

# A SURVEY ON ENERGY EFFICIENT MULTIPATH ROUTING IN WIRELESS SENSOR NETWORK

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**Abstract**— Recent real time applications and multimedia streaming applications over sensor networks have strong QoS requirements of delay and throughput. An ordinary Wireless Sensor Networks (WSN) protocol such as directed diffusion did not satisfy this requirement because it routes packets through a single path. So it does not meet the requirement of multimedia data. Wireless sensor networks in terms of energy are also limited. So an efficient Multipath Protocol based on direct diffusion is used. It uses multiple paths to route packets with reduced energy consumption. Multipath routing protocol guaranteed the QoS such as load balancing, fault tolerance, bandwidth and delay requirements. By using a multipath routing protocol the life time of the Wireless Sensor network will increase with the QoS.

**Keywords**— Wireless Sensor Networks, QoS, Multipath protocol

## I. INTRODUCTION

A wireless sensor network which constituting small sensor nodes, which can communicate among themselves by using radio signals and it is used to monitor, sense and understand the physical world. Wireless sensor network (WSN) acts as a bridge between the physical world and virtual world. It allows them to observe the previously unobservable at a fine resolution over large spatio-temporal scales. WSN has a wide range of potential applications like transportation, science, industry, security and civil infrastructure [1], [2]. Some examples are habitat and Ecosystem Monitoring [3], Seismic Monitoring, Civil Structural Health Monitoring [4], Monitoring ground water contamination, Rapid Emergency Response, Industrial Process Monitoring, Perimeter Security and Surveillance, Automated Building climate control.

A sensor network [35] consists of many sensor nodes that collect the required information from the environment that are distributed widely. Sensor networks to their wide applications in various fields and also the network has also given a special place in those applications. These kinds of networks have the ability to identify, classify, process and transmit data obtained from the sensing parameters within the network. Three

components are mainly associated with each sensor node in the network.

- Sensor component
- Processing component
- Communication component

The sensor component is used to sense the data in the environment[26],[27]. The processing component which performs the local computations on the sensed data, and the communication component which is responsible for sharing the sensed data with the neighboring sensor nodes which can also be sink node. A sensor network consists of different types of sensors such as seismic, visual, thermal and infrared. They are applied in various fields such as: life sciences, medical care and the vital signs, military affairs and development, and in general wherever it is needed to measure the physical quantity. A greater number of sensors allow sensing over the larger geographical regions with a greater accuracy. It is necessary that the place of the sensor nodes is not predetermined and specified. These features make it dropping in dangerous or inaccessible places. This means that the sensor network protocols and algorithms should be a self authorization. One of the features of sensor networks is that the sensor nodes are capable of cooperation and coordination. Each sensor node has a processor, instead of sending all the raw data to the center or to a node that is responsible for processing, a series of processes and the information obtained is performed semi-processed and then sends the data[28].

In most applications, sensor nodes are constrained in energy supply, conservation and communication bandwidth. To shorten the lifetime of the network and efficient use of the limited bandwidth many innovative techniques are proposed to eliminate the energy inefficiencies that are highly required. Such constraints combined with a typical deployment of a large number of sensor nodes produce many challenges to the design and management of WSNs and necessitate and produce energy-awareness at all the layers of the networking protocol stack.

