BRIEF SURVEY ON WIRELESS ENERGY CONSERVATION ROUTING SYSTEMS

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Abstract- Scientists use wsn networks for monitoring various environmental parameters. Routing protocols in WSNs emphasize on data dissemination, limited battery power and bandwidth constraints in order to facilitate efficient working of the network, thereby increasing the lifetime of the network. In several deployment scenarios, it is cumbersome to run cables to power the nodes. Therefore, sensor nodes are often equipped with pre-charged batteries, which supply the energy required for their operations. Over time, the node expends all the energy in its battery and becomes inoperable or dead. Eventually, the network itself fails to meet its sensing objective. Energy harvesting sensor (EHS) nodes provide an attractive and green solution to the problem of limited lifetime of wireless sensor networks (WSNs). Unlike a conventional node that uses a non-rechargeable battery and dies once it runs out of energy, an EHS node can harvest energy from the environment and replenish its rechargeable battery. Thus, this paper reviews some of the most efficient routing protocols and briefly discusses the components and architecture of WSN.
Keywords- Wireless Sensor Networks, Routing Protocols, Energy Efficient Protocol, Data-Centric protocols, Hierarchical Protocols and Location Based Protocols.

I. Introduction

With the advancement of advanced innovation wireless sensor nodes are discovering a ton of utilizations in regular life beginning from smart home framework to military surveillance. The essential building block of a wireless sensor network is a spatially appropriated set of autonomous sensor nodes or motes. To outline a wireless sensor network it is important to comprehend the structure and working of a sensor node [1]. The sensor nodes can be considered as tiny battery powered computers that comprises of a computing subsystem, communication subsystem, sensor subsystem, power subsystem. In this paper a review on the highlights of these subsystems is done, so that it is simple for the application developer to rapidly comprehend and select the kind of component for building customized sensor node platform.

A wireless sensor network (WSN) is a wireless network that consists of a spatially distributed set of autonomous wireless sensor nodes. The number of nodes in a sensor network can be up to hundreds of thousands. The nodes are tiny computing devices, each equipped with sensors (type of sensor depends on application), a wireless radio, a processor, and a power source. The sensor nodes can be considered as tiny battery powered

computers. Normal WSN nodes are powered by batteries. Therefore, the lifetime is limited and the batteries have to be replaced manually after a certain period of time. This problem can be solved by EHSs [2]. They exploit energy sources of the environment and store the harvested energy in energy buffers. The EHS supplies the electronic device and ensures a continuous operation. However, the EHS have to be adapted to the requirements of the application area and of the supplied device. This enhances the overall efficiency of EHS. To be able to do that, the fundamental mode of operation of an EHS has to be well-understood.

WSN typically contains hundreds or thousands of sensor nodes which allows for sensing over larger geographical regions with greater accuracy. Usually the sensor nodes are deployed randomly over geographical location and these nodes communicate with each other to form a network. Each node has three basic components [1] as shown in figure 1[2]:
1)Sensing unit, 2)Processing unit, 3)Transmission unit.

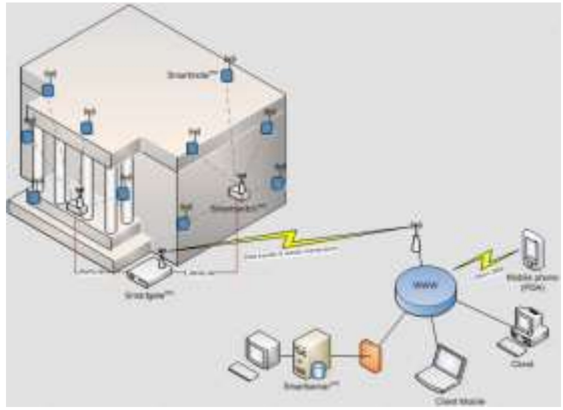

Figure 1. WSN and components of sensor node

I. Node Platforms

EHWSNs are composed of individual nodes that in addition to sensing and wireless communications are capable of extracting energy from multiple sources and converting it into usable electrical power. This section describes in details the architecture of a wireless sensor node with energy harvesting capabilities, including models for the harvesting hardware and for batteries.

