A Self-organizing Concurrent Global Information Dissemination Scheme for Sensor Networks

Ehssan Sakhaee, Naoki Wakamiya, Masayuki Murata
Graduate School of Information Science and Technology, Osaka University, JAPAN

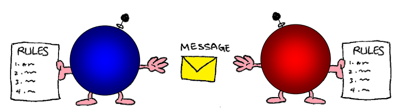
International Wireless Communications and Mobile Computing Conference 2008
(IWCMC'08), Crete Island, Greece.

Overview

- What is self-organization and why it's a good idea?
- Proposed Protocol
- Simulations
- Results
- Conclusion

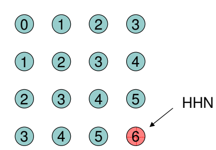
Self-organizing systems

- In biological systems, individual entities react by following some common rules, generally based on the state of their neighbors and environment (using feedback) without any centralized control
  - Purely distributed, and no single point of failure!
- In our model:
  - Feedback using exchange of messages between neighboring nodes.
  - All nodes follow the same rules, and define their state.



Proposed Protocol

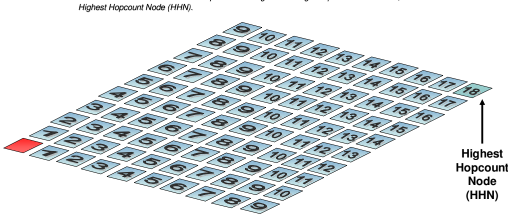
- A self-organizing *concurrent global* information *dissemination* scheme for wireless sensor networks:
  - Identifies *highest hopcount nodes* (HHNs) from the sink, from which their local (one-hop) broadcast can traverse the whole network.
  - Obtains global extremities in a pseudo-concurrent manner.



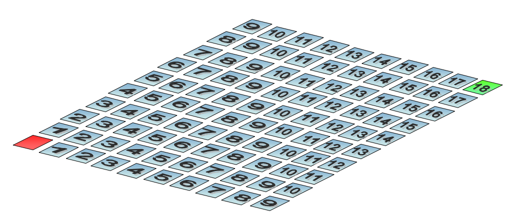
Highest Hopcount Nodes (HHNs)

The highest hopcount nodes of the network are discovered after the *hopcount initialization phase.*

1. *Sink broadcasts a "S" message to neighbors.*
2. *Neighbors of sink update their hopcount to sink to 1 and broadcast a "1" hopcount message to their own neighbors.*
3. *Neighbors which have not received any hopcount messages previously will increment their hopcount to k+1 where k is the hopcount message number (minimum hopcount among those received)*
4. *When a node* ***does not*** *receive a hopcount message with a larger hopcount than its own, it assumes itself as the Highest Hopcount Node (HHN).*



Highest Hopcount Node Initiated Broadcast

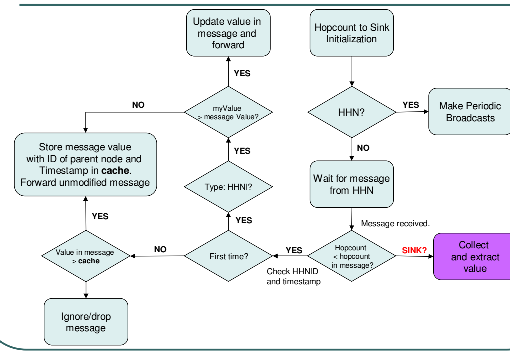


Local broadcast of a HHN will reach all nodes in the network, towards the sink…

Simplified HHNI Algorithm

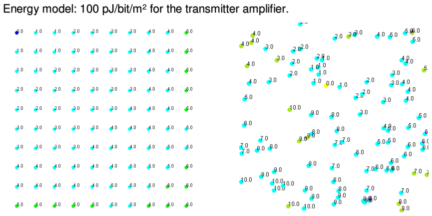
1. If I am the Highest Hopcount Node (HHN), I make periodic broadcasts.
2. If I am an ordinary node and I receive a message, I will first check whether my hopcount is **less than** that of the parent node from which the message is coming from. Then if I am receiving the message for the **first time** (check HHNID and timestamp) and the message is of type HHNI, if my value is more extreme than the one in the message, I will update the value in the message and forward it on. Else I will store the value of the message together with the ID of the *parent* node and corresponding timestamp in cache, and forward the unmodified message.
3. If I am an ordinary node and I receive a message (identical timestamp) **again**, I will only forward it if the value in the message is more extreme than the one stored at node, otherwise I will ignore the message. Before forwarding however, I will wait for a random time and if I do not hear my neighbors broadcasting this message, I will broadcast it.
4. If I am the sink I will collect and evaluate the messages, obtaining/extracting the desired value or extremity and broadcasting this to all sensor nodes.
5. If I am an ordinary node and I receive a sink extreme value broadcast (SXVB) message, I will set the Exteme Value and Threshold. I then monitor the node's sensed data against these values. If the threshold is compromised then I will send an SNI message with my current value.

