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A Fast Convergence and Quick Route Updates Based Energy Aware Tree-Based Routing Protocol for Mobile WSNS

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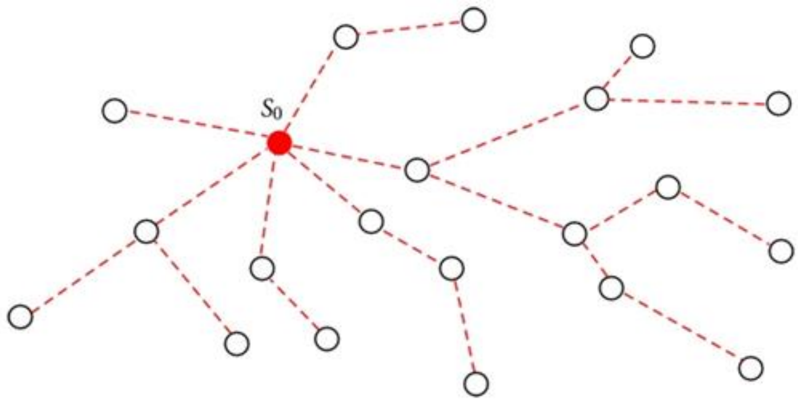
Abstract: *Wireless Sensor Networks is the result of latest advancements in the field of wireless technology. The recent upgrades to the wireless network provides the opportunity to wireless sensor networks to fully utilize all the possible resources to achieve results in the desired area of deployment, further leading to increased energy requirements within the network. There are plenty of routing algorithms applicable inside WSNs which claim to maintain the desired energy levels within the network by controlling certain parameters such as packet delay, load, etc. In this paper we have proposed a tree based routing approach that makes the use of aomdv routing to choose the path for transmission by taking each sensor node's distance and residual energy as a parameter and performs effective load balancing to increase the network lifetime. The Proposed model is tested under various performance parameters like network load, throughput, data loss and delay and the results shows an increased network lifetime incomparison to the existing model. The proposed work has been implemented in the Ns-2 simulator. The experimental results have shown the significant improvement in the results obtained from the proposed algorithm implementation.*

General Terms: *Routing Algorithm, Path forwarding, Energy consumption, Energy-aware routing.*
Keywords: *survey, routing, WSN survey, route metric, energy efficiency*.

I. Introduction

A typical WSN involves some tiny nodes being spread over a random location to be monitored, serving the purpose to record the activities within that area without any human involvement. These nodes are equipped with various types of sensors, processing unit, a transceiver and a battery to capture the changes and movements within that environment and then turning them into processed data to be transmitted via route through other live nodes till sink. In order to ensure successful delivery of data from source node to sink, a routing technique is required which best fits that scenario. There are ample of routing techniques available under wireless sensor networks but it needs to be selected keeping the mind certain factors like the need for increased network life-time, reduced delay, less packet-drop rate, best path selection. All types of routing in wsn falls under there categories namely: proactive, reactive and hybrid. In case of proactive routing the sensor nodes automatically starts sensing and forwards the sensed data to base station or sink by means of predefined path while in reactive routing whenever an unusual activity occurs the sensor nodes gets active in response and forwards the sensed activity to sink, the third type called the hybrid is a mix of both proactive and reactive routing, In hybrid routing the all the available routes are selected and from them the best route is pointed out through which the sensed data can be forwarded from source node to sink.



One of such is tree-based routing which involves the implementation of wireless sensor networks in the form of a tree structure where there is a root node acting as a sink and all other nodes as leaf within the tree who forward their sensed data till it reaches the root. The tree routing follows the parent-child relationship between nodes as each sensor node within tree network act as child of the parent node above them and forwards the sensed data through their parent nodes who are further child of another parent and ends with root being the parent of all. Each child node chooses from many nodes a single node as its parent based on the ability of the parent node to transfer the data to the root through shortest path and remain available for further transfers. The routing in tree-based network is done by metric calculation method in which current sensor node's metric is combined with their neighbor's metric to find the best and shortest route.

