# A Survey on Energy and Lifetime in Wireless Sensor Networks

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**Abstract:**

Over the past several years, wireless sensor network has attracted many researchers as well as general users; because of its various applications such as commercial and military applications. The sensor nodes are basic unit of a sensor network that is energized by low powered devices. In un-tethered wireless sensor nodes the power supply is a crucial system component. The energy supplying is made in two aspects, first store the energy and distribute it as per the requirement, else refill the consumed energy by scavenging from external power source like solar energy, Temperature gradients, Vibrations, Pressure variations, flow of air and liquid. If some nodes deplete their energy quickly, that node will not sense and that region is called blank region. This could be avoided by reducing the energy consumption of each sensor node to improve the lifetime of the wireless sensor networks. Therefore, the usage of energy of each sensor nodes must be optimized to maximize the network life. This survey paper is concentrated on the energy consumption for typical sensor node component and then discussed the directions to conserve energy in wireless sensor networks. This paper also gives the classifications of the energy conservation schemes, which are later discussed in detail. Special focus is given over the areas in the literature such as data aggregation along with load balancing techniques. Finally, the paper is concluded with insights for researchers about energy conservation in wireless sensor networks.

**Keywords:** Wireless sensor networks, Medium access control, Power aware protocols, Clustering, Scheduling, Quality of Service

## Introduction

Wireless sensor networks have recently developed in to prominence because; they hold the potential to revolutionize many segments of our economy and life from environmental monitoring to automation Industries. Mostly wireless sensor network is deployed over a hostile area, where human being could not be reached easily or frequently.A wireless sensor network consists of sensor nodes deployed over a geographical area for monitoring physical phenomena. Basically, a sensor is a transducer that converts a physical phenomenon such as heat, light, sound or motion in to electrical or other signals that may be further manipulated by other apparatus.

A sensor network consists of a sensor node which is a basic unit in a wireless sensor network with on board sensors, processors, memory, wireless modem and power supply unit.

Wireless sensor network is a combination of electronics and networking. The advantages of networked sensing are improved robustness and scalability. Even though WSN has a wide range of applications there are some traits that appear with respect to the characteristics and the required mechanisms of such systems stated by Akyildizet al., (2002). The authors explained various applications elaborately. They also listed the factors that are influencing sensor network design such as Environment, Fault tolerance, scalability, Node deployment, connectivity, coverage, data aggregation, quality of service, hardware constraints and energy. They also provide observations about the different approaches to energy management and highlight that the energy consumption of the radio is much higher than the energy consumption due to data processing. They concluded that the data processing phase may need a long time compared to the time required for communication, so that the energy consumption of sensor node can be very high as well. There are some challenges also existing in designing sensor network systems and applications, which is represented in the Table I.

In this paper, we try to investigate the usage of a senor node results in energy gain. We analyze the amount of energy utilization in all types of deployed sensor nodes. Motivated by the earlier research of wireless sensor network, the objective of this paper is to review some standard concepts regarding minimizing the energy consumption of network. In the scenario, we could analyze the network in all aspects such as routing, clustering, MAC protocols and its role, Scheduling and some query Processing. Thus, this survey paper gives various techniques to improve energy and lifetime of the network.

With these above mentioned challenges each sensor has to sense, transmit, receive and process. Each phase consumes certain amount of power which leads to depletion of energy of battery. Due to this energy depletion in battery, the life time of the network decreases. A statement made by Raghunathan et al., (2002)is that the network lifetime can be maximized only by incorporating energy awareness in to every stage of WSN design and operation, thus empowering the system with ability to make dynamic tradeoff between only consumption, system performance and operational fidelity. The lifetime of the wireless sensor network is determined by which the time taken by the first node to die. Therefore, the usage of resource must be optimized for each stages such as active, sleep and idle state in order to increase the lifetime of the network.

TABLE I. GENERAL CHALLENGING ISSUES

| Issues | Description |
|---|---|
| Environment | Mostly sensor nodes are deployed in harsh environments and they are usually unattended and remote geographic areas, thus environment is another constraint. |
| Fault Tolerance | It is the ability to sustain sensor network functionalities without any interruption due to sensor node failure. |
| Scalability | In a WSN, the sensor nodes used in the range of hundreds to thousands. Therefore, the network system must be efficient even if the number of nodes increased to monitor. |
| Node deployment | Depend on the applications the nodes are distributed either manually or randomly. This way of distribution either directly or indirectly affects the performance of the network. |
| Connectivity | The wireless sensor network nodes are deployed in region to be monitored either manually or in a random manner. All the nodes should be interconnected for better connectivity. The connectivity get failed in case of node failure. |
| Coverage | The coverage of network is determined by the radio range of transmitter and receiver of a node. |
| Data aggregation | Based on the application the raw data is collected from various sensing devices. These raw data are aggregated based on the aggregating function. This data aggregation avoids duplication of data packets which also leads to loss of energy and latency in network communications. |
| Quality of Service | This parameter is a most crucial part of any application. But sometimes power consumption is more critical than latency. Hence, routing protocols must consider the QoS parameter. |
| Hardware constraints | Sensor node consists of sensing using, processing unit, transceiver unit and a power unit. All these should be fit into a match box sized module and it is light enough to be suspended in |

| | |
|---|---|
| | the air. This module is autonomous and operates unattended and should be adaptive to the environment. |
| Energy | Most of the wireless sensor networks are battery powered and hence have power limitations. |
| Transmission media | In the sensor network all the sensor nodes are communicated by a wireless medium. These links are formed by radio, IR or optical media. This wireless link suffered by many problems like loss of data, environmental factors like rain etc. |

The rest of this paper is organized as follows: in section 2, the basic performance metrics are analyzed with respect to its operation. In section 3, the conventional MAC based models are analyzed with different classification. The clustering based models are reviewed in section 4. In section 5, the scheduling based concepts are discussed with its pros and cons. Based on improving energy and lifetime of WSN with the help of load balancing is illustrated in section 6. Next energy harvesting based approaches are discussed in section 7. In section 8, the review depends on query processing and data processing. In section 9, the routing protocol based research were focused. Finally the summary is made in section 10.

