Wireless Sensor Networks Routing Design Issues: A Survey

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ABSTRACT
A Wireless sensor network consists of many devices called as sensor nodes which communicate with each other, to sense the parameters of the environment in which they have been deployed. Sensor nodes communicate with each other using wireless communication techniques and these techniques are governed by routing protocols. Traditional routing protocols cannot be used in WSNs because of the inherent nature of WSNs that distinguishes it from other wireless networks. Performance of the Wireless sensor network depends on the routing protocol hence an extensive survey of the challenges and issues faced during the design of the routing protocols is presented in this paper. Major categories of routing protocols are discussed in detail in this paper. Energy efficient routing protocols are emphasized further.

General Terms
Wireless sensor networks, Routing, Protocols

Keywords
Wireless Sensor Networks Challenges, Routing in WSNs, Energy consumption

1. INTRODUCTION
Wireless Sensor Networks WSNs is a hot research topic which has gained much significance in recent years. WSN has many advantages when compared to wired networks because of their ease, low cost of installation, high mobility, simple deployment and no cabling. WSNs are the technology used for smart infrastructure; for example factory automation, building and process control applications [1].

Wireless Sensor Networks consists of many interconnected nodes capable of sensing i.e. gathering information about processes or objects, occurrences of events, they can also be defined as infrastructure less and self-configured collection of nodes to monitor environmental or physical conditions such as pressure, vibration, temperature [2]. Parameters or events in the physical world are translated by Wireless Sensor Node into signals that can be measured and analyzed. WSN consists of hundreds and thousands of sensor nodes which communicates using radio signals. A Wireless Sensor Node not only has the processing capabilities but also has storage and communication capabilities, such that it can communicate with other Sensor nodes in the network and store the data during processing. Capabilities of sensor nodes depend on the application for which the WSN has been designed. A simple sensor monitors only physical phenomenon where as a complex sensor is required to monitor multiple processes.

WSN consists of a base station (BS) which receives the data send by sensor nodes. Base station is the node which has more energy, computational and communication capabilities, it acts as a gateway of communication from sensors nodes to the outside world. Base station collect the data from various sensor nodes, and can also view the data collected and transform it so that it can be used in a better way. Base station is some time called as sink node.

The area covered by Wireless sensor nodes is called region of interest (ROI). There must be at least one base station for every region of interest as in Figure 1. Sensor nodes communicate with each other to send data to base station, this communication can be direct transmission or multi hop. If the area covered by base station is small then communication from sensor node to base station can be carried in a single hop as in WSN B which resembles a star topology. When the area covered by the WSN is huge and communication from sensor node to base station cannot be carried in a single hop as in WSN A, C, D then some nodes acts as relay which collaborates with other nodes to propagate data towards base station. Relay nodes can also perform aggregation of data that causes some redundant information to be removed before transmitting it to the base station. Multi hop transmission must conserve energy by minimizing the radio transmission power. Sensor node must find an appropriate route to direct the data to the base station in multi hop transmission. WSN can have either mesh topology or tree topology in multi hop transmission. Tree topology is represented by WSN A and C, which has base station as the root node data is passed from sensor nodes to the root node. Mesh topology is represented by WSN D where there are many paths to reach base station, mesh can be either a partial mesh or full mesh.

