MULTIPLE DYNAMIC SINK MODEL FOR SUPPORTING MOBILE USERS IN WIRELESS SENSOR NETWORKS

E.Nithyanantham[1], M.Yuvaraja[2]

ABSTRACT

Wireless sensor network consists of sensor nodes with sensing and communication capabilities. Typical communication model of wireless sensor network consists of several sensor nodes as Group members, Group leaders and sinks. The Sink mobility brings new challenges to large-scale sensor networks. The dynamic sink model does not rely on the traditional communication model of wireless sensor networks. The dynamic sink model is to avoid long relay paths organized by footprint chaining of the mobile sink model, a mobile user chooses a sensor node as a dynamic sink when the mobile user needs some information. The dynamic sink constructs a data gathering tree and collects data from all sources. The dynamic sink model also has the disconnection problem of remote users. Moreover, if the mobile user wants to gather data again, it reselects a new dynamic sink and reconstructs a new data gathering tree from the dynamic sink. The simulation results of the proposed model are compared with existing model in terms of energy consumption, packet delivery ratio, delay and avoid packet loss for future system design.

[1]Assistant Professor, Department of Computer Science and Engineering, PA College of Engineering and Technology, Pollachi, Coimbatore, Tamil Nadu, India 642002
E-mail : nithyananthame@gmail.com

[2]Assistant Professor and Head, Department of Electronics & Communication Engg., PA College of Engg. and Technology, Pollachi, Coimbatore, Tamil Nadu, India 642002
E-mail : yuvarajmuthusamy@gmail.com

Key words – Dynamic sink model, Static sink model, Energy efficiency, Packet delivery.

I. INTRODUCTION

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions like temperature, sound, vibration, pressure, pollutants and to cooperatively pass their data through the network to a main location. The modern networks are bi-directional, enabling to control the activity of the sensors. The development of wireless sensor networks was motivated by military applications like battlefield surveillance, today such networks are used in many industrial and consumer applications, like industrial process monitoring and control, machine health monitoring.

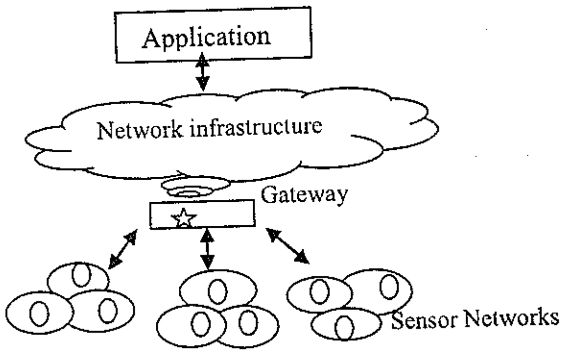


Figure 1 : Model of Wireless Sensor Networks

The WSN is built of nodes – from a few to several hundreds or even thousands, where each node is connected to several sensors. Fig 1. shows that the sensor nodes in the networks are randomly moves and they are connected to user through gateway sensor node. Each sensor networks of node has radio transceiver with an internal antenna or connection to an external antenna, a microcontroller and electronic circuit for interfacing with the sensors and energy source, usually a battery or an embedded form of energy harvesting. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few pennies depends on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources like energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network.

The propagation technique between the hops of the network can be routing or flooding. Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors including specific conditioning circuitry, a communication device like radio transceivers or alternatively optical and a power source usually in the form of a battery.

A. Models Of Wireless Sensor Networks

Typical communication model of wireless sensor networks consists of users, sinks, and a number of sensor nodes are shown in the Fig 2. In the communication model, users are remote from sensor networks and connect with a sink through legacy networks like Internet or satellite. The sink gathers data from many sensor nodes in data centric multi-hop communication and forwards the data to the users via legacy networks. The sink functions as the gateway between wireless sensor networks and users. In practical sensor network applications, there are mobile users like fire fighters and soldiers as well the traditional remote users.

The mobile users move around sensor fields to perform their missions like saving life of victims in disaster areas and might not have any direct communication through legacy networks.

