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An Overview of Routing Protocols Performance in Wireless Multimedia Sensor Networks

Huda A. Ahmed
Faculty of Computer Science and Mathematics,
\University of Kufa, Najaf, Iraq,
College of Computer Science and Information Technology,
University of Basrah,
Basrah, Iraq,
hudaa.ahmed@student.uokufa.edu.iq
huda.ahmed@uobasrah.edu.iq

Hamid Ali Abed Al-Asadi
*Department of Computer Science, CoEPS, *
North Campus (Karmat Ali),
University of Basrah,
Basrah, 61004, Iraq
hamid.abed@uobasrah.edu.iq

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***Abstract*—Wireless Multimedia Sensor Networks (WMSNs) have emerged as a leading method for providing multimedia data like audio, images, and videos in recent years. Multimedia delivery data in Wireless Sensor Networks with resource limits is a significant due to its file size, notably in terms of energy consumption and Quality of Service (QoS) assurance for Wireless Sensor Networks (WSN). WSN routing protocols are in charge of providing reliable communication and preserving the best network's paths. For multimedia applications, traditional routing approaches are insufficient, so needs to improve it by new techniques. In this survey paper, a various kinds of routing protocols are described that take place in WMSNs. They are classified and compared these efficient Performance routing protocols based on their development of a new techniques. Performance metrics includes End to End packets delay, Network Load, Throughput, Reliability, QoS metrics, and network lifetime. The various routing protocols techniques using WMSN are compared.**

Keywords—Multimedia, WMSNs, WSNs, Routing protocols, QoS.

I. INTRODUCTION

A. General Introduction

When starting a research on a specific topic, you must know its necessary requirements to obtain a desired results. The same case in Wireless multimedia sensor networks (WMSNs) due to its importance and some limitations in routing protocols. This work provides great assistance to a researcher in this field.

A WMSNs are considered as a special kind of WSNs that can detect and transmit scalar data as well as multimedia data such as audio, pictures, video, and a live media stream of video in real time and non-real time [1] [2]. WMSNs are utilized for a various applications, including surveillance, environmental applications, intrusion detection, real time traffic monitoring, and telemedicine [3], owing to substantial developments in image processing techniques, embedded systems, and communication technologies.

The majority of classic WSNs approaches cannot be used in WMSNs [4]. Instead, new techniques ranging from the application layer to the physical layer must be developed, and existing WSN techniques must be updated before being deployed to WMSNs, particularly routing protocols in network layers [5]. Fortunately, several researchers have launched various surveys that covered WMSNs specifics over the years, with top down surveys covering routing protocols leading the way [6] [7].

Developing multimedia applications in the WMSN, discussing various routing protocols categories, and contributing to these areas are the goals of this work. Make a comparison and performance analysis of the routing protocols used in WMSNs in order to provide the multimedia service's QoS and to achieve a network's appropriate performance, such as longevity and data transmission dependability.

B. WMSNs and its challenges

In order to support multimedia applications in mobile and fixed sensor systems, WMSN network-based solutions must be specified, implemented, and validated. The sensors are also restricted in terms of power supply and bandwidth due to limited power supplies. In terms of the routing protocol in WMSN, each of these constraints poses a challenge. It consists of a network of sensing nodes located throughout the area of interest that gather data and transfer it to one or more base stations (sinks) that act as network controllers to collect, store, and process the data. Considering that long-range radio connections use a lot of energy, sinks can also act as a gateway to communicate with other networks and should be situated close to nodes [8] [9]. The general layout of WMSNs is shown in Fig. 1.

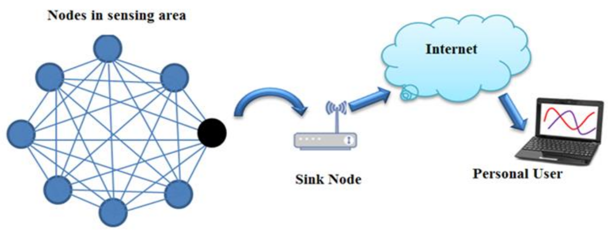

Fig. 1. General layout of WMSNs.

