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A Survey in Energy Efficient Multipath Routing Protocols for Wireless Multimedia Sensor Networks

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ABSTRACT

This study investigated the most important routing protocols proposed for constrained networks, such as Wireless Sensor Networks (WSNs) and Wireless Multimedia Sensor Networks (WMSNs). Wireless Sensor Networks and Multimedia Sensor Networks applications are growing in popularity due to the miniaturization of hardware and the availability of low-cost, low-power sensors. Each application has its own set of service quality and experience specifications. The lifetime of WMSNs is significantly limited because of the depressed energy of their sensor nodes. As a consideration, the most important scientific challenge for WMSNs is energy saving. In a WMSN, radio communication absorbs the most resources. To extend the lifetime and saving energy for WMSNs sensor nodes, energy-efficient multipath routing is required. As a result, several energy-efficient multipath WMSN routing protocols have been proposed. However, because of the traffic's sophistication, as well as its inherent features, demands, and constraints, the survey finds that current routing methods for wireless multimedia sensor networks still have bottlenecks.

Index Terms – Wireless Multimedia Sensor Network (WMSNs), Wireless Sensor Networks (WSNs), Multipath Routing, Load Balancing, CBMRP, HMPR.

1. INTRODUCTION

WSNs traditionally include low- cost sensors capable of detecting scalar physical phenomena (temperature and pressure) and the ability to send these data via wireless transmission, which in turn makes them distinct from sensor networks (e.g., sensors) that are only capable of measuring one physical property (location and motion) [1]. new applications in the latest years thanks to microelectronics and wireless communications, cheap CMOS cameras, and microphones, as well as a wide-spread use of multimedia sensors and networks has allowed promising new wireless multimedia sensing networks to develop (WMSNs). Most researchers envisioned that the performance of WSNs would greatly benefit from the implementation of multimedia sensors, which gather audio, video, image, and scalar data in addition to enhancing current applications such as smart homes, intrusion detection, multimedia surveillance, person locator services, environmental monitoring, and telemedicine service. More is required of multimedia than expected. Not only does this include finding a route that provides maximum efficiency, but optimizing the whole path, finding good delivery ratios given the dynamic network structure, and routing to meet application requirements, such as, end-to-end delay, packet delivery ratio, and data rates. There have previous studies that have discussed the unique characteristics of WSNs and WMSNs [2], [3].

Most WMSN multimedia applications necessitate the development of efficient mechanisms for the transportation of multimedia of the overall bandwidth along with specifications for a specific level of quality of service. Because data-sets are large, they quickly drain the battery even when gathering simple information, and cannot be used to determine the energy levels; thus, only essential data should be gathered from nodes that have battery-supplied sensors.

Wireless sensor networks have different techniques for how they are connected and how they are distributed, which is leads to the development of multiple routing protocols (WSNs). Because of their relatively slow speed and a small range, using conventional routing protocols is not feasible for transmitting Contents of multimedia, such as Streams of audio and video in WSNs. The QoS specifications "load-balancing, packet loss, and reliability" that have been implemented to WMSNs have also influenced the development of a more recent set of routing protocols. However, energy consumption is always an issue in WMSNs for transmitting multimedia content [4].

Routing is defined as the method of determining the route from sender nodes to receiver nodes. The routing process is much more difficult in WMSNs, because of the constraints of available energy, processing capabilities, and the critical needs for the majority of sensor networks. Compared to traditional WSN applications, multimedia applications, which transmit a significant amount of data, so sensor nodes for WMSNs consume more power than traditional sensor nodes for WSNs, resulting in the network's battery life for nodes being depleted and thereby making them ineffective. When sensor nodes die early, network efficiency and QoS specifications become inefficient. To improve the QoS while conserving energy, it is critical to find a routing protocol that meets the QoS requirements [4].

1.1. WMSNs Architecture

There are three types of model architectures for WMSNs (single-tier flat architecture, single-tier clustered architecture, and multi-tier architecture). In a single-tier flat architecture, all sensors are fitted with equivalent detecting for environment and processing capabilities. Every sensor node in this architecture gathers, processes, and transmits multimedia data straight to the base station (BS). A single-tier flat architecture has many advantages, including ease of maintenance, low power consumption, and management. Nodes are probably to drain their available resources because they have similar capabilities. Figure 1 shows a model of a single-tier flat architecture [5].

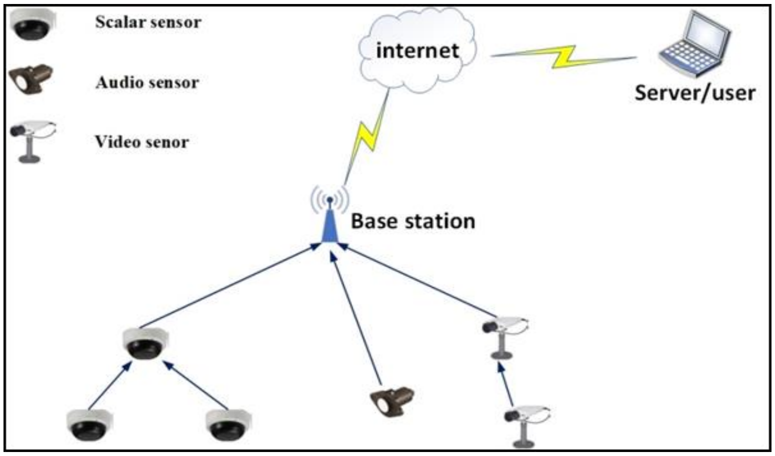

Figure 1 A Single-Tier Flat Architecture

In a single-tier clustered architecture, sensor nodes with different capabilities such as buffer size, energy, and communication range, which are used for transmitting Contents of multimedia, such as Streams of audio and video to a cluster head that the sensor nodes choose or that preselected by in-network model. If every sensor node in the network could sense, process, and transmit data, the network's lifetime will be quickly depleted, which is why cluster heads are used. Scalability, high bandwidth use, long network lifetime, and effective network topology maintenance are all advantages of using clustering nodes. [5]. Figure 2 shows a model of a single-tier clustered architecture.

