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Evaluation of various MAC Protocols for Node Density in Wireless Sensor Networks based on QoS

Mosami Pulujkar[1], Dr.Sunil Kumar[2], Dr. Vivek Deshpande[3], Dr. Dattatray Waghole[4]
[1]Kalinga University,Naya Raipur, TSSM's PVPIT,Pune
[2]Kalinga University,Naya Raipur
[3]VIIT, Pune
[4]JSPM's JSCOE,Pune
mosamib@gmail.com
Sunil.kumar@kalingauniversity.ac.in
vsd.deshpande@gmail.com
dattawaghole10@gmail.com

Abstract:
A wireless sensor network is a collection of sensor nodes that communicate with one another to gather data and send it to a base station. The quality of service provided by sensor networks determines their efficiency and lifetime. Energy, channel capacity, packet transmission, packet drop, and latency are all factors in QoS. In WSNs, routing protocols are designed to discover the shortest route to a network's destination, whereas MAC protocols are designed to transmit data through a communication channel. To increase the network's life span, the best routing and MAC protocols are required for communication. In this research, we examined the performance of different MAC protocols for a variety of QoS measures as node density increased. Future researchers will benefit from this research in establishing the best hybrid protocols for wireless sensor networks. The results demonstrate that CSMA is the best communication protocol among the others.

Keywords: - wireless sensor networks, packet delivery ratio, delay, throughput, energy consumption.

I.INTRODUCTION:

Topology management is one of the most difficult aspects of constructing computer networks, particularly in Ad-hoc networks when the number of nodes is large and the network infrastructure is unreliable. In Ad-hoc network topology management strategies, selecting possible neighbors for connection establishment and selecting the optimal neighbors for hop-by-hop data transmission are critical for improving scalability, resource consumption, dependability, and other factors.[3,4] Clustering is a form of topology management strategy that groups nodes in order to increase network performance by managing resources and rotating tasks among nodes in order to ensure fairness.[5] Each group has a number of participants and one or even more cluster heads to manage it, including fusing, processing, transfer, and managing the information of the nodes. [6,7]Finally, each network has one or even more base stations that can act as gateways or data processing nodes locally. BS (s) receives information from cluster heads either direct or indirect via middleman nodes, which are nodes that connect the CH and the BS.

In Wireless Sensor Networks,[8,9] clustering is a vital goal for energy efficiency and network consistency. Clustering is a well-known and often used technique in wireless sensor networks. Clustering over distributed methods is currently being developed to address challenges such as network lifetime and energy consumption.[10] Clustering in sensor nodes is critical for addressing a variety of difficulties in sensor networks, including scalability, energy consumption, and lifetime. Clustering methods limit communication inside a small area and convey just the information that is required to the rest of the network via forwarding nodes (gateway nodes). A cluster is made up of a set of nodes, and the local connections between cluster members are managed by a cluster head (CH), as shown in the diagram. Cluster members usually connect with the cluster head, as the data collected by the cluster head is consolidated & fused by the cluster head in order to save energy. Before approaching the sink, the cluster heads could additionally create a further layer of clusters among themselves.[11,12]

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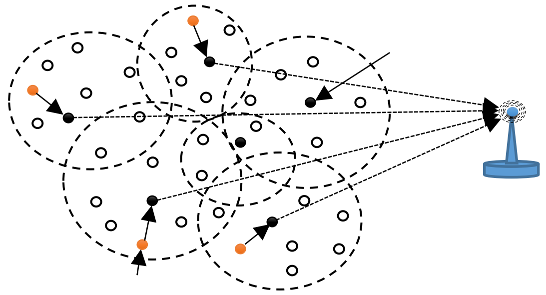

Figure1. Architecture of clustered WSNs

Cluster members, cluster head, gateway node, intra-cluster links and cross cluster links are the components of clusters.

II. Literature Survey:

This paper presents [1] a new method for ENEFC energy efficiency and load balancing for conventional data collection. The experimental findings indicate that ENEFC performance can increase the network's longevity and balance the node's performance. In order to save energy and compensation, the suggested ENEFC technique outperforms both HEED and ENEFCS.Clusters are the theme of the articles in this chapter. The cluster head can interact directly with the base unit in the same manner. During the collection and analysis phase, the cluster members identify their existence and distance from the ground station by recognizing signals delivered by the base station at a specified power level. Three steps: 1) select the head of the group, 2) create the group, and 3) transfer data. In the selection process of the team leader, the model selects a distributed team leader who has little management burden. When forming a group, a group of nodes will be created under the group heading. In the final stage of data transmission, the team leader will send the summary data received from the participants to the base station. In this article [2], we introduced the protocol proposed using appropriate node plans (ACTIVE and SLEEP) in a single aggregation of the entire network, which is an effective method for bundling the performance of WSN, and compared it with the traditional LEACH protocol. Our simulation results using MATLAB indicate that the suggested approach outperforms in energy savings and wireless sensor longevity. For future work, the heterogeneous wireless sensor node model with its topology can be studied to obtain a network with good energy efficiency and a longer service life. Kumar, Rohit, and Kad, Sandeep. (2017) Energy-saving protocols for wireless sensor networks [3]: an overview. The wireless sensor network (WSN) has a wide range of applications and is becoming more and more popular every day. not rechargeable or replaceable. As a result, the energy saving of the sensor assembly has become a serious problem, so that the entire service life can be extended. So far, various clustering protocols and tree structures have been proposed to extend the life of WSN. This document details some popular energy efficiency protocols for WSN. Facts have proven that the Game Theory Balanced Power Protocol (GTEB) is more effective than other protocols in terms of network lifetime. Use geographic routing protocols to balance the power consumption of large networks. He also compared some known protocols based on certain characteristics.

