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Proposed Energy Saving Routing Protocol for Wireless Sensor Network Utilizing Sleep Mode Peculiarity of Sensor Node

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***Abstract*: Data transmission in wireless domain is one of the major challenges in Wireless Sensor Networks (WSN). Wireless Sensor Networks make efficient use of energy and time in major field of research; different routing protocols have been proposed to overcome these problems. In this paper we proposed a modified version of SPIN protocol that not only solves the problem of "Blind Forwarding" and "Data Inaccessibility" in SPIN, but also extend the network life time and quick response to request is made.**

Keywords: Routing protocols; SPIN; Wireless Sensor Network.

I. INTRODUCTION

Wireless sensor network is used widely in a variety of applications such as public safety, environmental monitoring, medical, home and office security, transportation, and military [1] [2]. WSN uses SPIN protocol for data routing [3]. Future of mankind's life will be affected tremendously by WSN - America's '"Technology Review" magazine.

The environmental condition is measured through specially designed Sensor nodes .SPIN protocol [5] is used by routing protocols and sensor network applications for the ideal lossless network. SPIN uses metadata for reducing the transmission of redundant data in the network making good use of resources. However, the problem of "Blind Forwarding" and "Data unaccessible"is not fully overcome by the use of metadata. Both the problems lead to energy wastage and information blocking.

Energy efficiency is a central challenge in sensor networks, as battery replacement is costly and often difficult in inaccessible deployment regions. Through the design of energy saving MAC protocols, like duty cycling protocols or low power wakeup radio protocols, and routing protocols, sensor networks have addressed energy efficiency. Radio energy consumption is a major component contributing to the overall energy consumption at each node. In order to minimize energy consumption current MAC protocols put the radio in sleep mode while there is no data to send or receive.

Although most radios for sensor networks support multiple sleep modes, the radio sleep mode in current MAC protocols is static. Choosing a static low power mode involves an energy and delay trade off. The deepest sleep mod turns off the oscillator and voltage regulator, provides the lowest current draw of all low power modes. However, it also involves the highest energy cost and the longest latency for switching the radio back to active mode. In contrast, the lightest sleep mode provides a transition to active mode that is quick and energy inexpensive, but it has a higher current draw. In a low traffic scenario, it is better to use the deep sleep mode as nodes spend more time sleeping than switching back and forth between sleep mode and active mode. In a high traffic scenario, a lighter sleep mode is more suitable as the cost of switching the radio frequently into deep sleep mode would exceed the energy saving of the deep sleep mode's low current draw.

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II. CONVENTIONAL SPIN PROTOCOL

SPIN is an event driven data delivery model in which the sensor node senses data and routes data throughout the network by means of negotiation. A sensor node uses three types of messages for communication [5] [6]:

- ADV- Using ADV message a node can advertise new data arrived at it containing Metadata (information of data).
- REQ- For receiving actual data , a node sends a REQ message
- DATA-It contains actual sensor information.

The SPIN family contains protocols like SPIN-PP, SPIN-BC, SPIN-RL, SPIN-EC and SPIN-MI.

Protocol	**Used For**
SPIN-PP	Point-to-Point communication media
SPIN-BC	Broadcast communication media
SPIN-EC	Energy Conserving
SPIN-RL	Reliable Adaptation
(These 2 are Modified version of SPIN-PP, SPIN-BC)	
SPIN-MI	Efficient Energy Saver

In SPIN-BC, Using ADV message, nodes transmit data which is received by nodes within the transmission range. After reception, each node verifies whether it has already received or requested the advertised data. If not, sends a REQ message to the broadcast address with the original advertiser in the header of the message. After receiving a REQ message from neighbor node the original advertiser responds and sends the actual data to the requesting node. Due to negotiation mechanism Data delivery is not guaranteed in SPIN. Redundant data is eliminated but it does not establish any path for data transmission. Energy is consumed in Data sensing, Processing the sensed data and Transmitting or receiving them between 2 nodes . Hence to save significant amount of energy, one has to control the number of transmission and reception of messages.

