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A SURVEY ON ENERGY OPTIMIZATION IN WIRELESS SENSOR NETWORK

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ABSTRACT

Wireless sensor network is one of the emerging technology which provides a wider range of applications like monitoring pressure, temperature water level, minerals in soil, health care etc. Generally, this network is a collection of small sensors which can sense, process and communicate the data, based on the specified application. The major constraint of this type of network is the energy consumption by the sensor nodes which is mainly responsible for the prolonging the lifetime of the network. A limited amount of energy should be utilized very efficiently so that the life of a network can be prolonged. The first section of the paper presents brief introduction about wireless sensor network and its basic features and also about the concept of clustering with its applications. The next section briefly describes about energy consumption factors in the wireless sensor network and how the energy can be utilized efficiently and effectively to prolong the life time of the network.

KEYWORDS: *Wireless Sensor Network, Cluster, LEACH, Energy Saving.*

I. INTRODUCTION

1.1 Wireless Sensor Network

As Sensor networks are a special category of ad-hoc wireless networks that are used to provide a wireless communication infrastructure among the sensors deployed in a specific application domain. As the technological advances in wireless communications, processor, memory, radio, low power integrated digital circuits, and micro electro mechanical systems (MEMS); have made smart sensing a reality and it becomes possible to significantly develop tiny and small size, low power, and low cost multifunctional sensor nodes which are capable of wireless communications, sensing and computation (software, hardware, algorithms) [1]. Wireless sensor networks (WSNs) are highly distributed networks made of numerous number of light weight sensor nodes which are deployed in large number in geographical environment. The activity of sensing can be periodic or random depending on use. In the periodic type the sensing of environmental factors such as temperature, humidity, and nuclear radiation is done after specified period of time. Sensing activities belong to the sporadic type such as detection border intrusion, measuring the stress on critical structure or machinery.
Each node includes four basic components:
1. Sensing subsystem: It consists of sensors or array of sensors and actuators for sensing the characteristics of physical environment, where the nodes are deployed.
2. Processing subsystem: For local computations on the sensed data, according to the application and storage for temporary storage of gathered data.
3. Transceiver: It is a wireless communication subsystem which is responsible for message exchange with neighbor sensor node.

4. Battery: a power source which supplies the energy needed by all the devices to perform the programmed task having a limited capability to store and attain the power or energy. From [3] it is impossible or difficult to recharge the battery, because nodes may be deployed in an unpractical environment.

There are some factors/ designing consideration while developing some protocol or applications for wireless sensor network: after deployment of sensor node there should not be any human intervention so every detailed computation should be perform before deployment. All routing and maintenance algorithm should be distributed. Micro controller, operating system and applications should be design to conserve energy. Real time communication over sensor networks must be supported.

