IJITKMSpecial Issue (ICFTEM-2014) May 2014 pp. 51-56 (ISSN 0973-4414)

Wireless Sensor Networks: A Survey

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Abstract:-Wireless sensor network is an ad-hoc network having arrangement of nodes is self-configured with infrastructure less characteristic. Sensor nodes in WSN are densely deployed with their limited resources. There are large numbers of sensor nodes that forms a network and collaborate locally with each other in the neighborhood to do a specific task and gives some effective results. In this paper we will focus on the energy efficiency, routing and also QoS supporting proposed work in WSN. Our literature work purpose is to implement an energy efficient routing protocol with QoS support.
Keywords: WSN, Energy efficiency, QoS.

1. Introduction

Wireless networking technology and mobile communications has seen a flourishing progress in recent years. Determined by technological advancements as well as application demands various classes of communication networks have emerged such as Cellular networks, Ad hoc Networks, Sensor Networks. Cellular Networks are the infrastructure needy networks while Ad hoc networks are defined as the category of wireless networks that utilize multi-hop communication since the nodes are dynamically and randomly located. Ad hoc networks are infrastructure less or self configured networks. [4]

Sensor networks are also a category of ad hoc networks but it is different in many ways. In fact Wireless sensor network is a self configured, infrastructure less, wireless ad-hoc network having distributed tiny sensing devices which are called sensors, [1] [2] densely deployed in the large region to sense the conditions of the particular location. Nodes in the sensor network are very large in numbers due to which these are able to complete a bigger task over a large region as compared to mobile ad hoc networks. Sensor nodes in WSN cooperatively sense and may control the environment enabling interaction between persons or computers and the surrounding environment. The main idea behind the sensor network is to deploy the sensing devices which are capable of sensing some changes in the environment and incident parameters over a particular geographical area. There are some specific purposes such as traffic tracking, surveillance and environmental monitoring and also capable to monitor temperature, pressure, humidity, soil makeup, vehicle movement, lighting conditions and also detect the presence or absence of mechanical stress on attached objects.

Sensor nodes in WSN can communicate with each other and send collected data to the sink node (base station). The data is forwarded, possibly via multiple hops, to a sink(sometimes denoted as controller or monitor) that can use it locally or is connected to other networks (e.g., the Internet) through a gateway. [13] After that data from internet collected by the users. The nodes can be stationary or moving. They can be aware of their location or not. They can be homogeneous or not. Sensor nodes basically connect the physical world to the virtual world. Each node has its processing capability and having memory to store the sensed information. Each sensor node has its components such as memory, sensing unit, transceivers for communication and battery as a power source.

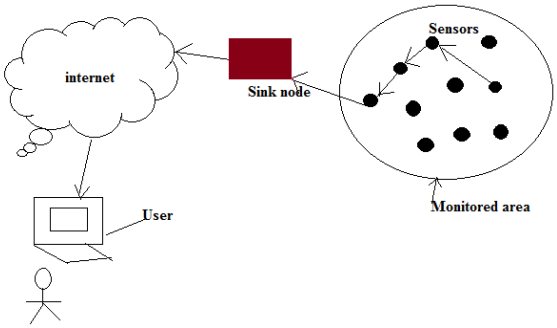

Fig.1: Simple model of Sensor Network

1.1 MANETs Vs WSNs

As MANETs and WSNs both are ad-hoc networks and getting great interest in research area. Even both are ad hoc networks but yet protocols designed for MANETs can't be used in WSNs. There are various factors that show the difference between these networks.

1. WSNs consists very large number of nodes and densely deployed by only single user and require scalable solutions while in MANETs less number of nodes are used and multiple unrelated entities can run the network.
2. Data rate in WSN is very low as compared to MANET and also statistical in nature while MANET used for distributed computing.
3. Topological changes in WSN can be done frequently but in MANET changes in topology will be according to the user's requirement.
4. Deployment of sensor nodes in WSN done once in their lifetime while nodes in MANET can move.
5. Both WSN and MANET are self configured but yet difference in the traffic and energy consumption requires different solution. There is limited power supply in WSN and recharging of battery in sensor nodes is impractical.
6. WSNs are application specified because sensor nodes in these networks are once deployed for a particular application while MANETs can carry rich multimedia data.
7. WSNs basically support broadcast communication paradigm while MANETs support point to point communication.[4]

1.2 Applications of WSN

While the application domain for WSNs is diverse, the applications can be classified with few basic characteristics. In general, a WSN may execute one or more of the following application tasks:

- **Data logging:** A node measures certain physical phenomenon e.g. high or low temperature, moisture, or luminance during environmental monitoring. The measurement may be triggered from time to time or when a change is detected.
- **Event detection:** A node monitors and detects an event of attention, e.g. motion or a sensor reading that exceeds certain limits.
- **Object classification:** A node processes sensor values to identify the type of entity or event, possibly combining values from several sensors. For example, the network might determine the type of moving object (animal, human, vehicle, etc.).
- **Object tracking:** Sensor information is used to trace the movement path of a mobile object based on location, direction, and speed estimates.
- **Control:** A node controls actuators, such as light switches or valves, based on direct commands from a user or an automation system, or by making independently decisions based on measured sensor values.

The tasks listed are complementary to each other, and a task does not need to be active all the time. Many tasks require collaborative operation between nodes, e.g. combining values from several sensor nodes to give more accurate sensor value or object classification. As an example, a surveillance network may perform continuous data logging, while the collected data is used as a basis for event detection. After an event (e.g. motion) is detected, the network classifies the moving object. Object tracking could be activated only when an unauthorized object is detected.

1.3 Challenges in WSN

Wireless sensor Networks has various challenges while designing it for a particular application. These factors are following: [1] [2] [3]

1. **Sensors deployment:** As sensors are densely deployed in a very large region so that they may able to sense or monitor the specified data by the user at the base station that may be temperature, humidity, soil monitoring etc.
2. **Limited Power Source:** Sensors are tiny devices that are having battery as a power source. Due to deployment in very large region it is impractical to provide recharging to the sensors.
3. **Dynamic Topology:** Sensor network is designed dynamically that means sensors can move in and out without any restrictions. But we require that system should be flexible while changing connectivity when more sensor nodes either coming or failed in the network..
4. **Self Dependency:** Once sensor nodes are deployed in the specified region, have no human involvement. Then nodes are self dependent or responsible to reconfigure themselves while changing in the network.
5. **Scalability:** Sensor nodes deployed in a region may be hundreds or thousands. So for a very large region, it may exceed up to millions. That's why network should be scalable to add more sensors according to the requirement.

6. **Fault Tolerance:** There may be possibility of nodes failure either due to battery damage or any physical damage. But it is required that whole network should not be affected due to one node failure that is fault tolerance.
7. **Production cost of network:** As sensors nodes are low cost devices but may be deployed millions number that may cause high cost for that network. So that cost should also adaptable.

2. Survey Key Points:

There are a number of papers that purposed different approaches and solution for problems in energy efficient routing and supporting quality of services in WSN. Main key points of survey are given below:

- **Energy Efficiency:** Energy efficiency is a dominant consideration because sensor nodes have finite source of energy. There may be some hardware and software solutions for this problem.
- **Routing:** Routing techniques in WSN are decided in the sense that communication cost in the network become low. As traditional and routing techniques used in MANETs also not directly supported by WSN because energy consideration in WSN demand that only efficient routing should be done.
- **Quality of Services:** Quality of services in WSN demands to calculate the error rates, packet delivery at the same time and better bandwidth utilization. There is various papers shows proposed work that gives different ideas for QoS support in WSNs.

2.1 Energy Efficiency in WSN:

Sensor nodes in sensor networks are having small size with a small battery as a power source and when these are deployed in unreachable region, this is not possible to provide an energy source. Energy consumption is an important factor to determine the lifetime of network. So energy optimization in WSN is very difficult because it concerned not only reduction of energy consumption but also prolonging the life of the network as much as possible. This can be possible by improving the hardware and software designing ideas.

While considering hardware design of sensor node, we describe mainly four units that are shown in figure: [2]

1. **Sensing unit**: Sensing unit contains small size sensors or actuators, to sense the activity of the environment and analog to digital converter that helps to convert the recorded information in the digital codes so that system may easily process it. Low power components may cause reduction in energy consumption.
2. **Computing unit**: Computing unit acts as a microcontroller and controls the sensor nodes; also execution of the protocols which cause energy consumption in the network. Operating modes of MCU cause power consumption, so energy consumption by operating modes also considered during the designing phase.
3. **Transmission unit**: Transmission unit of the sensor node that acts as a radio transceiver which helps in transmission of information and receives the recorded data by the sensors. Because this mode consumes more energy so the radio should be in the idle mode so that energy may be saved.
4. **Power unit:** Power unit is the main component of the sensor node because sensor node works on the basis of the battery that can be charged by any power generator. Battery of the sensor should be checked so that it can be saved from damage due to high current supply. A battery can be saved for a longer time by reducing the current and by turning it off. [2]

