Performance Analysis of Routing Protocols for Wireless Sensor Networks for Disaster Management

E.A. Mary Anita
Professor, Department of Computer Science and Engineering
S.A. Engineering College, Chennai, India
anitareginald@yahoo.co.in

ABSTRACT

In this paper, we analyze the performance of level controlled and gossip based routing protocols. We then combine both and analyze the performance as level controlled gossiping in the context of the occurrence of an abnormal event like Tsunami. We summarize the analysis mechanisms used to predict tsunami and briefly discuss the results of this algorithm. Our simulation results show that the combination of level controlled gossip and pure gossip yields better results.

Keywords: *Level controlled, Gossip, Routing protocols.*

1. INTRODUCTION

World is a ground for numerous disasters almost daily [9]. These mass destruction incidents irrespective of whether natural calamities or man-made catastrophes cause a huge loss of money, property and lives due to non-planning on the part of the governments and the management agencies. It is therefore required to take steps towards the prevention of these situations by predetermining the causes of these disasters and providing quick rescue measures once the disaster occurs. Wireless Ad hoc sensor networks are playing a vital role in wireless data transmission infrastructure and can be very helpful in these situations. Technologies which can cause an alert for the immediate rescue operation to begin when disaster happens can be utilized by Wireless sensor networks. The wounds of the survivors who lost their near and dear ones in 2004 Tsunami are still fresh which ravaged the complete east coast of India. It is estimated that tens of thousands of people died in that event only in India and lakhs in other countries of Asia. Wireless sensor networks (WSNs) provide a simple, economic approach for the deployment of distributed monitor and control devices, avoiding the expensive retrofit necessary in wired systems [10].

A wireless sensor and actuator network is a collection of small randomly dispersed devices that provide three essential functions; the ability to monitor physical and environmental conditions, often in real time, such as temperature, pressure, light and humidity; the ability to operate devices such as switches, motors or actuators that control those conditions; and the ability to provide efficient, reliable communications.

The implementation of this last capability is the most unique to WSNs. Since they are designed for low traffic monitor and control applications, it is not necessary for them to support the high data throughput requirements that data networks like Wi-Fi require. Typical WSN over-the-air data rates range from 20 kbps to 1 Mbps. Consequently they can operate with much lower power consumption, which in turn allows the nodes to be battery powered and physically small. WSNs are typically self-organizing and self-healing. Self-organizing networks allow a new node to automatically join the network without the need for manual intervention.

Paper Type: Research. Category: Computer Science and Engineering
Corresponding Author: E.A. Mary Anita, Email ID: *anitareginald@yahoo.co.in*

Self-healing networks allow nodes to reconfigure their link associations and find alternative pathways around failed or powered-down nodes. How these capabilities are implemented is specific to the network management protocol and the network topology, and ultimately will determine the network's flexibility.

A routing protocol specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network. Routing algorithms determine the specific choice of route. Each router has a priori knowledge only of networks attached to it directly. A routing protocol shares this information first among immediate neighbors, and then throughout the network. This way, routers gain knowledge of the topology of the network.

The specific characteristics of routing protocols include the manner in which they avoid routing loops, the manner in which they select preferred routes, using information about hop costs, the time they require to reach routing convergence, their scalability, and other factors.

Although there are many types of routing protocols, three major classes are in widespread use on IP networks [5]:

- Interior gateway routing via link state routing protocols, such as OSPF and IS-IS
- Interior gateway routing via path vector or distance vector protocols, such as IGRP and EIGRP
- Exterior gateway routing The Border Gateway Protocol (BGP) is the routing protocol used on the Internet for exchanging traffic between Autonomous Systems.

