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Energy Efficient Approach for Wireless Sensor Network

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Abstract— The study of Wireless Sensor Network (WSN) is considered to be one of the most challenging issues of recent research in the field of electronic communication as well as computer application. One of the major problems with the wireless communication sensors reflects an issue related to the high energy consumption against marginal performance in terms of output. In this paper, it has been attempted to give an overview of the energy consumption related issues and suggest some possibilities for improvement of the WSN in terms of optimized output. Power source in WSN often consists of a battery with a limited energy budget. it could be impossible or inconvenient to recharge the battery, because nodes may be deployed in a hostile or unpractical environment. Therefore, energy conservation is a key issue in the design of systems based on wireless sensor networks.

Keywords—Wireless Sensor Network, Energy, Clustering, LEACH, Multi-hop

I. INTRODUCTION

In computer networking there is a great value of wireless networking because it has no difficult installation, no more expenditure and has lot of way to save money and time. In the field of wireless networking there is another form of networking, which is called as wireless sensor network. A type of wireless networking which is constructed by number of numerous sensors and they are interlinked or connected with each other for performing the same function collectively or cooperatively for the sake of checking and balancing the environmental factors, this type of networking is called as sensor networking. Basically wireless sensor networking is used for monitoring the physical conditions such as weather conditions, regularity of temperature, different kinds of vibrations and also deals in the field of technology related to sound. Sometimes it is also used in pressure, and also checking the environmental pollutants. These sensors, which are used collectively for performing a function, are distributed spatially otherwise it is difficult for the sensors to perform cooperatively to play a role in monitoring. Scientists develop wireless sensor networking on the bases of inspiration from the application known as battle field surveillance which is completely a military application. As we know that this technology has great importance in the field of computational world and where it has computational importance it also has importance in industry. It is also play an important part in civilian technologies like monitoring of traffic control and many others. A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument Total working of wireless sensor networking is based on its construction. Sensor network initially consists of small or large nodes called as sensor nodes. These nodes are varying in size and totally depend on the size because different sizes of sensor nodes work efficiently in different fields. Wireless sensor networking have such sensor nodes which are specially designed in such a typical way that they have a micro controller which controls the monitoring, a radio transceiver for generating radio waves, different type of wireless communicating devices and also equipped with an energy source such as battery.

The working of sensor network can be categorized in four modules:

A. Computing Module: This module contains Micro controller unit (MCU), which is responsible for the control of the sensors and execution of communication protocols.
B. Communication Module: This module is responsible for radio communication between neighbouring nodes and the outside world. In this functioning it is better to completely shut down the radio rather than put it in the idle mode when it is not transmitting or receiving because of the high power consumed in this mode.
C. Sensing Module: It consists of a group of sensors and actuators and links the node to the outside world. Energy consumption can be reduced by using low power components and saving power at the cost of performance which is not required.
D. Power Supply Module: It consists of a battery which supplies power to the node. It should be seen that the amount of power drawn from a battery is checked because if high current is drawn from a battery for a long time, the battery will die even though it could have gone on for a longer time.

All the sensor nodes are scattered and entire area, where these sensor nodes are installed is called sensor field. Each sensor nodes has the capabilities to collect data and route data back to the sink. Sink is base station which store data and transmit to the centralized control. The architecture of node can be understands by following figure.

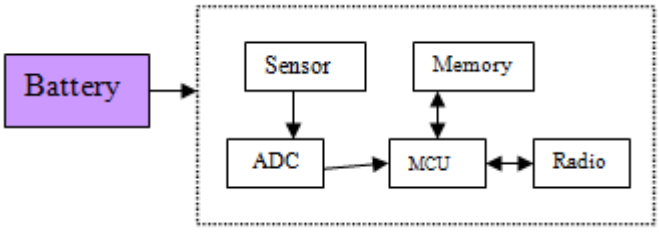

Figure 1: Wireless Sensor Network Architecture

Sink is the base station which is responsible to transmits data to authorize user. Data are routed back to the sink by a multi hop infrastructure less architecture through the sink. The sink may communicate with the task manager node via Internet or satellite. The design of the sensor network is influenced by many factors, including fault tolerance, scalability, production costs, operating environment, sensor network topology, hardware constraints, transmission media, and power consumption.

