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Energy-Optimized Routing Protocols Survey in Wireless Communication

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ABSTRACT

Most wireless network devices today operate on batteries. Hence, power consumption becomes an important issue. To maximize the lifetime of wireless networks, the power consumption rate of each node must be evenly distributed, and the overall transmission power for each connection request must be minimized. These two objectives cannot be satisfied simultaneously by employing normal routing algorithms proposed in past years. In this paper, different energy-optimized routing protocols have been studied to design efficient energy-based routing schemes. The main contribution of this paper is to provide an exhaustive survey of the energy-optimized routing protocols for wireless sensor and mobile ad-hoc networks as well as their classification based on their energy efficiency metrics.

Keywords: **Energy Efficiency, Life time of wireless, Mobile Ad hoc Networks, Power consumption, Routing Protocols**

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I. Introduction

The wireless network is a combination of many nodes that have sensors, and controllers that are used to sense and monitor the data and the environment interaction. This helps in establishing connectivity between computing devices, individuals, and surroundings.

Ad hoc is an infrastructure-less wireless network that is deployed in a large number of wireless sensors and mobile ad hoc networks in an ad-hoc manner that is used to monitor the system and physical or environmental conditions. Sensor nodes are used in WSN with the onboard processor that manages and monitors the environment in a particular area. They are connected to the Base Station, which acts as a processing unit in the WSN system. The base Station in a WSN system is connected through the Internet to share data. WSN can be used for processing, analysis, storage, and mining of the data [1].

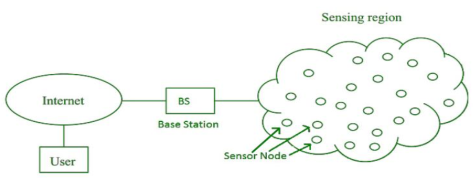

Figure 1: wireless sensor network

The main characteristics of wireless communication networks are:

- **Dynamic topology**: Nodes are free to move bout arbitrarily. In addition, radio propagation conditions change rapidly over time. Thus, the network topology may change randomly and rapidly over unpredictable times.
- **Bandwidth constraints and variable link capacity**: Wireless links have significantly lower capacity than wired links. Due to the effects of multiple accesses, multipath fading, noise, and signal interference, the capacity of a wireless link can be degraded over time and the effective throughput may be less than the radio's maximum transmission capacity.
- **Energy-constrained nodes**: Sensor nodes rely on batteries for proper operation. Since a sensor network consists of several nodes, the depletion of batteries in these nodes will have a great influence on overall network performance. Therefore, one of the most important protocol design factors is related to device energy conservation.
- **Multi-hop communications**: Due to signal propagation characteristics of wireless transceivers, ad hoc networks require the support of multi-hop communications; that is, mobile nodes that cannot reach the destination node directly will need to relay their messages through other nodes.

From the above-mentioned characteristics [2] a major concern is energy conservation due to the limited lifetime of sensor devices. Energy is a precious resource in sensor networks. For many multi-hop scenarios, nodes are battery-operated, thus requiring efficient energy management to ensure connectivity across the network. Numerous energy-aware routing protocols have been proposed using various techniques such as transmission power adjustment, adaptive sleeping, topology control, multipath routing directional antennas, etc. But most of the methods take into account routing metrics such as delay or hop count. They don't consider transmission energy cost and remaining battery energy. So, energy efficiency is directly proposed to network lifetime or network capacity. The main contribution of this paper is to provide an exhaustive survey on the energy-optimized routing protocols for wireless communication networks as well as their classification based on their energy efficiency into three main categories: Power control metrics, Remaining battery power, and multipath routing with reliability. We focus on the techniques these protocols use to route messages, taking into consideration the energy they consume and how they minimize this consumption and extend the lifetime of the network.

A Mobile Ad hoc Network (MANET) is a system of wireless mobile nodes that dynamically self-organize in arbitrary and temporary network topologies. A set of wireless mobile hosts dynamically establish their own network on the fly, without relying on any pre-existing communication infrastructure [3]. But this open network architecture and dynamic network topology are prone to be attacked internally and externally.

Moreover, we discuss the strengths and weaknesses of each protocol providing a comparison among them including some metrics (scalability, mobility, power usage, route metric, periodic message type, robustness) for researchers and practitioners to understand the various techniques and thus helping them to select the most appropriate one based on their needs.

Challenges in wireless communication networks:

1. Quality of Service (QoS):

Quality of service is the level of service provided by the networks to its users. Wireless networks are being used in various real-time and critical applications, so the network must provide good QoS. However, it is difficult because the network topology may change constantly and the available state information for routing is inherently imprecise. Wireless networks need to be supplied with the required amount of bandwidth so that they can achieve a minimal required QoS.

2. Limited processing and storage capabilities:

Nodes in a WSN and MANET are typically small and have limited processing and storage capabilities. This makes it difficult to perform complex tasks or store large amounts of data.

