ISSN:0975-9646

Comparative Analysis of Flooding and Gossiping in Wireless Sensor Networks Using SIR

Mukta Chandna
Department of Computer Science & Engineering
N C College of Engineering, Israna
Haryana, India

Bhawna Singla
Department of Computer Science & Engineering
N C College of Engineering, Israna
Haryana, India

***Abstract*— Wireless Sensor Networks consist of small nodes with sensing, computation and wireless communication capabilities. Routing in WSNs is a demanding task due to natural characteristics that differentiate these networks from other wireless networks like mobile ad hoc networks and cellular networks. Many routing protocols have been considered for WSN's where energy is always an important issue. The aim of this research is to overcome the drawbacks of flooding based routing algorithm by proposing a gossiping based routing algorithm that is SIR: source initiative reactive algorithm. And by the help of this algorithm we will differentiate between flooding and gossiping.**

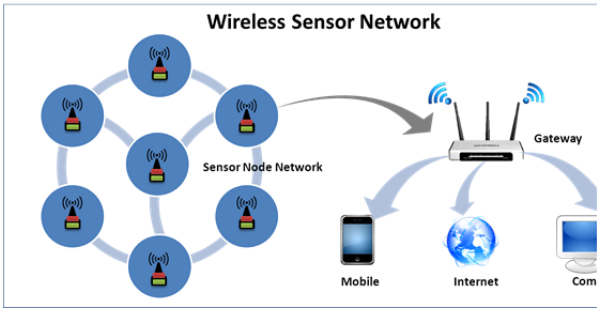
Keywords*—Wireless Sensor Networks, Source Initiated Reactive, Gossiping, Flooding.

I. INTRODUCTION

Advances in silicon technology have led to the development of next generation, low cost, low power, multifunctional, sensor devices. These devices communicate wirelessly to transmit their readings. They are called wireless sensors, which are compact devices and have the capabilities to integrate the communication data in a single chip. A Wireless Sensor Network can be defined as a network that consists of these low size and low complex devices called sensor nodes that can sense the environment and gather the information from the monitoring field and communicate through wireless links. A WSN can be made up by hundreds or thousands of these sensor nodes. A large number of these disposable sensors can be networked in many applications that require unattended operations. These sensor nodes have the ability to communicate with each other as well as with a base station. Each sensor node comprises of sensing, processing, transmission, mobilize, position finding system and power units [1, 2, 3, 4]. Figure 1 depicts the general architecture of wsn.

Sensor nodes are usually scattered in a sensor field. They have to capture the data and do routing to other nodes or back to base station. The base station can be fixed or a mobile node. The sensor nodes can be deployed in various ways. It can be done randomly i.e. dropped from an airplane or it can be done regularly i.e. well planned and fixed or mobile sensor nodes can be used. The objective is to yield accurate information about the environment. Sensor nodes make their decisions on certain parameters like its task, theinformation it currently has, communication range, and energy resources.

Primary task of a sensor nodeis to collectthe data and route the data to the base station. All of the nodesare not necessarily communicating at any particular time and nodes can only communicate with a few nearby nodes. The network has to follow a routing protocol for communication of data messages between the nodes. The routing protocol also attempts to get messages to the base station in an energy-efficient manner. [5]



Wireless Sensor Networks Architecture [17]

II. RELATED WORK

In Wireless Sensor Networks routing is always very challenging due to innate characteristic of that network which differs it from other networks like mobile ad hoc networks and mobile networks. The major task of WSNs has to capture the data available in environment and sent it for further processing. So algorithms have been proposed for that purpose [6, 7]. In flooding protocol, a node wishes to disseminate a piece of data across a network start by sending a copy of that data to all its neighbours. Whenever a node receives data it copies the data and send the data to other nodes. Except the node by which it just received the data. The amount of time it takes a group of nodes to receive some data and forward that data on their neighbours is called a round. Flooding is simple but it has problem of energy consumption and implosion. Gossiping also known as *Rumour Mongering* is an epidemiological protocol that implements broadcasting with a reliability that can be very high. Instead of indiscriminately forwarding the data to all its neighbours, a gossiping node only forwards data to one selected neighbour. Gossiping avoids implosion because only makes one copy of each message at any node. Gossiping distributes information slowly; it dissipates energy at a slow rate as well. [8, 9, 10, 11]
In case of reactive algorithm, the network may remain inactive until the communication process is triggered by

