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A SURVEY ON MULTIPATH ROUTING PROTOCOLS FOR WIRELESS MULTIMEDIA SENSOR NETWORKS

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ABSTRACT

Wireless Multimedia Sensor Networks have very critical applications of military, business and civilian domains. The major issue with these networks is the delivery of captured multimedia data with quality of service suitable for the application, with minimum delay, with less power consumption, and with reliability. Multipath routing is a promising solution to address all these issues. The objective the paper is to present all the literature on multipath routing protocols especially designed for multimedia transmission in Wireless Multimedia Sensor Networks. This paper also helps the researchers to identify the areas of further development to address the problem.

KEYWORDS: Wireless Multimedia Sensor Networks, WMSNs, Multipath Routing, Multimedia data transmission.

1. INTRODUCTION:

Wireless Multimedia Sensor Networks (WMSN) are the networks of interconnected heterogeneous wireless multimedia sensor nodes which are capable of sensing audio and video streams, images in addition to the scalar data[1]. The traditional wireless sensor networks (WSN) contain low-cost sensor nodes that can sense physical data like temperature, pressure, location, movement, etc. But in recent times, the latest applications like smart homes, intrusion detection, multimedia surveillance, person locator services etc. need multimedia data. Due to the low-cost CMOS cameras, microphones and advancements in microelectronics and wireless communications, WMSNs evolved as a special category of traditional WSNs. The comparison study of WMSNs and WSNs can be found in the previous work[2][3].

WMSNs are widely used in military, commercial and civilian applications. Large scale WMSNs are helpful as surveillance systems to monitor crime activities in public areas. Visual target tracking, smart home, traffic avoidance, environment monitoring, advance health monitoring systems, disaster management, Internet of Things (IoT) applications, etc are major applications of WMSNs [4]–[6].

As shown in Figure 1[7], usually battery powered multimedia sensor nodes send the captured data to the remote server via gateway for further processing. The multimedia data transmission requires large amount of energy in WMSN as the size of multimedia data is more than the size of normal scalar data. Moreover, it requires suitable quality of service of the specific application with minimum end-to-end delay using the available bandwidth of the system. Thus, efficient transmission of multimedia data requires efficient routing protocol in WMSN. A lot of research work [8]–[19] is done on designing energy-efficient, delay-aware, QoS based routing protocols for WSNs that cannot be directly adapted to WMSNs due to the unique characteristics as mentioned in [3]. Hence, researchers proposed several routing protocols uniquely designed for WMSNs [20]–[32].

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The major problem with the traditional single path routing protocols is uneven load distribution. Some nodes in WMSN transmit more data while other nodes are free or carry little data. Multipath routing is the promising solution to address the problem of load imbalance in data transmission. In this regard, several researchers focused on designing multipath routing protocols[33]–[38] for efficient transmission of multimedia data in WMSNs.

The objective of the paper is to study the multipath routing protocols proposed for the transmission of multimedia content in WMSNs to provide guidelines and future research directions.

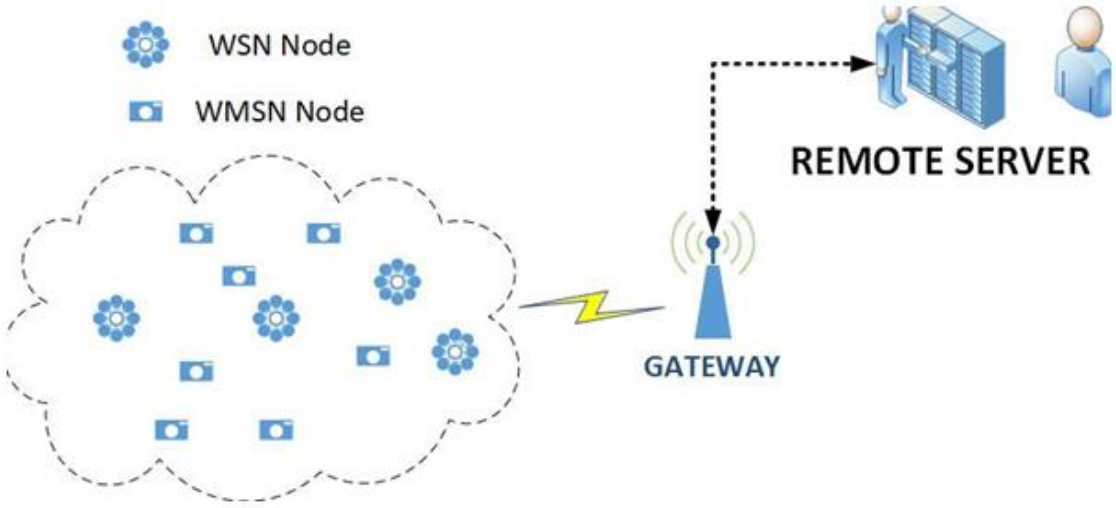

Figure 1. Wireless Multimedia Sensor Network[7]

The structure of the paper is as follows: Section 2 presents brief introduction of WMSN architecture, characteristics and research challenges. Section 3 presents the brief analysis of previous literature on multipath routing protocols proposed for WMSNs. Finally, section 4 concludes the paper with contributions and future research directions.

