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PERFORMANCE ANALYSIS OF ROUTING PROTOCOLS IN WIRELESS SENSOR

[1]N.PRIYADHARSHINI, [2]S.SUBASREE
[1]Asstt Prof., School of Computing, SASTRA University, Thanjuvar, Tamil Nadu, India
[2]Assoc. Prof., School of Computing, SASTRA University, Thanjuvar, Tamil Nadu, India
E-mail: priya.newplan@gmail.com, s_subasree@yahoo.com

ABSTRACT

Wireless Sensor Networks utilize large numbers of Wireless Sensor nodes to forward information from source to destination. Wireless Sensor Nodes are battery-powered devices. Energy saving is always vital to maximize the lifetime of Wireless Sensor Network. Recently, there are many Routing Protocols have been designed and proposed for Wireless Sensor Networks to improve its performance in terms of Communication Time, Residual Energy and Energy Consumption and also these protocols addressed Reliability and Shortest path. In this paper, this research work has implemented various Routing Protocols namely Power Efficient Data Gathering and Aggregation Protocol (PEDAP), Power Efficient Data Gathering and Aggregation Protocol-Power Aware (PEDAP-PA), Energy Efficient Spanning Tree approach (EESR), and Localized-Power Efficient Data Gathering and Aggregation Protocol (L-PEDAP) are studied thoroughly. From the experimental results, it is revealed that L-PEDAP outperforms PEDAP, PEDAP-PA and EESR in terms of Bandwidth, Resource Utilization and Communication Reliability. However, L-PEDAP fails to minimize the Energy Consumption and Communication Time due to Dynamic Routing Mechanisms. The PEDAP achieves less Communication Time to forward packets to destination. However, it fails to achieve Power-Aware Reliable Communication. From this analysis, it is observed that for faster communication, PEDAP could be used and for reliable communication with high bandwidth utilization, L-PEDAP is the best Routing Protocol in Wireless Sensor Networks.

Keywords: *Wireless Sensor Networks, Routing Protocols, Minimum Spanning Tree, Dynamic Routing and Power Aware Routing.*

1. 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 comprised on 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 Wireless 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.

Smart environments represent the next evolutionary development step in building utilities, industrial, home, shipboard, and transportation systems automation. Like any sentient organism, the smart environment relies first and foremost on sensory data from the real world. Sensory data comes from multiple sensors of different modalities in distributed locations. The smart environment needs information about its surroundings as well as about its internal workings with help of wireless sensor networks. The ideal wireless sensor is networked and scalable, consumes very little power, is smart and software programmable, capable of fast data acquisition, reliable and accurate over the long term, costs little to purchase and install, and requires no real maintenance.

A Wireless Sensor Network is a self-configuring network of small sensor nodes communicating among themselves using radio signals, and deployed in quantity to sense, monitor and understand the physical world. Wireless sensor nodes are called **motes.** A sample of Wireless Sensor Networks is given in figure 1.

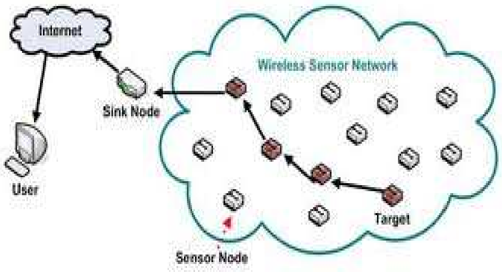


Figure 1.Wireless Sensor Networks

Sensor nodes are inexpensive and equipped with limited battery power and it is constrained in energy. So maximize network lifetime is one of the fundamental problems in wireless sensor networks. Network lifetime is defined as the time when the first node is unable to send its data to sink. In a scenario of data gathering application, each node sends its data to its sink. Data aggregation reduces the traffic of data and saves the energy by combining multiple packets to a single packet when sensed data are highly correlated. To increase the lifetime of the network many research has been carried out. In that most of the existing protocols use different approach called linear programming approach and cluster based approach. Using linear program as a problem is solved in linear programming approach whereas in cluster based approach the whole network is divided into groups where each group has a head.

An important problem is finding an energy efficient routing scheme for gathering all data periodically at the sink so that the network lifetime is prolonged as much as possible. The lifetime of network can be expressed in terms of founds where a round is the time period between two sensing activities of sensor nodes.

