Exercise Sensor Networks - (till June 6, 2005)

Lecture 6: Routing in sensor networks

Exercise 6.1: SMACS

a) How does the SMACS protocol try to avoid collisions? What is the difference with regard to allocating a communication channel compared to the approaches we got to know to far?

Solution:

The protocol avoids collisions by establishing communication links in advance. These links can either be found or they will fail. Other contention based channel allocation approaches negotiate channel access repeatedly ad-hoc. Another major difference of SMACS is that it extends the space for communication by using multiple frequencies.

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Exercise 6.1: SMACS

b) How does SMACS solve the hidden/exposed station problem? How can collisions still happen?

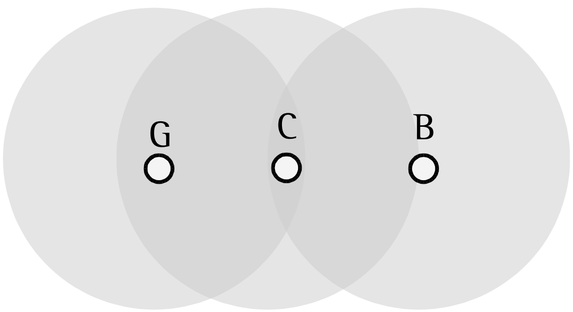
Solution:

A unique combination of a time slot and a frequency is defined for each communication partner, one for each direction. The combination of time and frequency will make collisions unlikely. Because of the larger number of frequencies several station can talk to one another at the same time within the same proximity. However, collisions can still happen.

Example:

Node C invites other local nodes to agree on a common slot. Node B responds and is chosen like shown on the lecture slides. Then B is allowed to find a free slot which coincides with its own schedule and the one of C.

Though this might work there is no guarantee that a node G unknown to B but in the neighborhood of C uses the same frequency at the same time slots as C and B. This is a typical instance of the hidden station problem.



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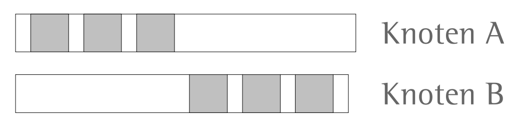
Exercise 6.1: SMACS

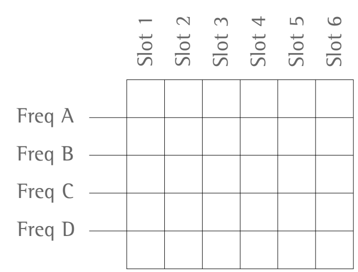
c) If two clusters meet it can happen that one cluster can not connect the other. How can this happen and what is the rare resource? Design an example in which one cluster in unable to connect another one.

Solution:

In the example on the right 50% of node A and B's slots are free but none of them coincides so that no communication can take place.



The combination of slots and frequencies extends the possibilities for communication significantly but in all 1-to-n relationships the limited number of time slots on the 1-side is still the sparse resource.



d) Can bottle necks identified in c) be resolved by sorting the schedules in another way? If yes how, if not why?

Solution:

A permutation of slots on one side is no option as this would only shift the problem to the peer node at the other side of the swapped slot. No good local solution is known at this time. Only a global optimization could mitigate the problem. E.g., a linear program could solve the problem.

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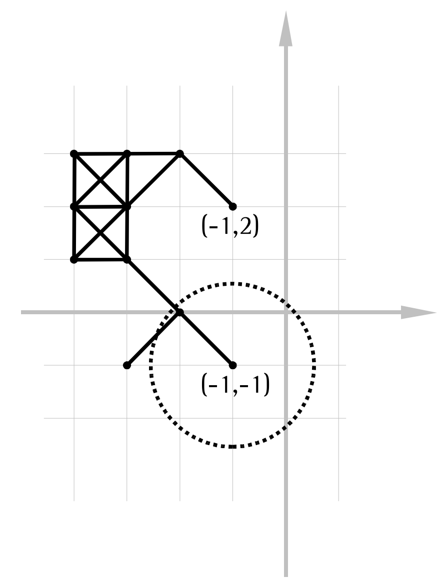
Exercise 6.2: Geographic Hash Tables

