Fast, Reliable and Efficient Event-Detecting (Freed) Protocol for Event-Driven Wireless Sensor Networks

Sangeetha K
M.Tech (Wireless Communication systems), Department of ECE,
Periyar Maniammai University,
Thanjavur, India - 613403.

ABSTRACT
Wireless Sensor Network (WSN) plays a significant role in wireless communication. Event-Driven Wireless Sensor Networks (EWSNs) are special cases of WSN in which numerous nodes are placed in such a way that nodes start generating and propagating data packets when an event of interest occurs. For event monitoring in EWSNs, we have to solve two problems, one is the accurate event detection, the other is the reliable and fast transmission. Design of a protocol for this purpose should be such that it should identify the event occurrence and providing emergency routing based on the detected event should be done as fast as possible. Fast, Reliable and Efficient event-Detecting (FREED) protocol fits well in this situation. To evaluate the performance of the freed protocol with the existing system, Network simulator (NS-2) is used .

Keywords
Event-Driven Wireless Sensor Networks (EWSNs), Event-Detection.

1. INTRODUCTION
Wireless Sensor Network (WSN) *[1]* is a self-configuring network of small sensor nodes/motes communicating among them using radio signals, and deployed in quantity in an area to sense the physical environment. Each Sensor node will be having a extremely small and low cost sensors, a processor, a limited memory and a power supply, a radio and an actuator. Sensor nodes are able to perform sensing, processing and communicating data packets among the nodes in the network. WSNs are applied in various fields for numerous application scenarios like habitat monitoring, Detection of a target, earthquake, flood, fire, chemical attack, home automation and for various military, environmental and home applications*[5]*.

The main purpose of a WSN is the target detection and efficient data dissemination about the detected target to the destination/sink/fusion center/base station/policy decision maker.

Event-driven wireless sensor networks (EWSNs) *[12]* are special classes of WSN in which it is composed of large numbers of sensor nodes and these nodes are deployed in the terrain to sense the desired phenomena. The main goal of EWSN is the detection of Physical phenomena of interest (PoI) to the desired user.

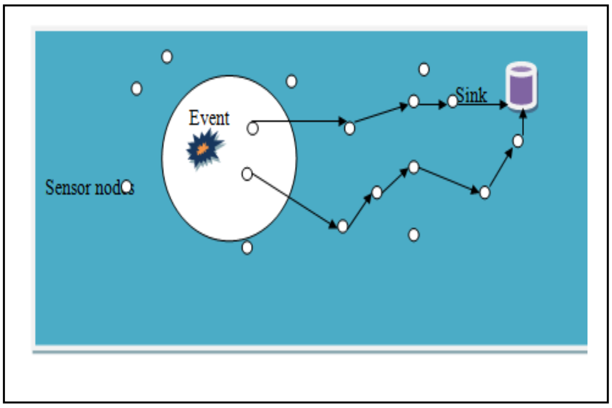

Fig.1. A Typical Event-Driven Wireless Sensor Network

An example of a typical EWSN network is shown in figure.1. The occurrence of an event is identified and the information regarding the detected event is immediately sent to the sink by the sensor nodes covering the event-occurring area. The three main functionalities of an EWSN*[8]* are detection of a observed event, processing the detected event and event communication among the sensor nodes.

Features of a EWSN:

a. Under normal condition, each node in the network will send their observation value to the sink periodically/constantly.

b. Under abnormal condition i.e., when an event occurs, nodes in the network will move onto emergency state and the nodes will start reporting to the sink regarding the occurred event.

The main objective of EWSN is fast and accurate event detection and event transmission.

This paper mainly aims at providing fast, reliable and energy efficient event-detection and event-routing scheme for an event-driven wireless sensor network. The proposed scheme is the enhancement of the existing Efficient Event-Detecting Protocol(EEDP) , incorporating an energy efficient sleep and awake scheduling scheme in addition to the features of EEDP. Geographical routing, Dynamic multi-copy scheme and local broadcasting schemes are used as such in EEDP. For saving the energy of the nodes and to increase the lifetime of a network, a sleep and awake scheduling scheme is used in the proposed FREED protocol.