2. RELATED WORKS

Routing techniques are needed for sending data between Sensor nodes and sink for communication. Several types of protocols are proposed for wireless sensor network. In different parameters these protocols are classified. So, the classifications are proactive, reactive and hybrid. The classifications are based on wireless sensor nodes. Heinzelman, Chandrakasn, and Balakrishnan proposed Low Energy Adaptive Clustering Hierarchy Protocol (LEACH) [1].The proactive protocol was utilized by LEACH. In LEACH sink is fixed and located far from the sensor nodes and the nodes are homogenous and energy constrained. In this one node is called as cluster-head which acts as a local sink. The high-energy cluster-head is rotated randomly so the activities are equally shared among the sensors and equally consumes the battery capacity. It also performs data fusion. The concept behind data fusion is compression of data when data is sent from the clusters to the sink. By this way it reduces the energy dissipation and increasing the system lifetime. Since the drawback of LEACH is, the sink is far away from the CH, it needs high energy for transmitting the data.

The reactive protocol was utilized by Threshold Sensitive Energy Efficient Sensor Network (TEEN) [2] and it was proposed by Manjeswar and Agarwal. This kind of protocol is used in time critical applications i.e. if any sudden changes happened in the sensed environment beyond some pre-determined threshold value, the nodes react immediately. In TEEN the sensor nodes and the sink have same initial energy and through the network, sink directly send the data. In this nodes sense the medium continuously, but in a less frequent manner the data transmission is made. TEEN uses the same strategy of LEACH to form the cluster and the network of TEEN consists of simple nodes, called first level cluster heads and second level cluster heads. First level cluster heads are formed far away from the sink and second level cluster heads are formed nearer to the sink. A cluster head sends two types of data to its neighbors-one is Hard Threshold (HT), and other is Soft Threshold (ST). IN HT, the nodes transmit data if the sensed attribute is in the range of interest and the occurrence of transmission is reduced. IN SH, any small change in the value of the sensed attribute is transmitted. The Sensed environment stores all the value of sensed data for transmission. Based on Threshold the nodes send the data for transmission. The drawbacks are, for data transmission a node has to wait for their time slots. Again if the node does have any data to transfer the time slot may be wasted. Cluster heads always wait for data from nodes by keeping its transmitter on.

Hybrid protocols like Adaptive periodic TEEN (APTEEN) [3] incorporate both proactive and reactive protocols. APTEEN was proposed by Manjeswar and Agarwal. It was developed for hybrid networks and captures both periodic data collection and reacts to time critical events. In this first we have to decide the cluster head (CH), and in each round CH broadcast the following parameters: Attributes, Thresholds, Time schedules and count time. APTEEN allows the user to set threshold values and also interval of the count time. If the data does not send by the node for the time period equal to the count time, then APTEEN forced to sense and retransmit the data thus maintaining energy consumption. Since we can compare proactive and reactive with hybrid protocol which depends on the count time and threshold value. The drawback in APTEEN is the requirement of additional complexity to implement the threshold function and count time measurements.

Lindsey and Raghavendra proposed optimal chain-based power efficient protocol called PEGASIS [4] (Power Efficient Gathering Sensor Information System). It is based on LEACH. In this protocol all the nodes have the capability of transmitting data to the sink directly and each node has the information about all other nodes. Here we assume that all the sensor nodes have the same level of energy and they are dying at the same time. Chain creation is started at a node far from sink because all nodes are fixed and each node has a global knowledge of the network. Each node sends and receives data from the closest node of its neighbors. The nodes use the signal strength to measure the distance from the neighbor and adjust the signal strength to locate the closest node of its neighbor. To make a communication in both sides the node passes token through the chain to leader. While constructing the chain node fuses data with their own data. From the chain the node randomly choose the node to transmit the aggregated data to the sink. The path to the sink was constructed by chain which consists of those nodes that are closest to each other. The data which is in the aggregated form is send to the sink by the leader. By this way PEGASIS outperforms LEACH by eliminating the overhead of dynamic cluster information, minimizes the sum of distances and limits the number of transmission. The drawbacks of these protocols are at any time each node requires the global knowledge about the network.