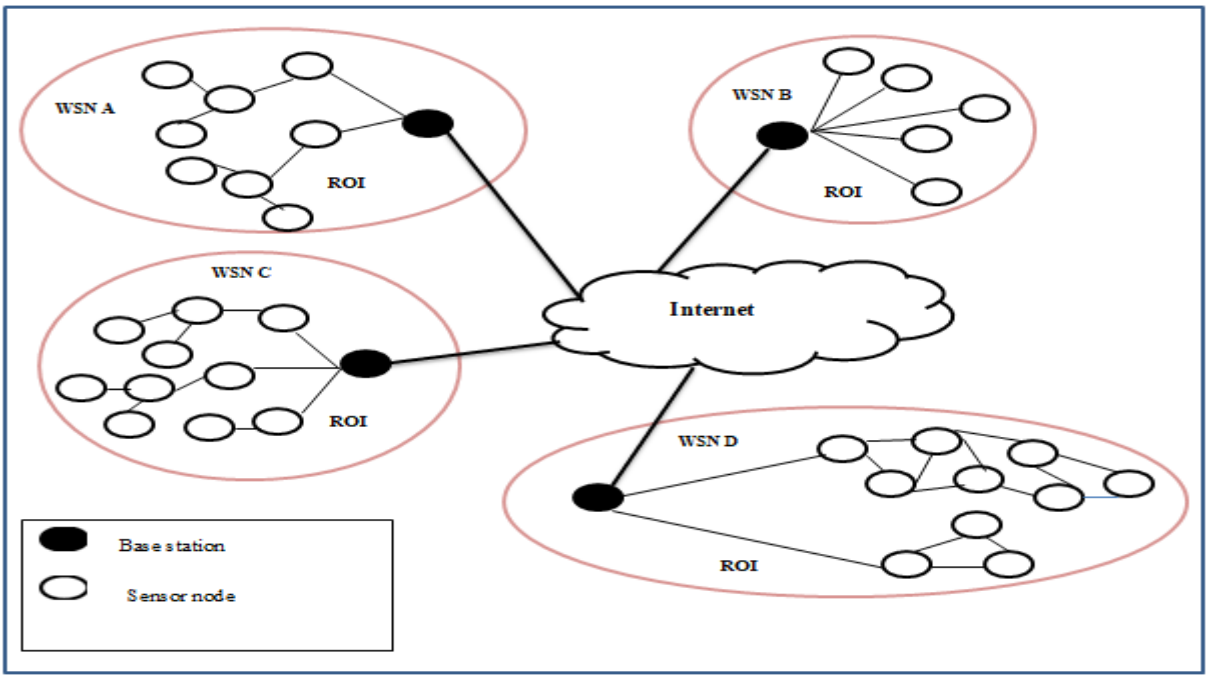

Fig 1: Wireless Sensor Network

2. CHALLENGES IN WSN

Wireless sensor networks has a great potential which is not yet reached because of various challenges faced in designing and deploying them. These challenges have become subjects of research interest and few of them are listed below [3].

2.1. Energy

First and foremost challenge is to reduce the energy consumption of sensor nodes as they run on the limited battery. Energy must be conserve to increase the lifespan of the sensor nodes. Energy is required by the sensor node to sense, collect, communicate and process data. Batteries when depleted can be replaced or recharged. The most important task in WSNs is to design and implement various energy efficient hardware and software protocols to manage limited battery life efficiently.

2.2 Environmental conditions

Sensor nodes are often subjected to harsh environmental conditions in region of interest, they have to face highly corrosive environment, dirt, dust, humidity, radio frequency interface and vibrations depending on the application for which they have been designed.

2.3 Communication

Communication is WSNs is through wireless medium using IEEE 802.15.1 and IEEE 802.15.4 protocols. IEEE defines physical and Medium Access Layer for Low Rate Wireless Personal Area Networks (LR-WPAN). IEEE 802.15.4 was developed for networks with low deployment cost, low power consumption, less complexity and short range communication while maintaining simple protocol stack. Three frequencies are supported by physical layer, i.e. 2450 MHz, 915 MHz and 868 MHz. MAC layer define two types of nodes: Reduced nodes and Functional nodes. Reduced nodes acts as sensor end device and Functional node as both sensor end device and network coordinator which does synchronization and communications and network joining services. Range of communication is WSNs is very short, up to 10 to 20 meters and the data rate of WSNs is up to 250 Kbits/second. Low data rate can cause congestion problem in large, highly active networks and affect the latency and throughput of the network.

2.4 Cost

WSNs consist of large number of sensor nodes and the cost of each node is very important and it should be economic. The cost and hardware and software must be less. Software must be hardware independent in WSNs besides being less energy consuming and light [4].

2.5 Deployment

Deployment is implementation of sensor nodes in real world scenarios. Deployment is an important issue to be looked at in WSNs. There are two deployment techniques used first is static deployment in which node location is decided according to optimization technique, location is static it will not change with time and the second is dynamic in which the nodes are placed or dropped randomly across the region of interest.

