NEIGHBORHOOD DISCOVERY FOR MOBILE WIRELESS SENSOR NETWORKS IN POST-WAR FIELD

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ABSTRACT

In real time, wireless sensor networks are used to gather physical phenomenon from the environment. Mobile Wireless sensor networks can be used to collect the data like live humans and unexploded bombs in the post-war field. Every data is very important in this application. To effectively collect the data, we propose a new neighborhood discovery algorithm based on the GPS coordinates and RSSI. In this algorithm mobile sensor nodes are used to acquire the data. The acquired data is forwarded/ transmitted to the sink node either directly or via relay nodes. Our neighborhood discovery algorithm is simulated using Omnet++ simulator and matlab. The obtained results show that our algorithm provides reduced data loss with uniform low velocity of mobile nodes.

Key words: Neighborhood discovery, Mobility models, Wireless sensor networks

I. INTRODUCTION

Wireless sensor network is a collection of large number of small sensor nodes intended for a particular application. Each sensor node consists of a hardware component and also a software component. Hardware component comprises the sensing module, processing module, communication module, and power module. Sometimes it may have the mobility and actuator modules. Processing module includes the memory unit. Software component comprises the operating system and also the drivers for sensing, mobility and communication modules [1],[2],[3], [4],[10]. Such a wireless sensor network is deployed either as a fixed fashion or as an ad hoc fashion. Sensor nodes deployment is done either by manually or by unmanned vehicles.

Research growth in the field of wireless sensor networks in the past decade shows the necessity and importance of this efficient network across varieties of applications like industrial monitoring, wildlife monitoring and health monitoring for biomedical, agriculture and civil structures. Also such networks are used in military and/or national security applications. Apart from these applications this network plays a vital role in the disaster management.

Sensors placed in the structures, machinery, and the environment, joined with the efficient delivery of sensed information, could provide various benefits. Major advantages of these include: conservation of natural resources, enhanced manufacturing productivity, immediate emergency response, and improved homeland security. But due to the breakages occur in the connector which can be a lead wire or fiber optic cable, the overall quality of the network is reduced. To reduce the connection failures as well as the maintenance cost it would be best to select the wireless sensor network. Wireless sensor networks are started spreading in industries. The wireless sensor networks in industrial applications comes under the category of low rate - wireless private area networks (LR-WPAN). The IEEE 802.15.4 [5] defines the industrial standard for LR-WPAN. Comparing to wireless local area network (WLAN) which is standardized under the category of IEEE 802.11, the LR-WPAN - IEEE 802.15.4 deals about low power, low energy, short range and low data rate.

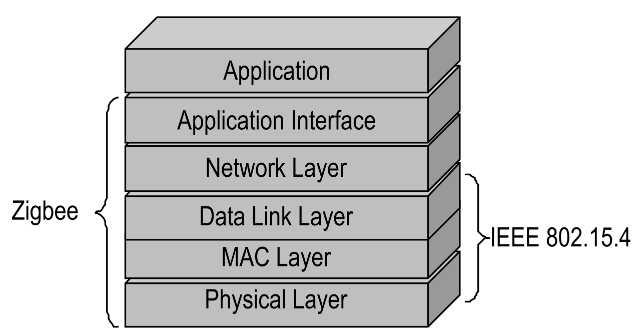

Fig. 1. Layer description of a sensor node

IEEE 802.15.4 defines the specifications of the physical layer and also about the Medium Access Control (MAC) layer. Zigbee is built on the standard in

IEEE 802.15.4 which deals about the energy efficiency. Fig.1 depicts the layer description of a sensor node.

II. RELATED WORK

State-owned Defence Research and Development Organization (DRDO) will soon be rolling out the bomb detection and disposal robot called 'Daksh' for the Indian Army. 'Daksh' is a two-foot-high, remote-operated, battery-run vehicle that weighs 350 kilograms and is designed to detect and defuse Improvised Explosive Devices (IED). The cost of each 'Daksh' robot will be $0.35 million [6]. A new type of bomb detecting robot that can also locate victims buried under blast rubble has been unveiled at a security expo in Japan.