3. EXISTING ROUTING PROTOCOLS

Routing in wireless sensor networks differs from conventional routing in fixed networks in various ways. There is no infrastructure, wireless links are unreliable, sensor nodes may fail, and routing protocols have to meet strict energy saving requirements. Many routing algorithms were developed for wireless networks in general. Huseyin and Korpeoglu purpose a new minimum spanning tree based protocol called PEDAP (Power Efficient Data Gathering and Aggregation Protocol) and its power-aware version (PEDAP-PA) [5]. In PEDAP the system provide good lifetime for the first node and for the last node it prolongs the lifetime, whereas its power-aware version decreases the lifetime of the last node and also provides near optimal solution for the first node. Similar to PEDAP-PA another algorithm was proposed by Hussain and Islam called EESR (Energy Efficient Spanning Tree Based) [6] multipath routing protocols, but ithas some advantages over PEDAP-PA. If the network is dense, EESR gives better lifetime using small number of routing trees. Huseyin and korpeoglu proposed localized, self-organizing, robust protocol called L-PEDAP (Localized Power Efficient Data Aggregation Protocol) [7].

3.1 *Power Efficient Data Gathering and Aggregation Protocol and its Power-Aware Version*

PEDAP is a new Centralized routing protocols. Compared to LEACH and PEGASIS, PEDAP achieves improvement in network lifetime. The defined constraint of sensor nodes 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 are various models for sensor networks. In this work we mainly consider a sensor network environment where:

- Sensor nodes and sink are stationary.
- If data wants to send then the node periodically senses its nearby environment.
- Sensor nodes are homogeneous and energy constrained.
- Data fusion or aggregation is used to reduce the number of messages in the network. We assume that combining n packets of size k results in one packet of size k instead of size nk.

In PEDAP the packet routes is based on Minimum cost spanning Tree (MST), which improves the lifetime of the system and node energy is directly related to it degree and the distance to its parents. In single round PEDAP takes minimum amount of energy. Additionally the authors propose a new version of power-aware called PEDAP-PA. It computes remaining energy of the sender using cost function.

$$c_{ij(k\ )} = \frac{2*E_{elec}*k+E_{amp}*k*d_{ij}^{2}}{e_i} \qquad (1)$$

$$c_i^{\iota}(k) = \frac{E_{elec}*k+E_{amp}*k*d_{ib}^{2}}{e_i} \qquad (2)$$

Where C_{ij} is the transmission between node i and j. C'_{i} is the cost between node i and the sink. d_{ij} is the cost transmission between node i and j. d_{ib} is the distance between node i and the sink. The energy dissipation of the radio in order to run the transmitter or receiver circuitry is equal to E_{elec} =50nJ\bit, and to run the transmit amplifier it is equal to E_{amp}=100pJ\bit\m2. Since C'_i is smaller than C_{ij} when the term with E_{amp} is much smaller than the term with $E_{elec.}$ From Equation (1) and (2) the advantage is overall lifetime and it increases the number of transmissions to the sink.

PEDAP extends the lifetime of the last node by minimizing the total data gathering in each round where as PEDAP-PA balances the energy consumption among the nodes. Edge cost is computed as sum of transmission and receiving energy in PEDAP. In PEDAP-PA considering the cost by dividing PEDAP edge cost with transmitter residual energy. The disadvantages of PEDAP and PEDAP-PA are however centralized in nature. This scheme is focusing only Shortest Path. It fails to achieve Bandwidth Utilization.ie, it unable to improve the Resource Utilization load; it recomputed the routing tree after a predefined number of rounds. In PEDAP and PEDAP-PA Edge weight assignment is calculated with only transmitters' residual energy. This is the major drawback to improve the reliability of the system.