III. THE PROBLEMS OF SPIN PROTOCOL

SPIN [7] protocol is more effective and saves higher energy than other protocols. It is suitable to small or medium-sized WSN that bridges other distribution environments. Before transmitting data, sensor nodes consult with each other. They avoid the emergence of explosion of information and some overlap in flooding.

A. "Blind Forward" Problem:

The source node sends DATA packets to all the neighbor nodes. An ADV message would be broadcasted to its entire neighbor nodes that have received data by mentioning DATA packets are consumed by those neighbor nodes that respond to ADV message. This process is repeated until the packets reach the destination which is repeated for all new data items leading to *Blind Forward" Problem which causes* wastage of energy & unbalance of energy consumption across the network nodes.

B. "Data Inaccessible" Issue:

Using ADV message, sensor nodes broadcast new data arrived at it. In some cases, due to low energy, some nodes unwillingly forward the new data; and if the neighbor nodes already have the same data, they doesn't receive same data. Also there is a problem in energy consumption in the WSN.

As the nodes around sink nodes are located on the only path of reaching the sink node & are bound to take more tasks, it is easy to run out of energy and failure. The problem above will result in data unaccessible in lossless network. In SPIN, due to the "blind forward" problem energy wastage shorts the life cycle of the network, and reduces the network performance. Due to "data inaccessible" problem, the network is unable to collect information.

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VI. PROPOSED E-SPIN PROTOCOL

A. Initial Assumptioin For Network Model:

The initial energy of each node is equal; node A and node B can communicate with each other, the link is symmetrical. Communication between two nodes is far away from the interference of other nodes, and power is without any constraints and nodes remain stationary. Assuming all nodes want to achieve the data, and are located on the path to reach sink nodes. Wireless signals in all directions consume the same energy, and the energy should be above threshold value (energy needed to complete all the phases), every node must be aware of threshold value.

B. Working Mechanism of E- SPIN:

Our proposed model consists of five phases. "Hop distance Calculation" phase determine the distance of sensor nodes from sink node at the time of initialization of WSN [10]. In "Advertising Phase" sensor nodes send request to its neighbor nodes.In response to advertisement message neighbor nodes having current energy value above threshold [9] and closer to sink node in comparison of advertising node will make the request in "Requesting Phase". In "Data Transmission" phase source node sort the requesting nodes on the bases of their energy values and node with maximum energy is selected to forward the data.

In "Sleep Mode" phase sensor nodes goes from sleep state to active state when they receive an active message packet from neighbor node. It also senses the information over a barrier value defined at the time of network initialization.

1) Hop Distance Calculation:

Hop distance is measured from sink nodes [10] while the Wireless Sensor Network is initialized. Initially the sink node broadcasts *initialization* packet in the network with *type, nodeId* and *hopd*. Here *type* provides the information of the type of messages. The *nodeId* represents id or address of the sending nodes and *hopd* represents hop distance from the sink node. *hopd* is initially set to 1. When a sensor node receives the *initialization* packet, it memories this hop value as its hop distance from the sink node in memory. After storing the value, the sensor nodes increment the hop value by 1 and then re-broadcast the *initialization* packet to its neighbor nodes with modified hop value. Sensor nodes may receive multiple *initialization* packets from different intermediate nodes. Whenever a sensor node *b* receives *initialization* packets from its neighbor a_i, $1 \leq i \leq n$, it checks the hop distances and set the distance to the minimum, i.e.

$Min \{ \forall h (a_i, b), i = 1, n \}$

Where $h (a_i, b)$, represents hop distances between the nodes a_i and *b* and n is the no. of neighbor nodes of node *b* from which it receives the *initialization* packets. This process is continued until each node in the network receives the *initialization* packets at least once.

2) Advertising Phase:

When a sensor node (source node) of a network has new data to send or forward, it first broadcasts ADV message to all its neighbor nodes. ADV message contains the metadata describing the properties of data to be transmitted and threshold value (Tadv).