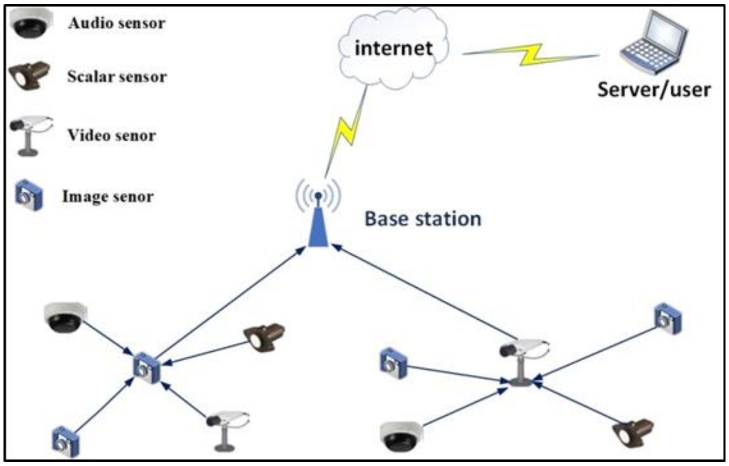

Figure 2 A Single-Tier Clustered Architecture

In a multi-tier architecture, it is made up of clustering or hierarchically multi-layered with sensor nodes having different processing capabilities, initial energy, and storage capacity. The cluster heads have significantly more computing power and resources than other normal nodes. Normal sensor nodes gather data from the environment areas and send data to the cluster head which area gathers, processes, and transmits multimedia data straight to the base station (BS) or to another cluster heads. When multiple layers are used, WMSNs are more energy-efficient and ideal for large-scale networks [5]. Figure 3 shows an example of a multi-tier architecture.

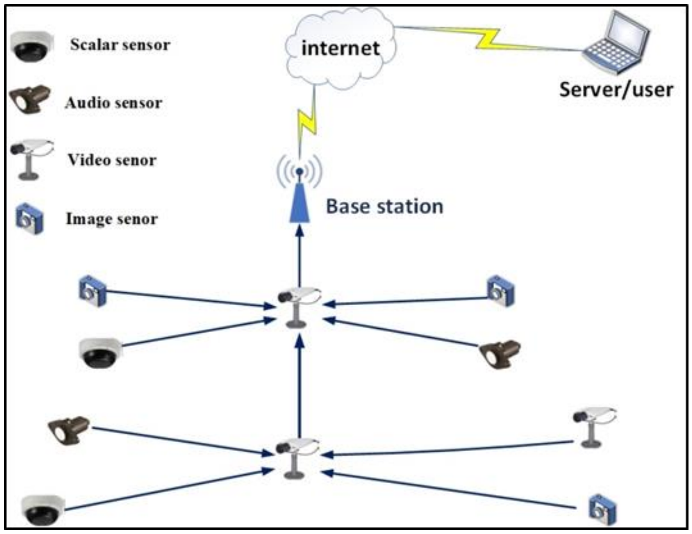

Figure 3 A Multi-Tier Architecture

2. BACKGROUND THEORY

From a communications standpoint, routing is a critical factor to consider. In WMSNs, routing is a difficult task. This demand has resulted in many routing protocols that make efficient use of the limited resources available at sensor nodes while also incorporating multimedia data features. In WMSNs, single-path routing and multipath routing are the most common routing techniques. Every sensor node in "single-path routing" transmits data to the base station in the shortest path, which is usually one path. On the other hand, WMSNs are sensitive to network congestion or connection failure, and any breaking down in one of its nodes can lead to disruption if the route is identical, thereby preventing data transmission. Single-path routing protocols cannot satisfy the varied multimedia applications, according to the general characteristics of WMSNs, because load balancing and latency demands cannot be met using a single path. Researchers recently discovered that multiple-path routing protocols can overcome the limitations of single-path routing protocols by allowing the development of multiple paths to transport data from a source node to a destination node. Furthermore, they spilled a packet into several parts and transmit them over several routes, ensuring network load balancing, evenly distributing energy consumption among sensor nodes, and reducing data delivery time, Reliability, throughput, and aggregate bandwidth can be improved by using Multipath routing protocols [6, 7].

Multipath routing protocols have several objectives to meet, including load balancing, (using multipath routing techniques to avoid having many nodes and links that are over utilized and thus using many nodes in the routing process to load balance is preferable Because the energy will be equally distributed across the nodes, the lifetime of the network will be increased. In addition, because the packets are routed to multiple paths that reduce nodes being over utilized, congestion will be eliminated); Energy-efficient, **(**Energy-constrained nodes in WMSNs are a problem because batteries on sensors, in general, are not recharged and therefore un-replaceable, and in the case of service in hostile environments is critical. To extend the network lifetime, it is important to make the nodes more energy-efficient, especially when dealing with nodes that connect over long distances); Fault-tolerance, **(**Wireless networks are prone to technical failure Because wireless technology can have reliability problems, their batteries must be regularly replaced, transmissions can be stopped, and they can also be obstructed by animals and humans, and some devices might be harmed, steps must be taken to ensure their maintenance and continued function. To accommodate failures, the entire network should offer alternate paths to the sink so that the routing protocol can guarantee the delivery when one or path becomes unavailable); Reduced delay, **(**Routing protocols usually use a single-path discovery of the network topology to discover a route. When a node fails in the network, it causes a delay in the next delivery. However, it is possible to reduce the impact of delay, as with multi-path routing protocols, which know about backup paths well in advance); Data reliability, (The probability of packets arriving at their destination successfully can be defined as reliability. By transmitting several copies of the same data over multiple paths, multipath routing can improve data reliability); Bandwidth aggregation, (When there are multiple paths to the same location, the multipath routing technique splits the data into multiple parts and handles every one individually) [8, 9].

3. ROUTING PROTOCOLS IN WMSNS

In this part, we investigate the different routing protocols designed for WMSNs. Depending on the network architecture, routing for WMSNs can be categorized as flat-based, hierarchical, and location-based. In flat-based routing, the sensor nodes are homogeneous which means all nodes have the same functionality and capabilities. In hierarchical-based routing, Clusters are created within the network. Different types of sensors are deployed in each cluster, with data forwarded to a cluster header (CH) with more resources. In order to perform efficient processing for data. Each cluster head (CHs) can directly send data to the base station or via another cluster head (CHs). Sensor nodes use locations for transmitting data in the network during location-based routing protocol. The operation of routing protocols is considered to be dynamic when some system requirements can be improved using existing power and network parameters. In addition, depending on the protocol's operation, these protocols can be categorized as multipath-based, query-based, and negotiation-based, and QoS-based, or coherent-based routing techniques. Although all three classifications are applied, three protocols are found in addition to these three approaches: reactive, hybrid, and proactive routing protocol, since they take various forms depending on how the source finds a path to transfer data to the destination. In proactive routing protocols, all paths are found at the initiation of the protocol's implementation, before they are required, while in reactive routing protocols all paths are found when they are required to send data, which is referred to as "on-demand". These two concepts were combined in the hybrid protocols. In a situation of static deployments for the sensor nodes, table-driven routing protocols are the best instead of reactive protocols. The finding and establishment of routes in the reactive routing protocols require a considerable amount of energy. Another type of routing protocol is co-operative in which, the nodes send data to a central node, where the data can be aggregated and subjected to additional processing. a wide variety of protocols for WSNs and WMSNs have been proposed in the last two decades. Many topics that pertaining to this have been included in relevant surveys [9]-[12]. This section presents a summary of various routing protocols for WMSNs. The classification for the routing protocol is shown in Figure 4.