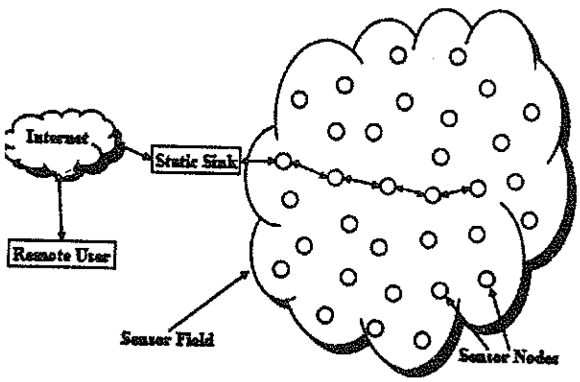


Figure 2 : Traditional model of communication

Many researchers have been studied to support mobility of the mobile users on sensor networks. The four categories according to communication models with respect to data collection of the mobile users are single static sink model with legacy network, mobile sink model, dynamic sink model, and single static sink model with sensor network, multiple static sink models with legacy networks.

B. Multiple Static and Dynamic Sink Model

Multiple static sink model has direct communication between the legacy network and the sensor network. The dynamic sink model does not rely on the traditional communication model. The comparison between the Multiple Static and dynamic Sink Model is shown in the simulation results.

The mobile user inside the sensor networks are mobile sink model and the dynamic sink model cannot perform a gateway function between sensor networks and remote users when the mobile sink cannot connect with legacy networks. The two models are not suitable for applications. The proposed method is multiple dynamic sink model for supporting the mobile users efficiently. It is used to overcome the disadvantages of the existing method.

II. Related Work

In survey on sensor networks [1], each sensor nodes collect data and route data back to the sink. The sink may communicate with the task manager node via Internet or satellite. Real-world habitat monitoring [2] provides an in-depth study of applying wireless sensor networks. In Two Tier Data Dissemination model [3], each data source in TTDD proactively builds a grid structure and it enables mobile sinks to continuously receive data on the move by flooding queries within a local cell only. If the lifetime elapses and the dissemination nodes on the grid do not receive any data. SEAD protocol [4] minimize energy consumption in both building the dissemination tree and disseminating data to mobile sinks.

In Mobile IPv6 [5], each mobile node is always identified by its home address, regardless of its current point of attachment to the Intemet. The multiple sinks in a large-scale WSN [6], manageability of the network increases and the energy dissipation at each node decreases. Scalable, energy-efficient data acquisition in large sensor network [7] uses simple querying and data collection trees for hop-by-hop query dissemination and routing of sensor responses back towards the sink. A new reliable transport scheme for WSN, the event-to-sink reliable transport (ESRT) protocol [8] is used.

Data aggregation algorithm [9] is used for gathering and aggregating data in an energy efficient manner so that network lifetime is enhanced. Dual-Sink [10] mobile and static sinks for lifetime improvement in Wireless Sensor Networks. The network lifetime increases from the sink mobility can be offset by the broadcasting which incurs extra high energy loss. Multiple static sink models [11] are used have direct communication between the legacy network and the sensor network. It increases the packet loss, delay and decreases the energy The IGAP [12] has a superior merit that it can use previously researched information gathering algorithms. IGAP can support the mobile user with low control packet overhead. The mobility is exploited [13] for efficient data dissemination and the sinks move towards randomly distributed destinations and each destination is associated with a mission. The sinks moving randomly, unpredictably and inartificially. The energy efficiency in Wireless Sensor Network is improved using mobile sink [14]. Wireless Sensor Networks have been deployed for various purposes like military applications, surveillance in volcanic or remote regions. But lack of energy efficiency retards the lifetime of the network.

In the previous work, Single static sink model is provided for communication [15]. It gathers data from sources and delivers the collected data to both the traditional remote users and the mobile users. It provides hotspot problem, high congestion, and large amount of energy consumption around the single static sink. So Multiple static sink models are used have direct communication between the legacy network and the sensor network. It increases the packet loss, delay and decreases the energy. It reduces hot spot problem. In the proposed method, multiple dynamic sink model is used to increase the network life time, energy and decreases the packet loss and delay without considering the traditional communication model of wireless sensor networks.

III. Multiple Static Sink Model

Multiple static sinks can be located in the places connected with legacy networks in the sensor field can communicate directly with each other via the legacy networks. The multiple static sinks divide the sensor network and dispersively collect data can solve the problems of single static sink. Multiple static sinks can support effectively the mobility of user inside the sensor field. Multiple static sinks divide a sensor network into domains.

