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Location Management in Wireless Sensor Networks with mobility

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***Abstract*—**Wireless sensor networks comprise motes which are nothing but small sensor devices. The challenging problems for motes are battery power, storage capacity, and less calculation power of the mote. In this paper developed structure for Real-Time Tracking, Sensing and Management System using IITH motes is proposed. Also the algorithm developed for location management of wireless sensor networks with the aspect of mobility is proposed. This developed framework and algorithm can be utilized in emergency events and safety threats and provides warning signals to handle the emergency.

Keywords*-Wireless sensor networks, mobility management, localization*

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I. INTRODUCTION

A lot of research is going on in the field of wireless sensor networks. Applications of WSN include habitat monitoring, health care, monitoring of environments and remote controlled area and of course in the field of defense. Realizing the importance of this area, with this in mind a Workshop on Wireless Sensor Networks was held at WCE, Sangli by IIT Hyderabad, India .The workshop was attended by students working in this field. It included research base ideas and fundamentals of WSN as well as applied aspects.

Another drive has been on the design of sensors. Four major components of wireless sensor network (WSN) are a processor, a radio, battery and sensors. A WSN is formed by closely deployed sensor nodes in an application area. The sensor nodes have self-organizing abilities in order to form an appropriate structure so as to perform a particular task inn most arrangements,.[1],[2],[3]. Wireless Sensor Networks are found suitable for applications such as surveillance, precision agriculture, smart homes, automation, vehicular traffic management, habitat monitoring, and disaster detection [5].

There are three crucial areas where much less attention is paid by the researchers (i) low power and low cost mixed signal design of the WSN radio chip, (ii) improved power sources like photovoltaic, and (iii) low cost sensors technology for different applications. Thus WSN has released the challenge for computing and communication.

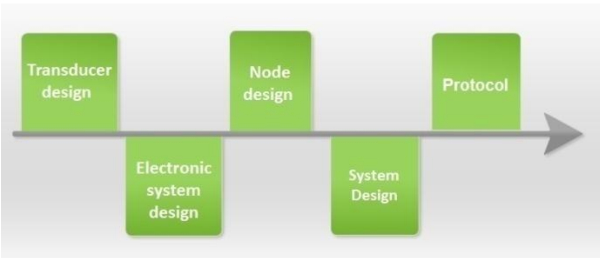

Figure 1. Research Issues in WSN

Some of the research issues are:

Transducer design: Developing new sensor transducers that are compact, low power, and cost effective. Bio-degradable / environment friendly sensor design is the key issue.

Electronic system design: The system design is one of the challenging areas where several new breakthroughs are possible in the near term leading to fundamentally new design directions. Integrating sensors with the appropriate electronic circuitry to extract digital data, using sensor feedback to enhance the data collection within the electronics, and providing low noise outputs using sensor arrays.

Node design: Development of low power sensor nodes with suitable Processing and networking abilities.

System Design: To develop sensor networks of abundant nodes and incorporating them with a particular application.

Protocol: Various types of protocol development can be carried out viz., Power Aware Routing, Distributed algorithms, Time Synchronization, Security, Localization of sensor nodes etc.

The important applications of wireless sensor networks include security and detection. Sensor nodes having capability of motion sensing can be deployed at the borders of particular area to detect the trespasser crossing the line of control. Hence surveillance of regions and areas can be efficiently done by organizing wireless sensor networks in that area. This idea boosted us to pursue this application of WSN and build up prototype to carry out Location Management in Wireless Sensor Networks with mobility.

This application of WSN is highly important and very useful. This application tracks the vehicular movement in hostile areas under military surveillance. e. g. Consider a remote place under the military surveillance and WSN motes are deployed in that area. If vehicular movement of any potentially lethal vehicle happens in the vicinity of any mote, it will notify the base station. Depending on the information provided by the mote, the base station will take subsequent action.

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II. EXPERIMENTAL SET UP

Software and hardware used in experimentation is described in this section. TinyOS is an open source software. It has a platform targeting wireless sensor networks (WSNs). TinyOS is an embedded operating system. It is written in the nesC programming language as a set of processes and cooperating tasks. TinyOS started as collaboration between the University of California, Berkeley in co-operation with Intel Research and Crossbow Technology, and has since grown to be an international group, the TinyOS Alliance.