3.2 *Energy Efficient Spanning Tree Based Multi-Path Routing Protocol*

In EESR edge weight assignment considers both transmitters and transceivers remaining energy levels. With the edge weights they use, the algorithm to prevent transmitters and transceivers from being overloaded, but in PEDAP and PEDAP-PA edge weight assignment is computed for only transmitter's residual energy. In this routing tree construction is based on kruskal algorithm [8]. This algorithm works when the node is in same transmission range and can communicate directly with the sink. The Routing Tree Generation Algorithm is given below:

```
Procedure Routing Tree ($V$, $N$)
$S \leftarrow V$/* Initialize all the variables */
List $A \leftarrow \varphi$
for each $i \in S$ do
    $parent[i] \leftarrow nil$
    $child[i] \leftarrow \varphi$
    $root[i] \leftarrow i$
    $rank[i] \leftarrow 0$
    $weight[i] \leftarrow \varphi$
end for
while $S$ _= $\varphi$ do
    $i \leftarrow ExtractMin\ (S)$
    for each neighbor $j \in N[i]$ do
        $weight[i] \leftarrow weight[i] \cup weight_{ij}\ (k)$
    end for
    $j \leftarrow getp\ arent\ (weight[i])$
    $parent[i] \leftarrow j$
    $child[j] \cup i$
    $UNION\ (i, j)$
    $A \leftarrow A \cup i$
end while
return $A$
```

In this above algorithm the inputs are the sensors list V, neighbor information for each node is containing in matrix N. This parameter returns a sensor list A. S is the priority queue which is keyed by current energy level of nodes. The Parent[i] Field directs a node to whom it should forward its data. The field Child[i] keeps information about the incoming packets into node i in a routing tree. To prevent the cycle in the tree Rank[i] and Root[i] fields are used. The Root[i] holds the information about root in which i is added. Parent[i], Root[i] and Rank[i]is used to create disjoint sets where each node is the only member of its set. The while loop constructs is used to create the routing tree until list S becomes empty. weight[i] ← weight[i] ∪ $weight_{ij}$ (k) is used to calculate the lowest energy node i and it is removed from S. The neighbor list of node i contained in the field N[i]. The getparent[i] procedure returns a node to which i should forward the data to save energy. Parent[i] field is updated when the parent of the lowest energy node is computed once. The child information of the parent node j is also updated by adding node i into child[j]. Next, UNION operation is performed for the weakest node i and its parent node j which are linked in the same tree. Similarly root [] and rank [] fields of both nodes i and j is updated. Finally in resulting list A the weakest node i is added. The procedure repeats with the next weakest node in the network. The parent selection algorithm is discussed below:

```
Procedure getparent (weight[i])
    j ← ExtractMax (weight[i])
    while findSet (i) = findSet (j) do
    j ← ExtractMax (weight[i])
    end while
    return j
```

In the above algorithm the ExtractMax (weight [i]) operation selects an edge that will leave maximum possible residual energy in node i and its neighbor. The findset (i) operation checks whether the selected edge creates cycle which is identical to kurskals algorithm. To minimize the number of generated tree, Hussain [6] proposed to use each routing tree for fixed rounds. To evaluate each routing tree and computation of appropriate frequency of that tree the adaptive formula was proposed. Once routing tree algorithm generates a tree T, and then the frequency of the routing tree is computed as follows:

$$F(T) = \min\left(\frac{e_i}{Load_i}\right) * 0.10 + f(T) + balanceFreq \quad (3)$$

In this formula (3) the residual energy of sensor ‘i’ is represented as e_i. The term min $\{e_i / Load_i\}$ ensures the frequency of a routing tree less than critical lifetime of that tree. A critical lifetime defines the maximum possible number of rounds using the tree. The critical lifetime is 10% so that sensors have enough lifetimes in the next routing tree. The term balancefreq represents the required number of rounds when the energy of the most powerful node will be equal to that of the weakest node and is defined as:

$$balancefreq = \left| \frac{e_{\max} - e_{\min}}{Load_{\max} - Load_{\min}} \right| \quad (4)$$

In this calculation (4) e_{max} and $Load_{max}$ represents the residual energy and load of node i, whose e_i and $Load_i$ is maximum. Similarly, e_{min} and $Load_{min}$ represents residual energy and load of a node with min ($e_i \backslash Load_i$). So, balancefreq balances the energy between the most powerful and weakest node in the network.

3.3 Localized Power Efficient Data Aggregation Protocol

In L-PEDAP Huseyin and korpeoglu tries to combine the feature of Minimum Spanning Tree (MST) and shortest weighted path gathering algorithm. PEDAP also focused a new family of localized protocols for the power-efficient data aggregation problem. The main concern of this work was the lifetime of the network. This consists of two phases: In the first phase, it computes a sparse topology and in second phase, it computes a data gathering tree over the edges of the computed sparse topology. In the first phase we have two different topologies namely Local Minimum Spanning Tree (LMST), Relative Neighborhood Graph (RNG).LMST is an alternative topology of a neighborhood structure proposed by Li, Nou, and Sha [9]. In computation of LMST first each node represents its one-hop neighbors and computes an MST for that set of nodes, which is based on the distance between nodes as the weight of the edges. After computing the neighbors of the MST, each node i selects the edges (e_{ij}) where node j is a direct neighbor of a node i in its MST. The resulting structure is a directed graph. In RNG an edge e_{ij} is included in the Euclidean RNG Graph if there are no nodes closer to both nodes i and j than the distance between nodes i and j. The Euclidean graph is the sub graph of its RNG.