Though tree-based routing seems to be convincing but still there are several issues lying with it. First and foremost lies with the parent node as if parent node is having too many child nodes, then they can put extra load on the parent node causing early death of the parent node which can further result in parent changes for all the nodes connected to that previous parent .In case of sudden death of parent node, the packet to be transmitted at the time also gets dropped. This situation creates a metric re-calculation and further route changes leading to instability within the network. Secondly rapid changing topology within the tree network increases energy consumption of the network leading to early depletion of sensor node's energy.

In this paper a modified aomdvprotocol under tree based routing scenario is introduced. The proposed routing protocol performs three major operations namely path cost evaluation on the basis of node energy and distance, path selection on the basis of least cost and path forwarding to send data through the least cost path. The default aomdv protocol performs multicast routing but this proposed aomdv performs multipath routing to forward the data from source to destination.

II. Literature Review

Delaney et al.(2014) developed a reliable structure for routing in wireless sensor network and presented the approach of Neighborhood Heuristics (NHs) , a technique that integrate routing metric of sensor with its neighbors to focus on the aspects of current route and as well as choices of routing accessible for the sensor. The extra information provided by recent metric favors sensors to select adequate quality of routes which accomplish better aspects. The structure of NH is enforced with routing protocol for lossy network and low powered routing standards. A novel scheme based on NH is introduced in this paper. NHs will make the use of all the metric information available to the sensor for making choices of routing path better. The objective of his approach is to present a fixed platform that transfers high level services.

Ghadimi et al.(2014) introduced ORW in wireless sensor network i.e an effective Opportunistic Routing Technique which works with new opportunistic routing metric known as EDC which depicts the expected number of duty-cycled wakeups that are necessary to transfer a data packed from source to destination successfully. The opportunistic routing based on EDC concludes in notable reduced delay and increases the energy efficiency. It enhances the flexibility to failure of nodes in the network and link dynamics. The opportunistic routing technique doubles the energy efficiency in large-scale networks.

Sahin et al.(2014) examined the purpose of single-path and multi-path QoS aware routing algorithms under severe smart grid environmental conditions to check their service differentiation proficiencies in trustworthiness and timeliness area. This investigation will help in developing routing protocols that will be specifically formed for smart grid environments. A smart grid a modernized power grid system with exception sensing, monitoring , communication and control abilities. A routing scheme is proposed in this paper that provides distinct services in reliable and timeliness fields in several kind of smart grid surroundings.

Singh et al.(2014) proposed an energy efficient source based tree routing with time stamp in wireless sensor networks. A tree-based routing approach depends upon tree structure where parent-child relation is used for transmission of packet. The security is matter of concern in packet transmission. A packet sent from sender to receiver should arrive at pre-specified time duration. The data packed that is transmitted should contain some additional parameters and some security approaches. Energy Efficient Source Based Tree Routing With Time Stamp (EESTTS) is implemented in this paper which target on consumption of energy and prevent from message failures. EESTTS chooses minimal number of hops for packet transmission in the route in order to preserve energy.

Kwon et al.(2012) proposed stateless P2P routing protocol (SPR) that is based upon shortcut tree routing algorithm. SPR transmit packet to the node that has small hop-count between neighboring nodes rather than sending a packet to parent or children. SPR supports stateless routing in which it decide route with the help of hierarchical network and one hop neighbor information. The SPR is implemented in IP-WSN platform termed as SNAIL. SPR enhances the route effectiveness on P2P. Three routing protocols have been tested in the physical environment:- RPL,SP``R and HiLow.

Tunca et al.(2014) presented a survey on existing distributed mobile sing routing for wireless sensor networks . Prerequisite of design and difficulties associated with the issue of mobile sink routing are determined and made clear. The authors viewed advantages and disadvantages of routing protocols related to mobile sink. The requirement of mobile sink emerged because the nodes that are nearby to sink are the way to transfer traffic from source node to the base station.