TinyOS programs are constructed out of software components, some of which present hardware abstractions. Components are connected to each other using interfaces. TinyOS provides interfaces and components for common abstractions such as packet communication, routing, sensing, actuation and storage.

Community ENTerprise Operating System (CentOS) is a Linux distribution. It attempts to provide a free enterprise class computing platform.It has 100% binary compatibility with its upstream source, Red Hat Enterprise Linux (RHEL).

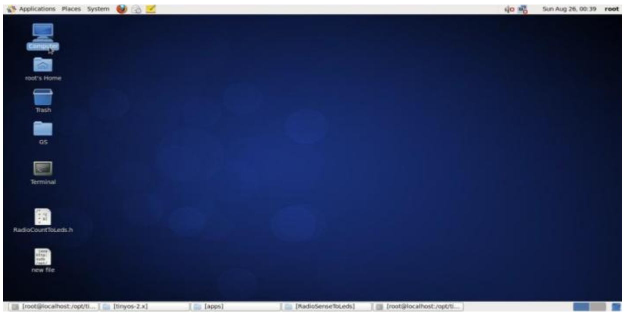

Figure 2 CentOS Desktop view

Hardware used: Sensor node

A mote is a node in a wireless sensor network. It is performs some kind of processing. It also collects sensory information and communicates with other sensor nodes present in the network.

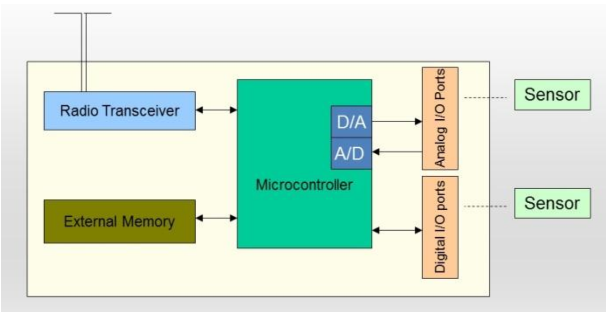

Figure 3. Basic structure of Mote

Radio transceiver, external memory, microcontroller, power source and one or more sensors are the components of a mote. Microcontroller, a general purpose desktop microprocessor, digital signal processors, FPGAs and ASICs are used as controllers. Radio frequency (RF), optical communication (laser) and infrared are the probable choices of wireless transmission media. Radio frequency-based communication fits most of the WSN applications. WSNs tend to use license-free communication frequencies: 173, 433, 868, and 915 MHz; and 2.4 GHz. From an energy viewpoint, appropriate kinds of memory are the on-chip memory of a microcontroller and Flash memory. Flash memories are used for their cost and storage capacity. Memory requirements are dependent on application. Most of the times sensor networks are formed at remote locations and motes are hard to reach. So there is a need to ensure that adequate energy will be always available to power the nodes. Sensors are exposed to physical data of parameter which is to be measured. They produce the response to change in physical condition. Sensors produces analog signal in response to change in physical condition. This analog signal is digitized by an ADC and sent to controllers for further processing.

In this research work IIT Hyderabad (IITH) motes developed by IIT Hyderabad are used.

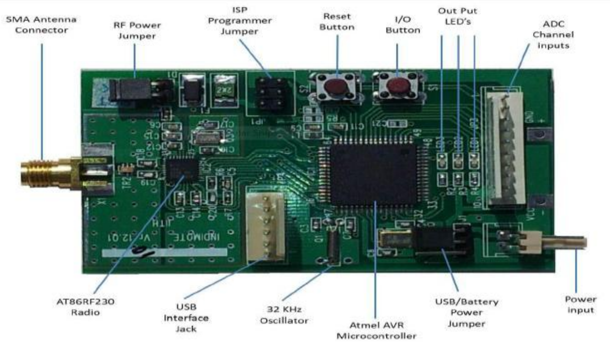

Figure 4. IITH Mote

IITH-Mote is designed with the following features [6]:
1) IEEE 802.15.4 compliant RF Trans- receiver.
2) 2.4 to 2.4835 GHz, a globally compatible ISM band with 250 Kbps data rate.
3) 8 MHz at mega microcontrollers with 8 kb RAM.
4) Low current consumption.
5) Programming and data collection is done via USB.
6) Runs TinyOS.
7) Can be used in the general purpose applications like environmental monitoring, agriculture, smart home etc

III. DEVELOPED ALGORITHM

Sensor node deployments

In the designed network few nodes are static and few are mobile. 13 motes are used, which are divided into two levels viz. level 1 and level 2 as shown in figure 5. In our prototype model, one node is used as Anchor which is also known as base node, which is directly connected to computer by wire. One node is mobile node. Twelve nodes are static nodes those are divided in level 1 and level 2 nodes.Level 1 nodes: 2, 5, 11, 8 deployed at single-hop distance.Level 1 nodes: 1, 3, 4, 6, 7, 9, 10, 12 deployed at multi-hop (two hop) distance.