2.6 Self-Management

WSNs consists of many sensors nodes across region of interest and in due course of time some nodes may fail and malfunction which leads to change in WSNs topology. Hence a sensor node must be self-managing i.e. adaptable to change in connectivity. Sensor nodes must be able to configure themselves and adapt to failures, changes in environment once deployed without human intervention.

2.7 Routing

Owing to the unstructured nature of WSNs traditional routing protocols are not suitable. Routing protocols in WSNs must be lightweight because of the limited network resources. Routing protocols in WSNs are classified as greedy forwarding, energy oriented, data centric and localisation and flood based. Greedy forwarding forwards packets to neighbors close to destination. Data centric protocols are attribute based protocols, they use compression and aggregation to route the packets. Energy efficient protocols choses a neighbor with

high energy level to route the packet. Localisation based protocols uses GPS or any other localisation model to localize the neighbors in the network and to decide the route. Flooding is technique in which a node broadcast da or control packets' for route determination.

2.8 Security

Security is one of the important issues in WSNs. WSNs operate on remote location and remains unattended which increase their chances of being exposed to malicious intrusion and attacks. All WSNs must be protected from unauthorized access to data. There are some fundamental security requirements to be meet by WSNs like: Data Authentication, Data confidentiality, Data integrity, Availability and Redundancy. Type of attacks possible in WSNs are Goal-oriented, Performer-oriented and layer-oriented. Goal-oriented attacks comprise of active and passive attacks. Active attacker listen and gather sensitive information and interrupt the functioning of the network, passive attacker just listen and gathers sensitive information does not interrupt the network. Performance-oriented attacks can be outside or inside attacks. An outside attack occurs when the adversary exhaust the node resources by injecting bogus data causing denial of service to legitimate nodes. Inside attack occurs when a malicious node acts as legitimate node and causes disruption in network operation.

3. ROUTING PROTOCOLS IN WSNs

Routing is the process of finding a route from sensor node to base station in WSNs. Traditional IP based protocols cannot be applied to WSNs because there are no global addressing schemes for large number of sensor node and the cost of maintaining the addresses is very high[5]. Self-organizing nature of WSNs must be taken into account while taking routing decisions. The main goal of routing protocols is to extend the lifetime of the network by keeping the sensors alive, by devising the routing protocols which consume less energy to transfer the data from sensor nodes to base station so that network is in operational condition for long duration of time.

3.1 Design issues of routing protocols

To design a routing protocol in WSNs many challenges has to be faced few of them are listed below [6].

3.1.1 Node deployment

Node deployment is application dependent; it influences the performance of routing protocol. Node can be deployed in manual and randomized manner, in manual deployment data travels predestined paths. Random deployment is mostly used for event detection where the data path is not fixed.

3.1.2. Energy consumption

Routing protocols transfer the data from the sensor nodes to base station in efficient manner. Energy is consumed by sensor nodes to sense, process receive and transmit data. Most energy is consumed in transmission of data. Sensor node have limited energy resources, energy depletion of sensor nodes result in many topology and network connectivity changes, reorganization of the network and finding new routes. Routing protocols in WSNs must be designed to accommodate tradeoff between accuracy and energy optimization.

3.1.3 Nature of nodes

In WSNs the nodes can be homogenous or heterogeneous. In homogenous all the nodes have the same capabilities such as processing capacity, battery life and range of transmission while heterogeneous node has different processing capabilities. Routing algorithm has to take into account the nature of nodes while making routing decisions.

3.1.4 Coverage

WSNs consist of many sensors spread across the region of interest. Each sensor has limited range and accuracy, the part of the environment area covered by the sensor node is important when designing the routing protocol.

3.1.5 Number of node

Routing algorithm is dependent on the number of the nodes deployed in the region of interest. If the number of nodes deployed is few then each node will have the knowledge of network topology which helps in making routing decision. If the number of nodes deployed is many then it is not feasible for a node to maintain knowledge of network topology.

3.1.6 Data reporting method

Data reporting method is dependent on the application for which WSNs has been designed and it also depends on the time criticality of data. Data reporting can be categorized as even-driven, time-driven, query-driven or hybrid of all the methods. For periodic data monitoring time-driven delivery method is required. Even-driven delivery method reacts immediately to drastic and sudden change in the sensed attribute due to occurrence of the some event. Query-driven method responds to the query generated by base station or another sensor node in WSNs.