3. Security:

Wireless networks are vulnerable to various types of attacks, such as eavesdropping, jamming, and spoofing. Ensuring the security of the network and the data it collects is a major challenge.

4. Scalability:

Wireless networks often need to be able to support a large number of sensor nodes and handle large amounts of data. Ensuring that the network can scale to meet these demands is a significant challenge.

5. Reliability:

Wireless networks are often used in critical applications such as monitoring the environment or controlling industrial processes. Ensuring that the network is reliable and able to function correctly in all conditions is a major challenge.

6. Interference:

Wireless networks are often deployed in environments where there is a lot of interference from other wireless devices. This can make it difficult to ensure reliable communication between sensor nodes.

II. Energy Efficient Route Selection Policies

Energy efficiency is a critical issue in wireless networks [4] [5] [6]. The existing energy-efficient routing protocols often use residual energy, transmission power, or link distance as metrics to select an optimal path. In this section, the focus is on energy efficiency and the route selection policies with novel metrics to increase the path survivability of wireless networks.

The nodes used in a wireles network are resource-constrained, they have a low processing speed, a low storage capacity, and a limited communication bandwidth. Moreover, the network has to operate for long periods, but the nodes are battery-powered, so the available energy resources limit their overall operation. Another important characteristic is that nodes have significant processing capabilities in the ensemble, but not individually. Nodes have to organize themselves, administering and managing the network all together, and this is much harder than controlling individual devices.

Furthermore, changes in the physical environment, where a network is deployed, make also nodes experience wide variations in connectivity thus influencing the networking protocols. The main design goal is not only to transmit data from a source to a destination but also to increase the lifetime of the network. This can be achieved by employing energy-optimized routing protocols. Depending on the applications used, different architectures and designs have been applied in wireless networks. However, the operation of the protocol can affect the energy spent for the transmission of the data. There are some terms related to the energy efficiency on sensor networks [7] that are used to evaluate the performance of the routing protocols are as follows:

- **Energy per Packet:** This term is referred to the amount of the energy that is spent while sending a packet from a source to a destination.
- **Energy and Reliability**: It refers to the way that a tradeoff between different application requirements

is achieved. In some applications, emergency events may justify an increased energy cost to speed up the reporting of such events to increase the redundancy of the transmission by using several paths.

- is effectively determined by its battery life. The main drainage of the battery is due to transmitting and receiving data among nodes and the processing elements.
- **Average Energy Dissipate:** This metric is related to the network lifetime and shows the average dissipation of energy per node over time in the network as it performs various functions such as transmitting, receiving, sensing, and aggregating of data.
- **Low Energy Consumption:** A low-energy protocol has to consume less energy than traditional protocols. This means that a protocol that takes into consideration the remaining energy level of the nodes and selects routes that maximize the network's lifetime is considered as low energy protocol.
- **Distance:** The distance between the transmitter and receiver can affect the power that is required to send and receive packets.

The selection of energy-optimized protocols in wireless sensor networks is a critical issue and should be considered in all networks. The main objective of current research is to design energy-optimized routing protocols that could support various aspects of network operations. So, techniques and protocols that would consider energy efficiency and transmit packets through energy-optimized routing protocols thus prolonging the lifetime of the network, are required. The potential task of the protocols is not only to find the lowest energy path from a source to a destination but also to find the most efficient way to extend the network's lifetime. The continuous use of a low-energy path frequently leads to energy depletion of the nodes along this path and in the worst case may lead to network partition.

III. Challenging Factors Affecting the Energy-Efficient Routing Protocols Design Issues:

Wireless sensor networks, despite their innumerable applications, suffer from several restrictions concerning, mainly limited energy deposits, limited processing power, and limited bandwidth of the wireless links connecting mobile nodes. One of the most significant design goals is to go through data communication while trying, at the same time, to contribute to the longevity of the network and to preclude connectivity in a basement through the use of aggressive energy management techniques. The design of energy-efficient routing protocols [8] is influenced by many factors. These factors must get over before efficient communication can be achieved in sensor networks. Here is a list of the most common factors affecting the routing protocols design:

- *Node Deployment*
- *Node/Link Heterogeneity*

- **Network Lifetime**: It is important to maximize the network lifetime, which means to increase the network survivability or to prolong the battery lifetime of nodes. Moreover, the lifetime of a node

- *Energy Consumption without Losing Accuracy*
- *Scalability*
- *Network Dynamics*
- *Fault Tolerance*
- *Connectivity*
- *Transmission Media*
- *Quality of Service*

Because of all these disparities, several new routing mechanisms have been developed and proposed to solve the routing problem in sensor networks. A highly efficient routing scheme will offer significant power cost reductions and will improve network longevity. Finding and maintaining routes in wireless network is a major issue since energy constraints and unexpected changes in node status (e.g., inefficiency or failure). Routing techniques proposed in the literature for wireless sensor networks employ some well-known routing tactics, suitable for sensor networks to minimize energy consumption.

