# An Efficient Analysis on Performance Metrics for optimized Wireless Sensor Network

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***Abstract*****—** *Wireless Sensor Networks have the revolutionary significance in many new monitoring applications and self-organized systems. Based on the nature of application WSN are needed to support various levels of Quality of Services. Quality of service parameters are most significant aspect in WSN during data transmission from sensor nodes to sink. This paper surveys the factor on reliability, predictability, sustainability, optimal clustering and scheduling by analyzing various models existing in WSN. A network that satisfies all these Qos parameters ensures outstanding throughput in performance. We concluded by exploring some of the dimensions for research interest and addressed open issues ahead to enhance the performance of WSNs.*

***Keywords-- Reliability, Predictability, Sustainability, Optimal clustering, Scheduling****.*

## I. INTRODUCTION

In recent years new paradigm in the field of wireless transmission and miniaturization has paved way to the drastic development of WSNs. In sensor networks, due to resource limitations like computing capability, limited buffer size, confined bandwidth and energy sources, satisfying QoS requirements in WSNs is a challenging task. QoS is considered as quality to be generally recognized by the user or application. As there exist vast applications in WSNs and their QoS requirements may vary. Also, there is a fact that “one size cannot fit for all” QoS support solution may differ for each application type. So we have considered QoS requirements enforced by the applications on the network. Reliable data transmission is one of the important aspect of dependability and QoS in wireless sensor networks. In WSNs event-driven data monitored by the sensor nodes should be transmitted reliably to the sink for successful surveillance of an environment. Reliable transfer of data is the assurance that the packet containing information about the event delivers at the base station.Event or packet reliability is concerned with amount of information is that required to intimate the sink about an occurrence of an event in an environment. Packet reliability revealed as all packets containing monitored information from all the sensor nodes to be reliably transmitted to the sink. Event reliability assures that the sink only gets sufficient amount of information regarding happening of particular event in the network instead of transmitting all sensed data. In most of the sensor network based applications, it is needed that information be reliable delivered over channels blended with noise and error. To attain the reliability, sensor networks must include error control and correction procedure to provide reliable data transmission.

Node activity determines the sustainable workload. It has been showed that power-constrained WSNs can be represented as transmit networks and that the maximization of the energetic sustainability of the workflow can be represented as the attribute of maximum flow. The solution of the maximum flow problem results non-deterministic routing tables that can be eventually implemented at the sensor nodes to attain optimum sustainability.Routing algorithms must route data from sources to sinks nodes at the specified rate. Routing algorithms impact sustainable workload. They impose power consumption to nodes for packet relaying. They must select the routes so as to ensure the required data flow. Routing algorithm must maximize the energetic sustainable workload. Sustainability can be determined by computing recovery time as the time to recover energy spent for packet processing from the environment.

In the case of event based application, event-driven information should be transmitted within the confined time limit. There may circumstance arise where sensor nodes are not present with enough energy to complete its operation due to connectivity failure or insufficient energy resource or prone to drain out of energy, which leads to drastic undesirable outcomes. Hence, Prediction mechanism is needed to analyze the energy level and lifetime of sensors. Predictability is termed to predict whether all nodes, are able to complete the committed task within the given lifetime requirement, energy limits are computed and a analysis will be carried out to check whether the nodes are within the limits or not.

Clustering promotes the synchronized coordination by grouping set of adjacent sensor nodes. Consequently, it minimizes energy utilization and enhances reliability. Optimal Clustering ensures the consumption of limited energy in an efficient way to enhance the network lifetime. Clustering is considered to be optimum if it satisfies the following requirements:

1. Clustering must promotes balanced load throughout the network and completely distributed.
2. Clustering and Cluster head (CH) selection terminates within a fixed number of iteration
3. Clustering must guarantees increased connectivity and ensure minimized delay.
4. Clustering should facilitates fault tolerance to avoid the chance of reclustering.
5. Concentration of CH within a particular geographic area is avoided, that is CH must be evenly distributed over the network.
6. Cluster size and number of clusters are optimized for the improved performance of the network.

Scheduling is an important aspect for enhancing the network lifetime which save the time and energy so the network becomes more robust flexible and efficient. Scheduling is termed as scheduling of packets, which is used to organize the sequence of packets in which order the packets should be transmitted and received to the base station. In most of the sleep-awake scheduling method, sender nodes are able transmit data to receiver nodes only when they are active. Sleep scheduling focuses in increasing the network life time. But in most of the cases it leads to increase in broadcasting delay. Whenever the number of nodes in the increases, the delay in transmitting also increase. So, a sleep scheduling algorithm is considered to be efficient if it is designed to minimize broadcasting delay from any node. Sleep scheduling algorithms aims to reduce the utilization of energy. Henceforth, a scheduling method must balance both energy utilization and transmitting delay in the network.

## II. RELIABLE DATA TRANSMISSION IN WSN

It is a well known fact that facilitating reliability support hop-by-hop fashion in intermediate nodes is highly energy-efficient than considering only reliability support in end-to-end fashion. Under hop-by-hop model, intermediate nodes present in the end-to-end path are supposed to participate in data transport by caching and retransmitting data packets, generating or changing the contents of control packets, in order to avoid end-to-end retransmissions. This makes it impossible to implement full transport layer encryption between the sender and the receiver. Both the event and packet level based data transfer methods are analyzed in the following sections.

### *Event-to-Sink Reliable Transport (ESRT)*

Akan et al. [11] proposed the concept of reliability on event by introducing the approach the most advantageous event-to-sink reliability protocol (ESRT). This algorithm ensures end-to-end transmission of information about individual event to the base station. It attains reliability in terms of number of packets containing data about a particular event that has been transmitted to the base station. Based on the amount of packets which is enough to detect the event delivered to the sink within a particular duration, reliability is calculated. ESRT deploys a control mechanism at the sink to control the node's event reporting frequency periodically, which in turn achieves the specified reliability level. The event reporting frequency of the nodes is increased When the specified reliability is not attained. Reduction in reporting frequency is required to avoid congestion at the sink and to retain. Energy consumption at the node is optimized by minimizing the reporting frequency after achieving the specified reliability. ESRT reveals under four different network conditions such as both reliability and congestion, only reliability and no congestion, only congestion and no reliability, and not both reliability and congestion. This algorithm assumes to broadcast the value of recently received event information to all nodes according to which the reporting frequency is adjusted, this done to eliminate redundancy. ESRT increases the data transmission rate in order to assure event reliability. And also the area which is prone to congestion is detected. In-network data processing leads to energy efficient event detection which accurate and reliable.