3.1.7 Fault tolerance

In the life time of WSNs many sensor nodes fail or become blocked due to lack of power, environmental interfaces and physical damage. The failure of the node must not affect the working of sensor networks; this can be achieved by rerouting the data to other sensor nodes which has more energy to transmit the data to base station. Hence routing protocols must be robust to handle the failure of the node.

3.1.8 Data aggregation

Sensor nodes produces data, some of the data produced by the sensor nodes might be redundant i.e. some data might be produced by more than one sensor node then data aggregation must be performed to reduce the number of transmission. Data aggregation combines the data according to aggregation function (e.g. minima, maxima, average and duplicate suppression). Many routing protocols use data aggregation to achieve data transfer optimization. Signal processing techniques can also be used for data aggregation.

3.1.9 Quality of service

Certain level of quality of service required by application must be provided by routing protocols. Quality of service parameter is application specific. Some time-critical application require that data must be delivered with in specific time period from the moment it is sensed whereas other application consider conservation of energy as more important than in-time delivery of data. Some quality of service parameters are delivery delay, bandwidth, throughput, jitter. The quality of service requirement can be fulfilled by designing specific protocols that meet them ex. Energy efficient routing protocols that reduces the energy consumption thus increases the life time of the network.

3.2 Routing Protocols

Routing protocols can be classified into various categories depending on the structure of the network, protocol operations. In this paper two categories of routing protocols are emphasized the first category are the traditional protocols

that do not take energy consumption into account when making routing decision and the next category is the energy efficient protocols that make routing decisions based on the energy consumed in transferring packets from source to destination. First category of routing protocols are further classified as data centric routing, hierarchical or clustering based protocols, location-based protocols, multipath routing protocols, query-based routing, Negotiation-Based Routing Protocols, QoS-based Routing. Energy efficient protocols are further classified based on homogenous and heterogeneous WSNs as shown in Figure 2.

3.2.1 Data centric routing

Data aggregation is performed by the intermediate sensors on the path form the source sensor node to base station in data centric routing [7]. The aggregation performed in data centric routing results in saving energy because redundant data form multiple nodes is removed , summary of data is transmitted like minimum, maximum and average values. Some example protocols for Data centric routing are discussed in the following paragraphs

SPIN: Sensor Protocols for Information Negotiation [8] is an adaptive protocol that works in an energy constraint environment by efficiently distributing information in WSNs. Meta-data is used by the sensor nodes to name their data, this meta-data negotiations is used to eliminate transmission of redundant data. The communication decisions made by SPIN nodes are based upon the knowledge of the resources available to them and application-specific knowledge of the data, this makes the sensors efficiently distribute the data with in a limited energy supply.

Directed Diffusion [9] is a data centric routing protocol where data is named using attribute-value pair. A sensor node request data by sending interests for named data. Sensor neighboring to node produces data matching to the interest which is drawn down. Each sensor node can interpret, transform, aggregate, cache data and it may also direct interests based on previously cache data. Energy efficiency is obtained by caching data in directed diffusion. It is query driven on demand data model.

Rumor Routing [10] is a method of routing queries. When an event, which consists of a set of sensor readings, is observed by the node, a query, which is a request for information is directed to the node where the event is observed. This is done by sending a query on a random walk until it finds the event path, instead of flooding the network with the query. When the query discovers the path of the event all subsequent queries can be directed on the discovered path. It reduces the energy required for transmitting the data by discovering routes rather than flooding the network with queries.

3.2.2 Hierarchical or cluster based routing

In Hierarchical routing protocols a high energy node is used to process and send the information and low energy nodes are used to sense the data within region of interest. A group called as cluster is created with a chosen cluster head which is the node with high energy; this contributes to increase the scalability, lifetime and utilization of energy in an efficient manner in WSNs. Hierarchical routing reduces the number of messages transmitted to base station by data aggregation and fusion. Hierarchical routing is two layers routing where first layer is used to select the cluster heads and second layer is used to route the data. Few important hierarchical clustering protocols are discussed in the following paragraphs.