The rest of the paper is organized as follows. Section.2 deals with current techniques in use and the issues associated with the existing techniques. Section.3 describes about the proposed architecture in detail. Simulation results and the inference from those results are given under Section.4.

Finally, Section.5 gives the conclusion and future enhancement of the proposed work.

2. CURRENT TECHNIQUES & ASSOCIATED ISSUES

The challenging issue concerned with WSN, in recent days, is the accurate event detection with appropriate energy-saving schemes. A design of a routing protocol for this purpose should be in such a way that it would meet all the requirements of a network to achieve high throughput by including various criteria such as interference, delay, loss rate, energy efficiency, reliability, timeliness, etc. This section deals with the current techniques in use and the problems associated with those techniques.

2.1 Reliability, Timeliness and Energy Saving methods

The term reliability*[16]* is used to know how much information is necessary to ensure the occurrence of event in EWSN. Correct timing of sending the information about the event occurrence is more important in a network else the purpose of sending the data packet may become useless. Since the sensor network has a limited memory and limited power resources, the usage of nodes should be energy-efficient to prolong the total lifetime of network. Many of the existing protocols aims at providing several techniques to ensure its characteristics like reliability, timeliness and for saving the limited sensor resources. Sleep scheduling *[6]* is one of the most commonly used mechanisms for saving the energy resources of the network. In sleep scheduling schemes, most of the sensor nodes are put into a sleep state and they are awakened periodically when needed.

Event-to-sink reliable transport (ESRT) protocol, a transport scheme for WSN, was proposed by *Akan.O.B and Akyildiz.I.F* in *[2]* , to achieve reliable event detection in WSN with minimal energy consumption by utilizing an congestion control component. The operation of ESRT protocol is determined by the current state of the network based on the reliability achieved and congestion condition in the network. The main disadvantage of ESRT protocol is that occurrence of extra delay due to feedback and rate control schemes.

Reliable Robust and Real time protocol(RRTP) proposed in *[4]* uses event-to-action delay bounds and congestion control mechanisms to achieve high reliability and to save energy. A fault tolerant optimal path is chosen for data delivery. Advantages of this technique is the reliable event-detection and energy conservation , because of using event-to-action delay bounds and reporting frequency adjustment schemes employed. High overhead occurs due to congestion detection and control mechanisms employed in RRTP.

EEDP *[11]* transmits the information about the event occurrence locally to the intermediate node(node closest to the destination) and then the event occurrence is intimated as a single alarm packet to the destination from the intermediate node. There are two main procedures in EEDP ,namely, Primary Detection Procedure (PDP) and Emergency Routing Procedure (ERP). In PDP, the accurate event decision is made based on decisions made by the nodes and their neighbours . In ERP, the information about the event is forwarded to the sink by using greedy forwarding approach. Loss of data due to link failures/ environmental conditions can be avoided by applying dynamic multi-copy scheme which will store the copy of alarm packet in a node's buffer and that copy can be used during link failure conditions. Advantages of EEDP includes less network load and accurate event-detection. Disadvantage is less reliability.

A Hierarchial routing protocol, EELLER proposed by *Ali.M et al* in *[3]*which aims at providing higher energy efficiency. Here, the number of intermediate hops are reduced due to clustering of nodes. Data packet is forwarded hop-by-hop through cluster heads. Information is sent through higher energy nodes and the event is sensed by using lower energy nodes. Advantages of this method is that it provides energy-efficient and accurate event-detection but reliability is less.