Bechkit et al.(2012) suggested a new weighted path cost function and represented that the cost function is more adequate for wireless sensor network. A simple and effective shortest path tree is constructed based upon this cost function which does not familiarize new overheads. The solution is more appropriate in many to one wireless sensor network. The problem of shortest path tree (SPT) is considered in wireless sensor network and evaluated it under different metrices. So a novel weighted shortest path tree (SPT) to convergecast traffic routing in wireless sensor network.

Musznicki et al(2012) introduced the concept of Localized Energy-Management Algorithm that is based upon Dijkastra (DLEMA) for the reduction of the load on bandwidth and preserving the energy to expand the overall lifespan of the network. This algorithm was introduced keeping in mind the energy requisite of the sensor nodes that are deployed in remote regions without the human reach to replace or recharge the batteries. DLEMA computes only the minimum cost path from the existing node to the destination node in a one-to-many network tree and results in t lowest delays and the life of the network lasts for longer duration.

Elhabyan et al(2103) proposed two routing protocols for wireless sensor networks namely CDDP (Control Data Dissemination Protocol) and CWCP (Centralized Weighted Clustering Protocol) for the high effectiveness of clustered networks within WSN. The first protocol that is termed as CDDP is capable for the design of a tree network, linking all the nodes together within the network. The second routing protocol CWCP is employed to transfer the control data to the base station which is accepted additionally to select the optimal cluster heads in the network. As a result the CDDP protocol points to adequate control under the base station with minimum amount of delays in the network and CWCP resulting in higher effeciency.

Aljawawdeh et al(2013) presented a Dynamic Load Balancing Protocol (DLBP) in wireless sensor netwoks whose primary objective is to achieve load balancing and upgrade the lifetime of the network. As per the authors, they benefited from DLBP protocol in creating a load-balanced tree that can transfer next-hop messages with no delays and also eliminated the requirement of route-discovery. The DLBP operates in three phases which are as follows:- Design a tree network which comprise of atleast one route to the sink or base station follow up by the second phase that makes use of filtering technique which decreases the number of messages ad therefore, the final phase being eradicates the purpose of control packets that lead to the balancing of load within the network.

Barceló et al(2013) states that all the novel wireless sensors have the ability to regulate their transmission power so that energy consumption can be reduced and making it mofreemnegy efficient but the sensor nods that are implemented under the Collection Tree Protocol (CTP) which operate on predefined power supply i.e these sensor nodes have limited battery life so these sensor nodes does not turn out into efficient energy conservation scheme. To overcome these drawbacks , the authors proposed a unique routing metric called MaxPDR for CTP that supports transmission power control and deals with issues related to signal compatibility with a parameter β to enhance energy efficiency in the network.

Wen et al(2013) specifies that existing routing algorithms for Wireless Sensor Networks (WSNs) and Ad Hoc Networks cannot be enforced in Wireless Mesh Networks (WMNs). So, the authors introduced a new load balancing routing protocol for Wireless Mesh Networks which is based upon the cross-layer knowledge and Ad Hoc On-demand Distance Vector (AODV) routing protocol , named as Load Balance Cross Layer based AODV (LBCL-AODV). The LBCL-AODV protocol is proficient of optimizing the process of route selection by utilizing load of the sensor node and the performance parameters such as packet delivery rate. It also takes the advantage of dynamic load migration technique which transmits the traffic of route that are busy to unoccupied state .

Gholipour et al(2015) studied the matter of traffic bottleneck which results in wastage of energy and therefore specified a distributed traffic-aware routing approach named as hop-by-hop gradient based routing technique which establishes a balance between the optimum paths by distributing the traffic from source node to sink node within the network. This technique works accepts all the available nodes and their neighbors traffic stats to attain selection of route . The result is appropriate usage of resources and reduction in retransmission of packet which gives rise to improved network lifetime.