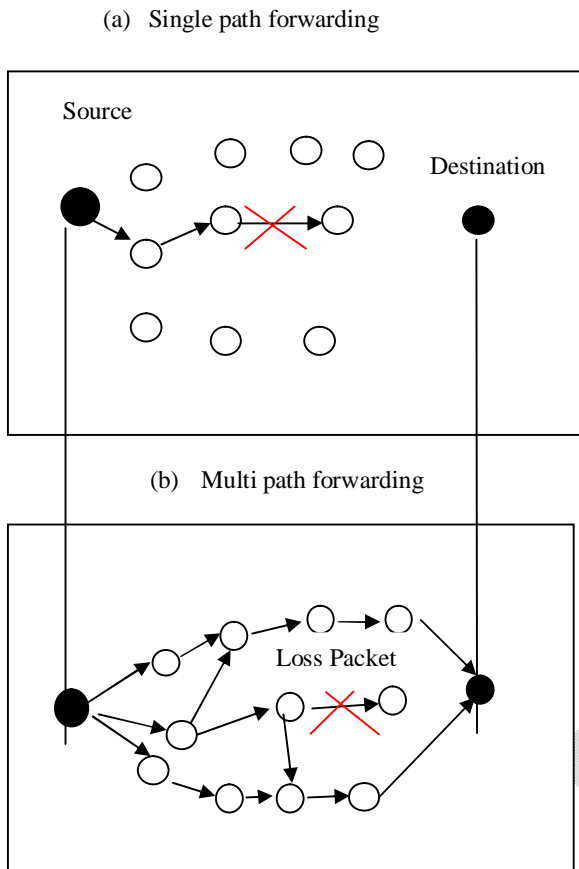


Fig 1 : Single Path and Multi Path Routing

Multipath routing [25],[26] is the technique of using multiple alternative paths in a network, which provides a variety of benefits such as improved security and increase bandwidth. The multiple paths computed might be edge-disjoint, overlapped or node-disjoint with each other. Fig.1 shows the differences between the single and multipath routing [29]. The multipath routing method provides a better fault tolerance and transmission performance by providing:

- Simultaneous, parallel transmission over multiple paths.
- Load balancing through the available resources.
- Avoidance of path discovery for reassigning an interrupted stream.
- By continuously offering packets to all paths, the paths are fully utilized.

Even though any number of nodes or paths may fail, so long as at least one path constituting the virtual path should be available and all sessions remain connected. This means that no streams are needed to be restarted from the beginning and no re-connection penalties are incurred. Multipath routing was used to enhance the reliability of WSNs [5].

One of the main challenges in the design of routing protocols [6], [7] in WSNs is energy efficiency due to the scarce energy

resources of sensors. Due to the inherent characteristics of wireless sensor network that distinguish these networks from other networks like mobile ad hoc networks or cellular networks, routing in WSNs is challenging. To minimize energy consumption of WSN, routing techniques proposed in this literature, employ some well-known routing tactics as well as tactics special to WSNs, such as data aggregation and in-network processing, clustering, different node role assignment, and data-centric methods. Almost all the routing protocol is classified according to the network structure as flat, hierarchical, or location-based. These protocols can be classified further into multipath-based, query-based, quality of service (QoS)-based, negotiation-based and coherent-based depending on the protocol operation [8].

### 1.1 IEATH

Many algorithms are proposed to improve the quality of service parameters in wireless sensor networks are presented. ReInForm algorithm [9] increased the reliability through multiple paths. Improved energy aware and two hop multipath routing protocol (IEATH) which does the efficient multipath routing [10] is done after the ReInForm protocol. Wireless sensor networks are energy limited due to the wireless communication infrastructure and channel errors the packet cannot possibly to reach the destination. To ensure the sending of packets from source to destination, the multipath forwarding method is used. Several copies of an information packet are sent via different separate routes to destination through the routing decision. A special packet "Hello packet" is sent periodically to know the nodes location and their remaining energy. The remaining energy of the neighbor node is sorted in the group, which will decrease the traffic load and increases the lifetime of nodes [29].

The routing decision also based on the nodes information that is located in two jumps. In this method the only information required is about the remaining energy of nodes. The traffic caused by the sending information packets can be reduced through the piggyback method, by sending acknowledge not packets to the applicant node. The route selected should be more accurate and more efficient and should prevent of sending to the lower energy nodes. When the nodes located in a jump have the same conditions are compared with nodes located in the next jump for the better path selection in terms of energy. The reliability of data sending and reduces the rate of dropped packets.

The hybrid method is used to enhance the reliability of data transmission. To improve reliability the copies of packets are sent more than the number of nodes which will cause large energy consumption. Among the sender node, one of the nodes is selected to send duplicate packet, so that energy consumption is reduced.

1.2 QEMPAR

In wireless sensor networks to enable the real time applications will require certain delay and bandwidth, which poses more challenges to design of routing protocols. The algorithm used for packet routing should establish a tradeoff between end to end delay parameter and energy consumption. In proposed, the new algorithm called QEMPAR [11] [30] is used, which is QoS aware and also increases the network lifetime. The performance metrics such as delay, energy consumption and bandwidth are referred to as Quality of Service (QoS) requirements. The QoS based protocols allow the sensor nodes to make a tradeoff between the energy consumption and some QoS metrics before the data is delivered to the sink node. Multipath routing establishes multiple paths between the source- destination pair. With load balancing, bandwidth aggregation, reduced delay and fault tolerance can be achieved.