2.2 Event Detection Methods

Detection of an event should be fast and accurate. Event Detection can be single or Composite event detection type. In Single event-detection type, the node will be confirming it decision based on the single event alone. In composite event detection , decision on the event occurrence is confirmed based on the decisions made by the several nodes in the network . Composite event detection gives a more appropriate information about the event occurrence than the single event detection type.

Lucchi.M and Chiani.M in *[10]* proposed a simple event detection protocol for a line-deployed wireless sensor network . In order to minimize the power consumption of each node , the packet transmissions has been reduced by making each node to take a local decision by considering its own observation and also the decision made by the previous node. Simple fusion rules for both the global and local phenomenon scenario are proposed for minimizing the error probability of event-detection. However, the scheme is suitable for a chain network only and it is not scalable for more complex network topology.

For accurate event detection, information about composite event is more desirable which was first proposed by *Kumar.A.V.U.P et al* in *[9]* , in To ensure the quality of surveillance, if an event occurs, some applications require that the event occurrence is to be detected by at least k sensors, where k is a user-defined parameter.

2.3 Existing Routing protocols

Routing protocols are mainly classified under three categories: Reactive(on-demand), Proactive(Table-driven) and Geographical routing protocols.

In Pro-active routing protocol *[13]*, routes to all the nodes are maintained as a table at every node in a network. The topology of the network is updated periodically. Examples are DSDV (Destination Sequenced Distance-vector Routing),WRP (Wireless Routing Protocol), etc. Disadvantage with these protocols is the restructuring of routes during link-failure condition will be slow.

The Reactive routing protocols*[15]* will establish a route only when a path is required by a node to send its data packet. Examples of this type of protocols are AODV (Adhoc On-Demand Distance-vector routing),DSR(Dynamic source routing), etc. These protocols will cost less energy when compared with the former one. Latency time is high in this type which degrades its performance.

Geographical routing protocols are more advantageous than reactive and proactive routing protocols. In Geographical Routing protocols, a neighbor node in a network is identified using geographical position of the nodes. Some examples of Geographical routing protocols are given in this section.

Information Quality Aware Routing(IQAR*)[14]* protocol which addresses the problem of finding the least-cost routing tree using IQ constraints was proposed by *Tan.H.X et al(2010)*.The optimal least-cost routing solution results in high overheads since it requires knowledge of the entire network topology and individual IQ contributions of each activated sensor node. Topology-aware histogram based aggregation and greedy approaches were used to handle this situation.

Greedy Perimeter Stateless Routing (GPSR*)[7]* is a very well-known routing protocol proposed by *Karp.B and Kung.H.T(2000)*. GPSR utilizes the positions of nodes and the destination to make packet forwarding decisions. GPSR makes greedy forwarding decisions using only information about a node's immediate neighbor's in the network topology. By keeping information about the state of the local topology alone, GPSR scales better than traditional routing protocols as the number of network destinations increases. However, GPSR is designed for the ad-hoc networks and does consider the characteristics in EWSNs, where the event decision should be made in the forwarding procedure to shorten the event information delivery delay.

3. PROPOSED ARCHITECTURE

The Proposed FREED protocol is the enhancement of existing EEDP*[11]* protocol . Here, sleep-awake scheduling scheme is applied to the EEDP protocol. FREED protocol has two processes, namely, Event-Detection and Emergency routing processes. In Event-detection process, nodes in the event-occurring area will be kept awake and all other nodes in the network will be kept in the silent mode to prevent energy depletion. Decision about the Event occurrence will be taken at intermediate node. In Emergency routing process, event information will be transferred as a emergency alarm packet to the destination from the intermediate node.

3.1 Event-Detection Process

During Event detection process, each node collects the environment information with its own equipped sensors and makes local primary decision at the intermediate node itself before reaching the sink. Decision will be made in favour of a event if the sensed (observed value) of a node exceeds the predefined environmental value. Nodes except the nodes in the event-occurring area are kept silent to save the energy.