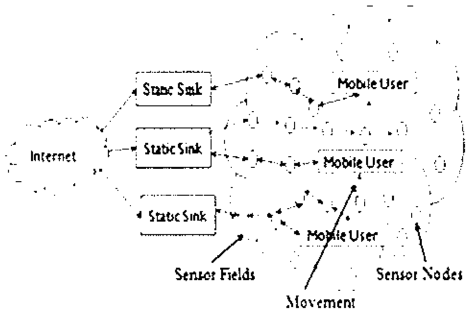


Figure 3 : Multiple Static Sink Model

The mobile user sends queries to the nearest sink from its location and multiples static sinks propagates fast the queries inside the sensor network through sharing the queries via legacy networks is shown in the Fig. 3. Multiples static sinks also share the collected data from sensor nodes via legacy networks and the nearest sink from the mobile user delivers fast the sharing data to the mobile user. The mobile user sends queries to the nearest sink from its location and receives data from the nearest sink from its location through short hops communications. This reduces energy consumption of sensor nodes, increases data delivery ratio and decreases delay. The sink1 receives queries from mobile users and shares the query with other sinks via legacy networks. Multiple static sinks disseminate the query to the sensor field is shown in the Fig. 4.

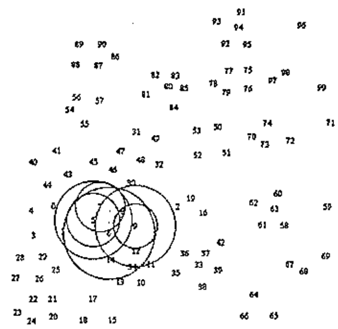


Figure 4 : Sharing the queries

Multiple static sinks distributed gather data from sensor nodes in their domains and share the data via legacy networks. The sink1 delivers information data to the mobile users is shown in the Fig. 5.

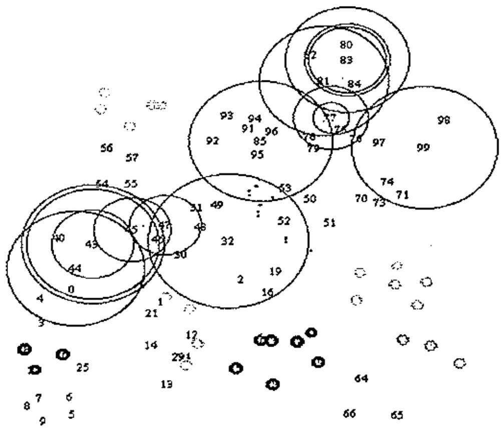


Figure 5 : Distibution of gathered data

The communication protocol supports mobile users in wireless sensor networks based on multiple static sinks. The protocol consists of three phases

A. Network initialization phase - allocates multiple static sinks and divides a sensor networks.

B. Data gathering of mobile user - gathers data effectively from the sensor networks through multiple static sinks.

C. User mobility support - it delivers data to the mobile users through mobility management.

A. Network initialization

i) Allocation of multiple static sinks

The multiple static sinks can communicate with each other for sharing information and can communicate with remote users for performing gateway functions between remote users and the sensor network through short hops communications.

ii) Network dividing of multiple static sinks

The sensor network is divided by multiple static sinks with new locations. Every sensor node has known hop counts and next hop neighbor sensor node toward each sink.

B. Data gathering of mobile user

i) Querying of Mobile User

If a mobile user makes a query with its ID for gathering data from sensor nodes, it selects a sensor node nearest from its location as its Primary Agent (PA) and sends the query to the PA. Each sink disseminates the shared query to sensor nodes which have smaller hop counts from it than hop counts from the other sinks. The proposed protocol can disseminate it within the whole sensor field by multiple static sinks. Firstly, the distributed query dissemination by multiple static sinks can reduce the number of transmitting and receiving than the query dissemination by one sink and hence reducing the energy consumption. Secondly, it can reduce query receiving times of sensor nodes and hence enabling faster data responses.

ii) Data Gathering, Sharing and Disseminating of Sinks

Every sensor node generates its data about the query and sends it to its parent node on the tree rooted at its sink. It reduces the energy consumption for data transmissions in the data gathering approach based on tree. Parent nodes can receive data from their children nodes, and send the aggregated data to their parent nodes. The tree-based data aggregation brings about much delay because parent nodes wait to receive data from all their children.