The second phase provides three different methods and their performance results of them. The methods which are proposed in second phase are based on flooding a special packet using only the edges of the computed structure. The tree is yielded according to the decision made in the flooding process. The methods are three and that can be executed at a node for choosing the parent node toward the sink is to choose: 1.The first node from which the special packet is received. 2. The node that minimizes the number of hops to the sink, and 3.The node that minimizes the total energy consumed over the path to the sink.

In general to obtain a tree structure in a given graph several methods are used. But in L-PEDAP a flooding-based tree construction algorithm is used. In this a special route discovery packet is broadcasted by the sink, and when a node receives that packet, it decides its parent according to the information available in the packet. The node rebroadcasts the packet after selecting the parent. In this the authors investigated the efficiency of three different route discovery methods:

- **First Parent Path Method (FP):** A node will set its parent as the first neighboring node from which the special route discovery packet was received.
- **Nearest Minimum Hop Path Method (MH):** The node chooses its nearest neighbor among those with minimum

hops to reach to the sink.

- **Shortest Weighted Path Method (SWP):** The SWP method tries to yield a tree that minimizes the cost of reaching the sink for each node.

In L-PEDAP routing scheme is computed the topology that each node has to know its all one-hop neighbors and their locations. The routing scheme consists of three parts: Route Computation, Data Gathering and Route Maintenance. In route computation topology is created. In this, the goal is to find sparse topology and set up the routes for it, which means representing the children and parent nodes for each node. The pseudo code for Topology and Route Computation is given below:

```
Send HELLO message
 Collect HELLO messages for $t_{hello}$
 Reset Parent ($\pi \leftarrow$ null)
 Compute neighbors on the sparse topology
 while ROUTE-DISCOVERY packet RD received in $t_{discovery}$ do
 if update require for RD then
 Update parent ($\pi \leftarrow$ source (RD))
 Broadcast ROUTE-DISCOVERY
 end if
 end while
 inform $\pi$ to construct its child-list
```

Initially, the sink and node are not aware about its environment. In the setup phase, all nodes and the sink broadcast HELLO messages, which include their location and remaining energy, using their maximum allowed transmit power. The remaining energy level is advertised only when dynamic (power-aware) protocols are used. We give a time threshold t_{hello} for waiting advertisements, which must belong enough to hear all possible advertisements. After receiving HELLO messages, all nodes are informed about their one-hop neighbors and their locations and energy levels. Each node can then locally compute its neighbors in the desired sparse topology (static and dynamic versions of RNG and LMST). After finding its neighbors in the sparse topology, a node can join the distributed route computation process in order to find its parent and children on the aggregation tree. In route computation data gathering and communication, route recomputation, node failure and node addition is also performed.

In the route recovery algorithm, when a node's energy reduces below threshold value, the node broadcasts a BYE message using maximum allowed transmit power. All nodes receiving the BYE message will immediately update their local structure. In this case the nodes cannot reach sink because of the energy deplete their ancestor must find a new cost efficient path to send their packets. The Route Recovery algorithm is given below:

```
$\pi_{old} \rightarrow \pi$
**if** BYE message B received **then**
remove source (B) from neighbor list
compute the sparse topology
 **if** source (B) = $\pi$ **then**
 Reset Parent ($\pi \leftarrow$null)
 Reset child list
 Broadcast PARENT-DISOVERY message
Enter route discovery phase
**End if**
 **End if**
 **if** PARENT-DISCOVERY message PD received then
 **if** source (PD) = $\pi$ **then**
 Reset parent ($\pi \leftarrow$null)
 Reset child list
 Broadcast PARENT-DISCOVERY message
 Enter route discovery phase
 **else**
 **if** $\pi \neq$ null **then**
 Send ROUTE-DISCOVERY
 **end if**
 **end if**
 **end if**
 **if** $\pi \pm \pi_{old}$ **then**
Inform $\pi_{old}$ and $\pi$ to construct their child-list
**end if**
```