In Event-Detection process (as given in algorithm.1), at first a timer is set to take decisions based on the event. During Decision time, node (very closer to destination) keep sending its own decision message and hears decision messages from its neighbors. If the decision message d(i) is equal to 1,then it denotes the occurrence of an abnormal event and hence for taking immediate action on that event, the event-detecting node will generate and forward a alarm packet(φ) as fast as possible. If the decision message d(i)≠1,then the decision-making process will be going as normal until it turn over to a abnormal process. An optimal sleep-awake scheduling scheme is adopted here to keep the unwanted nodes to keep silent to prolong the lifetime of EWSN.

Algorithm 1:During Event-Detection Process

Input: Observation values of node i , x^i
Output: Decision of node i , d(i)

Step.1: Set a decision timer(T).

Step.2: Node i keeps sending its own primary decision message & overhearing decision message from neighbors. Nodes other than node 'i' and its neighbors , are kept silent

Step.3: If decision value, d(i)=1, then it indicates the occurrence of an event and node i will goto *Step.4* else it will move onto *Step.5*

Step.4: Node i will generate & forward alarm packet (φ) to destination immediately.

Step.5: Node will forward its local message to its neighbors and keep in overhearing messages from other nodes.

Step.6: When node i receives alarm packet (φ) from other node, it will suspend to send its local message further.

Step.7: When timer T expires, node will keep silent and clears its observation value.

Advantages during Primary detection process:

1.Energy consumed by the nodes in the network is reduced since decision is made at the intermediate node itself and some energy is conserved by applying sleep-awake scheduling scheme.
2.The latency time of a network is reduced since congestion is avoided by sending a single alarm packet alone throughout the network.

3.2 Emergency-Routing Process

Geographic routing based on location information of the nodes is adopted. Protocol utilizes greedy forwarding while forwarding alarm packet during link failure conditions and uses broadcast nature of wireless communication for broadcasting the alarm packet to a the destination. In Greedy forwarding, each node will relay the packet to a neighbor closer to the destination area, the packet can eventually be delivered to the destination without global topology information. Large amount of raw event-information is aggregated to a single alarm packet and broadcasted to the destination using broadcast nature of a wireless network. The candidate forwarding node (the node closest to the destination) will f/w these local primary decisions to the sink in the form of alarm packets and further process for routing is made in the emergency routing process of the protocol.

Algorithm 2: During Emergency-Routing Process

Input: Observation values of node i, x^i
Output: Transfer of information about the event from intermediate node to the sink

Step.1: Large amount of raw data – aggregated to form a single alarm packet(Traffic load – extremely low).

Step.2: Node – very closest to destination - chosen as forwarder.

Step.3: Once the alarm packet is generated, it reaches the destination by routing it based on its geographical position.

During Emergency routing process(as given in algorithm.2*)*, the information about the event-detection is sent to the sink(user) for taking immediate reaction against that detected event. Here, the alarm packet is sent as soon as possible. The copy of the alarm packet thus generated is buffered in the intermediate node to avoid loss of data packet during link-failure conditions. This technique of storing a copy of the emergency data packet is referred as dynamic multi-copy scheme.

Advantages during Emergency routing process:

1.Dynamic multi-copy scheme is employed to transmit the copy of the alarm packet through candidate forwarding node and hence it will avoid the failure in the transmission of a alarm packet.

4. SIMULATION – ANALYSIS

The Performance of FREED protocol using NS-2 simulator is analysed in this section.

4.1 Deployment of Nodes

The proposed protocol is applied with total number of 100 nodes with sink at the bottom of the network represented by circle. Nodes are deployed randomly within a 200×200m square of area. Simulation time is set as 250s. Initial energy of the nodes is taken as 100. Fire and smoke events are incorporated for analyzing the performance of the protocol. Figure.2 shows the topology of the simulation environment.