Tan et al(2015) proposed a Sleep Scheduled Tree Based Clustering (SSTBC) routing technique which stated that each and every node in the network consumes equal amount of power whether the nodes are in use or not, so in this method the nodes are admitted to go into sleep mode when they are not in further use. The method is implemented with a minimum spanning tree where nodes are organized into clusters and cluster heads(CH) act as root node of their respective clusters. The nodes that lie within the cluster broadcast their sensed data to their cluster head which is accordingly transmitted from the cluster head to the base station.

Azharuddin et al(2014) states that fault tolerance is as important as energy consumption in wireless sensor networks. It is observed that in cluster-based networks, the cluster heads are solely responsible for data aggregation and transfer of aggregated data to base station. The authors highlight an issue that what if cluster heads goes down then how the data will be forwarded to the base station and how network will recover back into working state. To overcome this issue, the proposed algorithm allows to select next-hop cluster head based on various parameters like the residual energy in case of primary cluster head falls so that the network will stay alive.

Lachoskwi et al studied various distributed algorithms for tree based routing and following their drawbacks proposed a new algorithm for constructing a spanning tree. Based on existing Bellman-Ford algorithm, they named their algorithm as Efficient-Bellman Ford (EBF) which allows the creation out routing trees even at the time of node failure and furthermore requires less resources along with no topological information. EBF also handles load-balancing effectively due to the choice of alternate routes available.

III. Algorithms Used

Algorithm 1: Path Selection

The energy is the primary parameter that is used for the purpose of path selection. The energy of all the nodes will be stocked in the structure of energy array on the source node so that energy can be evaluated on the basis of path cost.

$$E = (E_1, E_2, E_3, E_4, E_5, E_6, \_\_\_\_\_\_\_\_\_, E_N)$$

1) Initialize Node N and the Node N negotiates with the nodes in the transmission range.
2) Node i establishes its Neighbor Table with initial cost parameter on the basis of distance, bandwidth & neighbor node id.

$d(pi) = ((dx_i - dx_j) + (dy_i - dy_j))^2$ ----------------------- (1)

$bw(pi) = \max(e1, e2, e3 \ldots \ldots \ldots en)$ ----------------------- (2)

$nid(pi) = \max(bestPath(nid1, nid2 \ldots \ldots \ldots nidn)$ ---------------- (3)

$$P_P(i) = \int_1^N P(E_i) < R^2, \text{ using (1), (2) and (3)}$$

Where, $P(E_i)$ denotes distance and R denotes Radius, $P_P(i)$ denotes path distance, $P(E_i)$ is Path Energy $P(D_i)$is Distance.

3) Node I forward its query ‘a’ to the neighbor node to obtain the path towards sink node.
4) If the neighbor node NN_i knows the path to the sink, then it will respond with route information to the querying node I and node i will restore the routing information
5) Else the Neighbor node NN_iwill forward the query to its querying node & it will proceed till it arrives at the the sink node.Once the path to sink is formed,the nodes will relay the route reply towards the querying node.
6) After accepting the path info, Node i cut down the path with repeated entries of nodes among multipath and establish finalized cost of path.

Algorithm 2: Path Forwarding

The path forwarding is the process of the choosing the path to transmit the data and then send the data over the selected path. The path forwarding process has been completed using the bandwidth, path energy and neighbor node.

Algorithm

1) When Node i has some data to transmit, it will reexamine the desirable paths towards sink node and the Node i analyze the Path P = $\{P_1, P_2, P_3, _______, P_N\}$based upon their cost information.
2) Node i measures the path information on the basis of Residual Energy (RE_p), Next Hop, Neighbor ID (Nid_p) & Available Bandwidth (bw_p).
3) The path with higher RE_p is chosen and If all the path have identicalRE_p then,Path with maximum bw_p is preferred and data is transmitted through the selected P.

