Exercise Sensor Networks

Lecture 8: Synchronization in sensor networks

Exercise 8.1: Signal propagation delay

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

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

Exercise 8.2: 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 error?

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

Exercise Sensor Networks

Lecture 8: Synchronization in sensor networks

Exercise 8.3: 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 event itself. Then some time passed and A informed B about the event 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?

Exercise Sensor Networks

Lecture 8: Synchronization in sensor networks

Exercise 8.4: RBS vs. RTT based

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 not known but it is known that it has no variance.

c) Only the time for processing an incoming packet is not negligible. The deterministic processing time is different for every node but it is known.

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

Exercise 8.5: RBS

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

Exercise 8.6: Comparison of fuzzily determined events

An event A takes place in the time interval [t1, t2], another event B in [t3, t4] and C in [t5, t6]. The following holds true: t1 < t3 < t5 < t2 < t4 < t6. What is the probability that C happens first, than B and finally A?