**Performance metrics**

A large majority of the algorithms were developed for WSNs and many surveys were presented about this problem to find the exact solution effectively. In networking, multiple layers were presented in the protocol stack. In that successful routing depends upon reliable data transfer across the layers, these layers are connected wirelessly and involve a shared medium. The medium access control layer is a sub layer of data link layer and manages access to the physical network layer. The fundamental task of any MAC protocol is to regulate the access of nodes to a shared medium in such a way that certain application dependent performance requirementsare satisfied. Some basic performance metrics are delay, throughput and fairness.

Within the OSI(Open System Interconnection) reference model the MAC is considered as a part of the Data Link Layer (DLL). The transceiver of a node is in any one of four states such as transmitting, receiving, idling or sleeping. In all the four stages, the transmitting and receiving is in same order in terms of costs, idling is somewhatcheaper and sleeping costs nothing.The energy components presented in the single node depending on the operations are explained below:

**Sensing energy:**

There is a need to activate the sensing circuit to retrieve the data from environment. While doing this an amount of energy must be dissipated with respect to the sensors and its level of energy during operation.

**Transmitter energy**:

In any network, there must be a transmitter to send the data towards the destination. Hence, for operating transmitter region some energy ($E_t$) is consumed based on power ($P_t$), size of the data packet and data transfer rate.

**Receiver energy**:

Normally, a sensor node is a relay node that may take care of both transmitting and receiving the data. For this operation, the receiver energy ($E_r$) is required which is irrelevant of the distance between nodes. While receiving the data packet with the given data transfer rate the power ($P_r$) will be spent.

**Computation energy**:

During the operations the sensor's processing unit must be activated. It must be realized with additional computations. When comparing the computation energy ($E_c$) with previous items, the energy is relatively low.

In each sensor nodes life cycle, the event or query will be followed by sensing operation thatderives a data packet and transmit it to the destination. The problems encountered related to energy and lifetime of WSN are collisions, overhearing, protocol overhead and idle listening depends on node's transceiver.

a) **Collisions**:

Collisions incur useless receive costs and transmits costs at both the source node and destination node. Collisions should be avoided either by design of fixed assignment/TDMA or demand assignment protocols or by appropriate collisions avoidance/hidden terminal procedures in CSMA protocols.

b) **Over hearing**:

Since, wireless medium is a broad cast medium all the source's neighbor that are in receive state, receives a packet and drop it when it is not designated to them. Sometimes, Overhearing also needed when collecting neighborhood information or estimating the current traffic load for management purpose.

c) **Protocol Overhead**:

Protocol overhead is induced by MAC related control frames like RTS, CTS or request packets in demand assignment protocols and further by per packet overhead like headers and trailers.

d) **Idle listening**:

A node is being in idle state and it is ready to receive any packet. This readiness is costly and useless in case of low network loads.

The overall network performance metrics is to be evaluated. Hence, the following metrics are used discussed as follows:

### A. *Packet Delivery Ratio*

Packet delivery computes the success of transport when loss of packet is taken into account and the network efficiency is determined by packet delivery ratio, it is defined as ratio between packets arrived and number of packet sent with a multiplication speed. The Packet Delivery Ratio (PDR) is totally based on the received and generated packets as recorded in the trace file. It is also defined as the ratio between received packets by the destination and the generated packets by the source.

$$Packet\ Delivery\ Ratio\ =\ (Number\ of\ packet\ received\ /\ Sent)\ *\ speed$$

### B. *End to end Delay*

The end-to-end delay or One-Way Delay (OWD) refers to the time taken for a packet to be transmitted across a network from source to destination. It is a common term in IP network monitoring, and differs from Round-Trip Time (RTT). It also includes all delays caused by buffering during routing discovery latency, queuing at the interface queue, and retransmission delays at the MAC, propagation and transfer times of data packets.

$$End\ to\ End\ Delay\ =\ End\ Time - Start\ Time$$

The average end to end delay is defined as

$$Average\ end\ to\ end\ delay = \frac{\sum e}{P}$$

Where, $e=T_d-T_s$,

$T_d$=Time when packet received at destination

$T_s$=time when packet created by source,

P=Total packets.

### C. Misbehaviour Ratio

Misbehavior ratio is defined as the quantity of routing control packets that are affected by wormhole attacks.

### D. Communication Overhead

Overhead is integration of additional or indirect computation memory, time, bandwidth and any other resources that are needed for achieving the specific aim. Communication overhead is defined as the total amount of packets which are to be broadcasted from one sensor node to another sensor node. This involves overhead of routing table, process of routing and arrangement of packets in sensor nodes. The network overload is defined as it is the ratio between numbers of packet losses to the number of packets received.

$$Network\ overhead\ = (Number\ of\ Packet\ Losses/Received) * 100$$

### E. Throughput

The average throughput is defined as the rate of successfully transmitted data packets in a unit time in the network during the simulation. Throughput is the ratio of number of packets sent and total number of packets. It is the rate of message successfully delivered through the communication channel. It is interference limited as a node transfers then its adjacent nodes are affected by interference. If the range of transmission is small, then the packet required to be broadcast in multiple hops that results in higher delay. Generally throughput can be measured in bps (bits per second) or in pps (data packets per second).

### F. Connectivity Ratio

The connectivity ratio is defined as ratio between weak connections to that of overall connection.

$$Connectivity\ ratio\ = weak\ connection\ /\ overall\ connection$$

### G. Energy Consumption

The energy consumption is defined as difference between initial energy and final energy. The energy factor is the major performance metrics used to improve the performance.

$$Energy\ Consumption\ = Initial\ Energy - Final\ Energy$$

### H. Packet loss

The packet loss is defined as ratio between number of packets dropped and the number of packets sent. It occurs if one or more packets of data travelling across a network fail to reach their destination. This loss typically caused by network congestion.

$$Packet\ loss = \left(number\ of\ packet\ \frac{dropped}{Sent}\right) * 100$$

It is also stated as a percentage of packets lost with respect to packets sent

## II. Traditional Methods Based on MAC Classification

In this section several MAC based models are discussed. Sensor MAC (S-MAC) is a protocol which is similar to Distributed Coordination Function (DCF) and Power Aware Multi-Access protocol with Signaling for Ad Hoc networks (PAMAS), in which the nodes sleep periodically and avoids over hearing. Scheduled based MAC protocols are divided into Node Activation Multiple Access (NAMA), Traffic adaptive medium access protocol (TRAMA) and Pair wise Activation Multiple Access (PAMA) which minimizes energy consumption by giving particular time slot to the nodes. For bandwidth allocation the control mechanisms is made by Carrier Sense Multiple Access (CSMA).