D. User mobility

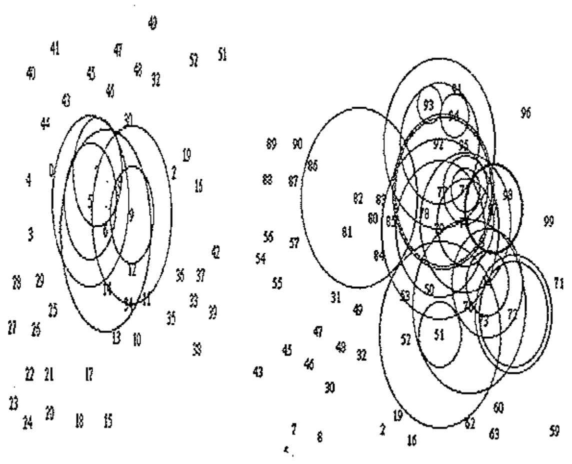
The data is disseminated to a mobile user through user mobility management. It supports user mobility in terms of two mobility managements are represented in the Fig. 6.

i) Local mobility management

The method uses Footprint-Chaining scheme for local mobility management. It supports user mobility inside the domain of a sink.

ii) Global mobility management

The mobile user can move from a domain of a sink ie. old sink into a domain of another sink ie. new sink. It supports user mobility between the domains of sinks.



(a) Local mobility (b) Global mobility

Figure 6 : User mobility management (a) & (b)

IV. Multipled Dynamic Sink Model

Wireless sensor networks (WSNs) consist of battery operated tiny sensor nodes and connected in a network for communication. The dynamic sink model does not rely on the traditional communication model of wireless sensor networks. The dynamic sinks in Wireless Sensor Networks consists of two types of users (i) The remote user can gathers data from sensor nodes through the static sink via the legacy networks. (ii) The mobile user can move freely inside the sensor networks but cannot connect with legacy networks. Dynamic Sinks solve the problem of packet loss and energy in WSNs. It moves dynamically to particular positions among the different positions in a predetermined order to collect data from sensor nodes. There is a considerable delay in the case of single mobile sink. But the multiple Dynamic sinks collect data in different nodes by using Multiple Dynamic Sink algorithm and it is used to reduce delay and energy consumption.

A. Multiple Dynamic sink node

Multiple dynamic sink nodes can coordinate to consolidate data collected from the static sensor nodes. The Wireless Sensor Network is divided into a number of zones are shown in the Fig.7. The movement of the dynamic sink is restricted to its cluster. This technique increases the collection of data from ordinary sensor nodes reducing the consumption of energy and delay. Both these features help in increasing the lifetime of WSNs. When one of the sink fails, the cluster is merged. The network still continues to function though at a reduced efficiency, there is increase in delay and is called graceful degradation. The employment of multiple dynamic sinks increases reliability and does not allow the WSNs to collapse even with the failure of some Mobile sinks.

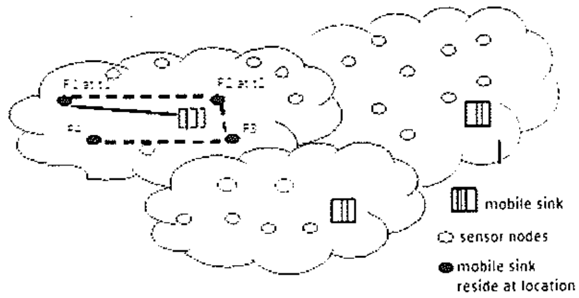


Figure 7 : Network Architecture of Multiple Dynamic Sink Model (MDS)

B. Routing and Iteration in MDSM

The Multiple Dynamic Sink algorithm comprises of two algorithms. They are MDSM Routing Algorithm and MSSM Algorithm. Each sink moves to a predefined position for a specified period to collect data from each zone. The neighbors of an active sinks are identified by sending the hello packets from all the sensor nodes to the nearest active sink. MDSM algorithm runs for various iterations for different sinks and positions. MDSM Routing Algorithm selects a minimum distance routing to reduce the energy consumption in the network. When a sensor node has data to forward, it checks for the active sink position and then forwards data.

V. Results

The performance evaluation metrics and the comparison of the Multiple Static Sink Models and the Multiple Dynamic Sink Model results are described through the NS2 Simulator.Three metrics to evaluate the performance of the proposed protocol are given and it is shown in the Fig. 8. The energy consumption is defined as the communication like transmitting and receiving energy the network consumes. The delay is defined as the average time between the time a sensor node transmits a data packet and the time a user receives the data packet. The data delivery ratio is the ratio of the number of successfully received data packets at a user to the total number of data packets generated by every sensor node.

