Connectivity-aware Neighborhood Management Protocol in Wireless Sensor Networks

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7. GI/ITG KuVS Fachgespräch „Drahtlose Sensornetze“
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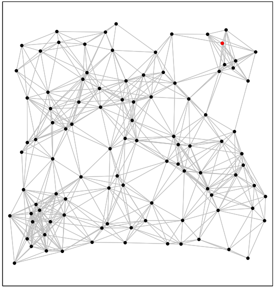
Motivation



- Many algorithms depend on neighborhood knowledge
- What is a “neighbor”?
- Neighborhood management protocols should be concerned about:
  - Agility
  - Stability
  - Symmetry
  - Connectivity

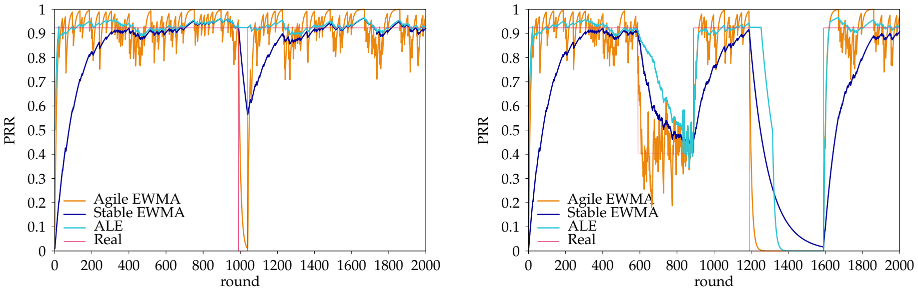
Link Estimator

- Links are not known a priori
- Behavior of the past is used for prediction
- Commonly used metric: packet reception rate (PRR)
- Estimated by receiving periodical broadcast packets
- Using exponentially weighted moving average (EWMA)
- Woo and Culler (2003) introduced agile and stable EWMA
  - Agile: low crossing time and high mean square error
  - Stable: high crossing time and low mean square error

Adaptive Link Estimator (ALE)

- Combines strength from agile and stable EWMA
- Low raising time and low mean square error
- Raising mechanism
  - New links are estimated agilely
  - When link reaches good quality switch to stable mode
- Dropping mechanism
  - Trust good links even if consecutive packets are lost for a short time
  - If link quality drops below a threshold switch back to agile mode

Comparison between EWMA and ALE



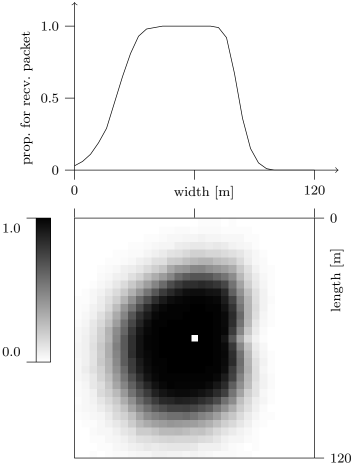
Mahalle – Neighborhood Management Protocol

- Node table contains neighbors and preparation list
- Periodical broadcasts
  - Neighbor identifiers and inbound PRR
- Each entry has information about
  - In- and outbound PRR ($\rightarrow$ ALE)
  - Number of neighbors and overlapping neighbors
  - Time stamp and symmetry flag
- Eviction scheme if new “good neighbor” available
- Scoring model to choose a “bad neighbor”

Scoring Model: Criteria

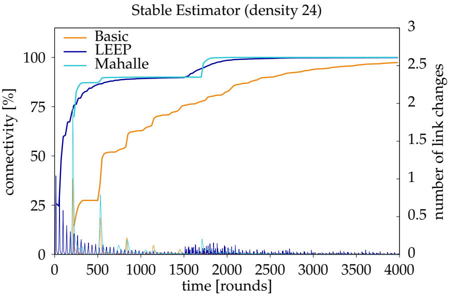
- Criteria:
  - Neighboring node regards local node as neighbor
  - Neighboring node does not own bidirectional links
  - Number of bidirectional links of neighboring node
  - New in local neighborhood
  - Number of overlapping neighbors
  - Relative number of unknown neighbors
  - Inverse age
  - Product of in- and outbound PRR
- Scoring model adaptable to applications
- Example: minimum hop-count or disjunct neighborhood

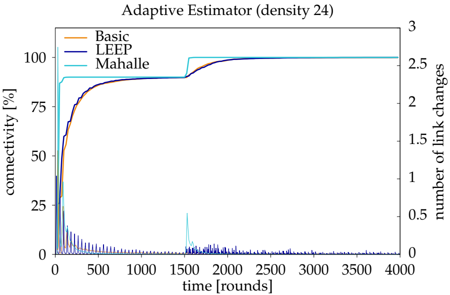
Simulation Environment



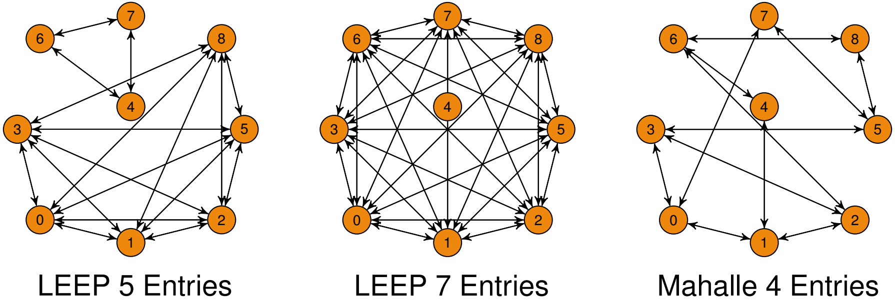
- ns-2 simulation
- Random topologies with given density
- Irregular propagation model
- 15 % asymmetrical links
- Compared with:
  - Basic approach
  - TinyOS LEEP

Comparison of Neighborhood Protocols





Connectivity Awareness



- 9 nodes within communication radius
- Node 4 starts after short delay
- Mahalle uses 1 entry for preparation list
- Only Mahalle achieves connectivity

Conclusion

- Mahalle & ALE show good performance
  - Low link detection delay
  - Decrease number of link changes
  - Ensure fast connectivity
- Real deployments
  - Testing estimator with 25 nodes over 3 month
  - Porting Mahalle to TinyOS
- Integration of physical metrics, e.g., LQI or RSSI
- Improve stability by decreasing link changes
- Integrate “snapshot” mechanism

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