IV. Energy optimizing routing protocols:

In this section, the literature survey of energy-efficient routing techniques is discussed to extend the lifetime of the network.

MTRP: MTPR (Minimum Total Transmission Power Routing) finds the path with the minimum power consumption. MTPR considers the SNR (signal-to-noise ratio) and sets a threshold (BER, Bit Error Rate) to select a path in which each link in the selected path satisfies, where SNR is the signal-to-noise ratio; i and j are the sending and the receiving nodes, respectively; Pi is the transmitting power of the sending node; Gi,j is the enhancement of the link between nodes i and j; μ_j is the noise detected by the receiving node; k is a neighboring node of the receiving node; and β_j is the threshold BER. A sending node can determine the minimum power necessary to transmit packets to minimize power consumption.

To find the path with the minimum power consumption, MTPR collects all the paths in which each link in a path satisfies SNR and P_l, where Pl is a path in which each link satisfies SNR. Accordingly, MTPR selects from all paths the one path that consumes the minimum power, as shown in $P(r_0)$

$$SNR = \frac{P_i G_{ij}}{\sum_{k \neq i} P_k G_{k_j} + \mu j} > \beta(BER) \quad (1)$$

$$P_1 = \sum_{i=0}^{d-1} P(n_i n_{i+1})$$

$$for\ all\ node\ n_i \in route\ l \quad (2)$$

$$P(r_0) = \min_{l \in r*} P_l \quad (3)$$

MTPR causes the nodes in the routing path to use less transmission power to reduce power consumption [9]. However, the decreased transmission power is significantly related to the threshold; that is, if the threshold is too high, a path in which the links satisfy SNR may not be found. If the threshold is too low, the decreased transmission power may result in poor transmission bandwidth, resulting in increased transmission delay and power. With power control, a receiving node can easily move out of the communication range of a sending node, leading to path breakage because of the mobility of the nodes.

MBCR: The Minimum Battery Cost Routing (MBCR) [10] takes into account the remaining power of nodes to prolong the network lifetime by selecting one path with the maximum remaining power from all available paths. To find the path with the maximum remaining power, MBCR calculates the sum of the remaining power of each node in a path, using

$$fi(t) = \frac{1}{Ci(t)} \quad (4)$$

$$B(r_d) = \sum_{i=0}^{d} f_i(t) \quad (5)$$

$$B(r_0) = \min_{rd \in r*}\left(B(rd)\right) \quad (6)$$

where *Ci(t)* is the remaining power of node *i* at time *t* and *B(rd)* is the sum of the inverse of the remaining power of nodes in path d. MBCR uses Eq.(6) to select from set *r** of all paths the path *B(ro*) with the maximum remaining power. Although MBCR uses the inverse of the remaining power of the nodes in a path to select the desired path, the selected path may have a node with low remaining power. This may cause path breakage during data transmission. xMBCR [11], which is an improved version of MBCR and MMBCR, has higher network lifetime than MBCR and MMBCR. xMBCR modifies the battery cost function of MBCR, as shown in

$$f_i(t) = \left(\frac{1}{c_i(t)}\right)^P \quad (7)$$

where *Ci(t)* is the remaining power of node *i* at time *t* and *p* is a constant. When *p* is 1, the battery cost function of xMBCR is equal to the one of MBCR. In addition, when *p* is equal to zero, xMBCR can find the shortest routing path. When p grows, the behavior of xMBCR is more and more similar to MMBCR. When p is approaching to an infinite quantity, xMBCR is almost equal to MMBCR. Therefore, with the adjustment of the p value, xMBCR has higher network lifetime than MBCR and MMBCR.

MMBCR: The Min–Max Battery Capacity Routing (MMBCR) [12] selects the path in which the minimum remaining power of nodes in this path is greater than the maximum remaining power in other paths, using

$$P_{MMBCR} = \min_{R \in S}\left[\frac{1}{BCn}\right] \quad (8)$$

where *S* is the set of all paths, *R* is a path, and *BCn* is the remaining power of node n. In MMBCR, a routing path that contains a node with low remaining power can be avoided. However, MMBCR does not take transmission power into account.

To solve this problem, Condition Min–Max Battery Capacity Routing (CMMBCR) [13] which considers both the power consumption during data transmission and the remaining power of nodes, was proposed. Taking into account the transmission power and the remaining power, CMMBCR combines MBCR and MMBCR. CMMBCR has a pre-defined threshold for the remaining power of nodes. When the remaining power of a node is greater than the threshold, the MTPR protocol is used to reduce power consumption. However, when the remaining power of nodes is less than the threshold, the MMBCR protocol is used to prevent nodes with low remaining power from becoming a part of the routing path.