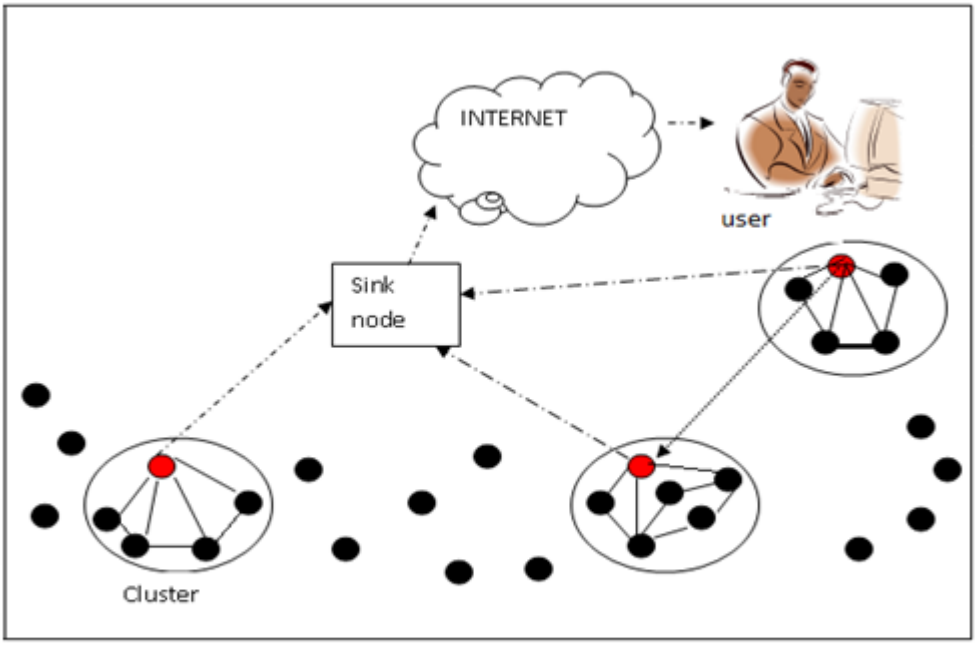

Fig.1. Wireless Sensor Network

Fig.1 shows the basic working principle in the network of sensors, first there is a targeted area where the sensors has to be deployed and then the sensors are densely deployed unevenly through the plane or by human or vehicle if the area is small, after that the cluster is formed according to some specified plan or by the node itself, and cluster head is elected. Sensors sense the characteristics of environment where they deployed and send the data to the cluster head, cluster head collect the data from the entire cluster member and after processing cluster head send the processed data to the sink node and sink node forward it further. Cluster heads can directly communicate with each other.

1.2 Applications

Advances in wireless sensors makes many application areas open for WSN

- Area Monitoring: it is very common application where the nodes are deployed in specific region or area where its phenomena has to monitor from [12].
- Industrial: In industries, sensors are used for monitoring working of equipments, pressure on equipments and manufacture monitoring.
- Forest fire detection and land slide detection can also be monitored using sensors so that preventive measures can be taken earlier.
- From [13] Traffic control and monitoring: the sensors are deployed on the lanes detect vehicle's number, speed and direction. It also provides control on dynamic change in traffic volume as it provides real time adaptive control of traffic light in wider area.
- From [14], another application is industrial motors which uses sensors for online monitoring and for energy management where current and voltage signals of motors are taken and

analyzed by a DSP device to know the condition of motors, and the analyzed output are send over the wireless network to a central supervisory station (CSS), where results are used to analyze the requirement of motor monitoring and energy management. This can be used in real time environment as this approach provide less transmission time.

- From [15,12] health monitoring or in medical applications the sensors are used for person's location and his health conditions like blood pressure, respiratory rate and oxygen measurement.

1.3 Clustering

From [17] sensor nodes are grouped into disjoint, non overlapping subset which provide scalability and better data aggregation called Clusters whereas the sensors have limited capabilities like sensing region, processing power, transmission capabilities ,energy utilization. They jointly provide reliable, robust and accurate sensor network which can cover a wide region. Clustering can be said as an effective approach to organize the sensors in the network into a connected hierarchy which incorporates efficient utilization of limited resources of sensor nodes. Every cluster or group of sensor node is controlled and coordinated by the node in the cluster called cluster head (CH). Cluster Head may be elected by the cluster members or can be pre assigned by the network designer. From [2] the cluster membership of a node in the particular cluster may be fixed or variable. In variable type of membership the cluster head is selected based on their remaining energy and the re-clustering may be done periodically among the remaining nodes, so that the uniformity can be maintained and no node will be over loaded.

Clustering provides energy efficiency and it can also reduce contention in the channel and packet collisions in the network, clustering also provide data filtering where the useful information from large amount of raw data is transmitted to the sink node and in the network which will definitely reduce the transmission power as well as energy, so we can say that it can provide better network throughput under high load. From [6] in clustering architecture, if we want to implement the algorithm in particular cluster but not in the whole network it can be possible. If there is large network, algorithm should be distributed so that it can provide better robustness and scalability. From [4] there are number of clustering algorithm for wireless sensor networks which specifically design to provide scalability and efficient communication in the network. In a hierarchical architecture of wireless sensor network, nodes which have higher energy selected as cluster head and they can be used to process and send the information to another node while the low energy nodes sense and transmit the sense data. Some of routing protocols in this group are: LEACH, PEGASIS, TEEN and APTEEN from [2].

The second section briefs about the factors that are mainly responsible for consumption of energy in WSNs. How the energy can be conserved in WSN is discussed in the third section. The fourth section briefs about the related work carried out in the view of energy conservation in WSN and finally in last section the result and conclusion about the work is discussed.

