Improve the Network Energy Consumption in Sensor Networks Using K-Level Hierarchical Algorithm

K.Gandhimathi
Assistant Professor (Sr.G)
Department of Information Technology.
Bannari Amman Institute of Technology.
Sathyamangalam, Tamilnadu.
Email – id: gandhimathiit@gmail.com

Dr.G.M.Tamilselvan
Associate Professor
Department of ECE.
Bannari Amman Institute of Technology, Sathyamangalam, Tamilnadu.
Email – id: tamiltamil@rediffmail.com

Abstract: Wireless Sensor Networks is a collection of wireless sensor nodes dynamically forming a temporary network without the aid of any established infrastructure or centralized administration. Routing protocols in wireless sensor networks helps node to send and receive packets. Traditional hierarchical routing algorithms combine adaptability to changing environments with energy aware aspects. In this project a new distributed, self organizing, robust and energy efficient, hierarchical energy efficient routing protocol is proposed for sensor networks .The proposed routing is based on Low-Power Localized Clustering (LLC).In this structure, which nodes can construct from the position of their 1-hop neighbors. This also describes route maintenance protocols to respond to predicted sensor failures and addition of new sensors. The LLC to a k-level hierarchical algorithm will improve the network energy management. The LLC protocol is compared with the existing Localized – Power Efficient Data Aggregation Protocol (L-PEDAP) and Ad hoc On demand Distance Vector routing protocol (AODV). The performance of these three routing protocols (L-PEDAP, AODV, and LLC) is based on metrics such as packet delivery Fractions, end to end delay, energy consumption and throughput, Also this work will analyze and compare the performance of protocols using NS-2.34, when various other mobility models are applied to these protocols.

Keywords- Mobile Sensor Networks, Mobile Node, Mobility model.

I. INTRODUCTION

With the introduction of low-cost processor, memory, and radio technologies, it becomes possible to build inexpensive wireless micro-sensor nodes.

Although these sensors are not so powerful compared to their expensive macro-sensor counterparts, by using hundreds or thousands of them it is possible to build a high quality, fault-tolerant sensor network. These networks can be used to collect useful information from an area of interest, especially where the physical environment is so harsh that the macro-sensor counterparts cannot be deployed. They have a wide range of applications, from military to civil, that may be realized by using different type of sensor devices with different capabilities for different kinds of environments [1]. The main constraint of sensor a node is their very low finite battery energy, which limits the lifetime and the quality of the network. For that reason, the protocols running on sensor networks must consume the resources of the nodes efficiently in order to achieve a longer network lifetime. There is an ongoing research on power management issues in order to reduce the power consumption when the nodes become idle [2]. When power efficient communication is considered, it is important to maximize the nodes' lifetimes, reduce bandwidth requirements by using local collaboration among the nodes, and tolerate node failures, besides delivering the data efficiently. There are several power efficient protocols defined for wireless ad-hoc networks ([3], [4]). When sensor networks are considered, Chang and Tassiulas ([5], [6]) give data routing algorithms which maximizes the system lifetime where only some of the nodes have data to send and where there can be more than one base station. In another work by Bhardwaj et al. [7], the upper bounds on the lifetime of sensor networks are derived. There are also different protocols proposed in the literature ([8], [9], [10]) to maximize the lifetime of the system under different circumstances. Since data generated in a sensor network is too much for an end-user to process, methods for combining data into a small set of meaningful information is required. A simple way of doing that is aggregating (sum, average, min, max, count) the data originating from different nodes. A more elegant solution is data fusion which can be defined as combination of several unreliable data measurements to produce a more accurate signal by enhancing the common signal and reducing the uncorrelated noise [11]. These approaches have been used by different protocols ([11], [12]) so far, because of the fact that they improve the performance of a sensor network in an order of magnitude by reducing the amount of data transmitted in the system. There are various models for sensor networks.

II. RELATED WORKS

The effects of various mobility models and the performance of two routing protocols Dynamic Source Routing (DSR-Reactive Protocol) and Destination Sequenced Distance Vector (DSDV-Proactive Protocol) is studied in [4].Performance comparison has also been conducted across varying node densities and number of hops. Experiment results illustrate that performance of the routing protocol varies across different mobility models, node densities and length of data paths. Mobile wireless ad hoc networks are infrastructure less and often used to operate under unattended mode. So, it is significant in bringing out a comparison of the various routing protocols for better understanding and implementation of them. In this paper, comparison of the performance of various routing protocols like Ad hoc On-Demand Vector routing (AODV), Localized-Power Efficient Data Aggregation Protocol are discussed. The comparison results were graphically depicted and explained [5].