Energy consumption, high bandwidth requirements, flexibility architectures and protocols, dependability, scalability for heterogeneous applications, localized processing, QoS, and real time support are just a few of the constraints and challenges that WMSNs face [9].

In general, there are many challenges that wireless multimedia sensor networks routing protocols faces, that can due to transmitting multimedia data or may be comes from infrastructures constraints, anyways it needs real solutions to get over it. WMSNs routing protocols challenges can be summarized as the following [10], [11],[13]:

1) Energy consumption and battery constraints: applications of multimedia need additional energy than others data, battery limitation needs a good power management to reduce energy consumption.

2) QoS requirement: Quality of service in multimedia requires high packet delivery ratio, low delay, high reliability, no path loss, and high bandwidth.

3) Filtering multimedia data: included the processing of removing redundancy to minimize data size and gathering data from variant distributed sensors. To reduce a cost of transmitting and packets sends a compression technique is use with low error rate.

4) Limited bandwidth: data transmitting in WMSN demands a high bandwidth, that is not easy in wireless channel as compared with wires networks that have a fixed infrastructure. Multi channels or multi paths may considered as a suitable solution to this challenge.

5) Fault tolerance: it requires when occurs a failure network to detecting and correcting the faults, especially in Mobile Ad hoc Networks (MANETs) when nodes join or leave the network.

6) Reliability: overall performance of network can affected by unreliable links and misbehaviors nodes.

C. Routing Protocols of WMSNs

a) General Categories

Routing protocols in Wireless Multimedia Sensor Networks (WMSNs) can be classified into a five categories, including network architectures, route discovery methods, route approaches, algorithm kinds, QoS requirements, multimedia type, etcetera [5],[9]. These types of WMSN classifications are demonstrated in Fig. 2.

There are three types of network architectures [5]: single tier flat, which contains homogeneous sensors with distributed processing and centralized storage; multi-tier flat, which contains heterogeneous sensors with distributed processing and centralized storage; Single tier clusters, on the other hand, consists of heterogeneous sensors with centralized processing and storage. Finally, multi-tier contains heterogeneous sensors that are processed and stored in a distributed manner

Routing discovery protocols, are divided into [14], proactive routing protocols, which finds all routes and stores them in the routing table before transferring data; routing table should update when topology changes; data transmission is made directly without delay because all routes are stored in the routing table. Reactive routing protocols, which finds all routes and stores them in the routing table before transferring data

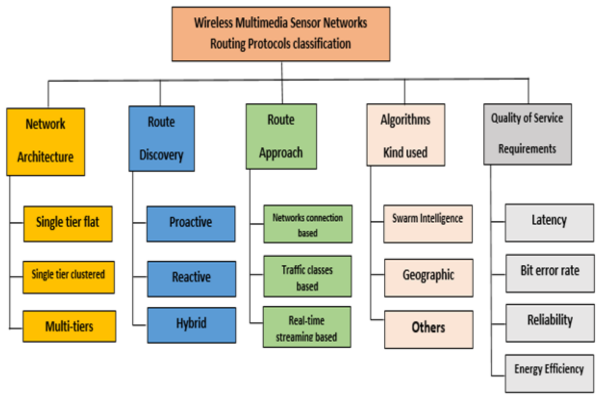

Fig. 2. Wireless Multimedia Routing Protocols Classifications.

. Though there are no routing tables and no necessity for an updating process with reactive routing, the routes are calculated on demand, requiring an additional calculation delay. While hybrid routing protocols consist of a combination of proactive and reactive routing protocols.

There are three types of route classification approaches [5]: (1) Routing based network conditions, in which a routing decision is made based on metrics to avoid paths that may not allow high bandwidth or that may cause data to be retransmitted due to poor channel conditions. (2) Routing based traffic classes, in which data is transferred from sensors to sinks based on varied priorities, such as video data for patient monitoring. (3) Real time streaming based on the routing protocol that provides real time communication services and takes packet delivery time into consideration.