Algorithm 3: Energy Based Load Balance Algorithm

The load balancing across the multiple paths is the process of the sending the data in the similar or different ratio across the possible path data. The rule based load balance models are usually based upon the automatically computed or manually given weighted threshold to pick out the alternative path from the vacant paths as the optimum path/s.

Algorithm

1) The best path P_B is calculated from the path data P = $\{P_1, P_2, P_3, \_\_\_\_\_\_\_, P_N\}$ and the threshold value T is computed as the weight to select the best alternate path P_A.
2) The alternative path P_A and best path P_B are assessed for distribution of data volume across the multiple best paths.

The data volume D_A and D_B becomes the acceptable data volumes for data transmission across the preferred paths P_A and P_B.

IV. Simulation

The simulation scenario for this research has been designed with adequate number of nodes to evaluate the performance of the proposed model under various circumstances. The standard transmission radius of 250 meters has been considered for the sensor nodes in the simulation. The queue length has been set to 200 packets and the standard WiFi communication interface. The random stable deployment of the sensor nodes in the wireless sensor network (WSN) with random mobility has been used for the tree based routing protocol testing in the case of stable sensor network and mobile sensor network in the hybrid formation. The flat ground based planar simulation has been designed for testing of the proposed energy balanced tree based sensor network routing protocol.

The simulation scenario is developed by the use of NS-2 simulator termed as network simulator version 2, on the Linux platform, namely Ubuntu version 12.04.

V. Experimental Result

The proposed model has been well tested under various situations in the sensor network simulation. The proposed energy based routing protocol on sensor network has been well tested for the performance parameters of delay, throughput, and network load. The nodes in the proposed model simulation have performed well in terms of all of the above parameters. The network load, throughput, and throughput has been recorded lesser than the ordinary sensor networks with mobility or stationary positioning under the similar situations.

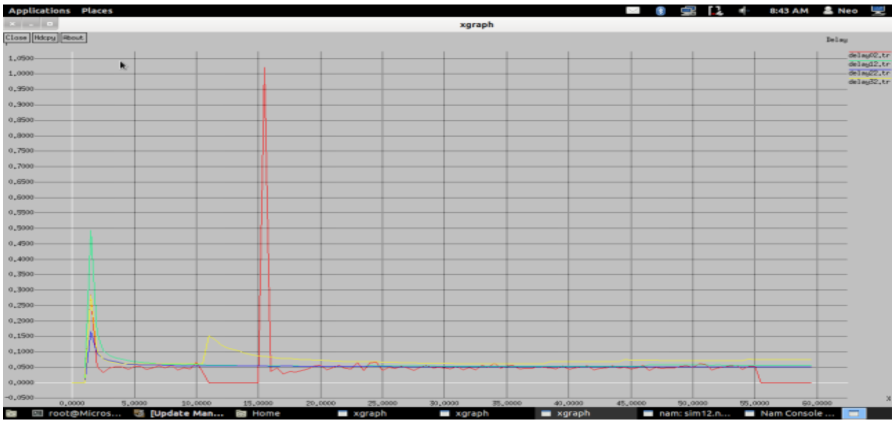


Figure 1: The delay obtained from the various groups of nodes in the topology.

The maximum delay recorded in the simulation is ranging between 0.5 and 1 milliseconds. (Figure 1) The delay is the parameter represents latency of a packet when it was being sent between two nodes. The time taken for a packet to reach the destination from the source is called the total delay.