II. BASE WORK

Because WSN is a kind of MANET, sometimes some existing routing protocols for ad hoc network are used directly in WSN [5]. However, the difference between MANET and WSN leads to routing requirements for the two are also quite different in some aspects.

- Data are collected from multiple data sources to a data recipient or terminal in WSN, rather than communication between any pair of nodes in MANET.
- Because the data being collected by sensor nodes is related to common phenomena, the data packets being communicated in WSN is likely to be redundant.
- In most scenarios nodes in WSN move slowly. This is not like MANET which has highly dynamic network topology generally.
- As mentioned above, energy is more precious and limited in WSN than MANET. Because it has been very difficult to advance battery technology recently, energy efficiency should be considered one of the most critical issues not only on the aspect of underlying hardware architectures but also upper communication protocols by researchers of WSN.

For these reasons many existing routing protocols proposed for MANETs are not suitable to WSNs. Recently some routing protocols specialized for WSN have been developed. There are two categories in routing protocols for WSN. One is data centric routing; the other is hierarchical routing.

Data centric routing protocols

Data centric routing protocols are different from most protocols for traditional MANETs, where all nodes are addressable and assigned identifications (IDs). In address centric routing some nodes send data queries to some specific nodes and routes are created between them. Whereas, in data centric routing the terminal node sends data requests to some regions and then the nodes in the regions send data back to the terminal nodes. During the course of data relaying, data centric routing performs some form of data aggregation to eliminate redundancy of the data. Two main data centric routing protocols are introduced as follows.

- Sensor Protocols for Information via Negotiation (SPIN)
- Directed diffusion

Hierarchical protocols

We have seen that cluster members can randomly form cluster heads within the groups as well as multiple clusters to avoid data collisions using CDMA code techniques. This can be extended to forming hierarchical clusters. Here the cluster heads communicate with the super cluster heads, i.e. the cluster heads of the above hierarchy and so on, towards the base station. Based on this many hierarchical algorithm has introduced and these are:

- LEACH: Low-Energy Adaptive Clustering Hierarchy
- LEACH-C (LEACH – Centralized)
- TL-LEACH: Two-Level Hierarchy LEACH

III. PROPOSED WORK

WIRELESS Sensor Network (WSN) is an emerging field of network technology since last decades, lot of researchers doing effort to find a low cost and energy efficient wireless sensor network. WSN can connect information world with physical world together and using in different applications such as battlefield surveillance, remote healthcare, land monitoring for smart farming and environmental monitoring [1, 2, and 3].

Clustering Techniques

Hierarchical based routing and in particular the clustering techniques make an immense enhancement in the field of WSNs. These approaches to reduce the utilization of energy and enhance the performance of the network, when the entire sensor nodes sending a data to base station or central collection centre.

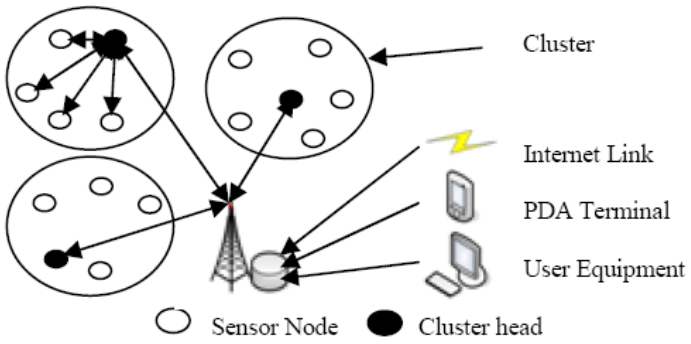

Figure 2: Cluster Based Wireless Sensor Network

The core components of the cluster based WSN are sensor nodes, clusters, cluster heads, base station and end user. Sensors nodes are an essential part of the WSN. The major objective of hierarchical routing is to preserve efficient energy utilization by multi-hop communication, the data aggregation and merger is to decrease the number of messages sent to the sink. Clustering technique is usually the energy maintain of sensors which is near the cluster head. This section provides a brief introduction about different hierarchical cluster based routing protocol.