sensors whose data is ready to be sent. So the communication can be triggered only when an event is detected. The advantage is that no management or control traffic is required. A simple reactive algorithm called Source Initiated Dissemination i.e. SID is proposed. That is similar to Push Diffusion. SID allows source nodes to flood their data to available route, when an event is detected. Data will not be sent periodically as in push diffusion. [12]

Using standard gossip algorithms can lead to a significant waste of energy by repeatedly re circulating redundant information. The inefficiency of gossiping scheme is related to the slow mixing times of random walk on the communication graph. A new geographic gossiping algorithm has been proposed which is better than standard gossiping algorithms in terms of energy spent. [13] In a densely deployed wireless sensor network where the initiator of search is unaware of the location of target information. A new protocol Increasing Ray Search i.e. IRS is proposed. On the basis of performance metrics like number of transmitted and received bytes, energy consumed latency and probability of finding target information. IRS is better than gossiping protocol. [14]

III. SIR: SOURCE INITIATED REACTIVE

In this work, we will consider a simple reactive algorithm i.e. SIR (Source-Initiated Reactive). In SIR, gossiping is used instead of flooding. In this as an event is detected, source nodes gossip their data as long as a route is not available. It does not flood the data on event detection as Flooding algorithm prefers. This attribute makes SIR more reactive in the presence of dynamic network behavior, but more responsive in scenario where the traffic is enormous. [12] The SIR protocol works as follows:

- A source node that senses event or queried to broadcasts the sensed data. The node will send the data, its identification and a timestamp to random number of members.
- Receiver node will store source node identification, timestamp and the sender's identification. The receiver node will receive packets from n random number of neighboring nodes, but it will store and forward only the first received packet. So the amount of memory required to store the path is directly proportional to the network size.
- After the sink node receives data from random number of neighbors. It will consequently send a control message to initiate the data to be sent by the node which sensed the event. It will carry on until the sink receives the requested data.
- The backtracking will be followed by the control messages till the source node to send the sensed data is identified.
- After receiving the control messages, the source node will update the routing information so that it could send the data packets to the first node requesting it. The data is sent through the same path demanded by the sink.
- The request messages are sent by the sink periodically to the sources by which it is receiving the data. So that, the network could handle topological changes like node failures, mobility or node inclusion.
- This process keeps on proceeding if events are happening and sensing the data. After event completion, the source node will stop sending the data and the sink node stop demanding for the data. As it is SIR, the network will become idle again.

The contribution of this paper is:

- Outlining and Simulating SIR algorithm on Wireless Sensor Network.
- Comparing Flooding and Gossiping on the basis of SIR algorithm.

IV. ENERGY CONSUMPTION MODEL

The energy model [18] that we can use for SIR depends on the objective of minimization of energy, if an event occurs. The basic assumption is that the energy consumption is related with the exchange of control messages i.e. for deciding the route and exchange of data messages i.e. transfer of data sensed. The values of this energy consumption form source to the sink are collected and the calculations can be done on the basis of round of simulations as already done by researchers.

Total energy consumed at the end of a round can be analyzed by (1)

$$E_{total}=E_{data}+E_{control} \quad (1)$$

Where E_{total} is the total energy consumed by the network which is the sum total of energy spent on data dissemination and the energy spent by the sink node on sending the requisition messages. $E_{data}$is energy spent on data dissemination. $E_{control}$is energy spent by the sink node on sending the requisition messages.