2. RELATED WORK

Gossip based routing method [4] has been used to reduce the number of messages in both wired networks and wireless ad hoc networks. In regional gossip approach only the nodes within some region forward a message with some probability, to reduce the overhead of the route discovery in the network. It shows how to set the forwarding probability based on the region and the network density both by theoretical analysis and by extensive simulations. The simulations show that the number of messages generated using this approach is much less than the simple global gossiping method. It already saves many messages compared with global flooding

Many ad hoc routing protocols are based on some variant of flooding [7]. Despite various optimizations of flooding, many routing messages are propagated unnecessarily. This paper proposes a gossiping-based approach, where each node forwards a message with some probability, to reduce the overhead of the routing protocols. Gossiping exhibits bimodal behavior in sufficiently large networks. In some executions, the gossip dies out quickly and hardly any node gets the message; in the remaining executions, a substantial fraction of the nodes gets the message. It depends on the gossiping probability and the topology of the network. For large networks, this simple gossiping protocol uses up to 35 % fewer messages than flooding, with improved performance. Gossiping can also be combined with various optimizations of flooding to yield further benefits. Simulations show that adding gossiping to AODV results in significant performance improvement, even in networks as small as 150 nodes

A novel power-aware routing algorithm is discussed in [1] leading to a high degree of reliability. The algorithm is ad-hoc, hierarchical, probabilistic and leverages the inherent multiplicity of routes in sensor nets to provide reliability even under adverse conditions.

An algorithm as suggested in [2]. has been implemented using a general regression neural network (GRNN) [6] to predict the path of the wave. The GRNN analyzes the pressure data from sensor nodes and predicts which barriers should fire to most effectively impede the tsunami. It also uses a real-time response mechanism for diffusion. This protocol is inspired by RAP [3] but it does not require location information

The traditional approach for ocean-bottom or ocean-column monitoring is to deploy underwater sensors that record data during the monitoring mission, and then recover the instruments. The problems with this approach in the detection of tsunamis are manifold.

- No real time monitoring
- No online system reconfiguration
- No failure detection
- Limited Storage Capacity

The current tsunami warning systems being deployed all over the world are:

- Buoy – Bottom Pressure Recorder System (Tsunameter)
- Satellite Network
- Global Positioning System

The Buoy – Bottom Pressure Recorder System BPRS uses a quartz crystal resonator to measure ambient pressure and temperature. The resonator uses a thin quartz crystal beam, electrically induced to vibrate at its lowest resonant mode. It communicates these measurements to the surface buoy through an acoustic modem.

The Satellite Network surface buoys are connected to a satellite network, which is used to relay information and commands from the BPRS to a Tsunami warning center or vice versa.

Global Positioning System in Tsunami Detection: Currently, estimating the magnitude of earthquakes accurately takes around 1 hour or more. In the case of tsunami detection, where time is of essence, measuring seismic activity as quickly as possible is of utmost importance. An earthquake's true size and tsunami potential can be determined using Global Positioning System (GPS) data up to only 15 min after earthquake initiation, by tracking the mean displacement of the Earth's surface associated with the arrival of seismic waves.

Numerical methods, called physical models, are used to simulate the air temperature distributions. The main drawback of these models is the extensive computation that leads to time-consuming simulations. Hence for a medium size building, it may take days to complete indoor temperature simulation in a modern personal computer. Most of the conventional modeling techniques run offline and it is quite difficult to run in a real-time. This is due to its computational time and thus requires high-end processing power to simulate the model. Further difficulties impose if the model includes environmental dynamics including energy absorbers and energy feeders.

3. LEVEL CONTROLLED ROUTING

The assumption of this approach is that the base station has the capability of transmitting at various power levels. During the initial stage of deployment the base station sends a level-1 signal with minimum power level, all the nodes that receive the signal will set their level as 1. Next the base station increases its signal power to reach the next level and sends a level-2 signal. All other nodes receiving the signal, but not having a level assigned previously, set their level to 2. This process is continued until the base station sends signals corresponding to all the levels. The number of levels is equal to the number of different transmission levels at which the base station can transmit.

There is no need of any local information apart from this level information. It differs from other protocols that assume local information where Leveling is done internally without the need of any external facilities such as GPS .At the end of the leveling phase, all the nodes will be assigned to certain levels. Each node belongs to a single level and the probability of that particular level will be assigned to all the nodes of that level.