Routing protocols in WMSNs can be classified according to algorithms used in [9]: (1) Swarm intelligence routing protocols that depend on ant colony optimization algorithms. (2) Geographic routing protocol that is responsible to find routing paths with bypassing holes that use greedy forwarding algorithm to WMSNs. (3) Variant other algorithms. In addition to this, Quality of Service (QoS) requirements consider major metrics for the performance of routing protocols, especially in WMSNs. QoS requirements have four essential parameters, latency, bit error rates, reliability, and energy efficiency [7] [15].

b) Open research issues

Due to the increasing need for multimedia applications in wireless multimedia sensor networks, it is necessary to discuss the classifications of existing routing protocols in it, in terms of their suitability for the future vision in this field. Routing protocols in WMSNs should have many characteristics in order to suit the requirements multimedia transmission, these characteristics are:

i. Fully distributed processing.

ii. Suitable bandwidth and power consumption.

iii. Reliable transmission.

iv. Fault tolerance.

v. Provides QoS requirements.

vi. Low control overhead.

These characteristics were taken into account in the design of the different classifications of routing protocols for

WMSNs, and there are observations extracted from our study of these classes that can be summarized as follows:

1) Networks architectures class: single tier flat, single tier clustered, and multi tiers are used, but to satisfy multimedia application requirements the single tier clustered and multi tiers was more suitable, due to single tier flat was limited performance.

2) Rout discovery class: includes the way taken by the protocol to discover next path to transmit data. Proactive, reactive, and hybrid routing protocols are used in variant existing researches. Proactive routing protocols may be distance vector or link state routing, for multimedia transmission link state routing was more suitable by increasing performance. In the other hand, reactive routing protocols may be Uni-path or multipath routing, multipath routing is best in case of multimedia data transmission, due to distributing data over multipath that reduce time of transmission. while in hybrid routing takes the advantages of both proactive and reactive routing protocols by applying reactive for long transmission distance and proactive for short transmission distance.

3) Route approach class: real time streaming based is well choice for transmitting real time video or video conference.

4) Algorithm's kind used class: there are several swarm intelligence optimizations algorithms, the most famous of which is Ant Colony Optimization (ACO) and Partial Swarm Optimization (PSO). The use of optimization algorithms is a convenient solution to increase network efficiency and performance and reduce the time required for data transmission. In the other hands, using of geographic routing needs GPS to determine route decision that may costly, and the information of nodes location saves that become network overhead. For previous reasons the geographic routing is underused in multimedia applications.

5) QoS requirement class: for QoS requirements, the best choice for multimedia file transfer is to use multipath to reduce file transfer time and parallel transfer, increase reliability and energy efficiency and reduce bit error rate.

II. LITERATURE REVIEW

Routing protocols must be simplified and optimized to meet the demands of real time characteristics and increased throughput in multimedia applications. A multi-tier network architecture is a key to enable energy optimization of battery powered high quality video surveillance applications. Using variant techniques, such as going towards multipath, is a good solution to provide QoS requirements in WMSNs where multipath routing protocols provide load balancing between discovered paths.

A Quality Aware Multipath Routing (QAMR) consider as a new multipath routing strategy for efficient WMSNs data transfer, transmission count, delay and energy are the three metrics that used to select multiple paths. the multiple paths with common nodes are disliked in data forwarding so QAMR is disjoint paths in which no two paths have one common node. Simulation is evaluated depending on throughput, packet delivery ratio, and Energy consumption. Jawwharlal R and L. Nirmala Devi [16].

A Practical Swarm Optimization Routing Protocol (MPSORP) M. Z. Ghawy et al [17] proposed an effective routing protocol for wireless multimedia sensor networks based on the Particle Swarm Optimization (PSO) algorithm, which was simulated using the NS2 simulator and compared to AODV and DSDV on a variant performance metrics parameter such as energy consumption, end to end latency, and packets loss. The results show that MPSORP saves energy, performs high packet delivery and throughput, has low end-to-end late.

Smart Greedy, based on the Throughput, Energy-aware, and Multipath Routing Algorithm SGFTEM W. A. Hussein et al [15], uses a smart geographical routing protocol to achieve high QoS and efficient energy consumption for WMSNs, simulated by OMNET++5, by reducing the coverage of radio transmission to a suitable distance that can reach sensor nodes. Packet multimedia routes choose a high throughput way to the sink rather than a shorter one, which improves dependability, minimizes packet loss and end to end delay by 35 and 40 percent, respectively, and improves load balancing of the routing channel.