A. LEACH: Construction of Low Energy Adaptive Clustering Hierarchy (or LEACH) is the initial significant developments to conventional clustering approaches in WSN. Traditional approaches to algorithms such as MTE (Minimum Transmission Energy) or a direct transfer does not lead to dissipation of energy through the network. LEACH to provide balancing energy consumption in a random rotation of cluster heads. The algorithm is self organized, employs single hop approach and the data combination technique can decrease the rate of data transfer as in below fig 3.

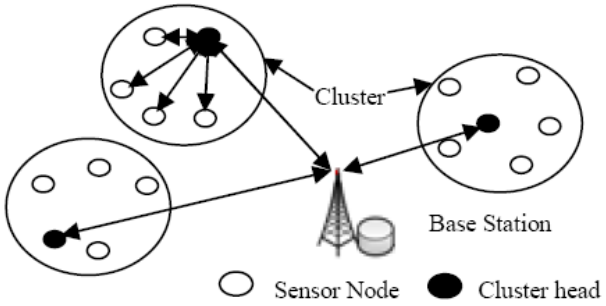

Figure 3: Single Hop LEACH Routing Strategy

B. TL-LEACH: Two levels of the hierarchy LEACH (or TL-LEACH) is a proposed extension of the algorithm of LEACH which support parent child combination and then transmits data to base station by single hop fashion. It uses two levels of cluster heads (primary and secondary), and other simple detection nodes. In this algorithm, the primary cluster head in each group communicates with the secondary and the contact with corresponding nodes in their sub-cluster. The structure of two levels of TL-LEACH as shown in Fig. 4 reduces the number of nodes when data is transmitted from source to the base station and reducing total energy consumption [12].

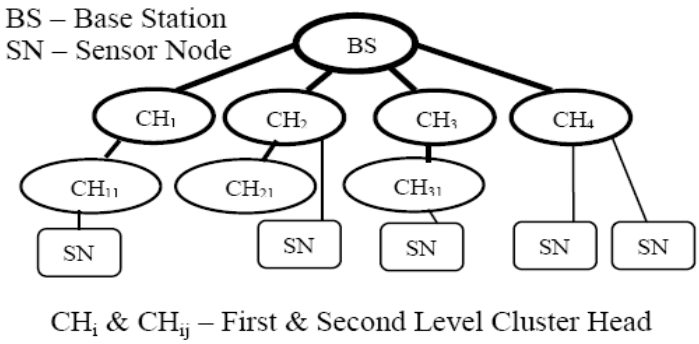

Figure 4: Various levels of Cluster Head

In assessing the data reliability of both LEACH and TL-LEACH protocols some of the important aspects that are included in the protocol. To avoid collision by CSMA method and CDMA techniques used to eliminate interference between clusters. Random selection of cluster heads to extend the network lifetime, providing full connectivity. TL-LEACH two-level hierarchy does not provide direct improvements in the reliability of the standard LEACH.

C. TEEN: Threshold sensitive Energy Efficient sensor Network protocol (TEEN) is another type of cluster based hierarchical and reactive protocol based on single hop, which is planned to be sensitive to unexpected modification in the perceived elements such as habitat monitoring and measuring the temperature. The simulation results of TEEN shows better than LEACH because TEEN's offers the best performance since number of the transmissions is reducing, but TEEN is not appropriate for high-quality applications which involve cyclic reports.

D. EECS: An Energy Efficiency Clustering Scheme (EECS) is a single hop clustering algorithm, where the cluster head candidates competing for the ability to raise the cluster head for a specified cycle. This responsibility includes broadcasting candidates' and remaining energy of neighbouring candidates. If a node fails to find the node with more remaining energy then it becomes a cluster head. This algorithm extends the size of the dynamic clusters based on cluster distance of the base station. EECS offers the same reliability as LEACH, but the energy consumption of EECS is better overall the network, connectivity can be fully achieved for a longer period [10].

