PEGASIS in Heterogeneous Environment To Improve Network Lifetime

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Abstract- **Wireless sensor network is made of sensor nodes which senses the data like temperature, humidity etc. from the environment and communicate with each other for the particular task. Sensor nodes are heart of the network. Because of scarce resources, energy consumption and battery lifetime is crucial aspects in WSN. Modified routing protocols help to improve the conventional routing protocols. The main goal is to improve network life time and conserve energy by modifying conventional protocol. Power Efficient GAthering in Sensor Information System (PEGASIS) is an improvement of hierarchical protocol in which chain is constructed in between nodes and data is transmitted towards sink via this chain. The center of the protocol is to make network energy efficient. The paper is followed by introduction of PEGASIS, problem statement and proposed PEGASIS scheme and analysis and simulation in order to improve the performance.**

Keywords: Wireless Sensor Network, PEGASIS, Energy, Network Lifetime.

I. INTRODUCTION

The wireless sensor network (WSN) consists of hundreds or thousands of sensing nodes to sense, compute, store and transfer the data from source to destination. WSN came into picture in military and heavy industrial area. The first wireless sensor network was the Sound Surveillance System (SOSUS), developed by the United States Military in the 1950s. It is developed to detect and track Soviet submarines. This network used submerged acoustic sensors – hydrophones – distributed in the Atlantic and Pacific oceans. This technology is still exist. Other applications of WSN are like undersea wildlife and volcanic activity.

The heart of any WSN lies in the sensors. From the last few years advancement can be seen in multiple sensing technologies:

- Micro electro mechanical systems (MEMS)
- CMOS-based sensors
- LED sensors[1]

What is WSN :

- Provide a bridge between the physical and virtual worlds.
- Allow the ability to observe the unobservable at a fine resolution over large scales
- Have a wide range of potential applications

A. Topologies

Following topologies are used in WSN:

- One-way communication
- Bi-directional
- Star topology
- Mesh topology

One way communication was first and basic protocol, for example applications like, tire pressure monitoring systems and television remote controls. Due to need of the network advancement in topologies came into picture, networking engineers developed low-memory protocols for bi-directional, star and finally mesh technologies. In addition, the industry is making the transition from proprietary to standardized protocols, networking protocols such as Zig-Bee and its variants removes the burden of continuous development costs and frees.

There are some challenges listed below:

- Node deployment
- Energy Consumption with accuracy
- Node Heterogeneity
- Scalability
- Network Dynamics
- Connectivity
- Coverage
- Data Aggregation
- Quality of Service

II. INTRODUCTION TO PEGASIS

The PEGASIS is hierarchical cluster based routing protocol. It is a near optimal chain-based protocol. Because of limited battery power, it is compulsory to increase network lifetime. For communicating, nodes need only to communicate with their closest neighbors and send data to the BS. To increase network lifetime basic radio model is used. Transmit to and receive from formula of radio model are respectively as follows:

$$E_{TX}(k,d)=E_{elec}*k+Eamp*k*d^2$$

Where,

k is a bit message at distance d[9]

$E_{RX}(k)=E_{elec} * k$
Where,
$E_{TX\text{-}elec}$=Transmitter Electronic
$E_{RX\text{-}elec}$=Receiver Electrionic
$E_{TX\text{-}elec}=E_{RX\text{-}elec}=E_{elec}$
$E_{TX\text{-}elec}$=50nJ/bit

PEGASIS has two main objectives:

1. Reduce energy consumption per data transceiver and increase the network lifetime.
2. Pass the data only to the neighboring node so the bandwidth consumption in the network is reduced.

Working of PEGASIS

Conventional PEGASIS has same characteristics as LEACH protocol. First of all it uses a node in a chain to transmit to the sink to avoid redundancy. With help of this time and energy consumption can be reduced. To get the information about closest neighbor node, each node uses the signal strength to measure the distance to all neighboring nodes. After adjustment of the signal strength only one node can be heard. The chain will constructed between farthest node from the sink node to closest node to the sink. For example following figure shows node 0 connecting to node 3, node 3 connecting to node 1, and node 1 connecting to node 2 in that order. When a node dies, the chain is reconstructed in the same manner to avoid the dead node. After completion of communication round of each CH to BS, a new round will start. This process follows until network dead. It reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes.[6]

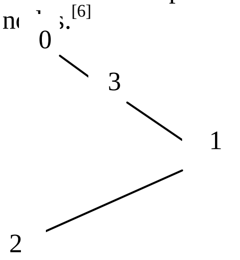


Figure1. Chain construction [6]

For data gathering, in each round, each node receives data From one neighbor, fuses with its own data, and transmits to
the other neighbor on the chain. Here, token passing approach is used which is initiated by the leader to start the data transmission from the ends of the chain. If token size is small, the cost to transmit data is small. In Figure 2, node c2 is the leader, and it will pass the token along the chain to node c0. Node c0 will pass its data towards node c2. After node c2 receives data from node c1, it will pass the token to node c4, and node c4 will pass its data towards node c2.