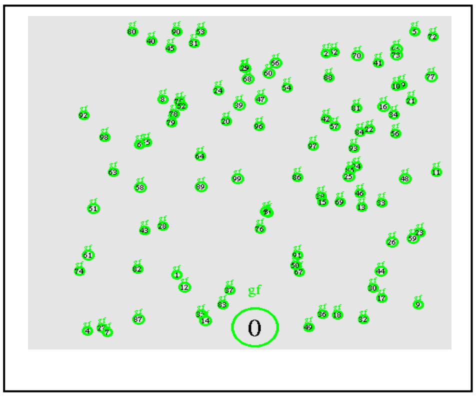

Fig.2.Deployment of Nodes

4.2 Data transmission before the occurrence of event

At normal condition, all the nodes will be in awake state and the nodes in the network will send its own observed environmental values and also the observation values of its neighbors to the sink / destination. Each node is equipped with sensor components capable of sensing different features like fire, smoke, etc.

The transmission of data packets among the nodes of the network during normal condition is shown in figure.3

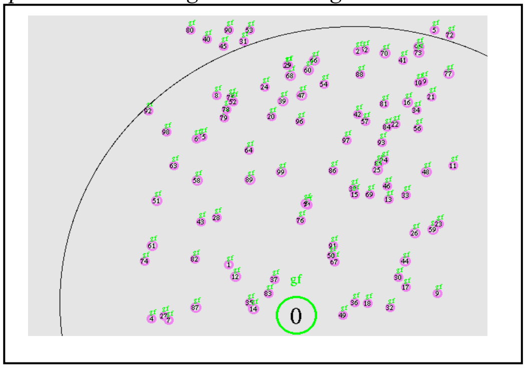

Fig.3.Data transmission before the occurrence of an event

4.3 Data transmission after the occurrence of event

If the sensed value of the node exceeds the predefined threshold value of the network ,in emergency condition(when an event occurs),the nodes will be making decision based on its environmental values and its neighbor's values and the decisions of the each node will be aggregated at the intermediate node(node closest to destination) and then the aggregated data packet is sent in the form of alarm packet to the destination from that intermediate node. When the event packets are transferred to the intermediate node , all the other nodes except the intermediate node will move onto sleep state to save their limited resource.

Neighbor node positions are identified using Geographical routing and dynamic multi-copy scheme is employed to avoid the loss of alarm packets during link failure conditions.*Figure.4* shows how data packets are transmitted during abnormal condition to the destination.

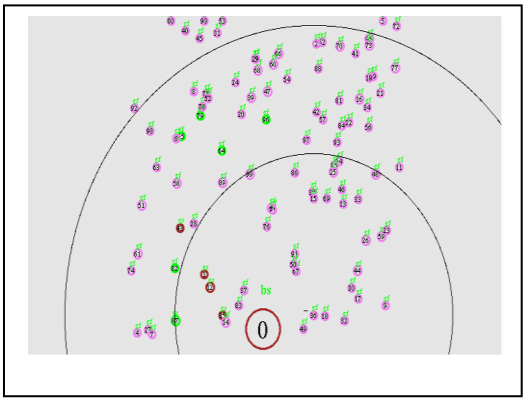

Fig.4.Data transmission after the occurrence of an event

Nodes transmitting same event-information are indicated with same color as shown in the above figure.

4.4 Packet Delivery ratio(PDR)

Packet delivery ratio can be defined as the ratio of data packets received by the sink node to those sent by the source nodes. The Packet delivery ratio of the proposed freed protocol is compared with those of the existing protocols like EEDP, GPSR . It is seen from the figure.5, the packet delivery ratio of FREED is far more better than the existing protocols. Network load is more in GPSR and hence the PDR of GPSR is very less when compared with EEDP and FREED. Although, the network load is less , in EEDP, delay in taking appropriate decisions gets more which reduces the PDR.