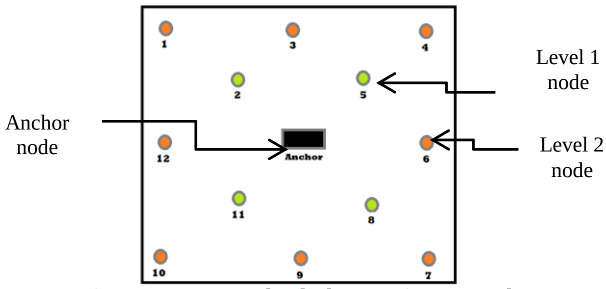

Figure 5. Sensor nodes deployment in a network

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Level 1 nodes are identified with node-ID which is arithmetic mean of its upper level adjacent node-IDs. Example of the same is shown in Figure 5

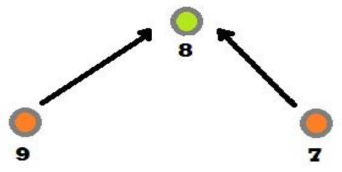

Figure 6. Node Id relations

Relation between level 1 node ids and level 2 ids is given by following equation,

$$NID(n) = \frac{NID(n-1) + NID(n+1)}{2} \text{..........}...(1)$$

where $NID(n)$ is node identification number of node 'n' .e.g. Following calculations shows relationship between node 8 and node 7, node 9.

$$NID(n) = \frac{7+9}{2} = 8$$

Wireless multi hop communication is becoming more important due to the increasing popularity of wireless sensor networks, wireless mesh networks, and mobile social networks. [4]. Multi hop transmission is also implemented during experimentation.

Reception by Anchor (Multi-hop)

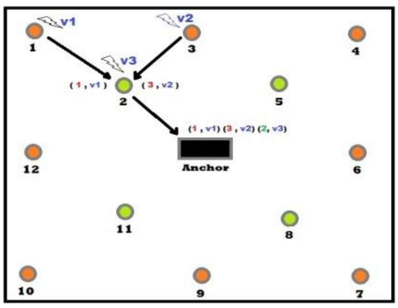

Figure 7. Reception by Anchor (multi-hop)

All Level 2 nodes broadcast its sensed values at interval of one second, broadcasted values of all possible level 2 nodes are received by a particular level 1 node but it rejects the values broadcasted by nodes which violets above node relationship and it transmits two received values to anchor node along with value sense by itself.

Suppose v1 and v2 are values sensed by level 2 nodes: node1 and node 3 respectively and v3 is value sensed by level 1 node: node 2 as shown in figure 6. Node 1 and node 3 broadcast its sensed values to all nodes but only node 2 accepts it as it follows node relationship criteria. Now node 2 have (1, v1) (3, v2) values, where 1, 2 are node IDs of level 2 nodes and v1, v2 being sensed values of respective nodes. Received values from node 1 and node 3 along with value sensed by node 2 [(1, v1) (3, v2) (2, v3)] are transmitted to Anchor node, it is known as multi-hop. This processes these values for further application as shown in figure 7.

Mobility aspect in WSN

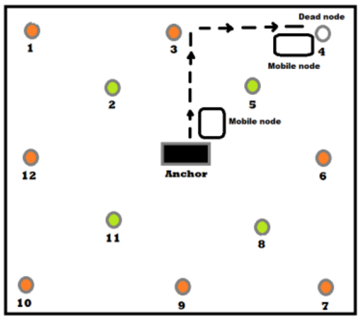

Figure 7. Mobility Aspect

Flow charts of developed Algorithm:

Following figures shows the flowcharts of our developed algorithm

Base station flow chart:

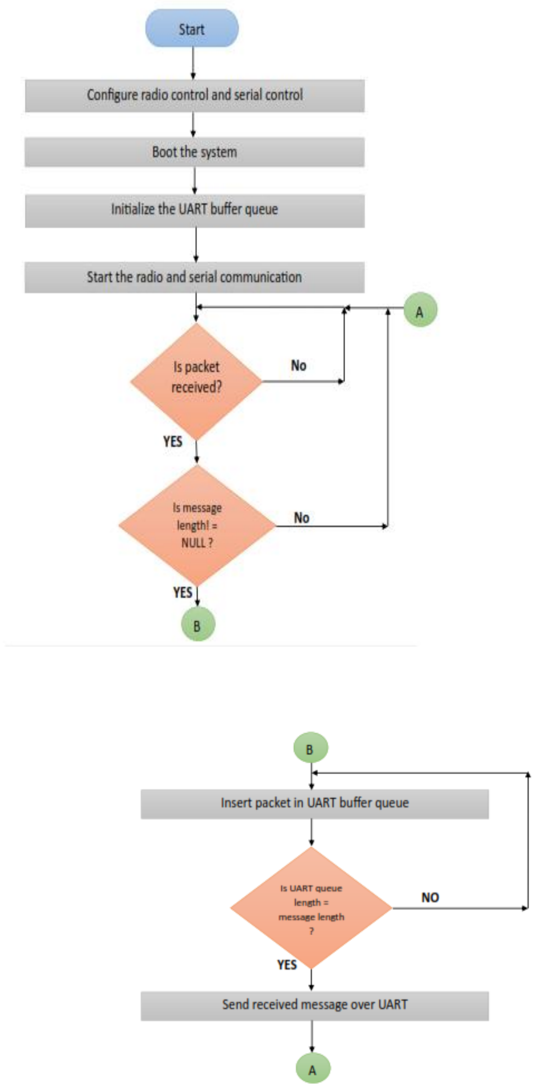

Figure 8. Base Station Flow Chart

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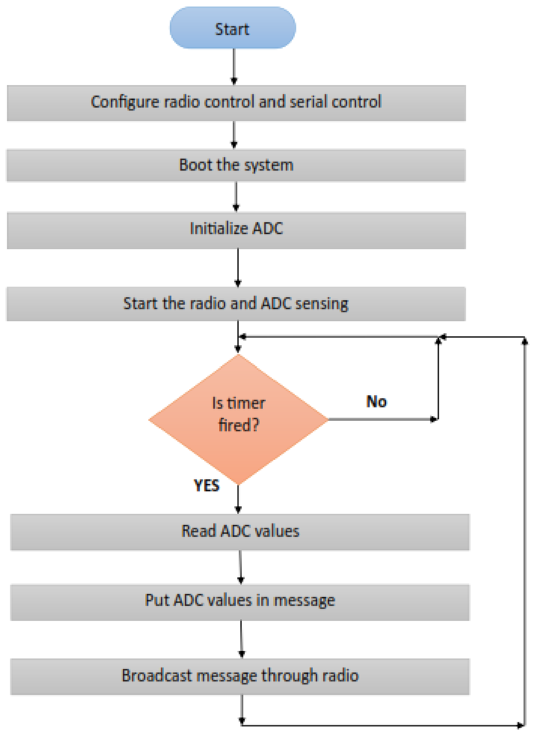


