Energy-efficient Information Dissemination Based on Received Signal Strength in Wireless Sensor Networks

Hiroyuki Hisamatsu
Osaka Electro-Communication University

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Wireless Sensor Networks (WSNs)
- Have already been applied in many fields
  - Disaster detection
  - Environmental monitoring
  - Environmental management
- When the network status change
  - Difficult to determine a path in advance
  - Disseminating information to the entire network is a method for guaranteeing the message is sent to a destination node

Disseminating Information
- Necessary in many cases when operating applications in WSNs
  - Efficiently gathering information [3]
  - Mitigating the effects of node failures [4]
  - Installing program to nodes with certainty [5]
- WSNs will be used in many fields and applications on WSNs will increase in numbers

Problem of Disseminating Information
- Increases electric power consumption
- In WSNs, the amount of electric power consumed by wireless communications accounts for a large percentage of the electric power consumed by nodes
- It becomes important to reduce the power consumed by wireless communications

Objectives
- Propose an Information dissemination method that takes into account the electric power consumption
- It controls the broadcast timing of messages using the strength of the received wireless signal
- Show propose method works effectively by simulation experiments
- The farther the transmitting distance of the wireless radio wave becomes, the more efficiently our method can disseminate information
Flooding Method
- A node having a new message
- Broadcasts a message to all adjacent nodes
- The node received the message
- Rebroadcasts the message, if the received message was new
- Does not rebroadcast the message, if it was not new

Outline of Proposed Method
- Controls the broadcast timing of messages by using the strength of the received wireless signal
- Received signal strength decreases when communicating over long distances
- The lower the signal strength is, the sooner the node will rebroadcast the message
- The node farthest from the sending node will rebroadcast the message first
- If the message is received multiple times before rebroadcast, the node cancels the rebroadcast

Process of Disseminating a Message
- Flooding method
- Proposed Method

Process of a Message Dissemination
- Flooding method
- Proposed Method

Number shows the number of times that node received the message
**Process of a Message Dissemination**

- Flooding method
  - 3 broadcasts

- Proposed Method
  - 1 broadcast

Number shows the number of times that node received the message.

**Broadcast Time**

- Receiver signal strength
  \[ P_r(d) = P_{tx} + G_t - L_p(d) + G_r \]

- Maximum receiver signal strength
  \[ P_{r, \text{max}} = P_{tx} + G_t + G_r \]

- Broadcast time
  \[ T = \text{DIFS} + \left( \frac{C W + C W \times \frac{P_r}{P_{r, \text{max}}}}{} \right) \times \text{slot time} \]

**Performance Evaluation:**

- Energy Consumption Model
- Network Model: square lattice

**Performance Evaluation:**

- Energy Consumption Model
  - Propagation loss follows free space loss model
  \[ L_p(d) = \left( \frac{4 \pi d}{\lambda} \right)^2 \]

- Radio Wavelength
  - Frame size

- Transmit power: 100 [mW]

- Communication success probability: 90%

- 100 simulations and measure

- Information delivery ratio

- Total electric power consumption
Simulation Results:

Information Delivery Ratio

The longer the radio range becomes, the smaller the threshold values become. The number of nodes that can receive a message from one broadcast increases as the radio range increases.

Performance Evaluation:

Randomly locate nodes

- Previous network model: nodes are arranged in square lattices.
- Randomly locate nodes in square region
  - Sides of length 4,000 [m]
  - The configuration of the nodes is the same as previous one
  - Propagation loss of the radio waves follows free space loss model

Simulation Results:

Total Electric Power Consumption (TEPC) when the information delivery ratio is at least 95%

- Flooding method: TEPC increases
- Proposed method: TEPC decreases

Both of the information delivery ratio rapidly increases after a threshold value, similar to the previous model.

Conclusion

- Proposed an information dissemination method that considers electric power consumption
- Based on the flooding method
- Controls broadcast times according to strengths of received signals
- Showed the proposed method can disseminate information in an energy efficient manner when the transmitting power becomes large
Future Works

- Evaluate the proposed method with other propagation loss models
  - two-ray ground model
- Evaluate proposed method in an experimental network
  - Crossbow MICAz motes
- Analyze the proposed method by applying percolation theory from statistical physics