***Limitations:***

1. It assumes all the nodes in the network to be present at one hop away from the sink which leads to a serious limitation because conventionally it is not possible.
2. Central rate control mechanism is not energy efficient when compared to retransmission-based hop-by-hop loss recovery methods. This in turn further leads to degenerate the overall bandwidth utilization and its leads to high energy consumption as network condition varies for different parts of the network.

3. Congestion detecting assumption is not effective, as an area where the event is clearly detected needs to report frequently resulting congestion in the network.

***Retransmission or redundancy transmission reliability***

Authors in [8] presented a study on the packet arrival probability and average energy utilization for retransmission and redundancy approaches to improve reliability for data transmission. Analysis predicates that when probability of loss is low or moderate, this Erasure Coding, approach which is based on redundancy reflects a high level energy efficient reliability than retransmission.

***Limitations:***

1. There is a performance lacking in Erasure Coding when the packet loss condition increases.
2. Increase in hop number affects resistance capability against packet loss.
3. Absence of specified method to avoid redundancy, makes the Erasure Coding method to compromise the energy efficiency factor of reliability.

***Routing based on hybrid algorithm***

Authors in [21], introduced a hybrid routing algorithm which is applicable for real-time wireless sensor networks to enhance network lifetime and to increase reliability aspects. The performance of this algorithm is compared with the existing algorithm in (Razzaque et al., 2006) under the same network conditions. Results showed that the proposed hybrid algorithm works well to improve reliability and proposes efficient method to enhance network lifetime.

***Reliable erasure-coding based Data Transfer Scheme***

Srouji et al. [3] proposed RDTS, an efficient reliability approach for hop-by-hop data transfer based on erasure coding approach. Most of the methods performed erasure coding technique only at level of source and the sink nodes, in contrast RDTS performs erasure coding at each hop level to attain reliability at hop-by-hop level. In the way to reduce computational overhead which is imposed by addition to erasure coding, RDTS performs the partial coding mechanism at each hop. At each intermediate node partial coding further reduces the need of complete erasure coding. This ensures that enough data fragments are transmitted and received to the next hop eliminating the process of encoding, decoding and reconstructing the missing fragments at every hop. Thus, there is a need for partial coding only if the complete fragments are missing and the received fragments are not sufficient. RDTS shows better performance when compared with end-to-end erasure coding and hop-by-hop erasure coding, in terms of energy utilization, communication overhead, traffic-balancing and network lifetime.

***Limitations:***

1. No specific technique is followed for the actual calculation for the number of fragments required for the upcoming hop, rather it takes random values from a predefined range of successful arrival probability. Methodology to estimate these probabilities should be formulated dynamically.

***Quality-based Event Reliability Protocol (QERP)***

Hosung et al. [4] introduced Quality-based Event Reliability Protocol (QERP), which in contrast to the existing quantity-based event reliability protocols has an impact on the quality of event-driven data reported to the sink. By using the concept of Contribution Degree (CD) QERP as an event-based reliability protocol shows better reliability than ESRT and MERT.Since there different environmental conditions like differing distance of nodes from the events there is a difference of sensor data in CD for event detection. The data frames are assigned with a CD value, where the nodes, located near to the event's location are assigned with the high CD values and considered to be critical data ranges. Similarly, the lower value of CD show the farther nodes within the event's region that also identified the event. The CD and Full Selection (FS) fields are set in the frame header, where FS field is used when the entire data packets within the event's region are needed by the sink. The node nearest to the event is considered as a leader node, while the rest of the nodes in the event's region transmit their data to the sink through the leader nodes. The sink compares the obtained reliability with the desired event reliability (DER) and may need the leader node to select and send the new data on the basis of the new DER range. The data with higher CD values are reported on priority by using CD-based buffer management and CD-based load balancing methods. The simulation analysis show that QERP performs better than ESRT and MERT in term of energy consumption and reliability. The data flow in QERP is managed by the sink, however, the buffer management and load balancing methodology are done at the node level. QERP forms the clusters by selecting the leader nodes within the event's region and selects the leader node work as a cluster head. QERP is an end-to-end event-based reliability protocol, having its data flow mechanism is based on the location of the event.

***Limitations:***

1. QERP considers that the quantity-based event reliability protocols are not applicable for the resource limited

wireless sensor networks, as their objective is to achieve reliability by increasing or decreasing the frequency of data transmitting rates.

2. Varying data reporting frequencies would sometimes maximize the overall data rate more than the desired rate, which would complicate the network conditions

3. If the node distribution density is high near the event's location, then the process of selecting the leader node would be longer, resulting more energy consumption.

4. At the end of transmission process, if the revision of the DER is required by the sink, using ACKs, this may cause overhead.

5. There is no mechanism to detect packet loss and also there is no mechanism to find the location of the event on the basis of predefined CD values.

*Table.1: Reliable Transport Protocol for WSNs*

| PROTOCOLS | TRAFFIC FLOW | RELIABILITY LEVEL | LOSS DETECTION AND NOTIFICATION | LOSS RECOVERY | RELIABILITY MODEL | COMMUNICATION MODE |
|---|---|---|---|---|---|---|
| **Event-to-Sink Reliable Transport (ESRT)** | Up Stream | Event | Implicit | End-to-End | Partial | UniCast |
| **Retransmission or redundancy transmission reliability** | Up Stream | Event | NACK | End-to-End | Partial | UniCast |
| **Routing based on hybrid algorithm** | Up Stream | Event | iACK | End-to-End | Partial | UniCast |
| **Reliable erasure-coding based Data Transfer Scheme** | Up Stream | Event | ACK/NACK | Hop-by-Hop | Partial | UniCast |

## III. SUSTAINABILITY IN WSN

Research efforts in the field of communication in wireless sensor networks has led to the development of various energy aware routing protocols which aim at selecting the routes for transferring data from sensors to base stations so that network lifetime is enhanced . When sensor nodes are battery-powered, network lifetime is a applicable metric for building the design of optimal routing algorithms. In fact, battery replacement is a critical problem for most of the areas for which WSNs are deployed, so that the lifetime should be typically unlimited.

