ENHANCING THE LIFETIME OF WIRELESS SENSOR NETWORKS USING EFFICIENT DUTY-CYCLING SCHEME

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Abstract

In Wireless sensor networks, the node have limited battery power and it is not possible to recharge or to replace the batteries, therefore power consumption should be minimized so that overall network lifetime will be increased using Asynchronous Duty-cycling scheme. The proposed work is to employ a Efficient Multihop Broadcast Protocol for Asynchronous Duty-cycle (EMBA) adopts forwarder's guidance and overhears the broadcast message and acknowledgement. A node can broadcast the messages with the guidance to neighbor nodes. With the guidance of the node, the broadcast message forwarded to neighbor nodes using unicast transmission, this will reduces redundant transmission and collision. Number of transmissions is reduced by overhearing of broadcast message and acknowledgement and it also minimize the active time of the node. EMBA improves the energy efficiency in terms of both duty cycle and energy consumption.

***Index Terms*—WSNs, Duty-Cycling, MAC, Multihop, Broadcast, ns-2.**

I. INTRODUCTION

Wireless sensor networks consists of numerous tiny autonomous sensing nodes deployed across a wide geographical area. These sensor nodes self organize and establish radio communication links with the neighboring nodes to form multi-hop routing paths to the central base station. The dynamic and lossy nature of wireless communication poses several challenges in reliable transfer of data from the sensor nodes to the sink.

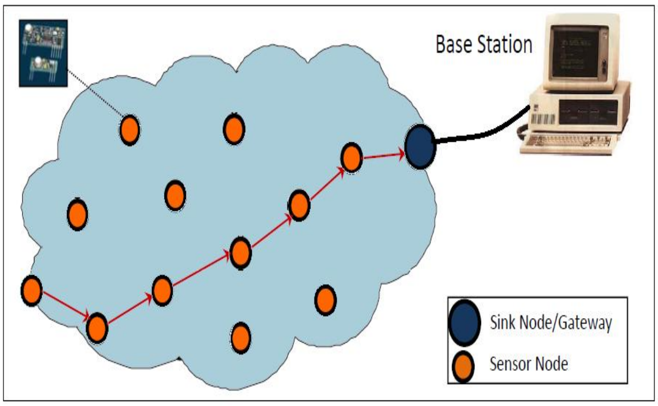

Fig.1 Wireless Sensor Networks

A sensor is a small device that has a micro-sensor technology, low power signal processing [1], low power computation and a short-range communications capability. Sensor nodes are conventionally made up of four basic components as shown in Fig.2 a processor, a radio transceiver and a power supply/battery

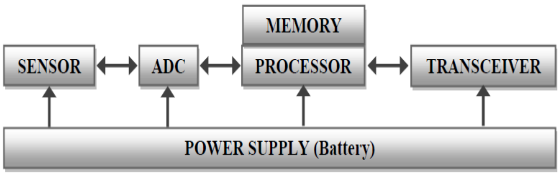

Fig.2 Components of a Wireless Sensor Node

Analog-to-Digital Convertor (ADC), location finding systems [5], mobilizers that are required to move the node in specific applications and power generators. The analog signals measured by the sensors are digitized via an ADC and in turn fed into the processor.

The processor and its associated memory RAM is used to manage the procedures that make the sensor node carry out its sensing and collaboration tasks.

The radio transceiver connects the node with the network and serve as the communication medium between the node. Memories like EEPROM or flash are used to store the program code.

The power supply/battery is the most important component of the sensor node because it implicitly determines the lifetime of the entire network. Due to size limitations of AA batteries, cells are used as the primary source of power. The indication of the energy consumption involved, the average sensor node will spend approximately 4.8mA receiving a message, 12mA transmits a packet and 5µA sleeping. In addition the CPU uses on average 5.5mA in active mode.

Reducing energy consumption is one of main challenges in WSNs [6]. In many application, sensor nodes run on a pair of batteries for several years. Replacing or recharging batteries may be difficult due to the scale of deployment, or in some cases, because the sensor nodes may be deployed in physical places which are difficult to access. Thus it is very important to increase the lifetime of the network by reducing the energy consumption of sensor nodes.

The most energy-consumption operation in WSNs are radio activities. Energy is consumed due to packet transmission and reception, but also in idle listening for a time period the radio transceiver of a sensor node is awake, listening to the wireless medium to that node. In sensor network, where sensor nodes in idle listening is generally the most significant source of energy consumption. Duty cycling is a mechanism used to reduce the energy due to idle listening. In this approach, each sensor node is alternate between active and sleep state. Most of the time the sensor node is in sleep state and wakes it up periodically for a time duration to sample the wireless medium in order to check if there is any transmission is intended for it.

Duty-cycled MAC protocol can be done either synchronously or asynchronously. In synchronous approach, wake up times of the neighboring nodes need to be synchronized before transmission in order to reduce energy consumption. The main drawback of the synchronous approach is the extra is the extra energy overhead required for time synchronization. Low Power Listening is a common method in asynchronous protocols, where each node samples the channel periodically for long preamble continuously transmitted by a sender. If a node detects a preamble, it turns its radio on until the packet is received. Duty cycling MAC protocols reduces the idle listening energy consumption because the radio awake period is significantly smaller than the radio sleep period.

