Power Management Techniques in Wireless Sensor Networks- A Survey

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***Abstract* - Wireless Sensor Network (WSN) is an ad-hoc network which has received tremendous attention in recent years because of the development of sensor devices, as well as wireless communication technologies. WSNs, are large scale networks of small embedded devices, each with sensing, computation and communication capabilities. Developments in last about two decades, implementation of low power micro-controllers based wireless sensors have been increased rapidly to solve many real life problems like traffic monitoring, patient monitoring, battlefield surveillance. Sensing, computations, communication are routines of wireless sensor networks which consume much power of these low powered sensor nodes. Since nodes have small battery with a limited life, power management is essential to be addressed to make sensors work for a long time. Hence these power hungry sensors are to be addressed by an effective and efficient power management scheme. This paper aims at the introduction of wireless sensor network, power issues associated with them and techniques for power management in WSN.**

***Index Terms* - Wireless, sensor, power, monitoring, micro-controllers.**

I. INTRODUCTION

Wireless Sensor Networks(WSN) consist of a large number of low-cost, low power and intelligent sensors with one or more sinks or base stations. These nodes are small in size and can perform many functions including event sensing, information processing and data communication. Due to various advantages such as ease of deployment, extended transmission range and self organization, WSNs can be employed in wide military applications and civilian scenarios.

In the last two decades, WSNs application and utility have attracted worldwide attention. Increasing demand of these tiny sensor nodes indicates how these can be applied in many areas of real-life problem solving applications [1]. A diverse set of applications for sensor networks encompassing different fields have already emerged including medicine, agriculture, environment, military, inventory monitoring, intrusion detection, motion tracking, machine malfunction, toys and many others[2]. In the medical field, sensor networks can be used to remotely and unobtrusively monitor physiological parameters of patients such as heartbeat or blood pressure, and report to the hospital when some parameters are altered. In agriculture, they can be used to monitor climatic conditions of different zones of a large cultivated area and calculate different water or chemicals needs [2]. Pollution detection systems can also benefit from sensor networks. Sensors can monitor the current levels of polluting substances in a town or a river and identify the source of anomalous situations, if any. Similar detection systems can be employed to monitor rain and water levels and prevent flooding, fire or other natural disasters. Another possible application that was recently experimented is the monitoring of animal species and collection of data concerning their habits, population, or position [2]. Sensors can be deployed to continuously report environmental data for long periods of time. This is a very important improvement with respect to previous operating conditions where humans had to operate in the fields and periodically take manual measurements resulting in fewer data, higher errors, higher costs and non negligible interference with life conditions of the observed species. In structure health monitoring applications, sensor networks are deployed on structures such as bridges, buildings, aircrafts, rockets or other military equipment requiring continuous monitoring to ensure reliability and safety. Sensor networks can be used to detect and locate damages as well as predict remaining life more effectively and economically with respect to traditional monitoring systems. The military can take advantage of sensor network technology too. They can deploy such networks behind enemy lines and observe movements/presence of troops and/or collect geographical information on the deployment area.

Wireless sensor nodes are mainly battery-powered and thus having restricted amount of energy. Even if they are equipped with power harvesting units, energy is a critical point and should be tackled wisely. A WSN should be autonomous and self-sustainable, with the ability to function for several years with a limited battery power supply [3]. A node’s lifetime is defined as the node’s operating time without the need for any external intervention, like battery replacement. A WSN lifetime can be defined as the lifetime of the shortest living node in the network, but, depending on the application, density of the network and possibilities of reconfiguration, it can be defined as the lifetime of some other (main or critical) node. Anyway, in order to prolong a WSN lifetime, it is required to reduce the energy consumption of the nodes as much as possible and form an energy and context-aware system.

A wireless sensor node usually consists of a power unit, sensing unit, communication unit (transceiver) and a processing unit (MCU), as shown in Fig. 1[3]. Each unit contributes to the node’s power consumption. The industry and research are still intensively trying to develop nodes that have power consumption as low as possible and that are appropriate for various types of applications. The first developed nodes that gained the community attention were from the MICA family. Some other popular and commercially available nodes are Imote, Telos, Tmote Sky, Shimmer, WaspMote. A node is built around a low power microcontroller unit, most often around an MSP430 or an ATmega 1281.