The embedded hardware and software design house iWave Systems Technologies in India has announced the availability of what is arguably the tiniest global positioning system (GPS) receiver module to be wholly designed and developed in India. The module weighs less than 25 grams and is just 27 mm by 25mm in size. Without the connector, it is only 7 mm in thickness.

So it is not so tough to design a sensor node with inbuilt GPS. Compared to Daksh, the sensor nodes will be cheaper with limited application [7], [8]. Like defusing bombs is not our interest but the detection is our main interest.

Various studies investigate wireless sensor networks with static nodes and static sink for many applications. But very few works are carried out with mobile strategies. Some researchers used the sink or the base station mobility due to the availability of exceeding knowledge in robotics. In our paper we worked with the mobile nodes.

Many papers used RSSI for distance measurement between nodes [9]. Likewise few people used GPS coordinates to identify the location of the sensor node. In our paper we used both GPS and RSSI to determine the neighborhood nodes.

III. SYSTEM DESCRIPTION

In this paper, we considered the field after the war as the sensor field of interest. The aim of the deployment is to collect all information about unexploded bombs and live humans. In our scenario, it is considered that all the sensor nodes have both the type of sensors to detect the live humans and to detect the unexploded bombs. Also the nodes have inbuilt GPS and mobile unit. The network contains homogenous nodes. All the nodes are named before deployment in a priori manner with efficient naming algorithm. Also position of the destination node or the sink node is given in a priori. Here the sensor nodes are deployed in adhoc manner. After deployment the nodes have to self organize themselves to form the network. In this network we considered, the communication medium or the transmission channel is divided into two as control channel and traffic channel. All the signaling information is communicated through control channel. Likewise all the data packets are transmitted or forwarded through traffic channel.

In our neighborhood discovery, after deployment all the nodes get their GPS information during self organizing. This is broadcasted through the control channel. The one hop neighbor nodes get the GPS information and they compute the distance between them and its one hop neighbors. Distance table is maintained by each sensor node for its neighbors. The distance is calculated by using the Vincenty's formula. According to this the accuracy of the position will be 0.5mm. This is the reason why the Haversine formula is not used (which is inaccurate).

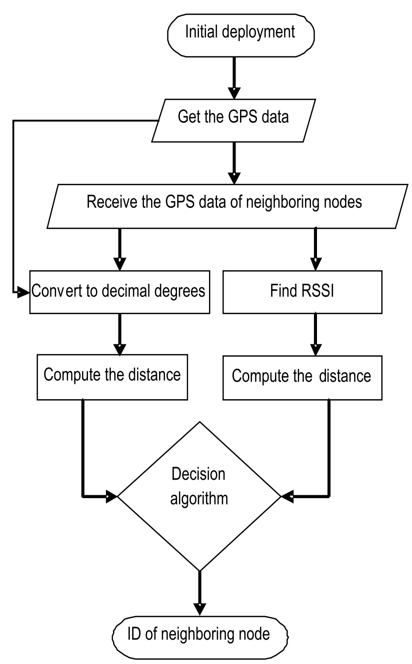

Fig. 2. Neighborhood Discovery Flowchart

While receiving the GPS information of the neighboring nodes, each node computes the Received

Signal Strength Indication (RSSI) of the received signal. The distance between the neighboring nodes are approximated from the power level received and compared with the distance calculated with the help of GPS location. These distance information are fed to the decision making session to obtain the neighboring node.

The algorithm is depicted as a flowchart in fig.2 and fig.3. The steps to be followed to determine the neighborhood nodes and also to the best forwarder node are given below:

Step 1: After initial deployment of sensor nodes, they self organize themselves and are static. Then the nodes get their GPS coordinates and broad cast the GPS data.

Step 2: Nodes receives the GPS data of nearby nodes. Nodes convert the GPS coordinates into decimal degrees and compute the distance between the node and its neighbor. Then the nodes construct the distance table with the name or id of the neighboring node and its distance.