Asynchronous Duty-Cycle MAC [4] protocols do not provide prior knowledge about the global or local timing information and schedules the node in a network to assist with data communications. Thus the nodes need not to remember the schedules of its neighbors which significantly reduce the usage of memory and energy cost due to schedule sharing between the nodes. Asynchronous duty-cycle MAC provides a frequent channel sampling mechanism for detecting possible starting transmissions in the network. The frequent channel sampling at the receiver is also known as a Low Power Listening (LPL) mechanism. The concept of preamble packet transmission is used in order to hit the intended destination node. When the destination receives the preamble packet, it waits for the data to be transmitted. The transmission of a preamble packet is one of the examples of transmitter-initiated approach in asynchronous WSNs.

II. PROBLEM STATEMENT

Nodes in a WSNs application should operate for a long time on limited battery capacity. Synchronous MAC protocols achieve comparable energy efficiency by reducing idle listening time and also extra complexity and overhead are required for synchronization. In order to reduce energy consumption, Asynchronous MAC protocol is used. In Asynchronous Duty-cycling scheme, where the sensor node have their own schedule, it is difficult for broadcast transmission to reach multiple neighbor nodes. To support multihop broadcast in asynchronous duty-cycling schedule, a node should use independent unicast transmission to reach all of its neighbor nodes. This will lead to redundant transmission of same broadcast messages and collision will occur frequently when a node receives the same broadcast messages from multiple senders and this will cause the energy dissipation and delayed propagation of broadcast messages.

III. PROPOSED SCHEME

Energy Efficiency of WSNs can be achieved by using the duty cycling scheme. Therefore to increase the life time of a network, an efficient multihop broadcast protocol for asynchronous duty-cycled WSNs (EMBA) is designed and it adopts forwarde's guidances and overhears the broadcast message and acknowledgement.

A. Forwarder's Guidance

A forwarder S transmits a broadcast message to a receiver R using unicast transmission [3]. The procedure of constructing the Guidance List consists of three parts, as shown in the Fig. 3,

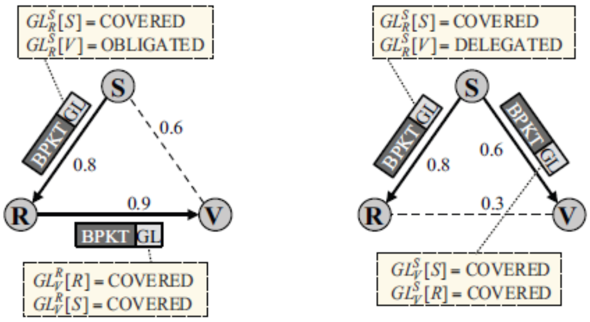

Fig.3 Constructing the Guidance List

B. Procedure for constructing the guidance list

If node V is a neighbor node of the receiver R is already covered, GL_R^S [V] is set to COVERED. If node R receives, GL_R^S [V] = COVERED from the forwarder S, R will not do anything for node V because V is already covered.

The node V is a common neighbor of nodes S and R. To keep away sending the broadcast message over a poor link [2], EMBA makes use of the following guidance to choose the forwarder which covers node V:

- LQ(S, V) ≥ LQ(R, V), GL_R^S [V] is set to DELEGATED
- LQ(S, V) < LQ(R, V), node S assigns GL_R^S [V] OBLIGATE

Node R receives GL_R^S [V] work as a new forwarder and broadcast message from node S. If node R receives GL_R^S [V] = DELEGATED and will never do anything for node V because V will be covered by another node which has better link quality to V than R. Node V is covered only if node R receives GL_R^S [V] = OBLIGATED.

If node V is not a neighbor of a forwarder S and this is executed when a forwarder is one of nodes forming a quadrangular topology. The forwarder S does not have any knowledge of whether node V is already covered. If two or more neighbors of node S can communicate with node V and denote them as r_1 ...r_n. The forwarder S assigns OBLIGATED to all of $GL_{r_1}^s$[v],......,$GL_{r_n}^s$, and this will lead to redundant transmissions and collisions will occur because all nodes r_1,.......r_n will attempt to cover node V. To avoid this problem, a forwarder S gives the guidance (OBLIGATED or DELEGATED) to each node of r_1,.......r_n. Node S gives OBLIGATED only to a node R because which has the best link. Node S, then, gives DELEGATED to other nodes r_1,...,r_{t-1},r_{t+1},....r_n.If node r_t receiving $GL_{r_t}^s$[v] = OBLIGATED will only attempt to cover node V.

After receiving broadcast message i from node S, node R sends an acknowledgement message to node S. Let acknowledgement message to signify receipt of broadcast message i. The forwarder finishes broadcast and goes to sleep, if obligation set becomes empty.

C. Analyze the guidance list

After receiving broadcast message i the node R the analyze guidance list. The procedure is to analyze a guidance list provided from a forwarder S and to follow the guidance. Node R analysis GL_R^S in broadcast message i to decide how to handle each neighbor node V.