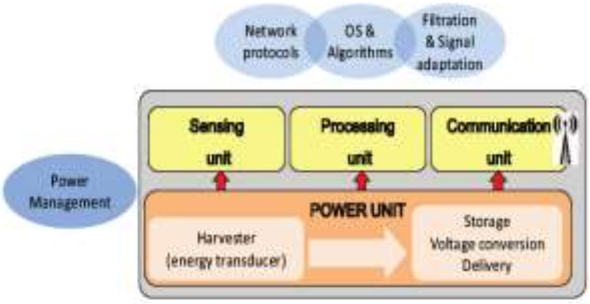

Fig.1. Block-scheme of typical sensor node architecture [3]

Traditionally, the nodes have been monitoring scalar values like temperature, atmospheric pressure, humidity. Those sensors are of very low-power and the major energy consumer of the node is the transceiver. A significant issue of a node's design has been the trade-off between the computation and the communication energy [4]. Most power management (PM) strategies assume that data acquisition consumes significantly less energy than their transmission. In this context, effective PM strategies should include policies for an efficient use of energy-hungry sensors, which become one of the main components affecting the network lifetime [5].

II. Challenges in WSN

The unique features of the WSNs pose challenging requirements to the design of the underlying algorithms and protocols. Several ongoing research projects in academia as well as in industry aim at designing protocols that satisfy these requirements for sensor networks. Some of the important challenges are presented as [6]:

a) *Sensor nodes are limited in energy, computational capacities and memory:* Sensor nodes are small-scale devices with size approaching a cubic millimetre in the near future. The batteries with finite energy supply must be optimally used for both processing and communication tasks. The communication task tends to dominate over the processing task in terms of energy consumption. Thus, in order to make optimal use of energy, the amount of communication task should be minimized as much as possible. In practical real-life applications, the wireless sensor nodes are usually deployed in hostile or unreachable terrains, they cannot be easily retrieved for the purpose of replacing or recharging the batteries, therefore the lifetime of the network is usually limited. There must be some kind of compromise between the communication and processing tasks in order to balance the duration of the WSN lifetime and the energy density of the storage element.

b) *Sensor nodes in the WSN are deployed in an ad-hoc manner and distributed for processing and sensing:* The sensor nodes must be able to configure themselves to form connections to set up the network so as to meet the application requirement. In case of any changes in the operating conditions or environmental stress on the sensor nodes that causes them to fail leading to connectivity changes, this requires reconfiguration of the network and re-computation of routing paths. Another point to take note is that using a WSN, more data can be collected as compared to just one sensor. Deploying a sensor with great line of sight, could also have obstructions. Thus, distributed sensing provides robustness to environmental obstacles. Hence, multi hop communication in WSNs is expected to consume less power than the traditional single hop broadcast communication because the transmission power levels can be kept low. Additionally, multi hop communication can also effectively overcome some of the signal propagation effects experienced in long-distance wireless communication.

c) *Network and communication topology of a WSN changes frequently:* When the sensor nodes are deployed, the position of sensor nodes is not predetermined. This means that the sensor nodes must be able to configure themselves after deployment. They must possess some means to identify their location either globally or with respect to some locally determined position. Once the network is set up, it is required that the WSN should be adaptable to the changing connectivity (for e.g., due to addition of more nodes, failure of nodes, etc.) as well as the changing environmental conditions.

The main goal is to prolong the wireless sensor network life time and preventing connectivity degradation through aggressive power management as the most of the devices have limited battery life .So we should follow power conservation techniques in order to the save the energy by improving the existing protocol or algorithm.

III. Power Management Schemes in WSN

In WSN, the main source of energy is usually battery power. Sensor are often intended to be deployed in areas such as a battlefield or radiation plants; once deployed, it is impossible to recharge or replace batteries of all sensors [7]. But long system life time is needed for any monitoring application. Important challenge to the design of a wireless sensor network is the energy efficiency problem. So energy conservation must be done. Static power saving techniques (e.g., Energy-Aware Protocols) maintains the same characteristics throughout the network lifetime [7]. On the other hand, dynamic techniques adapt to changes in the network, allowing enhanced power saving mechanisms for attaining prolonged network lifetime. To save energy, both approaches apply the partial or total turn off of some or all node units.