3) Requesting Phase:

After receiving the advertisement message ADV from source node if not in sleep mode, receiving nodes check weather their current energy values is above threshold value Tadv [9]. If energy valueof a neighbor node of advertising node is less than threshold value then do not reply to advertisedmessage ADV and set the status to sleep mode, else if it'scurrent energy value is above threshold value then compare its hop distance (Hnb) and hop distance (Hadv) of advertising node [10]. If aneighbor node hop distance is greater than advertising node hop distance, set Fhop to 1, else set Fhop to 0. After setting flag Fhop check if a neighbor node have received the data before by comparing the meta data available in its memory with the metadata transmitted along with the advertising message , if same data is sent again set flag Fdata to 1, else set Fdata to 0 in request message and then send request message to advertising node[11] . The whole process can be summarized as follow:

a. Receive the ADV message if not in sleep mode

- If energy level <threshold value (do not reply and go to sleep state)
- Else move to next step

b. Compare hop distance

- If HVadv<HVcn (do not reply)
- Else move to next step

c. Check if node already receive the data

- If yes do not reply
- Else move to next step

d. Send request message if above condition is satisfied.

4) Data Transmission Phase:

After receiving the request messages from different neighbor nodes source node separate the neighbor nodesin four list L1, L2, L3 and L4n on the basis of their flag values[]. First two lists are made on the basis of flag Fhop and then the two lists are further separated into two sub list on the basis of Fdata. Arrange all four lists in descending order on the basis of energy value of nodes send along with request message [11].

Select the first element (node with maximum energy) from the list containing neighbor nodes with flag values Fhop=0 and Fdata =0, if the list is empty select the first node from list having Fhop=0 and Fdata=1 and if this list is also empty we look in the list having Fhop=1 and Fdata=0 and then list with flag value Fhop=1 and Fdata=1 if previous is empty. If no nodeis selected (all the list is empty) then check weather current threshold value is less than or equal to minimum energy of node. If yes network is dead otherwise, reduce the threshold value by predefined value and move to advertising phase. The whole process can be summarized as follow [11]:

a. Receive the request messages from neighbor nodes.

b. Filter the node with flag Fhop (0) from flag Fhop (1) in two separate lists X and Y.

c. Filter the node in X with flag Fdata (0) from flag Fdata (1) in two separate lists L1 and L2.

d. Filter the node in Y with flag Fdata (0) from flag Fdata (1) in two separate lists L1 and L2.

e. If list L1 is not empty

Select first element in list, go to ‘j’.

Else go to ‘f’.

f. If list L2 is not empty

Select first element in list, go to ‘j’.

Else go to ‘g’.

g. If list L3 is not empty

Select first element in list, go to ‘j’.

Else go to ‘h’.

h. If list L4 is not empty

Select first element in list, go to ‘j’.

Else go to ‘i’.

i. If threshold > min_energy

Threshold = threshold-(predefined value)

Go to advertising phase.

Else go to j

j. Forward the data to selected node.

If no request message is received in give time interval then generate an ACTIVE_PACAKET message to all the neighbor node to bring them in active state [11]. After moving to active state all the neighbor nodes decreases their THR_SLEEP by certain factor and move to advertising phase.

5) Sleep Mode Phase:

Nodes can go from sleep state to active state only if following two events occur.

- Receive Active message packet from neighbor node.
- Sensed information around the environment goes over a barrier value defined at the time of network initialization.

V. CONCLUSION

The proposed protocol E-SPIN is suitable for application like alarm monitoring which need quick response. Proposed model uses the distance of nodes from sink node and neighbor node with maximum energy among the set of neighbor nodes which are nearer to sink node in comparison to advertising node is selected to forward the data by keeping unrequired nodes in sleep mode. This protocol is very good solution to solve the problems of *"Blind Forward"* and *"Data Inaccessible"*.

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