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PERFORMANCE ANALYSIS OF ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS USING MOTES

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ABSTRACT

Wireless Sensor Networks (WSN) have become an active topic of research with the upcoming demand and present-day technological interests. It is one of the ways to connect with the physical environment. Wireless sensor nodes (or Motes) are the basic units in forming Wireless Sensor Networks. Motes are low-cost microchips, which integrate a microcontroller, transceiver, gateway module, and a power unit. Many routing protocols have been proposed over the years in wireless sensor networks for data transmission. MAC Based Routing (MBR) is based on Medium Access Control routing protocol that can be used when the destination is always the sink. During the network setup, each node is associated with a source. In MBR, the routing is done in such a way that every node sends the packet to the source to which it is associated. This process repeats until the packet is received by the sink. Level Based Routing (LBR) protocol follows the multihop scenario in which each node sends the packet to its neighboring nodes which increases their level by '1' after which the neighboring nodes re-broadcast to the next level nodes and so on. The article analyzes these two protocols and presents the contrast between the two. These two protocols have been implemented in wireless sensor motes and their behavior has been noted. Various parameters such as the remaining battery, efficiency, etc are jotted down.

KEYWORDS— *Wireless Sensor Networks, Wireless Sensor Nodes, motes, transceiver, sink, source, multihop, broadcast.*

1. INTRODUCTION

There are different types of IEEE standards used in the workinggroups for wireless personal area networks that wirelessly connect the users within their communication and computational environment [1]. Wireless sensor network usesIEEE 802.15.4 to communicate between the devices, it provides a specification for a low rate, lower power personal area networks. For example, in a large market for home automation, security, and energy conservation applications which typically do not require high bandwidth.

To serve the design needs of various applications of WSN several commercial nodes are available in the market. One such commercially available node is motes. It consists of the following sub-systems: a power source; radio module; sensor module and gateway module. Batteries, both rechargeable and non-rechargeable serve as the power source. Radio Module consists of a microcontroller that computes the data sent by the source. The Sensor module is used to sense the environment. The gateway module serves the purpose of sending the data from the sink to the GUI. Figure 1 represents a wireless sensor mote.

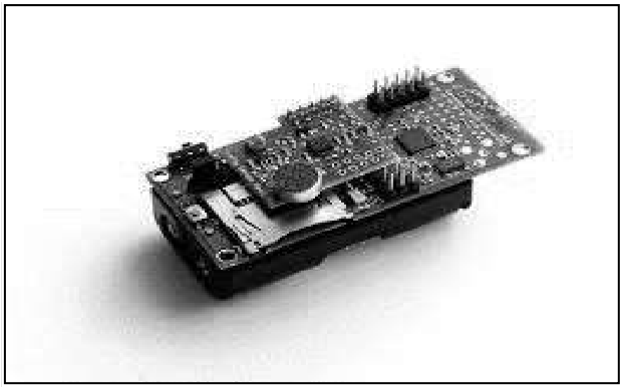

Figure.1: Sensor Mote

In wireless sensors networks, this particular standard defines the physical and Mac layer of the protocol stack. In 802.15.4 we have 3 types of devices those are:-

(1) Personal Area Network (PAN) Coordinator
(2) Coordinator
(3) Reduced Functioning Device

PAN coordinator is an important part of the network and is required to start a network [2]. It is also called an access point. The coordinator acts as routers i.e, if we want to send data over some distance in multihop then these routers are required to route the data from point to point to reach the destination. A reduced functioning device can just sense the data and send it into the network. In a wireless sensor network, we use the device either as a PAN coordinator or a coordinator. For communication IEEE 802.15.4 uses the ISM bands, there are many channels in these bands and IEEE 802.15.4 can use fromchannel number 11 to channel number 26. This standard performs an energy scan on these channels by finding the energy on each of these channels and comparing these with the energy level of other channels [3]. By this, the quietest channel is found i.e., the chances of interference on that particular channel are low. Therefore, the particular channel is selected anda personal area network is started on that channel and an ID is given to the PAN because there may be more than one workingPAN at the same time to differentiate them. Now the coordinator will ping on in and every channel to find