Energy aware routing protocol (EAR) [11] is a reactive protocol that aims to increase the lifetime of the network. This protocol seeks to maintain a set of paths instead of maintaining or enforcing one optimal path at higher rates, although the behaviour of this protocol is similar to directed diffusion protocols. These routes are selected and maintained by a probability factor [12]. The value of this probability depends on the lowest level of energy achieved in each path. Because the system has several ways to establish a route, the energy of a path cannot be determined easily. Network survivability is the main metric of this protocol. The protocol assumes that each node is addressable through a class-based addressing scheme which includes the location and the type of nodes. Initially, there is a process of flooding, which is used to discover all the routes between various source/destination pairs and their costs. This will allow the creation of routing tables, where high-cost paths are discarded. By using these tables, data is sent to its destination with a probability that is inversely proportional to the cost of the node. The destination node performs a localized flooding in order to maintain the paths that are still operative. However, having to collect location information, and the establishment of the steering mechanism for nodes, complicates the path settings.

An extra energy saving can be done in the system by using dynamic power management (DPM) [9], which shuts down the sensor node when there is no event. The basic idea is to shut down sensor devices when not needed and wake them up when really necessary so as to perform the sensor network tasks. However, it is not easy to decide which node should sleep and which should be active at any given time, because these decisions strongly depend on the application running on the top of the network. It is not desirable to keep nodes inactive for too long, because it can impact the network Quality-of-Service. Depending on the approach that is used, DPM policies are classified as predictive or stochastic policies [7]. Predictive schemes attempt to predict a device's usage behaviour in the future usually based on the past history of usage patterns and decide to change power states of the device accordingly. A widely used predictive technique consists of turning OFF the system components if the idle time being greater than or equal to a timeout threshold value T. This approach is based on the assumption that, if the idle time is greater than the threshold T, the system is likely to remain idle for a long time to save energy. Prediction based dynamic power management can be categorized into two groups: adaptive and non-adaptive. Non-adaptive strategies set the idleness threshold for the algorithm once and for all and do not alter them based on observed input patterns. On the other hand, adaptive strategies use the history of idle periods to guide their decisions of the algorithm for future idle periods. Stochastic approaches make probabilistic assumptions about usage patterns and exploit the nature of probability distribution to formulate an optimization problem, the solution to which drives the DPM strategy.

The problem of power consumption can be approached from two angles: one is to develop energy-efficient communication protocols (self-organization, medium access and routing protocols).The other is to identify activities in the networks that are both wasteful and unnecessary and mitigate their impact. Most inefficient activities are, however, results of non-optimal configurations in hardware and software components. For example, a considerable amount of energy is wasted by an idle processing or a communication subsystem. A radio that aimlessly senses the media or overhears while neighbouring nodes communicate with each other consumes a significant amount of power. A dynamic power management (DPM) [8] strategy ensures that power is consumed economically. The strategy can have a local or global, or both. A local DPM strategy aims to minimize the power consumption of individual nodes by providing each system with the amount of power that is sufficient to carry out a task at hand. When there is no task to be processed, the DPM strategy forces some of the systems to operate at the most economical power mode or puts them into a sleeping mode. A global DPM strategy attempts to minimize the power consumption of the overall network by defining a network-wide sleeping state. There are different ways to achieve this goal. One way is to let individual nodes define their own sleeping schedules and share these schedules with their neighbours to enable a coordinated sensing and an efficient inter-node communication. This is called synchronous sleeping. The problem with this approach is that neighbours need to synchronize time as well as schedules and the process is energy intensive. Another way is to let individual nodes keep their sleeping schedules to themselves; and a node that initiates a communication should send a preamble until it receives an acknowledgment from its receiving partner. This approach is known as asynchronous sleeping schedule and avoids the needs to synchronize schedules. But it can have a latency side-effect on data transmission. Once the design time parameters are fixed, a dynamic power management (DPM) strategy attempts to minimize the power consumption of the system by dynamically defining the most economical operation conditions. This condition takes the requirements of the application, the topology of the network, and the task arrival rate of the different subsystems into account.