II. ENERGY CONSUMPTION FACTORS IN WSNS

Energy is a very scarce resource of sensor networks and has to be managed carefully or wisely in order to increase the network lifetime. There are many activities in the network which are also responsible for wastage of energy, some are also suggested be author of [7, 9] are as follows:-

- Many sensor nodes sense the same data deployed in small area.
- Sending the repeated sense data frequently to the cluster heads also reduces channel utilization.
- Keep on listening to the channel to send the sensed data.
- In periodic sensing, keeping the node on while not in use.
- Sending control packets in large volume require more energy if packet is too big.
- Providing greater processing facility in sensor node consume more power.
- Overlap, same event may be sense more than one node due to overlapping regions of coverage.
- Collision and retransmission.

III. ENERGY CONSERVATION IN WSN

Energy is very important and center of consideration in developing applications, protocols and any kind of hardware for sensors or for sensor network. Sensor node process can be divided into 3 parts i. e. sensing or collecting data from environment according to application, processing the collected raw data and then send it to the cluster head. Where the cluster head aggregate the data, process it and send the result to the sink node. All the process describes above require certain amount of energy. Most of the energy is required by the data transmission task and least energy will be consumed when the sensor node is in the idle state or sensing. All the communication, processing and sensing should be performed by considering the limited amount of energy provided by the batteries. Some sensor nodes hesitate to have direct communication with a distant destination because high transmission power is required for attaining a reliable transmission. Low- energy adaptive clustering hierarchy (LEACH) uses local data aggregation to reduce global communication so that some amount of energy can be saved. It also enhances network lifetime when compared to fixed Cluster Head schemes. In paper [5] there are number of cluster based, routing based protocols have been develop to minimize energy conservation.

However, a large amount of energy is consumed by node components such as processor, transceiver, etc. even if they are idle. So there is some power management schemes are used for switching on & off the node components that are not temporarily required. As the new technologies emerging it can be possible to harvest energy from the environment so that the power constraints of the sensor nodes can be reduce in some extent (Power scavengers).

Main sources for acquiring or recharging the energy are:

• Solar: It is a much known source of energy so some techniques can be adopted or developed based on solar energy. (Generated by sunlight or artificial light)

• Mechanical: energy can be generated by the movements of objects.

• Thermal: Here energy can be generated by temperature differences between two objects.

IV. RELATED WORK

In paper [9] dynamic clustering and scheduling approach has been proposed in which an Energy Efficient Data Collection (EEDC) framework introduced where the spatial correlation approach used to group sensor nodes into clusters so that the sensors in the same group have similar observation time series. They can share the workload of data collection in the future as their future readings may likely to be similar. Since the clusters are based on the features of sampling data, scheduling based on the clusters is much more accurate than scheduling based purely on the sensing range of sensor nodes. EEDC method reduces the computational burden on sensor node and assigns heavy duty to sink node. Experimental results demonstrate that the EEDC framework can effectively save energy as strategic scheduling and clustering is done to reduce energy conservation. Paper [10] proposed a saving energy clustering algorithm (SECA) to provide efficient energy consumption in wireless sensor networks. This algorithm based on the centralized clustering architecture. Here the average distance between the sensor nodes is calculated and for selecting the appropriate cluster head nodes, the residual energy is considered. The lifetime of wireless sensor networks can be increased by using the uniform cluster location and balancing the network load among the clusters.

The main benefits of proposed scheme are that the energy consumption is reduced and network lifetime can be increased. where as in paper [11] EECS is a LEACH-like clustering scheme, an energy efficient clustering scheme (EECS) for periodical data gathering applications in Wireless sensor networks has been proposed in which cluster head selection is somewhat similar as SECA where, a constant number of candidate nodes are elected and compete for cluster heads according to the node residual energy but the election process is localized and without iteration, thus message overhead reduces. It also reduces and balances the load among cluster heads. Communication between cluster head and Base Station is direct (single-hop) in this scheme. Whereas in paper of S. V. Manisekaran and R. Venkatesan [22] they propose an adaptive distributed clustering technique .The two factors that they consider are the data sending rate and similarity of data between the nodes. They have introduce two phase of their technique the first is the cluster formation phase in which rate of data generation and the comparison between data sequence is analyzed by the sink node and cluster are

formed and cluster head selected based on residual energy. In the next phase, sleep duty cycle phase, Minimum threshold level is compared with the rate of data generation of the nodes of a cluster and the lower rate node cumulatively allotted a sleep duty cycle for a pre-defined period.