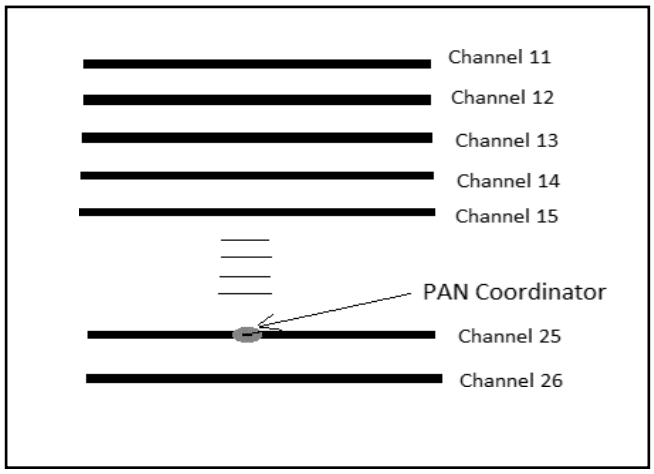

Figure.2: Energy Scan

We have considered the following features to implement a good MAC protocol for the wireless sensor networks. The first is energy efficiency. As mentioned above, sensor nodes are mainly battery-powered and are often very difficult tochange or recharge batteries. Extending the network lifetime for these nodes is a critical issue. Another important feature is the scalability of the change in network topology. Some nodes mayrun out of battery or die over time; some nodes might change their location. Hence, the network topology changes from time to time. A good MAC protocol should easily adapt to such network changes.

MBR or MAC Based Routing is used when the destination is always the PAN Coordinator. During the network setup, eachnode is associated with a coordinator [7]. MAC-based routing is based on the technique that every node sends the packet to the coordinator to which it is associated. This process repeats till the time the packet is received by the destination node, i.e. PAN Coordinator. If the packet gets dropped, it generates an exception and the node resets itself.
the PAN and when it detects the PAN coordinator on a particular channel it will send an associate request to the PAN and in reply PAN will send its node ID to the coordinator and both get associated with each other. Now, these coordinators which are in 1st hop will broadcast that PAN is present on this particular channel so that when the 2nd hop coordinator starts toping on each channel these 1st hop nodes broadcast the messageto them that the PAN is present and these also get associated with the PAN by which the network gets expanded and at MAC layer this network is based on unslotted CSMA/CA and the datacan be routed from one node to another [4]. This is how the setup is done to initialize the PAN and communicate between the different nodes in the network.
A wireless sensor network consists of many sensor nodes which can sense the environment and communicate. It has the source, destination, and intermediate nodes. These nodes consist of different modules like radio module, gateway module, sensor module, and an extender to add different modules to it. Every module has some function to perform in WSN and the radio module is the base for each node which is used to store the information. If a particular node senses any change in the environment, then it converts the analog data into digital data and sends it to the destination at which digital output is obtained[5]. For this sending purpose, some routing algorithms are written which can efficiently transfer the data from source to destination.

2. RELATED WORK

MBR and LBR were implemented on motes to check their behavior. Below discussed are MBR and LBR protocols.

1. MBR (MAC Based Routing) Protocol

Medium Access Control (MAC) is an important approachthat enables the successful working of the network [6].

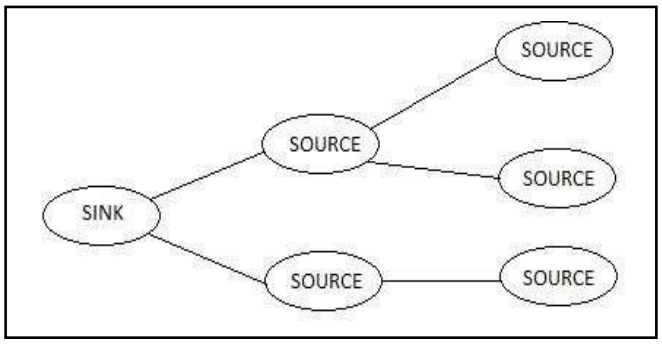

Figure.3: Flow of MBR from right to left

2. LBR (Level Based Routing) Protocol

There are different types of routing protocols such as on-demand routing protocol, proactive protocol, reactive protocol, etc. Level Based Routing (LBR) protocol comes under reactiveprotocol as there is no exchange of tables between the nodes. These nodes contain batteries that are used to route the data from one node to another to reach the destination. While routing, these nodes consume energy from the batteries, so it isan energy-oriented system.