Step 3: Using the received GPS information the nodes also calculate the power level of the signal (RSSI). By which it predicts the distance between the node and its neighbors. Thus it forms the extended distance table.

Step 4: From the extended table the best forwarder node is determined based on the bearing and RSSI. Here the one hop neighboring node which is closer and present in the forward path to the sink node is considered to be the best forwarder node. Bearing gives the direction of current position.

Step 5: Likewise the nodes repeat steps 2 to 4 until the best forwarder node is the sink node.

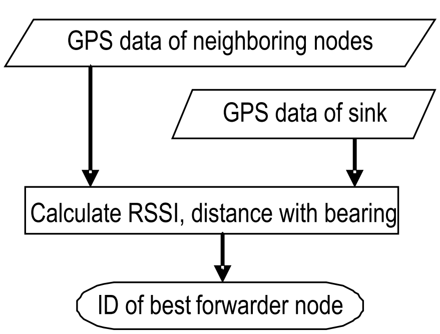

Fig. 3. Flowchart for best forwarder node

After executing the flowchart shown in fig.2, all nodes know their one hop neighbor. Next, with this intelligence, the node finds the forwarder node. To find this, the node utilizes the sink node's GPS information which is predetermined since in the first scenario sink is considered to be static. The known GPS information of the sink node is already fed to all the nodes. Using this information the node determines the best forwarder node by executing the flowchart shown in fig.3.

In the same way, the forwarder node finds its forwarder node by executing the same algorithm. This algorithm is repeated until the single hop neighbor of the sink node act as a best forwarder node. Thus the forward route is determined with the help of the best forwarder nodes. But the condition here is that all the nodes are static still they discover the first route.

Now, consider the sensor nodes are mobile. If the nodes are mobile then many questions arise like when the node will update its location? How to find the stable route to transfer the data? Here we considered the wireless sensor network as event driven network. So whenever any node detects any event (either unexploded bomb or live human) it stops its mobility. After transmitting this detected information to the sink node it will move again. To transmit this information it requires the routing information. At this stage, the routing information purely depends on the mobility models.

In the first scenario it is considered that all the nodes move with same angle and velocity. Thus the neighborhood nodes discovered in the static position are maintained. So the same route can be followed for data transfer even though the nodes are mobile. Here it is not necessary to stop the event detected sensor node or its neighboring nodes for data transfer. While they move they transmit through the data channel with different frequency and the sink receives the data without loss.

In the second scenario, it is considered that all the nodes move with different velocities and in different angles. So, for this scenario it is necessary to determine the new route. The route discovery is given in the flowchart shown in fig.4.

According to this the event detected node will send a query to the best forwarder node to check its availability within its coverage. If the node presents and received the query then the node reply back with acknowledgement data with its ID or name. But unfortunately if the nodes move out of the coverage then it won't reply back. The event detected node will wait for reply for predefined time which is considered to be the wait time. But when the wait time crosses half the time limit then the node sends the request to the next best forwarder node. But if there is no best forwarder node then the node will go for executing the initial route discovery algorithm again and at this time it will be static. It updates the distance table and best forwarder node. Then it sends a request to the best forwarder node to be static for a while. After that the node transmits the data. So the best forwarder node will be static until it receive the data and forward to its best forwarder. The same algorithm continues. After that both nodes start to move.