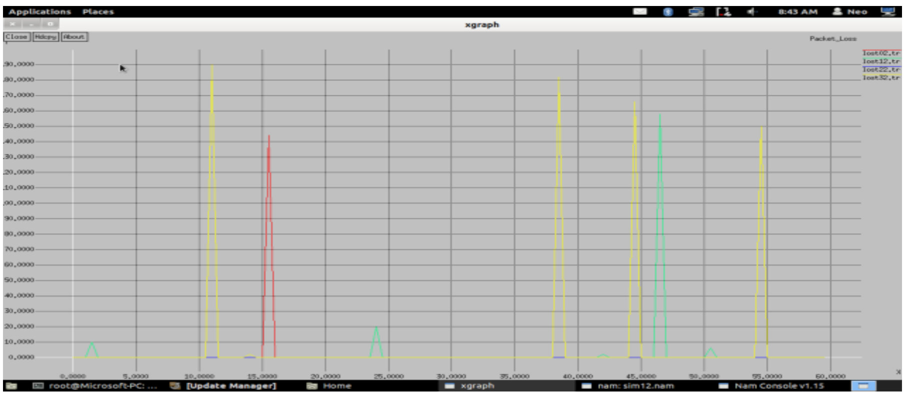


Figure 2: The graph of network load across the groups of nodes in the given cluster.

The network load is the parameter which shows the resource occupancy during the runtime. The proposed mode has been well tested for the load on the different times in the simulation. The proposed model has been found showing the minimum delay at 0 percentage resource usage and maximum load at 190 percent resource usage, where the sensor network is over-flown with the data, because a number of nodes are transmitting the heavier amount of data towards the sink nodes.

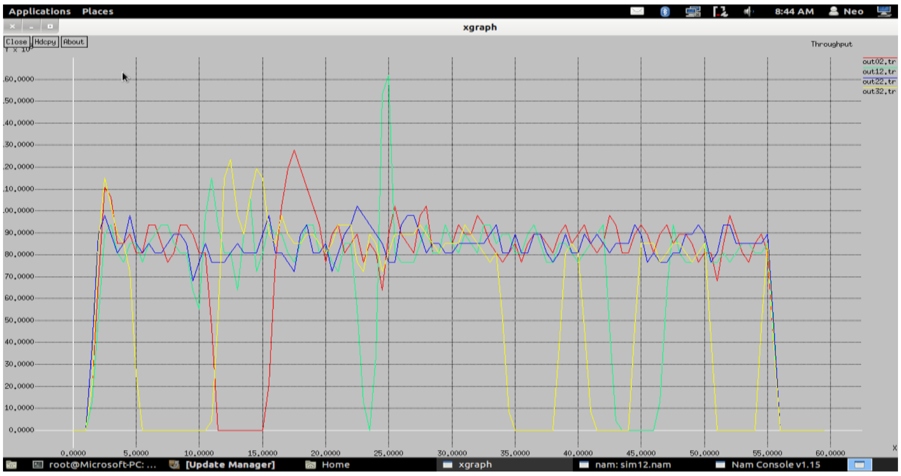


Figure 3: The graph of throughput obtained from different groups in the given topology.

The throughput (Figure 3) is the parameter represents the capacity of a node or a network to send the data per second. The throughput of the sensor network using our proposed energy aware tree based routing protocol has been recorded between 80 and 100 Kbps. The 0 kpbs is the value recorded when no data is being sent between the nodes in the initial stages. Once the data transfers start, the throughput starts going up. The maximum limit of the throughput is 160 Kbps.

VI. Comparative Analysis

The results obtained from the proposed model shows a certain level of improvement form the existing models in the following graphs.