### A. *Sensor MAC*

Generally, Sensor-MAC protocol provides the synchronization management and allocates the periodic sleep schedule. In real time application like environmental monitoring, the nodes are deployed in an ad hoc fashion, when comparing the traditional methods MAC has a merit to maintain the nodes in inactive region for long periods of time and it is activated in case of any detection. Hence, this process helps the MAC to use in many applications instead of IEEE 802.11. Due to this advantage, Ye et al., (2002) made a Medium-Access Control (MAC) protocol named as Sensor MAC (S-MAC) to reduce the energy consumption and support self-configuration. The problem identified by them is collision, overhearing and control packet overhead. They made an objective to process these issues with minimum energy consumption under collision avoidance capability. It is done with the combination of scheduling and contention scheme. Finally, they proved that S-MAC has 2 to 6 times reduction in energy when comparing with 802.11 MAC protocols. It is evaluated over the Mote, developed at University of California, Berkeley. Khatarkar and kamble (2013) stated the SMAC merits and demerits. The main advantage is the battery utilization is increased while implementing sleep schedules. With the help of message passing technique this protocol is simple to implement the long messages. The limitations of this method are that there is a collision while broadcasting. The limitations of S-MAC are results in energy consumption because of idle listening and overhearing.

### B. *Distributed Coordination Function*

One of the basic models of MAC technique is 802.11 which are termed as Distributed Coordination Function (DCF). It is under the scheme of Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) scheme. Bianchi (2000) made an analytical model to compute the 802.11 throughput in simple manner. They made this method to apply in basic access and Request To Send/ Clear To Send (RTS/CTS) mechanisms. They presented an analytic model under a saturated traffic assumption, it is accurate, but typical network conditions are non-saturated and heterogeneous. Hence, Malone et al., (2007) made an extension of same model to a non-saturated environment. It is specifically focused based on the predictions, validation and capture some interesting features of non-saturated operation. The best example is that the model predicts that peak throughput prior to the saturation. It has an advantage to encompass a wide range of methods particularly, Voice over Internet Protocols. Similarly, Alizadeh and Subramaniam (2003) made an analytical model with the help of the Frequency Hopping Spread Spectrum (FHSS) system parameters of 802.11 DCF. In recent emerging multimedia application the network integration is needed to provide support for quality of service. Hence, Singh et al., (2015) made a performance analysis based on IEEE 802.11n WLAN, it is randomly varies the RTS threshold using OPNET Modeler 17.5 academic. They made this variation to observe the WLAN behavior in terms of QoS.

### C. *Power Aware Multi-Access protocol with Signalling for Ad Hoc networks*

Raghavendra and Singh (2000) coined out the multi-access protocol for ad hoc radio networks. It consists of original Multiple Access with Collision Avoidance (MACA) protocol with the separate signalling channel. Its main advantage is that it saves battery power at nodes by intelligently powering off the nodes that are not in active, this process may not create any delay or throughput. Hence, they illustrated the power conserving behavior of PAMAS via extensive simulations over ad hoc networks containing 10-20 nodes.

### D. Node Activation Multiple Access

Bao and Garcia (2001) made a new approach namely Node Activation Multiple Access (NAMA). It is scheduled based on the protocol that identifies the nodes within two hop neighbour node and accesses the channel at a particular time slot. They have been made three types of collision-free channel access protocols by deriving from a novel approach to contention resolution that allows each node to elect deterministically in a given time slot. Hence, it is capable of obtaining maximum utilization of the channel bandwidth. Boukerche (2005) made a handbook for wireless sensor node, it describes that the NAMA elects the nodes for collision free broadcast transmissions over a single channel with the help of Neighbor-aware contention resolution based algorithm (NCR). Generally, channel in NAMA is time-slotted, transmissions are broadcasts through theomni-directional antenna and all one-hop neighbors can receive the packet from a node.Bao and Garcia (2002) combined the Node and Link layer to perform the Hybrid Activation Multiple Access (HAMA). In some traditional methods the activation is based only on the nodes or links. But in HAMA, the link activations are made in time to code activation channel. It requires identifiers for the neighbors within two hops from each node to schedule channel access. The main advantage is that the neighbor protocol supplements HAMA with up-to-date two-hop neighbourhood information by reliably propagating the one-hop neighbor updates through a novel random access technique. It achieves higher throughput the ideal CSMA and CSMA/CA protocols.

### E. Traffic adaptive medium access protocol

Rajendran et al., (2006) made a TRAMA that establish a transmission schedule with Neighbor Protocol (NP) and Schedule Exchange protocol (SEP). It is a self-adaptive with respect to the changes in traffic, node state or connectivity. The merit is it prolongs the battery life of each node and robust to wireless network. It is mainly used to maintain the scheduling slot information and maintains the network in low power mode; it is achieved by the Adaptive Election Algorithm (AEA) that uses the neighbor node information to select transmitter and receiver within a particular time slot. Hence, it avoids the wasting of time slots maintains the node in standby mode. This method is suitable for various applications which are not delay sensitive and guarantees higher throughput and energy efficiency. Finally, they summarized that the TRAMA outperforms CSMA, 802.11/S-MAC and also static NAMA with significant energy savings.

### F. Pair wise Activation Multiple Access

Bao and Garcia (2001) again coined out the pair wise activation based on MAC. Pairwise link Activation and Node Activation Multiple Access (PANAMA) is one of the distributed MAC protocols. It consist of two channel access scheduling algorithms namely Node Activation Multiple Access for Unidirectional Networks(NAMA-UN), which is suitable for broadcasting in wireless networks with unidirectional links. The second scheduling algorithm is Pair-wise link Activation Multiple Access for Unidirectional Networks (PAMA-UN), which is a link-activation oriented channel access control algorithm suitable for unicasting in wireless networks with unidirectional links.