Figure 9. Level 2 nodes flow chart

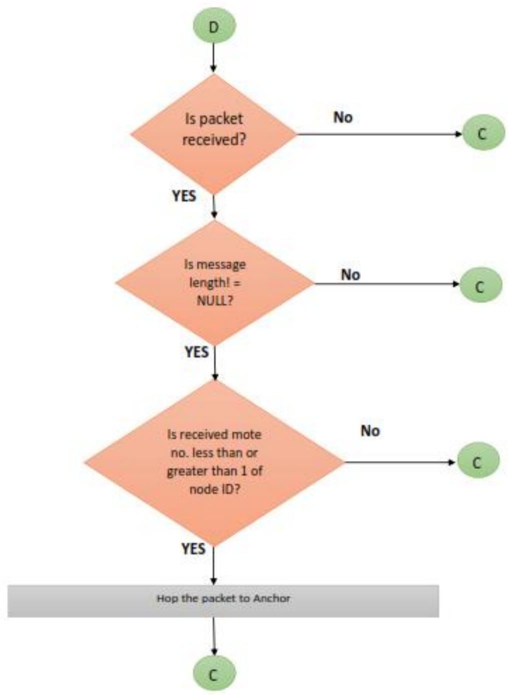
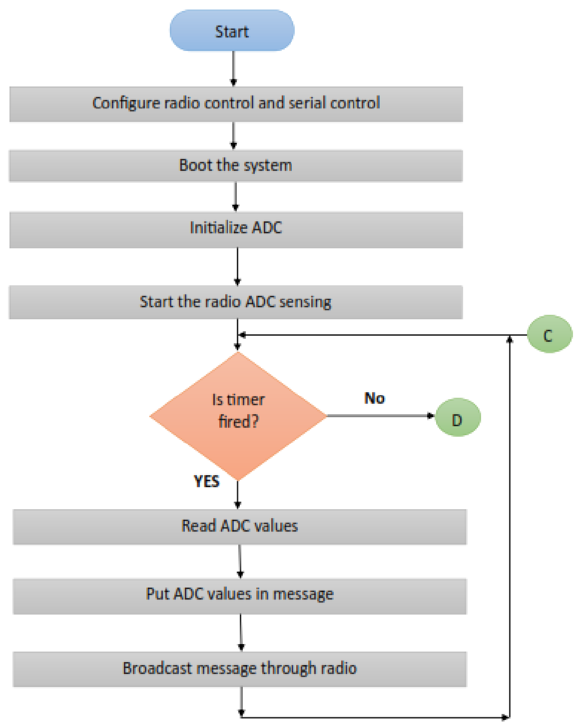
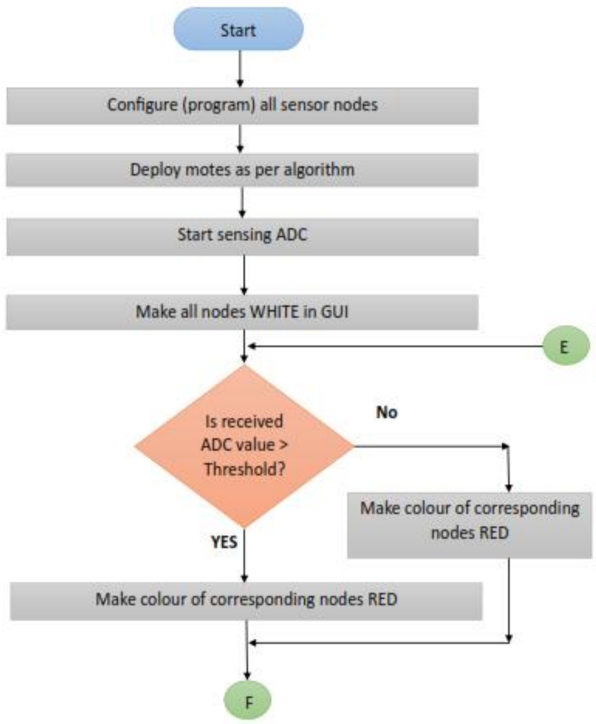


Figure 10. Level 1 nodes flow chart





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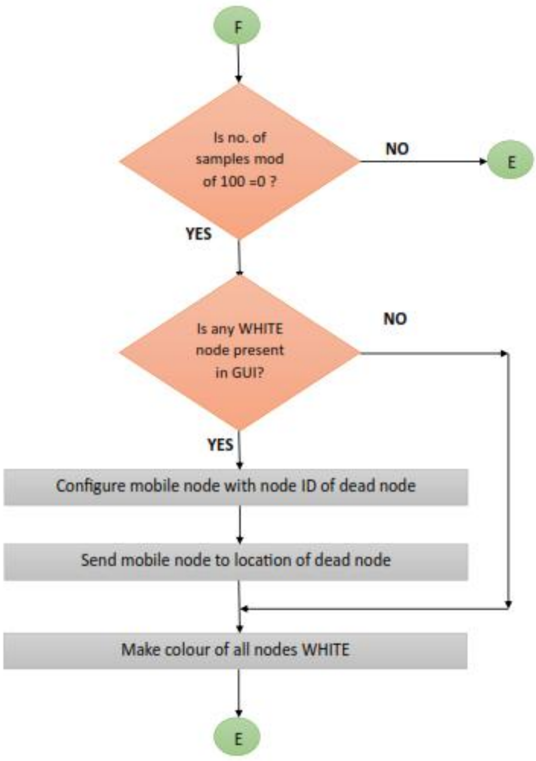

Figure 11. System flow chart

IV. HARDWARE IMPLEMENTATION OF DEVELOPED LOCALIZATION ALGORITHM

Anchor node is connected to computer via USB cable. Base node continuously sends data packets received from all other motes to computer, which plots status of all nodes of framework in GUI as shown in figure12.

