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Energy Efficient MAC Protocol for Wireless Sensor Networks Using Multi hop Optimization

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ABSTRACT -Wireless sensor networks are the devices to monitor the physical environments such as temperature, humidity, and the mobility of the objects concerned. Energy efficiency plays a vital role in the design of wireless sensor networks, as the major drawback of the sensor node is limited battery source which cannot be replaced/recharged for continuous operation. The energy consumption is mostly due to the communication subsystem in the sensor node. Thus proper design of the medium access control protocols will reduce the energy consumption of the sensor node per data transfer. The typical coverage area of the wireless sensor network is limited to 100 meters only so that multihop transmission is utilized with intermediate nodes for the transfer of data from source node to sink. The parameters such as throughput and latency are considered as quality factors for the energy efficient multihop MAC protocols. An efficient shortest path algorithm are being used to reduce power consumption and increase the efficiency with regard to different MAC protocols. The approach embraces comparison of two popular MAC protocols such as RMAC (Routing Enhanced Duty Cycle Medium Access Control), and HEMAC (Hop Extended Medium Access Control) of sensor networks related to energy consumption scenarios. The network model consists of average power consumption and path length optimization which leads to the reduction of the power consumption in the existing multihop MAC protocols of the wireless sensor networks.

KEYWORDS- wireless sensor networks, HEMAC, Shortest path algorithm, Multihop transmission

I. INTRODUCTION

Wireless sensor networks are detecting and communication the object via sensing the object of interest. The basic components of wireless sensor networks are sensors, memory, processor, GPS, radio transceiver and power source. The sensing and communication is done by sensor nodes [13]. Wireless sensor networks has major applications in industry, science, transportation and security. The challenges of wireless sensor networks are energy efficiency, response of nodes, robustness, scalability and adaptability. Sensor nodes used in wireless sensor network is based on battery power which is limited one. Since energy is major issue in wireless sensor networks. Hence energy management is very much important in sensor networks. This can be obtained by finding the operation in a particular node consume energy per data transfer. Second one is how much energy is used while data flow is taking place in a networks. Third one is how much energy is used while there is no data flow takes place in networks [14]. The challenges obtained in sensor networks regarding energy models are idle listening, retransmission because of collision, overhearing. The solution is to manage the energy models in the networks for maximizing energy efficiency. Thus the energy can be consider as an important part for the wireless sensor network. The energy efficiency of hop extended MAC protocols are obtained for multihop transmission. Mainly multihop transmission in wireless sensor networks deals without unwired networks. Here the

sensor nodes are not stationary in the multihop wireless sensor networks. Multihop networks had two categories namely relay and mesh networks. The relay is tree based and in which one end reach to the base station. The mesh networks are consist of multiple connection between the users [15]. Multihop networks can be deployed in environment such as static infrastructure, in building coverage, temporary coverage and coverage by moving sensor nodes. The main advantage of multihop wireless sensor networks are faster deployment with lower cost, easy to provide connection to area in which wired connections can't be supplied, increment of hops in networks, increase in throughput, reduction of battery usage in multihop transmission. The disadvantage of multihop wireless sensor networks are collision, interference, coverage area and channel assignment etc.