MMPR: The Minimizing the Maximum Used Power Routing (MMPR) [14] selects the path that has minimum power consumption for data transmission by finding all the routing paths from a source node to a destination node and calculating the power consumed by each path. In addition, MMPR also takes into account the power consumption of each node to balance the total power consumption, so the result is network lifetime is increased. In the path discovery phase, MMPR computes the power consumption of each node for data transmission to obtain the total power consumption of a routing path using

$$B(r_0) = \min_{rd \in r*}\left(B(rd)\right) \quad (9)$$

where *B(rd*) is the power consumption of path *rd* and *r* is the set of all paths. Concerning the balance of power consumption of the nodes, MMPR computes the "loading value" of a node by taking into account the remaining power, transmission power, receiving power, overhearing power, and threshold value. If the loading value of a node is larger than that of another node, then the node consumes more power. To balance the power consumption of nodes in a network, a node with a high loading value has a low probability of being a part of the routing path. In MMPR, although the power consumption for data transmission and the balance of power consumption among nodes are taken into account, the result depends on the threshold value. If the threshold is too high, the routing path may be difficult to construct. By contrast, if the threshold is too low, the effect of balancing the power consumption may not be obvious. Channel contentions and transmission bandwidth are not considered in MMPR.

LEACH: LEACH is the low-energy adaptive clustering Hierarchical Routing Protocol. The whole network area is divided into multiple clusters. Every cluster consists of multiple no. of sensor nodes, one sensor node will be designated as CH, and all other sensor nodes existed in that cluster become member nodes. Member nodes transfer data to CH, and CH forward collected data to BS after performing aggregation process. CHs perform as an intermediate node between member nodes and BS. Due to additional duties, CHs dissipate more energy as compared to normal nodes. The main aim of this protocol is to keep the balanced weightage among all the needs. This process is maintained with

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1. Sink 2.Cluster Head 3.Cluster Node In terms of operations, a LEACH protocol consists of two stages, which are set-up and Steady-state. LEACH protocol is fully performed by a Distributed algorithm. LEACH algorithm is denoted by the following Equation [15]

$$T(n) = \begin{cases} \frac{P}{1-P[r*mod(1/P)]}, & if\ n \in G \\ 0, & otherwise \end{cases} \quad (10)$$

It reduces energy consumption by insignificant the communication rate between sensors and their cluster Heads and turning off non-head nodes as much as possible.

PEGASIS: Power-Efficient Gathering in Sensor Information System is one such hierarchical routing protocol that follows a chain-based approach and a greedy algorithm. The sensor nodes organize themselves to form a chain. If any nodes die in between then the chain is reconstructed to bypass the dead node [16].

The main process in the PEGASIS protocol is for nodes to receive from and transmit to close neighbors and take turns being the leader for the transmission of data to BS (Base Station). This approach distributes the energy load evenly among the sensor nodes. The nodes randomly placed in the field, organize themselves in the form of a chain using a greedy algorithm. Alternatively, BS computes this chain and broadcasts it to all the nodes [17].

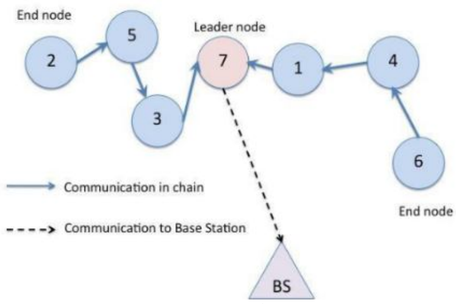

Figure 2: The process of PEGASIS Protocol

PEGASIS protocol has its main application in characterizing and monitoring the quality of environments.

Energy Efficient LEACH protocol: LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. In LEACH, the nodes organize themselves into local clusters with one node acting as the local base station or cluster head [18]. Energy Efficient LEACH protocol using Network coding (EENC-LEACH) is designed to enhance the network lifetime of WSN by addressing the energy issues of sensor nodes. Initially, the EENC-LEACH protocol forms the clusters based on the energy level and its drain rate.

A cluster head is elected for each cluster to minimize the energy dissipation of the sensor nodes and to optimize resource utilization. The energy-efficient path selection can be obtained by nodes that have the maximum residual energy. Hence, the highest residual energy nodes are selected to forward the data to BS. It helps to provide a better packet delivery ratio with lesser energy utilization.