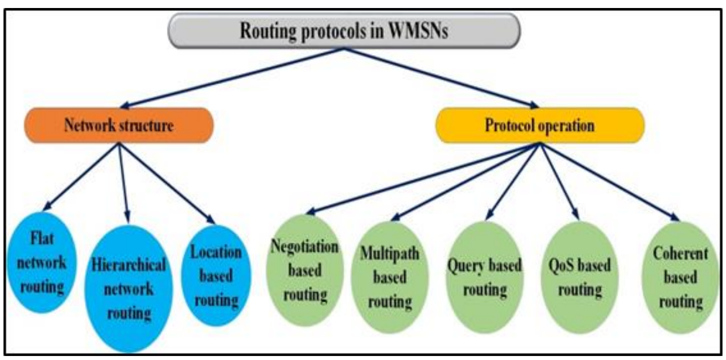

Figure 4 The Classification of Routing Protocols for WMSNs

3.1. Routing Protocols Based On Network Structure

Protocols referring to the network structure strategy are split into three categories: Flat, Hierarchical, and Location-based routing protocols, as described below:

3.1.1. Flat-Based Routing Protocols

In Flat-based routing protocols, each sensor node generally has a similar feature, and sensor networks collaborate to execute the sensing process. Because of the vast number of nodes, a global identifier cannot be assigned. As a consequence, data-centric routing has evolved, in which the BS sends queries to specific locations and waits for sensor responses in those areas. Because data is demanded through queries, data is needed to define data properties. Directed Diffusion (DD) protocol, which was proposed by the authors in [13]. It conserves power by disseminating sensing data through the sensor nodes and avoiding the execution of unnecessary operations. Directed diffusion provides a list of value attributes that identify geographical locations as a source of importance. Interests are sent to one or more neighbors for later use, as the interest is spread across the network gradients are configured to draw data that satisfies the request to the requesting node. Every sensor receiving the interest establishes a gradient to the sensor nodes from which the interest is received. This process will continue until gradients from the sources to the BS are configured. More generally, an attribute value and direction are specified in a gradient. The gradient strength can vary from one neighbor to another, resulting from different amounts of information fluid flow. When interests fit the gradients, information flow paths are formed by multiple paths, and the best paths are then strengthened to prevent additional flooding under the local rule. Data are aggregated on the way to reduce communication costs. The objective is to find a good aggregation tree that takes information from the source nodes to the BS. When the BS receives information from the source, it regularly refreshes and returns the interests, since it is important as interests' data are not transmitted directly across the network. Directed diffusion has the benefit of not needing to know the entire network structure and no necessary network address configurations, making it highly applicable for simple naming mechanisms. High energy efficiency was also observed. However, the model is described does not apply to all the WSNs. Also, as well, DD is not applicable for environmental monitoring. Additionally, prior planning of the naming of the application should be done.

Gradient-Based Routing (GBR) protocol, which was proposed by the authors in [14]. It differs from Directed Diffusion, which uses link heights and gradients to enhance communication link by fusing the number of hops with interest. When information is transmitted throughout the network, the hop count is stored. The minimal hop count to the BS that each node can determine is referring to as the node's height. The gradient of a link is the height difference between the two neighboring sensor nodes A sensing information is sent via a gradient relation with a high gradient. The technique evenly distributes congestion throughout the network, reducing the node load and extending the network lifetime, as sensor nodes operate as relays for multiple-paths, techniques such as data aggregation and traffic spread are used. This protocol uses less energy for communication than Directed Diffusion. This protocol also offers excellent load balancing. However, there is an increase in overhead.

Topology Dissemination Based on Reverse-Path Forwarding Protocol (TBRPF) protocol, which was proposed by the authors in [15]. In which it compares the current and previous states of the network, and the difference between them will be broadcasting, to greatly expand the number of possible routes that can be sent. In the same way, this protocol generates hierarchical structures like trees from source to destination by determining the shortest paths for broadcasting link-state updates in the reverse direction. Each source builds a broadcast tree after calculating the shortest paths. Every sensor node has a list of children, a list of neighbors and their parents, connection states, the sequence number of the most recent connectivity updates, and a topology table that contains all connection states. The hierarchical structure is modified with new topology information if a link-status update broadcast from a source is received from the source's parent and has a higher range number than on the conforming link-status entry in the parent's topology table, it is accepted by another node. The list of topologies after that is then modified and transmitted to all children in the sensor network. In this protocol, there are multiple-paths to the destination. This protocol has the additional benefit of requiring fewer updates. In addition, loop-freedom wastes bandwidth and packets.

The authors in [16] proposed the correlation-aware QoS routing algorithm (CAQR). Throughout this paper, the author discusses an optimal QoS routing method that takes power consumption, and transmission latency, reliability into account. The closest video sensors nodes will communicate with each other eliminate correlation information by analyzing the connection between sensing data, which reduces network traffic. However, network congestion is difficult to avoid if all of the sensing data is sent over the same routing route. As a result, to avoid traffic load, a correlation-aware load balancing system is proposed. Separating correlated flows into separate routing routes can help reduce traffic load. CAQR, on the other hand, ignores data aggregation and lacks an effective congestion management strategy.

3.1.2. Hierarchical based routing protocols

Through node clustering, hierarchical routing protocols are designed to enhance network scalability and energy efficiency. The sensor network is divided into clusters when using hierarchical routing. Sensor nodes which have Low energy act as cluster members (CHs), while sensor nodes with high energy act as cluster head (CH). Cluster members (CHs) detect the environment and transmit information to the cluster head (CH), then cluster head (CH) collects information and sends it in aggregated form to the sink. The number of messages sent to the sink is reduced using this method.