In the proposed protocol, consider that the nodes are aware of remaining energy and also remaining energy of other nodes in their transmission radio range. With this information the nodes can calculate its probabilities of packet sending and receiving. The decisions of packet transmission are made by examining the recent link quality information. In the energy consumption model, the QEMPAR is obtained by using both the open space and multipath channels by taking the amount of distance between the transmitter and receiver. By this method the energy consumption for transmitting a packet, and receiving a packet are calculated.

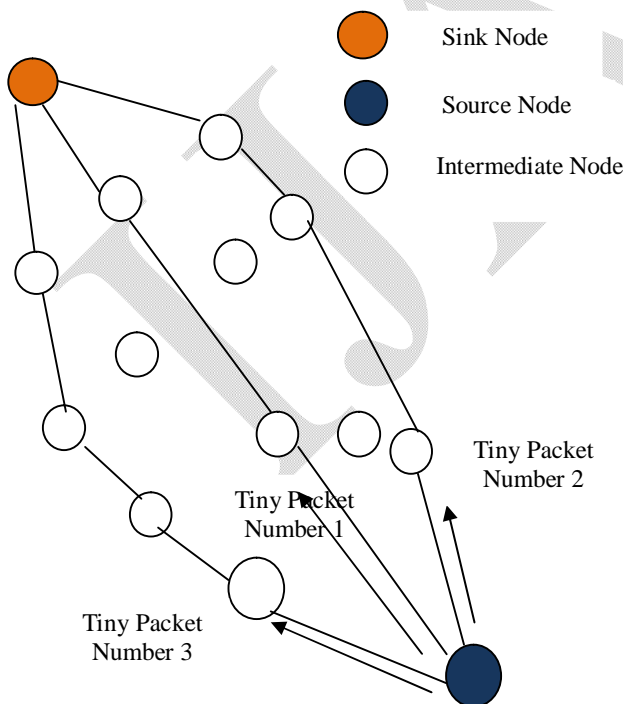


Fig 2 : Tiny packets sending through different paths

The link suitability is used by the node to select the node at the next hop as a forwarder during the path discovery. The path discovery mechanism in QEMPAR uses multipath routing with node disjoint paths because they utilize the most available network resources and they are more fault tolerant. The path assortment is used by the source node to assortment all the paths according to the hop counts. The source node divides the data packet to be sent into few smaller packets with sequence numbers assigned to each of them. Each packet is transmitted through the path has the least number of hops. Hence the tiny packets are sent through different paths.

II MULTIPATH ROUTING PROTOCOL OF MULTIMEDIA WIRELESS SENSOR NETWORK

One main challenge in WMSN is Quality of Service (QoS). QoS is mainly related to the quality of audio and video, end to end delay, jitter, network consumption and service time. The designing of a WSM is an emphasis on the appropriate QoS, security system [12][31]. Now a day, WSN cannot satisfy all the requirements for the environment.

In this paper, a routing protocol of WMSN based on directed diffusion and mobile agent is proposed. The directed diffusion method consists of two steps. One is the path building of the ordinary data and the latter is the path building of the video data. The path building used is based on directed diffusion. The first step tells about the Neighbor Information Entry (NIE) and the nodes. NIE contains the distance details i.e., the distance between a node and its neighbor node. The second step gives an idea about the event driven video data delivery path. It adopts a direct diffusion two-phase pulling diffusion method and a new filter is designed for this purpose. With directional geographical routing the forward error correction coding is combined with a normal multipath scheme for a real time video streaming over a bandwidth limited unreliable network environment[36].

SinkID	Seq Num	Previous node energy	Hop Count	Interval	Data Type
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Fig 3a : Interest Packet format

SinkID	Previous node ID	Previous node energy	Next node ID	VNID
HopCount	Distance	Time stamp	Status	

Fig 3b : Node Neighbor Information Entry

PathID	SinkID	VNID	Previous node ID	Next node ID
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Fig. 3c-Node Path Information Entry

