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Evaluation of Robustness in Time Synchronization for Sensor Networks

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Sensor Networks

- Sensor nodes are deployed in a monitoring region
- Gather the information on environment
  - Temperature, humidity, position, sound etc..
- Applications
  - Disaster prediction
  - Weather forecast
  - Home security
  - Health and welfare
  - Factory administration




Why Time Synchronization ?

- Precise synchronized timers between nodes are required for
  - Position estimation
  - Scheduling
  - Gathering time information
- Node timers differ from each other
  - Clock frequency
  - New node entry
- **Periodic time synchronization is necessary for realistic sensor networks**


Why Robustness ?

- Sensor nodes are facing to
  - unstable wireless communication
    - → **Tolerance to packet loss**
  - large deployment in large area
    - → **Scalability**
  - limited power source
  - high probability of topology changes

MICAz sensor node by Crossbow

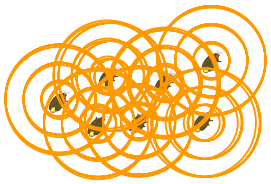
- **Robustness is crucial for reliable sensor networks**

Motivation & Contribution

- Some papers have clarified on the robustness of bio-inspired method, e.g. clustering, routing, data gathering
- However, time synchronization has not yet been investigated in detail
- Our contribution:
  - Evaluation of robustness in time synchronization
  - Comparison of bio-inspired vs. centralized method
  - Performance metrics: packet loss and scalability

Bio-inspired Synchronization

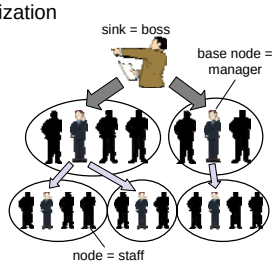
- *Pulse Coupled Oscillator* (PCO) model [7]
  - Inspired by the flashing of fireflies and pacemaker cells
  - No leader, no control packets required
  - Only local interactions among coupled oscillators
  - Fully-distributed and self-organizing



[7] R. Mirollo and S. Strogatz, "Synchronization of pulse-coupled biological oscillators," Journal on Applied Mathematics, vol. 50, pp. 1645-1662, Dec. 1990

Centralized Synchronization

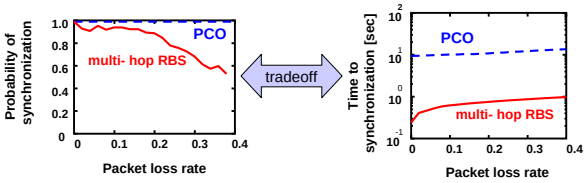
- *Reference Broadcast Synchronization* (RBS) [5]
  - Similar to the hierarchical structure of company
  - Fast and accurate synchronization
  - Problems
    - Limitation of network size
    - Requirement of high communication quality
  - Multi-hop RBS



[5] J. Elson, L. Girod, And D. Estrin, "Fine-grained network time synchronization using reference broadcast,"In Proceedings of Operational Systems and Design Implementation , vol. 36, pp. 147-163, Dec. 2002.

Tradeoff: Success vs. Delay

- Bio-inspired method shows higher robustness in the presence of packet loss
- Centralized method realizes a fast synchronization



Appropriate synchronization method depends on application requirements and type of environment

Conclusion

- Comparison of robustness between bio-inspired and centralized synchronization control
- Tradeoff:
  - Robustness toward packet loss
  - Time to synchronization
- Future work:
  - Improvement of the PCO mechanism
  - Comparison with hybrid synchronization control
- In poster session
  - Detailed synchronization mechanism
  - Other simulation results