Energy-Efficient and Reliable Relay Path Determination in Wireless Sensor Networks with Mobile Sink

GLOBECOM 2006

Presented by Chia-Yi Lien

July 12, 2007

Outline

- Introduction
- System model
- Transmission Backoff (TB)-Based Relay Path Determination Algorithm
- Simulation Results
- Conclusion

Introduction (1/2)

- In the environment where the WSN operates in the query-and-respond mode, sink broadcasts to all the sensor nodes whenever new data collection is needed
- Drawback of simple flooding
  - Frequent collisions
  - Can’t determine energy-efficient and reliable path

Introduction (2/2)

- Proposed Method
  - The proposed method is a relay path determination scheme that maximizes the network lifetime and guarantees the end-to-end reliability in the WSN with an mobile sink
  - TB-based broadcasting algorithm that uses a transmission deferring approach to reduce the number of collisions, while guaranteeing the end-to-end reliability.

System model (1/3)

- Described in aspects of energy, channel and reliability

Energy Model (2/3)

- Transmit energy consumption
  - $E_{tx} = \frac{8F}{R}\left(P_{cir} + \frac{P_{tx}}{\eta(P_{tx})}\right)$
- Receive energy consumption
  - $E_{rx} = \frac{8F}{R}P_{rx}$
- We assume $P_{idle} = P_{rx}$, and $P_{sleep} = 0.01P_{rx}$
- Definition
  - Lifetime of a sensor node
  - Network lifetime

Channel and Reliability Model (3/3)

- Channel Gain
  - $G(d) = G(d_0) + 10n \log_{10}\left(\frac{d}{d_0}\right) + X_\sigma$
- Per-hop packet success probability
  - $f(\gamma) = \left(1 - \frac{1}{2}\exp^{-\frac{\gamma R}{2B_N}}\right)^{\rho 8F}$

Transmission Backoff (TB)-Based Relay Path Determination Algorithm

- A distributed and stateless algorithm
- The route setup can be done by each node without requiring any local and/or global information of network topology
- This algorithm Adopts Deterministic backoff
  - different from IEEE 802.11 – random backoff

Determination of Transmission Backoff Time (TBT)

- TBT refers to the time for each node to wait until it rebroadcasts the received broadcast packet
- Network lifetime related component of the TBT
  - $T_{TB,NL} = 1 - \frac{E_{res}}{E_{ref}}$
- Cumulative success probability
  - $P_{cum} = \left(\prod_{j=1}^{h-1} f(\gamma_j) \right)$
- End-to-end reliability related component of the TBT
  - $T_{TB,ER} = |P_{alloc} - f(\gamma)|$

Determination of Transmission Backoff Time (TBT)

- TBT of a sensor node
  - $T_{TB}^{i} = \alpha \left| P_{alloc} - f(\gamma_i) \right| + (1-\alpha)\left(1 - \frac{E_{res}(i)}{E_{ref}}\right)$, where $\alpha \in [0,1]$

End-to-end reliability

Energy-efficiency

Simulation Results (1/3)

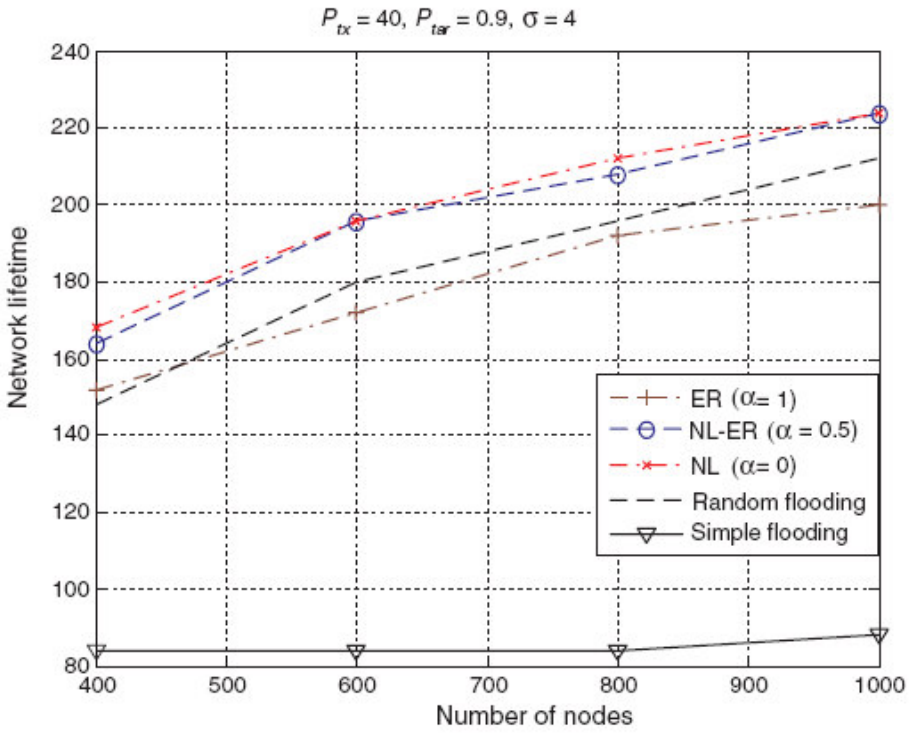

Fig. 2. Performance of the TB-based algorithms in terms of network lifetime vs. total number of sensor nodes in network.

