pseudo code) to find the minimal size TDMA frame (i.e. smallest N), and show a solution for this case. Assume that a node does not cause any interference outside its range. Do not worry about the communication cost of the algorithm - i.e. a centralized solution is acceptable.

b. Now, modify the setup. Instead of TDMA slot to each node, we wish to allocate a TDMA slot to each link (i.e., each pair of neighbors). Describe a general algorithm to find the minimal size TDMA frame (i.e. smallest N), and show a solution for this case.

c. What are the trade-off between allocating TDMA slots to nodes vs. allocating slots to links?

Q 4. [0.5+0.5+0.5+3.5 = 5 points]

Consider Bhagwat & Perkin's generic mobile-IP framework based on Forwarding Agent (FA), Location Directory (LD), Address Translation Agent (ATA), and Location Update Protocol (LUP) as shown in the following figure.



- Where would you locate ATA if one decides not to use LD caching? Why?
- What are the security problems if one does caching?
- What is the problem in using loose source routing for address translation?
- Functionally compare the Columbia, IBM LSR, IETF IPv4, and IETF IPv4 + Route Optimization Mobile-IP schemes along the following dimensions (i) ATA location, (ii) FA location, (iii) LD, and (iv) LUP. You can just make a table.

Q 5. [12.5 points]

Read, summarize, and critique (weaknesses, strengths) of the following three papers from Infocom. The style should be similar to that of a detailed review of the paper that one might do when deciding to accept or reject for a conference or a journal.

Joint Scheduling and Power Control for Wireless Ad-hoc Networks

Tamer ElBatt (HRL Laboratories), Anthony Ephremides (University of Maryland at College Park)

<http://www.ieee-infocom.org/2002/papers/098.pdf>

Energy Efficient Communications in Ad Hoc Networks Using Directional Antennas

Akis Spyropoulos (University of Southern California), Cauligi Raghavendra (University of Southern California)

<http://www.ieee-infocom.org/2002/papers/289.pdf>

Base station scheduling of requests with fixed deadlines

Mohit Agarwal (University of California at Berkeley), Anuj Puri (University of California at Berkeley)

<http://www.ieee-infocom.org/2002/papers/784.pdf>