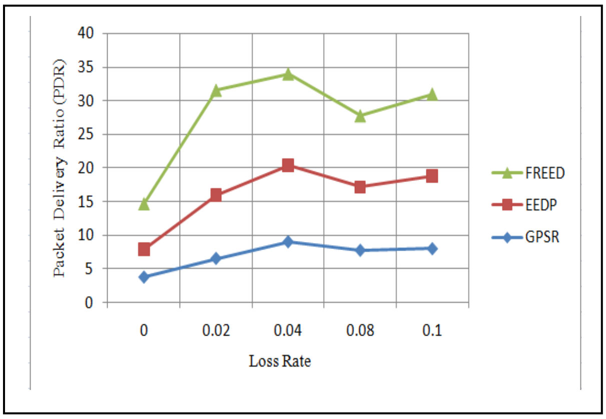

Fig.5.Packet delivery ratio

Figure.5. shows the comparison of packet delivery ratio of FREED protocol with the existing protocols viz., EEDP and GPSR.

4.5 Latency Time

Latency time is the time-limit from detecting the event by a node to the reception of event-information to the Destination. Latency time is obviously low in FREED when compared with EEDP and GPSR protocols.

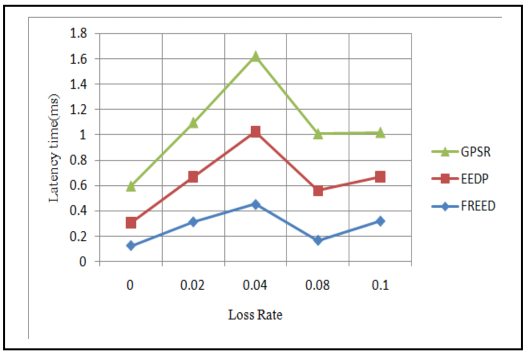

Fig.6.Latency time

Latency time taken by the nodes is possibly low when using freed protocol than compared with the existing protocols and it is shown in figure.6.

4.6 Energy Efficiency

Energy efficiency is evaluated based on the number of packets sent by the node to the destination to identify the occurrence of event. Since, Sleep-awake scheduling scheme is adopted in FREED, the energy efficiency of FREED will be more than that of GPSR and EEDP.

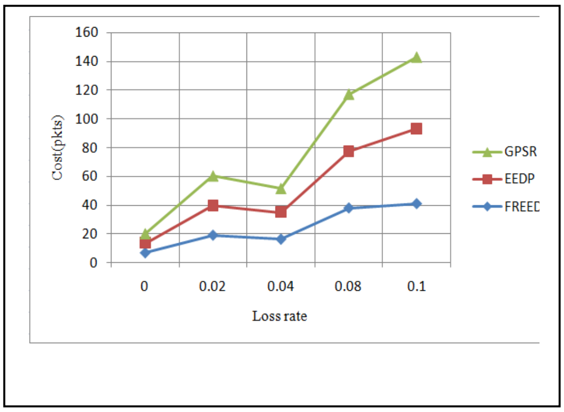

Fig.7.Energy efficiency

Energy efficiency (in terms of cost) of a freed protocol in comparision with the existing protocols is shown in figure.7

5. CONCLUSION

In this paper, a fast, reliable and energy- efficient event detection protocol for a event-driven wireless sensor networks has been proposed . The aim of the protocol is to detect the event occurrence and to disseminate the event information to the sink as fast as possible with accurate and timely detected event packet. An enhancement to the existing EEDP system has been tried using an optimal sleep-awake scheduling scheme. The performance of the proposed system over existing system has been analysed using NS-2. Transmission delay can occur because of using sleep and awake scheduling scheme , since the time taken by the next node to wake –up may become more and hence, in further research , the aim is to introduce a new another method without affecting the transmission time of the emergency packet, to improve the energy efficiency of the proposed protocol.

6. REFERENCES

[1] I.F. Akyildiz, W.Su, Y. Sankarasubramanian, and E.Cayirci,"A survey on sensor networks",IEEE Commun. Mag., vol.40, no.8, pp. 102-114, August, 2002.

