Exercise Sensor Networks – (till May 2, 2008)

Lecture 10: Synchronization in sensor networks

Exercise 10.1: Signal propagation delay

A church bell is rang by a digitally triggered mechanics. How long does the sound travel to a sensor node in a distance of 2km if sound travels at 300m/s?

In another setting a node hears the radio synchronization signal of the "Physikalisch-Technischen Bundesanstalt" (federal ministry for physics and technology) in a distance of 1.800km. Radio signals propagate at a speed of 300.000 km/s. How large is the delay?

Exercise 10.2: Reference Broadcast Synchronization

Node A receives the last acoustic synchronization signal **2000ms** (milliseconds) after its initialization. At time **2100ms** it detects an event.

At **3400ms** B tells A that B has detected the same event **1700ms** after its initialization. B's last synchronization took place at **1500ms**. Sound travels at a speed of 300 meter/second and all acoustic synchronization signals origin from the same global source.

a) How many ms did B detect the event sooner or later than A, based on the given information. For what reasons may your result contain some uncertainty?

b) In addition it is now known that node A is 100 meters away from the sync. source and node B 300 meters. How can the precision of the result from a) be improved?

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Exercise 10.3: Estimation of a time interval with uncertainty

3400ms after its initialization node B receives a message from node A that an event has happened. Node A tells in addition that its clock showed 7800ms when A got to know about the even itself. Then some time passed and A informed B about the even at time 8400 (according to A's clock).

According to B's clock it sent the last message to A at time 1200ms. Node A also tells B in the message that it did not hear from B for a time span of 2000ms.

Finally it is known that B's clock has a maximum deviation of p_B=0.08 (this means that the clock is at most too fast about the factor 1+0.08 and at most too slow about the factor 1-0.08). A's clock has a max. deviation of p_A=0.1.

a) Obtain an interval as small as possible but which is large enough so that it must contain the event.

b) In the above mentioned scenario A informs B about events over a long period however, B has no reason to communicate with A and thus only receives data. In this context collisions on the radio channel are not considered. What is the problem here and how can it be solved?

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Exercise 10.4: RBS vs. RTT basiert

In order to determine the drift of clocks the Reference Broadcast Synchronization (RBS) or the NTP-like round trip time based approach can be used. Decide which model is the better one based on the following assumptions:

a) There are no errors other than the access time to the medium. But the access time has a high variance.

b) There is no other error than the access time to the medium. The access time is unknown and the same for all nodes and it is known that it has no variance.

c) Only the time for receiving a packet is not negligible. The deterministic reception time is different for every node but it is known.

d) The only influence is the signal propagation time (of acoustic signals of the synchronizer) and the locations of the nodes are unknown.

Exercise 10.5: RBS

The drift between two nodes A and B should be determined using RBS. These two nodes are the only ones available. So one node chooses to be the synchronizer and sends the sync signal. Which inaccuracy is caused in this situation as compared to using a central node? For what reason is a central synchronizer essential?