II. RELATED WORKS

Energy efficiency is a major drawback for multihop transmission in wireless sensor networks. The efficient medium access control are able to transmit the data for transmission in a multihop transmission. This leads to the reduction of power consumption in all nodes of any kind of sensor networks. But still there are lot of examples for several drawbacks in energy efficiency problem even the effective usage of medium access control protocols. There are lot of parameters such as collision, overheads, latency as well as idle listening. The discussion is about how some of the medium access control protocols works for multihop transmission and also its advantages and its disadvantages. The problem which the medium access control protocol deals with a particular networks and the kind of solution that are suggested to overcome is also to be discussed. In [12] The Amit Kumar Saha and David.B.Jhonson suggest an MAC protocol named as Routing Enhanced Duty Cycle MAC protocol in which existing problem present is end-to-end delivery latency and provide poor traffic handling. The solution is obtained by introducing pioneer frame (PION) which clears the way for effective transmission.[1] The Sha Liu and Kai-Wei Fan obtain a MAC protocol named as An Energy Efficient MAC Layer Protocol Using Convergent Packet Forwarding For Wireless Sensor Networks consist of existing problem as decreasing in performance of throughput and latency. The solution suggests is three mechanism such as Aggressive RTS, Any cast based forwarding and converging from any cast to unicast.[2] Hamed Yousefi and Mohammad Khansari proposes an MAC protocol as An Interference Aware Duty Cycle MAC Protocol for Wireless Sensor Networks Employing Multipath Routing has the existing problem as just single path transmission. The solution gives as multihop transmission with PION relaying for transmission. The literature [3] Giorgio Corbellini and, Elyes Ben Hamida recommends an MAC protocol as Density Aware MAC for Dynamic Wireless Sensor Networks deals with existing problem such as existence of collision while transmission. The solution can be obtained by scheduling the transmission.

The literature [4] Sung-Hwa Hong, Hoon-Ki KimA submits an MAC protocol named as Multi-hop Reservation Method for End-to-End Latency Performance Improvement finds the solution for the existing problem such as energy efficiency and latency in multihop transmission. The solution given in literature is adjusting the wakeup time for reservation regarding coverage area. [5] Chilukuri Shanti, Anirudha Sahoo put forward an MAC protocol named as A Delay Guaranteed Routing and MAC Protocol for Wireless Sensor Networks deals with the existing problem such as delay while routing the packets in a wireless sensor networks. The solution in order to overcome the delay is done the technique named as contention free operation. [6] Y.Z. Zhao, M. Ma, C.Y. Miao,T.N. Nguyen suggests an MAC protocol as An energy-efficient and low-latency MAC protocol with adaptive Scheduling for multi-hop wireless sensor networks dealt with previously obtained problem about energy consumption and latency in a multihop transmission of a wireless sensor networks. The solution such MAC produces is by achieving scheduling during sleep period while transmitting the data. [7] YanhuaGao, Jiangtao Fu, Shengyu Tang proposed an MAC protocol such as An Energy Efficient and Low Latency MAC Protocol for Multihop Wireless Sensor Networks which has obtained solution for the existing problem like idle listening and non-participation of nodes during transmission. The solution for idle listening problem can be overcome by making the neighbor to wake up adaptively during sleep period on transmitting the packets.

The study shows [8] PhilippHurni, Torsten Braun invents the a new MAC protocol for regarding regulation of energy such as A Maximally Traffic-Adaptive MAC Protocol for Wireless Sensor Networks gives solution to previously identified problem as nodes consuming more energy while radio state is on during transmission of packets. The best solution that are proposed in the literature is by making the radio state to off stage during most part of transmission duration. [9] Beakcheol Jang, Jun Bum Lim, Mihail L. Sichitiu designs MAC protocols such as an asynchronous scheduled MAC protocol for wireless sensor networks deals with the existing issues regarding increased usage of energy while transmitting the data during multihop transmission. The solution is by improving the life time of wireless sensor network by reducing energy consumption in nodes by reducing idle listening is obtained. [10] Andrea Richa, Christian Scheideler, Stefan Schmid, Jin Zhang develops a new kind of MAC protocols for cryptographic mechanism as

A Jamming-Resistant MAC Protocol for Multi-Hop Wireless Networks provides an result to the existing problem for cryptographic attacks in nodes especially on physical and MAC layers. The solution for this attacks can be done by introducing defensive mechanism as

jamming defense and hence avoid the cryptographic attacks in wireless sensor networks. The analysis by [11] Kyong-Tak Cho, SaewoongBahk designs a most effective energy efficient MAC protocol in a wireless sensor networks is Optimal Hop Extended MAC protocol for wireless sensor networks which mainly overcome most of all the existing MAC protocol problem such as collision, over hearing and latency. But the only existing problem reduction in power consumption by nodes during data transmission. The solution to this problem can be obtained by introducing a shortest path algorithm and varying the path length to get an effective reduction in power consumption by the nodes in a wireless sensor networks.