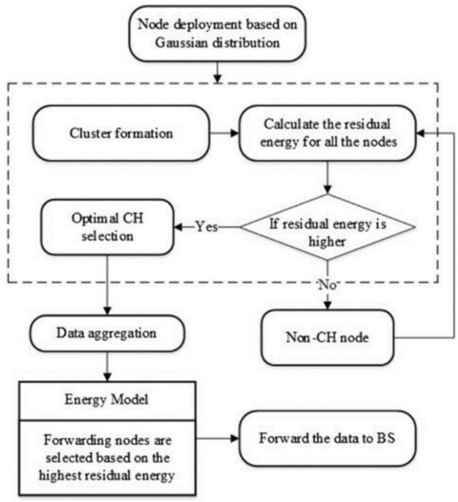

Figure 3: EE- LEACH Protocol Flow chart

The EE-LEACH protocol results in a better packet delivery ratio, lesser energy consumption, and lesser E2E delay than the EBRP and LEACH protocol [19].

HEED Protocol: HEED is a Hybrid, Energy Efficient Distributed protocol that Widnes the LEACH protocol with balanced energy and node degree as a metric for cluster selection to achieve power balancing. It executes in multi-hop networks, using an adaptive transmission power in the inter-clustering communication. HEED protocol proposed the following four main things that are

- Prolonging network lifetime by speeding energy consumption.
- Ending the clustering process with stable numbers of iterations.
- Insignificant control overhead, and
- Producing well-distributed CHs and compute clusters [20].

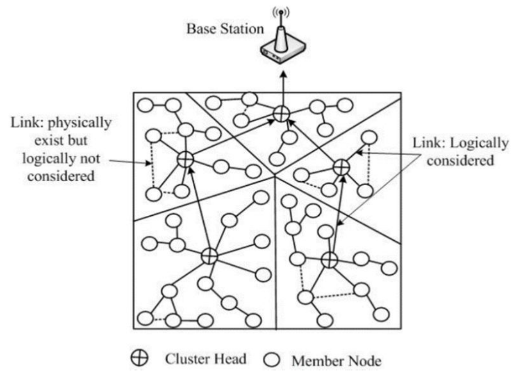

Figure 4: HEED Protocol Process

This protocol improves network lifetime compared to LEACH clustering as LEACH particularly selects CHs, which results in faster death of some nodes. The last CHs selected in HEED are well-distributed crossways of the network and the communication cost is reduced.

LEACH -Centralized: The LEACH-centralized protocol for WSN is an improved version of the LEACH protocol. It adds a centralized control component,

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commonly known as the “Master” or “sink”, to monitor and enhance the cluster creation procedure. During the set-up phase, each node sends information about the current location and energy level to the base station (BS) [21]. BS will determine the

- Cluster
- CH node and
- member nodes of each cluster.

The BS utilizes the global information about the network to produce a better cluster that requires less energy for data transmission. Their protocol plays a significant role in selecting cluster heads based on elements such as

*Node Energy

*Communication quality and proximity to the sink [22].

LEACH-C is a cluster-based protocol in which cluster heads are selected by the base station randomly. All the nodes having the energy above average are eligible to be cluster heads. The base station runs a simulated annealing algorithm to find the optimal solution with better positions to reduce the energy consumption of cluster heads.

Multi-hop LEACH protocol: MH-LEACH protocol establishes a multi-hop communication between cluster heads and the base station in the network. It is a distributed clustering-based routing protocol setup phase like LEACH.

In the steady-state phase, CH collects data from all member nodes and transmits the aggregated data directly or indirectly through other CHs to the BS. In MH-LEACH, each cluster head has enough energy and is turned toward the Base Station. If a cluster head cannot send a message to another one. It will try to find another cluster head based on the information contained in its Routing Table. After examining the candidate cluster head nodes, it selects those with maximum residual energy and then calculates the quadratic sum of the distances from each cluster head to its member nodes to find the optimal solution.

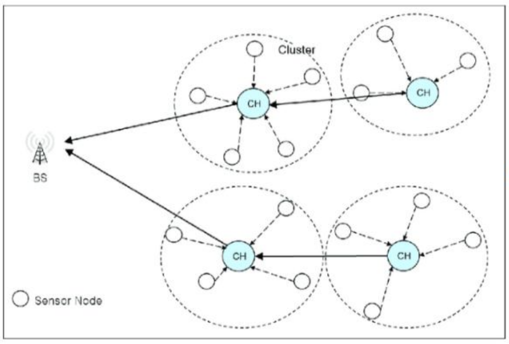

Figure 5: Multi-hop LEACH Protocol

There are two different types of possible communication in MH-LEACH

i) Inter-cluster communication
ii) Intra-cluster communication

The algorithm selects the best path with a minimum hop count between the CH and BS [23].

Assisted LEACH (A-LEACH): Assisted LEACH (A-LEACH) archives a lessened and uniform distribution of dissipated energy by separating the tasks of routing and data aggregating. It introduces the concept of Helper Nodes which assist cluster heads for multi-hop routing [24]. In cluster member nodes send collected data to CH, and CH forwards accumulated data to the next helper node, and soon. The last helper node forwards collected data to BS. To assign timeslots, Time Division Multiple Access (TDMA) schedules are used by CHs [25].