The result of this handled in a local manner as follows: The child nodes of the failed node that receive the BYE message and reset their routing tables and enter the PARENT-DISCOVERY phase by broadcasting a special packet to its neighbor on the structure. According to the receiver of that special message, and if the sender is its own parent on the way to the sink, the receiver also resets its routing table and broadcasts the packet to its neighbors. By this way all the nodes that should enter the PARENT-DISCOVERY phase will be reached. If the PARENT-DISCOVERY packet is received by a neighboring node of the sender and if it is a valid parent, the receiver constructs a new ROUTE-DISCOVERY packet and broadcasts it to the sender. After the ROUTE-DISCOVERY phase converges, the new routes are set up and data gathering can continue. So the features of L-PEDAP are robust, scalable, and self-organizing. This algorithm is appropriate for systems where all the nodes are not in direct range of communication of each other. Finally L-PEDAP outperforms the shortest weighted path-based approach, and achieves 90% of lifetime.

4. PERFORMANCE ANALYSIS OF VARIOUS ROUTING PROTOCOLS

In this section, various routing protocols namely PEDAP, PEDAP-PA, EESR and L-PEDAP have been implemented. To compare these protocols, our work has considered various parameters such as Communication Time, Energy Consumption, and Residual Energy. The experimental Execution set up is shown in the Figure 2 and all the above said Routing Protocols have been studied thoroughly.

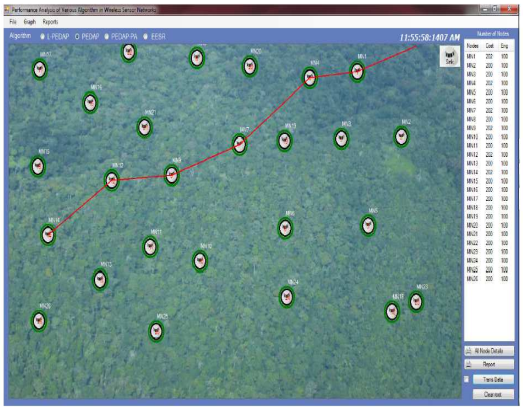


Figure 2. Execution scenarios' of various Routing Protocols

From the figure 3, it is identified that PEDAP-PA has some advantages over PEDAP because in PEDAP-PA the energy level is calculated for sender's residual energy after transferring the packets from source to sink. But when compared to EESR and L-PEDAP, PEDAP-PA fails to calculate receiver's residual energy.

From the Figure 4, it is observed that PEDAP is performing well in term of Communication Time as compared with PEDAP-PA, EESR and L-PEDAP routing Protocols. It is because, PEDAP focuses only shortest path and doesn't focus the Energy Level of each node i.e. PEDAP fails to concentrate Resource Reliability. This major drawback leads to network performance degradation in terms of Bandwidth Utilization.

From the Figure 5, it is identified that both the L-PEDAP and EESR have been performing better as compared with PEDAP and PEDAP-PA in terms of Residual Energy for forwarding Packets. It is also would like to state that although EESR and L-PEDAP residual energy is same, L-PEDAP is better one for reliable routing because it has the feature to identify the node failure, which could recover the node immediately. EESR doesn't have this mechanism and hence EESR can't provide Reliable Communication. From the figure 6, it is observed that EESR and L-PEDAP is consuming more energy than PEDAP and PEDAP-PA because both EESR and L-PEDAP is calculating both Source and Sink energy to find the best node for communication.

It is also noted that PEDAP is consuming less energy to find the route. But however, it fails to provide reliable communication and hence we can't use PEDAP for Reliable communication in Wireless Sensor Networks.