Multi Hop Leach Routing Strategy

Multi hop LEACH routing strategy is based on single hop LEACH routing protocol, usually LEACH protocol transmits compressed data from cluster heads to base station directly.

Basically there are two approaches to transmit data from sensor node to base station:
Single hop or direct transmission.
Multi hop or minimum transmission
Single and multi hop are shown in following figure.

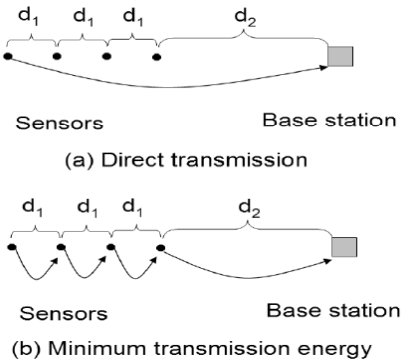

Figure 5: Single Hop vs. Multi Hop

The amount of energy consumed by single hop can be calculated by this formula:

$$\text{§eampk } (3d1 + d2)2$$

Whereas the amount of energy used by multi hop can be calculated by this formula:

$$\text{§eampk } (3d12 + d22)$$

By above formulas we will see that in multi hop transmission consumes less energy than single hop.
In large environmental setup sensor nodes are distributed pervasively, begin at same energy storage and create clusters. Some of the clusters utilize more energy dissipation due to the far away from the base station and rest of the clusters operates at less energy consumption. Therefore, after the some successful rounds there will be a significant variation in nodes energy consumption. Finally, the network performance will be turn down because the distribution of the live and dead nodes within the network. Furthermore, during the setup phase, nodes short messages are collide to each other due to the nodes communication ranges are to each other and uses same frequency band. The network performance will be degrading partially; some of the nodes have not maintained the cluster membership and lost the network connectivity [12].

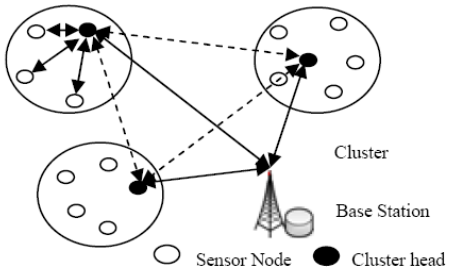

Figure 6: Multi Hop LEACH Routing Strategy

Multi hop routing strategy is vital solution to enhance the energy transmission dissipation and network lifetime with same single hop LEACH routing strategy. The recent trend is multi hop routing strategy, which uses in many sensor and Ad-hoc networks. In this strategy the data sent from source to destination node relayed by the assistance of middle nodes to take multiple hops. The most important benefit of this strategy is to decrease the nodes energy consumption but increase end-to-end delay. Most of the sensor applications are delay sensitive that cannot afford end-to-end delay, but some applications require energy efficient and enhance network lifetime approaches. Within the cluster the data is directly transmitted from sensor nodes to cluster head and then cluster head responsible to forward the data to base station using by multi hops with another cluster heads. Cluster heads operate as a backbone of the network, multi hop routing strategy implies to reduce the energy consumption between the sensor nodes. As we discussed earlier multi hop routing strategy follows a single hop LEACH network model, all sensor nodes are homogenous and utilizes same infrastructure. Sensor nodes have limited power and the transmission range is enough to communicate straight with another node and base station as well as. Each sensor node is able to support multiple protocols and signal processing tasks because of sufficient processing power. Moreover, the neighbouring nodes whose are nearby to each other have redundant data for base station. During cluster formation all nodes are autonomous; self organized and arranged into clusters through short messages same as single hop LEACH strategy. Every node has to make a choice to be converted into a cluster head or not with the probability of Pi, Pi is calculated same as LEACH cluster head selection. The next is steady-state phase that contain many frames, each frame send the data to cluster head within the given time period. Time Division Multiple Access scheduling to avoid collisions and reduce energy consumption between data messages in the cluster and enables each member of the radio equipment off when not in its time slot. During the time of each frame all member sensor nodes forward the data to cluster head, then cluster head combined and discard the unnecessary data and finally send the compact data to base station.