Level Based Routing protocol is generally used when thedestination is PAN coordinator and this routing algorithm can be modified to work with any other node acting as a sink. In most, it is used in the multihop scenario. This protocol starts with an assumption that the MAC layer will take some time to set up throughout the network. When the timer expires for which the task is added to be

executed after the time assumed for the setup. The routing process is initiated whenever the timer expires for a specific task then the PAN coordinator sends a packet in the network with its level(hop) set to '0'. Thenodes which are in the range of PAN Coordinator and receivethe packet set their level to '1' after which they rebroadcast the packet [8]. The next-hop now may receive the packets from multiple nodes in level '1'. At this stage, each node saves the information of four nodes at max and sets their level as '2'. Theydo a rebroadcast only for the first packet received from level '1'. This is how each node gets a level and saves the information about the nodes in the previous level. The node follows the round-robin principle to send a data packet to the previous level, this principle is applied between the nodes in theprevious level whose information is saved in its memory. This may help in saving the battery and hence increase the network lifetime.

In Level Based Routing only the source node senses and the intermediate nodes are used to route the data to the destination.Therefore, links are made between each node to pass on the data. The lifetime of the network mainly depends on the energy, if the battery is consumed more by the nodes then the energy decreases fast as here we can break the long-distance links into shorter ones because while routing longer distances more energy is required [9]. This method is used to increase the efficiency of the network.

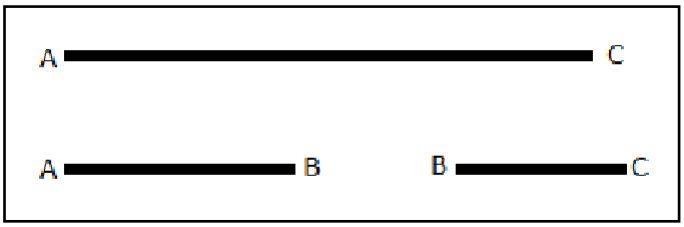

Figure.4: Multihop in LBR
'A'-SOURCE (LEVEL 2)
'B'-NODE (LEVEL 1)
'C'-SINK (LEVEL 0)

3. ALGORITHMS

Following are the routing algorithms that were implemented inthe motes by setting up a network.

MAC Based Routing Protocol

1) Nodes at the sink perform energy scan:-
    a. Find the quietest channel.
    b. Set up a PAN(Personal Area Network)
2) Nodes at the source perform the active scan:-
    a. Check for the personal area network in eachchannel and get associated with it.
3) After every 't' seconds
    a. Create a packet that has to be sent to the sink.
    b. Check if the destination is the sink to whichit is associated.
    c. Send the packet to the sink.
4) Nodes at the sink receive the packet.

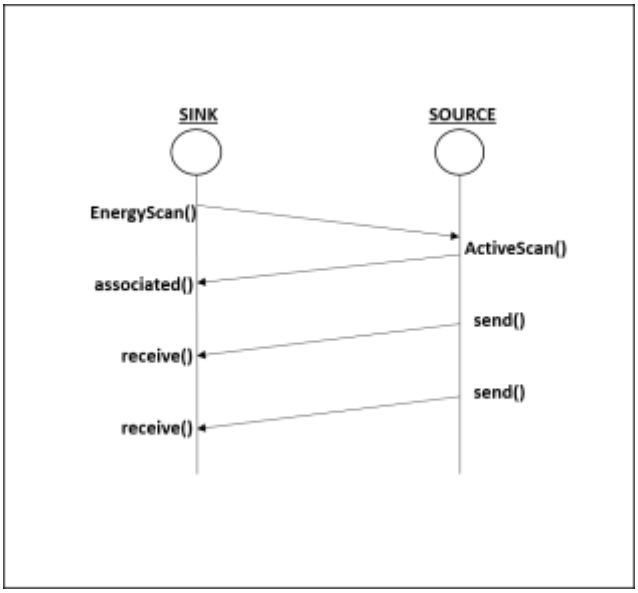

Figure.5: Timing Diagram of MBR

Level Based Routing Protocol

1) Nodes at the sink perform energy scan:-
    a. Find the quietest channel.
    b. Set up a PAN (Personal Area Network).
2) Nodes at the source perform the active scan:-
    a. Check for the personal area network in eachchannel and get associated with it.
3) Set the level of the sink as 0.
4) The sink broadcasts a setup packet with its level as 0.
5) The nodes receiving the setup packet perform thefollowing:
    a. If their current level is set
        i. Do nothing