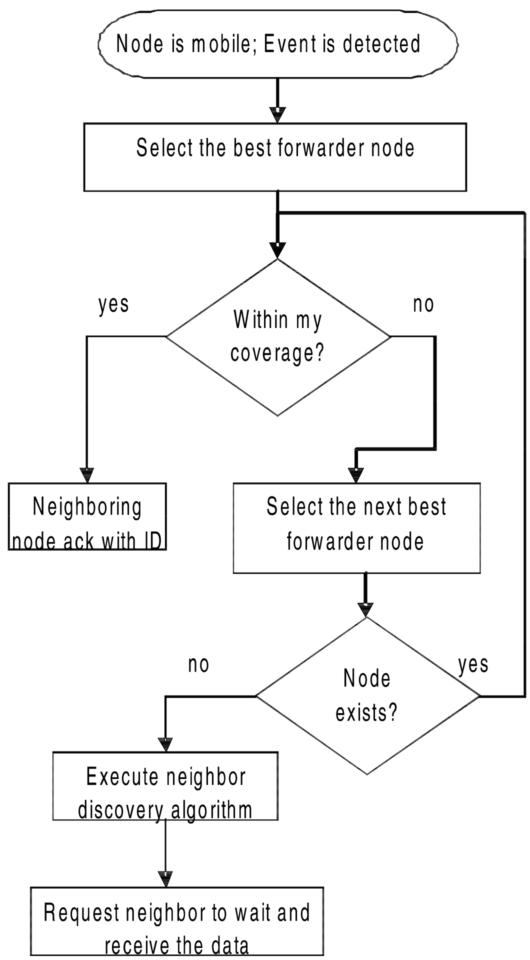

Fig. 4. Flowchart for route discovery during mobile

Since every data is important the wait time is neglected. Moreover in our scenario we consider there is no collision between the nodes during mobility. Velocities of individual nodes are preset. Sink is considered to be present nearby the center of the sensing field.

IV. RESULTS AND DISCUSSIONS

Let A, B, C, D, E and F are the neighboring nodes of the node A then their distance between the nodes and its bearing are calculated using Vincenty's formula and given in the Table 1 and Table 2 for the sample GPS data taken.

Table 1. Distance between nodes based on GPS

	GPS	Distance (m)					
		A	B	C	D	E	F
A	120.1512 E43.1205 N	0	32.7	54.9	45.8	84.4	13.5
B	120.1514 E43.1206N	32.7	0	70	77.5	57.2	22.9
C	120.1509 E43.1207 N	54.9	70	0	75.3	89.1	65.5
D	120.1510 E43.1203 N	45.8	77.5	75.3	0	130	54.9
E	120.1515 E43.1209 N	84.4	57.2	89.1	130	0	78.9
F	120.1513 E43.1205 N	13.5	22.9	65.5	54.9	78.9	0

Table 2. Direction of the nodes based on GPS

	Bearing ($)					
	A	B	C	D	E	F
A	0	304.4	47.55	143.91	331.33	270
B	124.4	0	74.65	135.81	346.32	143.9
C	227.55	254.65	0	190.33	294.57	235.55
D	323.91	315.81	10.32	0	328.72	312.44
E	151.33	166.34	114.57	148.72	0	159.97
F	89.99	323.9	55.55	132.44	339.97	0

Table 3. Actual and Calibrated RSSI

	Actual RSSI (-dBm)					
	A	B	C	D	E	F
A	–	68	47	34	80	23
B	68	–	74	79	59	27
C	47	74	–	77	92	66
D	34	79	77	–	120	55
E	80	59	92	120	–	80
F	23	27	66	55	80	–
	Calibrated RSSI (-dBm)					
	A	B	C	D	E	F
A	–	66	47	35	87	25
B	66	–	75	76	60	28
C	47	75	–	79	90	67
D	35	76	79	–	116	56
E	87	60	90	116	–	82
F	25	28	67	56	82	–

Table 4. Distance between nodes based on GPS

	Distance (m)					
	A	**B**	**C**	**D**	**E**	**F**
A	0	31	54	44	86	14
B	34	0	71	78	58	23
C	54	71	0	76	90	67
D	44	78	76	0	130	55
E	86	58	90	130	0	80
F	14	23	67	55	80	0

The distance and bearing obtained from the sample GPS coordinates for 20 nodes and their distance calculated using RSSI are fed to the Omnet++ simulator. Also the events are generated as one per 10 minutes. Simulation is undergone for 120 minutes. Sink's position is chosen as (0,0) in 2-D plane. After simulation, the neighborhood nodes are discovered. The fig.5 and fig.6 shows the multihop network with their neighboring nodes and best forwarder nodes for 20 and 30 as the total number of nodes deployed in the network.