TABLE II. CHARACTERISTICS OF EACH PROTOCOL

| Protocol | Characteristics |
|---|---|
| PAMAS | Access channel without collision and overhearing |
| DCF | Avoids collision by hand shaking using CSMA |

| | |
|---|---|
| NAMA | Identifies nodes within two hop neighbor node and access the channel. |
| TRAMA | It has NP, SEP and AEA in order to maintain the scheduling information and avoids wasting of time slot. |
| PAMA, LAMA, HAMA | Operates over multiple channels that are orthogonal by codes or frequencies to elect their links or nodes for collision free uni-cast transmission or mix of broadcast and uni-cast transmission |
| S MAC | Unlike PAMAS, S MAC used in channel signaling and message passing tocollision. |

Ahmed et al., (2016) compared a performance evaluation between IEEE 802.11 and IEEE 802.15 Zigbee Medium Access Control (MAC) protocol. They have analyzed the mobility of Reference Point Group Mobility Model (RPGM), Random Way Point Mobility Model, Freeway Mobility Model and City Section Mobility Model. For simulation, Network Simulator (NS-2) is used, the simulation made with a specification of 25 mobile nodes and 10sec to 80 sec with total simulation time of 100 sec. They have made various performance metrics like throughput, end to end delay, and packet delivery ratio and data loss.

Khanafer et al., (2014) made a survey about beacon-enabled IEEE 802.15.4 MAC protocols, to improve a diverse field of applications. They have described some solutions to resolve the coexistence problems and highlighted their strengths and weaknesses. The book representing the performance analysis of the IEEE 802.15.4 MAC layer with its applications are mentioned by Palattella et al., (2014).

**CLUSTERING**

Normally in multi-hop networks, there is a need of collecting and estimating the information from central location. As per the Pottie and Kaiser (2000) statement, the cost of the transmitting bit is higher than the computation. Hence, it is necessary to organize the sensors into clusters. While implementing this process, the data processing unit is considered here to communicate the data through Cluster Heads (CHs). Hence, it may be advantageous to organize the sensors into clusters. The data processing unitmay be any one of the sensors itself. By utilizing this clustering process, the communication will be in smaller area, it means the sensors are now exchanging the data over smaller distances in the clustered environment. Finally, it results in the minimum energy because all nodes may communicate directly through the information processing center. This section reviews some clustering concepts applied in recent wireless applications.

Naruephiphat and Charnsripinyo (2009) proposed a Limiting member node Clustering (LmC) algorithm. It is functioning based on the threshold value the number of member nodes for each cluster head may get limited. Their clustering approach selects a cluster head based on a new cost function, it consider distance to the base station, residual battery level and the energy consumption. The transmission range ofthe base station is considered by them to improve the clustering performance. They proved packet delivery and lifetime is improved when comparing it with four different cluster head selection algorithms, namely, Minimum distance Clustering (MdC), Maximum battery Clustering (MbC) and Minimum cost function Clustering (McC).

Krishnan and Kumar (2016) identified the problem in static link. In multi hop network, the data is transferred from each node to base station with the help of static link, while collecting the information from each node the data packets may flood over a network. Hence, the energy utilization is inefficient. So, they have been made an effective clustering approach with data aggregation using multiple mobile sinks for heterogeneous networks.

Recent days the evolutionary algorithms are mostly used to solve the complex problems in network. Kuila and Jana (2014) analyzed the Linear/Nonlinear Programming (LP/NLP) formulations problems. Their contribution is in both clustering and routing. Specifically, they identified some problems in a popular cluster-based routing algorithm (LEACH). It has some merits as load balancing made by dynamically rotating the work load of the Cluster Heads (CHs) amongst the sensor nodes. Since, the demerit is that a node with very low energy may results in node failure. To avoid such issues, the efficient particle encoding scheme is used for routing with multi objective fitness function. Secondly, the clustering algorithm is presented by considering energy conservation of the nodes through load balancing.

Next clustering algorithm is based on Distributed Self-Organization for Wireless Sensor Networks (DSBCA) made by Liao et al., (2013). It is totally based on non-uniform distribution by considering optimal configuration of clusters. They compared Weighted Clustering Algorithm (WCA), Hybrid Energy-Efficient Distributed Clustering and LEACH with DSBCA. It results in more stable and reasonable cluster structure and lifetime is improved.

**SCHEDULING**

In a multi-hop fashion, the position of the PAN coordinator has several performance impacts. Hence, it affects the network energy for both topology formation and data routing. So, it is necessary to develop the efficient self-configuring, self-managing and self-regulating protocols for the election of the node. The node coordinating and managing the IEEE 802.15.4/ZigBee wireless sensor network is still an open research issue. Hence, cuomo et al., (2013) proposed a standard-compliant procedure named as PAN coordinator ELection (PANEL) to self-configure IEEE 802.15.4/ZigBee by electing a suitable PAN coordinator in a distributed way.

Ergen and Varaiya (2005)proposed TDMA MAC protocol is having a problem that, smallest length conflict free assignment of slots in which each link or node must be activated at least once. The network is affected by two types of conflicts: primary conflict and secondary conflict. Primary conflict is when the node transmits and receives at the same time slot. In secondary conflict the node that receives the information is also intended to receive the information from another node at the same time slot. This problem is mitigated by the authors by proposing two centralized heuristic algorithm such as node based scheduling and level based scheduling algorithm. Node based scheduling algorithm based on coloring on the original network and the nodes of the color corresponds to one slot. In level based scheduling the original network is transformed into linear network where each node corresponds to a level in the original network.

Wen et al., (2014) considered five major factors that affect the energy consumption of a sensor node. They made a rigorous integer nonlinear programming for IEEE 802.15.4-based sensor networks with dynamic transmission range which is corresponding to the physical layer, duty cycle scheduling in MAC layer, cluster-based routing in network layer, and data aggregation in application layer. To address and solve these issues, two cluster construction algorithms are used, such as Average Energy Consumption (AEC) and Maximum Number of Source Nodes (MNS).Finally a Cluster-based Data Aggregation Routing (CDAR) was made to include duty cycle scheduling and a dynamic transmission range scheme were proposed. Their result were made with minimum tradeoffs and avoiding the duplication in transmissions. In addition to that the proposed algorithms balance the trade-off between the aggregated data and interference.