Simulation Results (2/3)

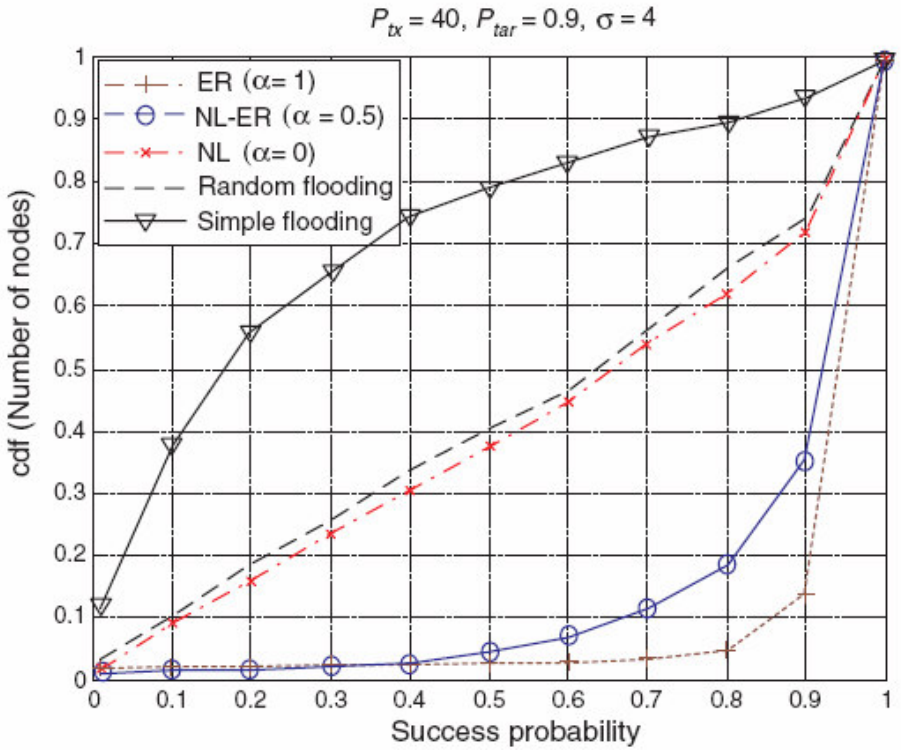

Fig. 3. Performance of the TB-based algorithms in terms of end-to-end reliability vs. number of hops.

Simulation Results (3/3)

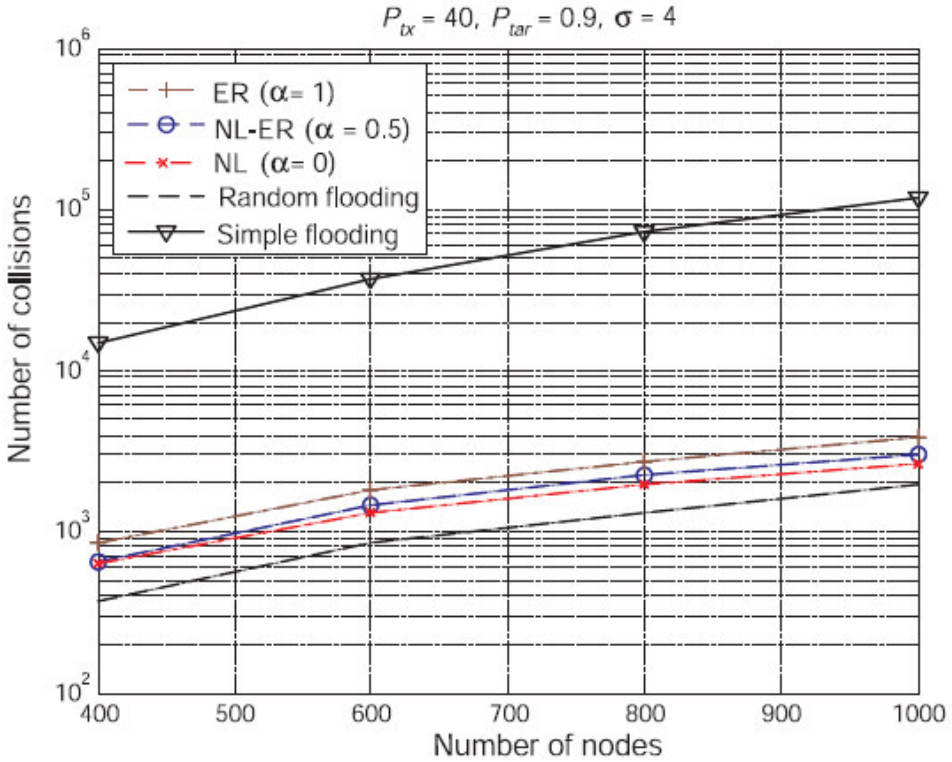

Fig. 4. Performance in terms of number of collisions vs. number of sensor nodes.

Conclusion

- The advantages of the proposed TB-based algorithm: distributed algorithm, longer network lifetime, and higher end-to-end reliability
- Among three variations of proposed algorithm, NL-ER performs best in achieving a longer network lifetime and a higher end-to-end reliability performance at the same time