Then we have an equation for analyzing the approximate energy consumed on data dissemination:

$$E_{data}=P_t\times D\times h+P_r\times D\times h \quad (2)$$

Where P_t is the transmission power measured in joules/sec and $P_r$is the reception power measured in joules/sec. D defines the size of data to be sent in data bytes. h is the no of hops that the data packet hops to the sink. n is the random number of neighbors selected to whom the data would be sent.

The equation for analyzing energy for requisition messages is:

$$E_{control}= [N_s*(P_t*D*h+P_r*D*h*n) + (P_t*C*h+P_r*C*h*n)]*(Td/Tc) \quad (3)$$

where N_s is the number of source nodes sending data, $T_d$and $T_c$are the average time duration for every source data and the sink's requisition messages interval (in seconds) respectively

V. Simulation And Analysis

In this section, comparative analysis of Flooding and Gossiping will be done. The SIR will be simulated in both the cases. MATLAB will be used as simulation tool. The parameters used for this purpose are Packet Delivery Ratio i.e. PDR, alive sensor nodes and energy consumed.

Steps

- To create a field with the help of nodes.
- Connect the node with the appropriate sink.
- Initialize the nodes with some energy.
- Algorithm will be implemented on network.
- Graphs will be the result of algorithm which will depict the difference between flooding and gossiping.

Performance Metrics and Evaluation

Packet Delivery Ratio: The key aspect of measuring the performance is packet delivery ratio.In a round, a number of packets can be transmitted. PDR is the number of packets successfully received by the destination. The graph depicts the performance of gossiping and flooding. By the graph it is apparent that more packets will be received in case of Gossiping. In percentage, approximate 16% more packets will be received with gossiping as compared to flooding.

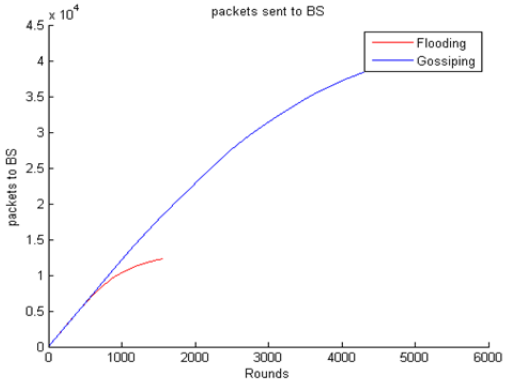


Fig. 1. Packets sent to BS

Total Energy Consumed: Total energy consumed is considered to be the sum of energy consumed in sending and energy spent in receiving the packets. The graph below depicts the energy consumed of Gossiping and Flooding. Gossiping consumes 20% less energy than Flooding.

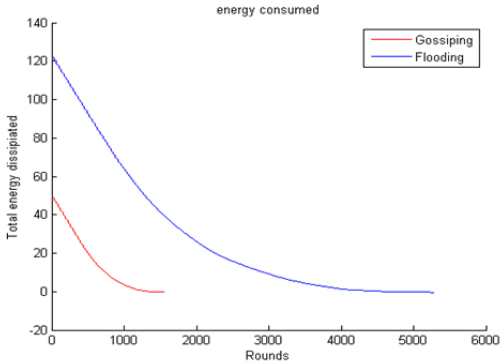


Fig. 2. Energy consumed

Alive Sensor Nodes: The number of alive nodes is directly related with the total energy consumed. As the graphs of total energy consumed states that Gossiping consumes lesser energy than Flooding. From the graph below we can conclude that as the number of rounds is increasing alive sensor nodes are reducing in Flooding. Initially it is same, but with the increase in rounds it is falling as an average of [20] for Flooding. As the rounds proceeds, it became almost same because in Gossiping nodes consumed in data transmission.

