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A Simple Neighbour Discovery Procedure for Bluetooth Ad Hoc Networks

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Overview

- Bluetooth & Neighbour Discovery
- Inquiry procedure
- Simple Neighbour Discovery (SND)
- Comparison of SND and Inquiry
- Analysis of SND
- Conclusion



Bluetooth



- Neighbour discovery:
 - Called inquiry in Bluetooth;
 - Find other nodes in radio range;
 - Refresh information about nodes



Bluetooth inquiry

- Mechanism:
 - One node sends inquiry message;
 - Other nodes reply with inquiry_response;
- Features:
 - Primarily designed for cable replacement;
 - Discovers all devices in fixed time;
- Drawbacks in ad hoc scenario:
 - Takes lot of time;
 - Complex (Inq, Inq_scan, Inq_resp);
 - Inefficient with parallel data transmissions;
 - Nodes play asymmetric roles







Simple Neighbour Discovery Proc.

- Mechanism:
 - nodes **send beacon** packets regularly;
 - nodes perform **scanning** for beacons;
- Differences between SND and inquiry:
 - symmetric roles (all nodes perform both scanning and sending beacons);
 - nodes that want to be discovered send messages;
 - performed when data communication allows



scanning

beacon

SND details: sending beacons

- Sending beacons
 - Beacon period (parameter) -> how often send beacons;
 - Timeslot inside the period and radio frequency chosen pseudo-randomly from the clock and address of the node -> other nodes can take it into account;
 - Priority over base band data packets;
 - **32** frequency is used from 79;
 - beacon is one slot long



SND details: scanning

- Scanning for beacons:
 - Scan period tunable parameter;
 - Scanning frequency randomly selected;
- Beacon packets contain:
 - clock;
 - address;
 - beacon period length of the node



Comparison of SND and inquiry



Simulation results

- Plasma: discrete, event driven simulator
- Results:
 - Probability of discovery vs. time spent with scanning
 - Analytical results

$$P_{disc} = 1 - e^{-P_1 \frac{T_{tot}}{T_{BCN}}}$$



Comparing SND and inquiry

Inquiry procedure Inquiry procedure hп hп hп ΠП hп hп Master Node 1 Slave and Node 2 2.56 sec random (0. 1023) slots slave is scanning inquiry message inquiry response message inquiry scan Asymmetric roles inquiry Symmetric roles SND procedure SND procedure beacon period beacon period Node 1 Node 1 Node 2 Node 2 random (0., 1000) slots random (0..1000) slots the node is scanning beacon packet the node is scanning beacon packet Probability of discovery Time needed to discover the neighbours 0.9 0.9 0.8 0.8 0.7 0.7 Probability 0.6 lity Probabili 9.0 0.4 0.4 0.3 0.3 0.2 0.2 0.1 0.1 inquiry inquiry × FND random scanning 0**#** 0 04 25 2 3 5 6 8 5 10 15 20 4 7 9 Time spent with scanning or time spent with inquiry (s) Time spent with inquiry or scanning (s)

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Conclusion

- Proposing SND in ad hoc scenarios
 - Assumes **symmetric** roles;
 - Better fits to data transmissions;
 - Configurable discovery time vs. overhead (power consumption);
 - Simple
- Discovery time depends on the total time spent with scanning and not depends on time between scanning periods;
- SND can be performed faster than inquiry



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Thank you!

Questions?

Formulas

$$T_{SCAN} >= 2T_S$$

 $T_{SCAN} < T_{BCN}$

$$P_1 = \left(\frac{1}{N_{BCN}}\right) \left(1 - \frac{2T_S}{T_{bcn}}\right) (1 - P_{err}),$$

$$P_{disc} = 1 - \left[1 - \frac{T_{SCAN}}{T_{BCN}}P_1\right]^{\frac{T_{tot}}{T_{SCAN}}}$$

$$P_{disc} = 1 - e^{-P_1 \frac{T_{tot}}{T_{BCN}}}$$

Periodic vs. random scanning

- Scanning periods chosen:
 - Periodically
 - Randomly