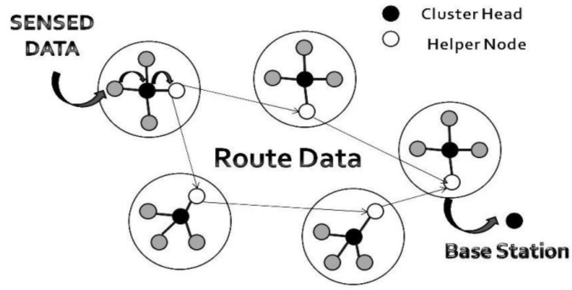

Figure 6: The Process A-LEACH Protocol

AS only helper node is involved in routing process with other cluster and BS, during routing phase, all sensor nodes remain in sleeping mode except helper node which minimizes energy dissipation.

TEEN: TEEN is a reactive clustering routing protocol that is improved by LEACH. TEEN approved Threshold Sensitive Energy Efficient Sensor network protocol which groups different sensor nodes into clusters with each having CH. The cluster Head (CH) of each cluster collects data from its cluster members. CHs fuse and process data and send data to the BS or high-level CH. All of the nodes only need to transmit data to their CH. Only the CHs need to aggregated data which is the main energy saving process in this protocol. All nodes take turns becoming the CH in order to evenly distribute the energy consumption [26].

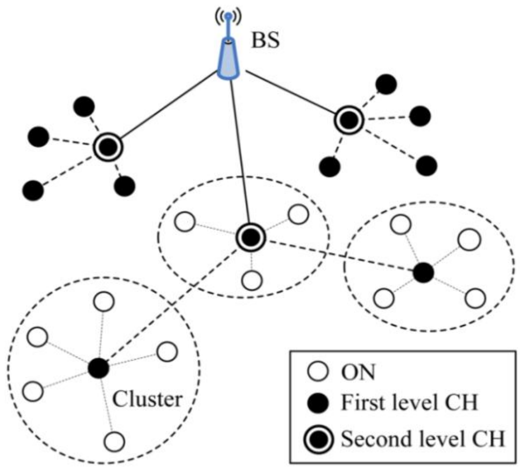

Figure 7: TEEN Protocol Overview

In TEEN the cluster Head development procedure depends on LEACH. In the TEEN routing protocol, CHs broadcast HT and ST to their members to control the quantity of data transmission [27].

- HT Hard Threshold: HT is the minimum possible value of an attribute. When the process meets the condition SV > HT, communication will start between nodes to the Cluster Head for transfer to the sensed node. Here SV is the sensed value used to store the value of the sensed attribute value.
- ST Soft Threshold: ST represents small interval values to prevent a node from communicating when no minor changes occur. It reduces the frequency of data transmission by abandoning little changes in sensed attributes. The value of ST can be changed according to the needs of the user.

TEEN has high cluster stability, small delivery delay, good load balancing, and very high energy efficiency.

REAR protocol: Reliable energy-aware routing protocol considers the residual energy capacity of each sensor node in establishing routing paths and supports multipath routing protocol for reliable data transmission. This protocol allows each sensor node to confirm the success of data transmission to other sensor nodes by supporting the DATA-ASK-oriented packet transmission. REAR considers the current energy levels of sensor nodes when it establishes routing paths from source to destinations, the process of this protocol is considered as i) The source node broadcasts a multipath route request message (MREQ) to find a routing path for a destination node. ii) The next nodes having received the MREQ msg continuously forward it after checking their energy value [28]. REAR guarantees the disjoint Ness between the first route and the second route for satisfying robust network topology.

IZ-SEP Protocol: IZ-SEP is extended for Improved Zonal Stable Election Protocol SEP is based on weighted election probabilities of each node to become cluster head (CH) according to the remaining energy in each node. SEP is a WSN protocol that assumes heterogeneity in a network, making it the basis for prolonging the stability period in a hierarchically clustered. SEP and Zonal SEP are types of proactive routing protocols, where nodes in these protocols sense and transmit the data continuously.

In IZ-SEP, normal nodes follow the direct communication method to send data to BS. Whereas advanced nodes follow the clustering techniques and elect CHs then CHs collect data from their member nodes and aggregate it as well as send it to the BS. The IZ-SEP protocol considers the residual energy of each node and the number of neighbors of each node within the cluster range during CH selection [29].

In IZ-Sep network area is divided into two zones, that are zone1 and zone2. Zone 1 has normal nodes that are equipped with less energy than advanced nodes are located while only advanced nodes are placed in zone 2. This protocol has two types of communication which are *Direct Communication *Communication via cluster Head. A node with higher residual energy and more neighbors has more chance to be selected as CH. The result of this protocol extends the life span of the sensor network over the existing parent protocol and also increases the network stability.