LEACH: Low-Energy Adaptive Clustering Hierarchy [11] is very popular energy-efficient hierarchical clustering algorithm. Clusters are created in LEACH, cluster head are chosen on randomized rotation policy to distribute the energy load among the sensors nodes in WSNs. Cluster head forwards the data to the base station. LEACH performs data aggregation or fusion technique to reduce the amount of data that must be transmitted to base station, it also make data dissemination and routing more scalable and robust. PEGASIS: Power-Efficient GAthering in Sensor Information Systems [12] is an enhancement of LEACH where sensors nodes chains are formed. Nodes can communicate with the neighbor nodes in the chain, only one node in the chain can transmit data to the base station. Power consumption of the nodes is reduced by making the nodes communicate only with their closet neighbor and the nodes take turns in communicating with base station. Data aggregation is performed as the data moves form node to node.

TEEN: Threshold sensitive Energy Efficient sensor Network protocol [13] is designed for reactive WSNs which respond immediately to changes in the parameters sensed. These protocols were designed for time critical applications. Each sensor node senses the data continuously but does not transmit the data. Two types of threshold are set by CH sensors hard and soft threshold. When the soft threshold is reached by the sensed attribute, the sensor node switch on its transmitter and starts transmission. When hard threshold is reached by the sensed attribute, the sensor node sensing this value switch on transmitter and report the value of the sensed attribute to its cluster head. Power consumption is reduced in TEEN because more sensors nodes are sensing the data and

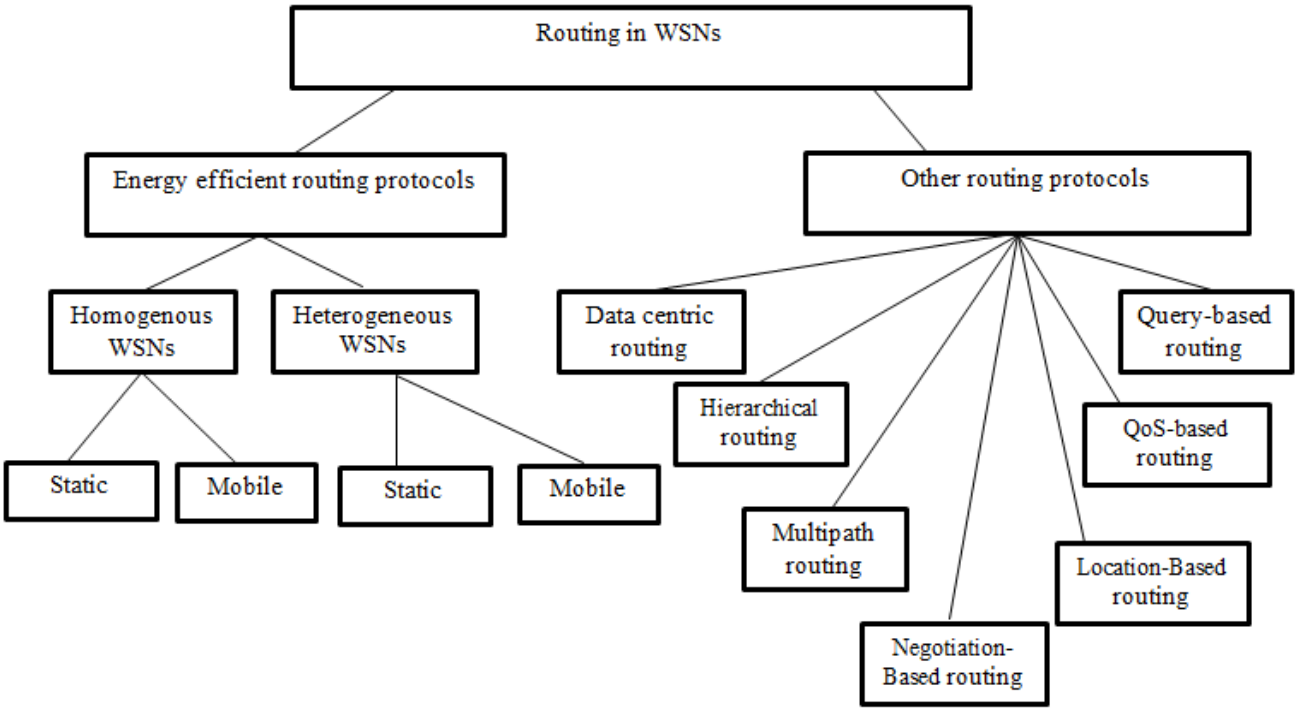

Fig 2: Classification of routing protocols

transmitting data only when the sensed attribute value reaches hard threshold.