Ding et al., (2013) made a new traffic scheduling algorithm for real-time (Industrial applications) data transmission through guaranteed time slots (GTSs). It concentrates on time-critical industrial periodic messages and determines the values of network and node parameters for GTS. Based on the network traffic conditions it provide guarantee requirement in terms of tens to hundreds of milliseconds. It improved both real time requirements and improves the scalability and energy efficient of network. The Collision Free Multichannel Super frame Scheduling (CFSS) has proposed by Jin et al., (2014) for IEEE 802.15.4 cluster–tree networks. They concentrated in beacon collisions, initially they formulated this collision as Satisfiability Modulo Theories (SMT) specification. Then the proposed method CFSS is compared with MSS made by Toscano and Bello (2012).

TABLE III. SURVEY ON VARIOUS ALGORITHMS

| Sl.no | Citation | Methodology | Contribution |
|---|---|---|---|
| 1 | Yoo et al., (2010) | Distance-constrained real-time offline message-scheduling algorithm | • It generates beacon order, superframe order, and guaranteed-time-slot information.<br>• It allocates each periodic real-time message to superframe slots for a given message set. |
| 2 | Toscano and Bello (2012) | Multichannel Superframe Scheduling for IEEE 802.15.4 | • To avoid beacon collisions in cluster-tree networks,<br>• To avoid loss of synchronization between nodes and their coordinator |
| 3 | Palattella et al., (2012) | Traffic Aware Scheduling Algorithm (TASA) | • Presented an innovative approach to support emerging industrial applications.<br>• Itis applied for low latency at low duty cycle and power consumption |
| 4 | Zhan et al., (2016) | Guaranteed time slots Size Adaptation Algorithm (GSAA) | • The beacon frame, command frame and packet frame format have been modified to save more GTS resources, and more end devices in one superframe. |
| 5 | Saleh (2015) | Enhancement of The IEEE 802.15.4 Standard By Energy Efficient Cluster Scheduling | • An adaptive data rate control for clustered architecture is proposed.<br>• To regulate its data rate adaptively using the feedback message |

LEACH is the first clustering protocol for periodical data gathering applications in WSNs. The sensor nodes communicate with each other by single-hop only, and they can transmit the data to the base station directly and the cluster heads rotate in each round, by this way the load is balanced to certain extent. Energy Efficient Clustering Scheme (EECS) proposed by the authors Ye et al., (2005) is similar to LEACH clustering scheme, where the network is partitioned into a set of clusters with one cluster head in each cluster. In LEACH there is no interaction during cluster head election and this drawback is overcome by EECS in which at least one cluster head is present in the communication range and synchronization is guaranteed for each procedure to complete.

**Load Balancing**

In sensor network, load balancing reduces hot spots in the sensor network to improve the lifetime. Several designs were made in past years similar to a node-centric algorithm. In some cases, the load balancing is achieved by routing tress. Other traditional algorithms such as Breadth-First Search (BFS) and Dijkstra's algorithm are used to achieve this concept to find the shortest path.

Kacimi et.al (2013) proposed a heuristic algorithm that balances the traffic load as equally as possible among the sensor nodes. They mentioned that the load balancing technique based on transmission power control. The major limitation of this method is that all the sensors have equal transmission power control. The authors formulate lifetime maximization into nonlinear programming and have the assumption of network topology and static traffic demand distribution. Most of the load balancing technique tries to reduce Maximum Link Utilization (MLU) as much as possible. The authors Zhou and Chen (2014) proposed control theory to ensure actual Link Utilization (LU) by setting a controller to get the real time load balancing.

Heuristic based routing technique is used to control transmission power of all the sensors with assumptions that could overcome by Dohare et al., (2014) by proposing Energy Balanced Model (EBM) with three algorithms such as annulus formation algorithm, connectivity ensured routing algorithm, coverage preserved scheduling algorithm. This algorithm equally balances the total energy consumption among the distributed sensor network within the specified time. The algorithms send hello packets, ensure the connectivity and ensure the coverage too. Also, the authors Kariman et al., (2015) proposed Energy Balanced- Joint Routing and Asynchronous Duty Cycle Scheduling (EB-JRADCS) algorithm for life time maximization by load balancing. This algorithm can be formulated with new asynchronous MAC protocol having flooding of RTS and random sending of CTS called FRTS-RCTS.

Petrioli et al., (2014) proposed a relay selection and load balancing (ALBA)and Rainbow protocol for converge casting in wireless sensor networks. It has a mechanism to detect and route around connectivity holes (Rainbow). They made an objective to solve the problem of routing around a dead end without overhead-intensive techniques such as graph planarization and face routing. They verified it inNS-2based simulations. Yao et al., (2015) made a recent research on Open Vehicle Routing (OVR) problems. They made Energy-efficient Delay-aware Lifetime-balancing data collection (EDAL). The algorithm design reduces computational overhead in OVR and a made the algorithm scalable for large-scale network operations.

**Energy Harvesting**

In traditional wireless sensor networks, the energy is the important constraints. As per the discussion made in previous sections the energy consumption is determined by the choice of media access mechanism. Normally sensors are equipped with capacity-limited battery it me withstand depending upon the energy usage pattern and state of the sensor nodes. In some cases, the solar intensity is one of the major problems that affect the system performance based on the density. It may according to the time depending factors.

Tadayon et al., (2013) made a solar energy-harvesting model into SMAC. It includes solar energy harvesting and deriving the throughput of SMAC. Next, they made a queuing theory model to calculate the average number of energy packets in battery in terms of both duty cycle and throughput. Lee (2012) made an energy harvesting model by identifying the problem in traditional systems. Beyond the above said algorithms, protocols in some sensor networks the power managed by harvesting energy from the environment itself. Power management is a technique that may use the maximum power efficiently rather than having a limit on maximum energy rate. This harvesting energy from environment is a supplement to the battery energy. Hasenfratz et al., (2010) proposed an energy harvesting model from the nodes in terms of maximum utility of the network and maximum delivery of data. Here the authors gave a detailed view of routing algorithm for energy harvesting systems. Wang et al., (2008) mentioned that the mobile relays are not only meant to carry data packets, but it distributes the energy resources, computational power, sensing and communication capabilities.

Chen et al., (2007) mentioned that there are some similarities between isolated and sparse wireless sensor network. The difference is in an isolated network where the entire network is located remotely from the outside world where as in sparse network only a single node is far from each other. In case of sparse network Message Ferrying (MF) is used for data delivery which is a set of special mules in order to afford communication services to the network.

