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Evaluation of Multi hop Performance of MAC protocols in Wireless Sensor Networks

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Abstract— The reliability of data delivery is a major concern in Low power Lossy Networks as they are deployed of devices of low energy, processing power and memory. The limitations of these devices leads to the dynamicity of the network.RPL is the routing protocol developed for these networks by the ROLL, working group of IETF. RPL is based on Destination Oriented Direct Acyclic Graph (DODAG). DODAGs have more than one path to the destination unlike the normal tree structure. Mac protocol supports the routing protocol to discover paths to the destinations using the link matrices. In our paper, we are comparing the three protocols: SBMAC, RBMAC and a RANDOM protocol on DODAG in terms of performance: drop rate and throughput. SBMAC follows the usual procedure of forwarding data packets depending on the routing table stored within the nodes. RBMAC forwards data packets to the nearby nodes and these nodes are then subjected to a competition to determine the next packet forwarding node. In random method, same procedure of forwarding data packets to the nearby nodes happens, but a random node will be chosen to forward the data packet.

Keywords— *LLNs, SBMAC, RBMAC, DODAG, MAC Protocols*

I. INTRODUCTION

LLNS (Low Power Lossy Networks) are distinguished by the resources of limited energy, power etc. They get depleted of energy sooner which pave the way to the dynamic nature of network. Storing and maintaining routing table within each sensor node will demand much more energy consumption. The reliability of data packets is less in Low Power Lossy Networks.RPL was suggested by IETF which works based on DODAGs (Destination Oriented Direct Acyclic Graph). This offers more than one path from nodes to the root unlike the regular tree structure.

MAC Protocols are used for supporting the routing in Networks depending on the matrices. In Preamble sampling, the sensor nodes spend most of their time sleeping in order to save energy. They wakeup for a short duration of time called clear-channel-assessment (CCA) at every checking interval(CI).The nodes check for any primary user using the channel for the current time. If not, a preamble of length, CI followed by the data is transmitted by the sensor node. This makes sure that all receivers obtain the data. SB-MAC and RB-MAC are the two categories for preamble sampling approach based on the forwarding mechanism.

In RB-MAC, when a node needs to send the data packet to the destination, unlike the normal routing of sending data packet to the next hope node, it sends the data packet to the nodes in the nearby region. The receiver nodes then undergo a competition to determine the next packet forwarding sensor node. The SBMAC follows the usual procedure of routing. When a node wants to send data packet to the destination, it forwards the data packet to the next hop node depending on the routing information. A disadvantage of this case is that, if the next hop node is not active as it depleted of energy, the packet delivery is failed. So it demands, higher retransmissions, which further uses more energy. Other than comparing these two protocols, an additional protocol called RANDOM which differs from RBMAC in the selection of next packet forwarding node is also used in comparison for

performance. In this method, when a node want to send data packet to the destination node, it forwards the data packet to all the nodes in the nearby region. One among the receiver nodes is elected randomly as the next packet forwarding node.

II. RELATED WORK

The receiver based Mac protocol is used in many proposals. The CRB-MAC[6] is a receiver-based MAC protocol emphasising on reliability requirements of CSNs. CSNs(Cognitive Sensor Networks) can access both licensed and unlicensed spectrum bands(dynamic spectrum access). Low-Power Distributed Queuing [8] is an energy efficient MAC protocol which concentrates on network synchronization and channel access. It is based on three design principles: Low-Power Listening (LPL), Distributed Queuing (DQ) and Channel Hopping (CH). DODAG (Destination Oriented DAG) and its development is well explained in [5]along with the messages in the structure like, DIO,DAO. DODAG along with the Trickle algorithm to control DIO messages is explained in [3].The importance of storing nodes is also explained. A survey regarding RPL is described in [1].The impact of Rank attack in RPL is studied in [4].A Hybrid Routing Protocol for Low-Power and Lossy Networks called Hydro[2] introduces the concept of border routers. The performance of RPL under different variant of interference is studied in [10].The detailed explanation of SBMAC and RBMAC, along with the explanation of preamble sampling is provided in [9].