APTEEN: Adaptive Periodic TEEN is an extension of TEEN. APTEEN is aimed at captures periodic data along with reacting to time critical events [14]. In APTEEN, Cluster heads broadcast attributes which consists of physical parameters which are of interest to the user, hard and soft thresholds, Schedule which assigns a slot to each node, Count Time is the maximum time period within which the node must send the report. APTEEN combines both reactive and proactive routing policies.

3.2.3 Location-Based Routing Protocols

In location based routing protocols sensors node are addressed by means of their location. Distance between the neighboring nodes is calculated based on their location to estimate energy required for transmission data. GPS can also be used to get the location information of the nodes if the nodes are equipped with small low power GPS receiver. There is a provision in location based routing protocols that a node can go to sleep if there is no activity, which helps in energy conservation in WSNs. Few location-based routing protocols are discussed in the following paragraphs.

GAF: Geographic Adaptive Fidelity [15] is an energy aware location-based routing algorithm. GAF creates a virtual grid by dividing the network area into fixed zones. In each zones sensor nodes play different roles and collaborate with each. In each zone one sensor node is elected to stay awake for a certain period of time and the rest of the nodes go to sleep. The node elected is responsible for monitoring and reporting data to base station on behalf of all the nodes in the zone. Power consumption in reduced in GAF by turning off unnecessary nodes in network without affecting routing fidelity.

GEAR: Geographic and Energy Aware Routing [16] uses geographic information to propagate queries to appropriate regions. It uses neighbor selection heuristic to restrict the number of neighbor to route the packet towards the destination region, in doing so energy is conserved by GEAR. It keeps an account of estimated cost and learning cost of reaching to destination. Estimated cost is the combination of residual energy and distance to destination. Learning cost is refinement of estimated cost incurred for routing around holes in networks. Hole occurs when the node does not have any closer neighbor than itself to the target region. There are two phases in the algorithm first phase is forwarding packets towards the target region and second is forwarding the packets within the region.

3.2.4 Multipath routing protocols

Two types of routing paradigms are possible with respect to data transmission between source and base station, first is single path routing where there is single path from source to base station, second is multipath routing where there are more than one path from source to base station. All the earlier discussed approaches for routing are a single path where each source sensor sends its data to the base station via shortest path. Whereas in multipath routing protocols each source sensor has to first find the shortest paths to base station and divide the load equally among these paths. Fault tolerance of the protocol is dependent on the number of alternate paths that exist between the source and destination when the primary path fails. The alternate paths are kept alive by periodically sending messages on the path. Network reliability is increased by maintaining alternate paths.

Authors proposed in [17] an algorithm that routes the data through a path whose nodes have highest residual energy, this path is changed whenever a better path is discovered. Energy depletion of primary path node through continuous use is avoided by changing the paths. Another approach in [18] uses suboptimal paths to increase the lifetime of WSNs. The choice of the path is based on probability of the value of energy consumption of the path. In [19] a multipath routing algorithm

was proposed to deliver data in unreliable environment. Network reliability is increased by providing many paths form sources to destination which increases the traffic on the network. The algorithm split the data packets into sub packets and each sub packet is send through one of the available multipath, in this approach original data packets can be reconstructed at the destination node even if some of the sub packets' are lost during transit.

3.2.5 Query-based routing

In this type of routing the destination nodes prorogates a query for data (sensing task) from a node through the network, the node that holds the data matching to the query and send back the data to the initiator of the query. Mostly these queries are described in high level languages or natural languages. Directed diffusion algorithm discusses earlier is an example of query based routing techniques.

3.2.6 Negotiation-Based Routing Protocols

These protocols use high level data descriptors to eliminate the redundant data transmission through negotiations. Communication decisions are made on the available resources. The main goal of the negotiation based protocols is to suppress the transfer of duplicate data to the base stations or to the next node by sending a series of negotiation messages before beginning the transfer of the data. SPIN protocol discussed earlier is an example of negotiation based protocols.