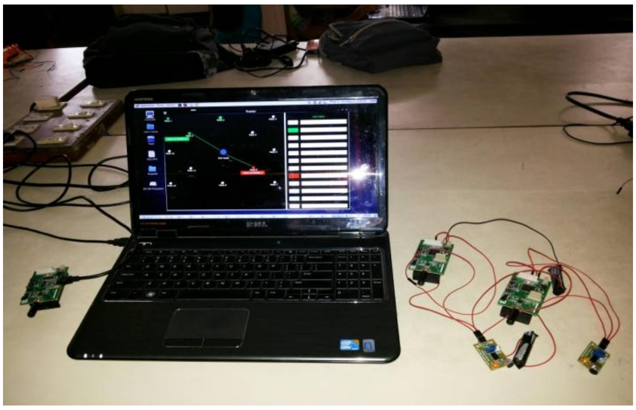

Figure 12. Base Station sink node and motes

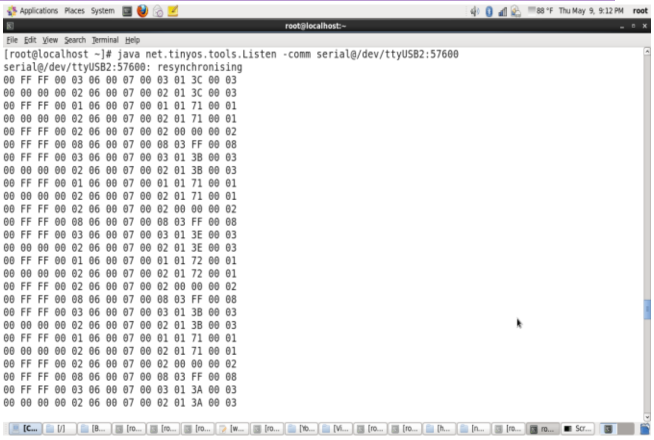

Figure 13.Data packets reception in terminal of CENTOS

Figure 13 shows data packets received by Anchor node which is connected to computer.

1. Last two (12^{th} and 13^{th}) bytes indicates the initial mote ID from which the data packet was initially sent.
2. Byte number 10^{th} and 11^{th} shows the ADC value sensed by the sensor.
3. Byte number 8^{th} and 9^{th} shows the mote ID from which the data packet is received by Anchor.

Initial deployments of motes in GUI

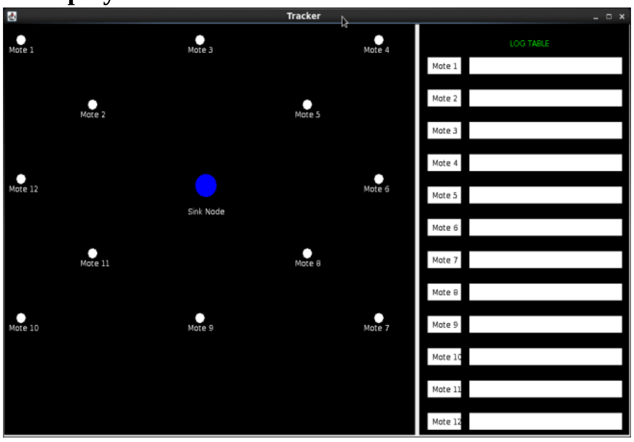

Figure 14. Initial Deployment of motes in GUI

Figure 14 shows initial deployment of motes in GUI, all nodes in GUI are initially white which signifies no data packets from these nodes are received by Anchor node.

On the right section of GUI, log table is created, it shows time stamp (date and time of reception) of data packets received from all motes of framework.

One illustrative example of Data Transfer between mote 2 and mote 8 is given in figures 15(a), 15(b),15(c) and 15(d).

