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Outline

- Introduction
- Background And Related Works
- Brief Description of SEEM
- Description of the QoS Multipath Routing Protocol
- Performance Evaluation
- Conclusion And Future Work
Introduction

- Wireless Communications
  - Sensors
    - Tiny, Low-cost, Low energy
  - Tasks
    - Military and Civilian
  - Application
    - Environment monitor, Wild animals track and Battlefield surveillance
Introduction (Cont.)

- Wireless Sensor Network limit
  - Storage space
  - Energy supply
  - Data processing
  - Communication bandwidth
Secure and Energy-Efficient Multipath Routing (SEEM)

Performance

SEEM gains a better performance compared to Directed Diffusion routing protocol

- Term
  - Network throughput, Network lifespan, Communication overhead
Introduction (Cont.)

- Quality of Service (QoS)
  - Two attributes
    - Reliability and Delay
  - Reliability
    - Packets delivery ratio
      - Hardware failures
      - Collision
Quality Of Service Multipath Routing Protocol (QOSMR)

- Extends SEEM
- Providing QoS guarantees
  - Network throughput, Network lifetime
- Data transmission at the same time
  - QOSMR: More than one source to the base station
  - SEEM: Only one source to the base station
The main goal for most proposed routing protocols
- Consuming low power, extending the network lifetime
  - Example
    - Habitat monitoring
- For some mission-critical, energy-efficiency is far more enough
  - Example
    - Warning alert systems
Background And Related Works (Cont.)

- QoS have three basic data delivery models
  - Event-driven model
  - Query-driven model
    - Example: Microsoft SensorWeb
  - Continuous delivery model
Background And Related Works (Cont.)

- SensorWeb
  - By Microsoft Corporation
  - Is an example of query-driven applications
  - Deployed by contributors across the globe
  - Use the shared sensing resources, the sensor querying, tasking mechanisms
Background And Related Works (Cont.)

- SensorMap

Reference: http://atom.research.microsoft.com/sensormap/
Brief Description of SEEM

- **SEEM**
  - Secure and Energy-Efficient Multipath routing protocol
  - Better performance
    - Network throughput, Network lifespan, Communication overhead
Brief Description of SEEM (Cont.)

- SEEM consists of three phases
  - Topology Construction
  - Data Transmission
  - Topology Maintenance
Brief Description of SEEM (Cont.)

- Limitation of SEEM
  - Not suitable
    - Multiple source nodes sending data to BS at the same time
    - More sensor nodes transmitting simultaneously
      - Collision occurs
  - QOSMR
    - Overcome the limitations of SEEM
Description of the QoS Multipath Routing Protocol

- QOSMR Overview
  - Adopt the same mechanisms as SEEM
    - Building network topology
    - Multipath
  - Improvements of QOSMR include two points
    - BS selects disjoint paths for different source nodes
      - Send data to the BS at the same time
    - If no disjoint paths are available
      - BS schedules the data transmission of each source node
        - Avoid collisions
Description of the QoS Multipath Routing Protocol (Cont.)

- Example
  - node 5 to node 1
    - 5 ←→ 3 ←→ 2 ←→ 1
  - node 8 to node 1
    - 8 ←→ 5 ←→ 3 ←→ 2 ←→ 1
    - 8 ←→ 7 ←→ 6 ←→ 4 ←→ 1
  - Overlapped with the only available path to node 5
    - Great chance of collisions
Description of the QoS Multipath Routing Protocol (Cont.)

- If all the source nodes send packets to BS simultaneously
  - Cause three problems
    - High collisions occur at the intermediate node
    - Energy will run out very quickly
    - Protocol takes to deal with packets missing

- Avoid this situation
  - Use multiple source nodes
Description of the QoS Multipath Routing Protocol (Cont.)

- **Multiple source nodes**
  - Use the 1st path for node 5
  - Use the 2nd path for node 8

- **Example**
  - 3 ←→ 5 ←→ 2 ←→ 1
  - 6 ←→ 5 ←→ 4 ←→ 1
  - 7 ←→ 5 ←→ 8 ←→ 1
Description of the QoS Multipath Routing Protocol (Cont.)

- One node exists on three paths
  - Intermediate node 5

- Transmission schedule
  - Interval time of sending
    - between two source nodes is 0.1s
  - After the last source node sending packet
    - Pause of 1s
Description of the QoS Multipath Routing Protocol (Cont.)

- **Transmission schedule**

  | 3  | 6  | 7  | pause | 3  | 6  | 7  | pause | ...
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<td>0.1s</td>
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- **Total interval of transmitting two packets**
  - Waiting time of each source node
    \[0.1s + 0.1s + 0.1s + 1s = 1.3s\]
  - When \(N\) source nodes share one intermediate node

    \[0.1s \times N + 1s\]

    - When \(N\) is too large to make the interval too long
      - Decrease waiting or pause time
Performance Evaluation

- Simulation tool
  - Network Simulator NS-2

- Simulation Model and Evaluation Metrics
  - Region: 150m * 150m
  - Change the network size
    - Number of nodes from 30 to 130 nodes
    - Increment of 20 nodes
Performance Evaluation (Cont.)

- Compare the performance
  - QOSMR and SEEM
    - Throughput
      - Source nodes to Base Station
        - Ratio of successfully received data packets
    - Network Lifetime
      - First node failure occurs
        - Energy reserve is reduced to zero
Simulation Results

Network throughput

SEEM

- Not benefit from the increase of network size either
- Collisions occur
Performance Evaluation (Cont.)

- Network throughput (Cont.)
  - QOSMR
    - It can select disjoint path to different source nodes
      - SEEM can not
    - When the network size increases
      - Possibility of finding disjoint path increases
    - Avoid collisions

![Network Throughput Graph]

\[ \text{Throughput} \]

\[ \text{Density} \]
Performance Evaluation (Cont.)

- Network lifetime
  - SEEM does not perform well
    - Two reasons
      - Energy consumed much faster
      - Send Lost packets, needs additional energy
Conclusion And Future Work

- QOSMR
  - Reliability of packets delivery
  - To guarantee the reliability
    - Decrease the collisions occurred while multiple source nodes send packets to the BS at the same time
    - Adopts two mechanisms
      - Select completely disjoint multipath for different source nodes
      - If no disjoint multipath, use transmission schedule
Conclusion And Future Work (Cont.)

- Future Work
  - Considers another element of QoS routing
    - Delay
      - Vital to some real-time applications
      - Long-time waiting can not be tolerated