III. HEMAC OUTLINE

HEMAC protocols is a synchronized MAC protocols. Here the message is send by frame named as explorer frame (EXP). They show the way for the source to send the packets without any hurdle. HEMAC protocols are used for multihop transmission and they can be transmitted for long distance. This can be done by a state in the HEMAC protocol which is ready to receive state (RTR). This take the messages beyond the sleep period and able to transmit the data for long distance. Hence this protocol overcome maximal problem occurred in the previous MAC protocols for energy efficiency problem [11]. The advantages are reduction of latency and significance reduction of power consumption. The disadvantage is idle listening, overhearing, and energy efficiency.

A. HEMAC DATA TRANSMISSION:

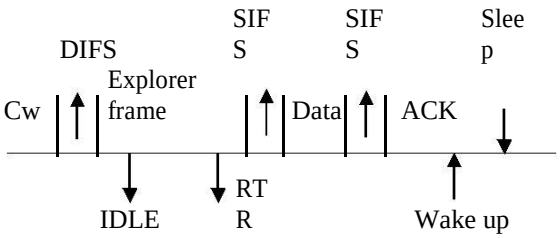

Fig. 1 HEMAC Data Transmission

1) SOURCE:

The data is transmitted from the source to the sink. Here first the synchronization takes place where the clocks are to be synchronized. Then the source node contend for the medium through contention window. This window is used by MAC layers and they are able to win the medium in the channel for transmitting the packets [12]. There will be lot source like this that are contending for the same medium. Hence the source that contend effectively will win the medium for transmission. So the source that wins the contention is able to transmit it data first. But the main problem occur here in this contention will be collision. I order to avoid this problem the mechanism used is distributed Interframe space (DIFS). This mechanism defines if a source sense that channel is idle then even that it transmits the data after a short period of time. Here also source while using DIFS mechanism just wait for short duration and after that it transmits data along the medium which it win for transmission. Thus the data from source is now reach the channel and it is now on the radio period.

2) EXPLORER FRAME INFORMATION:

PION frame is mainly used for multihop data transmission. This frame is able to carry messages from one to another nodes in a multihop data transmission without loss of data. The PION frame has done this process effectively by carrying previous hop address and next hop address. The information carried by this frame is most important for data transmission because if the information is not reached effectively then loss of data packets can be obtained. So according to the information given by PION frame nodes sleep/wakeup period is obtained and hence effective duty cycle can be obtained for multihop data transmission. Data is first period of data transmission where the messages are send by the source and contending the medium with a short period of duration such as distributed Interframe space [21]. The data period can be classified as start of data period and end of data period. Start of data period depends on the wakeup period and sleep period. At the same time end of data period can be obtained by adding the time which data period get started and duration in which the data is get transmitted. Short Interframe space is small duration period that takes place between the data and acknowledgement period. This duration takes place when the node get PION confirmation and node send the data to the next node with next hop address. And while getting this confirmation and sending both RTS and CTS among the nodes and by knowing the next hop and sending the data and SIFS is get obtained and then the ACK is send back to the pervious node.

3) IDLE/RTR:

Ready to receive (RTR) state is able to extend the transmission of data beyond the sleep period. This is state which can be change from idle state. The idle state is in which node will be wake up still that particular nodes sleep period had been started. So if the node can't receive any messages still that start of sleep period it goes to sleep state. But when the same node still wake up beyond that start of the sleep period the same node goes into RTR state. This RTR state can be able to help hop extended operation in HEMAC protocol and which is able to transmit the data in a multihop transmission. RTR state will able to help the node which is wake up beyond the sleep period to receive the explorer frame hence the data can be gathered easily by the node and will be get transmitted. Hence the nodes in RTR state cant goes for

sleep period and will be in transmission [22]. Other nodes checks for a particular time period if not then goes to sleep period in order to maintain duty cycle and save energy in HEMAC protocol. Som the neighbor nodes caused irregularities on following the duty cycle and this can be affect RTR state in hop extension operation in HEMAC protocol etime due to interference caused by the neighbor nodes caused irregularities on following the duty cycle and this can be affect RTR state in hop extension operation in HEMAC protocol