The mobility model is the most important factors in the performance evaluation of a mobile ad hoc network (MANET). Traditionally, the random waypoint mobility model has been used to model the node mobility, where the movement of one node is modeled as independent from all others. However, in large scale military scenarios, mobility coherence among nodes is quite common. One typical mobility behavior is group mobility. Thus, to investigate military MANET scenarios, an underlying realistic mobility model is highly desired.

III. MOBILITY MODELS

Mobility models consist of two different type of Dependencies such as spatial and temporal dependency. Mobility of a node may be constrained and limited by the physical laws of acceleration, velocity and rate of change of direction. Spatial dependence is a measure of node mobility direction. Two nodes moving in same direction have high spatial dependency. The current velocity of a mobile node may depend on its previous velocity. The velocities of single node at different time slots are correlated. This mobility characteristic is called as the temporal dependency of velocity [1].Frequently used mobility models includes Random waypoint, Manhattan, Energy consumption model. We compare the performance of these models with parameters like packet delivery radio, end to end delay, energy consumption and throughput, and hop count using two different routing protocols.

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A. Random way point mobility model:

The Random Waypoint model is the most commonly used mobility model in research community. At every instant, a node randomly chooses a destination and moves towards it with a velocity chosen randomly from a uniform distribution

[0, V_max], where V_max is the maximum allowable velocity for every mobile node. After reaching the destination, the node stops for a duration defined by the 'pause time' parameter. After this duration, it again chooses a random destination and repeats the whole process until the simulation ends.

IV. ROUTING PROTOCOLS

A. Ad-Hoc on Demand Distance Vector Routing (AODV)

AODV is a distance vector type routing protocol. This protocol does not maintain the routes to destination that are not activity used .Till the nodes have valid routes to each other AODV does not play a role. It uses Router request (REREQ). Route r e p l i e s (RREPs). Route error (RERR). message to discover and maintain the routes. When a node wants a route to a destination it broadcasts RREQ to the entire network till the destination is reached or a fresh route is found. Then a RREP is send back to the source with the discovered path. When the node detects the route is not valid it broadcasts a RERR message [4] [7].

B. *Localized – Power Efficient Data Aggregation Routing Protocol (L-PEDAP)*

L-PEDAP is table driven algorithm based on Lmst routing .Each node has a routing table having the destination, next hop and number of hops to the destination. The nodes periodically broadcast the updates. A sequence number is tagged with time also the shortest path to a destination is used .if a node detects route to a destination is broken then the hop number is set to infinity and its sequence number is updated to a odd number .Even numbers represent the sequence numbers of connected paths. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops [4] [7] [8]

C. X-LLC: the Proposed Routing Algorithm

We propose an autonomous and adaptive hierarchical routing algorithm, named *X-LLC* that is a multi-level extension of LLC. The proposed multi-level extension is particularly appealing for reducing the energy consumption of LLC since it allows a short range transmission activity. Moreover, the proposed algorithm grants adaptability to changing environments (since it automatically provides quick reaction to topological changes in the network by instructing new clustering configurations) and is autonomous in the routing decision (the routing algorithm is not centralized and nodes perform local decisions to select the optimal path route).Traditional hierarchical routing algorithms consider only one level of cluster heads. Here, we propose to extend the LLC algorithm so has to have $k \geq 1$ intermediate levels of cluster heads by considering k distinct LLC election phases. Each election phase i elects cluster Heads of the i-th level. Iteratively, the i-th level cluster heads participate to the election of the $i + 1$-th level cluster heads. The process iterates up to the k-th level. Extension to k levels implies that cluster heads at level $i - 1$ send data to cluster heads at level i with a star network topology, level 0 are sensor nodes while cluster heads of the last k level send packets directly to the base station. Cluster heads, in addition to communication and data, also provide sensorial data acquisition. The suggested *X-LLC* algorithm is given in Algorithm 1 while the nomenclature of the symbols is presented in *X-LLC* a distributed algorithm, the routing algorithm is executed by each node when participating to the election. Each node generates a random value u between 0 and 1 (Step 2) that is compared (Step 3) with a threshold *pjir* defined in (1): if *pjir* is greater than u, the node becomes a candidate cluster head and participates to the election phase; otherwise it stays silent (Step 12) until the election process terminates.