## 2.1 EMPFWSN

WSN's are one of the useful factors in the case of streaming multimedia in infrastructure and hazardous environments. But these types of networks are entirely different because they are dealt with nodes of constrained bandwidth and energy. The only solution for ensuring QoS routing in both wired and wireless situation is the usage of multiple-path transmission method. The recent multimedia streaming applications over sensor networks are the multimedia surveillance, city traffic controlling and avoidance of a vehicle collision. An effective way to establish multiple paths which maximize throughput and minimize deadline miss ratio and interference is proposed [13] [32] [33]. Strong QoS requirements are needed for this type of applications. WSN's have some limitations in supporting these audio/video streaming applications [14] because of the poor raw bandwidth, lack of link characteristics and power supply shortage. However, the recent techniques such as multiple description coding and inexpensive hardware like CMOS cameras and microphones, made transmission of multimedia over WSN's possible. The results have shown that this new algorithm finds route where both throughput and video quality at the sink are much higher than single path counterpart EDGE [15] and standard directed diffusion [16] with retransmission. It has fewer frames that miss the decoding deadline.

The directed diffusion [24] is modified by selecting the links for transmission from source to destination by using the metric (path-cost) and obtains the disjoint paths from source by selecting multiple links at the sink. It will increase the throughput and decreasing delay in multi-hop WMSNs. These diffusions does not use the particular Multimedia QoS requirement for bandwidth. The sensor nodes avoids the fast depletion of routing through decision process or prioritized packet scheduling, playout deadline helps to end to end delay constraint (QoS requirement). When the data arriving later means deadline becomes useless. ETX is used for achieving throughput and is estimated by the signal noise ratio (offers more accurate and stable).

## 2.2 CMQ

A multipath routing algorithm is mainly used to improve QoS requirements in WSN's. It provides an easy way to control the balance of networks load and traffic. The wireless devices in WSNs called node which forms an infrastructure less network. Multipath is a QoS based protocol makes sensor nodes to form a trade-off between energy usage and certain QoS parameters. Multipath routing protocols use multipath, it will increase the reliability and robustness. As a result, network performance will increase.

The proposed protocol CMQ (Cluster based) [17] [34] which ensures required QoS and focus on load balancing, fault tolerance and delay reduction. The previous proposed protocols are Sequential Assignment Routing (SAR) protocol [18] [22], SPEED [19], MMSPEED [20] and MCMP [21].

Table-1 Comparison of Multipath Routing Protocol

Protocol/parameter	Scalability	Hop count	Energy efficient	Use of location Information	Data aggregation	Load Balancing	Fault tolerance	Centralized	Reliability
IEATH	Yes	Single hop	Very high	Yes	Yes	Yes	Yes	No	Yes
QEMPAR	Yes	Two hop	High	Yes	Yes	Yes	No	Yes	Yes
Multipath Routing protocol	Yes	Two hop	Very high	Yes	Yes	Yes	Yes	No	Yes
Efficient multipath protocol	Yes	Two hop	Very high	No	Yes	Yes	Yes	Yes	Yes
CMQ	Yes	Two hop	Very high	Yes	Yes	Yes	No	No	Yes

The CMQ has three phases. They are cluster head announcement, cluster formation and data transmission. The data transmission consists of four steps. They are linked suitability, path discovery, path maintenance and path selection. It guarantees that the required quality of service is obtained through multi-path routing.

**Average end to end delay:** The time required to transfer data successfully from source to destination node. It gives better performance than EQSR.

**Average energy consumption:** The average energy consumed by the nodes participating in message transfer from source node to destination.

**Average packet delivery ratio:** The number of packets generated by the source node and number of packets received by destination node. CMQ has 3 phases that are cluster head announcement, cluster formation and data transmission.

### III. CONCLUSION

In this paper, Multipath routing algorithms are proposed for real time applications and multimedia applications with improved energy efficiency in Wireless Sensor Networks namely IEATH Multipath routing protocol which increases the reliability in data sending and reduces the rate of dropped data packets based on the routing decisions on the remaining energy of nodes, QEMPAR Multipath routing algorithm which is aware of QoS with path discovery mechanism and optimized in end to end delay to the MCMP protocol, GMDDMA Multipath scheduling mechanism protocol which provides better guaranteeing energy efficiency, delay jitter, transmission reliability and video quality when compared DGR, Directed diffusion and mobile agent based routing protocol which can achieve desirable delay, high throughput and meets the QoS requirements of multimedia streaming, CMQ algorithm provides better end to end delay, energy efficiency, delivery ratio and QoS compared to the EQSR.

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