2. BASIC BACKGROUND:

WMSNs are composed of wireless interconnected multimedia sensor nodes that capture audio, video, image data as well as scalar data which is sent to remote locations for further processing. WMSNs have three types of architectures: single-tier, single-tier clustered and multi-tier architectures[29], [39].

As shown in Figure 2[40], the single-tier flat architecture consists of homogeneous sensor nodes with same functionalities and capabilities leads to easy maintenance of the network. The sensor nodes capture the multimedia data and transmit the data towards the sink node using multi-hop communication. Since all the nodes are capable of processing multimedia data, the life time of network increases.

As shown in Figure 3[40], in the single-tier clustered architecture, the heterogeneous sensor nodes form multiple clusters such that each cluster has a head node. All the cluster head nodes have wireless connection to the sink node directly or indirectly via other cluster heads in a multi-hop fashion. A few advantages include long network life time, scalability and effective topology maintenance.

The multi-tier heterogeneous architecture is shown in Figure 4[40], in which sensor nodes are organized into multiple tiers where each tier has different functionality and capability. The sensor nodes in the first tier perform simple tasks like motion detection. The sensor nodes in the second tier perform complicated tasks such as object detection. Third tier sensor nodes perform more complicated tasks such as object tracking. Each tier has a

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central hub to process the data and to communicate with the higher tier. The third tier is directly connected to the sink node or gateway node. Due to the layered approach, the network is scalable and easy maintenance.

Figure 2. Single-tier Flat Architecture [40]

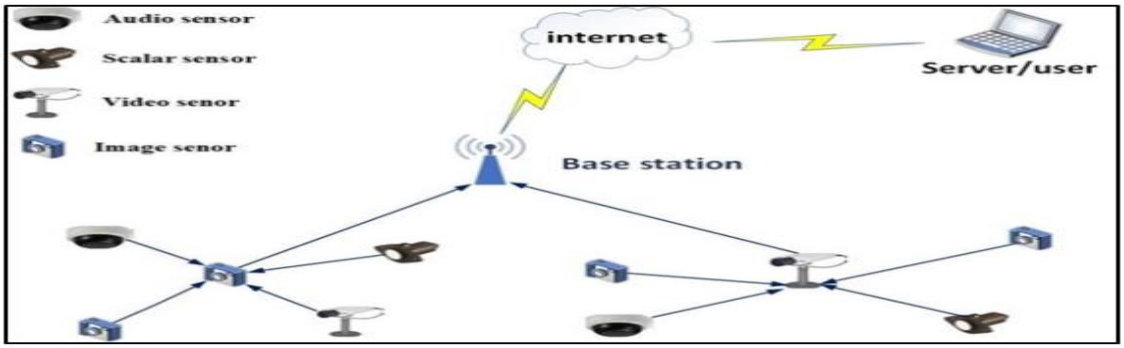

Figure 3. Single-tier Clustered Architecture[40]

