Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

21. January 2008

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Exam Ad Hoc and Sensor Networks HS 2008

- Please write your **Name and Legi-Number** on all sheets you hand in.
- You have **60 minutes**.
- There are **3 questions** with a total of **60 points**.
- Put your Legi on the table, we will check them.
- **No auxiliary material** is allowed.
- You may answer the questions in **German or English.**
- Where indicated stick to the expected answer length.

→ **Do not open or turn until told to do so by the supervisor!**

Name:	Legi-Nr:

Question	max	achieved
1	29	
2	25	
3	6	
Total	60	
	Grade:	

Question 1 (29 Points): Geo-Routing

a) (3 points) What is the basic idea of *geo-routing*? (2-3 sentences)

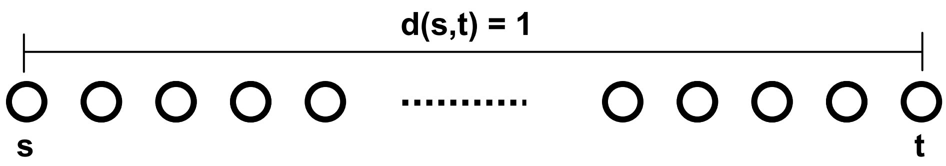
b) (3 points) The simplest form of geo-routing is the *greedy geo routing algorithm*. Does this algorithm work on all planar graphs (nodes are points in the plane, no intersecting links)? If yes: give a high-level proof; if no: give a counter example.

c) (3 points) There is a fairly well known approach how to escape from a maze by sticking to the right wall. The rule says: "Hold your right hand to the wall and follow that wall at any intersection. After some time you will come to the exit". Assume you have been dropped in a maze and try to get out of it by using this rule. After hours you still have not found the exit (although there is a reachable exit) and you know that the maze is small enough so that you could have visited all corridors of the maze in a tenth of this time. What is going wrong? Give an example and explain in 1-2 sentences.

d) (3 points) In networking there is the rule that solving different tasks on different independent layers is a good idea (e.g. the OSI model). In chapter 2 of this course we have discussed geo-routing. In chapter 13 *location services* were introduced. Where would you place these two tasks in a layered communication stack? How would you place them with respect to each other? (2-3 sentences)

e) (5 points) Assume a *Unit Disk Graph (UDG)* which fulfills the $\Omega(1)$ model. For the sake of simplicity we define $d_0=0.5$. In other words we have a UDG over a node set in which all nodes have a mutual distance of at least 0.5. Using an example, show that in this model any geo-routing algorithm may need up to x^2 hops to reach a destination if the optimal path requires x hops.

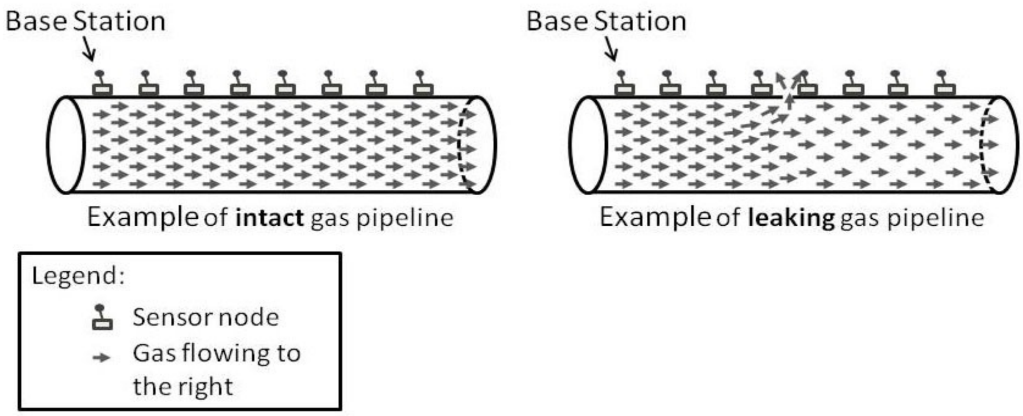
f) (3 points) We have a line of n nodes in which the outmost two nodes s and t have a distance of 1. In between these nodes n-2 additional nodes are placed uniformly. The connectivity model is a UDG. The employed cost model is the *energy metric* which means that the cost to transmit a message over a link from node u to v is: $\text{cost}(u,v) = \text{EuclideanDistance}(u,v)^2$. What is the minimum energy cost to send a message from s to t?