### *Maximum Energetically Sustainable Workload(MESW)*

With the concern of the problem about energetic sustainability , the authors[] discussed the maximum energetically sustainable workload(MESW) as the major function to be used to build the optimization of routing algorithms for energy consuming wireless sensor networks EH-WSNs.In EH-WSNs, if the average power spent by each nodeto complete its task for a given workload is lower than the power it can consume from the environment, then we saythat the workload is energetically sustainable. Since workload has impact on the nodes, data delivery protocols for EH-WSNs must be aimed at generating workload as energetically sustainable. Thus, instead of enhancing lifetime, the problem becomes maximizing the workload under given environmental power constraints. We mentioned this problem as energetic sustainability. In this work we introduce a new technique for assessingthe energetic sustainability of routing algorithms. First,we explain the maximum energetically sustainable workload(MESW) for a given EH-WSN (Net) with a given routingalgorithm (rAlg) under given environmental powerconstraints (Pmap), mentioned by MESW(Net,rAlg,Pmap).Second, we define the optimum MESW for a givensensor network with a given power map, mentioned byMESWopt(Net,Pamp), as the good MESW applied to the network, which is achieved by routing algorithm: To study the energetic sustainability of a workload for a given routing algorithm we need to build a model for packet energy, that is the energy consumed by each node to process a packet, and the environmental power available at each node to sustain packet processing. Packet energy includes the energy required to produce (or receive) the packet, to process it and to available it on the selected route. Production (or reception) and processing energy can be considered as constant contributions, while transmission energy required to the process is depends on the distance between the transmitter and the receiver. For instance, the transmission power level of a node can be adjusted to the lower level needed to give the required signal to noise ratio at the target receiver, selected within a given optimum transmission range. The enhanced energetically sustainable workload(MESW) is a workload that can be sustainedenergetically by each node involved in packet processing androuting and that cannot be increased without changingthe sustainability at some nodes. For continuousmonitoring applications, the MESW is themaximum rate at which data packets can be sentby all sensors and transmitted to base stations. As statedin the introduction, to evaluate the optimality of a routing algorithm we need to calculate both the MESW ofthe routing algorithm under study, and the theoreticaloptimum MESW, that is theMESW of the best routing algorithm applicable to thenetwork.

***Limitations:***

1. Since the transmission energy is determined from the distance of the sensor nodes it is applicable for mobile nodes.

### *Maxflow Algorithm*

It has been recently shown that power-constrained WSNs can be mentioned as flow networks and that the optimization of the energetic sustainability of the workload can be combined into an instance of maxflow [24]. The solution of the maxflow problem results non-deterministic routing tables that can be applied at the sensor nodes in order to attain the theoretical optimum energy. The workload of a sensor network can be represented as the average number of packets routed from the sensor nodes to the sink in a unit of time. Generally, a graph-traversal algorithm can be implemented by a network of preliminary processing units having the similar topology of the graph under study. Each unit directly implements the local operations of the corresponding node, while function calls and returns are implemented as exchanging of message through the edges of the graph. A framework for calculating the MESW of an arbitrary WSN based on a modified version of Ford Fulkerson's MaxFlow algorithm (FF from now on) was recently introduced. As such, a distributed version of FF algorithm could be directly implemented on the sensor network by achieving the computational and communication resources of the nodes.

### *Randomized Max-Flow (R-MF)*

This algorithm is one of the energetically sustainable routing algorithm for EH-WSN. Each edge is assigned with Capacity which depends upon harvesting rate of the transmitter and the packet energy. This routing algorithm is based on offline routing table, stored in each node that represents the node links used for packet transmission. The probability to use the edge i in node n is proportional to the maximum flow from that edge. For determining the node-constrained max flow in each edge we have to use the modified version of Ford-Fulkerson method

### *Randomized Minimum Path Recovery Time (R-MPRT)*

This algorithm has two versions to find the maxflow. We mentioned the original one as R-MPRT-org and to the modified algorithm as R-MPRT-mod. This algorithm is really same as to the E-WME explained before with a simpler cost function. Selecting a route at each node is based on sustainable energy information. The idea is the similar to E-WME, selecting a shortest path with considering the cost function. We can denote a cost function to each edge.This cost function is inverse function of R-MF, so the probability to send a packet in the path is indirect proportional to the corresponding path recovery time. Because cost function is similar to the recovery time here. As explained before recovery time is the time needed to gain energy required for packet transmission. The algorithm needs local knowledge about the network, because for transmitting the packet to other nodes, it should know about cost function of nodes and select minimum one for sending data. The responsibility of transmitting the information of each node to the local neighbors is within the beacon transmission. This modified version performs much better when it utilizes available energy of the transmitter instead of using the harvesting rate.

***Limitations:***

1. However, FF is not the good choice to select the maxflow, because it is generally sequential in nature.
2. This distributed implementation is not achieve parallelism and it require a significant synchronization overhead.
3. FF is not efficient algorithm to solve maxFlow, because its run-time execution would require more time and too much energy for processing.

