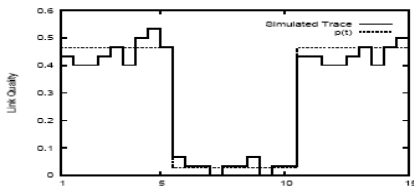
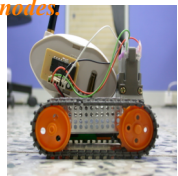


PSGR: A Stateless Routing Protocol for Location-Aware Wireless Sensor Network

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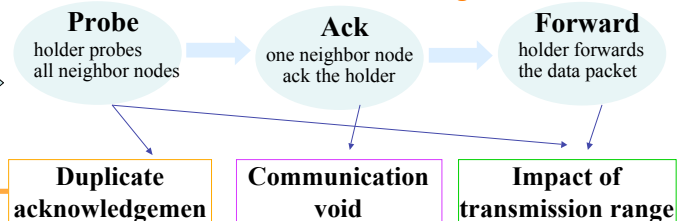
Problem and Motivation

Wireless sensor networks face sensor *node motilities*, *unstable communication links*, *sleeping cycles of sensor nodes*



Stateful Geo-routing protocols not applicable under dynamic network scenarios

Solutions: Volunteer Forwarding !



Research Challenges !!

Analysis of Transmission Ranges

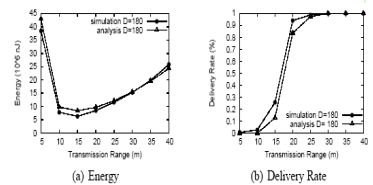
- The expected routing progress at i hop: $f_i = R - \int_0^R e^{-\rho A(D_i, D_i-r, R)}$
- The probability of i holder successfully finding a PF is

$$P_i^{hop} = P_i^{bc} + (1 - P_i^{bc}) \sum_{j=1}^{B_{max}} (1 - P_i^{rbc})^{j-1} P_i^{rbc}$$

- Energy cost: $e_{total}(R) = h_a [e_{pkt}(R) + e_{ack}(R) + e_{fwd}(R)] + h_b \bar{b}_i e_{fwd}(R_{max})$
- Delivery rate:

$$1 - \sum_{l=1}^{h_a-1} \sum_{k=0}^{j-1} P_k^{hop} (1 - P_j^{hop})$$

- Balancing energy consumption with delivery rate, 20m, 25m, and 30m are reasonable choices for transmission range



Design of PSGR



- Dynamic forwarding zone formation based on density estimated on-the-fly
- Rebroadcast and bypass schemes.
- Mathematical analysis routing performance as functions of transmission range

Prioritized Acknowledgement

- Assign Ack precedence to a *forwarding zone*

Zone scope

- The covered area of the forwarding zone
- DTD: reduces energy consumption
- M_{DTD} reduces routing latency



Zone size

- Only one potential forwarding in each zone
- Density is estimated within a time window
- The time window is the average time a node remains in the zone

$$\frac{\rho \pi R^2}{\tau} = \frac{\pi R}{2V_{max}}$$

Ack delay

- Acknowledgment delay

$$AckT_i = AckT_{i-1} + AT_i = \sum_{j=1}^{j=AckP_i} AT_j$$

- AT_i : acknowledgment timer interval associated with FZ_i

Communication Void Problem

- Forwarding is forced to stop due to an empty forwarding zone

Stateless rebroadcast

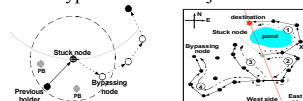
- Believe that a PF may appear in FZ after a period of time

$$\frac{1}{\tau} = \frac{\rho V_{max} C}{\pi}, \text{ where}$$

$$C = 2R \cos^{-1}\left(\frac{R}{2D}\right) + 2D \cos^{-1}\left(\frac{2D^2 - R^2}{2D^2}\right)$$

Stateless bypass

- Considering for permanent void region or low network dynamics
- Based on the right hand rule
- Being stateless by volunteer forwarding
- Bypass direction adjustment



Applications & Impacts

PSGR is routing candidate for:

- Sensor nodes with sleeping cycles
- Sensor nodes with mobility
- Sensor networks with asymmetric links

For other applications:

- Infrastructure-free query dissemination and data collections

Infrastructure-Free Window Query Processing

Why not infrastructure based scheme

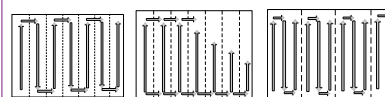


- Two phases query execution: query propagation and data collection

- High infrastructure maintenance overhead and long execution delay

Infrastructure free query processing

- Integrate the query propagation with data collection
- Not relied on any infrastructure
- No infrastructure maintenance



Itinerary based window query execution



- Require a stateless routing protocol (e.g., PSGR)
- Itinerary width ensures the coverage of query propagation
- Itinerary route: tradeoff between the energy efficiency with latency
- Itinerary traversal: data collection and query forwarding