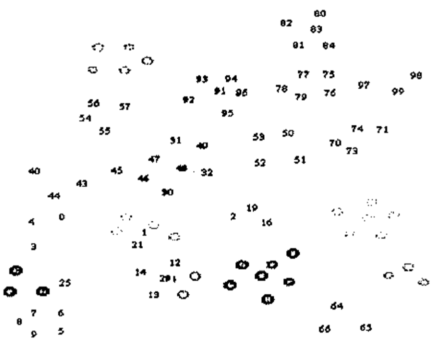


Figure 8 : Multiple Dynamic Sink

The results show that energy at all nodes are used effectively through multiple dynamic sinks and it increases the lifetime of network are shown in the Fig. 9.

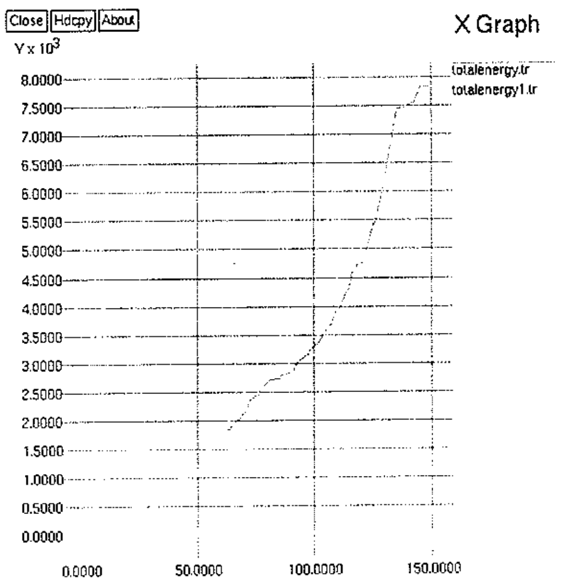


Figure 9 : Energy Calculation

The following results are the comparison of routing between two sinks when an event occurs in the range of both sinks. Source sensor node forwards data to the sink which is nearer among the sink nodes. The variance is lower for the network with multiple dynamic sinks. It is observed that all nodes in MDSS network, drain their energy uniformly and thus improves the lifetime of the network, decreases the packet loss and delay.

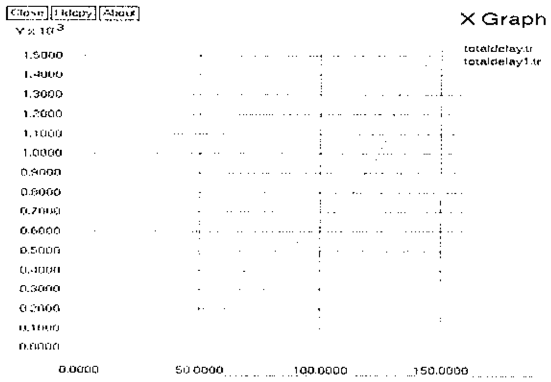


Figure 10 : Delay Calculation

The delay and the packet delivery ratio calculations are shown in the Fig. 10 and Fig. 11.

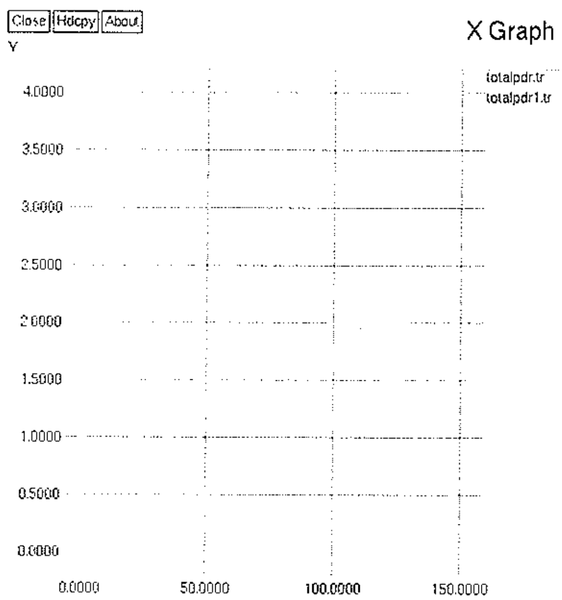


Figure 11 : Packet Delivery Radio Calculation

VI. Conclusion

In Wireless sensor Network with Multiple Static Sink, all source node forwards data towards the sink. The proposed method introduced the Multiple dynamic sink model to improve the network lifetime, energy efficiency and reduce the delay. During the last iteration of MDSS WSN, the residual energy of all the sensor nodes is almost same which shows that energy drains uniformly and thus increases the lifetime of the network. The proposed MDSS algorithm minimizes the delay in the network at a very small increase in cost of multiple dynamic sink. In future, this can be developed for large scale WSNs including reliability and recovery.