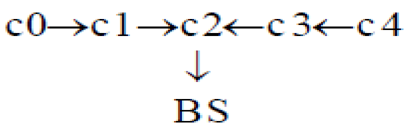


Figure 2. Data aggregation [6]

PEGASIS is able to increase the lifetime of the network 2x as much the lifetime of the network under any other hierarchical protocol. The clustering overhead is avoided; PEGASIS still requires dynamic topology adjustment. A sensor node needs to know all the information of its neighbors in order to know where to route its data. Such topology adjustment can introduce significant overhead especially for highly danced area. Furthermore, Conventional protocol assumes that each sensor node can be able to communicate with the BS. But in this protocol Only a nearer node can transmit the data to the base station (BS). Sensor nodes use multi-hop communication to reach to the base station. It also assumes that all nodes maintain a complete database about the location of all other nodes in the network. PEGASIS assumes:

- all sensor nodes have the same level of energy and they are likely to die at the same time.
- sensors will be fixed or immobile, some sensors may be allowed to move and hence affect the protocol functionality.

III. PROBLEM STATEMENT

PEGASIS is a near optimal chain-based protocol. The basic idea of the protocol is to extend network lifetime. Nodes need only communicate with their closest neighbors. And finally data will be send to the base station (BS). When the round of all nodes communicating with the base-station ends, a new round will start and so on. This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes.

As previously discussed the PEGASIS mainly works in the scenario like nodes have same properties or characteristics. It means the nodes are homogeneous. So it is so easy to maintain this kind of homogeneous environment. But with the help of heterogeneous nodes, energy consumption can be reduced and time can be saved . It is somehow complex to maintain.

IV. IMPROVED PEGASIS

PEGASIS is an extension over other hierarchical protocol. It uses cluster formtion to transmit the data from source to destination. Till now PEGASIS protocol is only for homogeneous environment. So new improvement on PEGASIS: PEGASIS for heterogeneous environment is proposed.

Improved PEGASIS has following assumption has been made:

- The heterogeneity of environment is defined on energy level and battery to be used.
- Radio channel is symmetric.
- Two type of node for heterogeneity, type A is for CH and type B for its member.
- Solar cell are used as battery support for TypeA nodes while AA battery is used for TypeB
- Nodes are static.

All the operation are divided into two rounds.

- Set-Up phase (cluster formed)
  - Cluster head selection
  - Cluster Formation.
- Steady-state phase (cluster operation)

It divides the whole network into several clusters, and time of network is divided into many rounds. In each round, the nodes in a cluster formed to be cluster head according to the random number selection. In this protocol, two different type of nodes are there. Both are different based on the energy level. Only typeA node can be take part in the cluster Head (CH) formation. This makes the nodes in the network consume energy in a relatively balanced way so as to prolong network. TypeB node can be worked as a member node. This is the important aspect of improved PEGASIS. Here basic radio model is used to energy conservation which is the first order radio model. In this model, a radio dissipate E_{elec} = 50 nJ/bit to run the transmitter or receiver circuitry [6]. The radios have power control and can expend the minimum required energy to reach the intended recipients. The radios can be turned off to avoid receiving unintended transmissions. With the help of random number selection cluster head can be selected. This process can be follows until the network will dead. There are two important aspects of conventional PEGASIS. One is chain construction and another is data aggregation as respected above. After this, the heterogeneous network can be shown like this.

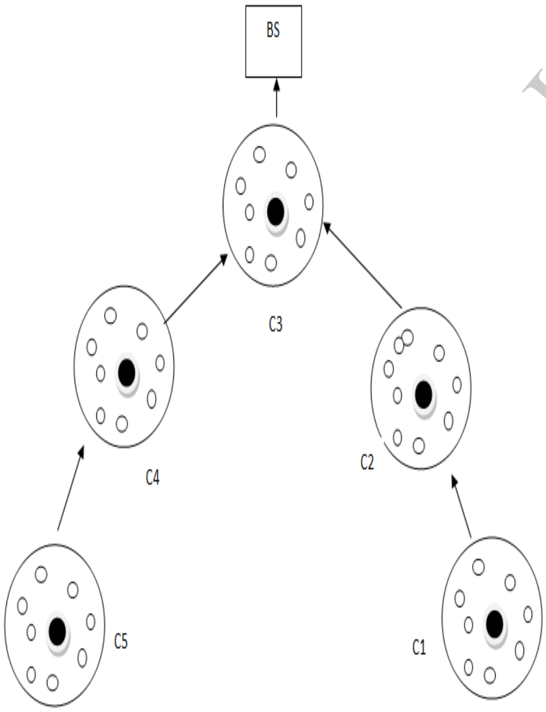
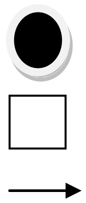


Figure 4.1 PEGASIS heterogeneous environment



Cluster Head (CH)