3.2.7 QoS-based Routing

In these protocols a balance between energy consumed and data quality is proposed. The network must satisfy certain QoS metrics such as energy consumed, delay and bandwidth etc. when delivering data to the base stations.

4. ENERGY EFFICIENT ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS

In the previous section major categories of routing in WSNs are discussed among them the most significant one which influences the lifespan of Wireless sensor networks is energy efficient routing protocols. Energy efficient routing protocols plays a great role in prolonging the time of the Wireless sensor networks by making routing decisions based on the battery constraints. As wireless sensor networks consist of large number of sensor nodes distributed across region of interest and have dynamic topology, each sensor node has limited battery, and these batteries must be recharged or replaced. Dependence of WSNs life time on the batteries of sensor node has introduced the need of energy efficient routing protocols.

Sensor node consists of energy constraint batteries, effective energy efficient protocols are needed to balance the energy consumption level in WSNs. Schematic diagram of sensor node is given in the Figure 3. Each sensor node comprises of Sensing unit, Processing unit, Transmission unit. Sensing unit consists of a sensor and ADC, sensor job is to sense the change in parameters' these parameters are converted into digital domain by ADC. Processing unit receives the transformed parameters from ADC. Processing unit consists of processer and storage. Processing is carried out by the processor and storage is used to help in processing of the task. Transmission unit consists of a transceiver used for communicating with other sensors or the sink in WSN. Mobilizer, position finding unit and power unit are optional components.

Most of the power is consumed by wireless transmission unit. The communication module has four states, send, receive, idle and sleep [20]. Sending and receiving signals take about two third of sensor node energy consumption. Routing strategy describes the number of transmission made by the node; hence efficient routing algorithms are required to reduce the amount of energy consumed, increase the lifespan of WSNs and as well as improve the quality of data transmission.Other routing protocols focus on finding the shortest path from the source node to destination node without taking into account the energy consumed in transferring the data packet. Most of the other routing protocols assume that their sensors nodes are static.

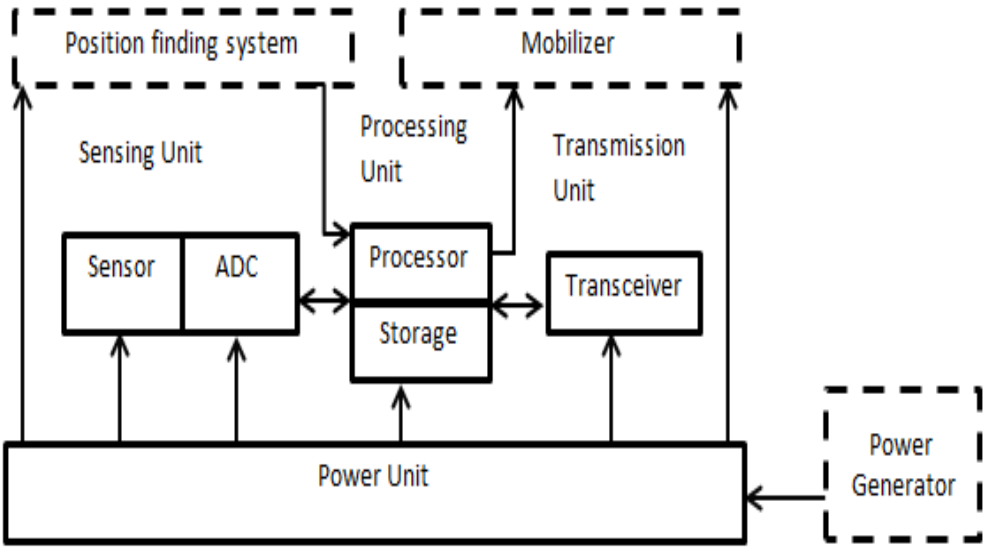

Fig 3: Schematic diagram of sensor node

Consequently, sensor node near the base station tends to deplete their energy quickly because of their frequent use in transmitting the data packets, when compared to other nodes in WSNs creating energy holes in network. Hence routing protocols must incorporate mobility in WSNs. Second assumption by other routing protocols is homogeneity of the sensor nodes. Many protocols assume that all sensor nodes are homogenous. Homogenous WSNs help the researchers to understand WSNs initially because of their simplicity, but in practical Heterogeneous WSNs are more common. Nodes in heterogeneous WSNs have different processing capability, transmission bandwidth and sensing capabilities. Protocols designed for homogenous WSNs cannot be used for Heterogeneous WSNs.