The authors in [17] proposed Low Energy Adaptive Clustering Hierarchy (LEACH). This protocol uses cluster heads (CH) to collects information and sends it in aggregated form to the sink, and it establishes cluster members (CHs) based on signal strength. The optimum number of cluster heads is calculated to be about 5% of total nodes, Data aggregation and data fusion processes are carried out regionally in clusters. Cluster heads are selected randomly in order to decrease the energy consumption and increase network lifetime. Nodes compared the signal strength of their neighboring cluster heads during cluster formation and join the one with the strongest signal. For P rounds, a node that has previously acted as a cluster head is unable to serve in that function again. In order to select a node to act as a cluster head, a node N generates a random number between 0 and 1 and compare with the threshold T if a number is less than threshold node became a cluster head, equation (1) is used to calculate the threshold T.

$$T(n) = \frac{P}{1-P\left(r \, mod\left(\frac{1}{P}\right)\right)} \; if \; n \in G, \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, "r" is the current round, "p" is a percentage of cluster heads, and "G" refers to the nodes which haven't been cluster heads in the previous 1/p rounds. Transmissions are reduced in LEACH, resulting in lower energy loss. Furthermore, no awareness of global networks is required. For sensor networks used in large areas network, it's not really recommended, however, because it uses single-hop routing. Furthermore, dynamic clustering adds overhead, which can decrease power consumption.

The authors in [18] proposed Low-Energy adaptive Clustering Hierarchy-Centralized (LEACH-C), in which the base station (BS) is used to form clusters. Through clustering formation, nodes send information about their energy levels and locations to the BS. Based on the energy needed to transmit information from cluster members (CHs) to cluster heads (CH), the network field is divided into a certain number of cluster members (CHs) and cluster heads via the sink. Clusters for data transmission that are more energy efficient are created using LEACH-C. Furthermore, the ideal number of cluster heads has been calculated. The BS, on the other hand, receives overhead.

The authors in [19] proposed Cluster-based Multipath Routing for Wireless Multimedia Sensor Networks (CBMRP). Each cluster has two cluster heads, one for data collection and one for data transmission. The load and connection efficiency, as well as residual energy, are used to select the main cluster heads. When the main cluster heads become overloaded or malfunction, the secondary cluster heads are chosen to forward the data. These secondary cluster heads relieve the main cluster heads of some of their energy consumption. The result is that the load on the cluster head is shared, extending the overall life of the cluster and improving its overall efficiency. To ensure timely delivery, the information to be submitted is taken priority and sent through the required priority disjoint paths.

The authors in [20] proposed Hierarchical Multi-Path Routing Protocol for Wireless Multimedia Sensor Networks (HMPR). In this protocol, the data is transmitted to the base station via resource-rich nodes selected as cluster heads. The main cluster heads aggregate the data before sending it on to the base station node to minimize transmission and thus ensure network stability. To save energy while establishing a bounded delay and enhancing accuracy, transmission takes place one-hop or multi-hop within the cluster. This ensures that both intra or inter clusters, QoS requirements are met. Another layer is needed to achieve optimal QoS when evaluating cluster heads routing to the base station.

The authors in [21] proposed Efficient Multipath Routing based on Genetic Algorithm (EMRGA), in which the protocol uses clusters and Genetic Algorithm to perform the multipath-based protocol. The cluster is usually made of sensor nodes that are near to the event's position. The Cluster Head (CH) is the most powerful node in the cluster. Data is sent to the CH by the Cluster Members (CHs), which gathers and then transmits aggregate data to the base station. Since the Cluster Head (CH) consumes higher resources than the other nodes, all nodes act as Cluster heads in order to save a single node from dying early. A genetic algorithm is used to searches for multiple paths for data transmission. Based on the cost function, it selects the best route with the minimum energy consumed and the shortest distance traveled.

3.1.3. Location-Based Routing Protocols

The position of nodes in most WSN protocols is used for determining the distance among sensor nodes and the energy consumption. Because there is no addressing mechanism in place, such as IP addresses, sensor networks are spatially distributed around a region, and location information could be used to effectively route data. This protocol informs nodes about the locations of their neighbors and messaging sources, which are supposed to be aware of the information's location.

In [22], the authors propose the Geographic Energy-Aware Multipath Stream-based (GEAMS) routing protocol for effective multimedia information forwarding without global knowledge in order to minimize high power consumption. At each forwarding node, GEAMS routing decisions are made in real-time, and no need for regional network topology or management. Smart greedy transmission and walking back forwarding are two techniques used by GEAMS for efficient routing. The issue with this protocol is that it is unable to support effective path selection for next-hop node selection, resulting in a significant decrease in routing efficiency.

Two-Phase geographic Greedy Forwarding (TPGF) routing algorithm is proposed by the authors in [23] for reducing power consumption. This protocol uses two phases to choose one shortest path per execution and can be repeated several times to find multiple shortest paths on-demand. Possible paths are chosen in the first phase, and the paths are customized in the second phase to determine the most effective routing path. Multipath transmission, Hole-bypassing, and shortest-path transmission are all supported by TPGF, all of which improve energy efficiency. But in the geographical transmission process, the method has a small downside, which is not good.

Energy-Aware Greedy Stateless Geographic Routing (EAGSGR) is a method proposed by the authors in [24], which uses energy as a cost function. Data is transmitted in two paths in the proposed routing protocol; strategic areas avoid paths that interfere, and dead-end routes are pruned by an algorithm, resulting in better performance. EAGSGR's route selection is stateless, and each node reports its power level. The power distribution of nodes in the entire network is effective using this technique. In dead-end nodes and clusters, EAGSGR prevents loops. After the strategic area nodes have been exhausted, another solution that aids power delivery is to move from multipath to single-path routing.

3.2. Routing Protocols Based on Protocol Operation

Protocols referring to the protocol operation strategy are split into as multipath-based, query-based, negotiation-based, QoS-based, and coherent-based routing protocol as described below:

3.2.1. Multipath-Based Routing Protocol

Multipath-based protocols can use a variety of routes, allowing them to handle Fault-tolerance, load balancing, Energy-efficient, Data reliability, Bandwidth aggregation, and reduced delay.

The authors proposed in [25] Hierarchy-based Multipath Routing Protocol (HMRP), in which this protocol implements several characteristics in the execution of each sensor node: a once-broadcast layer development packet and a table that includes Candidates Information. Sender nodes must only know the root sensor node, which will receive the messages via packet transmission. Data aggregation through all nodes including multiple candidate paths for data forwarding, the ability to use multiple base stations, and leaf nodes are all features of HMRP. The proposed protocol allows for the extended lifetime of sensor nodes by aggregating data and balancing energy consumption. Besides that, better scalability is achieved with minimal overhead between nodes. Furthermore, each node has restricted computations and states, which makes it simple. The layer construction packet, however, is broadcast only once.