References

1. Akyildiz. I, Sankarasubramaniam. Y, Su. W and Cayirci. E (2002), *'A Survey on Sensor Networks'*, IEEE Communication Magazine.

2. Mainwaring. A, Polastre. J, Szewczyk R., Anderson. J and Culler. D (2002), *'Wireless Sensor Networks for Habitat Monitoring'*, in Proc. ACM WSNA.

3. Ye. F, Luo. H, Cheng. J and Zhang. L (2002), *'A Two-Tier Data Dissemination Model for Large-scale Wireless Sensor Networks'*, in Proc. ACM MOBICOM.

4. Kim. H, Abdelzaher. T (2003), *'Minimum-Energy Asynchronous Dissemination to Mobile Sinks in Wireless Sensor Networks'*, in Proc. ACM SenSys.

5. Johnson. D, Perkins. C and Arkko J (2004), *'Mobility Support in IPv6'*, RFC3775.

6. Oyman. E and Ersoy. C (2004), *'Multiple Sink Network Design Problem in Large Scale Wireless Sensor Networks'*, in Proc, IEEE ICC.

7. Das. A and Dutta. D (2005), *'Data Acquisition in Multiple-sink Sensor Networks'*, ACM SIGMOBILE Mob. Compu. Commun. Rev., Vol. 9, No. 3, pp. 82-85.

8. Akan. O and Akyildiz. I (2005), *'Event-to-Sink Reliable Transport in Wireless Sensor Networks'*, IEEE/ACM Transactions on Networking, Vol. 13, No. 5, Oct. 2005, pp. 1003-1016.

9. Rajagopalan. R and Varshney. P (2006), *'Data-Aggregation Techniques in Sensor Networks: A Survey'*, IEEE Commun. Surveys Tuts, Vol. 8, No. 4, pp. 48-63.

10. Wu. X. and Chen. G. (2007), *'Dual-Sink: Using Mobile and Static Sinks for Lifetime Improvement in Wireless Sensor Networks'*, in Proc. IEEE ICCCN.

11. Euisin Lee, Fucai Yu (2011), *'Multiple Static Sink for Supporting Mobile Users in Wireless Sensor Network'*, IEEE Transactions on consumer Electronics, Vol. 56, No. 3.

12. Lee. E, Lee. D, Park. S and Kim. S (2007), *'IGAP: an Information Gathering Protocol for Mobile User in Infrastructureless Area'*, in Proc. IEEE ICACT.

13. Lee. E, Park. S, Kim. S and Yu. F (2009) *'Exploiting Mobility for Efficient Data Dissemination in Wireless Sensor networks'*, Journal of Communications and Networks, Vol. 11, No. 4, Aug. 2009, pp. 337-349.

14. K. Deepak Samuel, S. Murali Krishnan, K. Yashwant Reddy (2011), *' Improving Energy Efficiency in Wireless Sensor Network Using Mobile Sink'*, Communications in Computer and Information Science Volume 132, pp 63-69.

15. Park. S, Lee D., Lee. E and Kim. S (2007), *'A Communication Architecture to Reflect User Mobility Issue in Wireless Sensor Fields'*, in Proc. IEEE WCNC.

Author's Biography

E. Nithyanantham, was born on May24, 1986. He received his B.Sc, degree from S.N.M.V College of Arts and Science, Coimbatore (Bharathiyar University) in the year 2008. He received his MCA, degree from Kongu Engineering College, Perundurai (Anna University, Coimbatore) in the year 2011 and he completed M.E, degree in P.A College of Engineering and Technology, Pollachi (Anna University, Chennai) in the year 2013. Currently he is working as a Assistant Professor in P.A College of Engineering and Technology, Pollachi. His area of interest is Wireless Sensor Networks.

Mr. M. Yuvaraja, was born on Sep02, 1983. He received his B.E, degree from Sri Krishna College of Engineering & Technology, Coimbatore (Bharathiyar University) in the year 2004 and M.E, degree from Bannari Amman Institute of Technology, Sathyamangalam (Anna University, Chennai) in the year 2008. He has 7 years of teaching experience in various Engineering Colleges. Presently he is working as a Assistant Professor and head in P .A College of Engineering and Technology, Pollachi. His areas of research interest are Signal Processing and Wireless Sensor Networks.