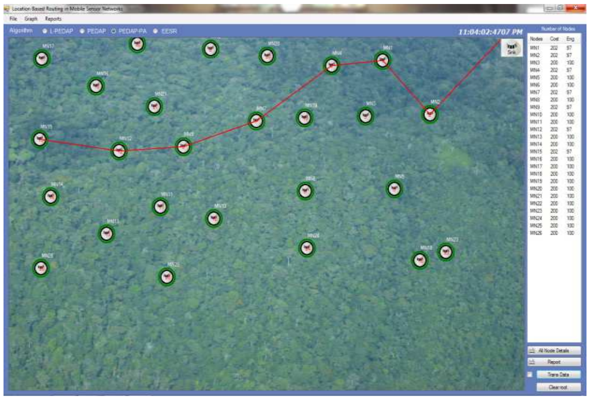


Figure 3. Execution scenarios' of PEDAP-PA

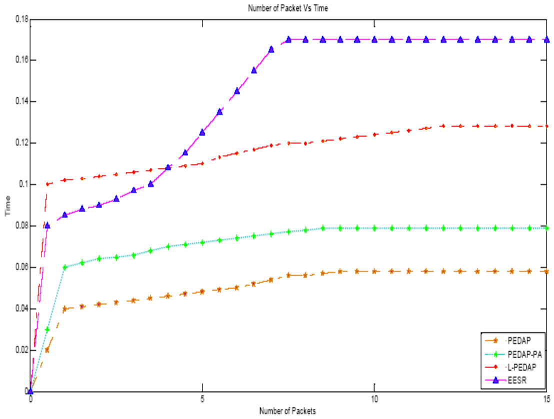


Figure 4 .Number of Packets Vs

The Routing Scenario of L-PEDAP is shown in the Figure 7 and Figure 8. From the Figure 7, it is noted that the L-PEDAP is measuring the residual energy before finding the best route for communication. If any one of the nodes energy is less than the threshold level, this L-PEDAP will find the alternate best route for communication, which is shown in the Figure87. As shown in the Figure 8, the yellow colored nodes are used for communication earlier by L-PEDAP and it finds the alternate path as previously used nodes for communication reaches the threshold level.

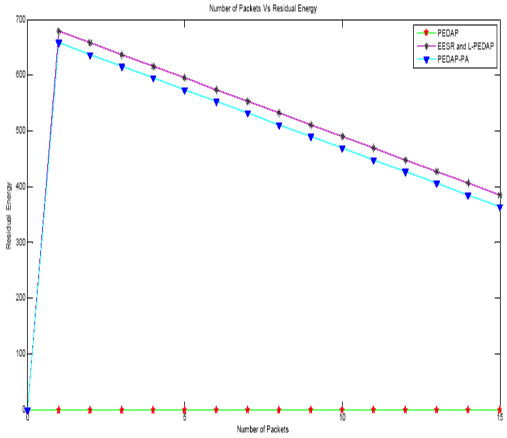


Figure 5 .Number of Packets Vs Residual energy

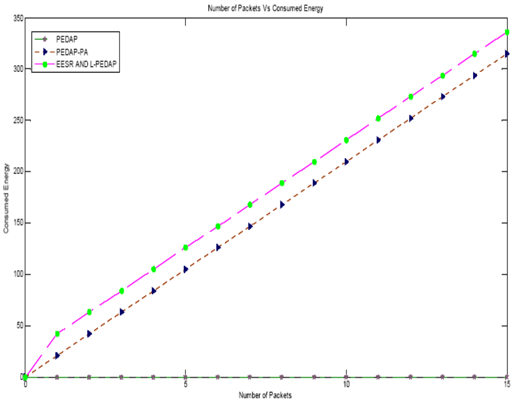
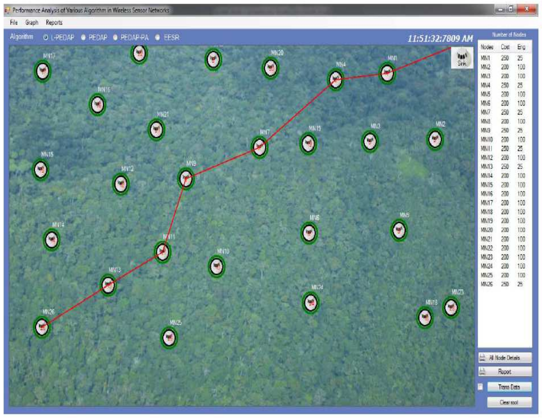
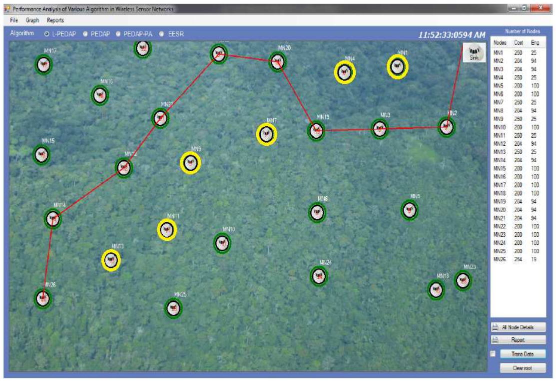