When the compressed data successfully arrives at cluster head then cluster head discover a best possible path to deliver the data to base station indirectly by multi hops. The strategy of route selection is same like MTE routing strategy not like LEACH protocol. Consequently, the selection on multi hop routing strategy uses one or more central nodes to deliver the data towards the base station which reduce the squared distance.

IV. SIMULATION WORK AND RESULT ANALYSIS

OPNET Simulator

OPNET Modeler accelerates the R&D process for analysing and designing communication networks, devices, protocols, and applications. We can analyse simulated networks to compare the impact of different technology designs on end-to-end behaviour. Modeler incorporates a broad suite of protocols and technologies, and includes a development environment to enable modelling of all network types and technologies.

OPNET's software environment is called access modeler which is specialized for network research and development. It can be flexibly used to study communication networks, devices, protocols, and applications. Because of the fact of being a commercial software provider, OPNET offers relatively much powerful visual or graphical support for the users. The graphical editor interface can be used to build network topology and entities from the application layer to the physical layer. The parameters can also be adjusted and the experiments can be repeated easily through easy operation through the GUI.

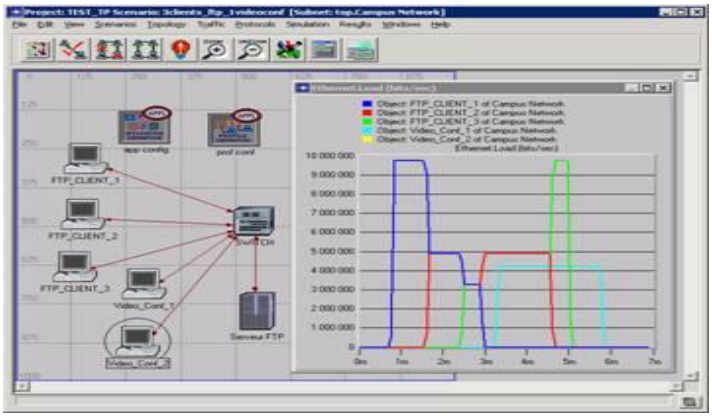

Figure 7: OPNET GUI View

OPNET is based on a mechanism called discrete event system which means that the system behavior can simulate by modeling the events in the system in the order of the scenarios the user has set up. Hierarchical structure is used to organize the networks. As other network simulators, OPNET also provides programming tools for users to define the packet format of the protocol. The programming tools are also required to accomplish the tasks of defining the state transition machine, defining network model and the process module.

Various result analyses

Here, we have total 40 mobile nodes dispersed in 100*100 meters area followed by WSN. All the nodes have been supported by mobility feature and there is a Base Station (BS) which is communicated by all nodes to give acknowledgement and take proper response and vice versa.

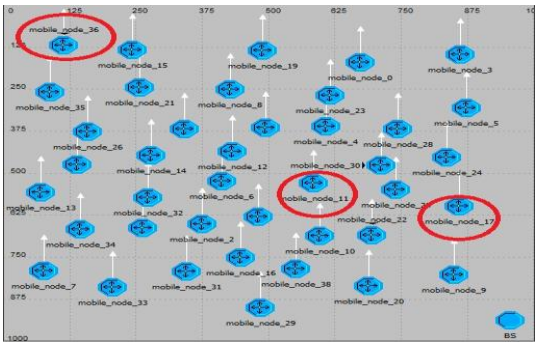

Figure 8: Simulation Scenario

As above we are seeing that node no. 36, 11 and 17 are circled.
To observe the energy consumption, we analyse Single and multi hop for nodes 11, 17, 36 at different distance. We can also view energy consumption of nodes 11, 17 and 36 in single hop by following figure. Where figure 9 for Single hop and figure 10 for multi hop.