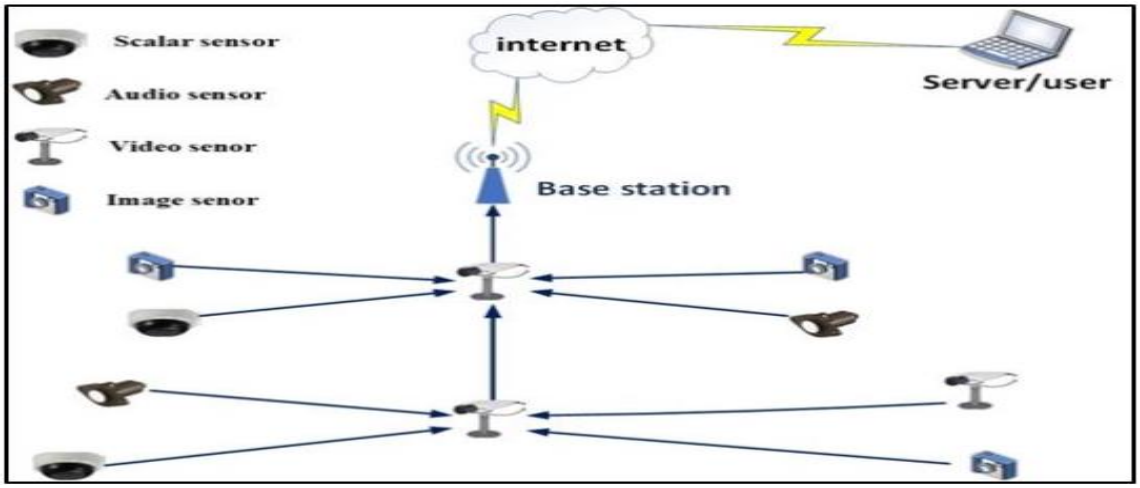

Figure 4. Multi-tier Architecture[40]

The unique characteristics of multimedia sensor nodes in WMSN impose challenges to the researchers while designing routing protocols. Limited Battery Powered Nodes, QoS requirements of Applications, redundancy of multimedia traffic, dynamic network topology, nature of monitoring environment, wireless link quality variance, limited computing power and storage capacity are the challenges that must be considered by the researchers while developing a routing protocol for the multimedia data transmission in WMSN[27].

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Multipath routing is better than single path routing in addressing the routing challenges of WMSNs. A lot of literature[33]–[38] is available on the multipath routing protocols developed for multimedia transmission in WMSNs.

3. LITERATURE REVIEW:

The Two-Phase geographical Greedy Forwarding (TPGF) [41] is a location-based node-disjoint multipath routing protocol proposed for WMSNs. Each path contains different sets of nodes. TPGF is simple and fast but the limitation is inter-path interference.

The work in [42] presents the construction of on-demand non-interfering multiple paths to transmit the data from sensor nodes to sink node. Two non-interfering paths are used by the protocol but the nodes in the paths are not changing until they are dead.

Location based multipath routing protocol is proposed in [43]. At most two paths are used for data transmission. The protocol is better in reducing average end-to-end delay but important parameters such as remaining energy of the node are not considered while forwarding the packet.

Energy-aware location based non-interfering multipath protocol [44] handles the dynamic topology better compared to other algorithms. But it is suitable for single source-sink area network.

Reliable data transmission is guaranteed by the work [45] in which multiple copies of each packet are transmitted to the sink. The protocol uses all paths discovered to keep load balancing in the network.

Another multipath routing protocol [46] which guarantees the reliable data transmission and better load balancing. The protocol solves the problem of interference between parallel paths but it consumes more energy.

The protocol proposed in [47]increases the overall network throughput by reducing the interference between multiple paths used while transmitting the data. The protocol does not consider the usage of directional antennas while reducing the interference between multiple paths.

Online multipath routing protocol proposed in [48] focused on load balancing and energy conservation. Dynamic network topology is handled by the protocol by making packet-forwarding decision at each hop in real-time.

The protocol [48] is enhanced by the authors of [49] . Enhancements include the extension of wider-angle scope for discovering path, consideration of angle view and distance as routing metrics and supporting different traffic types.

Another location-based multipath routing protocol [50] focused on minimizing inter-path interference by considering a routing metric of triangle link quality. Cross-layer interaction is used in making packet forwarding decisions. Moreover, the protocol avoids hidden-node problem without using RTS/CTS handshake mechanism.

Another cross-layer multipath routing protocol is proposed in [51] uses different transmission rates to guarantee the QoS of applications with reliable and timeliness delivery. Since multiple copies of packets are forwarded to selected nodes, energy consumption is more in protocol.

The multipath routing protocol in [52] splits the multimedia stream into audio stream and image stream. Content-based priority and end-to-end transmission delay-based priority are the metrics used in routing the packets. Splitting the multimedia stream incurs overhead.

The authors of [53] proposed a node-disjoint multipath routing protocol which is energy efficient by considering the routing metrics as remaining energy, expected transmission count and interference level. Though the protocol achieves load balancing, the channel acquisition is the challenge with the protocol.

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Multiple paths are discovered faster in [54] by considering carrier sense range instead of interference or transmission range of neighbouring nodes. The protocol minimizes inter-path interference by using the metrics of number of common neighbours while discovering multiple routing paths.

The protocol [55] has the objectives of improving network performance and life time. It classifies the packets based on the multimedia content and high priority packets are forwarded through most reliable paths.

Multipath routing protocol [56] is mainly designed for real-time video streaming in WMSNs. Sensor nodes are given priority based on their link quality towards the sink node. Accordingly, multiple paths are selected for data transmission and adaptive switching takes place to handle dynamic topology of the WMSNs. Network life-time improvement and QoS guaranteed delivery are the advantages of the protocol.