Above discussed are the general approaches for the energy conservation in the WSN. There are various schemes for energy conservation in the network such that duty cycling, data driven and mobility based [6].Duty cycling approach remove node redundancy cause topology control in the network and connected node goes to sleep when not require that saves power referred as power management by the node. Data driven strategies helps in data reduction and provide sampling for energy efficient data acquisition. Mobility based scheme controls the disturbance occurs in the sensor network design due to moment of sensor nodes. The lifetime of sensor network is increased by designing the operating system, application layer and network layer energy aware. Traffic during the transmission also causes more energy consumption. Routing play an important role to set communication cost but also consume more energy. So energy efficient routing protocols should design to make communication more efficient and reliable.

2.2 Routing

Routing protocols designed for traditional networks and MANETs are not supported by wireless sensor networks because another consideration of energy efficiency and network lifetime another issue for different routing strategies. **Kemal Akkayaet al** [5]describe that generally all of the routing protocols can be classified as data-centric/flat, hierarchical or location-based although there are few distinct ones based on routing operations. **Data centric/flat protocols** are query-based and depend on the naming of desired data, which helps in eliminating many

redundant transmissions. **Hierarchical protocols** aim at clustering the nodes so that cluster heads can do some aggregation and reduction of data in order to save energy. **Location-based protocols** utilize the position information to relay the data to the desired regions rather than the whole network. Another category includes routing approaches that are based on routing operations named as network flow modeling and protocols that is used for meeting some QoS requirements along with the routing function. There are descriptions of proposed protocols that are energy efficient.

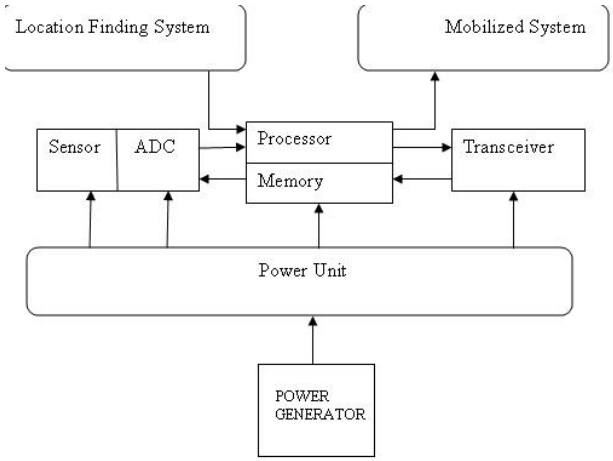

Fig.2: Sensor nodes components

Low energy adaptive hierarchical routing protocol (LEACH) [15] is a hierarchical routing protocol and having distributed cluster formation. This protocol has two phase of working. In setup phase, there is cluster head node selection after each round by applying a stochastic algorithm. In steady phase, data will be sent from source node to the sink node through the cluster heads. This is proposed that LEACH reduce energy consumption and further enhanced in various versions of to make communication more energy efficient.

Power-Efficient Gathering in Sensor Information Systems (PEGASIS) is an energy efficient protocol [8], which is enhancement over LEACH. In PEGASIS, each node can communicates only with its neighbor node to exchange data or information. In order to transmit data to the base station or sink node, it takes turn; thus reducing the amount of energy spent per round. The nodes are configured in form of chain that can be formed using greedy algorithm, starting from a certain node. Here BS can also compute this chain and broadcast it to all the sensor nodes.

The cluster head selection does not take into concerned either the residual energy of the nodes or the location of the base station. PEGASIS has better performance over LEACH, but the nodes ordering into chains cause redundancy in data transmissions.Threshold Sensitive Energy Efficient (TEEN) is a hierarchical protocol designed for unpredicted changes in the sensed environment. The response of the network in time-critical applications is extremely important; such kind of network will operate in a reactive mode. The sensor network architecture in TEEN is based on hierarchical arrangement. Data transmission from source node to the sink node will be using nodes that are nearest nodes of the upper level cluster and this process that goes on the sink is reached. [16][17]

Advantage of TEEN is that it works well when sudden changes in the sensed parameters occur. Drawback is that in large area networks TEEN tends to consume considerable amounts of energy due to long distance transmissions.