***Push relabel algorithm***

The major drawbacks mentioned in above algorithm are overcome by the Push-Relabel (PR) algorithm [24], that achieves a fluid-flow analogy by building a model for network edges as pipes and network nodes as junctions among them. Each junction has a height attribute, reflecting its virtual elevation is related to other nodes, and an arbitrarily large reservoir, which can temporarily accommodate excess flow. As its name suggests, the algorithm makes use of two basic operations:**push** operation is applied when a node has excess flow in its reservoir and a non-saturated downhill edge (i.e., an edge with non-null residual capacity that leads to a lower node) to push (part of) the excess flow across the edge. The output is a transfer of excess flow from a node to another. **Relabel** operation is applied when a node has excess flow but there is no available downhill edges to push it across. The height of the overflowing node is set just above the lowest of its neighbor nodes connected by a nonsaturated edge. Initial preflow (actually saturating all outgoing edges of the main source node) is generated by using subroutine in PR algorithm and to set the height of all nodes to 0 (except the source, whose height is set to the number of nodes + ). The algorithm then processed by applying push and relabel operations until no more operations are allowed. All possible flow is pushed either to the sink or back to the source eventually. The algorithm terminates when no nodes are left overflowing, except the sink and the source. At the end of the execution, the MaxFlow corresponds to the excess flow found in the sink's reservoir. PushRelabel algorithm, runs directly on the sensor nodes, to calculate optimal routing tables. The distributed algorithm not only gives the desired self-adapting property to the sensor network, but also achieves parallelism to reduce the execution time significantly.

***Limitations:***

1. Node constraints cannot be transformed in edge constraints in case of edge-dependent transmission energy;
2. Routing tables are not continuously adapted to the environmental conditions;
3. MESW recomputation takes energy and time that could be spent by the network to perform normal operations, thus making it necessary to trade off routing optimality for recomputation frequency

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## IV. OPTIMAL CLUSTERING IN WSN

Clusters create hierarchical WSNs which provides efficient utilization of constrained resources of sensor nodes and thus enhances network lifetime. A CH may be elected by the nodes in a cluster or predefined by the network designer. The members of the cluster may be fixed or variable. There exists a large number of clustering algorithms have been specifically designed for WSNs for improved scalability and efficient transmission. In a hierarchical architecture, nodes with high energy can be used to process and send the information while low energy nodes can be used to performs the sensing operation .While these analysis imply a clear need for benchmarks for comparison among clustering mechanism in WSNs, this paper concentrates on identifying the optimal clustering scheme. Together with communication benchmarks, the optimal clustering will simplify comparison among varying algorithms and protocols and even enable comparison at a very high level, e.g. number of clusters and cluster sizes.

***Coverage-preserving clustering protocol (CPCP) [7]***

To ensure balanced energy utilization among the cluster head nodes throughout the network lifetime, many clustering protocols conforms uniformly distributed clusters with non-varying average cluster sizes. However, maintaining the constant number of well distributed clusters over time is a real challenge in cluster-based sensor networks. In coverage-based algorithms, the best candidates for cluster head roles should be the redundantly covered nodes in densely populated areas with high residual energy. These CH nodes are able to support clusters with a large number of members. While the excessive energy utilization of the cluster head nodes makes these nodes drained out of energy before the other nodes, their energy drain out should not affect the overall network coverage since these nodes are present in densely populated areas. By this approach, which considers only the full network coverage, the set of cluster head nodes can be selected based on the cost factors . However, cluster head selection based solely on any of the proposed cost factors using existing clustering algorithms will lead to an undesirable situation. The densely populated parts of the network will be highly concentrated with cluster head nodes, while the scarcely covered areas will be left without any cluster head nodes. In such a situation, it is likely that the high cost sensors from poorly covered areas will have to perform expensive data transmissions to distant cluster head nodes, further reducing their lifetime. In order to avoid this condition, the authors of [7] proposed a clustering method called coverage-preserving clustering protocol (CPCP). CPCP scatters the presence of cluster head nodes more uniformly throughout the network by restricting the maximum cluster area. Thus, clusters present in sparsely covered areas are formed as well as clusters present in densely covered areas, which avoids the high cost nodes from having to perform costly packet transmissions to distant cluster head nodes.

***Limitations:***

1. Energy aspects are not considered.

2.There is no balanced energy utilization throughout the network because CH nodes in redundantly covered areas serve clusters with large number of nodes than the CH nodes in sparsely covered network areas.

***HEED protocol [13]***

Hybrid Energy-Efficient Distributed Clustering or HEED is a multi-hop based clustering algorithm for wireless sensor networks, with an aim to facilitate an efficient clustering by proper selection of cluster-heads based on the distance between nodes. The objectives of HEED are to Equalize energy consumption to enhance network lifetime; Minimize energy consumption during the cluster-head selection phase; Minimize the control message overhead of the network. Cluster heads are determined based on two important factors: 1.The remaining energy of each node is considered to probabilistically choose the initial set of cluster heads. This factor is commonly used in many other clustering schemes. 2. Intra-Cluster Communication Cost is used by nodes to calculate the member of the cluster to join.

***Limitations:***

1. The algorithm does not consider about synchronization, energy utilized during data transmission for nodes present far away from the sink.

2. Prior knowledge of the entire network is normally required to determine the intra cluster communication cost .

3. Number of clusters and size of clusters are not considered.

***An Energy Efficient Hierarchical Clustering Algorithm [14]***

Each sensor in the network becomes a cluster head (CH) with a predefined probabilityand advertises itself as a cluster head to the sensors within its transmission range. These cluster heads are termed as volunteer cluster heads. This advertisement is broadcasted to all the sensors that are no more than $k$ hops away from the cluster head. Any sensor in the network that receives such advertisements and is not itself a cluster head joins the cluster of the nearest cluster head. Any sensor that is not a cluster head and also left remaining to join any cluster itself becomes a cluster head; These cluster heads termed as forced cluster heads. As this possess a condition to forward the advertisement to limited $k$ number ofhops, if a sensor does not receive a CH advertisement within limited time durationit confirms that it is not within $k$ hops of any cluster head and it decides to become a forced cluster head. Since all the sensors within a cluster are at most $k$ hops away from the cluster-head, the probability of occurring forced cluster head is limited. This limit on the number of hops thus allows the cluster-heads to organize their transmissions. The energy consumed in the network for the information gathered by the sensors to reach the processing center will depend on the factors predefined probability and limited number of hops. Thus the aim of this work is to group the sensors into clusters to reduce this energy consumption.

***Limitations:***

1. Since this is a distributed algorithm ,clock synchronization among the sensors are not considered.

2. The algorithm is applicable on a contention and error free environment. The predefined computed probabilities are not optimum for such environment.