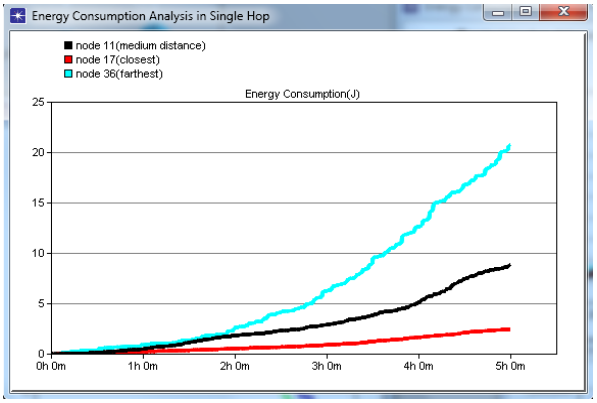

Figure 9: Energy consumption analysis in single hop

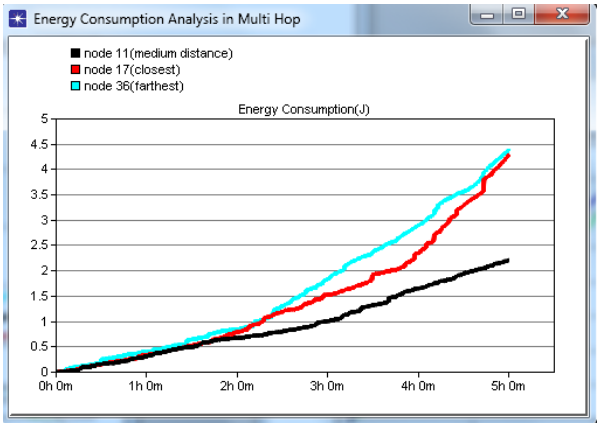

Figure 10: Energy consumption analysis in multi hop

Figure 11. Shows comparison of throughput between single and multi hop at nearest distance:

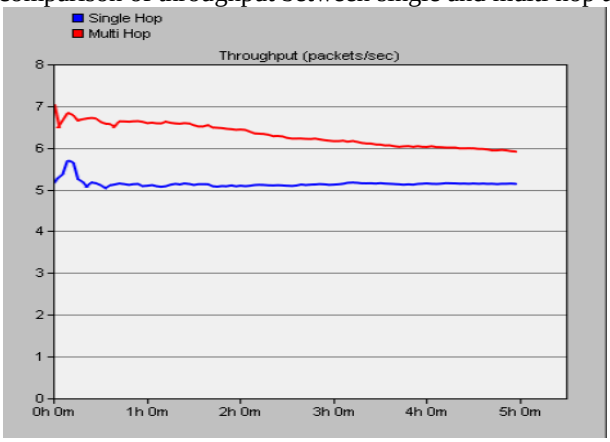

Figure 11: Nearest Distance Node Throughput

Figure12. Shows comparison of throughput between single and multi hop at average distance:

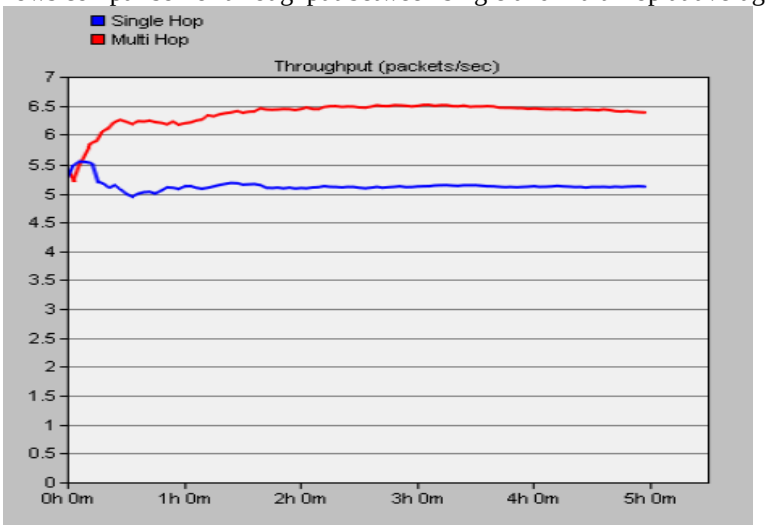

Figure 12: Average Distance Node Throughput

Figure 13. Shows comparison of throughput between single and multi hop at farthest distance:

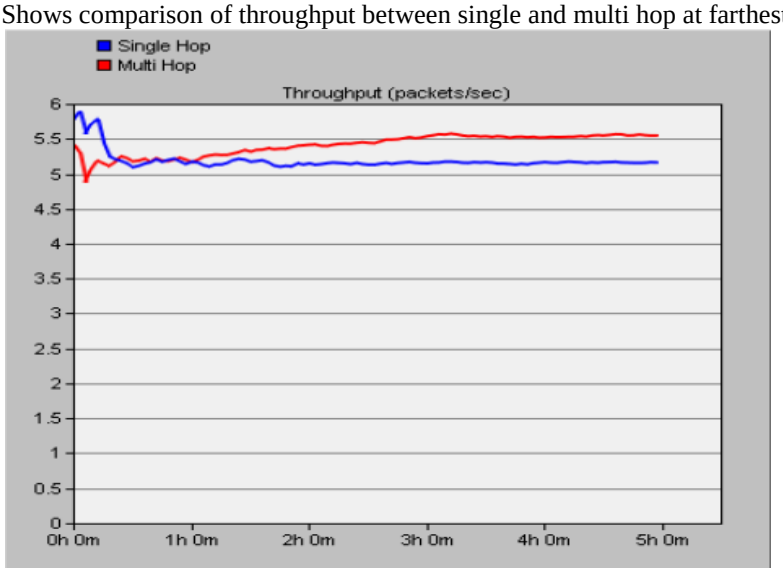

Figure 13: Farthest Distance Node Throughput

Figure 14. Shows the lifetime of network. Here we can see easily that till what time how many nodes will alive:

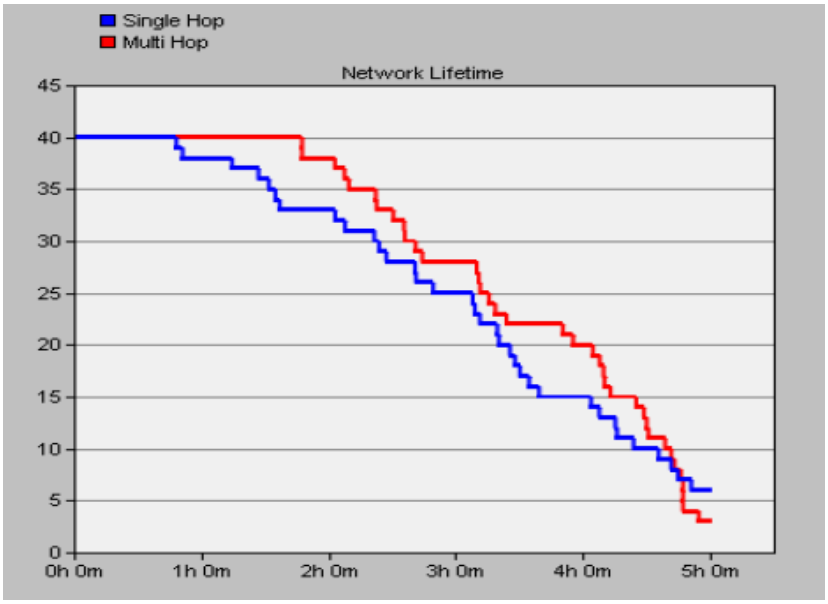

Figure 14: Network Lifetime

V. CONCLUSIONS

In this Paper we demonstrate the idea to save the energy in a wireless sensor network for reduction of energy onsumption. We are using LEACH protocol on both single and multiple hops (as results shows). OPNET is a good tools to demonstrate our work in fully supported almost feature of IEEE 802.15.4. We are chosen this idea to help in today's era to reduce global warming like issues. This studied addresses the considerable comparison in single and multi hop routing strategy for cluster based LEACH protocol. Simulated results are the evidence for multi hop routing strategy is better than single hop routing.

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