EAST:Energy-efficient Adaptive Scheme for Transmission in Wireless Sensor Networks

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Outline

Introduction to the Problem

- Challenge in design of Wireless Sensor Networks (WSNs) is to reduce energy consumption of sensor nodes to prolong lifetime of Network
- Limited battery requires low power sensing, processing and communication system
- In WSNs, sensor nodes are widely deployed in different environments to collect data
- Low power wireless link causes link quality variation due to environmental dynamics like temperature, humidity etc
- Therefore, while maintaining good link quality with nodes we need to reduce energy consumption

Related Work and Motivation

- Existing schemes set some minimum transmitter power level for maintaining reliability
- To adjust transmitter power, reference node periodically broadcasts a beacon message
- When nodes hear a beacon message from a reference node, these nodes transmit an ACK message
- Through this interaction, reference node estimate connectivity with nodes
- In Local Mean Algorithm (LMA), a reference node broadcasts LifeMsg message

Related Work and Motivation

- Nodes transmit LifeAckMsg after they receive LifeMsg
- Reference nodes count number of LifeAckMsgs and transmission power is controlled by maintaining appropriate connectivity
- For example if number of LifeAckMsgs is less than NodeMinThresh transmission power is increased
- In contrast, if number of LifeAckMsgs is more than NodeMaxThresh transmission power is decreased
- Local Information No Topology/Local Information Link-state Topology (LINT/LILT) and Dynamic Transmission Power Control (DTPC) uses transmission power loss $RSSI_{loss}$ to estimate transmitter power level

Related Work and Motivation

- Transmission power also controlled by Packet Reception Ratio (PRR) metric
- Since $RSSI_{loss}$ is directly proportional to temperature. Adaptive Transmission Power Control (ATPC) adjusts transmission power dynamically according to spatial and temporal effects
- In adapting link quality for environments where temperature variation occur, packet overhead for transmission power control should be minimized. Reducing number of control packets while maintaining reliability is also an important technical issue

Proposed Energy Efficient Adaptive Transmission Scheme

- Propose Energy-efficient Adaptive Scheme for Transmission (EAST) of data in WSN,s is IEEE 802.15.4 standard compliant
- In this approach, Open-loop for temperature-aware link quality estimation and compensation and Closed-loop feedback process for
- a)Logical division of network into three regions
- b) Minimization of control packets overhead
- Threshold transmitter power loss ($RSSI_{loss}$) for each region helps to adapt transmitter power according to
- a)Link quality changes due to temperature variation
- b)Current number of nodes in that region

Proposed Energy Efficient Adaptive Transmission Scheme

- By adopting both open-loop and closed-loop feedback processes we can divide network into three regions on the basis of threshold $RSSI_{loss}$ for each region
- 1: A for High $RSSI_{loss}$
- 2: B for Medium $RSSI_{loss}$
- 3: C for Low $RSSI_{loss}$
- EAST has two phases, i.e., initial and run-time phases
- In the initial phase, reference node builds a model for nodes of each region
- In the run-time phases, based on the previous model, EAST adapts the link quality to dynamically maintain each link over time

Mathematical Formulation of Proposed Scheme

- Transmission power loss due to temperature variation formulated using relationship between $RSSI_{loss}$ and temperature experimented in Bannister et al:

$$RSSI_{loss}[dBm] = 0.1996 * (T[C^o] - 25[C^o]) \quad (1)$$

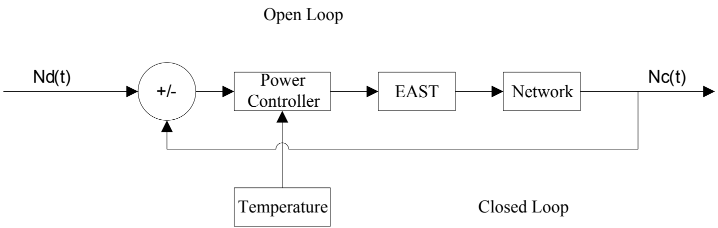
- To compensate $RSSI_{loss}$, relationship for required power level is given in Eq.(2) using least square approximation:

$$P_{level}[dBm] = [(RSSI_{loss} + 40)/12]^{2.91} \quad (2)$$

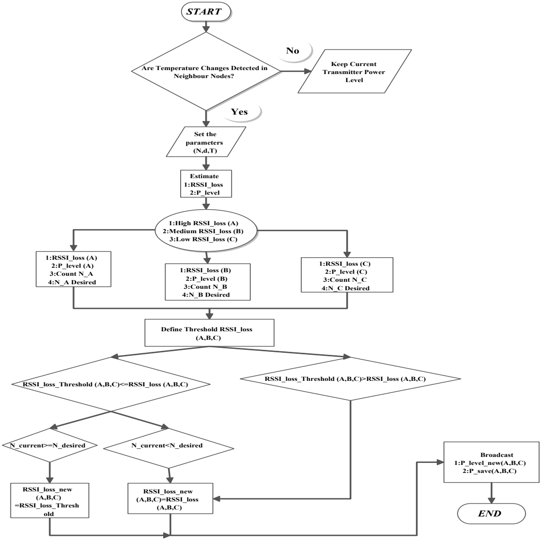
- To compensate path loss due to distance between sensor nodes free space model help to estimate actual required transmitter power as given in Eq.(3):

$$P_t[dBm] = [\eta*(E_b/N_0)*mkTB*(4\pi d/\lambda)^2+RNF]+P_{level} \quad (3)$$

Block Diagram



EAST Flow Chart



Simulation parameters

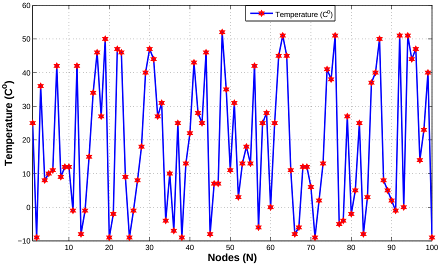
Rounds	1200
Temperature	-10-53 C^0
Distance	(1-100)m
Nodes	100
Regions	A,B,C
η	0.0029
SNR	0.20dB
Bandwidth	83.5MHz
Frequency	2.45GHz
RNF	5dB
E_b/N_0	8.3dB

Estimated parameters

Desired Nodes (A,B,C)	41,25,19
Current Nodes (A,B,C)	41,22,17
Threshold power level (A,B,C)	43.24,31.77,22.21 dBm
Nodes above threshold (A,B,C)	23,11,8
Nodes below threshold (A,B,C)	18,11,9
PRR (A,B,C)	(80-98),(70-96),(63-97) %
Threshold $RSSI_{loss}$ (A,B,C)	3.78,-0.61,-5.17 dBm

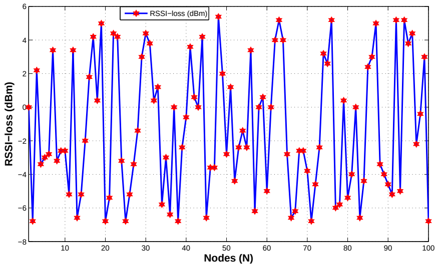
Temperature for different sensor nodes

- Suppose we have 100 nodes in 100*100 m^2 square region and temperature can have values in range (-10 - 53)C^o for given meteorological condition
- Each sensor node placed at random location in given area and we clearly see variation of temperature for different nodes in WSN



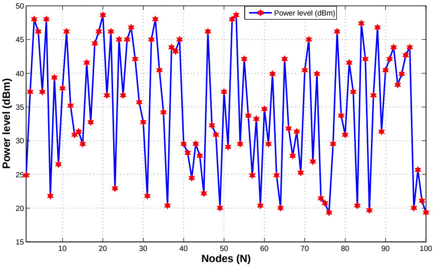
Transmission power loss for different sensor nodes

- Figure given below shows transmission power loss due to temperature variation in any environment
- $RSSI_{loss}(dBm)$ high means that sensor node placed in region where temperature is high so link not have good quality