[2] O. B. Akan and I. F. Akyildiz, "Event-to-sink reliable transport in wireless sensor networks," *IEEE/ACM Trans. Networks*, vol. 13, no. 5, pp. 1003–1016, Oct. 2005.

[3] Ali.M, Fazard.T, Mohammad.H.Y.M, Mohsen .T.H, "EELLER: Energy-Low Latency Express Routing for WSNs", IEEE,vol.3, pp.334-339, 2010.

[4] Deepali Virmani, Stabirjain, "Reliable Robust and Real-Time Communication Protocol For Data Delivery in Wireless Sensor Networks", *International Journal of Information Technology and Knowledge Management (* IJITKM) , vol.4, pp. 595-601,July- Dec.2011.

[5] T. He, J. Stankovic, C. Lu, and T. Abdelzaher, "Speed: A stateless protocol for real-time communication in sensor networks," in *Proc. 23rd Int. Conf. Distr. Comput. Syst.*, May 2003, pp. 46–55.

[6] Jiang.B, "End-To-End Delay Analysis For Event-Driven Wireless Sensor Network Applications", a preliminary proposal submitted for Doctor Of Philosophy ,Computer

Engineering, Virginia Polytechnic Institute And State University, Blacksburg, Virginia,May 4, 2009.

[7] B. Karp and H. T. Kung, "GPSR: Greedy perimeter stateless routing for wireless networks," in *Proc. MobiCom*, Boston, MA, Aug. 2000, pp. 243–254.

[8] K.C.Krishnapriya and Sebastian Terence , " A Survey on Event Detection and Transmission Protocols in an Event Driven Wireless Sensor Network", International Journal of Computer Applications (0975 – 8887) Volume 58– No.4, November 2012.

[9] A. V. U. P. Kumar, A. M. V. Reddy, and D. Janakiram, "Distributed collaboration for event detection in wireless sensor networks," in *Proc. MPAC*, Grenoble, France, Nov. 2005, pp. 1–8.

[10] M. Lucchi and M. Chiani, "Distributed detection of local phenomena with wireless sensor networks," in *Proc. ICC*, Cape Town, South Africa, May 2010, pp. 1–6.

[11] Lulu Liang, Deyun Gao, Hongke Zhang, and Oliver W. W. Yang,"Efficient Event Detecting Protocol in Event-Driven Wireless Sensor Networks", IEEE Sensors Journal, Vol. 12, No. 6, June 2012.

[12] Lulu Liang, Qi Zou, Guang Yang, Lei Shi, "Security Issues and Challenges in Event-Driven Wireless Sensor Networks", Proceedings of the 2012 2nd International Conference on Computer and Information Application (ICCIA 2012), ISBN (on-line): 978-94-91216-41-1

[13] C.Siva Ram Murthy and B.S.Manoj, *AdHoc Wireless Networks: Architectures and protocols*, Prentice Hall PTR,2004,ISBN 978-81-317-0688-6

[14] H. X. Tan, M. C. Chan, W. D. Xiao, P. Y. Kong, and C. K. Tham, "Information quality aware routing in event-driven sensor networks," in *Proc. INFOCOM*, San Diego, CA, Mar. 2010, pp. 1–9.

[15] L.J.G.Villalba , A.L.S.Orozco.A.L.S., A.T.Cabrera and C.J.B.Abbas,(2009) , *"Routing Protocols in Wireless Sensor Networks"* Sensors-Open Access Journal *Sensors* (ISSN 1424-8220; CODEN: SENSC9),2009, *9*, 8399-8421; doi:10.3390/s91108399.

[16] Y. Xue, B. Ramamurthy, and Y. Wang, "Providing reliable data transport for dynamic event sensing in wireless sensor networks," in *Proc. ICC*, Beijing, China, May 2008, pp. 3146–3150.