III.Results Analysis:

In this scenario, sensor nodes are randomly deployed in the sensor field for communication. One node acts as a sink node and the remaining nodes act as source nodes. The best route from the sender to the receiver is obtained by using the AODV routing protocol. The CSMA, TDMA, and 802.15.4 i.e. ZigBee MAC protocols are used to analyze network performance and watch network behavior. The node density, i.e. the number of nodes, varies from 15 to 90 nodes. to check the performance of the MAC protocols for different QoS (Quality of service) of the network. The total area for deployment of nodes is 1000m*1000m.

Table 1: Simulation Parameters for performance analysis for MAC

Parameters	Range of parameters value
Rate of packet transmission	10 packets/sec
Number of Layers & Levels	4 to 5
Number of nodes (Density)	15-90 nodes
Protocols used for simulation	CSMA, TDMA, 802.15.4
Size of Packet	50 Bytes

1. Packet delivery ratio for Node density

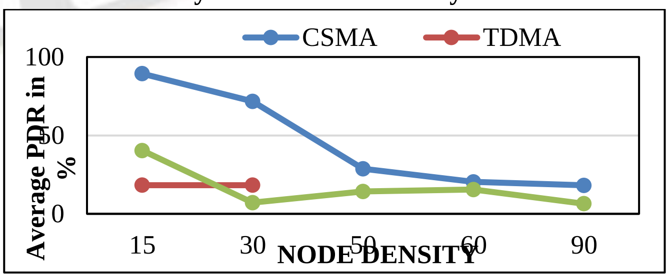

Figure 2. Packet delivery ratio for Node density

Figure 2 shows the performance analysis of various MAC protocols. The behavior of protocols in networks is very important for communication. The network's behavior can

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change depending on network load and congestion. A packet delivery ratio (PDR) is a measurement of how quickly data is delivered. It refers to the total number of packets sent to the destination node. In the graph above, the CSMA works significantly better than some other techniques, such as TDMA and 802.15.4. The CSMA protocol's initial performance is 40 to 45 percent greater than 802.15.4 and 60 percent better than the TDMA protocol. But after changing node density from 15 to 90 nodes, the CSMA protocol's performance has decreased significantly, but it still performs well when compared to other protocols. The node density of TDMA remains constant, whereas the node density of 802.15.4 is up and down.

2. Average End to End delay for Node density

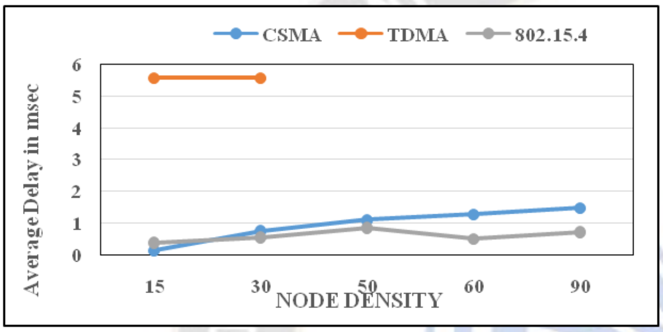

Figure 3. Average End to End delay for Node density

Figure 3 depicts the average end-to-end delay. In wireless sensor networks, the delay parameter is important. A Delay is the time required for transmitting packets from one end to another end over the network. Maximum delay can have an effect on the performance of the network and the reliability of the network. Due to the parallel transmission of data by nodes, delays can increase. Heavy congestion can increase network delays for packet transmission. In the above graph, 802.15.4 is better for the delay parameter because it reduces the delay in packet transmission. 802.15.4 is designed for small networks. Because CSMA uses a collision avoidance strategy, it performs well when compared to TDMA and slightly worse when compared to 802.15.4.TDMA allocates separate slots for data delivery from one node to another node. This mechanism in TDMA increases delay parameters in the network. The End- to-end delay raises as the number of nodes increases from 15 to 90 nodes, as shown in this figure.