        Else
        ii. Increment the level in the setuppacket
        iii. Set it as their level.
    b. Rebroadcast this setup packet with its currentlevel.
6) After every ‘t’ seconds the source creates a packet (with its level and destination address) and broadcastsit.
7) Nodes receiving this packet perform the following.
    a. If it is not the destination
        i. Check the level in the packet
        ii. If (level in packet > current level)
            1. Rebroadcast the packet with its current level
        iii. Else
            1. Drop the packet
    b. Else

        1. Packet is received at the destination.

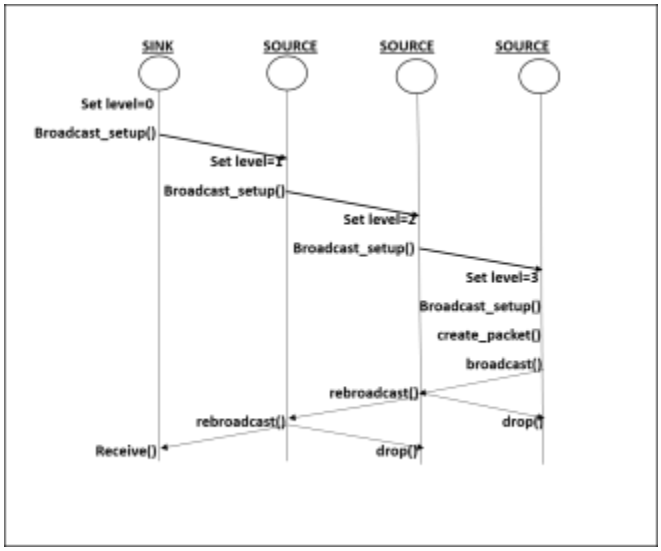

Figure.6: Timing Diagram of LBR

4. SIMULATION

A) COMPARISON OF ENERGY EFFICIENCY BETWEENMBR AND LBR

From the analysis of algorithms, the remaining battery versus time of MBR and LBR are graphically represented in Figure 4.

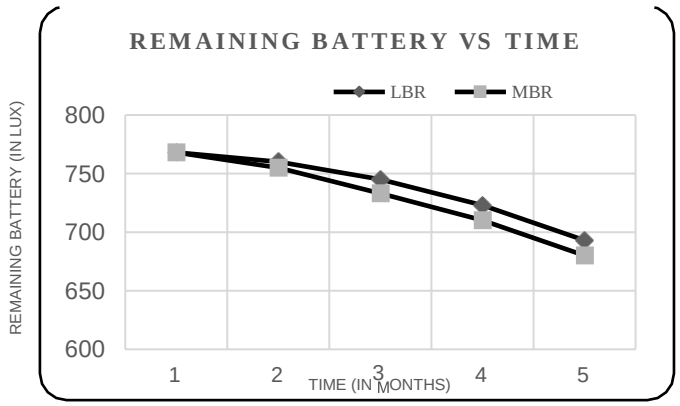

Figure.4: Remaining Battery versus Time of MBR and LBR

The time elapsed is taken on the x-axis and the remaining battery the y-axis. In MBR, the nodes consume more battery asthe destination is fixed and hence the source has to directly transfer the data packet to the sink which consumes moreenergy [10]. Whereas in LBR, the source sends the data packetto the nodes present in the previous level and so on to the sink.

5. CONCLUSION

The above-mentioned algorithms are executed on motes with 256 KB flash memory. From the results shown in the graph, itis observed that LBR is more energy-efficient than MBR as the chances of collision of packets in LBR is less as compared to that of MBR. The graph represents a decrease in both the curvesbut over time the curve representing MBR goes steeper thanLBR. The future work is to come up with an energy-efficient algorithm with low cost.

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