Reduction of the power dissipation in the various operations can be accomplished from two different scopes: device-level, and network-level [10]:

Device-Level Approaches

This section presents approaches for reducing the power consumed in MNs excluding networking operations. It comprises hardware component selection and their configuration to achieve minimum energy consumption. Based on this concept, many techniques have been proposed.

Scaling: Peak accuracy is not always required. Therefore, the processors operating voltage and frequency can be dynamically adapted based on instantaneous computational load requirements. As a result, significant processing power can be saved through this method, called dynamic voltage scaling (DVS) [13]. Additionally, dynamic modulation scaling (DMS) [14] can be used to optimize broadcasting energy with respect to the number of packets that need to be transmitted at that particular time intervals.

Data Compression: Radio power consumption strongly depends on the packet size. Therefore, removing redundancy existing in the data is essential to find a more compact representation. Compression (sometimes called encoding) may be lossy or lossless according to the compression algorithm. There are different algorithms for data compression in WSNs such as wavelet transform and low-complexity video compression [15].

Software Sensors: Sensors may dissipate a huge amount of energy depending on the application. Therefore, implementing sensors using software algorithms may be an effective technique for reducing the overall power consumption. For instance, a GPS sensor is very expensive in terms of energy. Thus, determining the location relative to other nodes may save a considerable amount of energy.

Energy-efficient Cognitive Subsystem: Cognition can be defined as the process of learning through perception, reasoning, knowledge and intuition [16]. In the WSN context, the protocol stack of WSNs was modified by adding a Knowledge Plan (KP) [17] to build a network that has the ability to adapt itself to changes. For instance, KP can learn the radio component's characteristics. Based on this information, the radio parameters and component characteristics can be adapted to minimize the radio power consumption. Obviously, the same approach can be applied to other subsystems in measurement nodes (MNs). On the other hand, data acquisition controls the sensing power especially in cases of "energy-hungry" sensors such as gas and GPS sensors. For instance, adaptive sampling techniques reduce the number of samples by exploiting spatiotemporal correlations between sensed data [18].

Memory Leakage Control: The leakage current can be optimized to save energy [19]. Different approaches were proposed such as 1) ones which make their leakage management decisions based on performance feedback, 2) techniques that manage cache leakage in an application-intensive manner (e.g. by periodically turning off cache lines), and 3) techniques that utilize feedback from the program behaviour.

Software Optimization: Micro-operating systems (µOSs) in WSNs are classified into event-driven µOS and multi-threaded µOS. The former is efficient in terms of resource utilization, whereas the latter one have superior event processing capabilities [20]. Recent µOSs, such as Contiki and SOS, comprise generic abstractions to manage the power consumed by peripherals of the sensor devices. Generally, µOSs can accomplish significant energy reduction by performing energy-aware task scheduling and resource management. On the other hand, compilers have been studied to generate efficient code in terms of power consumption. For instance, spill code reduction techniques managed to save energy and improve the overall system performance. Power-aware instruction scheduling is also a known technique for decreasing energy consumption.

Network-Level Approaches

In this section, a collection of power saving techniques which involve optimization of communication techniques and networking protocols is presented.

Mobility: The techniques are based on employing mobile sinks or mobile relay nodes in order to reduce the number of multi-hops and thereby minimizing the transmission cost [21]. These mobile nodes are often attached to mobile entities in the environment such as vehicles, animals, or dedicated robots.

Data-driven: In this approach, distributed processing is made throughout the entire network in order to prolong the WSN lifetime. For instance, compressive sensing (CS) is a distributed compression technique in which the data is processed to remove redundancy by exploiting spatial correlation. CS depends on reconstructing the sparse WSN's data from a small number of random-linear readings [22]. Coding by ordering and pipelined in-network are other distributed compression techniques which can be applied in the context of WSNs [15]. Data predictions are another technique in which identical predictors, implemented in the source and sink nodes, are utilized in order to minimize the number of transmitted packets [23]. Many prediction algorithms are utilized in WSNs including time series forecasting, stochastic and algorithmic approaches.