4.1 Classification of Energy efficient routing protocols

Classification presented for WSNs is according to homogenous and heterogeneous WSNs together with static and mobile scenarios.

4.1.1 Homogenous WSNs

All the nodes in homogeneous WSNs are identical. The protocols in Homogenous WSNs can be further divided into static protocols and mobile protocols. The static protocols can be further divided into cross-layer routing, cooperative routing, opportunistic routing, biological-inspired routing, while mobile protocols can be categorized based on the mobility of the source nodes, sink nodes and both.

Opportunist routing protocols [21] is based on multiple forward technique to increase network communication throughput. EEOR: An energy efficient opportunistic routing protocol [22] is proposed which aims to increase the lifetime of network by reducing the cost of selecting and prioritizing a forwarder list under opportunist protocol. E^2R: Energy efficient routing protocol [23] is introduced which compares each node own route metric value to the one received in the data packet. K-S routing protocol [24] integrates routing with network coding, it avoids transmitting duplicate packets thereby increasing the lifetime of the network

Cross-layer routing protocols allows interaction among the non-adjacent layer has received much importance in recent years. These protocols are used to control and manage WSNs in an intelligent manner. JPRA: Joint Routing, power control and Random Access Algorithm [25], proposed an energy efficient approach by combining physical, MAC and routing layers.

Cooperative routing protocols allows multiple nodes to share their resources and antennas to achieve space diversity in multimode scenarios. RBCR: Relay Selection based Cooperative routing protocol [26] make routing decisions on channel quality and energy consumed.

Biologically inspired optimal routing uses biologically inspired principal in routing. BIOSARP: A Biologically inspired self-organized secure autonomous routing protocol [27] it is based on ant colony optimization techniques, it performance depends on the handling on pheromone and involves two types of ants forward and backward. BeeSensor [28] is based on honey-bee colony. BeeSensor is used in application where frequent data is transferred and it achieves better results when compared to ant colony optimization algorithm.

Mobile homogenous protocols are based on mobility of the sink, source, both. Termite-hill [29] algorithm has a mobile sink that can move without any constraint, it manages the energy consumption of the WSNs without creating any energy holes. TARS: Trace-Announcing Routing Scheme [30] proposes protocols where the sink and target can be move, it works by broadcasting a trace announcing packets rather than constructing a route path.

4.1.2 Heterogeneous WSNs

The protocols used for heterogeneous WSNs can be further divided into static heterogeneous and mobile heterogeneous.

ECDC: An energy and coverage aware distributed clustering protocol [31] is an example for static heterogeneous protocol which divides the sensor nodes into three categories i.e. plain nodes in terms of energy, cluster head, cluster member. Cluster created are even in this protocol because it elects a cluster head based on coverage and energy. EEMHR: An Energy efficient Multilevel Heterogeneous Routing [32] reduces the energy consumption by partitioning the nodes into k level normal nodes and k level advanced nodes.

HARP: A hierarchical Adaptive and reliable routing protocol [33] is an example for mobility based protocols in heterogeneous WSNs, it partitions the nodes into two types normal nodes and cluster nodes based on the residual energy capacities. It builds a hierarchical tree with the normal nodes and cluster head as root node, cluster nodes and sink node as root node. RAHMoN: Routing Algorithm for Heterogeneous Mobile Network [34] divides all the nodes into static and mobile. Energy of the static nodes is less than the energy of the mobile nodes. Mobile nodes can be cluster heads or sink nodes.

5. CONCLUSION

This paper started with an introduction to Wireless Sensor network and differences of WSNs from the other wireless network is being highlighted followed by the architecture of WSNs. Challenges faced in WSNs are discussed next. Followed by routing protocols and design issues. Energy efficient routing which is the hot topic of research in WSNs community is discussed. Classification of energy efficient routing algorithms is presented in the last section.

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