The Shortest Hop Routing Tree protocol (SHORT), provides energy efficiency and efficiently collects useful data from a remote wireless sensor network to the base station. The cluster head node selection will be based on the threshold value of energy. This also extends the lifetime of whole network and May helpful in reduction of energy spent.Extending lifetime of cluster head (ELCH) routing protocol is self-configured and hierarchal routing protocol. It elects cluster heads based on the votes that it collects from all nodes in the network.

The Energy Efficient Cluster Formation Protocol (EECFP) elects the nodes based on the higher residual energy(threshold value of energy), as cluster heads and turns those in each round to provide a balance of energy consumption and to minimize the energy spend for cluster formation.

Base-Station Controlled Dynamic Clustering Protocol (BCDCP), also called centralized routing protocol in which distributes the energy dissipation positively among all the sensor nodes to prolonging the network time and calculation of average energy also done by the base station(sink node). The base station receives the residual energy of each node, and then, it computes the average energy level or threshold value of all the nodes. Then, cluster heads will be of higher residual energy than the average threshold value. However, the selection of the node with the

highest residual energy as a cluster head at first round may cause to spend more energy in case of other nodes to send data to the current CH. The selection of a node that allows balancing to spend energy in case of other nodes is a better solution [17].
Efficient Cluster Head Election Routing Protocol (ECHERP), in which cluster head selection will be based on a model like previously proposed protocols. This protocol uses more efficient method of cluster head election as compare to other protocols. This is performed by considering the current and estimated future energy of the nodes for each round, to maximize the network lifetime. ECHERP models the network as a linear system and use Gaussian Elimination algorithm for cluster head selection. [5]
All the above mentioned protocols try to minimize the energy consumption using different algorithms. These algorithms offer a good solution, since they select the node with the higher residual energy in the cluster as the cluster head for the next round. However, this does not assure the maximum prolongation of the overall network lifetime. So there is needed to make routing more energy efficient to prolong the network lifetime.

2.3 Quality of Service

At present data acquisition, data dissemination and data distribution are the main considerations that increase the popularity of sensor networks. For the better implementation and deployment, MEMS, digital electronics and communication and quality of services support in network for the application running at the top of the network. Commonly used QoS parameters are delay, jitter, throughput, bandwidth and efficiency of the protocols. [9] There are mainly two internet models for QoS support i.e. integrated services provide end to end services and differentiated services provide per class service differentiation. Some existing mechanism for QoS are classified as resource reservation in which bandwidth allocation based on the QoS requirements and traffic classification involves the categorization of the data packets into different levels of priority or classes of services. Dynamic topology, nodes heterogeneity and resources managements are the challenges to support QoS in WSN.

Nikhil Ranjhan et al [9]presented the performance analysis on QoS parameters and analyzed results on the basis of delay, throughput and data transfer rate. mainly focused on the working and usage especially the Quality of Service parameters in for the Wireless Sensor Networks and providing the various outcome of the QoS parameters like Data transfer rate, data packet transmission rate, Delay, Load parameters and Throughput as well.
There are currently proposed work in the field of QoS support in routing of WSN gives the idea that how much work has been done in this field. Routing protocols in WSNs are designed for efficient communication but also required quality of services for traffic engineering and bandwidth utilization properly. So QoS support in WSN are required at various layer and each layers has a different layers below it to provide QoS services as described by **Yuanli Wang et al** [14] in their review paper. **JiPeng et al** [10]proposed an energy efficient routing protocol based on the LEACH protocol and main purpose of this proposed protocol was to achieve QoS parameters requirements by excluding the node with improper geographic location to be the cluster heads. **Xin Song et al** [12] proposed a protocol 2ASenNet, and tried to achieve balancing of energy-efficiency with QoS improvements for applications specific, a multiple QoS metrics hierarchical routing protocol based on swarm intelligence optimization (combination of improving ACO and AFSO) for WSN. The 2ASenNet is an efficient method for solving routing problem of wireless multimedia sensor networks in order to satisfy QoS requirements. **Rina Wu** [11] proposed a protocol CBRP-L that is based on clustered based real time routing protocol (CBRP). This protocol cuts off the high delay connections and runs LEACH algorithm for these nodes to forming a new cluster. The proposed protocol solved the problem of congestion and energy consumption, caused by only one cluster head with too many neighbors.

3. Conclusion

In this paper we have described an overview of wireless sensor network with its architecture, its working and challenges factors in designing a wireless sensor network. Our focus was to discuss about proposed work in direction of energy efficient routing and also support of QoS to design a routing protocol. Future consideration will be to design an energy efficient routing protocol with QoS support.

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