Duty Cycling: Transceivers consume majority of the available energy. Therefore, switching the transceiver into sleep mode helps to greatly prolong the network lifetime. Selecting which node (or set of nodes) must go to sleep can be based either on aggregation techniques, redundancy control, or on MAC protocols. In the first approach, data is aggregated either through event-driven, periodic sampling, or store and forward strategies. The second approach exploits network redundancy to extend the network longevity by switching a number of redundant MNs into sleep mode. In the meantime, active MNs can also be switched into sleep mode according to the workload to further save energy. Choosing the active MNs can be accomplished in two ways: a location-based approach or a connectivity-based approach. In the former procedure, the sensing field is divided into cells. In each cell, only one MN is activated while the others are switched to sleep mode [24].Consequently, power consumption and collisions are reduced. The latter procedure determines the minimum number of nodes that still guarantee network connectivity. Redundant MNs are deactivated [25].

MAC protocols are responsible for the coordination between neighbours. Optimizing MAC protocols leads to significant reduction in power consumption. For instance, time division multiple access (TDMA) is a well-known MAC protocol. Data collision is avoided by dividing the time frame into slots. As shown in Fig.2, time frames are divided into slots where each node is assigned two fixed time slots for transmitting and receiving packets. As a result, MNs are active during their assigned slots and inactive during other slots. Advantages of the TDMA protocol comprise eliminating data collision and conserving significant amount of energy. However, this technique requires a precise synchronization among the various nodes which may be difficult in many situations [26]. On the other hand, contention-based MAC protocols allow nodes to independently access the shared wireless medium [27]. These protocols propose minimizing collisions rather than avoiding them completely. Contention-based protocols depend on a carrier sensing mechanism called carrier sense multiple access (CSMA). In this mechanism, transceivers are switched on only for listening to the traffic before broadcasting in order to check the availability of free channels.

Energy-efficient Networking: Routing is the process of delivering information to the destination through a hope-fully – short path. Many optimization techniques have been proposed to improve the performance of this task in terms of energy consumption [28]. A classification of routing protocols for WSNs focuses on the following categories [30]:

- *Multipath-based protocols:* Here, MNs determine the k-shortest paths to the sink node. Thereafter, MNs divide their load evenly among these paths. Sensor-disjoint multipath and braided multipath protocols are based on this concept.
- *Data-centric protocols:* In this category, MNs send their information to the sink node via neighbouring nodes. These intermediate nodes aggregate the readings and perform different processing in order to reduce the traffic. Examples of this approach include sensor protocols for information via negotiation (SPIN) and energy-aware data-centric routing (EAD).
- *Heterogeneity-based protocols:* The core idea of this category is to utilize special nodes with unlimited energy sources for assisting the battery-powered sensors in aggregating information. Examples of protocols include information-driven sensor query (IDSQ) and cluster-head relay routing (CHR).
- *QoS-based protocols:* Here, many paths are formed between the sink and the sensor nodes. Then, one path is selected which optimizes the energy consumption and other Qos parameters such as availability, reliability or latency. Examples are sequential assignment routing (SAR) and energy-aware QoS routing.
- *Hierarchical clustering:* These protocols are suitable in case of continuous transmission due to the presence of redundant data. Specifically, this approach is based on splitting the network into groups called clusters [29]. In each cluster, one node is elected as a cluster head which aggregates the packets from its cluster members. Optimizing the collected information might be accomplished by the cluster head in order to decrease energy and traffic. Examples of hierarchical clustering include low-energy adaptive clustering hierarchy (LEACH), power-efficient gathering in sensor information systems (PEGASIS), and adaptive periodic threshold sensitive energy efficient sensor network protocol (APTEEN).

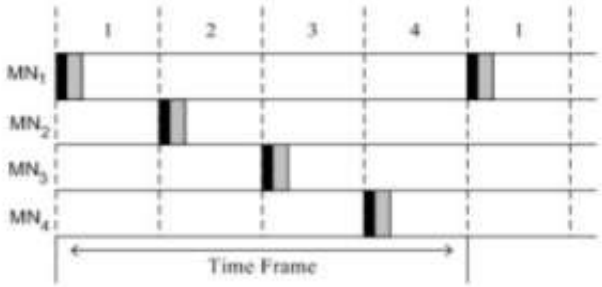

Fig.2. Allocation of time frames to MNs in TDMA [10]

