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Reducing neighbor discovery latency in docking applications

Key words: Neighbor discovery; Docking applications; Slot index synchronization; Mobility-assisted slot index synchronization

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Motivation

- Neighbor discovery is important for docking applications where mobile nodes communicate with static nodes situated at various rendezvous points.
- Among existing neighbor discovery protocols, the probabilistic methods work well in average cases but have aperiodic and unbounded discovery latency, and thus cannot be used in docking applications.
- Deterministic protocols can provide bounded worst-case discovery latency by sacrificing the average-case performance.
- A new method that can improve the average-case performance of deterministic neighbor discovery without incurring additional energy consumption is needed.

Main idea

- Discovery latency can be minimized by synchronizing the active and sleeping slots of the sensor nodes.
- A system called mobility-assisted slot index synchronization (MASS) is proposed to improve the average-case performance of existing deterministic neighbor discovery protocols via slot index synchronization.
- Reducing the number of beacons to mitigate beaconing collisions poses a challenge in reducing discovery latency.

Method

1. Based on the moving pattern of mobile nodes in docking applications, a distributed reference election technique is designed to synchronize the sensor nodes.
2. Instead of accurate clock synchronization, a slot index synchronization technique is proposed to reduce discovery latency.
3. An optimized beaconing strategy and a heterogeneous working pattern called ABPL are adopted to mitigate the beaconing collisions.

Major results

- MASS can greatly reduce the discovery latency of existing deterministic neighbor discovery protocols

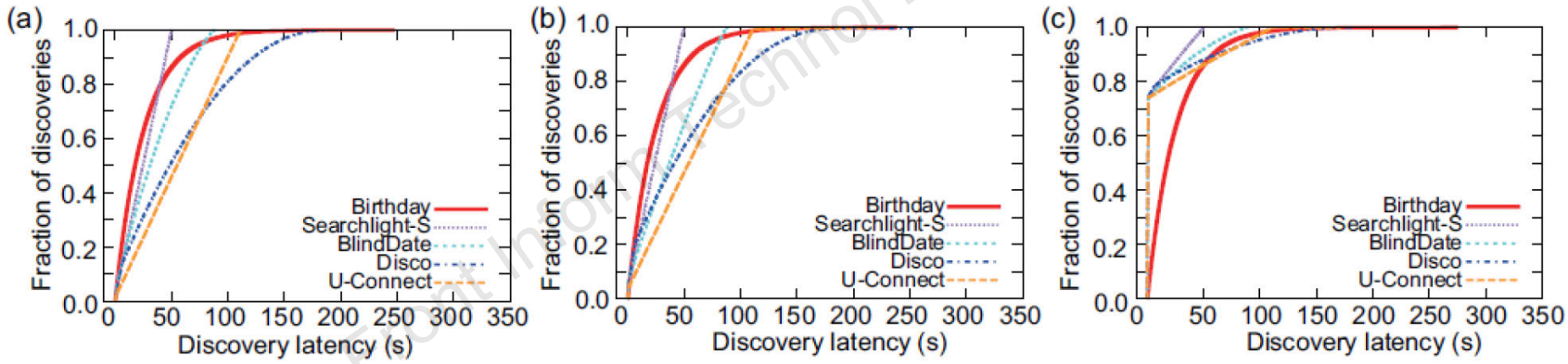

Fig. 16 Discovery latency of each protocol at a 1% duty cycle and 5 ms slot size: (a) no synchronization; (b) distributed asynchronous clock synchronization; (c) mobility-assisted slot index synchronization

