Center for Embedded Networked Sensing
UCLA – UCR – Caltech – USC – CSU
CENS

Understanding Packet Delivery Performance In Dense Wireless Sensor Networks

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Introduction: Radio Frequency Wireless Communication in Sensor Networks

Notoriously Unpredictable

- Variable Environment Noise
- Non-linear Signal Strength Decay
- Multi-path Effect
- Inter-node Collision
- Additional Constraints for Sensor Network
  - Energy Efficiency (Low Power Radio)
  - Possibly High Density Deployment

⇒ High Packet Loss, Asymmetry, High Temporal Variance

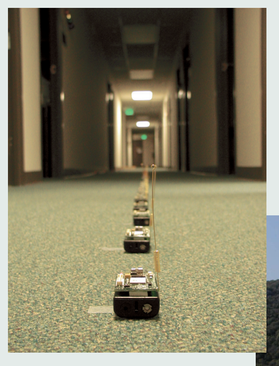
Impact on System Design

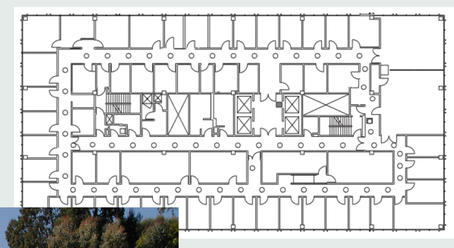
- Hardware/Physical Layer
  - Modulation Scheme
  - Base-band Frequency
  - Encoding Scheme
- MAC Protocol
- Reliable Data Delivery
- Path Selection in Routing
- Congestion Control
- "Soft-state" Maintenance

Problem Description: Systematic Measurement of Packet Delivery Performance

Experimentation Setup

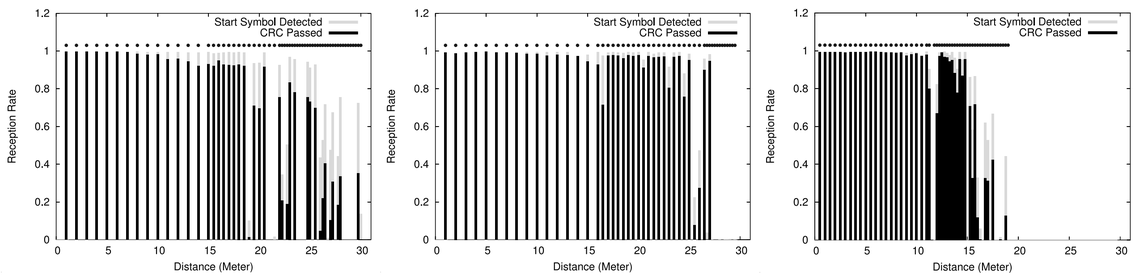
- ~60 MICA Motes with RFM Radio(433Mhz)/TinyOS 1.0
- Packet Delivery Performance on Physical Layer(Single-hop)
  - Regular Placement (Line) for Detailed Spatial Profile
  - Long Term (8-hour) Measurement
- Packet Delivery Performance on MAC Layer(Multi-hop)
  - Dense and "Realistic" Deployment
  - Artificial Traffic Load
  - Acknowledgment and Retransmission
- Impact from Environment
  - In-Door(ISI office), Habitat(State Park), Unobstructed(Parking Lot)





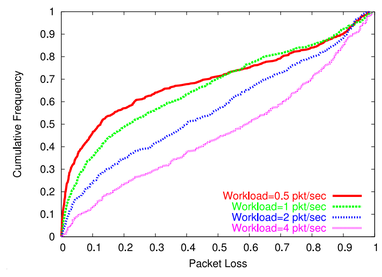
Results: Pessimistic Packet Delivery Performance Can't Be Ignored

Single-Hop Experiments

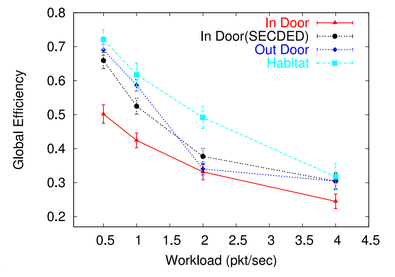


Spatial Profile of Packet Loss in Different Environments
In-Door(Left), Out-Door(Center), Habitat(Right), High Tx Power, 4b6b Coding

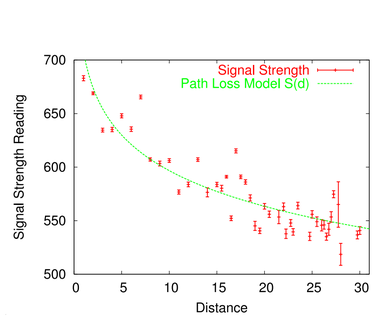
Multiple Hop Experiments



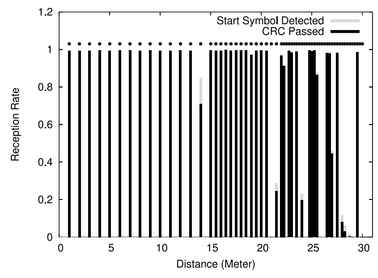
Packet Loss Distribution



Efficiency with Retransmission

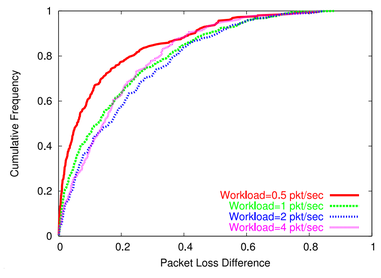


Signal Strength Measurement (In-door)

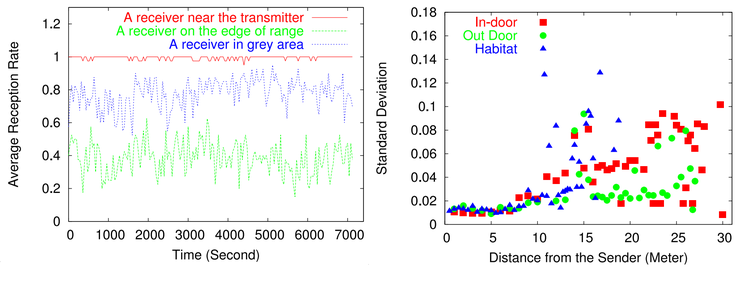


SEC-DED Coding (In-door)

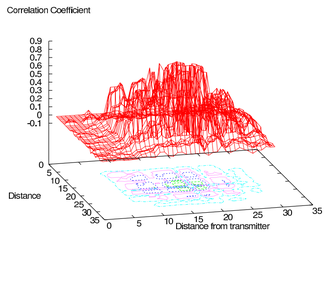
Common existence of links with high packet loss, asymmetry and variance



Asymmetric Links



High Variance in Packet Delivery



Correlation of Packet Loss

Future Work

- Measurement on MICA-II with CHIPCON Radio
- Measurement on S-MAC in Dense Network
- Topology Control Protocols re. packet loss.
- Reliable Link Layer Protocols
- A Test Suit to Evaluate Next Generation Platforms

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