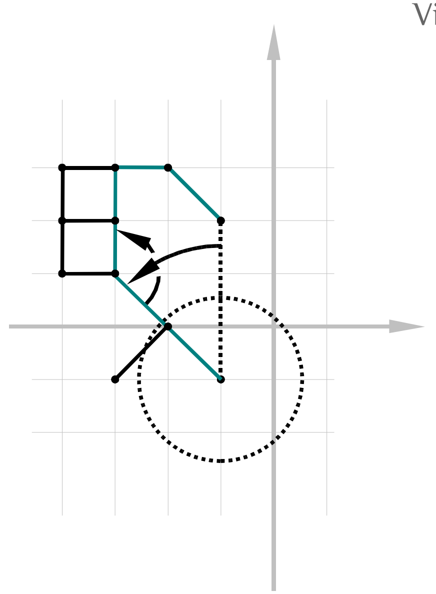
a) A number of nodes are shown in the right figure as small dots. Each node has a radio range of 1.5 units. The mutual connectivity is already included as connecting lines in the figure. Reduce the graph according to the Relative Neighborhood Graph (RNG) algorithm to a planar graph.

b) Route a packet according to the GPSR Algorithm from node (-1, -1) to node (-1, 2) and write down the visited nodes.



Solution to a) and b) :

Visited node: (-1,-1), (-3,1), (-3,2), (-3,3), (-2,3), (-1,2)



Exercise Sensor Networks

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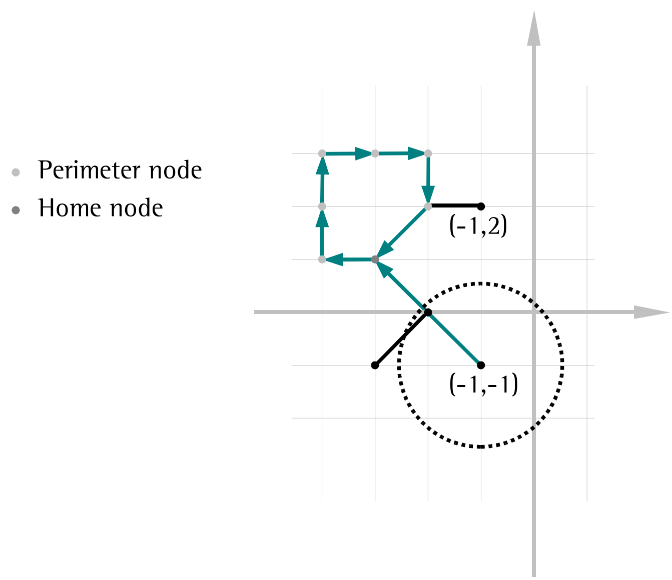
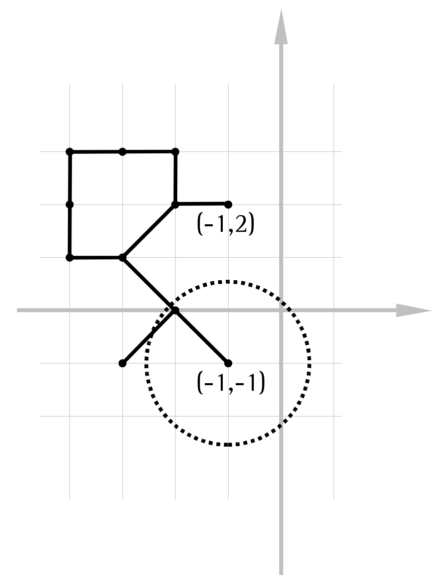
Exercise 6.3: Geographic Hash Tables

c) Node (-3, 2) moves to position (-2, 2). Shortly afterwards the sensor network has to associate some information with position (-3, 2). Which nodes become replica nodes according to Geographic Hash Tables and which one becomes the home node if we always rotate counter clockwise?

Solution:





Exercise Sensor Networks

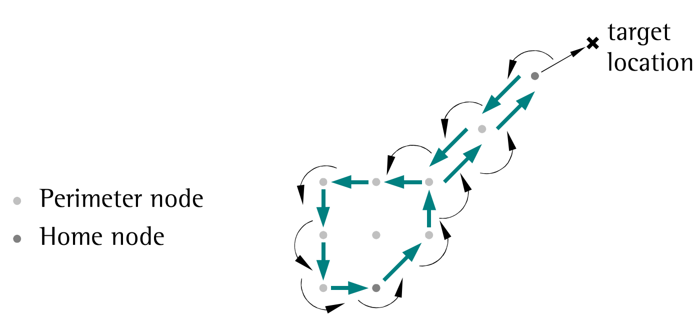
Lecture 6: Routing in sensor networks

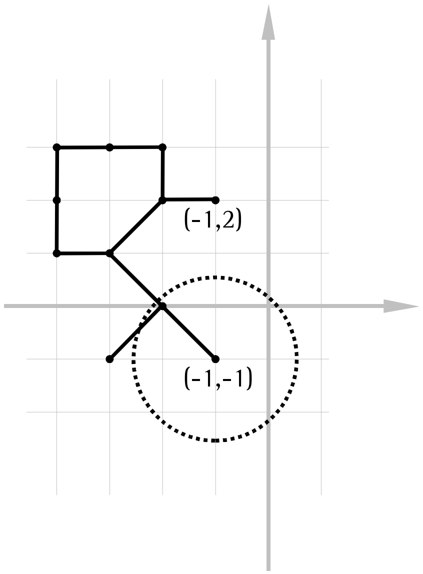
Exercise 6.3: Geographic Hash Tables

d) Some researchers claim that perimeter mode can cause a packet to traverse a network's entire outer boundary. Prove that this is false or show an example.

e) Again, information has to be associated with a specific location. A chain of sensors leads to that location however, in the fashion of a dead-end road. The last node before the considered location is only connected with the chain in one direction. How does perimeter mode behave here?

Solution for d) and e)





Exercise Sensor Networks

Lecture 6: Routing in sensor networks

Exercise 6.4: GeoCast

In order to route a packet a router has to intersect the target region contained in a packet with the region it is responsible for. Circles and arbitrary polygons are considered in the approach. In order to cut circles with polygons the authors suggest to decompose a circle into a number of line segments and cut the evolving polygon using a conventional polygon-polygon intersection.

a) Why is this solution not optimal?

Solution:

The circle is already defined precisely and simple by its midpoint and radius. Tessellating it into a number of line segments is demanding and not precise.

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Exercise 6.4: GeoCast

b) Design an approach which treats the circle as such. Think of the normal-based line equation to ease the task.

Solution:

$$dist = (\vec{P}_1 - \vec{M})\vec{n}_0$$

whereas n0 denotes the normal unit vector of length 1. If dist < the circle's radius then the circles cuts the straight line through P1 and P2. If the distance dist is larger no intersection is possible.

But we are not yet ready because the intersection (in case it exists) has to occur between P1 and P2 on the line and not beyond.

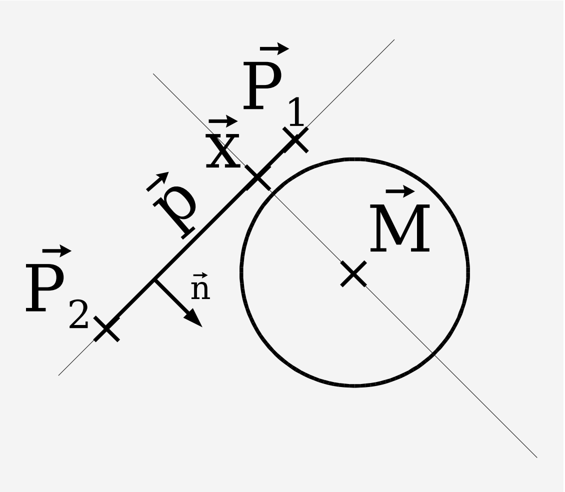
Therefore the perpendicular through M onto the line is constructed in order to obtain the intersection x. Ist is however, not necessary to calculate the coordinates of the intersection but only the parameter on the line through P1 and P2. If the parameter is in [0, 1] then the intersection is asserted.

$$\vec{X} = \vec{P}_1 + r\vec{p} \qquad \vec{p} = \vec{P}_2 - \vec{P}_1$$

Obtain the parameter r for which M-X is orthogonal to p:

$$(\vec{X} - \vec{M})\vec{p} = 0$$

$$(\vec{P}_1 + r\vec{p} - \vec{M})\vec{p} = 0 \Leftrightarrow \vec{P}_1\vec{p} + r\vec{p}\vec{p} - \vec{M}\vec{p} = 0 \Leftrightarrow r = \frac{\vec{M}\vec{p} - \vec{P}_1\vec{p}}{\vec{p}\vec{p}} = \frac{\vec{p}(\vec{M} - \vec{P}_1)}{\vec{p}^2}$$



Conclusion: It is a lot easier to calculate the intersection between the original circle and a line rather than to break the circle into a larger number of line segments as suggested in the paper.