Algorithm 1 *electClusterHeads*: *i, r, njir*
1: $m = 0$;
2: $u = rand\ \{U(0, 1)\}$;
3: if $pjir \geq u$ then
4: *enableTimer*(*Ta*);
5: *send* (*msgADV ,Rw*);
6: while *isNotExpired* (*Ta*) do
7: if *receiveMessage* (*msgADV*) then
8: $m = m + 1$
9: end if
10: end while
11: else
12: *sleep* (*telection*)
13: return
14: end if
15: *Tb* = *calculatePromotionTimer* (*m, eilr*)
16: *enableTimer*(*Tb*)
17: while *isNotExpired*(*Tb*) do

18: if *receiveMessage* (*msgADV*) then
19: sleep (*telection*)
20: return
21: end if
22: end while
23: if $i < k$ then
24: *electClusterHeads* (i + 1*, r, njir*)
25: else
26: *associateNodes*: (i + 1*, r, njir*)
27: end

Symbol Explication

*N*0 = Total number of nodes
Si = The set of nodes that may partecipate to elections at the *i*-th level
Njir = The *j*-th node € *Si* at election round *r*
Ejir = The residual energy of *nijr*
Pjir = Probability that *nijr* partecipate to the election mechanism (computed with Equation 1)
Rw = The transmission radius at the *w*-th transmission power level
Ta, Tb = The node timers
Telection =*the* time required for the procedure completion

Message with transmission power *Pw* and, consequently, covers a spatial neighborhood of radius *Rw*. Then, each candidate node collects the advertisement messages coming from the other candidate nodes in the neighborhood (Step 7) and sets a promotion timer *Tb* that is function of the amount of received messages and the node residual energy (Step 19). When *Tb* expires the candidate node becomes a cluster head at level *i* and broadcasts an advertisement message with transmission power *Pw*. If *Tb* has not yet expired and a candidate node receives an advertisement message (coming from a candidate node that becomes cluster head) (Step 18), it interrupts the promotion time and waits until the election process terminates (Step 19). Nodes that become cluster heads at the (i)-th level participate to the election of the (i + 1)-th level cluster heads. Cluster heads not elected at the (i)-th level simply remain (i − 1)-th level cluster heads. The election phase is then iterated up to the *k*-th level. To allow transmissions to higher distances, the value of the transmission power *Pw* has to increase with *i*. Selection of *Pw* and *i*, which depends on technological constraints and is application-dependent, can be taken by suitably mapping the number of levels available for the transmission power *W* to the number of cluster heads levels *k*.

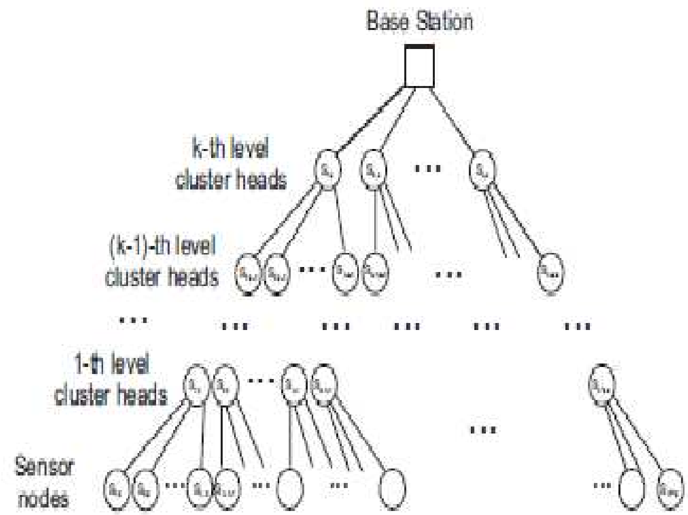

Figure 4 . Hierarchical structure of the sensor network

table to the associated (k − 1)-th level cluster heads). This process iterates up to the sensor nodes level. *X-LLC* provides a remarkable advantage in terms of transmission energy consumption (once compared with traditional hierarchical algorithms) since reduces the cluster size in terms of radius and, hence, number of nodes. Moreover,

- Each cluster head rules over a small - possibly balanced number of nodes.
- Cluster heads forward collected information to a cluster head at higher abstraction level instead of sending them directly to the base station.
- The transmission range of simple nodes can be reduced w.r.t. the LLC one: the transmission requires less power and the inter-cluster interference decreases.

A larger number of clusters (or, equivalently, a smaller cluster size) is always profitable from the energetic point of view but at the expense of an increased bandwidth overhead for transmission management..

V. EXPERIMENT AND RESULTS

Each model is implemented with the X-LLC and L-PEDAP protocols and their performance is analyzed with various node densities such as 10,20,30,40 and 50 with standard 802.11 MAC layer. The packet type generated in the trace file is UDP .In the simulation scenario we used omni directional antennas with transmission range is 250m.Our simulation result has shown that packet delivery ratio is higher in X-LLC when compared with L-PEDAP. Energy consumption and End to End delay is less in X-LLC. When compared with L- PEDAP.