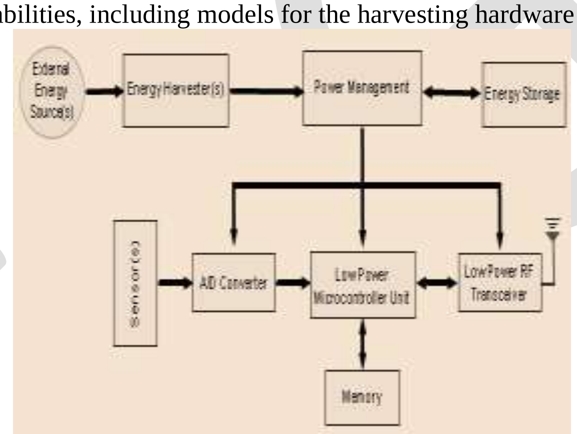

Fig.2 System architecture of a wireless node with energy harvester

The system architecture of a wireless sensor node includes the following components (fig, 2). The energy harvester(s), in charge of converting external ambient or human-generated energy to electricity; 2) a power management module, that collects electrical energy from the harvester and either stores it or delivers it to the other system components for immediate usage; 3) energy storage, for conserving the harvested energy for future usage; 4) a microcontroller; 5) a radio transceiver, for transmitting and receiving information; 6) sensory equipment; 7) an A/D converter to digitize the analog signal generated by the sensors and makes it available to the microcontroller for further processing, and 8) memory to store sensed information, application-related data, and code.

II. Harvesting hardware models

The general architecture of the energy subsystem of a wireless sensor node with energy harvesting capabilities is shown in Fig 2. The energy subsystem includes one or multiple harvesters that convert energy available from the environment to electrical energy. The energy obtained by the harvester may be used to directly supply energy to the node or it may be stored for later use. Although in some application it is possible to directly power the sensor node using the harvested energy, with no energy storage (harvest-use architecture [3]), in general this is not a viable solution. A more reasonable architecture enables the node to directly use the harvested energy, but also includes a storage component that acts as an energy buffer for the system, with the main purpose of accumulating and preserving the harvested energy. When the harvesting rate is greater than the current usage, the buffer component can store excess energy for later use (e.g., when harvesting opportunities do not exist), thus supporting variations in the power level emitted by the environmental source.

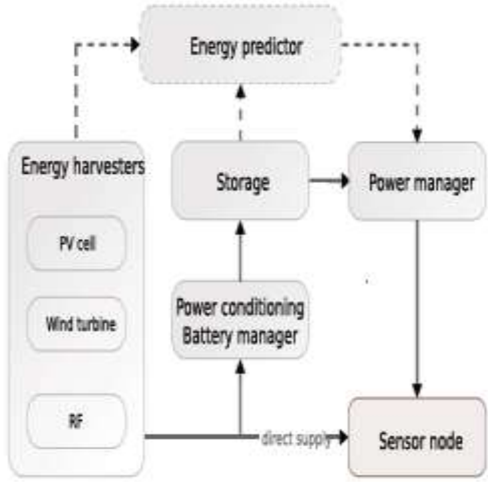

Fig 3 General architecture of the energy subsystem of a wireless sensor node with energy harvesting capabilities.

III. ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORK

Routing protocols in WSNs have a common objective of efficiently utilizing the limited resources of sensor nodes in order to extend the lifetime of the network. Different routing techniques can be adopted for different applications based on their requirements. Applications can be time critical or requiring periodic updates, they may require accurate data or long lasting, less precise network, they may require continuous flow of data or event driven output. Routing methods can even be enhanced and adapted for specific application

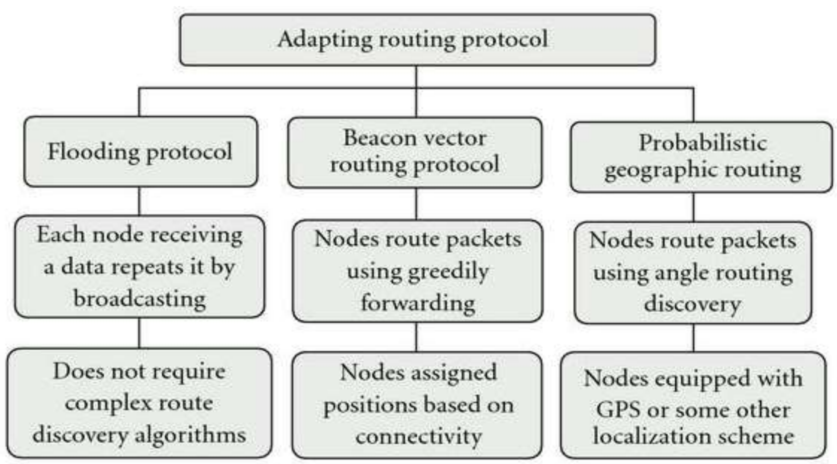

Fig 4. Classification of routing protocols in WSNs

Generally, the routing protocols in WSNs can be classified into data-centric, hierarchical, location based routing depending on the network structure as shown in fig 3. In data-centric, all the nodes are functionally equivalent and associate in routing a query received from the base station to the event. In hierarchical approach, some nodes have added responsibilities in order to reduce the load on other nodes in the network. In location based, the knowledge of positions of sensor nodes is exploited to route the query from the base station to the event. Thus, this section reviews some of the routing protocols as follows.

a) Sensor Protocols for Information via Negotiation (SPIN)

SPIN protocols [4] are a family of negotiation based information dissemination protocols used in WSN. In this protocol, the nodes name their data using high level descriptors called metadata. Metadata is used to negotiate and avoid the transmission of the redundant data. The transmission of a node is based on both the application specific knowledge of the data and the knowledge of the resources available to them. This allows the sensors to use their energy and bandwidth efficiently. The classical Flooding has 3 major obstacles as shown in fig 4.