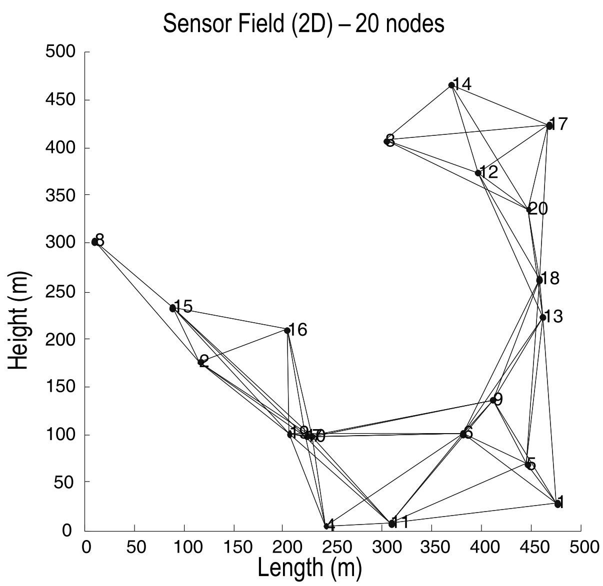

Fig. 5. Neighborhood Nodes with 20 nodes

Without varying the velocity, it is verified that whether all the events generated by the nodes are correctly transmitted to the sink. After that for few nodes velocities are increased and again the received data at sink is plotted. The output is shown in fig.7 and fig.8. From that it is seen that when there is a small change in velocity that will not affect the data delivery. But if the velocity increases rapidly network is partitioned and so there is a chance for data loss.