A priority-based data collection issued to reduce data distortion and increase Quality of Service in WMSNs. In addition to the high transmission rate needs to use an energy harvesting sensor nodes to reduce energy consumption. Simulation results appears that this approach is exceeds previous approaches in many performances metrics Mohammed Falah Abbood et al [18].

Enhanced Greedy Forwarding with Efficient Multipath and Dynamic Routing (EGFMDR) H. A. Abed AL - Asadi [19] findings in QoS performance measurements by OMNET++5 demonstrate that EGFMDR boosts efficiency and reduces End to End Packets Delay and Loss Ratio when compared to other protocols AODV and DYMO.

The two steps of Link Quality and Load Balancing Multipath Geographic Routing (LQLB-MGR) A. Chikh and M. Lehsaini [20] are: (1) Finding multipath node disjoint paths using high link quality, and (2) Load balancing across the detected paths using residual energy. For WMSNs, LQLB-MGR performs better than other standard protocols.

Optimized Compressed Sensing Routing Protocols (OCSRP) S. Ramesh et al [21], a design of an optimized compressed sensing routing protocol for WMSNs that was then compared to the LEACH algorithm in terms of security and QoS metrics, revealing that OCSRP has a high level of QoS and security.

Crashing Concept of Priority (CCP) is WMSNs and end device methodology, that was reduced transmission time. Battery life is extending by reducing energy during data transmissions. The simulation results shows that the CCP is better in sensor lifetime, and transmission time that makes it very suitable to use in biomedical data transmission C.N.Vanitha, and Malathy.S [22].

Energy Efficient Security Aware Localization and Clustering in Wireless Sensor Networks (ESLC-WSN) M. A. Tamtalini et al [23] uses localization methods and hybrid approaches termed Chicken Swarm Optimization and Adaptive Neuro-Fuzzy (CSO-ANFIS) to reduce energy usage and increase data transmission.

The OMNET++ simulator was used to evaluate the improved AODV routing protocol for image transmission over a mobile video sensor network R. J. M. MUHSIN ATTO [24] to the traditional AODV and found it to be more efficient in terms of QoS metrics parameters.

The Low Energy Adaptive Clustering Hierarchy Centralized Sleeping (LEACH-CS) T. W. Tukisi et al [25] protocol was utilized for swarm optimization in MATLAB and then compared to the regular LEACH protocol. Overall network energy was maximized, cost was reduced while expanding nodes, and network lifetime was improved.

Advanced Optimized Link State Routing (A-OLSR) protocol is proposed to improve Quality of Service by enhancing the nodes connection and stability for routes as compared to traditional OLSR protocol. Simulation results appears that A-OLSR was better than others protocols in many performance metrics such as, Throughput, Delay, Routing Overhead, and Energy Consumption. In the other hand, the performance remains stable by increasing network size, that deals to A-OLSR provides scalability to the network H. R. Hussen [26].

Designing an Efficient Multipath Routing Protocol (EMRP) based on QoS parameters, such as, bandwidth, hop count, and delay. Both kinds of traffics was studied real time and non-real time to improving reliability by decrease the number of retransmissions packets. In addition to non-real time traffic needs to generate an additional packet. Results of simulation shows that the performance of EMRP is the best in many performance metrics as Transmission Ratio (TR), End to End delay, Peak Signal Noise Ratio (PSNR), and packets delivery ratio (PDR) V. Saritha et al [27].

Four MANETs routing protocols (OLSR, GRP, DSR, and AODV) was analysis and performance studied for Unmanned Aerial Vehicles (UAVs) communication based on varying data rates. Results of simulation proved that delay performance of protocol was affected by varying data rates. OLSR is the lowest delay than other protocols, while in the other hand OLSR has a highest Routing Overhead traffic Moumita Deb and Abantika Choudhury [12].