Major results

- MASS can also work with random routes

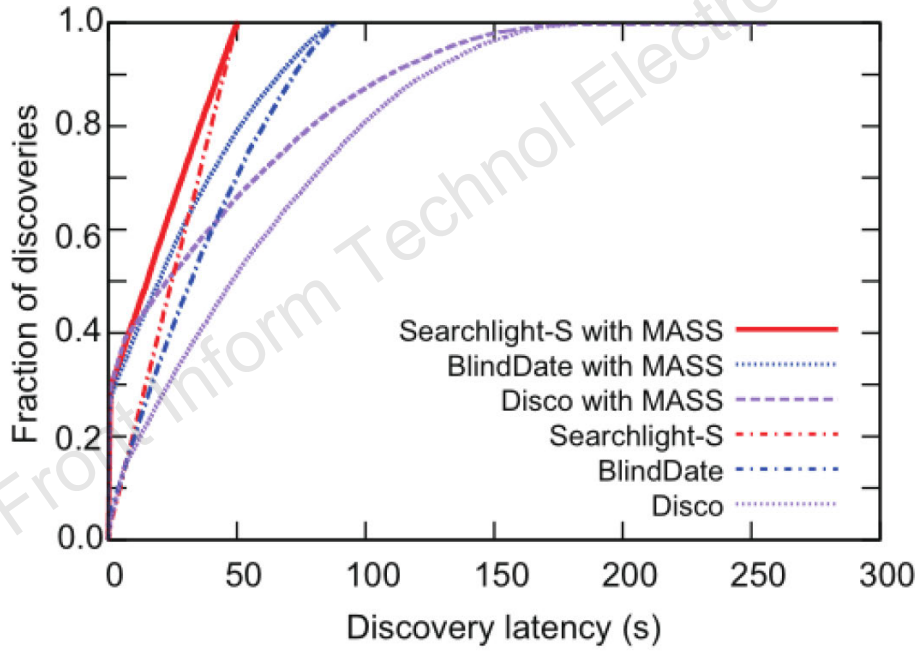

Fig. 20 Distribution of discovery latency with random routes

Major results

- MASS can synchronize the sensor nodes quickly

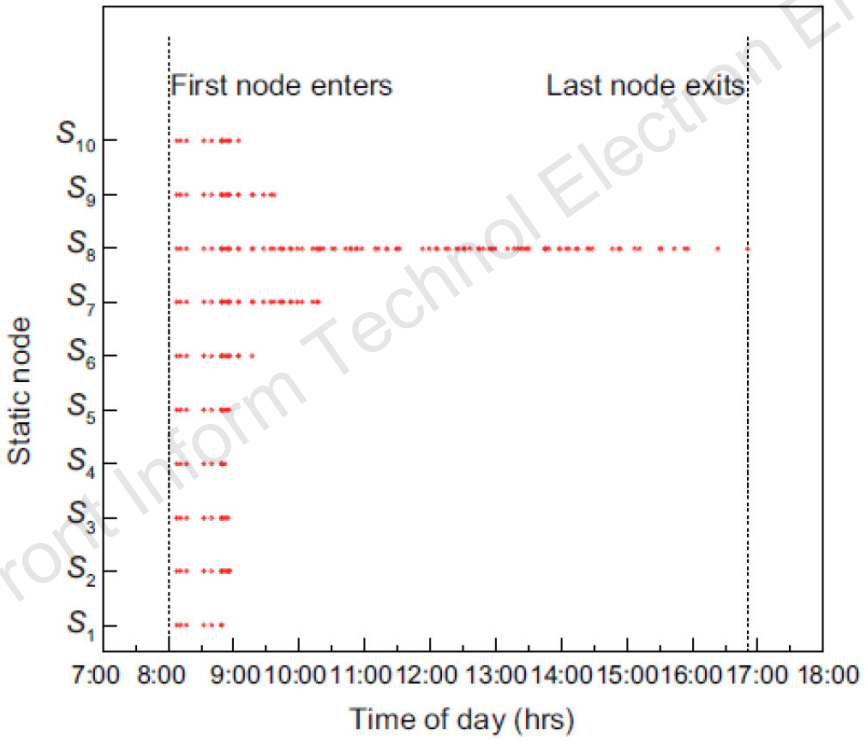

Fig. 24 Reference selection process on the first day

A dot on the graph indicates that the corresponding static node has not finished slot index synchronization with any other static node

Conclusions

- Slot index synchronization is a practical technique that can significantly improve the average-case performance of deterministic neighbor discovery protocols.
- By exploiting the mobility patterns of mobile nodes in docking applications, MASS can improve the average discovery latency while keeping the energy consumption constant.
- We showed with simulations based on real traces and experiments with real sensor hardware that MASS can improve the average discovery latency by up to two orders of magnitude.