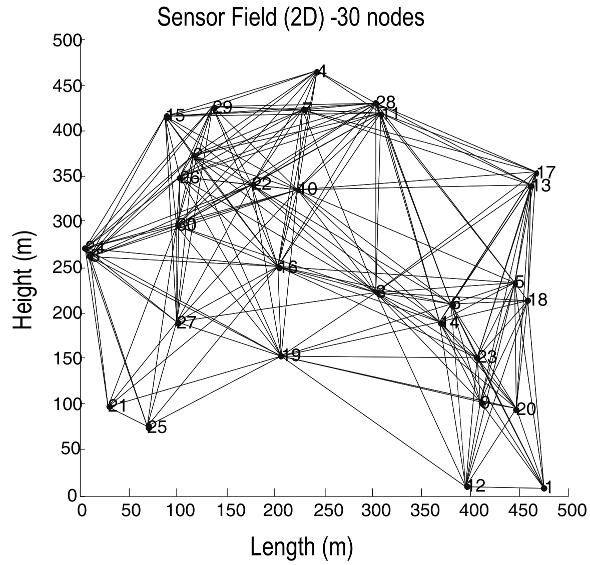

Fig. 6. Neighborhood Nodes with 30 nodes

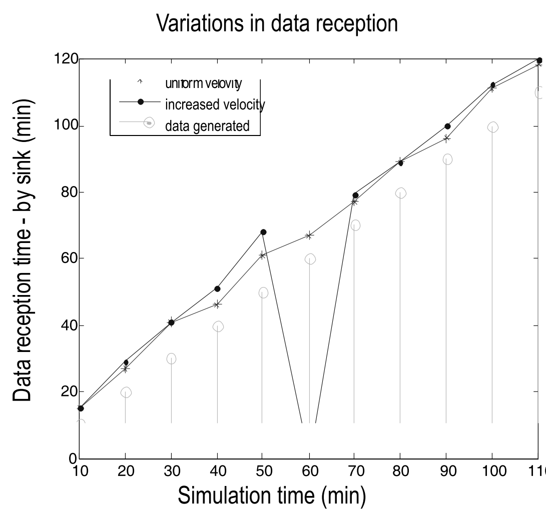

Fig. 7. Variations in data reception

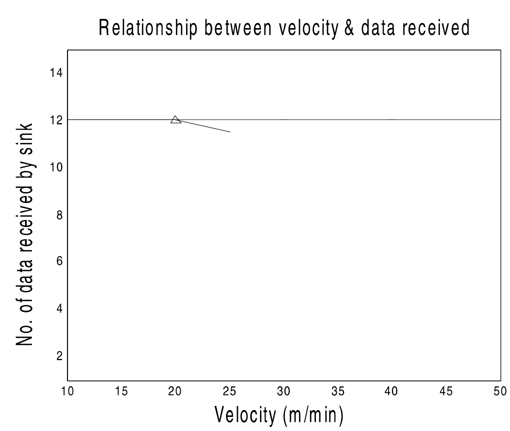

Fig. 7. Relationship between velocity and data received

In the fig.7 data generated or event detected is indicated by stem line. It can be seen in the plot that there is a delay between the data generated and the data received by the sink. In the fig.8 changes in the data delivery with respect to velocity is plotted. From the output it is clear that if the velocities of all the nodes are changed uniformly then there will be no problem of data loss. But if it is varied only to few nodes it affects network topology and there is a chance for data loss.

V. IDEA JUSTIFICATION

In our application with the GPS coordinates RSSI is also considered. One can think that GPS will be giving the accurate position. Then what is the need to use the RSSI? Actually the GPS receiver clock is very sensitive to errors. For example an error of one microsecond can lead to an error of 300m which can not be allowed in our wireless sensor network.

In the wireless sensor networks (WSN) many protocols directly use the Received Signal Strength Indication (RSSI) measurements that the radios provide, the standard requires that the reported RSSI values should be linear and within 6 dB of the actual RSSI values. However, 6 dB is a wide error margin. Because, for example data reception ratio can decrease from 100% to 0% with a 2 or 3 dB difference in the received signal strength. In order to improve accuracy actual RSSI is calibrated with the standards. Calibrated RSSI is not a must. Depends on accuracy we can select whether to go for the calibration procedure.

VI. CONCLUSION

From our simulation results it is seen that for mobile wireless sensor network which are used in post-war field application our neighborhood discovery is accurate enough to deliver all the data. Since GPS a well as RSSI are used enhance the accuracy level in neighborhood discovery. Thus not only for this application, where every data is important, then we can use this neighborhood discovery algorithm for accurate results.

REFERENCES

[1] M.S.Godwin Premi, K.S.Shaji, "MMS Routing for Wireless Sensor Networks", IEEE Computer Society, Feb.2010.

[2] Jamal Al-Karaki, Ahmed E.kamal, "Routing Techniques in Wireless Sensor Networks", IEEE Wireless Communications. Dec.2004.

[3] Jun Luo, Jean–Pierre Hubaux, "Joint Mobility and Routing for lifetime Elongation in Wireless Sensor Networks", IEEE INFOCOM, 2005.

[4] Lei Zhang, Z.Hu, Y.li, X.Tang, "Grouping based Clustering Routing Protocol in Wireless Sensor Networks", IEEE Communications Society, 2007.

[5] Feng Chen, Nan Wang, Reinhard German and Falko Dressler, "Simulation study of IEEE 802.15.4 LR-WPAN for industrial applications", Wirel. Commun. Mob. Comput. 10: 609–621 (2010), Published online in Wiley InterScience.

[6] http://indiadefenceonline.com/

[7] http://www.dailymotion.com/video/xf3tg4_ new-bomb-detection-robot-unveiled_news

[8] http://www.csgnetwork.com/gpsdistcalc.html

[9] Yin Chen, Andreas Terzis, On the Mechanisms and Effects of Calibrating RSSI Measurements for 802.15.4 Radios. Appeared in the proceedings of the 7th European Conference on Wireless Sensor Networks (EWSN 2010).

[10] M.S.Godwin Premi, K.S.Shaji, "Impact of Mobility Models on MMS Routing in Wireless Sensor Networks" International Journal of Computer Applications Volume 22– No.9, May 2011.

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