3. Load is not balanced throughout the network. CH located near to sink consumes more energy than other CHs.

***Centralized clustering algorithm [1]***

Objective of this algorithm is to determine the optimum cluster size. As cluster size increases, the number of intra cluster transmissions increases and also decreasing the cluster size leads to the increased number of clusters which has worse impact on the inter cluster transmissions. Thus, there exists an optimal cluster size in such a way both the intra and inter cluster transmissions are balanced, which in turn reduces the total number of data transmissions by using hybrid CS method.The sensor field is partitioned into small grids. Cluster formation is based upon the edge length of a grid, distribution density of the nodes and the transmission range of the nodes. Any two adjacent nodes are within communication range. If two nodes are considered within the communication range of each other, then there exist link between the two nodes. The sink will divide the sensor nodes into clusters, choose a CH for each cluster, and construct a backbone tree that connects all CHs to the sink. After computing the clustering, the sink can broadcast the clustering information to all sensor nodes and start data collection subsequently. Centralized algorithm has two steps: 1. Select optimum numbered CHs and divide the sensor nodes into optimum number of clusters and 2. Construct a data transmitting routing tree that connects all CHs to the sink. This algorithm starts from an initial set of randomly selected CHs. For each cluster, choose a new CH, such that the sum of the distances from all sensor nodes present in this cluster to the new CH is minimized. Repeat the previous steps until CH with minimum distance from all the nodes are selected . This is iterative algorithm.

***Limitations:***

1. As the centralized algorithm, the sink node has the full knowledge of the network topology.
2. Since it is a iterative algorithm the number of iterations are not able to predict.
3. Centralized algorithm is prone to crowded effect problem

***An Energy Efficient Clustering Scheme(EECS)***

EECS is a clustering algorithm in which cluster head candidates compete for the ability to promote to cluster head for current round. This competition involves candidates forwarding their residual energy to adjacent candidates. If a given node have enough residual energy, it plays the role of cluster head. Cluster formation varies from LEACH. EECS extends this algorithm by dynamically varying the clusters size based on cluster distance from the base station [12]. The result is an algorithm that addresses the problem that clusters that are far away from the base station needs more energy for transmission than those that are present closer. Ultimately, this enhances the distribution of traffic load throughout the network, resulting in better resource usage and improved network lifetime. In every cluster there exists a single cluster head, reachable by k hops from all cluster members. In one round of data transmitting each node sends exactly one packet to its cluster head and the cluster heads send exactly one packet to all base stations.

***Limitations:***

1. The position of the cluster head inside the cluster is not considered.
2. Considered only residual energy as cluster head selecting parameter.

*Table.2: Comparison of Protocol Clustering Algorithm*

| ***Clustering Approaches*** | ***Convergence Time*** | ***Node Mobility*** | ***Cluster Overlapping*** | ***Location Awareness*** | ***Energy Efficient*** | ***Failure Recovery*** | ***Balanced Clustering*** | ***Cluster Stability*** |
|---|---|---|---|---|---|---|---|---|
| ***Coverage-preserving clustering protocol (CPCP)*** | ***Constant O(1)*** | ***Fixed Base Station*** | ***No*** | ***Not Required*** | ***No*** | ***N/A*** | ***Good*** | ***High*** |
| ***HEED protocol*** | ***Constant O(1)*** | ***Stationary*** | ***No*** | ***Not Required*** | ***Yes*** | ***Yes*** | ***Ok*** | ***Moderate*** |
| ***An Energy Efficient Hierarchical Clustering Algorithm*** | ***Variable*** | ***Possible*** | ***No*** | ***Required*** | ***Yes*** | ***Yes*** | ***Good*** | ***Moderate*** |
| ***Centralized clustering algorithm*** | ***Constant O(1)*** | ***Fixed Base Station*** | ***No*** | ***Required*** | ***Yes*** | ***Yes*** | ***Ok*** | ***Moderate*** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *An Energy Efficient Clustering Algorithm* | *Variable O(k1+k2…+K)* | *No* | *No* | *Required* | *Yes* | *N/A* | *Ok* | *N/A* |

***Analysis of Optimal clustering***

Optimal clustering is attained by k-hop clustering methods. Additionally, location-based algorithms also assures optimal clustering since they are able to accommodate any hop diameters. Their parameterization may not be convenient, since the knowledge of network topology must be known a in advance to determine the optimal cluster size.Cluster properties depends upon number of cluster, Predictability, Intra-cluster and inter-cluster communication cost. Capabilities of cluster head are mobility, sensor node types, role and responsibilities of CH. The clustering process comprises mechanism, aim of node grouping, complexity of Cluster head selection algorithm. Many algorithms are compared with respect to their requirement of clustering during each round of transmission for selecting the cluster heads, cluster formation required after each rotation of cluster head role, distribution of cluster heads all over the network, creation of energy balanced clusters, parameters used for CH selection and some aspects that are considered to elevate the effect of cluster head selection methodology.

## V. PREDICTABILITY IN WSN

Energy consumption is the main concern in designing Wireless Sensor Network (WSN) applications. Consequently, several methodologies have been developed for investigating the energy consumption of this kind of application. These approaches assist to predict the WSN lifetime, provide suggestions to application developers and may maximize the energy consumed by the WSN applications. To ensure predictability, it is mandatory to estimate the energy utilization at each round of data transmission. To predict whether all the nodes comes under scheduling, energy limits are derived and test for schedulability were conducted. For calculating energy consumption, energy utilization model should be developed. The following section describes Predictability of Lifetime.