EEMCL protocol: Energy Efficient Multipath Clustering with load balancing Routing protocol abbreviated EEMCL. The protocol which segments the network into layers of clusters, would be implemented using multi-hop. Sensing data from the sensor is transmitted to the sink by the main cluster heads in each layer, cooperating with the cluster heads in the upper layer[30]. This protocol uses cluster-based routing with multi-path routing protocols to decrease energy consumption without sacrificing network performance. The main cluster head (MCHs) for each cluster has been preselected with more energy than normal sensor nodes, and two secondary cluster head nodes (SCHs) are selected in each round based on distance and residual energy.

- Intra-cluster multipath (or) single-path routing is built based on distance and residual energy.
- Inter-cluster multipath routing is established based on residual energy. This maximizes the network lifetime and improves energy dissipation and network stability.

BSMH protocol: A new geographic routing protocol for WSNs is named the load-balanced and constant stretch protocol for bypassing multiple holes in WSNs. The unique feature of BSMH design is jointly considering three essential factors, which are minimizing the routing path length, minimizing control overhead, and maximizing load balancing [31]. Before forwarding data, we need some setup phases that help to determine the hole as well as the core polygons and broadcast their information to the surrounding nodes. The load balance is evaluated by the maximum packet forwarding ratio which is the maximum ratio of the number of packets sent. In general, the smaller maximum packet forwarding ratio reflects a better load balance. If the load is balanced energy is optimized.

VGRP: The virtual Grid Routing Protocol algorithm splits the area that involves sensor nodes into a grid of sub-cells with equal size then collects the sensed data using cluster and chain techniques. The problem of load balancing happens when a group of sensor nodes is repeatedly selected to operate as a cluster head. The CH would be responsible for receiving and aggregating the sensed data from all cluster members and then forwarding the aggregated data either to the BS or the next cluster head based on the routing mechanism. Therefore, the cluster head consumed more energy compared to the energy consumed by a normal cluster member [32].

So, the VGRP protocol tries to keep the robustness and validity of WSN as long as possible by balancing the load evenly among all sensor nodes. This protocol distributes the duty of being a group head(chain/cluster) by taking into consideration its remaining energy. The algorithm of the VGRP can be divided into two main stages

- Virtual Grid Setup – > The network topology is initialized based on dividing the sensing field into a virtual grid topology with equal-sized

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cells. The field axes are equally divided and numbered according to the number of cells, which are located along each field axis.

- Data transmission-> To collect, aggregate, and send the sensed data to the BS nodes called cell heads and chain heads act as intermediators between non-need nodes and the base station.

IGRP: Interior Gateway Routing protocol is a type of routing protocol used for exchanging routing table information between gateways (commonly routers) within an autonomous system (Local Area Network). IGRP uses a maximum hop count of 100 by default**,** meaning that any destination beyond 100 hops is considered unreachable. IGRP allows network administrators to set a maximum hop count (255) for each network, which can be customized based on the network topology. A higher hop count limit allows packets to reach more remote networks but increases the time required to route the packets and Routing updates may use a substantial amount of bandwidth since the whole routing database is delivered whenever the state of a connection changes. Routers are prone to routing loops, these processes take some energy, which will affect the energy consumption of the protocol [33].

The IGRP has two board classification

- Distance Vector Protocol

  Uses the Bellman-Ford algorithm which calculates the shortest path from a single node considering the negative edge weights. Data is forwarded using the best path selected from the routing table.

- Link state Routing protocol

  Uses the Dijkstra algorithm and provides the best path from source to destination in the form of three routing tables [34].

One of the main advantages of IGRP is its ease of use and configuration. IGRP is relatively easy to set up and configure, making it a good choice for small to medium-sized networks. Additionally, IGRP has lower bandwidth usage compared to other routing protocols, making it ideal for networks with limited bandwidth. IGRP also supports unequal-cost load balancing, which allows routers to use multiple paths to reach a destination, improving network efficiency.

VRRP: Virtual Router Redundancy protocol could offer the energy and load balancing for the problem of a single point failure under configuring the default routers. As the best choice for improving high availability, the routers running VRRP work as virtual gateway equipment with a virtual IP address. When one of these routers has problems that do not break off the communication, the problem with single-point failure has been solved [35]. The process of VRRP is performed with the following two types of modes. Preemptive Mode: when a backup receives a VRRP advertisement, it compares the priority in the packet of the master router with its priority, A VRRP group always has a router with the higher priority as the master for packet forwarding to the destination.

Non-Preemptive Mode: A router in the VRRP group remains a master/ backup router as long as the master does not fail due to some reason. A backup doesn't become the master even if it is configured with a higher priority because the non-preemptive mode helps avoid frequent switchover between the master and backups [36]. If the timer of a backup expires but the backup still does not receive any advertisement from the master, it is considered that the master fails. In such a case, the backup considers itself the master router and sends VRRP advertisements to all the other routers to start a new master selection.