The authors in [26] proposed the Energy Balancing Multi-Path Routing Protocol (EBMR), in which the protocol is dependent on the remainder of the node energy as well as the distance of the node from the base station. The algorithm is separated into two sections. For begin, define a number of node's non - overlapping paths from the sender nodes to the sink or base station (BS). Secondly, using the next-hop selection approach to improve energy efficiencies, normal sensor nodes increase energy efficiencies by measuring cost efficiency, thus increasing the EBMR performance for network lifetime and the energy balance. In general, the current node chooses neighbors whose cost function value is equal to or lowers than the next-hop node's cost function value. The cost function takes into account not only the distance between the chosen node and neighboring nodes but also the remaining energy of neighboring nodes. However, if the energy of the neighbors is less than the average remaining energy of the neighbor, the cost function will be added. Otherwise, the cost function value is removed.

Dynamic routing for data integrity and delay differentiated services in wireless sensor networks (IDDR) is proposed by the authors in [27]. This algorithm implements a virtual hybrid potential area based on the depth and queue length. Depending on the potential field, different QoS requirements and weights separate packets, which are then transmitted to the sink through multiple paths. In addition, IDDR is unable to meet application-specific delay requirements.

The authors in [28] proposed A Fast, Adaptive, and Energy-efficient Multi-path multi-channel Data Collection Protocol for Wireless Sensor Networks (FAEM), In this protocol the "basketball Network architecture" is used to allocate each node a several root several leaf link tables as well as a separate receiving channel from its neighboring nodes, thus reducing communication interference. This protocol separates operating time into service cycles, which are split into two phases: scheduling and forwarding. The first phase is the Distributed iterative scheduling method, which schedules a sensor node's three network operations: download to leaf nodes, sleep and upload to root nodes. Slot-based data transmission is the second phase. It separates the transmission time into frames, each with its own collection of slots. Only one slot can be transferred among two nodes by one data packet. Sleep mode is used in FAEM to achieve low energy consumption. Additionally, data transmission is collision-free. Furthermore, interference avoidance is achieved. The network, on the other hand, is unable to link mobile parent-child nodes.

3.2.2. QoS-Based Routing Protocol

The network must balance the requirement for network energy efficiency and data quality in QoS routing protocols A subnet that needs to be able to deliver data to the sink must meet certain quality of service (delay, energy, bandwidth, and throughput) requirements.

The authors in [29] proposed the Stateless Protocol for Real-Time Communication in Sensor Networks (SPEED). It is a WSN QoS routing protocol that requires a lower delay from source to destination, enables each node to keep data for the nearest node, and uses Location to find paths. For each network packet, it speeds such that the delay from source to destination can be estimated by splitting distances from the base station into packet speed and preventing congestion of congested networks. Stateless Geographic Non-deterministic Forwarding (SNFG) is the routing module of SPEED, and it works with four other network layer modules. It also provides a two-tier adaptation for the transmission of network layer traffic and for localized control systems sent to the MAC layer, which ensures the network maintains the optimum distribution rate. Since the routing is simple and the traffic management is consistent, SPEED has less overall transmission power. SPEED is therefore preferable in relation to the miss ratio and the end-to-end latency. The drawback is the lack of a metric for power consumption.

Multipath and Multi SPEEDs (MMSPEED) in [30] will achieve high QS both in terms of reliability and timeliness. It guarantees multiple delivery ratio options for the timeliness domain, thus providing probability multipath routing for different reliability domain requirements. The proposed protocol does not require geographical network information but can overcome local decision errors on the routing path by using localized geographical forwarding of packets and a dynamic alternative. The proposed protocol may never have to learn about the geographical requirements of the network field, but it may use a dynamic compensation and a regional geographic forwarding package to compensate for any incorrect local routing decisions. MMSPEED provides both scalability and energy efficiency. However, MMSPEDD cannot comply with end-to-end latency specifications whenever the load is overhead.

Multimedia Geographic Routing (MGR) in [31] is a multimedia application protocol designed to exploit Mobile Multimedia Nodes (MMN) in Wireless Multimedia Sensor Network architecture (WMSNs). MGR prioritizes ensuring network latency and then constantly lowers energy usage to extend network lifespan. It calculates the optimum hop distance by dividing the distance between the selected node and the base station by an ideal number of hops from the given node to the base station. In comparison to traditional geographic routing, MGR saves up to 30% more resources. Furthermore, a minor delay is almost always guaranteed. The highest priority target, however, is to guarantee the delay.

The authors in [32] proposed a multi-agent-based context-aware multipath routing scheme (MACMR) for establishing the context of sensed multimedia information, which employs static agents. The mobile agent through the possible activity node is initiated depending on the context to establish the node's non - overlapping path to the sink. Before reaching the sink node, the mobile agent nodes move through intermediate nodes, transporting bandwidth available, number of hops, and residual energy of node. Based on the energy and context provided, the sink determines the node non - overlapping paths. After the computation, it then sends the routing path to the activity node through the shortest paths to mobile agents. Finally, the activity node sends information to the sink about the alternative pathways available to it. This protocol is less scalable in terms of route discovery and maintenance because it can increase network latency over a large network.

3.2.3. Query-Based Routing Protocol

Data is transmitted using queries in this protocol. When requested new information, it sends queries to the node which already has it. The data is then sent to the node that ran the query by the node that owns it.

The cougar approach to in-network query processing in sensor networks (COUGAR) represented in [33] is a network protocol that operates as a database model. The propositional requests for information are used to improving energy efficiency by eliminating network layer operations like node selection and packet compression. It adds a new request layer among the network and application layers to reduce network layer operations. Nodes in this protocol choose a head node in order to aggregate data and then transmit it to the base station (BS). The BS then creates a request plan for network traffic, which contains information on the head collection, in-network processing, and information stream then transmits it to the optimal nodes. COUGAR's main advantage is that it is energy efficient despite having a large number of active nodes. The use of an extra layer, however, adds more overhead. Besides, synchronization is needed for data computation in the network.