The problem of reliable data transmission is addressed by the protocol [57]. Energy efficient routing is achieved by the protocol but network load balancing fails when multiple networks like WLAN, Bluetooth etc are associated with it.

The major issue of WMSN routing, load balancing, is addressed by the protocol [58]. A primary path and a few backup paths are discovered for data transmission using clustering techniques with minimum spanning trees.The protocol is scalable but failed to maintain success rate of transmissions at all situations.

The limitation of the protocol in[58] is addressed by the protocol [59] that maintains the success rate of transmissions at all situations. The protocol uses hierarchical approach to select best paths for video transmission. Moreover, video packets are scheduled to minimize the video distortion.

QoS routing and network life time improvement are achieved in a unique manner by the protocol [60]. The sensor nodes in WMSN are grouped into two sub-networks such that the nodes in the first sub-network occasionally participate in routing decisions while the nodes in the second sub-network fully participate in routing decisions.

Another QoS based multipath routing protocol is proposed in [61] that achieves load balancing, energy conservation by reducing network congestion. The protocol requires advanced compression techniques for video data transmission.

Minimizing transmission delay and network congestion are the objectives of the protocol [62]. QoS requirements of the applications are guaranteed by the protocol without selecting point to point communication. Maintaining of selected routes becomes easy with the protocol.

The protocol [63] in targets at improving energy efficiency by reducing the control messages exchanged during routing process. The protocol is sensitive to the dynamic changes in delay and reliability even resource deficiency exists.

A multipath routing protocol [64] concentrates on balancing energy of the sensor nodes during the routing process. The main metrics used in the protocol are residual energy of the nodes and the distance of the node from the base station.

The multipath and multi-channel routing protocol [65] has the objectives of collision-free data transmission, interference avoidance. The protocol discovers energy-efficient adaptive multiple routing paths faster. The limitation of the work is unable to connect mobile parent with its child nodes.

The protocol in [66] choses randomly two paths using Euclidean distance for the multimedia data transmission in WMSNs. The protocol uses QoS parameters, energy values and delay estimation as the metrics in selecting the suitable routes to the sink node. But the limitation of the metric is Euclidean distance is a non-deterministic polynomial-hard problem with no known polynomial time algorithms.

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The authors in [67] focused on energy-aware QoS satisfying multipath routing protocol. The number of paths is chosen based on the remaining energy of the nodes. But the limitation of the work is non-availability of monitoring tools for the end-to-end delay and bandwidth requirements.

The location-based multipath routing protocol [68] focused on energy conservation. The protocol is simple to implement as it takes routing decisions at each forwarding node in a greedy manner. But the work is unable to address the issues with dynamic topology of the network.

Table 1. Summary of Literature Survey

Protocol	QoS	Energy-Efficiency	Reliability	Load-balancing	Minimum delay	Dynamic Topology
[41]		yes		yes		
[42]		yes		yes		
[43]				yes	yes	
[44]		yes		yes		yes
[45]			yes	yes		
[46]			yes	yes		
[47]				yes		
[48]		yes		yes		
[49]	yes	yes		yes		
[50]				yes	yes	
[51]	yes		yes		yes	
[52]				yes	yes	
[53]		yes		yes		
[54]				yes	yes	
[55]		yes	yes	yes		
[56]	yes	yes		yes	yes	yes
[57]		yes	yes	yes		
[58]	yes			yes	yes	
[59]	yes			yes	yes	yes
[60]	yes	yes				
[61]	yes	yes		yes		
[62]	yes			yes	yes	
[63]		yes	yes			yes
[64]		yes		yes		
[65]		yes			yes	yes
[66]	yes	yes		yes	yes	
[67]	yes	yes		yes		
[68]		yes		yes	yes	

4. CONCLUSION

WMSNs are playing significant role in many important military, business and civilian applications. The major challenge in WMSNs is the delivery of multimedia content with QoS requirement, minimum delay, minimum energy consumption. Multipath routing addresses many issues compared to single path routing. A brief overview of literature on multipath routing schemes for multimedia content transmission in WMSNs. A quick overview of literature is also presented in tabular format to identify the areas of further development in WMSNs. Most of the multipath routing protocols proposed so far have a goal of addressing single issue. Practically, it is a challenging task for the researchers to design a multipath routing protocol for transmitting multimedia content in WMSNs such that it satisfies QoS requirements of different applications, minimum end-to-end transmission delay, less energy consumption and reliability.

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