The probabilities associated with each level can be set during leveling phase. The probabilities decrease as we move from inner levels to outer levels as shown by the relation.

$$P_1 > P_2 > P_3 > ... > P_{n-1} > P_n.$$

Here P_1 , P_2 ,P_3 , ...P_n., denote the transmission probabilities with which a node should forward a received message to the nodes in other levels. These probabilities denote these probabilities can be varied any time by the base station to suite the monitoring requirements.

For proper communication between the levels, a node should have a coverage radius R, which is at least 2X, where X is the distance between any two adjacent levels. The coverage radius

$$R = 2X + \alpha$$

where α should be minimal so as to decrease the energy wastage due to signal propagation beyond the intended levels.

4. GOSSIP BASED ROUTING

In pure gossip the transmission probability of a message is set according to the level in which Tsunami event is first detected after the initial leveling. Then messages from the non critical region are transmitted with the same minimal probability as that of the initial source level in which they are initiated, which saves number of messages in the inner levels. So, in the outer layers the gossip probability will be less and in the inner layers that are closer to the base station the gossip probability will be more.

With the assumption that base station is in the direction of the coastal area, the criticality of the Tsunami increases with the proximity of the level in which it is initially encountered. After the reception of the message by a node, it checks to see if it is from a higher level. If it's reception level is same or lower the message is discarded. If the packet is from a higher level, depending upon the gossip probability, the node either sends or discards the message that has to be transmitted.

Compared to pure flooding Gossip based approach saves 35 % messages. The gossip probability ranges from 0.6 to 0.8 assuming the node degree as 8 in random networks. In pure gossip, nodes in all the levels transmit the messages with equal probability, which is same as the probability of the level in which the event was detected. This is not the case in level controlled gossip where gossip probability increases during the transmission along the levels.

5. PERFORMANCE ANALYSIS

The combination of level controlled gossip and pure gossip is said to be efficient routing. The advantage of level controlled gossip is that it balances the gossip (probabilistic flooding) happening in the levels according to the proximity of the level to the base station. In the outer levels, the impact of the event is less and hence it is broadcasted with less probability. But as the Tsunami wave approaches the inner levels, the impact of the event gets increased. So the gossip probability of the event is also increased as we move inwards, level wise. The network life time and monitoring reliability are balanced by this approach.

The events in the areas which lie under critical region need to be reported with more prominence than the events in the areas which lie beyond the critical region since the monitoring area is huge. This should be done in such a way that the network life time gets prolonged. There will be maximum improvement of the network life time without risking the warning system if Level Controlled gossip is used in the critical region and pure gossip in the regions beyond critical region. This is due to following reasons: Messages from the non critical region are transmitted with the same minimal probability as that of the initial source level in which they are initiated, which saves number of messages in the inner levels(as the outer levels have less probability). Messages from the critical region are transmitted with probabilities increasing inwards to base station. This approach optimizes the number of messages and at the same time reports the event with safe probability.

6. RESULTS AND DISCUSSION

For the purpose of evaluating the algorithms, we have simulated them in NS-2 environment by varying the number of nodes in the network. For each algorithm we generate the number of events that the network could handle. Similarly, the number of nodes has been varied and the corresponding number of events that these networks could handle was plotted. Messages from the non critical region are transmitted with the same minimal probability as that of the initial source level in which they are initiated, which saves number of messages in the inner levels, as the outer levels have less probability. Messages from the critical region are transmitted with probabilities increasing inwards to the base station. This approach optimizes the number of messages and at the same time reports the event with safe probability**.** The two metrics of interest provided by our simulator are the number of events, which defines the life time of the network and the number of nodes that are present in the network.