4) DATA:

Data is first period of data transmission where the messages are send by the source and contending the medium with a short period of duration such as distributed Interframe space. The data period can be classified as start of data period and end of data period. Start of data period depends on the wakeup period and sleep period. At the same time end of data period can be obtained by adding the time which data period get started and duration in which the data is get transmitted. In HEMAC protocol data is the period in which explorer frame are to be transmitted and the change of state from idle to RTR is to be obtained. Still this data transmission the HEMAC plays same role as RMAC protocol [17]. The operation changes from the hop extended operation by HEMAC protocol. Since then data is transmitted accordingly the nodes that can be able to participate in the RTR state. Hence data transmission for HEMAC protocol from source to sink is multihop type data transmission*5) SHORT INTERFRAME SPACE (SIFS):*

Short Interframe space is small duration period that takes place between the data and acknowledgement period. In HEMAC protocol this duration takes place when the node get explorer frame confirmation and node send the data to the next node with next hop address. And while getting this confirmation and sending both RTS and CTS among the nodes and by knowing the next hop and sending the data and SIFS is get obtained and then the ACK is send back to the pervious node [23]. The source node in HEMAC protocol also came to know about its successful transmission of the message by the explorer frame which is send by taking duration of SIFS. The SIFS is main advantage is to get the confirmation messages without any collision or any traffic. This is also helpful in scheduling the nodes to goes to sleep period after transmitting and receiving the confirmation messages. Another advantage is to maintain the duty cycle in hop extended MAC protocol like HEMAC protocol that can be effectively transmits the data for a multihop sensor networks.

6) ACKNOWLEDGEMENT:

Acknowledgement is send by the message receiving node

as a CTS to the previous node. The main function for the explorer frame is only if a node receive the ACK message then that node goes for the sleep period by saving energy for the networks in a multihop transmission [16]. The acknowledgement is also had two classification such as ACK start and ACK end in which ACK start is by adding data period and SIFS and ACK period at the same time the ACK end is by calculating starting period of ACK and duration in which ACK takes for transmission in multihop transmission.

The hop extension can be obtained by considering one of the parameter as hop count value. This hop count value is calculated by the acknowledgement send by the nodes to the previous node in a multihop transmission in HEMAC protocol

7) SLEEP/WAKEUP:

HEMAC protocol transmits the data during the sleep period. Here all the nodes will stay awake still sleep period starts while that duration the nodes that receives the messages that will stay awake and transmits the data. The other nodes that don't receive the messages will goes to sleep in order to save energy in a multihop networks. When the node is on the sleep period then there will be no usage of energy by the networks. But when the nodes are in a wake up period the amount of energy used can be obtained by adding data period duration and SIFS and also with duration take by ACK [17]. Duty cycle is main concept while discussing about sleep/wakeup period and this need to maintain for energy efficiency in a multihop networks. The receiving of ACK by nodes that participate in data transmission is most important in maintaining the sleep/wakeup period. The problem in HEMAC protocol uses multiple duty cycle the sleep/wakeup period get differ and hence node transmission get delay according the duty cycle. Hence constant maintenance of duty cycle for sleep/wakeup period in multihop data transmission need to be obtained.

8) SINK:

Sink is the destination where the message send by source need to be reached. The data can be reached effectively because of explorer frame communications among the nodes and better maintenance of the sleep/wakeup period. If the data get lost while the transmitting period the explorer frame don't try to retransmits the data and it will once try to send a new frame on the next data period transmission. HEMAC protocols transmits the packet as max hops for multihop transmission of data [11]. This protocol use RTR state to take the data for this multihop transmission in order to reach the sink. The data reaches to the sink by considering parameters such as contention window, distributed Interframe space, idle or ready to receive state, data, acknowledgment, short Interframe space. Since the hop extension operation the message can be delivered

effectively with less consumption of energy to the sink. Hence the energy can be save and clear message transmission can be obtained. This energy consumption will makes the nodes to make effectively reach the messages to the sink which is transmit by the source in a multihop sensor networks.