Low Energy Adaptive Clustering Hierarchy (LEACH) [31], a hierarchical routing protocol is a TDMA-based MAC protocol which is integrated with clustering and a simple routing protocol in WSN. The goal of LEACH is to lower the energy consumption required to create and maintain clusters in order to improve the lifetime of a WSN. In LEACH protocol, BS is fixed and located far away from sensors and all sensor nodes are same in nature. LEACH randomly select cluster head for energy balancing purpose. So, all sensors consume same battery power. BS is a high energy node and leaf node is low energy node. In this, most nodes transmit to cluster heads and CHs aggregate and compress the data and forward it to the base station. LEACH performs in rounds, it has two phases: Setup Phase, Steady phase. In setup phase, clusters are created and CH is selected randomly for each cluster, whereas in steady phase leaf node sends data to CH within certain time period using TDMA.

TEEN (Threshold sensitive Energy Efficient sensor Network)[32] is a cluster based routing protocol which is based on LEACH. This protocol transfers the data less frequently and senses the medium continuously. The network consists of simple nodes, first-level cluster heads and second-level cluster heads. LEACH strategy is used in this protocol for cluster formation. First level CHs are formed away from the BS and second level CHS are formed near the BS. It is targeted at reactive networks and is the first protocol developed for reactive networks. The main drawback of this scheme is that, if the thresholds are not reached, the nodes will never communicate and the user will not get any data from the network at all and will not come to know even if all the nodes die. Thus, this protocol is not well suited for applications where the user needs to get data on a regular basis.

APTEEN (Adaptive Threshold TEEN) [31, 32] is the improved version of the TEEN which enables reliable monitoring and analysis of the environment. In this once the CHs are decided, in each cluster period, the CH first broadcasts the following parameters: attributes, thresholds, schedule and count time. If a node does not send data for a time period equal to the count time, it is forced to sense and retransmit the data thus maintaining energy consumption. Since it is a hybrid protocol, it can emulate a proactive network or a reactive network depending on the count time and threshold value. One of the limitations of this protocol is that in order to implement the threshold function and count time additional complexity is required.

In PEGASIS (Power efficient Gathering Sensor Information System) [33], each node communicates only with a close neighbour and takes turns transmitting to the base station, thus reducing the amount of energy spent per round. This approach will distribute the energy load evenly among the sensor nodes in the network. Nodes will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes. For gathering data in each round, each node receives data from one neighbour, fuses with its own data, and transmits to the other neighbour on the chain. PEGASIS performs data fusion at every node except the end nodes in the chain. Each node will use its neighbour's data with its own to generate a single packet of the same length and then transmit that to its other neighbour (if it has two neighbours). Thus, in PEGASIS each node will receive and transmit one packet in each round and be the leader once every 100 rounds.

Recently there arise some atypical hierarchical routings, which are variants of cluster-base routing and present special hierarchical architecture, including chain-based, tree-based, grid-based, and area-based routing[34] as shown in Fig.3.These types of hierarchical routing are similar to the traditional cluster based routing, but are different in hierarchy division and communication.

i) Chain Based Routing

In chain-based topology, one or more chains are constructed to connect the deployed sensor nodes for data transmission [34]. In a chain, a leader is selected to perform the task of data collection, like a sink. Data is delivered along the chain, and ultimately to the leader node. Data aggregation is performed during the process of transmission. For chain-based routing, it has a simple topology compared with traditional cluster-based routing, because such a topology is easy to implement and maintain. In chain-based routing, a node only sends data to its next node, which is very close to it. So, a part of energy is saved by local communication compared to intra-cluster communication in cluster-based topology .The whole network is organized to one or multiple chains in chain-based topology, and generally a chain is very long with large number of hops from one end to the other in the chain. Thus, data transmission needs large delay with large number of hops.