EESAA: The Energy Efficiency Sleep Awake Aware Protocol is used to improve the CHs selection techniques by choosing CHs according to the remaining energy of the nodes. The nodes switch alternatively to sleep and active modes to minimize power consumption. For that nodes transmit their location information as node identifier, to the BS, after locating their position by GPS, the base station calculates the mutual distance between the nodes. Nodes switch from “Sleep” mode to “Awake” or “Active” mode during a single communication interval [37].

In the network configuration phase, the optimal number of CH is selected using a distributed algorithm. Initially, all nodes have the same energy. The selection of CHs after the first round is based on the remaining energy of each node. Nodes in active mode participate in the CH selection process. In the data transmission state, all nodes in active mode transmit their detected data to CH during their TDMA-assigned slots. Nodes in sleep mode are not affected by the transmission phase. EESAA protocol improves the performance of clustering algorithms in terms of stability period, network lifetime, and throughput for the WSN network.

The demand of multimedia video streaming services in MANET is expected to significantly grow in the next years. Video streaming services require the provisions of Quality of Service (QoS) and Quality of Experience (QoE) are the qualitative measures of the videos have to be delivered over wireless communication networks, but QoE reflects the user perception. Numerous multipath routing protocols get attention and are a promising technique for video delivery in MANET. Recent research demonstrates that it supports reimbursement such as robustness, load balancing, energy efficiency and increased throughput and so on [38].

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V. Comparisons of energy-efficient routing protocol schemes:

This section provides a qualitative and theoretical comparison of above mention energy-efficient routing protocols to extend the lifetime of the node in MANETs. The key differences among the routing protocols lie in the method of energy factor estimation and the decision on route selection based on energy cost for transmission, residual battery energy, link reliability and number paths selected for transmission, routing overheads, and scalability.

Table 1: Energy-Efficient Routing Protocol Comparison

Routing Protocol Scheme	Route metric	Route Discovered	Scalability	Routing Overhead
MTPR	Signal to noise ratio & Bit error rate is considered	Single	Low	High
MBCR	Nodes with high remaining power and transmission cost is considered	Single	Low	High
MMBCR	Paths with high remaining battery energy is selected	Single	Limited	High
MMPR	Based on the Load value of the node power consumption is taken into account	Single	Limited	High
LEACH	energy is equally divided among all the sensor nodes in the network, CH node periodical changes reduce the network lifetime.	Single	Good	High
PEGASIS	a chain cluster-based routing protocol, reconstructed to bypass the dead node, monitoring the quality of environments.	Single	Low	High
EE-LEACH	a CH is elected for each cluster to minimize energy dissipation, better packet delivery ratio, and lower energy consumption.	Multiple	Good	High
HEED	balanced energy and node degree as help to achieve power balancing, MH networks, and communication cost is reduced.	Multiple	Good	High
C-LEACH	a centralized control component requires less energy for data transmission.	Multiple	Good	High
MH-LEACH	The Routing Table contains all information and selects the best path with a minimum hop count	Single	Good	High
A-LEACH	Helper Nodes which assist cluster heads for multi-hop routing, minimize energy dissipation.	Single	Good	High
TEEN	Data transmission controlled by thresholds it is provides high cluster stability, small delivery delay, good load balancing	Single	Limited	High
REAR	Low energy nodes are excluded and provide a backup path with less routing overhead	Multiple	Limited	Low
IZ-ZEP	considers the residual energy and the number of neighbors of each node, extends the life span, increases the network stability	Single	Good	High
BSMH	minimizing the routing path length, minimizing control overhead, and maximizing load balancing, the smaller maximum packet forwarding ratio reflects a better load balance	Multiple	Good	High
VGRP	chain techniques used to collect sensed data, the protocol distributes the duty being cluster head, considering its remaining energy	Multiple	Limited	Low
IGRP	exchanging routing table information, routers to use multiple paths to reach a destination, improving network efficiency	Multiple	Good	High
VRRP	virtual gateway equipment with a virtual IP address. that do not break off the communication single-point failure has been solved	Multiple	Good	High
EESAA	Nodes to sleep and active modes to minimize power consumption, which improves the performance in terms of stability period, and network lifetime.	Single	Good	High

VI. Conclusion:

This paper has been specifically focused on energy-optimized wireless communication routing protocols based on their characteristics and route metrics. To extend the network's lifetime, scalability and energy consumption we must consider and employ the energy-optimized or energy-efficiency routing protocols. In his survey, we summarized the energy-optimized protocols based on SNR, BER, inverse of remaining energy, Battery cost function, chain-based approach, EENC Network Coding, Routing table information, Helper Nodes, weighted election probabilities, distributed algorithm metrics for efficient path selection process. Hence the protocols are evaluated and compared on Route metric to achieve scalability and minimize routing overhead.

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