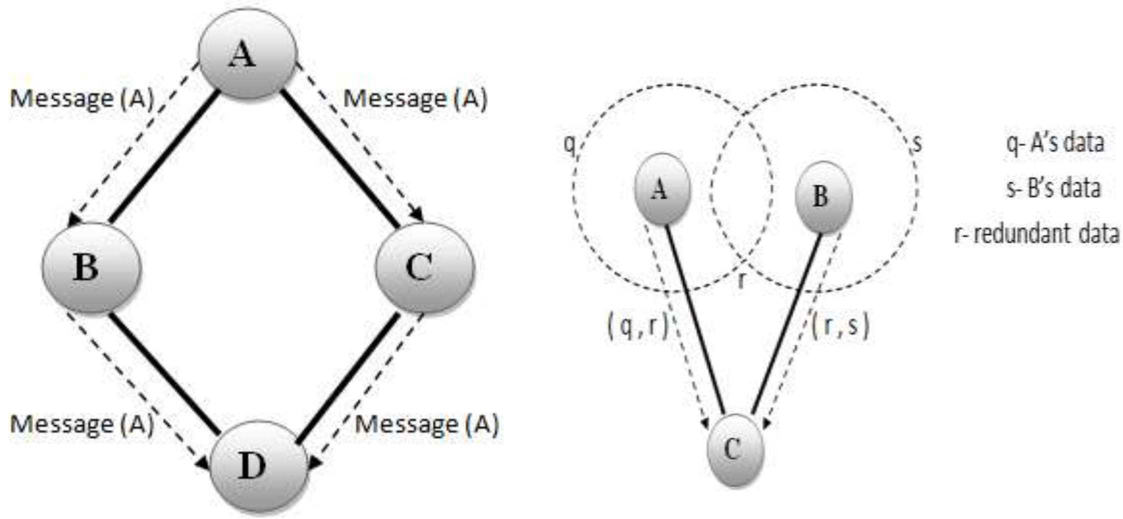

Figure 5. Implosion and Overlap

1. *Implosion*: A node receives multiple copies of the same data from its different copies of the neighbours, because the sender node has no way of knowing whether the receiving node has already got the information from a different neighbour.
2. *Overlap*: Sensor nodes often cover same geographical area, and nodes gather overlapping pieces of sensed data. Since the nodes send redundant data to the same destination, bandwidth and energy are used inefficiently. Implosion is a function of only the network topology, whereas overlap is a function of both network and sensor attributes, making overlap a much harder problem than the implosion.
3. *Resource blindness*: The nodes are unaware of the status of its resources which makes them die sooner. It can be rectified by using a local resource manager at each node.

SPIN family of protocols overcome these limitations by negotiation and resource adaption. Together, these features overcome the 3 obstacles of classical flooding. SPIN-1 is a 3 stage hand shake protocol for disseminating data, and SPIN-2 is a version of SPIN-1 that backs-off from communication at low energy threshold. Such resource adaptive approach holds the key to the future of routing in WSNs. SPIN keeps up the promise of achieving high performance at low cost in terms of complexity, energy, computation and communication.

b) Direct Diffusion

Direct diffusion [5,6] is a data centric query based and application-aware protocol where data aggregation is carried out at each node in the network. The nodes will not advertise the sensed data until a request is made by the BS, and all the data generated by sensor node is named by attribute-value pairs. Each node in the network maintains an interest cache that contains information about the interest received. The interest cache stores the information about only one-hop neighbour from which it received the interest. When the node receives an interest, it checks the interest cache to see if the interest already exists. If no matching entry exists in the interest cache, then the node creates one interest entry and stores the information about the interest. If the entry already exists then the timestamp and expires. All sensor nodes in a directed-diffusion-based network are application-aware, which enables diffusion to achieve energy savings by selecting empirically good paths, and by caching and processing data in the network. Caching can increase the efficiency, robustness, and scalability of coordination between sensor nodes, which is the essence of the data diffusion paradigm.

c) Low Energy Adaptive Clustering Hierarchy (LEACH)

Low Energy adaptive clustering hierarchy (LEACH)[7] is a popular energy efficient adaptive clustering algorithm that forms node clusters based on the received signal strength. The cluster head (CH) aggregates the sensed data from all transmits it to the BS as shown in figure 5.

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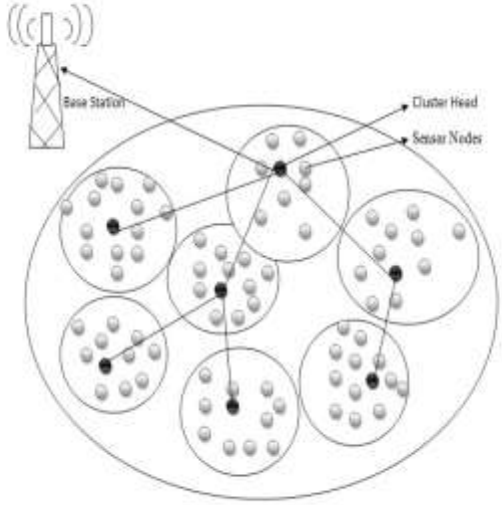

Fig 6. Clusters in WSN

LEACH assumes that the base station is immobile and is located far from the sensors. All nodes are capable of communicating with the BS directly. At any point of time, all the nodes have data to send and nodes located close to each other have co-related data. The cluster head (CH) can perform data aggregation and data dissemination as shown in figure 5. Further energy dissipation can be reduced by aggregating the data from various sensor nodes at the cluster head. LEACH enhances the network lifetime by utilizing the resources efficiently, distributing the load uniformly, aggregating data at the CH to contain only the meaningful information, rotating the CH randomly to achieve balanced energy consumption. Also, the sensors do not need to know the location or distance information. Depending on the applications, the different variations of LEACH such as LEACH-C (centralized)[8], E-LEACH (enhanced) and MLEACH (multi-hop) can be used.

