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Review of Energy Saving Protocols in WSNs

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Abstract: The modern developments of micro sensor devices have lead to the a number of protocols in the field of wireless sensor networks(WSNs). The sensor networks are capable enough to collect information and transmit it to the end user. But storage capacity, computing capability and limited energy are the major constraints for the wireless sensor networks. This paper describes the components of the wireless sensor networks and then a review of various energy conservation techniques is given.

Keywords: WSNs, Energy conservation, Power Management, Energy harvesting, Energy saving protocols

I. INTRODUCTION

Wireless Sensor Networks is vast research field which involves cross multi-disciplinary and highly integrated research. WSNs provide the benefit of accessing information and communicating the information using the transmission networks. The upcoming generation of networks will give the direct, authentic and effective information [1].

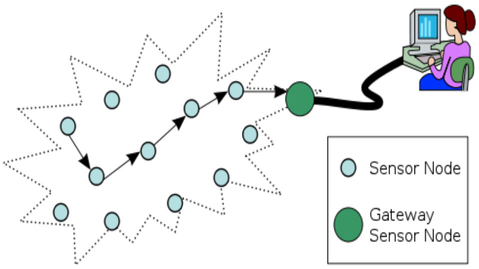

Fig. 1: Wireless Sensor Network

A sensor network has multiple detection stations which are called sensor nodes. These nodes are small, portable and light. Each sensor node has a microcomputer, transducer, power source and transceiver. The role of microcomputer is to process and store the sensor output. The transducer is responsible for generating electrical signals which are based on the physical effects and phenomena. The task of receiving commands from central computer and transmitting data to that computer is done by the transceiver. A battery is used as the source of power for each sensor node [2].

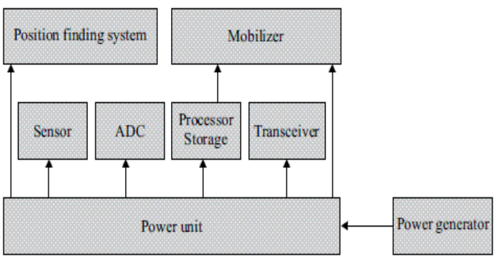

Fig. 2: Components of Sensor Nodes

The various potential applications of sensor networks are [1]:

Video surveillance: WSNs help to provide security services. This application area has attained large importance due the fact that the number of terroristic attacks had increased in the last decade.

Health Applications: Patient monitoring systems, internal monitoring of body parts the patients, providing interfaces to the disabled, drug administration in hospitals, and monitoring of patients by the doctors.

Environmental Applications: Keeping watch on the environmental conditions affecting the crops, tracking of birds and animals, forest fire detection, detection of flood, and study of pollution.

Automated and smart homes: Domestic devices are available with sensor nodes inside them. They are capable to communicate by the satellite or internet. Eg. Smart Kitchens, Vacuum cleaners, Micro Waves etc.

Monitoring of weather conditions: Satellites and sensors are used to monitor the weather conditions. The GPS facility in mobile phones etc keeps us update with the weather information of the place at which the person is presently in.

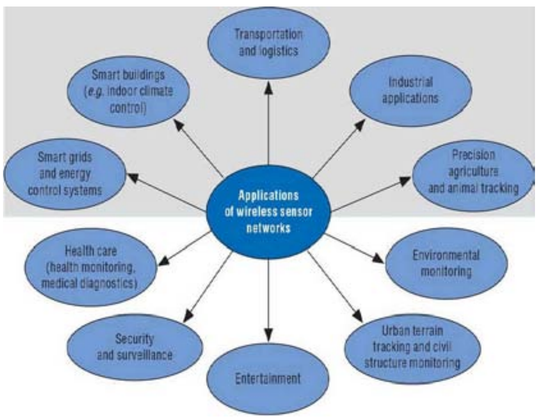

Fig. 3: Applications of WSNs

Figure 1-Applications of WSNs

Air traffic control: The proper routing and monitoring of the air traffic is of vital importance. Using the sensors it can be easily monitored and controlled.

Hence, the wireless senor networks have large number of application areas.

II. CLASSIFICATION OF WSNS

From network architecture point of view[3]:
Flat Architecture – Each node plays the same role in performing sensing task and all sensor nodes are peers.
Hierarchical Architecture – Sensor nodes are organized in clusters, where the cluster members send their data to the sink.