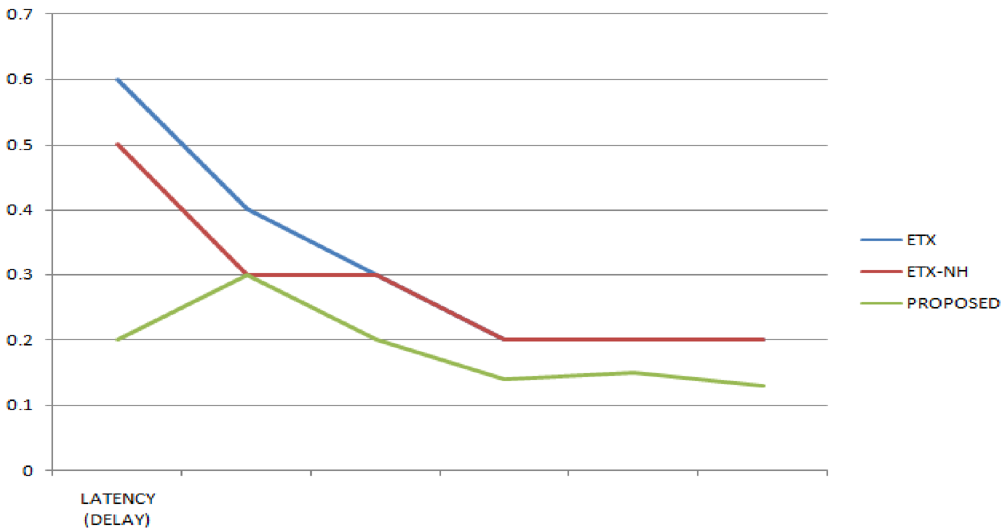


Figure 4: The comparison graph of latency.

The comparative analysis that the proposed algorithm performs much better than the existing algorithm. The proposed work is based upon the improved tree based routing algorithm, where the proposed work has proved well in terms of dealy (or latency). The latency is the parameter, which signifies the transmission delay produced by a single packet in the particular point of time in accordance with the best time taken for the delivery.

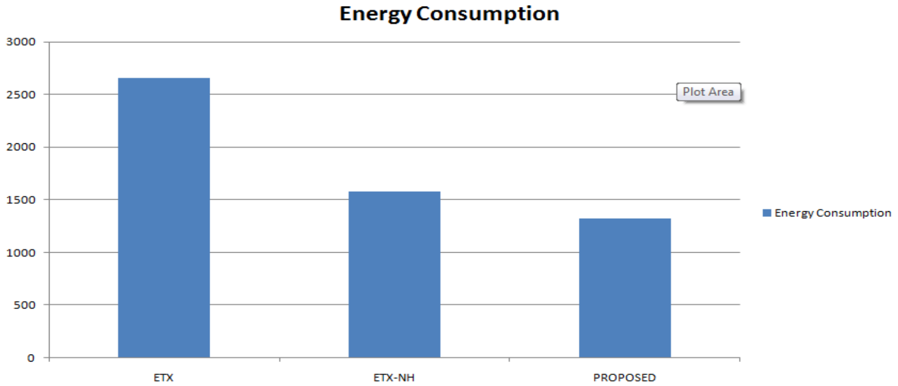


Figure 5: Energy Consumption Graph of the proposed model.

The proposed model have proved the efficiency of the proposed model in energy overhead caused due to the packet transmission. The packet transmission if will be less due to any process, it will directly affect the energy consumption of the proposed model.

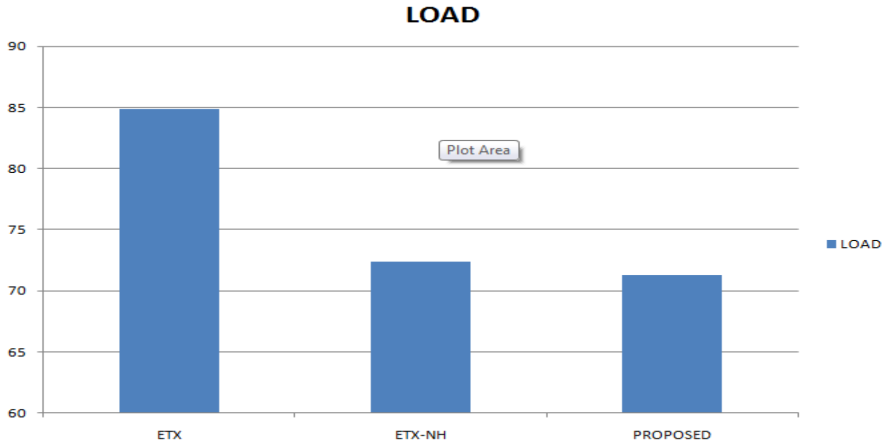


Figure 6: Network Load Graph between the existing parameters.