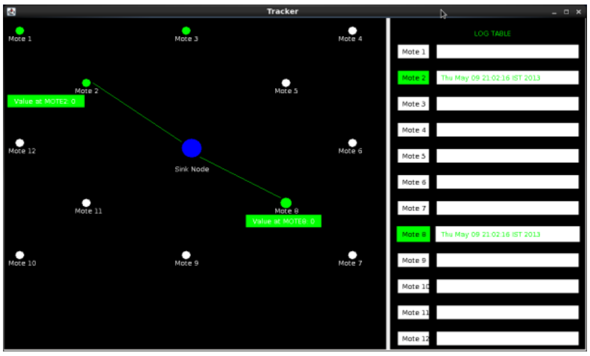

Figure 15 (a)

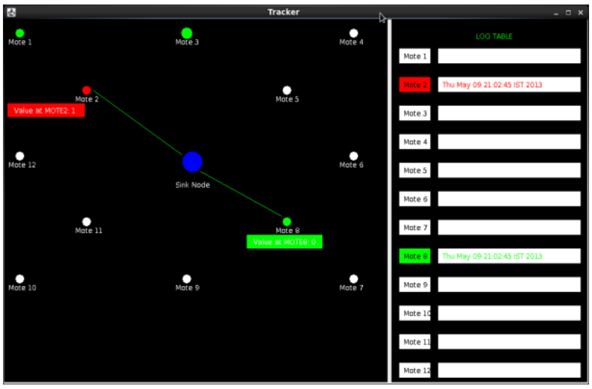

Figure 15 (b)

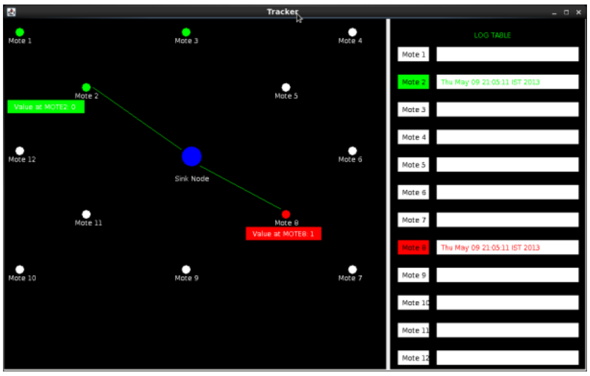

Figure 15 (c)

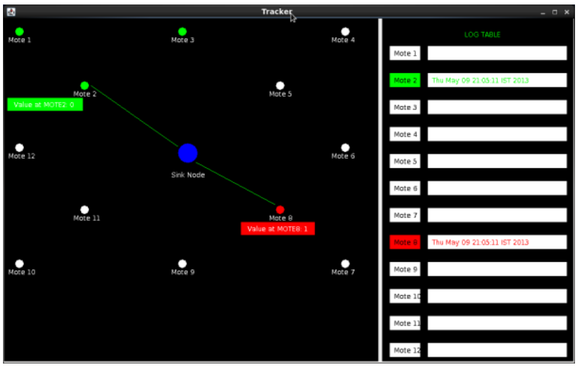

Figure 15 (d)

Figure 15 (a): Data transfer from mote 2 and mote 8, both motes are shown GREEN as data packets received from motes has LESS value than predefine Threshold value. Log table shows time stamp of data packets received from mote 2 and mote 8.

Figure 15 (b): Data transfer from mote 2 and mote 8, mote 2 is RED as data packets received from mote 2 has MORE value than predefine Threshold value. And mote 8 is GREEN as data packets received from mote 8 has LESS value than predefine Threshold value.

Figure 15 (c): Data transfer from mote 2 and mote 8, mote 2 is GREEN as data packets received from mote 2 has LESS value than predefine Threshold value. And mote 8 is RED as data packets received from mote 8 has MORE value than predefine Threshold value.

Figure 15 (d): Data transfer from mote 2 and mote 8, both motes are shown RED as data packets received from motes has MORE value than predefine Threshold value.

V. CONCLUSION

In this paper a new localization algorithm for wireless sensor networks is proposed, where mobility of node is also taken into account. The developed algorithm is useful in the scenario where there are few static and few mobile nodes. Also framework for the deployment of static nodes is developed. The effectiveness of the proposed formulation has been investigated via real experiments involving the IITH mote platforms produced by IIT Hyderabad, India.

In order to build up prototype of developed framework and for the implementation of proposed localization algorithm, one anchor node, 12 static nodes and one mobile node has been used. Experimental results show that proposed localization algorithm achieves high accuracy.

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