Paper [18] also introduce algorithm for achieving energy efficiency in communication among the nodes as reducing the distance of transmission will reduce the energy consumption as if the distance is greater among the sender and receiver node the usage of power would me more . Here a hybrid technique of TDMA/ FDMA is used which provides efficient bandwidth utilization and better throughput. In the sensor network nodes are distributed into clusters with a close proximity so the Deepali Virmani in paper [18] has proposed scheduling the activities of node and also the construction of a decentralized lifetime maximizing tree within clusters whereas in paper [19] data transportation in sensor network is considered. In this Wei-Peng Chen derive the link delay and the node capacity in the single and multi-hop environments based on the Markov model whose objective is to maximize the information collected at sink while minimizing the energy and bandwidth utilization.

As compared with the Ad hoc On Demand Distance Vector (AODV) routing and load balancing routing, the result of the proposed approach achieves better utility and lower latency. Whereas, author Fei Hu in [21] proposes efficient data aggregation timing control protocol to reduce the amount of data transmission that results in reduction of energy consumption. This protocol aims to dynamically change the data aggregation period according to the aggregation quality. It uses intelligent timer and network knowledge to implement this protocol. It efficiently handles the data query of the sink to relatively balance the data freshness and energy consumption.

There is another paper which provides energy efficiency in clustering in which author proposes an Energy-Efficient Distributed Unequal Clustering (EEDUC) algorithm where each sensor node set the waiting time for broadcasting which can be considered as function of residual energy, number of neighborhood nodes. This algorithm uses this waiting time to distribute cluster head. Number of neighboring nodes and their energy users to select the cluster head. We present an unequal clustering algorithm to solve the hot-spot by the paper [23]. EECS is fully distributed and more energy efficient and the simulation results show that it prolongs the network lifetime as much as 135% of LEACH suggested by paper [11]. Whereas in paper [23] the simulation results shows that EEDUC obviously improves performance over LEACH and EEUC. In EEDUC, the performance of energy consumption is improved 24.2% compared to EEUC.

As there are very limited amount of energy for the sensor nodes in the network, so there should be some measures to monitor energy consumption and battery life of the node so that some techniques can be adopted to minimize the energy consumption as to increase the life of the network. In the paper [24] the author formulate Maximum Sensor Network Life Problem and suggested centralized and distributed algorithms for solving the problem and also efficient data structure to represent the monitored area providing full coverage. Whereas in [25] network aggregation is used to design and evaluate a mechanism for collecting a residual energy scan (eScan). Remaining energy can be depicted using this scan as it provides abstracted view or aggregated picture, inspired by e-scan. Another energy efficient mechanism for monitoring energy is the CREM (Continuous Residual Energy Monitoring) provides the presentation of energy profile of the entire network. The residual energy is presented in form of energy map. All the regions in the network are colored differently depending on the different energy ranges, by paper [26]. This paper also proposes a hierarchical approach to construct a continuous energy map of the sensor network. It involves number of phases such as topology discovery phase, clustering phase, and an aggregation phase. Energy information is collected and merged into energy contour. The nodes with similar energy level are grouped into the same region. The monitoring tree topology is restructured periodically.

Using these energy maps network manager can decide how resources can be utilized according to the energy remaining, it also provide information to the network manager about the region where the new nodes need to be deployed to maintain the efficiency of the network.

V. RESULT AND CONCLUSION

In this research work, a survey on Wireless Sensor Networks (WSN), their technologies and applications was carried out. There are number of power management and data dissemination

protocols have been specifically designed for Wireless Sensor Networks. Sensor network also has number of conceptual and optimization problems such as deployment, tracking and energy, in which energy awareness is an essential design issue. As the energy is the scarce resource there are number of techniques which are specified for reduction in power consumption but the solutions tend to be very application specific. Spanning tree is the basic topology for data gathering since the flow mainly is many – to – one flows. Sensor can be said energy harvester if it transduces surrounded environmental energy into its useful electrical energy. Energy harvesting techniques can gather useful energy from vibrations, blasts of radio etc. There are number of characteristics such as fault tolerance, flexibility, rapid deployment and low cost of sensor network support wider area of application which will make sensors as one of the important part of our life.

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