The Energy-Aware Delay-Constrained Routing proposed by the authors in [34] is an energy-effective routing protocol for WSNs that provides a minimum latency for data transmission in the network. This approach creates energy-aware multi-hop data paths by evaluating transmission power, sensor energy, and end-to-end delay as constraints. Each sensor uses a Weighted Fair Queuing (WFQ) scheduling method to generate an end-to-end delay. In addition, congestion management systems are used to monitor congestion entering from sources and distinguish between different real-time and non-real-time traffic congestion for every node through using two independent queues. The packet-scheduling approach is a drawback of this protocol. Furthermore, tag computation and tag sorting at line speeds are needed. This criterion creates a bottleneck that is incompatible with the multimedia transmission.

The authors in [35] proposed Active query forwarding in sensor networks (ACQUIRE), Similar to the COUGAR protocol, which can split complicated requests for information down to several sub-requested, which uses a "data-centric" approach for data transmission and represents the topology as a shared data model. The base station transmits a request for information that is propagated by all the receiving nodes. During the request for information transmission, nodes use precached data to partially respond to the request, modifying precached information as required through neighbor nodes within an N hops range. After the request has been replied to, it can be transmitted straight to the base station taking the shortest or inverse path once the look-ahead criteria N is suitably established the proposed scheme provides efficient requests for information. If the look-ahead parameter N matches the network size, the traffic acts as flooding, however, small requests for information have to travel further when the parameters are significant. As responses arrive from several nodes, ACQUIRE needs to request information efficiently. If a value that's too small in the look-ahead parameter, the requested information moves through more hops.

The authors in [36] proposed a QoS-based energy-efficient routing (QuESt) protocol, which uses a multi-target genetic algorithm to define a set of non-nominated and nearly suitable routes in flat-network architecture. In Wireless sensor networks, the proposed method takes into account application-specific QoS criteria bandwidth requirements, energy consumption, and end-to-end delay. The limitations for the QoS-routing approach were transformed into a limited Steiner-tree issue to accommodate multiple QoS requirements. Furthermore, this protocol presents two randomly chosen paths from the population using Euclidean distance. Unfortunately, the Steiner tree problem's Euclidean distance has turned out to be a non-deterministic Polynomial-Hard problem (NP-Hard), with no known polynomial-time algorithms.

The authors in [37] propose the Multipath data transfer in wireless multimedia sensor network designed to be, low delay power-aware, and efficient protocol in QoS. The routing algorithm is divided into two phases: route setup and data transmission. During the route setup phase, the source node sends a discovery message to all neighbors, discovering different paths. If the number of paths established along with this node is less than the threshold and the node's residual energy is greater than the required energy, the message will be forwarded to the next hop; further, the node will send a negative acknowledgment message. The same steps will be repeated before the message is sent to its intended recipient. If the receiver is ready to receive available information, the sender will receive an "ok" response. When the sender node receives an "ok" message, the sender message node ID "ok" is added to the multipath collector's list, which includes sensor nodes used as next-hop. Through the transmission phase, a number of paths are chosen based on the remaining energy. The data is divided into "m" sections and sent down several routes. Reed-Solomon encoding is used to encrypt the transmitted data in the suggested protocol to ensure reliability. The main limitations of the proposed work include the usage of Reed- Solomon for reliability, which decreases power consumption and unavailability of monitoring of end-to-end delay and bandwidth needs

3.2.4. Negotiation Based Routing Protocol

An origin node negotiates with its targets when forwarding data in this kind of routing protocol. These mechanisms access the data using a naming structure and then use them to negotiate, promote and, and in case of degradation of data on the target.

Sensor protocols for information via negotiation (SPIN) were suggested by the author in [38]. It is a protocol utilized for the identification of data through consistently high identifying information or metadata. Nodes exchange meta-data via the advertising mechanism before data is transferred. The meta-data structure is not standard, but the application is justified. Each node broadcasts messages to its neighbor nodes through advertising messages (ADV) whenever new data is gathered. Neighbors who have no data send a request message (REQ). The actual information is then sent to the interesting nodes via sending nodes. The meta-data negotiation not only addressed traditional flood issues, but it is also improved energy quality. Furthermore, metadata negotiation removes half of the redundant data, and topology improvements are localized. However, there is no guarantee that data will be transmitted to the intended destination. That is because there could be no value in sensor nodes from the sender and receiver. In addition, for applications requiring continuous data transmission, including intruder detection, a SPIN protocol is sufficient.

Real-time and Energy-Aware Routing (REAR) proposed by the authors in [39], which is an event-driven protocol that seeks paths using meta-data instead of real data. It includes a function for determining communication costs depending on neighboring node queuing delay distance and residual energy. It using sophisticated Dijkstra's algorithms to find paths dependent on a link function. To apply logical priority, dual queues have been used: one for real-time data and another for non-real-time data. To reduce the energy consumption and processing delay in each node, a metadata negotiation method amongst neighboring nodes has been used. In contrast, the metadata sharing algorithm is not well adjusted to multimedia sensor networks.

Energy-efficient QoS assurance routing (EEQAR) for WMSNs is proposed in [40]. For data transmission. EEQAR is dedicated to the selection of trusted neighbor nodes. The trust values of neighbor nodes can be evaluated using trust metrics such as packet loss rate, reliability, and transmission delay by detecting neighbor node communication behaviors. The trust values are required to be determined by the service characteristics of sensor nodes. As a result, establishing a routing path based on the trust value will effectively satisfy the QoS requirement. Furthermore, the common cluster nodes are permitted to turn off their radio model and operate only periodically to reduce energy consumption. EEQAR considers a network with three types of nodes: sensor nodes, agent nodes, and sink nodes. A considerable amount of unnecessary data transmission can be reduced thanks to data fusion performed by the mobile cluster head, which lowers the communication cost for data transmission. Besides that, the traveling path of the node of the mobile agent affects the data collection and transfer performance directly. As a result, the mobile agent node's path planning requires more investigation.

The authors in [41] proposed a Hop and Load-based Energy-Aware Reactive protocol with swarm intelligence (HLEAR). It is based on a beta (β) routing, which is estimated using remaining nodes resources number of hops, and available bandwidth. The node with the lowest (β) value is the best intermediary choice in the path. Through the route discovery phase, any nodes with four active paths are also not enabled to take part Nodes with the least cut-off remaining energy are identified as switching nodes and therefore are not intended to operate in the route discovery phase, avoiding holes from appearing close to the sink HLEAR is not scalable since it is based on a table-driven method.