3. Average throughput for node density

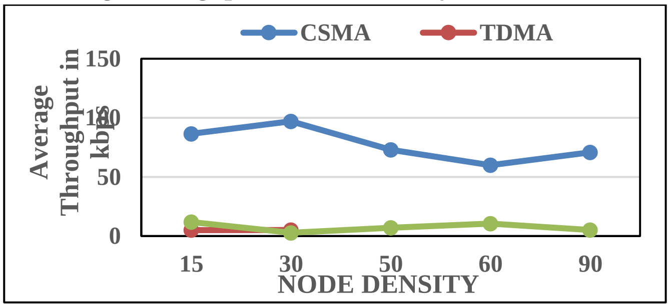

Figure 4. Average throughput for node density

Figure 4 depicts the average network throughput for node density. Collision-free data transmission within the network can increase the network throughput. Network throughput depends upon the channel capacity, i.e. bandwidth of the network. Throughput is the number of packets transmitted through a communication channel using available bandwidth to the destination node. The above graph shows the performance of the CSMA protocol is best when node density varies from 15 to 30 nodes, but when it varies from 30 to 90 node density, the performance of the CSMA decreases. Due to the collision avoidance mechanism in CSMA, it gives 20 to 25% better results as compared to the other two protocols for throughput. The performance of the TDMA and 802.15.4 is very bad for throughput when node density changes from 15 to 90 nodes.

4. Average energy consumption for Node density

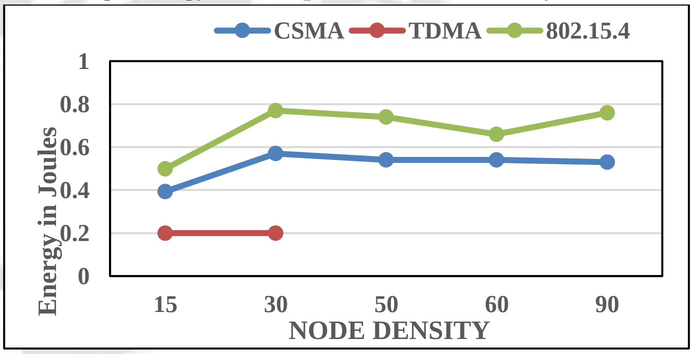

Figure 5. Average energy consumption for Node density

Figure 5. Shows the performance of the MAC protocols for energy consumption by the nodes, when they change from 15 nodes to 90 nodes. Maximum utilization of energy during data transmission can reduce the lifespan of the network. Heavy traffic as well as congestion over the network can increase the packet loss ratio of the network. In this case, the network requires re-transmission of lost packets to the destination node. In comparison to CSMA as well as 802.15.4, the efficiency of the TDMA protocol is dramatically better in the above figure, because it avoids

collisions between the nodes as well as packets. The time slot allocation mechanism in TDAM helps to reduce collisions between packets. Only one time frame can be open for data forwarding at a time, while the remaining nodes are going to sleep. As a result, TDMA saves extra power during packet transfer. When compared to CSMA, TDMA offers 20% good energy benefits and 30% good energy outcomes when matched to 802.15.4. The CSMA collision avoidance protocol is also 10% better as compared to 802.15.4 but poor as compared to TDMA.

IV.Conclusion:-

Transmission of data is the function of MAC layer algorithms like CSMA, TDMA, as well as 802.15.4. In wireless sensor networks, the MAC protocol is extremely important. The performance of MAC protocols CSMA, TDMA, and 802.15.4 is evaluated for node densities ranging from 15 to 90 nodes across the network. The figures depict Mac layer protocols efficiency for several quality of service parameters, such as delivery ratio, latency, network throughput, and energy usage for mobile nodes density. When compared to other techniques such as TDMA as well as 802.15.4, the CSMA performs significantly better. The CSMA protocol's initial performance is 40 to 45 percent greater than 802.15.4 and 60 percent better than the TDMA protocol. But after increasing node density, performance decreases. The performance of 802.15.4 is significantly good for delays compared to TDMA as well as slightly better compared to CSMA. Protocol end-to-end delays increase as the number of nodes in a network rises. When node density varies between 15 to 30 nodes, the CSMA technique looks better. However, when the number of nodes varies between 30 to 90 nodes, the CSMA technique performs badly. In terms of throughput, CSMA outperforms the other two methods by 20 to 25% because of its own traffic management strategy. TDMA gives 20% better results for energy compared to CSMA and 30% better results for energy as compared to 802.15.4. The CSMA collision avoidance protocol is also 10% better as compared to 802.15.4 but poor as compared to TDMA. This analysis will be useful for new researchers to implement hybrid protocols in wireless sensor networks. In future work, we will try to implement the best hybrid protocol for achieving QoS parameters of the network.

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