***Residual Energy Based Algorithm***

Residue Energy Based algorithm (REB) [10] considers remaining energy as well as connectivity quality of nodes. REB is based upon hierarchical clustering method in heterogeneous environment. In this model, network has set a group of clusters, Gateway Node and Mobile nodes. Each cluster set has one Cluster Head (CH) and a set of member nodes. Here cluster head and member Nodes are assumed to be of identical energy limit, but Gateway Node is of high energy level. Member nodes send data to its CH. Cluster Head transmits data to corresponding Mobile Agent. The implementation of REB algorithm is considered into rounds. Main processing areas of each round are Cluster Head Selection, Cluster Formation, Data forwarding, Placement of Mobile Agent and its Routing strategy. In REB, nodes that remains with maximum residual energy and good connectivity quality is selected as Cluster Head. Connectivity quality is estimated by considering the asymmetric factor. A node which has low asymmetric factor is selected. Asymmetry is the difference in connectivity between the upward and the downward direction. To calculate the asymmetric level, four bit estimator is considered. It determines uplink quality and downlink quality based upon RNP and PRR values respectively. Therefore nodes with highest residual energy and also low asymmetric link quality are selected as Cluster Head.

***Limitations:***

1. Predictability aspects are well achieved whereas there is no other information included to attain reliability and sustainability.
2. There is no rotation of CH role.

***Energy-aware routing***

Shah et al. [18] proposed a routing strategy which depends upon a set of sub-optimal paths opportunistically to enhance the lifetime of the network. These paths are selected based upon probability function, which depends on the energy utilization of each route. Network survivability is the main factor that the methodology is concerned with. This approach confines that using the minimum energy path all the time will drain the energy of nodes on that route. Instead, one of the multiple paths is considered with a certain probability so that the entire network lifetime enhances. The protocol considers that each node is addressable through a class-based addressing which comprises the location and node types. There are three main phases in the protocol:

**1.Setup phase:** In this phase localized flooding takes place to find the routes and design the routing tables. The total energy cost is estimated in each node. Here, the energy factor used captures transmission and receiving costs along with the residual energy of the nodes. Paths with a very high cost are eliminated. The node selection is done according to adjacentness to the sink. The node assigns a probability to each of its neighbors in routing (forwarding) table (FT) corresponding to the assigned paths and then calculates the average transmission cost for reaching the destination using the adjacent nodes in the forwarding table using cost estimation method . This average transmission cost is set in the cost field of the request and forwarded.

**2.Data Communication Phase:** Each node transmits the packet by randomly selecting a node from its forwarding table using the predicted probabilities.

**3.Route maintenance phase:** To maintain all the paths active localized flooding is performed infrequently.

***PEGASIS & Hierarchical-PEGASIS***

Power-Efficient GAthering in Sensor Information Systems (PEGASIS) [19] is an extension of the LEACH protocol. Instead of organizing multiple clusters, PEGASIS forms connected chains from sensor nodes so that each node transmits and receives from an adjacent node and only one node is choose from that connected chain to transmit to the sink. Gathered data passes from node to node, data are aggregated and sent to the base station. The connected chain formation is performed in a greedy way. Hierarchical-PEGASIS is an improvement to PEGASIS, whose objective is to reduce the delay incurred for packets during transmission to the sink and introduces a solution to the data gathering problem by considering energy and delay metric. In such a way to decrease the delay in PEGASIS, parallelized transmissions of data messages are scheduled. This approach eliminate collisions and probability of signal overlapping among the sensors.

***Limitations:***

1. PEGASIS imposes excessive delay for nodes that are located distantly on the connected chain which in turn leads to bottleneck at the single leader.
2. Even though this approach avoid the clustering overhead that exists in LEACH, they still need dynamic adjustment in topology since energy of sensors are not tracked. Every sensor needs to be aware of the status of its adjacent nodes so that it decides where to transmit that data. Such adjustment of topology can introduce significant overhead specifically for highly consumed networks.

***Energy-aware routing for cluster-based sensor networks***

Younis et al. [20] have introduced a different three tiered hierarchical routing algorithm. Sensors are organized into clusters before network operations begin. The algorithm selects cluster heads which acts as a gateways, that are less energy limited than sensors and assumed to be aware of the location of sensor nodes. Gateways tracks the states of the sensors and sets up multi-hop routes for collecting data from sensors. The sensor nodes in a cluster can be in any one of four main states. They are only sensing, only relaying, both sensing-relaying and inactive state. In the only sensing state, the node monitors the environment and generates data at a predefined time interval. In the only relaying state, the node does not performs sensing the target but its transmitting circuitry is turned on to relay the data from other active nodes in the network. When a node is both relaying the data from other nodes and sensing the environmental changes, it is considered in the both sensing and relaying state. Otherwise, the node is assumed to be in inactive state and can turn off its sensing and transmission circuitry.

A cost function is determined between any two nodes in the network in terms of performance metrics ,energy consumption and delay optimization. Based upon this cost function as the connectivity cost, a minimum-cost path is determined between sensor nodes and the gateway. The gateway will continuously track the residual energy available at every sensor which is in active state in data processing, sensing, and also in forwarding/relaying data packets. Rerouting is initiated by an application-related event requiring different set of sensors to monitor the environment or the draining of the battery of an active node.

***Maximum lifetime energy routing***

Chang et al. [23] presents a significant solution to the problem of routing in sensor networks which depends upon a network flow. The main aim of this approach is to maximize the network lifetime by defining connectivity cost as a function of node’s residual energy and the needed transmission energy using that link. Determining traffic load distribution is a convenient solution to the routing problem in sensor networks and which depends upon maximum lifetime energy routing. The solution to this problem maximizes the possible time the network is alive. In order to determine the best connectivity metric for the mentioned maximization problem, two maximum remaining energy path algorithms are presented and analyzed. Both of the algorithms differ in their definition of connectivity costs and the inclusion of nodes’ residual energy. Instead of depending only upon $e_{ab}$, the energy utilized when a packet is forwarded over link a-b, the following link costs are used:

$\mathrm{Cost}_{ab} = \frac{1}{E_a - e_{ab}}$ and $\mathrm{Cost}_{ab} = \frac{e_{ab}}{E_a}$

where $E_a$ is the remaining energy at node a. The minimum cost path obtained is the path whose remaining energy is maximum among all the paths. The algorithms using these connectivity costs are compared to Minimum transmitted energy (MTE) algorithm, which considers $e_{ab}$ as the connectivity cost. The proposed maximum remaining energy path methodology has better average lifetime than MTE for both connectivity cost models. This is due to the accurate remaining energy metric that MTE uses. The newly designed metrics are concentrated with relative residual energy that reflect the predicted energy consumption rate.