3.2.5. Coherent/Non-Coherent Based routing protocol

The process of Nodes obtained node level data before it was routed incoherent of routing protocols. Only the information it gathers is processed via a coherent protocol node. On the other hand, nodes for based interventions are needed before it is transmitted to aggregator nodes [42] for non-coherent routing protocols

The routing that occurs at the sensor level begins with this principle was introduced in [43]. There are two separate implementations of this algorithm: Coherent Data Processing Routing: This method is a power-saving technique in which the SNs only perform the minimum required of processing. The task performed in minimal processing is the timestamp and duplicate deletion. The data is then transmitted to the aggregator's node.

Non-Coherent Data Processing Routing in [44]: Throughout this variant, the sensor nodes process the raw data geographically before sending it to other SNs for further processing by the so-called aggregators. Three data processing phases are included in this routing mechanism, the identification of targets involves the detection of actions, as well as the aggregation and pre-processing of data, the selection of the central node, which is performed more reliable information processing, and the declaration of membership, in which the sensor Nodes demonstrates its intention of taking part in a collective process to all of its neighbors.

4. CONCLUSION

This survey looked at both traditional and modern protocols that have been suggested for achieving energy-efficient multipath routing in WSNs and WMSNs. WSN and WMSN applications require specialized hardware and have a complex set of requirements. Generic solutions aren't always the right choice. For an application to operate effectively, highly specialized solutions are recommended. Routing protocols are still an important consideration in any application's design. The principle of multipath routing is presented with its applications in WSN and WMSN. Multipath routing is an efficient strategy for increasing throughput, load balancing, aggregate bandwidth, end-to-end delay, and energy consumption. Multipath routing protocols ensure that applications' Quality of Service (QoS) demands are met while also addressing energy efficiency. In a WSN, multipath routing will reduce the need for route updating, balance traffic loads, and increase data transfer rates, allowing sensor nodes to make better use of their limited energy. It has been discovered that there is a pressing need to establish routing protocols that are more energy-efficient, more effective, and have better control over multimedia data QoS requirements. We have addressed all aspects of energy-efficient multipath routing and Qos in this paper, which are critical for multimedia data transmission over wireless Sensor Networks.

REFERENCES

[1] Buratti, Chiara, Andrea Conti, Davide Dardari, and Roberto Verdone, "An overview on wireless sensor networks technology and evolution", Sensors, vol. 9, no. 9, pp. 6869-6896, 2009.
[2] Akyildiz, Ian F., Tommaso Melodia, and Kaushik R. Chowdhury, "A survey on wireless multimedia sensor networks", Computer networks, vol. 51, no. 4, pp. 921-960, 2007.
[3] Shashi Baith, Neha Yadav, Ankita Ganvir, Pranali R. Dandekar," Wireless Multimedia Sensor Network", International Journal of Mobile Computing and Application (SSRG-IJMCA), vol. 5, no. 1, 2018.
[4] Lee, Sung-Keun, Jin-Gwang Koh, and Chang-Ryul Jung, "An energy-efficient QoS-aware routing algorithm for wireless multimedia sensor networks", International Journal of Multimedia and Ubiquitous Engineering, vol. 9, no. 2, pp. 245-252, 2014.
[5] Al Nuaimi, Mariam, Farag Sallabi, and Khaled Shuaib, "A survey of wireless multimedia sensor networks challenges and solutions", In IEEE International Conference on Innovations in Information Technology, pp. 191-196, 2011.
[6] Li, Zhi-yuan, and Ru-chuan Wang, "Load balancing-based hierarchical routing algorithm for wireless multimedia sensor networks", Journal of China Universities of Posts and Telecommunications, vol. 17, pp.51-59, 2010.
[7] Nayyar, Ayesha, and Faisal Bashir, "Load based energy aware multimedia routing protocol-(LEAR)." In IEEE 3rd International Conference on Computer Research and Development, vol. 2, pp. 427-430, 2011.
[8] Chaudhari, Prashant, Haresh Rathod, and B. V. Budhhadev, "Comparative Study of multipath-based routing techniques for wireless sensor network" In Proceedings published by International Journal of Computer Applications (IJCA) International Conference on Computer Communication and Networks CSI-COMNET, pp. 1- 6, 2011.
[9] Jayashree, A., G. S. Biradar, and V. D. Mytri, "Review of multipath routing protocols in wireless multimedia sensor network–a survey", International Journal of Scientific & Engineering Research, vol. 3, no. 7, pp. 1-9, 2012.
[10] Shen, Hang, and Guangwei Bai, "Routing in wireless multimedia sensor networks: A survey and challenges ahead", Journal of Network and Computer Applications, vol. 71, pp. 30-49, 2016.