III. PREAMBLE SAMPLING MAC PROTOCOL

The sleep/wakeup time of each sensor nodes is independent of other nodes in the network. The nodes spend most of their time in sleep mode in order to save energy. They wake up periodically each CI(Checking Interval) for a short duration of time called clear channel assessment(CCA).If the channel is found free, i.e.; no primary user is using the channel, the sender node transmits a long preamble of length CI followed by the data packet. This ensures that all receivers detect the preamble and gets the data frame.

Based on the forwarding mechanisms, the preamble sampling is divided in to two categories: SBMAC and RBMAC. SBMAC stands for Sender Based MAC and RBMAC for Receiver Based MAC.

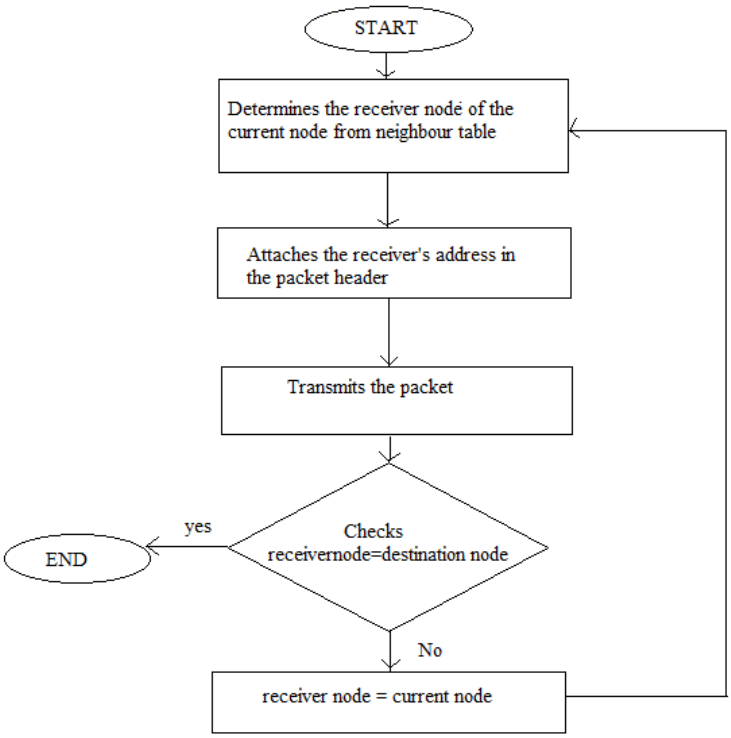

Fig 1 Flow chart- SBMAC

A. *SBMAC : SENDER BASED MAC*

Sender Based-MAC protocol works based on the routing table. When a sensor node need to send data to the destination, it checks the routing table stored within, to know the next hop node and determine the address. The node attaches the address of the next hop node along with the data frame. The maintenance of the routing table for each sensor node in case of Low Power Lossy Networks demands depletion of energy due to the dynamic nature of network. The routes changes as the nodes are depleted of their energy.

B. *RBMAC : RECEIVER BASED MAC*

In RB-MAC(Receiver Based-MAC) a sender node transmits its data without determining a receiver. All the neighbouring nodes within communication range of the sender node receive the data packet. Based on the information received from the micro-frame in the preamble, each individual node decides if it is eligible to participate in forwarding the data. Receivers undergo a competition to forward the message to the next node and the winner of this competition, forward the data to the next hop towards sink.