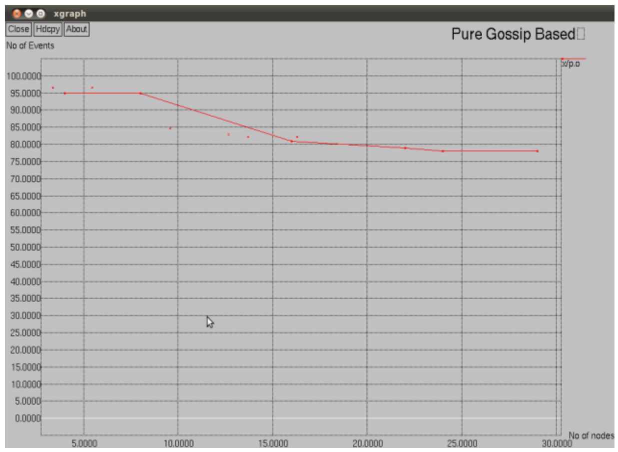

Figure1 Pure gossip based approach

Figure 1 depicts that with 30 node network model a pure gossip approach has a larger network life time and has efficient gossiping. With 30 node network the gossiping protocol network dies down at around 75 events where as the pure gossip protocol network can withstand up to 90 events.

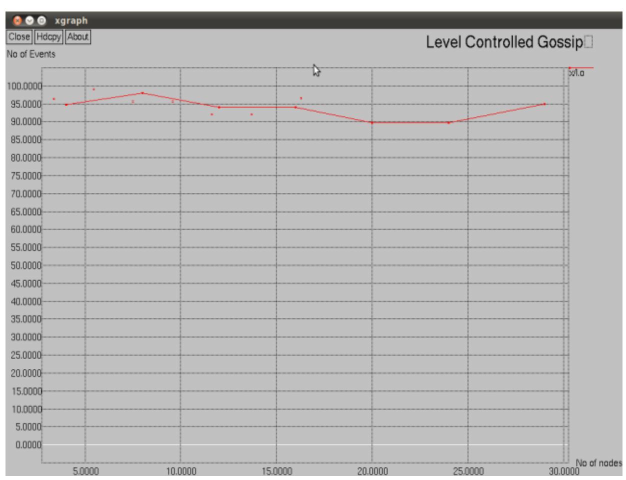

Figure 2 Level controlled gossip based approach

Figure 2 depicts the network life time for level controlled gossip . Initially with 30 node network the protocol lasts until 90-100 events but, as the size of the network increases there is a change in the performances of the protocol. With 50 node network model, a Level controlled gossip model lasts longer and is quite efficient than gossiping

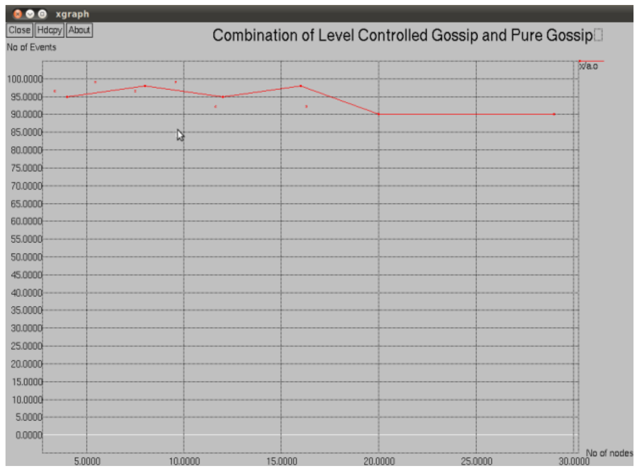

Figure 3 Combination of level controlled gossip and pure gossip

Figure 3 depicts the network life time of a network model that employs a combination of level controlled gossip and pure gossip approach. It is evident that the combination of level controlled gossip and pure gossip is quite efficient than gossiping. The results show that all the algorithms, level controlled gossip, combination of level controlled gossip and pure gossip yields better results than gossiping