If GL_R^S [V] is COVERED, node R inserts the ID of node V into covered set and eliminates it, from both uncovered set and obligation set.

If GL_R^S [V] is DELEGATED, node R adds the ID of node V into delegated set and removes it from obligation set. Node R inspects whether obligation set is empty after analyzing the GL_R^S. If obligation set is empty, immediately node R goes to sleep. Otherwise, node R serves as a new forwarder and performs the same procedures as explained above.

D. Overhears The Broadcast Messages And Acknowledgement

If a forwarder overhears BPKTi or ACKi message to a certain node and it removes the ID of node(s) specified in the message from the obligation set. Therefore, the number of transmission required for covering the neighbor nodes will be minimized. This technique significantly maximize the energy efficiency by minimizing the active time of each forwarder and the number of transmission required for covering neighbor node.

IV. SIMULATION

This section to evaluates the performance of EMBA and RI-MAC using ns2. The simulation is performed in 3 random networks and the density of the network is 6,8,10. The reason for varying the network density is to show that the EMBA have efficiently support the multihop broadcast in sparse network. If the density of network increases, the collision occurs easily due to multiple forwarders. In this simulation, the sink node act as a source node and broadcast the message periodically between the random interval 20 and 40 seconds. All the nodes in the network periodically transmit the advertisement message to the neighbor nodes for every 150 seconds. The table 1 shows the parameter values of the network.

Energy efficient is analyzed by taking two parameters into account. From the obtained results
it is inferred that the energy efficiency is improved by using EMBA technique. The following are the parameters which are taken for comparison:

- Energy
- Delay

Table I Parameters for simulation

PARAMETER	VALUE
Bandwidth	200 kbps
SIFS	180 µs
Slot time	280 µs
Transmission range	20 m
Carrier sensing range	15 m
Transmitting power	52.2 mW
Receiving power	56.4 mW
Listening power	56.4 mW
Sleeping power	3 µW
Size of the packet	10-11B

A. Nodes Vs Energy

Energy is referred as the amount of time a node spent in the processing. Energy efficiency is improved by reducing the number of transmission and active time of the node. Energy efficiency is improved in EMBA compared with RI-MAC. Energy variation is shown in Fig. 4,

C. Node Vs Delay

Delay refers to time taken for the entire message to completely reach the destination from the time it starts from the source. Delay is reduced in EMBA compared to RI-MAC due to reliable data packet delivery to the destination. Delay variation is shown in the Fig. 5,

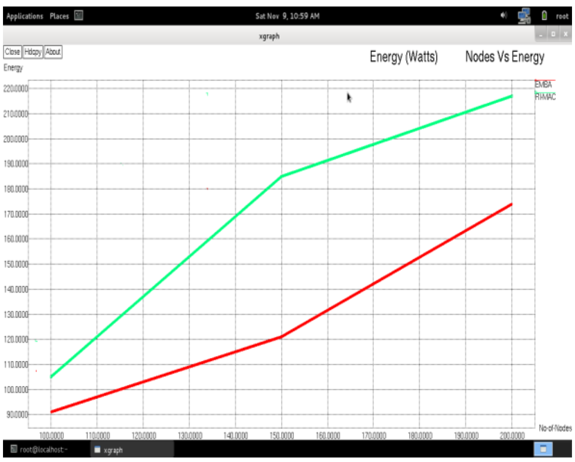

Fig. 4 Node Vs Energy

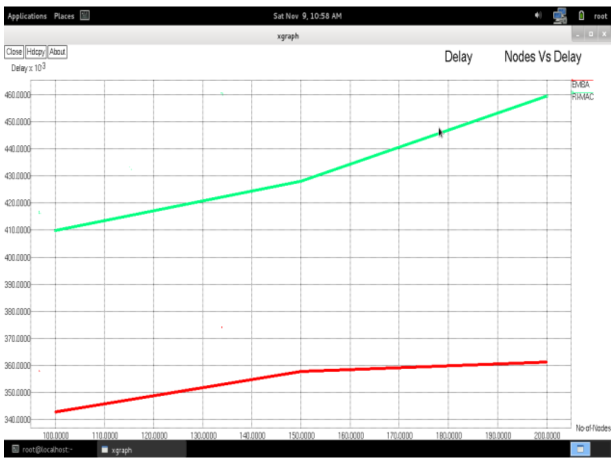

Fig. 5 Node Vs Delay

IV. CONCLUSION AND FUTUREWORK

The system measures the energy efficiency based on duty-cycling scheme in asynchronous environment. EMBA protocol enables the sensor nodes to efficiently support multihop broadcast. The forwarder’s guidance significantly reduces redundant transmission and collisions. The overhearing of broadcast messages and Acks helps to reduce the number of transmissions and this technique minimize the active time of the forwarders. The performance results show that EMBA extends the network lifetime. Delay increases while increasing the number of nodes. The duty-cycling scheme can be combined with other protocols to improve the lifetime of the network without increasing the delay.

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