Zhang et al., (2013) developed a hybrid routing algorithm which explores the available connectivity in clusters through gate way nodes. They carried out a Distributed Storage Management Strategy (DSMS) to buffer data in an isolated network which anxieties on space limit and data priority. Data collection from energy harvesting sensor network looks for fair and high throughput data extraction and the batteries are re-energized by renewable sources. Dai et al., (2012) hunt for computing lexicographically maximum data collection and routing paths for all the nodes hence, no node will run out of energy. In a large scale wireless sensor network where the battery could not be replaced frequently, in such a network the sensed data is distributed in the static nodes and the mule will visit the sink node at particular time interval and forward the data packets to the base station. The network is designed with Conservation Area (CA) adjacent to the sink node with a scale of 3 to 10 hop counts. The node is defined with a threshold value in order to justify the node status. Residual energy of each node is decided by energy grade. All the nodes in conservation area know its distance from the sink node. The data collected is of different types and have different priorities. According to their priority the survival of the data exists, and it uses as tack like structure to store the data in the buffer and newer data will be sent earlier.

Drew and Albinger (2014) made a real time mobility assembly configured to facilitate movement of the lawn care device over ground. Similarly, many researchers were focussed particularly on that application and analyzed the energy conserving factors to improve the lifetime.

TABLE IV. ENERGY HARVESTING IMPORTANCE

| | Objective | Protocol design |
|---|---|---|
| Battery operated WSN<br><br>Without energy harvesting | For improving lifetime throughput and latency are the major tradeoff. | Sleep and wakeup schedules can be determined exactly |
| Battery operated WSN with energy harvesting | Lifetime of the network is improved by supplementing battery power with harvested energy. | Sleep and wakeup schedules can be predicted later based on the energy availability |

## QUERY PROCESSING

QUERY PROCESSING IS DESCRIBED AS A DATABASE THAT CONTAINS COLLECTION OF DATA FOR ONE OR MORE USERS; IT IS MADE EXACTLY BY DIGITAL FORM OR IN ANALOG FORM. WHILE DESIGNING A NETWORK SOME OBJECTIVES ARE MADE SUCH AS LOW COST, AND LOW POWER SENSOR NODES. THIS PROCESS IS MADE TO PROCESS, STORE AND USED FOR COMMUNICATION. WSN'S COLLECTS THE INFORMATION FROM TARGET ENVIRONMENT BY SENSOR NODES. WHILE COLLECTING THE RAW DATA AND TRANSMITTING THE DATA THROUGH NETWORK, DIMINISHES THE LIFE TIME OF THE NETWORK. THIS PROBLEM CAN BE ALLEVIATED BY AGGREGATING THE DATA IN SOME NODES BY TAKING THE ADVANTAGES OF SPATIAL AND TEMPORAL CORRELATIONS AND THUS AVOID REDUNDANT TRANSMISSION OF DATA. THUS, TWO NEIGHBORING NODES SHOULD NOT ACT AS CORRELATING NODES, FURTHER AT ALL TIMES THE NODE IS REPRESENTED WITH ACTUAL READING OR ESTIMATED READING. ANOTHER CONSTRAINT WITH WSN IS THAT ENERGY GETS DEPLETED ON QUERY RESPONSE ALSO. THE PROBLEMS IDENTIFIED THAT THE SENSORS NEAR THE SINK DEPLETE THEIR ENERGY FASTER THAN OTHER SENSORS. THIS PROBLEM IS ADDRESSED BY LIAN ET AL., (2006) BY INTRODUCING BROADCASTING BASED QUERY SCHEME (BBS). BBS PROVIDE SUPPORT FOR THE QUERIES BASED ON ZONE BASED QUERIES. ZHANG AND SHEN (2009) PROPOSED A METHOD TO OVERCOME THE DRAWBACK OF UNEVEN ENERGY DEPLETION PHENOMENA WHICH STATES THAT THE SENSORS ARE DISTRIBUTED EVENLY IN CORONA AND THE SIZE OF THE NETWORK DEPENDS ON THE RADII R.

Stine and De (2002) mentioned that the wireless sensor network access protocols can assist the nodes to conserve the energy by identifying the low energy state of nodes. These access protocols depend on network size, traffic rate and channel bit error rate. The authors concluded that by recommending an energy conserving implementation of the IEEE 802.11 Point Coordination Function. While entering into the real time network, it is necessary to monitor a set of targets even if the ground access is prohibited. One solution is there by deploying the sensor remotely from an aircraft. In large sensor population the probability of target coverage is improved by sending the data to the central node for processing. The network is managed by partitioning the sensor into disjoint sets. These maximum numbers of disjoint set covers that are activated successively by round robin technique.

Ahn and park (2011) proposed a heuristic called a s Genetic Algorithm for Maximum Disjoint set Covers (GAMDSC). This heuristic algorithm improves both the speed and the quality of solution. They adjusted the power level by proper routing and thus lifetime is maximized. Chang and Tassiulas (2000) applied a fast approximation algorithm to control the tradeoff between the performance bound and running time. The drawback of fast approximation algorithm is in collecting the data and storing it. In order to avoid this, Kalpakis and Tang (2009) proposed Revised Simplex Method- Maximum Lifetime Data Aggregation (RSM-MLDA) algorithm that depends on the network topology and initial energy of the system.

Sadagopan and Krishnamachari (2005) mentioned the problems associated with RSM-MLDA such as data awareness and energy awareness are rectified using maximum data extraction problem which is a linear program referred as Approximation algorithm (A-MAX), by balancing the load equally to all the nodes by making the nodes to send their data directly to the sink. Continuous data gathering in wireless sensor network is the application of maximum data can be extracted by data awareness in addition to energy awareness. The maximum data extraction can be formulated using Linear Programming (LP). Based on LP Luo et al., (2006) adapt multi commodity flow algorithm which suggests a new link based on the remaining energy in the nodes. Conditional Max-Min Battery Capacity Routing (CMMBCR) selects shortest path for routing data from one node to another node. Energy efficient routing protocol such as an adaptive protocol called SPIN, a clustering protocol called LEACH, and Power-Efficient GAthering in Sensor Information Systems (PEGASIS) in which the nodes organizes themselves for communication. Bhardwaj and Chandrakasan (2002) scrutinize Feasible Role Assignments (FRA) of aggregated as well as non-aggregated nodes in order to maximize the network life time. This Data gathering scheme is used to improve the network lifetime and to handle hotspot problem. Based on the data generated by the network and capacity of the network, the data collected by the different nodes are estimated within the prescribed distortion value. By constructing Radio radius the transmission like TDMA is introduced. To enhance this transmission, a small co-ordinate system with a delay is introduced to reduce the occurrences of collisions. Scaglione and Servetto (2005) proposed an energy model to transmit L number of bits over the distance d as, in equation 3.