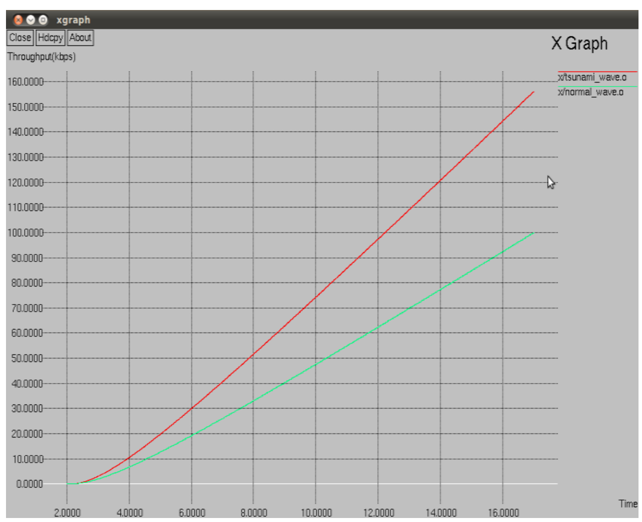

Figure 4 Normal wave and Tsunami wave

Figure 4 depicts the variation between the normal wave and the tsunami wave. The variation of throughput with time is depicted in the graph. For a tsunami wave the throughput increases rapidly when compared with a normal wave. When the speed of the wave is high the throughput increases and hence from this observation it is concluded that the wave is a tsunami wave. Similarly when the speed of the wave is low the throughput is less and hence from this it concluded that the wave is a normal wave.

8. CONCLUSION

Level controlled gossip is a novel improvement over gossip. We have analyzed both pure gossip and level controlled gossip in the context of Tsunami warning system and analyzed the performance of level controlled and gossip based routing protocols. Our results prove that combination of level controlled gossip and pure gossip yields better results than gossiping in the context of abnormal event detection.

REFFERENCES

[1]Arora, Shashank, M. B. Srninvas, G. Ramamurthy, "Power Aware, Probabilistic and Adaptable Routing Algorithm for Wireless Sensor Networks", National Conference on Communications (NCC 2004), IISc, Bangalore, pp. 60-64.

[2] K. Casey, A. Lim, and G. Dozier, "Evolving General Regression Neural Networks for Tsunami Detection and Response," in Proceedings of the International Congress on Evolutionary Computation(CEC). IEEE, July 2006.

[3] Chenyang Lu, Brian M. Blum, Tarek F. Abdelzaher, John A. Stankovic, and Tian He, " RAP: A Real-Time Communication Architecture for Large-Scale Wireless Sensor Networks," IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS 2002) San Jose, CA, September 2002

[4]5. X. -Y. Li, K. Moaveninejad and O. Frieder, "Regional Gossip Routing for Wireless Ad Hoc Networks, Mobile Networks And Applications (Monet), Vol. 10, No. 1-2, 2005, pp. 61-77

[5]Santosh Bhima, Anil Gogada and Ramamurthy Gaarimella, "Level Controlled Gossip based Tsunami Warning Wireless Sensor Networks", Sensors & Transducers Journal, Vol. 106, Issue 7, July 2009, pp. 27-34

[6] Donald F. Specht, "A General Regression Neural Network," IEEE Transactions on Neural Networks, Vol.2, No. 6, 1991.

[7] Zygmunt J. Haas, Joseph Y. Halpern, And Li (Erran), Gossip-Based Ad Hoc Routing, IEEE/ACM Transactions on Networking, Vol. 14, No. 3, June 2006.

[8] Aziz N.A.A., "Managing disaster with wireless sensor networks", 13th International Conference on Advanced Communication Technology (ICACT), 2011, pp. 202 – 207

[9] Naveed Ahmad, Naveed Riaz, Mureed Hussain."Ad hoc wireless Sensor Network Architecture for Disaster Survivor Detection", International Journal of Advanced Science and Technology Vol. 34, September, 2011

[10] Harminder Kaur, Ravinder Singh Sawhney, Navita Komal, "Wireless Sensor Networks for Disaster Management", International Journal of Advanced Research in Computer Engineering & Technology, Volume 1, Issue 5, July 2012