IV. REDUCING POWER IN HEMAC

The HEMAC protocol the power reduction can be obtained
by the following parameters such as network formation, adapting DSR to find shortest path, calculate varying path length, compare power consumption is described in fig.2

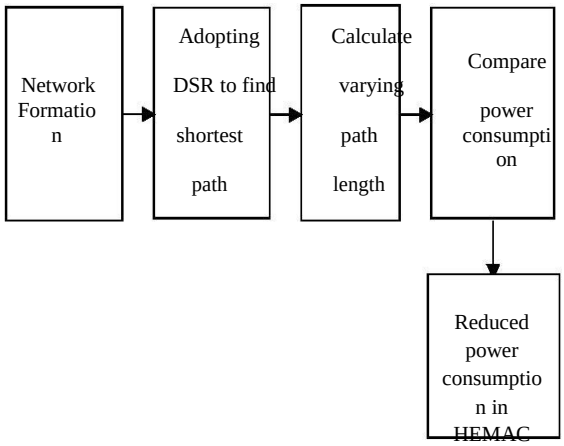

Fig. 2 Reducing Power in HEMAC

A. NETWOTK FORMATION:

HEMAC network is formed with channel model with wireless channels. This network consist of radio propagation delay model as two ray ground propagation. The type of network interface used for HEMAC protocol for wireless sensor networks is between data link layer and physical layer. The type of queue used for this network formation is drop tail queue and prior queue [13]. The antenna model used for this network is Omni directional antennas. The routing protocol used to finding the shortest path is dynamic source routing protocols. The topology used for this network is flat grid. The totals number of nodes deployed for this network is choose in which the source node as well as destination nodes are to be determined and intermediate nodes are also to be assigned accordingly to the path variations. The nodes are to be changed with random topology accordingly with varying path length and the simulations are obtained by using ns2 simulations.

B. ADAPTING DSR PROTOCOL:

Dynamic source routing (DSR) is most energy efficient routing protocol for finding the shortest path effectively. They works mainly under two mechanism such as route discovery and route maintenance. The route discovery takes place only after the source attempt to send data from source to destination [22]. On the other hand route maintenance is the process to be used while the link for transmission get broken. The route discovery consist of other two process such as route request and route reply. In which route request is one which identifies the source and destination in which it consist of request id. The route reply is the one which identifies source and it sends messages to the source. In route maintenance there is a confirmation for receiving the
messages to the previous node which can be named as passive acknowledgement. Then there is a route error which is able to resend the packets while the link get broken on multihop transmission. But the route error messages will be send to the source.

C. SHORTEST PATH USING DSR:

HEMAC protocol the data from source is transmitted by multiple paths to the sink. Hence there will be lot of routes for transmitting the packets. Hence identification of shortest path while transmitting the data need to be identified. For this dynamic source routing protocol is very important for finding the shortest path in which data need to be transmitted. Because the long path length while transmitting the data for multihop transmission will consume lot of energy in the HEMAC protocol [12]. In order to overcome this problem the shortest path need to be identified for transmitting data hence energy consumption can be reduced by each nodes taking part in packet forwarding and also life time of network. HEMAC protocol use DSR for identifying the shortest path by choosing one of the effective mechanism which coincide with the multihop transmission protocols. The mechanism which HEMAC protocol identifies are route maintenance. In HEMAC protocol data is transmitted from source to the sink through various intermediate nodes. Here there is no need for route discovery mechanism used by DSR protocol. Because the route is already discovered and cleared by using explorer frame in HEMAC protocol. Hence second mechanism used by DSR named as route maintenance is obtained for routing in HEMAC protocol. Here route maintenance is done by passive acknowledgement where like HEMAC protocol that is used for hop extension like the messages are transmitted by next hop address and previous hop address. This shows that previous nodes are responsible for the message transmission. Likewise if the message had not reach the sink it can be due to the loss of explorer frame and it

won't retransmits the frame at once [22]. The frame can be transmitted again newly in the radio state like in the route maintenance process for DSR protocols. Thus in HEMAC protocol the DSR protocol can be get adopted and shortest path can be obtained for multihop transmission in wireless sensor networks.