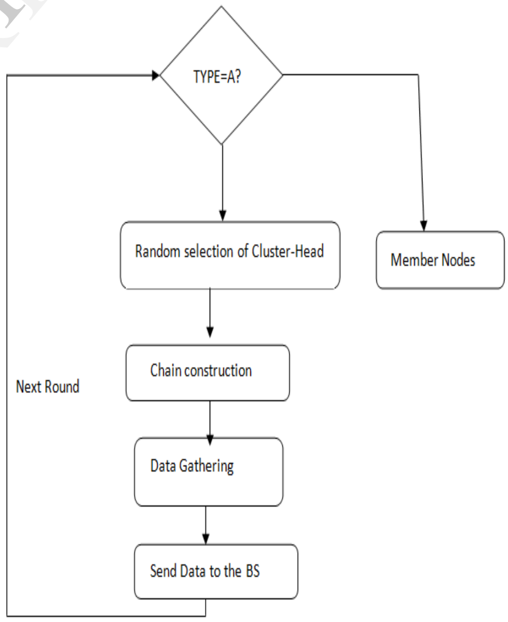
Base station

Data passing Direction

As shown in figure 4.1 there are five clusters and a base station. At first CH selection will be processed and the process is random. Next chain will be constructed. Then the cluster head which is nearer to the base station will be selected as a leader. The next step is passing token which requires energy consumption but cost of passing token is very small because token size is very small. As per algorithm, C3 will be selected as leader. C3 will pass token along the chain to CH1. CH1 will pass the data to CH2. CH2 will aggregate the data and pass it to the CH3. Now further CH3 will pass token along the chain to the CH5. CH5 will pass its data to CH4.CH4 will aggregate the data, and further pass the data to CH3.CH3 will fuses the data and send it to the BS. Each node will fuse its neighbor's data with its own to generate a single packet of the same length and then transmit that to its other neighbor.

V. SIMULATION AND SOLUTION

Following flow chart and algorithm are proposed to give difference between conventional PEGASIS.



Algorithm:
Following parameter is used in this protocol:

P=probability of node participating in cluster-head formation
N =number of nodes
type A=nodes containing solar battery
type B=nodes containing AA
ran= random number
I,j= neighbor node
disFromSink= distance From sink;

1. If(typeA) then,
2. ran is generated by random function
3. If(ran<p)
4. Select as Cluster-Head(CH) then,
5. Broadcast advertisement message
6. Other node will join to cluster head is based on RSSI value.

Algorithm for chain construction:

1. If(isCH) then
2. If(distFromSink(i)<disFromSink(j)) then
3. Send join message to cluster-Head i
4. Else
5. Send join message to cluster-head j

Simulation Parameter	
Variable name	Value
Radio dissipation (E_{elec})	50 nJ/bit
Initial energy (E_{init})	0.5 J, 1.0 J
Sensed field (M_2)	100m × 100m
Number of sensing nodes (N)	100 nodes
Based station location (X ,Y)	(25,150)

To evaluate the performance of PEGASIS, Castalia tool has been used. It gives scenario like that fits to the real world. We used OMNeT++ as the base to build a reliable and fast event-driven simulator. There are some features of castalia like: uses advanced model to measure sensed data, used advanced radio model and node clock drift. The following graph has been generated which shows the comparison of the proposed PEGASIS and the PEGASIS that is proposed in [6]. The results shows no of rounds in which 1%, 20%,50% and 100% dies respectively. The initial energy is 0.5J/node and 1.0J/node. Based on this the result shows with the graph.

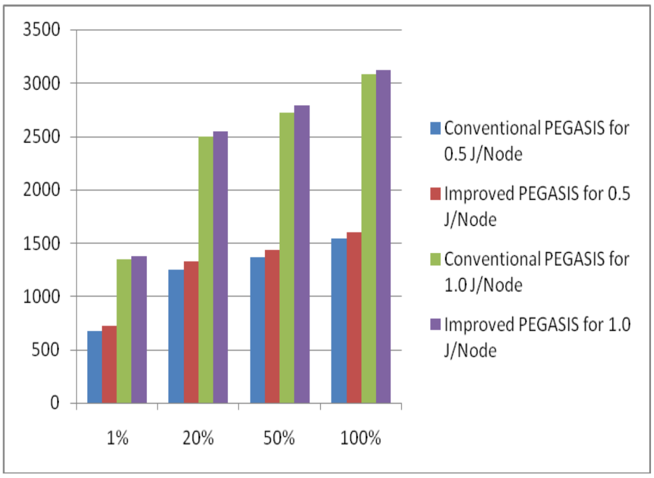


Figure 5.1 network lifetime between conventional and improved PEGASIS based on dead node

VI. CONCLUSION

The protocol that is proposed in this paper, uses greedy chain construction and data gathering approach, there by provides near optimal solution. It provides the solution of load balancing so energy consumption is less. It gives the solution of data redundancy. The quality of network is improved using this protocol. The simulation results shows that proposed PEGASIS is far better than conventional PEGASIS. Due to all this, energy is conserved and network lifetime is improved.

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