The network load is the indicator of the data volume on any sensor node. The higher is the data volumes, the performance goes lower in terms of network load. The network load can be decreased by using an effective method to compute the load on the network on the specific time, when the node is communicating with the proposed model. The network load is the load indicator, which signifies the use of the resources on a point of time. The network load varies due to the control and topology packets also.

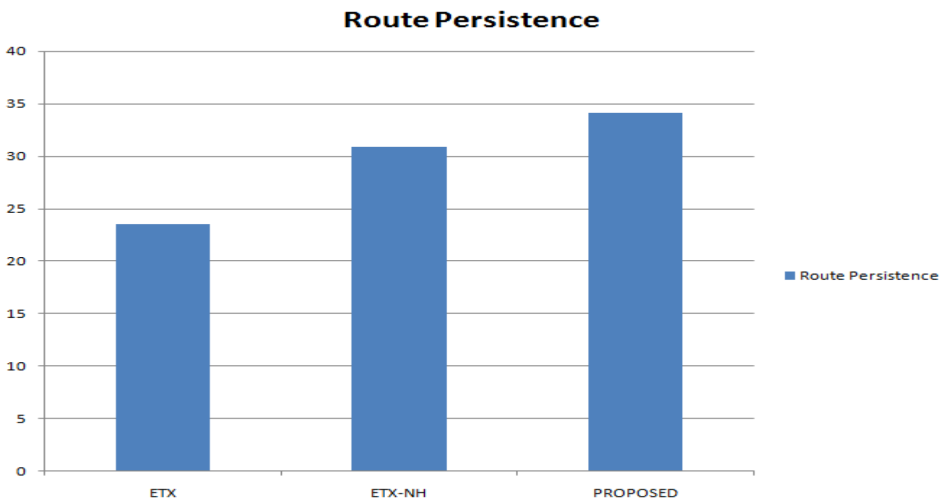


Figure 7: Route persistence of the existing model vs proposed system

The route persistence is the parameters, which signifies the elongation of the available routes. It means the availability of the route for the elongated period. The route persistence is higher in the case of proposed model than the existing model.

VII. Conclusion And Future Work

The wireless sensor networks are the network consisted of several sensor nodes. The wireless sensor nodes are equipped with low range equipments for the wireless connectivity to keep the sensor node cost low. The wireless sensor networks highly depend upon the routing scheme to deliver the data from the nodes to the sink. The nodes build topology and prepare the routing paths using the routing algorithms, which helps the not-in-direct-range nodes to deliver the data to the sink node. The wireless sensor nodes are also deployed on the animals in the forest area in order to conduct various studies. The routing becomes the tedious task in the mobile WSNs. The routing in the mobile WSNs require the quick route updates and fast network convergence, which is not usually present in the normal WSN routing algorithms. The tree based routing approach is considered the most balanced routing approach in the case of WSNs, because it uses the low size neighbor information table, which saves a lot of space on the memory hence energy. The proposed model is based upon the tree-based WSN routing mechanism. The proposed model has been designed to work efficiently in the case of mobile WSNs. The proposed routing protocol for the mobile wireless sensor network has been designed for energy based metric calculation with quick updates and fast convergence. All of the latter mentioned properties are the reason behind the rise in the energy efficiency levels of the proposed model. The proposed model has been evaluated on the basis of load, routing overhead and other communication parameters. The proposed model has been proved better than the exiting scheme and highly adaptable to the mobile WSNs.

In the future, the proposed model will be extended for the very fast convergence for the mobile WSNs along with small route updated in the controlled cluster scenarios. The controlled neighbor update can be also used to improve the performance of the proposed algorithm, which will increase the time of neighbor communication for alive/activity check and lowers the levels of data produced by the topology change.

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