$$E_{TX}(L,D) = \{L.E_{elec} + L.\varepsilon_{friis-amp}.d^2\} if d < d_{crossover} \quad 1$$

$$E_{TX}(L,D) = \{L.E_{elec} + L.\varepsilon_{tworay-amp}.d^4\} if d \geq d_{crossover} \quad 2$$

$$E_{RX}(L) = L.E_{elec.} \quad 3$$

where, $d_{crossover}$ is the distance for friis and two ray ground attenuation models.$E_{elec}$is the electronic energy and depends on factors such as digital coding, modulation and filtering of signal before it is sent to the transmitter amplifier. The parameters $\varepsilon_{friis-amp}$ and $\varepsilon_{tworay-amp}$ depends on sensitivity and noise figure. Data gathering is specially designed for hot spot problem since the nodes closer to the sink deplete their energy quickly. To handle this hotspot problem Centrally Aggregating Scheme (CA) that relay on data from far nodes as well as delivering local data, the nodes closer to the sinks have heavier workloads, which causes an early rupture of the network because, these nodes run out of their energy. Related to the hotspot problem many researchers proposed different algorithms like Energy Aware Routing (EAR) in which each node builds multiple paths to the sink node and using stochastic method. This optimal next hop is found in order to balance the energy. Zhu et al., (2006) proposed Power graded Data Gathering (PODA) which assigns high power for the node which is far from the sink than the node nearer to the sink and hence consumes energy evenly and this is suitable for small size network. To overcome this draw back in hotspot, Bi et al., (2007) proposed a Geographical TDMA like Routing (GTR) protocol. This protocol improves the radii and packet reception rate and each sensor having self-configuration capability. GTR adapts DAR approach to solve hotspot problem. The amplifier circuitry is considered for both friis and two ray model in DAR algorithm. The disadvantage of this algorithm is that for large network, it may consists of many hop grades, and in such a case the energy wasted by the nodes near the sink may overwhelm the energy efficiency done by scheduling the data flow in the network.

Pattem et al., (2008) coined out a pragmatic data correlation model for a set of data obtained by experimentation and reconnoiter several tree construction schemes such as routing driven data aggregation, aggregation driven routing and static cluster based routing for wireless sensor networks. Here, the authors consider cost function per symbol, transmission and interference. Von and Wattenhofer (2004) proposed optimal Minimum Energy Gathering Algorithm (MEGA) for foreign coding data aggregation model and Low Energy Gathering Algorithm (LEGA) for self-coding data aggregation model. Xu et al., (2010) explored data aggregation by exploiting cooperative communication using spatial diversity to reduce power consumption in wireless sensor networks. In general correlated data gathering problem is incorporated with transmission structure and data rate. Zeydan et al., (2012) contribute to incorporate correlation and interference awareness in to total network energy minimization problem.

## III. ROUTING PROTOCOLS

Pantazis et al., (2013)surveyed on routing protocol and its classification data centric, hierarchical and location based. They presented only routing protocols and does not concentrate on energy efficiency methods. Each WSN exhibit a unique traffic patterns, based on the collection of data, sending message to the base station and the base station sends control message to the sender nodes. The multi-hop traffic patterns can be divided in to the following,

i. Local Communication – It is the communication used to transmit status of the node to its neighbours also to transmit the data between two nodes directly.

ii. Point to Point Communication – It is the communication to send data packet from one arbitray node to another arbitrary node, mostly used in WSN.

iii. Aggregation - It is the communication to send the data that are aggregated in the relay nodes rather than raw data.

iv. Convergence –Multiple nodes are communicated with the single node to send the data packet.

v. Divergence –This communication is used to send a command from the base station to other nodes.

If a data packet is transmitted by a node to a distance node some amount of energy is depleted. The energy of each node is decreased after every transmission and at once the node is eliminated from the network because of empty power. Many of the researchers mentioned that the network lifetime depends on suitable routing protocol. In general, the entire routing algorithm considers only transmitters energy consumption whereas the energy consumption is extended to the receiver is taken into account which is made by the Jiang et al., (2010). Ok et al.,(2010) proposed distributed energy balanced routing algorithm balances the routing path by calculating total energy cost of each path from source node to destination node and selects an energy efficient routing path for data dissemination. The drawback of the above mentioned algorithm is it may not properly work for large networks. Hence it isovercome by Jain et al., (2012)with the Energy Efficient Maximum Lifetime Routing Algorithm (EMLR). This algorithm selects the energy efficient routing path, if the node is already included the energy cost of the node is calculated and then the shortest path is routed. Perwaiz andJaved(2011)mentioned that the design of routing algorithm for WSN is that how much energy efficient and their role to improve the lifetime of WSN. They suggest that it is important to give the location information intelligently through MAC layer integrated approach. In order to rectify the problems related to geographical location based routing they proposed Energy Aware Load Balancing Geographic Routing (ELBGR) consider neighbor node’s energy level, packet reception rate and geographic location of the nodes for data forwarding.

Zheng and Fang (2006)mentioned that the draw backs of multiple short paths as they are not energy efficient than direct transmission when processing power is also considered. A Semi Markov Chain Model (SMC) is used to predict the Distributed Coordination Function behavior which is better than Discrete Time Markov Chain (DTMC) models. The authors proposed an analytical model IEEE 802.11 DCFwhich considers hidden terminals and traffic load. This IEEE 802.11.DCF gives energy efficient relaying strategy which depends on traffic load also affects the scalability of WSN.