Simplified HHNI Algorithm Flowchart



Simulation

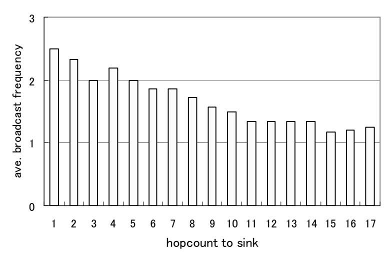
- 100 – 10000 node scenarios.
- Static topology (not mobile nodes)
- Uniform distribution of nodes 50 m apart.
- Randomly distributed node scenarios.
- Communication range varies from 60m to 540m
- Energy model: 100 pJ/bit/m² for the transmitter amplifier.



Uniformly distributed Randomly distributed

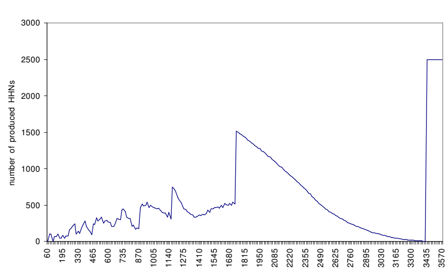
Simulation Results

Broadcast frequency of individual nodes for 100 nodes.

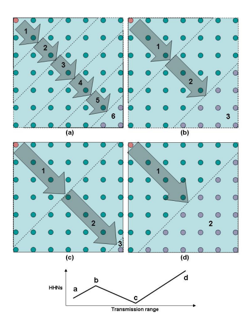


HHN Production

Number of HHNs produced by increasing the transmission range for 2500 nodes.

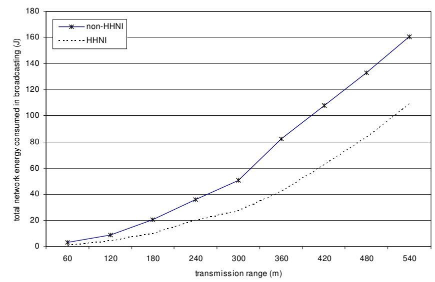


HHN production



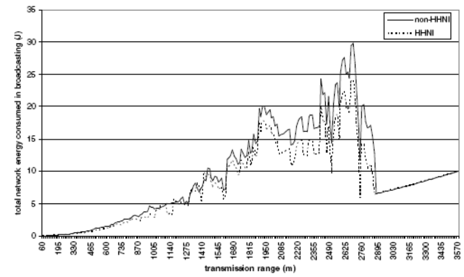
Simulation Results

Energy consumption vs transmission range for HHNI and non-HHNI routing for 10000 nodes after 30 reports



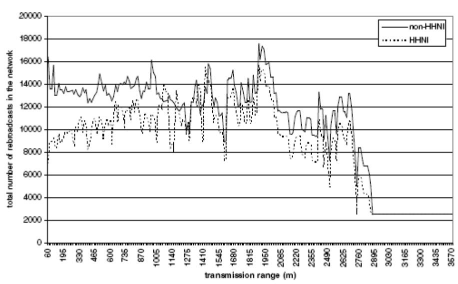
Simulation Results

total network energy with varying transmission range.



Simulation Results

Total number of rebroadcasts in the network.



Conclusion

In this presentation

- Proposed a routing protocol for wireless sensor networks which efficiently retrieves extreme values of the network.
- Simulation results show that the proposed highest hopcount node initiated (HHNI) broadcasting effectively retrieves the maximum value of the network in an energy-efficient manner.
- Future work should focus on the effect of randomness and mobility on the protocol, and efficient synchronization.

Thank You.