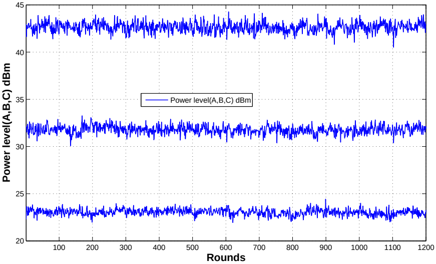
Transmitter power level for different sensor nodes

- After estimating $RSSI_{loss}$ for each node in WSN we compute corresponding transmitter power level to compensate $RSSI_{loss}$
- P_{level} assigned to each node on basis of nodes estimated $RSSI_{loss}$



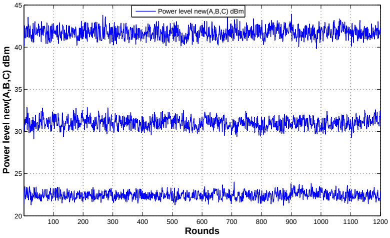
Transmitter power level for three region before EAST

- For region A required power level high then both other region that shows for that region $RSSI_{loss}$ is large
- For region B required power level is between both region A and C and for C region required power level is less then both other two regions

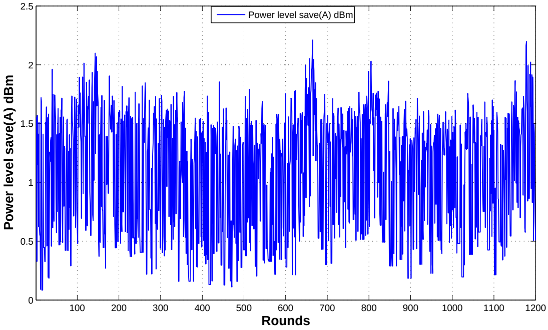


Transmitter power level for three region after EAST

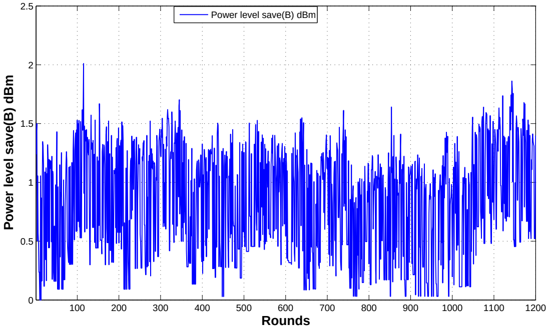
- After applying our propose technique we see what power level required for each region
- We clearly see difference between P_{level} as shown in Figure that required power level decrease for each region and for region A it decreases maximum



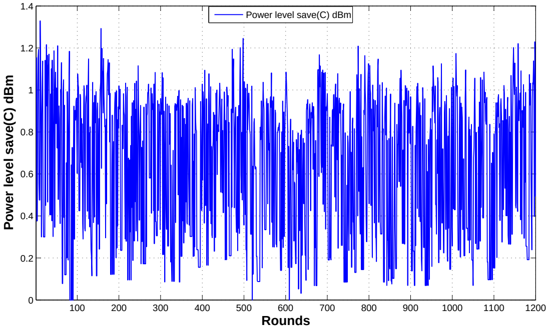
Transmitter power save for region A



Transmitter power save for region B



Transmitter power save for region C



Conclusion

- In this thesis , I have presented propose technique EAST to study temperature effect on wireless link quality
- Relationship between $RSSI_{loss}$ and temperature has been analyzed for propose scheme
- This scheme uses open-loop control to compensate for changes of link quality according to temperature variation
- Further extension of this scheme by dividing network into three regions on basis of Threshold $RSSI_{loss}$ and assign power level to each node in three regions on basis of current number of nodes and desired number of nodes help to adapt transmitter power according to link quality variation and increase network lifetime
- Combining both open-loop temperature-aware compensation and close-loop feedback control cause significant reduction overhead of transmission power control in a WSN

Questions

Thank you!