D. VARYING PATH LENGTH CALCULATION:

The same 16 nodes are to be simulated for varying path length calculation. Here the already shortest path had been found out. The same path are to be consider for varying the path lengths for reducing energy consumption in HEMAC protocol. The same shortest path that are taken by path length calculation find by the DSR routing protocol must be consider [9]. Then by varying the path length using simulation in NS2 can be obtained by implementing the Dijkstra which is shortest path algorithm. By using this
algorithm the shortest path can be varied and the power consumption can be determined. Because the power consumption that normally the node consume on using the path length must be first identified and then the power consumed by nodes while varying the node is also measured and can be compared as a results and which can be identified as the reduction in power consumption by the node while varying the path length.

A) DIJKISTRA algorithm:

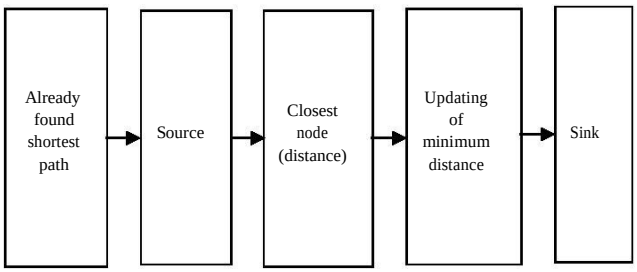

Fig. 3 Dijkstra Algorithm

1) ALREADY MEASURED SHORTEST PATH:

The shortest path is already calculated by using dynamic source routing protocol. Then the path that are shortest for transmitting the data for a multihop protocol like HEMAC protocol are to be obtained. Then the shortest path length can be obtained by closest nodes to the source nodes which can be just determine by the neighbor nodes [3]. By taking the shortest path and measure the power consume each nodes while transmitting the data in a multihop transmission. So by determine the shortest path then the source can be easily transmit the data.

2) SOURCE:

The source transmits the data through the path that can be determine already. This path is shortest and source can easily transmits the data to the sink. In HEMAC protocol the explorer frame need to bring the acknowledgement message to the source and hence it can able to transmits the message by using the contention window and also short period of duration as distributed Interframe space (DIFS) [17]. Then by confirmation message by the explorer frame the information reaches to the closest nodes. This can be obtained by the explorer frame with next hop address. Thus the hop extension operation can be operated in HEMAC protocol in a multihop data transmission.

3) CLOSEST NODE:

The HEMAC protocol choose the neighbor node or the closest nodes with the help of next hop address send by the source. Here since the path length are to be get varied the closest node need to choose by the distance since it is a multihop protocol transmission. Considering the size of the networks and amount of nodes placed in the topology the source need to be first check the minimum distance among the nodes [4]. Hence the node that have minimum distance next to the source node are consider to be the closest nodes. Thus the closest nodes to the source need to be identified and message from the source should be transmits to the closest node. This process continuous for the multihop transmission and still the data reaches to the sink.

4) UPDATING MINIMUM DISTANCE:

The closest node near to source get the message and after that data need to transmit by considering the minimum distance. The node which have minimum distance need to be consider as next closest node and data need to be transmitted. The difference arise here by varying the path length because the closest node is not choose by neighbor one they can be choose by minimum distance. The path length normally are choose by just neighbor node but here by choosing the just by distance the node distance from the neighbor node is also differs and hence able to vary the path length [7]. Hence in HEMAC protocol the multihop transmission of data can be obtained easily by varying the path length which is mainly depend on the distance in which the nodes are to be deployed. Since this varying path length can be able to easily transfer differs and hence able to vary the path length. Hence in HEMAC protocol the multihop transmission of data can be obtained easily by varying the path length which is mainly depend on the distance in which the nodes are to be deployed. Since this varying path length can be able to easily transfer the data between the nodes by maximum hops and the due to this energy can be saved in HEMAC protocol.