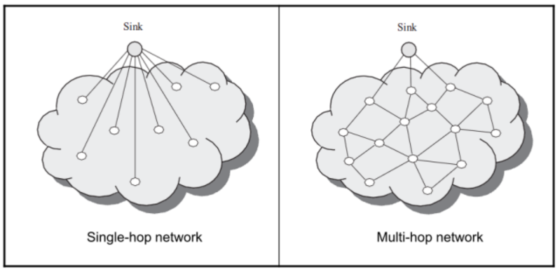

Fig. 4: Example of Flat Architecture

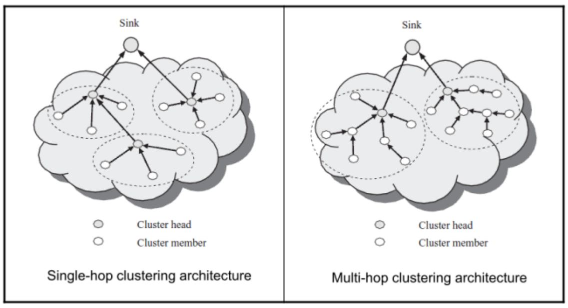

Fig. 5: Example of Hierarchal Architecture

III. CRITICAL DESIGN ISSUES IN WIRELESS SENSOR NETWORKS

Some of the challenges in the routing nad seign issues that have impact on the routing in WSNs are as follows: [4, 5, 6]
Node deployment: Using an efficient node deployment protocol not only reduces the complexity of the network but also extend its lifetime by energy conservation.

Energy consumption without losing accuracy: The energy level of the node can affect the routing of the nodes. Node energy level can be considered as a routing metric if some nodes are energy-constrained and their involvement in the routing process can lead to path failure if they suffer from energy diminution. This problem is particularly important in MANETs and WSNs.

Fault Tolerance: Environmental interference or lack of power or physical damage may result into the failure of the sensor nodes. But, this should not affect the overall functioning of the network. The ability of the network of the to carry out its operations without the interruption is called Fault tolerance.

Scalability : There can be a large number of sensor nodes deployed in a sensing area. So the routing protocols should be able to respond the events accordingly. This called scalability.

Production Costs: The cost of every sensor node effect the overall cost of the network. So, the cost nodes should be kept low in order to reduce the production cost
Connectivity: The routing protocol should be capable of handling quick hand-offs in order to ensure the mobile users with consistent connectivity.

Quality of service: Selecting the best possible route for all the classes of the network traffic is important for the QoS.

Energy Management : WSNs have important applications like biomedical research, human imaging and tracking, military applications, target detection and surveillance, and environmental monitoring etc. Now as the sensor nodes are battery driven the energy management is crucial in WSNs. Thus the use of energy efficient methods is the only key solution for this purpose.

Now-a-days WSNs had become an integral part of daily life. Therefore in order to improve the network lifetime the methods and techniques to reduce the energy consumption significantly are required. For this purpose we propose to design an energy efficient technique for WSNs.

IV. ENERGY HARVESTING METHODS IN WIRELESS SENSOR NODES

Energy harvesting is the method used for capturing, accumulating and storing the unexploited energy. The applications which require low power supply continuously or high power for small time period utilize the energy harvesting methods. The different energy harvesting sources are:

Solar: The use of solar cell (photovoltaic) is most commonly used energy harvesting method. In this technique the optical light of sunlight is converted to the electrical energy. It is suitable for the areas where ample sunlight is available. the efficiency of the solar cell depends upon the sunlight as well as the load attached.[6]

Thermoelectric : It is the process in which temperature gradient is used to generate electricity. The potential difference generated due to the difference in the temperature is utilized by the thermoelectric generators.

Mechanical vibration : Electrical energy can be generated by changing the inertial mass of an object[6] . The three methods used to generate the electrical energy in this technique are:

1) *Piezoelectric:* in thus method mechanical energy in the form of pressure or vibration is converted into the electrical energy.
2) *Electrostatic:* Vibration is used to separate the planes of varactors which are initially charged. The mechanical energy produced is used to generate the electrical energy. In order to charge the capacitors initially a source of electrical energy is required.
3) *Electromagnetic:* This method does not suffers from the effects of the mechanical damping. Permanent magnets, coils and

resonating cantilever beam are used for this type of energy harvesting. It is difficult to integrate it with WSN due its large size.

A. Far field RF energy harvesting :

There are two methods for far filed RF energy harvesting*:*

1) Active energy harvesting: in which dedicated energy transmitter is used.
2) Passive energy harvesting: in which the sources of energy like sunlight or radio waves ,from the environment are used [9]. Television broadcast energy can also be used for RF energy harvesting.

V. DIFFERENT ENERGY CONSTRAINTS IN WSNS

All the operations of any type of application need Energy. The sensors have the batteries, but the batteries also have life which is limited one. The microprocessor technology is ahead of the battery technology. Efficient networking protocols are needed now days.

VI. DIFFERENT ENERGY SAVING METHODS IN WIRELESS SENSOR NETWORKS

There are three categories of energy saving methods in wireless sensor networks, viz Duty cycling , data-driven approaches, and mobility. These can further also classified.