Figure 6 .Number of Packets Vs Consumed energy



Nodes	Cost	Eng
MN1	250	25
MN2	200	100
MN3	200	100
MN4	250	25
MN5	200	100
MN6	200	100
MN7	250	25
MN8	200	100
MN9	250	25
MN10	200	100
MN11	250	25
MN12	200	100
MN13	250	25
MN14	200	100
MN15	200	100
MN16	200	100
MN17	200	100
MN18	200	100
MN19	200	100
MN20	200	100
MN21	200	100
MN22	200	100
MN23	200	100
MN24	200	100
MN25	200	100
MN26	250	25

Figure 7 .Node reaches to Threshold value



Nodes	Cost	Eng
MN1	250	25
MN2	204	94
MN3	204	94
MN4	250	25
MN5	200	100
MN6	200	100
MN7	250	25
MN8	204	94
MN9	250	25
MN10	200	100
MN11	250	25
MN12	204	94
MN13	250	25
MN14	204	94
MN15	200	100
MN16	200	100
MN17	200	100
MN18	200	100
MN19	204	94
MN20	204	94
MN21	204	94
MN22	200	100
MN23	200	100
MN24	200	100
MN25	200	100
MN26	254	19

Figure 8. Alternate routing by L-PEDAP

I.e. if the energy level of any node's energy is less than the threshold value it will automatically re-route the packet to the destination by means of alternate route, which is also shown in the Figure 7.

The node MN13 reaches the minimum threshold value of 25, so that L-PEDAP identified the alternate route MN14 to forward the data from source to destination.

With this Smart Mechanism, L-PEDAP is established Reliable Communication and also achieved both Resource and Bandwidth Utilization. However, L-PEDAP Communication Time is more as compared with that of PEDAP.

5. CONCLUSION

The Wireless Sensor Networks are purely depends on battery power. There are several algorithms have been proposed to address Reliability, Bandwidth Utilization, Resource Utilization, Dynamic Routing and Shortest Path. This work evaluated and analyzed various Routing Protocols, namely Power Efficient Data Gathering and Aggregation Protocol(PEDAP), Power Efficient Data Gathering and Aggregation Protocol-Power Aware(PEDAP-PA), Energy Efficient Spanning Tree approach(EESR), and Localized-Power Efficient Data Gathering and Aggregation Protocol(L-PEDAP). From our experimental results, it is established that L-PEDAP outperforms PEDAP, PEDAP-PA and EESR in terms of Bandwidth and Resource Utilization and Communication Reliability. However, L-PEDAP does fail to minimize the Energy Consumption and Communication Time. The PEDAP achieves less Communication Time to forward packets to destination. However, it fails to achieve Power-Aware Reliable Communication. This work would like to conclude that for faster communication, PEDAP could be used and for reliable communication with high bandwidth utilization, L-PEDAP is the best Routing Protocol in Wireless Sensor Networks.

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AUTHOR PROFILES

Priyadharshini.N. received Bachelor of Computer Application from Bharathidasan University in 2008 and Master of Computer Application from SASTRA University in 2010. Now she is currently working as an Assistant Professor, School of Computing, SASTRA University, Tamil Nadu, India. She is interested in the area of Wireless Sensor Networks, Networking, and Data Mining.

Subasree. S. received the Ph.D., Degree in Computer Science from SASTRA University, Tamil Nadu, India in 2006. She is currently a Associate Professor with School of Computing, SASTRA University, Tamil Nadu, India. Her research interests include Next Generation Networks, Active Queue Management Scheme, High Performance QoS Routing, Wireless Sensor Networks, Bioinformatics and Computational Biology, Semantic Web Services, Data Mining and their Applications. She is the member of Computer Society of India(CSI), India, Advanced Computing and Communication Society, Bangalore. she has published more than 15 Technical Papers in International Journals and Conferences