g) (9 points) Assume a Unit Disk Graph (UDG) which unlike in e) no longer fulfills the Ω(1) property. This means that nodes may be arbitrary close. We use the energy metric as defined in question f) to compute the cost of a path by summing up the energy costs of traversed links. What is the approximation ratio of any geo-routing algorithm in this model? That is, how much worse than the optimal path can the solution of a geo-routing algorithm become?

Question 2 (25 Points): Gas pipeline

The petroleum gas company iGAS is using sensor network technology to monitor the state of one of their pipelines. The monitored segment of the pipeline is 1.5km long and forms a completely straight line. Every 15m a sensor node is placed on the pipeline in order to guarantee a mostly interference free communication between neighboring devices. Each node has a unique numeric ID in the range from 0 to 100. The base station has ID 0. All other nodes are placed such that their IDs increase with their distance to the base station. The nodes constantly sample (10 times a second) the pressure within the pipeline. If a node detects an abrupt change of pressure it triggers a leak-alarm message which is sent to the base station at the entry of the monitored pipeline segment.



a) (5 points) iGAS has bought a communication stack using the low-power listening (LPL) based B-MAC to forward the data. The chief technical officer of iGAS has no idea how this MAC layer works and only tells you that he has been told that nodes listen to the channel every 30 seconds. The problem is that iGAS is not happy with the delay at which alarm messages arrive at the base station. Sometimes more than 30 minutes pass between the leak detection at a node and the moment when the base station gets informed where the leak occurred. Can you explain why this is happening? Explain the principle of B-MAC and show why such a delay is not surprising.

b) (6 points) The leadership board of iGAS is convinced by your explanations and decides that they do no longer want to rely on B-MAC. You are asked to propose a new communication stack which minimizes the delay for alarm messages. As the sensor nodes are battery driven your solution must also be energy efficient. Give a high-level description how your MAC and Routing layers work. Also consider possible side effects of your solution and discuss how these may be handled.

c) In a second installation the nodes were accidentally deployed in the wrong order. They are still deployed every 15m but instead of having their IDs form a monotonously increasing chain, they are now in a random order. Luckily it is still possible to reprogram all nodes wirelessly from the base station. You are asked to devise an algorithm which reconstructs the topology of the nodes on the pipeline.

   I. (1 point) Assume all nodes have a constant transmission range of 32m. All neighbors within this range are perfectly reachable. All nodes outside of this range are not reachable. Which network model presented in the lecture corresponds to these assumptions?
   II. (5 points) Using the definition of I. propose a simple algorithm which recovers the network topology.
   III. (2 points) Assume a more realistic network model. Nodes within 20m are perfectly reachable. Nodes within 70m are sometimes reachable and sometimes they are not. As a simplification assume that links are static. That is, if a link once exists it will always be there. Which network models correspond to this definition?
   IV. (6 points) Propose an algorithm to (approximately) reconstruct the topology of the network under the conditions defined in III. Discuss why it is harder to solve the problem under the conditions of III. than under I.

Question 3 (6 Points): TinyOS

a) (2 points) In TinyOS there are three types of files, **Modules**, **Configurations**, and **Interfaces**. What is the difference between **Modules** and **Configuration** files?

b) (4 points) In the lab exercise you have worked with the light sensor. To access this sensor you have used a so called split-phase interface.
   I. Explain what a split phase interface is.
   II. Why is such an interface used to access the light sensor?