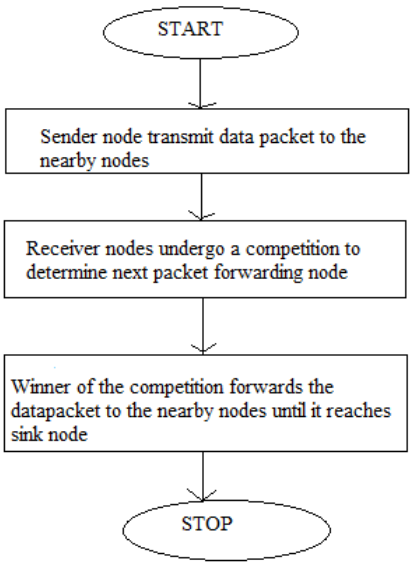

Fig 2 Flow chart – RBMAC

IV. RBMAC ON DODAG

The RPL for Low power Lossy networks put forward Destination Oriented Direct Acyclic Graph for the transmission of data from different sensor nodes to the sink node. In DODAG, there can be multiple path from sensor nodes to the destination node. The usual procedure of packet routing demands neighbour table on each nodes. The main distinguishing feature of LLNs is their low energy and power. The depletion of sensor nodes is faster. The situation demands the change in routing paths. This again forces the nodes to get updated of the changing scenarios which further consume more energy.

The usual procedure of routing happens in Sender based Mac protocol, i.e., when a node need to transmit data to a destination node, it looks the next hop address in the neighbour table to reach the destination. The Receiver based method is different in working of routing: i.e.; if a node need to send data packet to the destination, it sends the packet to each of the nearby nodes. The receiver nodes see if they are eligible for participating. Next in order to determine the next packet forwarding node, they undergo a competition .Here in the simulation we choose node queue size as a factor to determine the winner. The winner will be the next packet forwarding node. The process repeats until it reaches the destination node.

The RBMAC protocol can be applied in DODAG to improve the performance of the LLN. Since the packets are forwarded to multiple nodes, the chance of packet lose due to a inactive member is minimized. So the retransmissions in the network reduce. Retransmission of data packets is a reason for the energy depletion of nodes. As the number of drop rate decreases, the throughput must be increased.

In random method, when a node needs to transmit data to the destination, it will send the data to all the nearby nodes. Without a competition, one among them is elected as the next packet forwarding node. The elected node maybe one which gives best routing path, or it may be the one which gives worst path.

V. IMPLEMENTATION

For the simulation of our proposed scheme we used ns 2.35 version.

A.NS2

Ns2 stands as a tool to simulate what we find or experiment in network scenarios. Simulation scripts are written in the OTcl(object oriented Tcl) language, an extension of the Tcl scripting language. It runs on GNU/Linux, FreeBSD, Solaris, Mac OS X and Windows versions that support Cygwin.

B.CONFIGURATION

The configuration details for the simulation are explained here.TCP is the transport protocol used, which is more reliable. We used AODV routing protocol.802.11 is the medium access control for sensor node. Uses NS-2 LL default link layer configuration. For physical layer, two configurations are provided: first one simulating crossbow mica2 sensor node and and other simulating a 914MHz Lucent WaveLAN DSSS radio interface. Simulation used the former one. Omni directional antenna is used. Tworayground radio propagation model is used. Depending on the queuing model used we develop two scenarios: one using droptail and the other one using priority queue. Queue length is set to 20.Number of nodes is 21.

Two scenarios where created for simulating RBMAC, SBMAC and random method. The RBMAC and random method can be edited in the mac files inside ns 2.35.Three mac protocols are executed in two scenarios.

1) Graph: Number of packets dropped Vs Time : The graph 3 and 4 shows the drop rate of three protocols for the two scenarios. Even though the packet drop rate is higher for RB-MAC, the throughput is found higher for the protocol. This implies, the number of packet delivery is higher for RB-MAC.

2) Graph : Throughput : Throughput for the two scenarios are shown for RB-MAC,SB-MAC and random method in figure 5 and 6.The red graph shows the RB-MAC, green shows SB-MAC and blue shows random method. The throughput is higher for RB-MAC and SB-MAC, random method gives lower throughput.