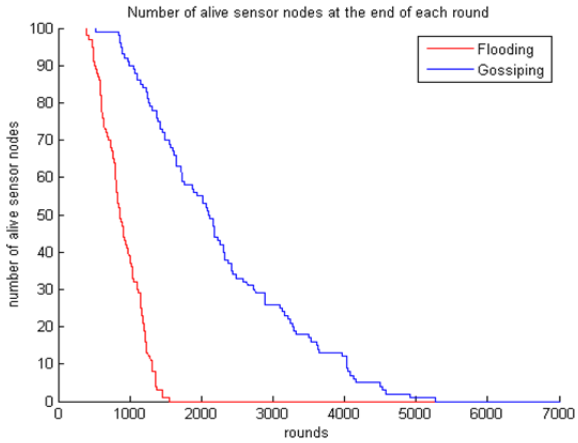


Fig. 3. Number of Alive Sensor Nodes

VI. Flooding V/S Gossiping

An old and simple strategy to disseminate information into a network or to reach a node at an unknown location is to Flood the entire network. A sender node broadcasts packets to its immediate neighbours, which will repeat this process by rebroadcasting the packets to their own neighbours until all nodes have received the packets. This causes unnecessary retransmissions increasing the number of collisions, together depriving sensors of valuable battery power. Therefore, flooding algorithms may not be suitable in the context of dense networks like wireless sensor networks. The main advantage of flooding is its simplicity while the main disadvantage is that it causes heavy traffic. Therefore, measures should be taken to ensure that packet do not travel through the network indefinitely. Flooding face number of challenges:

1. Implosion: a situation where duplicated messages are sent to the same node. For example, if node A has n neighbours that are also the neighbours of node B, node B receives N copies of the same packet sent by node A.
2. Resource Blindness: The flooding protocol does not take into account the available resources at the node or links.
3. Reduced Network Lifetime. A variation of flooding is Gossiping; a node does not necessarily broadcast data. Gossiping addresses some critical problems of flooding overhead.

The goal of gossip protocols is to reduce the number of retransmissions by making some of the nodes discard the message instead of forwarding it. Gossip protocols exhibit both nondeterministic and probabilistic behaviour. No determinism arises as they deal with distributed networks in which the activities of individual nodes occur nondeterministic ally. As to the probabilistic behaviour, nodes are required to forward packets with a pre-specified gossip probability Pgsp. When a node receives a message, rather than immediately retransmitting it as in flooding, it relies on the probability Pgsp to determine whether or not to retransmit. The main benefit is that when Pgsp is sufficiently large, the entire network receives the broadcast message with very high probability, even though only a nondeterministic subset of nodes has forwarded the message. It uses probabilistic approach. Probabilistic broadcast approaches, broadly called gossip, offer a simpler alternative to flooding. With gossiping, nodes in the network are required to forward packets with a pre-specified probability. The main advantage of gossiping protocol is that it is easy to implement and maintenance and low overhead than flooding. But there are some disadvantages also need a long time for a message to propagate throughout the network, does not guarantee that all nodes will receive a message. Gossiping consumes less energy than Flooding. It suffers from latency; information propagates slowly, one node at each step. Despite the simplicity and inefficiency of Flooding and Gossiping, they could be used for specific functions.

VI. CONCLUSION

In this paper, we have proposed a new algorithm that is SIR: gossiping based source initiative reactive algorithm. And on the basis of this algorithm we differentiated between the concept flooding and gossiping.

The main advantage of gossiping protocol is that it is easy to implement and maintenance and low overhead than flooding. Gossiping consumes less energy than Flooding. It suffers from latency; information propagates slowly, one node at each step.

VII. FUTURE SCOPE

For future scope, as we know that sometimes the wireless sensor network works in the event detection. The events further can be related or not. If the events are related because of time then that relation is called temporal correlation. And if the events are related because of space then that relation is called spatial correlation. The temporal correlation is of two types either the events are related or uncorrelated.

So we can perform this gossiping algorithm on temporal correlated events. And further more if algorithm is suitable for temporal correlation then what can be its effects on the spatial correlation.

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