Energy Conservation

Turn-off the transceiver when not required.
Use shorter data packets for the communication.
Multiple paths could be derived and used to reach the destination, to increase the network lifeline.
Data should be transmitted by the source node only when the destination node is ready, so that data could be reach without error at first place.
Avoid collisions between nodes.
Node idle-listening and overhearing should not happen in the network working.
Multi-hop data transfer can save a lots of power in the sensor network working.

Energy usage can be minimized at the MAC layer by:
Reducing the collisions
Reducing the overhearing
Reducing the idle-listening
Reducing the control packets overrun
Reducing the again and again transitions between various modes viz. sleep, idle, transmit and receive.

Energy usage can be minimized at the network layer by:

Efficient routing: An efficiently established route is capable of increasing the productivity by saving large amount of network energy.

Reliable communication among sensor nodes: The data collected from the sensor nodes is sent to a master collector. The data can be transmitted directly or by relay method. The reliable communication saves the energy by avoiding the resending of data.

VII. VARIOUS ENERGY EFFICIENT ROUTING PROTOCOLS

There are a number of routing protocols which are energy efficient. Some of them are:

Directed Diffusion: In this protocol data diffusion is done by sensor nodes with the help of the available data naming schemes. This results into energy saving as it eliminates the unwanted operations of network layer. Attribute based value pairs are used for naming the data which are used to query the sensors on the basis of demand. An interest entry contains various gradient fields, which are defined using the attribute-value pairs like geographical location, time duration etc. The link received from the interested neighbor is called gradient link. The path between the source and data collector is created by the interest and gradients. Only one path is selected from the multiple path options available.

Rumor Routing: It is a variant of directed diffusion protocol. It is used in the places where geographic routing can not be done. Here the concept of flooding is used, in which the nodes which observed some particular events are only queried. This in turn avoids the flooding of the entire network. The detection of the event generates an agent. This agent is used for the communication of the information. The nodes respond to a query by consulting their event tables. Thus the cost of flooding is reduced as the entire network is not flooded, only the best route is used.
Leach Routing : It is a cluster based method which used adaptive clustering hierarchy which minimizes the energy dissipation. This protocol needs two steps for execution a) Set – up phase and b) Steady Phase. The first phase i.e set-up phase works as follows:
A node advertises for its presence after the selection of cluster head.
The decision of the selecting the cluster head or not depends on the strength of the signal.
The sensor nodes get their time table using the TDMA method. The data is sent by the cluster head at the indicated time.
Second phase i.e. Steady phase works as follows:
Transmission of data to cluster heads is done by Sensor nodes.
Data is sent to the base station after combining data from all the nodes.
After some particular time period Set-up phase again starts.
E-Leach : It is the improved version of LEACH protocol in which the technique of cluster head selection is changed. There is equal chance of selection for all the nodes in the first node. Energy consideration is done after the completion of first round. The node having the high residual energy is used for cluster – head selection.
TL-Leach : This two level leach sends data to the base station in two hops. Cluster head collects the data from the other nodes. Transmission of this data to the base station is done by the cluster heads in between.
M-Leach: In this multi-hop protocol data is transferred to base station in multiple hops. The problem of data

transmission from the clusters at distance to the base station is solved by this method. This method is energy efficient.
GEAR : In this method geographical information is used for the distribution of the queries to the proper regions. Here neighbor is selected on the basis of energy and the location to route the packet. It saves a lot of energy as compared to directed diffusion as the region in which the forwarding is done is limited.

Protocol	Based on	Technique	Connections	Suitable Area
Direct Diffussion	Data – centric Protocol	Gradient fields and links	Multiple paths in source and destination	Geographic routing is possible
Rumor Diffussion	Flooding	Agents	Single Path in source and destination	Geographic routing is not possible
Leach	Clustering	Cluster selection	Two Phase connection establishment	
GEAR	Geographical	Energy level and location		

VIII. LITERATURE REVIEW

In order to reduce the overhead and save the energy a hybrid technique is presented by the [7]. The proposed method uses the energy efficient forwarding scheme which is adaptive and uses the information provided by the 1-hop neighbouring radios. Grouping of networks is done on basis of the power level of transmission. In comparison to Pure-Flooding AODV and Dynamic-Power AODV the proposed method reduced the routing overhead and consumption of energy. The transmission power control mechanism is used to enhance the throughput of the network and decrease the interference among the nodes.