d) Threshold sensitive energy efficient protocols

Threshold sensitive energy efficient protocol (TEEN)[9] and Adaptive threshold sensitive energy efficient protocol (APTEEN)[10] are the two threshold sensitive hierarchical routing protocols based on the clustering approach used in LEACH. LEACH is targeted at pro active network applications where as TEEN and APTEEN are targeted at the reactive network applications. In pro active network, the sensed data is sent periodically to the sink which provides the snap shot of relevant parameters at regular intervals. In reactive networks the nodes react immediately to the sudden change in the sensed data and transmit it to the sink. Since they remain in the sleep mode most of the time, the number of transmissions is reduced, thus reducing the energy consumed.

Therefore, the hard threshold tries to decrease the quantity of transmissions by permitting the nodes to transmit just when the sensed attribute is in the scope of interest. The soft threshold further diminishes the quantity of transmissions by taking out all the transmissions which may have generally happened when there's practically zero change in the sensed attribute once the hard threshold is reached. The soft threshold can be changed relying upon the criticality of the sensed attribute and the target application.

e) Geographic Adaptive Fidelity (GAF)

GAF[11] is a location based routing protocol for WSN. It is also an energy aware routing protocol. GAF works in such a way that, it turns off pointless nodes in the system without influencing the level of routing fidelity, this conserves energy. A virtual grid for the area that is to be covered is formed. The cost of packet routing is considered equivalent for nodes connected with the same point on the virtual network. Such equivalence is exploited in keeping a few nodes spotted in a specific grid area in sleeping state so as to spare energy. By doing this the network lifetime is increased as the number of nodes increases. There are three states in this protocol and they are discovery, for determining the neighbors in the grid, active tells that the nodes are participating in routing and sleep when the radio is turned off. The load is balanced when nodes change states from sleeping to active in turns. GAF keeps the network connected, by keeping a representative node always in active node for each region on its virtual grid. Although GAF is a location based protocol, it can be considered as a hierarchical protocol, where the clusters are based on geographic location.

f) Minimum Energy Communication Network (MECN)

MECN [12] is a location based routing protocol. It maintains a minimum energy network for wireless networks by utilizing low power GPS. This protocol can be used for mobile networks but it is best suited for sensor networks. This is because sensor networks are not mobile [36]. A master node is included to a minimum power topology for stationary nodes. MECN expects an expert site as the data sink, which is dependably the case for sensor networks. MECN recognizes a relay region. This area comprises of nodes in an encompassing range where transmission through those nodes is more energy proficient than direct transmission. The principle thought of MECN to discover a sub-system which will have less number of nodes and obliges less power for transmission between two nodes. MECN is self organizing and dynamically adapts to nodes failure or the deployment of new sensor nodes. Small Minimum Energy

Communication Network (SMECN) in [37] is an extension of MECN. In SMECN, possible obstacles between any pair of nodes are considered.

II. Conclusion

With the advancement on energy harvesting techniques, and the development of small factor harvester for many different energy sources, EHWSNs are poised to become the technology of choice for the host of applications that require network functionalities for years or even decades. WSNs have discovered a wide range of applications in the recent era. Growing demand for WSN has accelerated the research and development of routing protocols used in WSNs. In this paper in depth classification is done for the routing protocols in WSNs into data-centric, hierarchical and location based depending on the network structure. Data-centric protocols use the metadata structure to transmit the sensed information to the BS. Regardless, the sensor nodes can also be grouped for efficient data dissemination to the sink. Hierarchical routing protocols adopt the clustering approach by grouping sensor nodes. This approach is highly scalable and thus used in a number of applications. Location based protocols use the information of position of sensor nodes intelligently to route data.

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