### *Energy-Aware Routing Using Local BetweenessCentrality(EAR-LBC) [2]*

EAR-LBC algorithm improves upon the existing methods in two ways concerned with the extension of network lifetime. First, this strategy implements greedy forwarding, which considers both the shortest path and the residual energy at each node into consideration, rather than using solely shortest path. A tunable weight is used as a metric to determine the combination of path length and remaining energy in route finding. This can be easily adjusted to maximize the routing strategy with the particular demands of a given network. Second, the routing strategy proposes the local BC to dynamically determine the energy utilization of the neighboring nodes. Because of these approaches, even in the absence of global information on network topology and energy utilization, data packets can be forwarded to the sensor nodes with highest residual energy, which provides a more balanced energy utilization in the network. Because of these two developments, EAR-LBC maximize network lifetime without imposing additional transmission overhead or a longer average path length.

*Table.3: Predictability comparison*

| **Approaches considered** | **Convergence Time** | **Node Mobility** | **Cluster Overlapping** | **Location Awareness** | **Energy Efficient** | **Failure Recovery** | **Balanced Clustering** | **Cluster Stability** |
|---|---|---|---|---|---|---|---|---|
| **Residual Energy Based Algorithm** | Constant o(1) | Adaptive | Yes | Required | Yes | N/A | Ok | Moderate |
| **Energy-aware routing** | Variable | Yes | Yes | Required | No | Yes | Ok | High |
| **PEGASIS & Hierarchical-PEGASIS** | Constant o(1) | No | Yes | Required | Yes | No | Ok | High |
| **Energy-aware routing for cluster-based sensor networks** | Constant o(1) | Yes | Yes | Not Required | No | Yes | Ok | N/A |
| **Maximum lifetime energy routing** | Variable | Possible | Yes | Not Required | No | Yes | Ok | Moderate |
| **Energy-Aware Routing Using Local Betweeness Centrality(EAR-LBC)** | Constant o(1) | No | Yes | Not Required | Yes | No | Ok | High |

## VI. SCHEDULING TECHNIQUES IN WSN

This sensor nodes are work on the energy source i.e. battery which is need for its communication. Scheduling technique is used to save the energy of the network with WSN to maximize the lifetime of the network. In sleep scheduling most of the nodes are put into sleep mode to maximize the lifetime of the network. Sleep scheduling is most important to enhance network more efficient and flexible. Main objective of sleep scheduling algorithm is to enhance the network for long period of time. The different method is used with the sleep scheduling like routing and tree based algorithm which is really maximize the performance of the network. In the tree based network sink node is used with other sensor node with sleep scheduling but the sink node maintains the unlimited energy supply which is always in active mode. In tree network sleep scheduling is only apply with the nodes other than sink. In this paper we are study the various types of sleep scheduling techniques like energy efficient scheduling, energy efficient TDMA sleep scheduling, Balanced-energy sleep scheduling, Optimal Sleep Scheduling, and Dynamic Sleep Scheduling and methods used in it which work with the WSN for saving the power of the sensor nodes and increase the lifetime of the network. Each method of sleep scheduling is used for enhancing the efficiency of the network and every technique having some drawbacks while maximize the lifetime of the network.

### *Balanced-energy Sleep Scheduling*

The sleep scheduling technique has been used to save energy of battery powered sensors. Rotating active and inactive sensor nodes in the cluster, some of the nodes which provide redundant data, is one way that sensor nodes can be intelligently managed to extend lifetime of the network. Some researchers [22] even suggest putting redundant sensor nodes into the network and allowing the extra sensors to sleep to prolong the lifetime of the network. This is possible by the low cost of individual sensors. When a sensor nodes are put into the sleep state, it completely shut down itself, leaving only one extremely low power timer on to wake up itself at a later time and power costs of both computation and communication activities were considered in the task allocation issues for wireless networked embedded systems with homogeneous elements. In order to enhance the lifetime of the network, the authors' aim is to balance the energy dissipation of the elements during each period of the application with respect to the remaining power of elements. We use a probabilistic method to balance the power consumption of the sensor nodes while maintaining the balance the power consumption of a large fraction of the sensor nodes in a cluster, we need to establish the sleeping probability of each sensor node according to its distance from the cluster head. However, unlike the DS method where the only criterion was to select the sleeping probabilities to reduce overall power consumption, the aim here is to ensure the average power consumption of a large number of the nodes is the same. Assuming that the nodes start with at the same initial energy, this will led into that these energy-balanced nodes run out of energy at the same time, thereby enhancing network lifetime while maintaining adequate sensing coverage. To attain this goal, we introduce and analyze the balanced energy Scheduling (BS) scheme. Redundant sensor nodes and using the extra sensor nodes to sleep to enhance the lifetime of the network. To balance the load in network which enhance the efficiency of the wireless sensor network.

***Limitations:***

1. While balancing load in the network which cannot pass data to long distance because some route needs more energy and some route needs less energy.

### *Optimal Sleep Scheduling*

A wireless sensor network whose nodes sleep periodically; however, instead of evaluating the system with a given sleep control mechanism, we impose a cost structure and search for an optimal mechanism amongst a class of mechanisms. In order to solve the problem in this method, we need to consider a simpler system than those used in the previous studies. Thus, we consider only a single sensor node and focus on the tradeoffs between power consumption and packet delay. Such as, we do not consider other QOS measures such as connectivity or coverage. The single node under consideration in our model has the option of changing its transmitter and receiver off for fixed durations of time in order to save energy. Doing so obviously results in additional packet delay. We attempt to identify the manner in which the optimal sleep schedule varies along with the length of the sleep period, the statistics of packets arrival, and the charges assessed for packet delay and power consumption.[16] This technique is used to reduce the communication delay. Optimal sleep scheduling enhance the lifetime of the network.

***Limitations:***

1.In this technique do not maintain the quality of service such as connectivity or coverage.