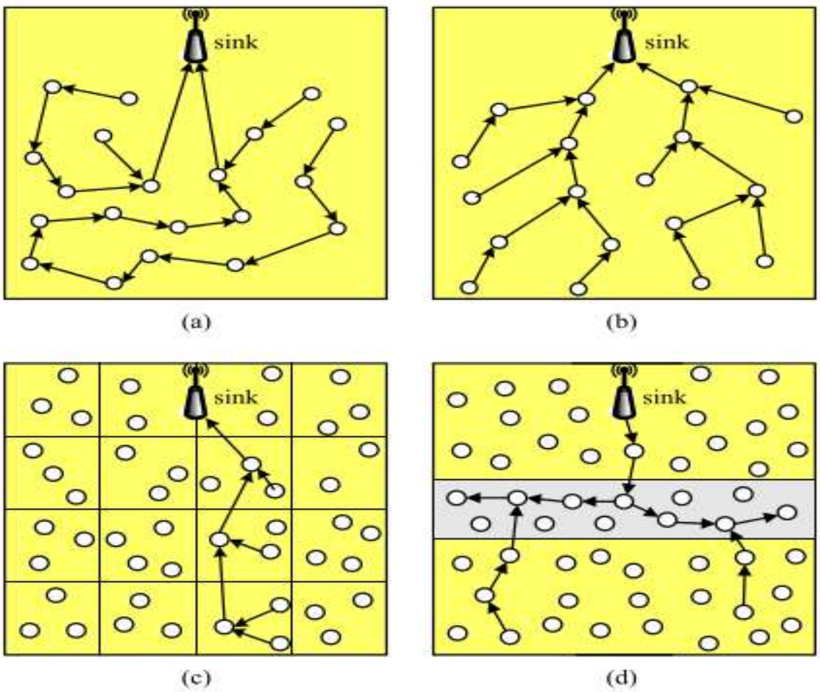

Fig.3.(a) Chain-based topology, (b) Tree-based topology, (c) Grid-based topology, (d) Area-based topology [34].

ii) Tree Based Routing

In tree based routing, a logical tree is constructed by all sensor nodes [34]. Data is delivered from leaf nodes to their parent ones. In turn, the parent nodes send the received data to their parent nodes towards to root nodes. Data aggregation is possibly performed in each node. Tree-topology is simpler than cluster-based routing which includes a relatively complex process of cluster formation. Energy consumption is decreased compared to flat routing in WSNs, because flooding is not necessary for data transmission. Data transmission is performed between neighbor nodes and therefore can save much energy consumption.

iii) Grid Based Routing

In a grid based topology, the network is divided into various grids by geography approach. Thus, grid-based routing generally belongs to location-aware routing. The distinct characteristic of this type of routing is that the routing operation is performed without any routing table. Once the position of the destination is achieved by the source, all routing operations are locally performed. In grid-based networks, grids are regularly constructed by geographic locations and CH competition and ON selection can be left out. So the hierarchical structure is simple compared with cluster-based routing. It can provide efficient data delivery in WSNs, since each node only maintains a simple forwarder candidate to transmit data [34].

iv) Area Based Routing

Area-based topology is an up-to-date structure, in which some sensor nodes are designated in a specific area and act as high-tier nodes [34]. Generally, such nodes perform the task of data collection from ordinary nodes (ONs) and data transmission to the sink. The size of the area can be adjusted according to the load balancing requirements. Such topology is always used in mobile WSNs. Only a specific area must be determined and it is easy to determine which nodes act as high-tier tasks. Therefore, the structure of area-topology is also simpler than that of cluster-based routing which includes a relatively complex process of cluster establishment. Energy consumption is decreased compared with other clustering routing schemes in WSNs, because data exchange is performed in local regions. This can avoid long-distance communication and decrease large energy dissipation.

This overview presents various PM techniques that comprise reduction in both communication and sensing energy in WSNs. Traditionally, communication energy has been a major part of a node's energy consumption. But, with the necessity of implementing high-consuming sensors in WSNs, sensing unit has to be driven carefully. Real-life implementations of these WSNs require autonomy of several years, with battery power supply. Thus, energy resources should be managed judiciously — with reduction in energy consumption on the sensor level, node level and network level.

IV. CONCLUSIONS

A sensor network consists of one or more sensors, processing circuits, memory, and a wireless transceiver. The main goal of WSN is to prolong the life of the network and preventing connectivity degradation through aggressive energy management as most of these sensor network devices have limited battery life and it is impossible to replace batteries of up to tens of thousands of sensors in most of the applications. So we should follow power conservation technique in order to save the energy. In this paper, power management techniques at various levels are approached.

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