[8] have presented a dynamic routing algorithm which is capable of adapting dynamically to the energy level of networks node. In the proposed algorithm the node which is capable of balancing the WSN energy is selected to transmit the data to the base station of the network. The MSN-AESA algorithm results into 10% increased throughput. The duplicate messages are decreased eight times, nodes' life is increased and congestion is decreased upto 0%. As compared to flooding scheme MSN-AESA algorithm gives better results**.**

For enhancing the network life span in mobile and ad-hoc networks new Maximal Power Conserved and Battery Life Aware Routing (MPCBLAR) topology is proposed by [9]. This protocol uses the conditional broadcasting to eliminate the need of battery capacity verification. It is a highly scalable protocol.

[10] proposed FAF-EBRM energy balanced routing technique. It is based on the forward aware factor. Also for local topology a spontaneous reconstruction mechanism is designed. Experimentally it is compared and showed that FAF-EBRM is much better than the EFUC and LEACH. It guarantees the high QoS, and balances the energy consumption. It has been demonstrated that power law is followed by the distribution of node degree, strength and edge weight. The topology reduces chances of successive node breakdown and increases the synchronization of WSN of IA.

A framework is proposed by [11] which utilizes relative variation (RV) and a data aggregative window function (DAWF). It can overcome the redundancies of temporal as well as spatial methods in WSNs. RV and window functions are used to supress the TRs. This method is capable to reduce 90% of redundancy in data transmissions. The results are depended on dead or faulty readings, due to which the performance can vary.

An algorithm called multi-sink and load-balance routing algorithm (MSLBR) is given by [12]. Its aim is to balance the load in the neighbouring sink nodes. The quotient of the dividing the residual energy by the shortest hop to the destination is used a forwarding factor. This factor is used to select the next hop. As compared with PBR and ELBR the MSLBR shows better performance in terms of load balancing and is capable of increased network lifetime. Future work involves : i) enhancing MSBLR to route the data only in which the node is interested in ; and ii) in order to detect the bottleneck among the multi-sink wireless sensor it should be improved.

A transmission range adjustment method is given by [13] to solve the energy whole problem in WSNs. The DTA is a dynamic e algorithm, so that it can permit the range of transmission of the sensor nodes to be varied on the basis of the distance from the base station and their residual energy. The selection of the transmission level facilitates the balancing of energy consumption in the senor nodes, avoids the energy hole problem and hence extends the lifetime of network.

[14] proposed CSDAS that is capable to adopt Treelet transform as a sparse transformation tool. It has the features of both spatial and temporal data. It results in energy saving by using a clustering method which is based on the localized correlation structure of sensory data returned by Treelets. The error rate of reconstruction in CSDAS is 18% less than the traditional ones and 35% of energy saving is done. The future work is to find the results of CSDAS with abnormal events and get the in detail routing protocol for CSDAS.
[15] had given a spatiotemporal compressive network coding (ST-CNC). Its purpose is to get readings of sensors across the WSNs in a manner which is more energy efficient. This method has the capability to reduce the number of transmissions and receptions with similar recovery performance.
[16] presented a Spatial and Temporal Data Correlation algorithm for Data Aggregation (DASTDC). It has the capability of minimizing the loss of energy reducing the number of transmissions. It enhances the network lifetime and the redundant data in nodes. The proposed method can be improved to increase the energy efficiency and decrease the computation cost.

[17] proposed a method viz. EECPK –means which is based on K-means algorithms, an energy efficient clustering protocol. The initial centroid selection is improved by using the midpoint algorithm. In order to improve the network lifetime the proposed method uses the balanced clusters. The cluster heads (CHs) are selected by considering the residual energy along with the Euclidean distance. According to the distance between the CH and BS the multi-hop communication is done. The proposed method is 50% better than LEACH-B, 14% better than BPK-means protocol 6% better than Mk-means and 10% better than Park's approach.

[18] have studied dynamic power management (DPM) in wireless sensor networks. The authors showed that DPM method is capable to efficiently utilize the power. It is done by the monitoring of the activities of the memory unit, processor, communication interfaces and transceiver. The capacity of the battery can be enhanced by the discharging of the current from the battery. Here two types of DPM techniques are proposed viz. a) Selective Switching and b) Dynamic power and frequency scaling. Both the methods have their relative merits and demerits.

[19] presented a probabilistic method of network congestion control viz. decentralized predictive congestion control (DPCC). This study presents a new approach for predicting network congestion using the rate reduction (RR) , rate regulation (RRG) and split protocol (SP). This improves the throughput of the network by reducing the packet dropping. Also an energy efficient method of routing is proposed. The future direction is to consider the packet delay in SP while choosing additional neighbor nodes.

IX. CONCLUSION

The lifetime of the sensor networks depends a lot on energy of the network. The main aim of the network is communication and the key factor involved in this communication is energy.

In this paper a study of protocols for the terrestrial sensor networks is presented. The main aim of this paper is to study the energy efficient protocols. The energy saving and energy harvesting is the need of the hour. As the networks are growing at very vast speed there is more research scope in the area of energy saving protocols.

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