TABLE 1 SIMULATION PARAMETERS

Area	**1000m X 1000m**
MAC	**IEEE 802.15.4**
Transmission Range	**250m**
No of Source Nodes	**10,20,30,40,50**
Simulation Time(sec)	**180sec**
Mobility	**Random Waypoint**
Traffic Type	**CBR**
Transport Layer	**UDP**
Packet Size	**1400**

A. PACKET DELIVERY FRACTION

In the figure X axis represents the varying number of node and y axis represents the packet delivery fraction

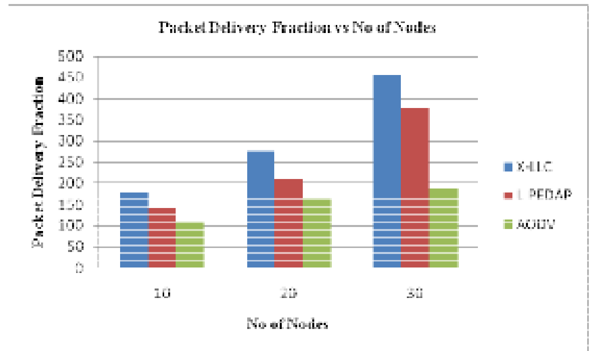

Figure 5: Packet Delivery Fraction

based on the Figure 5, it is shown than X-LLC perform better when the number of nodes increases because nodes become more stationary will lead to more stable path from source to destination L-PEDAP performance dropped as number of nodes increase because more packets dropped due to link breaks.

B. END – TO- END DELAY

In the figure X axis represents the varying number of node and y axis represents the end to end delay in mille second

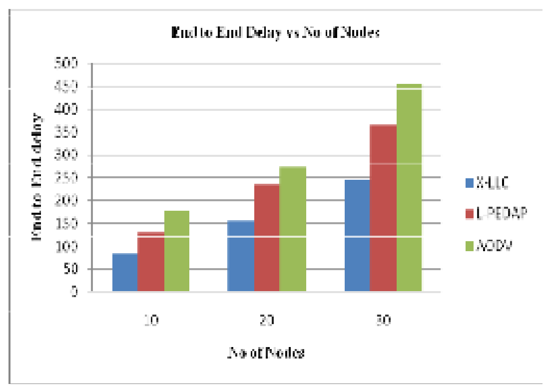

Figure 6: End to End delay

Based on Figure 6, X-LLC didn't produce so much delay even the number of nodes increased. It is better than L-PEDAP protocols.

C. ENERGY CONSUMPTION

In the figure X axis represents the varying number of node and y axis represents the end to end delay in mille seconds.

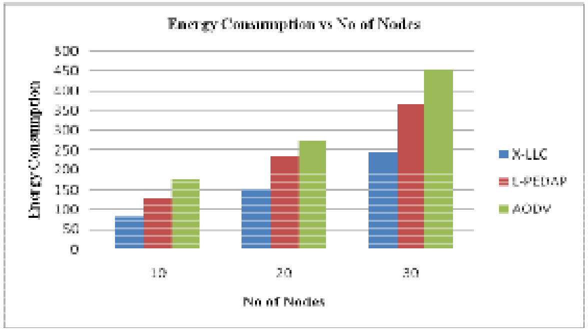

Figure 7: Energy Consumption

From Figure 7 X-LLC less prone to route stability compared to L-PEDAP For X-LLC, the routing consumption is not so affected as generated in L-PEDAP.

D. THROUGHPUT

In the figure X axis represents the varying number of node and y axis represents the throughput.

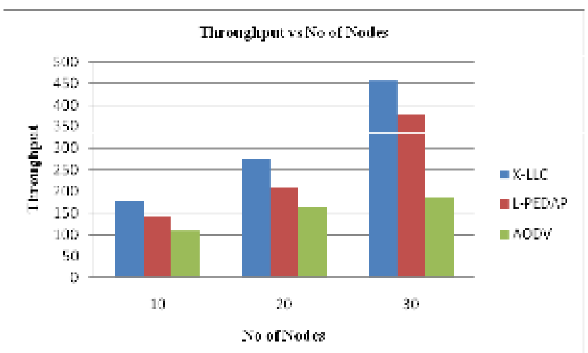

Figure 8: Throughput

The number of packets received in X-LLC is higher when compared to L-PEDAP protocol. It is also dependent of time. When time increase number of packet received at receiver side also increases correspondingly.

VI. CONCLUSION AND FUTURE WORK

The paper presents an extension of the LLC routing algorithm by introducing a hierarchical structure in the network management (network nodes are clustered with a hierarchical approach) which, by exploiting the nature of the topology, allows us for improving adaptability, network lifetime and overhead load balance among clusters. The novelty of the proposed approach resides in a *k* level hierarchical structure of cluster heads (the literature only considers one level of cluster heads) and considering the realistic case of finite bandwidth for nodes. This latter point is crucial in WSN nodes since available routing algorithms may become unfeasible in a large class of applications for technological constraints associated with a reduced bandwidth. Moreover, the proposed algorithm is particularly appealing for its ability to maintain a uniform distribution of alive nodes in the deployment area, feature associated with the monitoring QoS, where other routing algorithms introduce vast areas not covered by sensor nodes

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