### *Dynamic Sleep Scheduling*

The dynamic sleep Energy conservation[17] is generally required while during periods with no activity and occurrence of events. Crucial issue is to reduce traffic overhearing since the transceiver consumes same energy for inactive listening as transmission. The overhearing can be reduced if nodes can find out when they are estimated to send and receive packets. To help energy savings during event occurrence, smart sleeping schedule can permit nodes to sleep for short interval when a node is neither transmitting nor receiving. Even though sleep-scheduling in sensor networks is an active area of research, scheduling to preserve energy for nodes shipping traffic has not received much consideration. MAC layer protocols that set nodes to low duty-cycle typically lead to minimum throughput and elevated event reporting latency. Some applications like event tracking, throughput and latency are also significant metrics in addition to energy saving. To preserve energy on nodes carrying traffic, TDMA based link scheduling is broadly studied to place nodes to idle while they are not transmitting and receiving packets. The per-packet scheduling is based on information gathered from all links. For the global synchronization excessive messaging is required which cause some delays in link scheduling. Diminishing the limitation of centralized scheduling, TRAMA suggested distributed scheduling at every node based on information gathered within a fixed range of hops. Though TRAMA can preserve energy, the conservative local coordination results in latencies that go beyond 100 times the latency of CSMA based approach. Thus TRAMA is helpful only in scenarios where latency and throughput are not the crucial metrics of performance, which is scarcely the case in most sensor networks. The part of this paper is an energy efficient MAC layer sleep scheduling protocol for sensor networks that sustain high through put as well as low latency.Avoiding packet loss while communication in the wireless sensor network. With dynamic sleep scheduling used with the MAC layer which enhance the high throughput.

***Limitations:***

1. Traffic controlling is very difficult.
2. Large network may cause data loss.

### *Delay Efficient Sleep Scheduling*

Wireless sensor networks (WSN) are estimated [9] to operate for months on small inexpensive batteries with average lifespan. Ultimate goal of these networks is energy efficiency. Existing works have identified idle listening of the radio which preserves more energy. Measurements on existing sensor device radios confirm that idle listening consumes merely the same power as receiving. In sensor network applications the traffic load is very light for most of the time, it is therefore enviable to turn off the radio when a node does not take part in any data delivery. The S-MAC medium access protocol introduced synchronized periodic duty cycling of sensor nodes as a method to reduce the idle listening energy cost. In S-MAC every node follows a periodic active/sleep schedule, coordinated with its neighboring nodes. During sleep periods, the radios are totally turned off, and while active periods, they are turned on to transmitting and receiving messages.

Even though the synchronized low duty cycle operation of a sensor network is energy efficient, it has one major drawback it maximizes the packet delivery latency. At a point of source node, a sampling reading might arise during the sleep period and has to be lined up until the active period. An intermediate node may have to wait till the receiver wakes up before it can forward a packet received. This approach offers some reduction in sleep latency at the expense of greater energy expense due to extensive activation and overhearing, but is not satisfactory for long paths. In a recent work, we look into an alternate approach to delay-efficient sleep scheduling, considered specifically for wireless sensor networks where the communication pattern is constrained to an established unidirectional data gathering tree. In this case, we illustrate that the sleep latency can be essentially eradicated by having a periodic receive-transmit-sleep cycle with level-by-level offset schedules, in which data flow in step by step from the leaves of the tree to the sink, with nodes going to idle as soon as they transmit their packets to the next level, and waking up in a minute to receive the next packets.While broadcasting in WSN, collision will not occur. Energy Consumption and delay in communication is reduced.

***Limitations:***

1. It is very complicated to minimize the Delay in communication while broadcasting the message.
2. Hard to retain latency parameter.

### *Wakeup on-demand (out-of-band wakeup)*

The nodes can be signaled and awakened at any time and then a message is sent to the node. This is can be implemented by applying two wireless interfaces. The first radio is used for communication and by the second ultra-low power radio which is used for only paging and signaling. Stem and its variation, and passive radio-triggered solutions are some examples of this class of wakeup techniques [6]. Although these methods can be optimal in terms of both delay and power, they are not yet to be practical. The cost problems, currently limited available hardware options which results in limited range and poor reliability, and stringent system requirements establish the wide use and design of wakeup techniques. Consequently, there is a need for efficient scheduled wakeup methods which are reliable and cost-effective and can also guarantee the delay and lifetime conditions. We are defining on the synchronous scheduled wakeup technique which provides bidirectional delay guarantees. We analyses the methods and introduce new efficient wakeup methods that perform well over the existing ones. We present a novel class of wakeup techniques called multi-parent schemes which assign multiple parents (forward nodes) with different wakeup schedules to each node present in the network. This technique takes a cross- layer approach and it exploits the existence of multiple paths between the nodes in the network to significantly enhance the energy efficiency of wakeup process and therefore maximize the network lifetime while meeting the message delay constraints. We derive the best-case, worst-case, and the distribution of delay for many existing and our new wakeup schemes process, and also characterize the trade-offs between energy consumption and it guaranteed the delay for different wakeup mechanisms [5].

*Table.4: Comparison of scheduling algorithms*

| **Scheduling Scheme** | **Time Latency** | **Co-Channel Interference** | **Time Synchronization needed** | **Communication Pattern Support** | **Adaptively to Change** |
|---|---|---|---|---|---|
| **Balanced-energy Sleep Scheduling** | Low | Yes | Yes | All | Good |
| **Optimal Sleep Scheduling** | Low | Yes | Yes | All | Good |
| **Dynamic Sleep Scheduling** | High | Yes | Yes | All | Good |
| **Delay Efficient Sleep Scheduling** | Low | Yes | Yes | All | Good |
| **Wakeup on-demand (out-of-band wakeup)** | High | Yes | Yes | All | Good |

## VII. CONCLUSION

WSNs emerges with many specific requirements for many new applications in the field of monitoring and control systems. With the advantage of cheap and compact sensors, monitoring systems can make use of them to monitor numerous environmental characteristics. All these applications are designed for specific purposes, and required to satisfy certain Qos parameterswhere achieving all these factors discussed in this paper is one of the most important challenges until now.

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