[11] Han, Guangjie, Jinfang Jiang, Mohsen Guizani, and Joel JP C. Rodrigues, "Green routing protocols for wireless multimedia sensor networks", IEEE Wireless Communications, vol. 23, no. 6, pp. 140-146, 2016.
[12] Hasan, Mohammed Zaki, Hussain Al-Rizzo, and Fadi Al-Turjman, "A survey on multipath routing protocols for QoS assurances in real-time wireless multimedia sensor networks", IEEE Communications Surveys and Tutorials, vol. 19, no. 3, pp. 1424-1456, 2017.
[13] Intanagonwiwat, Chalermek, Ramesh Govindan, and Deborah Estrin, "Directed diffusion: A scalable and robust communication paradigm for sensor networks", In Proceedings of the 6th annual international conference on Mobile computing and networking, pp. 56-67. 2000.
[14] Schurgers, Curt, and Mani B. Srivastava, "Energy efficient routing in wireless sensor networks", In IEEE MILCOM Proceedings Communications for Network-Centric Operations: Creating the Information Force, vol. 1, pp. 357-361, 2001.
[15] Ogier, Richard, Fred Templin, and Mark Lewis, "Topology dissemination based on reverse-path forwarding (TBRPF)", IETF RFC 3684, 2004.
[16] Dai, Rui, Pu Wang, and Ian F. Akyildiz, "Correlation-aware QoS routing with differential coding for wireless video sensor networks", IEEE Transactions on Multimedia, vol. 14, no. 5, pp. 1469-1479, 2012.
[17] Heinzelman, Wendi Rabiner, Anantha Chandrakasan, and Hari Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks", In Proceedings of the 33rd IEEE annual Hawaii international conference on system sciences, pp. 10-16, 2000.
[18] Heinzelman, Wendi B., Anantha P. Chandrakasan, and Hari Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks", IEEE Transactions on wireless communications, vol. 1, no. 4, pp. 660-670, 2002.
[19] Anandan, Ranjith Kumar, and Sivagami Amirthalingam, "Cluster based Multipath Routing for Wireless Multimedia Sensor Networks", International Journal of Intelligent Engineering and Systems, vol. 9, no. 4, pp. 79-87, 2016.
[20] Acharya, Biswa Mohan, and Ajit Kumar Nayak, "Hierarchical multi path routing protocol for wireless multimedia sensor networks", International Journal of Intelligent Engineering and Systems, vol. 11, no. 1, pp. 239-247, 2018.
[21] Genta, Addisalem, D. K. Lobiyal, and Jemal H. Abawajy, "Energy efficient multipath routing algorithm for wireless multimedia sensor network", Sensors, vol. 19, no. 17, pp. 36-42, 2019.
[22] Medjiah, Samir, Toufik Ahmed, and Francine Krief, "GEAMS: a geographic energy-aware multipath stream-based routing protocol for WMSNs", In IEEE Global Information Infrastructure Symposium, pp. 1-8, 2009.
[23] Shu, Lei, Yan Zhang, Laurence T. Yang, Yu Wang, Manfred Hauswirth, and Naixue Xiong, "TPGF: geographic routing in wireless multimedia sensor networks", Telecommunication Systems, vol. 44, no. 1, pp. 79-95, 2010.
[24] Gargary, Danesh Zeynali, Fariba Osali, and Ali Mohammad Afshin Hemmatyar. "Geographic Routing with Energy Constraint in Wireless Multimedia Sensor Networks", In IEEE 27th Iranian Conference on Electrical Engineering (ICEE), pp. 2028-2032, 2019.
[25] Wang, Ying-Hong, Chih-Hsiao Tsai, and Hung-Jen Mao, "HMRP: Hierarchy-based multipath routing protocol for wireless sensor networks", Journal of Applied Science and Engineering, vol. 9, no. 3, pp. 255-264, 2006.
[26] Sun, En Yan, Xuan Jing Shen, and Hai Peng Chen, "Energy balancing multipath routing protocol in wireless multimedia sensor networks", In Applied Mechanics and Materials, vol. 155, pp. 245-249, 2012.
[27] Zhang, Jiao, Fengyuan Ren, Shan Gao, Hongkun Yang, and Chuang Lin, "Dynamic routing for data integrity and delay differentiated services in wireless sensor networks", IEEE Transactions on Mobile Computing, vol. 14, no. 2, pp. 328-343, 2014.
[28] Tan, Cheng Kiat, Soung-Yue Liew, Hock Guan Goh, and Ivan Andonovic, "A fast, adaptive, and energy-efficient multi-path-multi-channel data collection protocol for wireless sensor networks", In IEEE International Conference on Recent Advances in Signal Processing, Telecommunications and Computing (SigTelCom), pp. 33-38, 2017.
[29] He, Tian, John A. Stankovic, Chenyang Lu, and Tarek Abdelzaher, "SPEED: A stateless protocol for real-time communication in sensor networks", In IEEE 23rd International Conference on Distributed Computing Systems, pp. 46-55., 2003.
[30] Felemban, Emad, Chang-Gun Lee, and Eylem Ekici, "MMSPEED: multipath Multi-SPEED protocol for QoS guarantee of reliability and. Timeliness in wireless sensor networks", IEEE transactions on mobile computing, vol. 5, no. 6, pp. 738-754, 2006.
[31] Chen, Min, Chin-Feng Lai, and Honggang Wang, "Mobile multimedia sensor networks: architecture and routing", EURASIP Journal on Wireless Communications and Networking, vol. 2011, no. 1, pp. 1-9, 2011.
[32] Bhanu, K. N., and T. Bhaskar Reddy, "Multi-agent-based context aware multipath routing in wireless multimedia sensor networks", IOSR Journal of Computer Engineering, vol. 19, no. 4, pp. 64-73, 2017.
[33] Yao, Yong, and Johannes Gehrke, "The cougar approach to in-network query processing in sensor networks", ACM Sigmod record, vol. 31, no. 3, pp. 9-18, 2002.
[34] Akkaya, Kemal, and Mohamed Younis, "Energy-aware delay-constrained routing in wireless sensor networks", International Journal of Communication Systems, vol. 17, no. 6, pp. 663-687, 2004.
[35] Sadagopan, Narayanan, Bhaskar Krishnamachari, and Ahmed Helmy, "Active query forwarding in sensor networks", Ad Hoc Networks, vol. 3, no. 1, pp. 91-113, 2005.
[36] Saxena, Navrati, Abhishek Roy, and Jitae Shin, "QuESt: a QoS-based energy efficient sensor routing protocol", Wireless Communications and Mobile Computing, vol. 9, no. 3, pp. 417-426, 2009.
[37] Poojary, Shobha, and MM Manohara Pai, "Multipath data transfer in wireless multimedia sensor network", In IEEE International Conference on Broadband, Wireless Computing, Communication and Applications, pp. 379-383, 2010.
[38] Heinzelman, Wendi Rabiner, Joanna Kulik, and Hari Balakrishnan, "Adaptive protocols for information dissemination in wireless sensor networks", In Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking, pp. 174-185. 1999.
[39] Lan, Yao, Wen Wenjing, and Gao Fuxiang, "A real-time and energy aware QoS routing protocol for multimedia wireless sensor networks", In IEEE 7th World Congress on Intelligent Control and Automation, pp. 3321-3326, 2008.
[40] Lin, Kai, Joel JPC Rodrigues, Hongwei Ge, Naixue Xiong, and Xuedong Liang, "Energy efficiency QoS assurance routing in wireless multimedia sensor networks", IEEE Systems Journal, vol. 5, no. 4, pp. 495-505, 2011.
[41] Nayyar, Ayesha, Faisal Bashir, and Zara Hamid, "Intelligent routing protocol for multimedia sensor networks", In IEEE Proceedings of the 5th international Conference on Information Technology and Multimedia, pp. 1-6, 2011.
[42] Shabbir, Noman, and Syed Rizwan Hassan, "Routing protocols for wireless sensor networks (WSNs)", Wireless Sensor Networks-Insights and Innovations, 2017.
[43] Sohrabi, Katayoun, Jay Gao, Vishal Ailawadhi, and Gregory J. Pottie, "Protocols for self-organization of a wireless sensor network", IEEE personal communications, vol. 7, no. 5, pp. 16-27, 2000.
[44] Jolly, Vasu, and Shahram Latifi, "Comprehensive Study of Routing Management in Wireless Sensor Networks-Part-I", In ICWN, pp. 37-44, 2006.

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