5) SINK:

HEMAC protocol by using the varying path length can be able to reach the data from source to the sink. Here varying path length is able to reduce energy consumption while transmitting the data in a multihop sensor networks. The data reaches by comparing the maximum hop value and hop count value. Here the maximum hop value is inform by the explorer frame and the hop count value is mainly depend on the varied path length. By introducing the new method of measuring the closest node by distance the size of hop count value will be less than maximum hop value transmits by the explorer frame. This will be able to help the node to be in RTR state and be able to go beyond the sleep period for more possible transmission in HEMAC protocol. This will help the data to reach from source to sink with reduced energy consumption in multihop protocols. Thus the transmission between the source to sink takes place in the HEMAC protocols and this kind of transmission can be obtained in multihop process.

V. SIMULATION ANALYSIS

The simulation for both RMAC and HEMAC protocols are obtained by network simulator 2.34. The main parameter consider for both simulation is energy and no of nodes. This simulation is done in order to show the energy consumption by each node between both RMAC and HEMAC protocols. The simulation runs at 10m sec of duration in which energy comparison obtained by both RMAC and HEMAC protocols for multihop transmission are too analyzed. The shortest path is consider for both RMAC and HEMAC protocol are consider and the result is tabulated

Table I.
RMAC and HEMAC energy simulation analysis

Shortest path	RMAC (Energy consumed per node)	HEMAC (Energy consumed per node)
N3	22.25	14.68
N4	26.81	17.93
N5	29.06	17.18
N6	34.06	17.68
N7	32.75	25.56

The results that are tabulated shows that HEMAC protocol is better than RMAC protocol. Because while simulating by constructing an shortest path for both RMAC and HEMAC protocol results displays that energy consumed by HEMAC protocol is lesser than RMAC protocol while transmitting the data in a multihop data transmission.

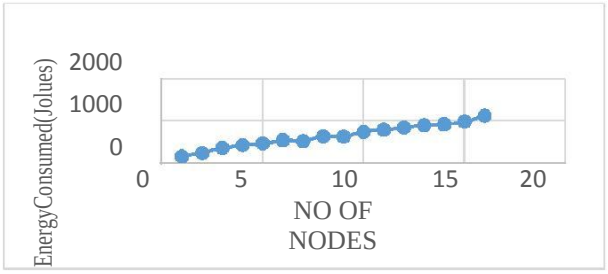

Fig. 4 RMAC Simulation

This graph for RMAC is plotted between energy consumption in joules on y-axis and no of nodes on x-axisHere the energy is varied from 156 to 1125 is displayed on the graph.

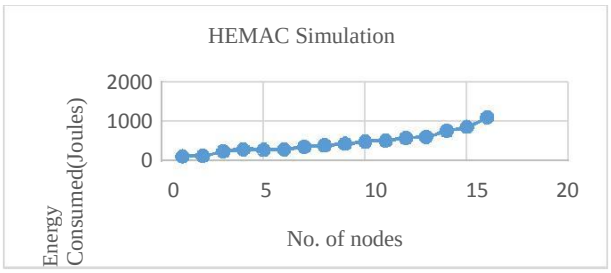

Fig. 5 HEMAC Simulation

Here from fig.7 varying path length is calculated by using ns2 simulation. Energy consumption is plotted on the y-axis and varying path length is plotted on the x-axis. Here the distance that are to be varied while simulating is 5m. The result shows that the energy can be varied in the range of 7 to 8. This amount of variation can be shown particularly in this graph.

VI. CONCLUSION AND FUTURE WORK

The path length in HEMAC protocol is varied withrespect to distance and the energy consumed for varying path length is recorded for sample nodes. Energy get varied for different path length and compared to HEMAC with respect to RMAC. The optimized path length which is having lower value of product of path length and energy consumption can be set for the distance between multihop nodes using HEMAC. By this way the network life time is increased by reducing number of active nodes per data transfer from source to sink node. In future other algorithm for finding energy efficient path can be implemented in HEMAC protocol and performance in power consumption is compared for further improvement.

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