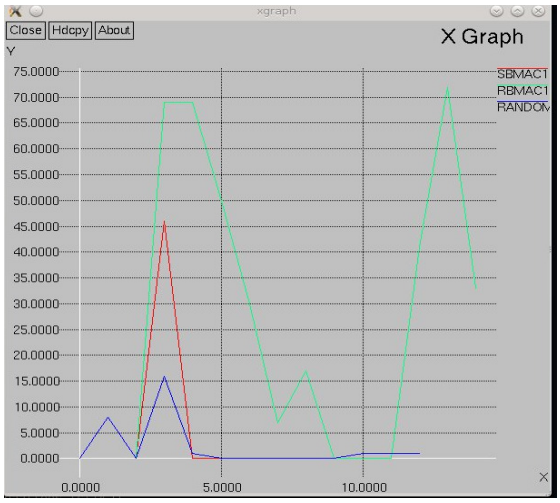

Fig 3 Number of packets dropped Vs Time-First scenario.

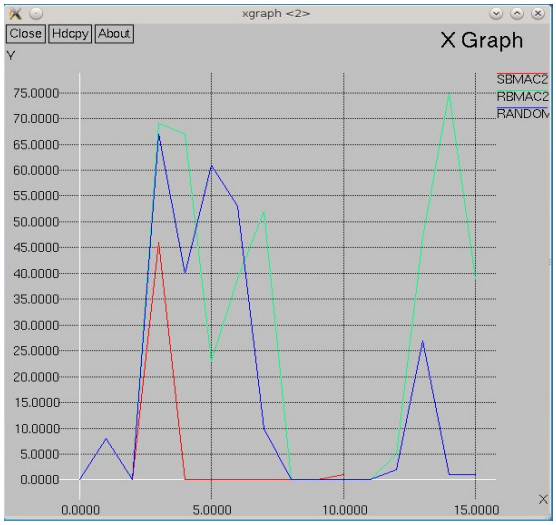

Fig 4 Number of packets dropped Vs Time-Second scenario

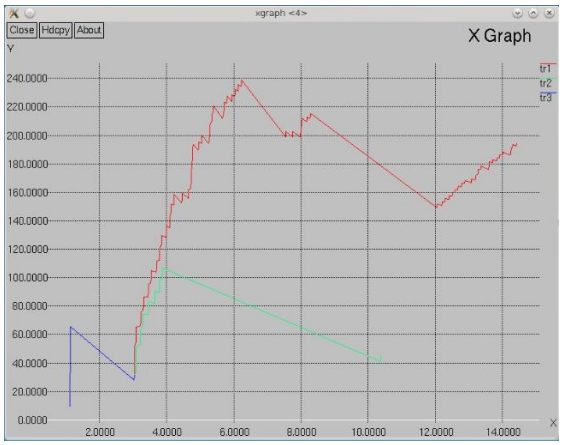

Fig : 5 Throughput-First scenario.

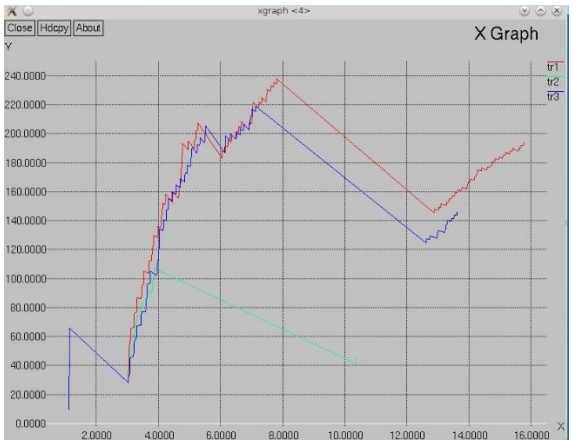

Fig : 6 Throughput-Second scenario

VI. CONCLUSION

Three mac protocols are simulated in two scenarios. The droprate and throughput for RBMAC was found higher.The
number of packets dropped is very less for SB-MAC and random protocols because they forward only very few packets. But the total number of packets delivered is very high for RB-MAC. On concluding, RBMAC performs better in Low Power Lossy Networks. Less retransmission can be implemented on these networks. Here we used node queue size to determine the next packet forwarding node, but we can also add the factor: distance from the sink node in determining the next hop node in RBMAC. This must further improve the performance of LLN.

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