### A. ***Routing based on Scalability***

In large scale WSN multiple sinks are used to provide scalability which does not affect the performance of the flooding protocol. In wireless sensor network scalability is an important problem. Scalability of a network is affected by the topological changes. The authors proposed to use multiple mobile sinks to enhance the performance of wireless sensor networks.Soyturk and Altilar(2007) proposed MS-SWR (Stateless Weight Routing –with Multiple Sinks) reactive stateless routing protocol which possesses scalability for large scale wireless sensor networks. MS-SWR does not require any local or global topological information. In MS-SWR a threshold value is inserted into the packet to be transmitted. This threshold value is used to reduce the rebroadcasting also. Wu et al., (2008) mentioned the drawback of wireless sensor network with multiple sinks leads to frequent reestablishment of routes from source to destination which results in high energy consumption and delay. They had proposed Load balanced and Lifetime Maximization (BLM) routing protocol. This protocol chose relay nodes based on the neighbors' potential rather than nearest nodes. This protocol also adaptive to the change in topology and has additional Global Informative Mechanism (GIM). This mechanism monitors the entire node and provides global information to all the nodes to adjust the nodes' behavior.

### B. ***Routing in health care Applications***

WSN also plays an important role in the domain of health care application like patient monitoring and data collection in the context of E-Health. In this context WSN has to work for a long time without human intervention and at the same time appropriate reliability and quality of service. Abreu et al., (2014) proposed Energy Aware Object Function (EAOF) for the RPL (Routing protocol) for prolonging network lifetime without human intervention on battery changing. Since, wireless sensor networks operate on scarce energy resources the routing protocol focused on energy efficient path so as to increase the network lifetime, but it does not guarantee that the network lifetime increases. To avoid over use of efficient path it is necessary to consider the remaining energy on each sensor node. This problem could be solved by Energy Aware Object Function (EAOF) for Low Power and Lossy Network (RPL) routing protocol used in Biomedical Wireless Sensor Networks (BWSN). This protocol is responsible for maintaining the path and reliability in the communication link.

### C. ***Cluster based routing***

Lin et al.,(2012) proposed Energy Balanced Cluster Routing based on Mobile Agent (EBMA) to balance the energy consumption. It is proven that the energy consumption is high if multi hop is adopted in intra cluster. Multi hop is adopted for inter cluster communication. Energy balancing is done in intra and inter cluster by establishing a local energy map by providing necessary information to the mobile agent such as remaining energy of the nodes by determining its movement. Number of mobile agents is determined by the length of the hexagon cell. This EBMA mitigates uneven energy distribution problem. The both(Lin et al., 2009) and (Ergen and Varaiya2005)authors mentioned that they took the advantages of hexagon like cellular instead of square, but the problem is that it is not suitable for random deployment of nodes. This method considers only the position of sensor node and not the energy level where the cost factor in wireless sensor network is not met. This is solved by Equilibrium Multi-hop Cluster Hierarchy (EMCH) proposed by Lin et al., (2012) which balances the energy consumption and prolong the network lifetime. It is not optimum to distribute the clusters and select the cluster heads. This proposed EMCH is to balance the energy and avoid energy consumption by having two communication distances such as longer and shorter. Longer one used for neighbor cluster head communication and shorter one used for intra cluster communication. Theauthors Misra and Banerjee (2002) compared the multi hop routing for maximizing minimum lifetime of the network and minimize the total energy consumption. They also suggested that increasing the transmission range to save energy in sensor network and the amount of energy spent in transmission amplifier and circuitry.

### D. Scheduling

Ergen and Varaiya(2005)proposed TDMA MAC protocol is having a problem that, smallest length conflict free assignment of slots in which each link or node must be activated at least once. The network is affected by two types of conflicts: primary conflict and secondary conflict. Primary conflict is when the node transmits and receives at the same time slot. In secondary conflict the node that receives the information is also intended to receive the information from another node at the same time slot. This problem is mitigated by the authors by proposing two centralized heuristic algorithm such as node based scheduling and level based scheduling algorithm. Node based scheduling algorithm based on coloring on the original network and the nodes of the color corresponds to one slot. In level based scheduling the original network is transformed into linear network where each node corresponds to a level in the original network.

### E. Coordinate System

The authorsBicakci et al., (2013) showed that the multi domain cooperation can significantly increase the network lifetime. Each domain has a separate sink. Only intra domain communication is possible if there is no domain cooperation. Bicakci and Tavli (2010) investigated the cooperation of neighbor sensor network through Linear Programming (LP) frame work. In addition to prolonging the network lifetime, the cooperation of the nodes in the network improves the connectivity and thus reducing the probability of disjoint partitioning. Akgün et al., (2010) used mixed integer linear programming in addition to linear programming frame work. These models were used to reduce the complexity in the network due to inward and outward connection of the nodes. For broadcasting the authors Chang et al., (2005) proposed a new coordinate system called Cellular Based Management (CBM) system. CBM model changes from node level flooding to manager level flooding in which each node has unique ID and communicates with the neighbor node manager and thus relays the packet. In Zone Based Protocol (ZBP) which is proposed by them with three phases. This protocol is based on coordinate system. The axes could be extending from the cell to its six neighbouring cells. Along the six axes the managers of each cell are located, and they are responsible for broadcasting. Based on coordinate system the manager receives a data packet from a new coordinate system is the first phase. In second phase the manager uses the new coordinate system and determines whether to send the data packet or not. In third phase the manager evaluate the time in order to avoid collision. Also, ZBP reduces power consumption, collision, bandwidth by reducing the number of managers. The disadvantage of ZBP is that the authors were not considering "blank region" i.e the region which is not covered properly. This region will disturb the broad casting schedule. Based on ZBP the manager node sends information to the neighboring manager nodes with timer acknowledgement. If the timer expires then it is identified that a blank region exists. Olariu and Stojmenovic(2006) proposed ZBP with recovery mechanism. The recovery mechanism is "finding other routes" to relay the packet to the available axis manager node which is on the same axis to the blank region.

## IV. Conclusion

In this paper, we have reviewed the most critical parameters which create energy related issues and presented the causes of decrease in lifetime of WSN. Based on those observations elaborated above, it is important to create a new algorithms or model to solve the complex problems. We have also surveyed the main approaches to conserve energy in wireless sensor networks based on comprehensive classification of the solutions proposed in the literature. We have also stressed the importance of various approaches such as data driven, scheduling, power management, load balancing and routing schemes. It is observed that the life time of WSN can be increased if there is significant reduction of energy consumption of nodes nearer to the sink. This could be achieved by balancing load of the sensor nodes in the bottle neck zone. We have given final observations about the different approaches to energy conservations.

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