Constrained low power scalar sensor nodes and Single Board Computers make up a heterogeneous wireless multimedia sensor networks prototype T. Mekonnen et al [28]. (SBCs). In comparison to a single tier for power consumption, Libelium's Waspmote wireless sensor platform has introduced a simple power model.

Evaluated AODV protocol to be suitable for different MANET networks traffics kinds such as, File Transfer Protocol (FTP), Voice, Video Conference. Many performance metrics is measured such as, Delay, Throughput, Network Load. Simulation appears that there are significant differences between the three types of traffics. Then conclude that the impact of traffic type on MANET depend on the QoS requirements for each type of traffics F. Hazzaa and S. Yousef [29].

The priority rate-based routing protocol (PRRP) L. Tshiningayamwe et al [30], which was designed to alleviate traffic congestion, resulted in massive amounts of multimedia data, making meeting QoS criteria challenging. PRRP uses their own C++-programmed simulator to allocate traffic priorities based on their service requirements. When compared to the PCCP and PBRC-SD algorithms, the findings reveal that this protocol improves queue delay, packet loss, and throughput. The Energy Efficient Tree-based Multipath Routing for WMSNs (EETMRP) A. Yousefiankalareh [31] method is used to boost energetic path and reduce energy consumption in audio and image files.

A novel protocol for local service discovery R. Helal and A. ElMougy [32] uses a hierarchical system of Distributed Hash Tables (DHTs) to eliminate the need for a dedicated getaway and uses a multi-tier architecture to achieve both energy efficiency and a high success rate in fulfilling the service request. This protocol saves energy without compromising the rate at which requests are fulfilled.

A comparison of two MANETs routing protocols AODV and OLSR in video streaming transmitting in different performance metrics likes, End to End delay, throughput, and retransmission attempt. Simulation shows that OLSR is very suitable and effective for MANETs video streaming and in general all real time data transmitting H. J. Alqaysi and G. A. QasMarrogy [33].

Bruijn Hierarchical Clustering (BHC) T. T. Huynh et al [34], a multi-hop, multi-path approach replicated using an NS2 simulator, is used to assure energy efficiency with a suitable delay.

A performance comparison of three routing protocols AODV, OLSR and TORA applied on real time video transmitting. Many performance metrics is measured such as, End to End Delay, Networks Load, and Throughput. Simulation shows that OLSR is better than other in delay time and other metrics S. Naseer et al [35].

In comparison to IEEE 802.11 and IEEE 802.15.4, OPNET uses two-tiered WSN Y. Zhou et al [36] as a multi-tier protocol for health monitoring.

The LEAR protocol (load-based energy-aware multimedia routing protocol) U.-U.-R. Ayesha Nayyar et al [37] employs an NS2 simulator to determine viable disjoint pathways for multimedia traffic faster than the classic AODV protocol.

Using AODV, DSR and OLSR in multimedia transmission data in many performance metrics like, End to End packet delay, jitter, and Packets Delivery Ratio. Simulation shows that DSR is better than other protocols in E2E packets delay and jitter G. Adam et al [38].

In comparison to MHC and floods, OMNET++ uses Minimum Hop Disjoint Multipath routing methods with Time Slice (MHDMwTS) G. Sun et al [39] to assure reliability in WMSNs. MHDMwTS achieves a higher data rate and longer network lifetime, making it more reliable to carry multimedia data.

By balancing the energy consumption of nodes through power allocation, Routing-based Energy Prediction (REP) K. Lin and M. Chen [40] enhances energy efficiency and dependability.

Improved routing protocols to satisfy WMSNs that were discussed previously, can be summarized in TABLE I below in clear, concise form.

TABLE I. COMPARISON OF ROUTING PROTOCOLS FOR WMSNS.

Protocol	Class kind	Year	Simulator used	Performance metrics	Compared with	Results
QAMR	Multipath routing	2022		Throughput PDR E2E delay Average Energy Consumption (AEC)	EEMR AMCMR	QAMR has outstanding performance than other
MPSORP	PSO swarm optimization	2022	NS2	E2E latency Energy consumption Losing packets	AODV DSDV	-reduce energy -reduce E2E delay -increase packet delivery ratio -increase throughput -reduce load
SGFTEM	Geographical routing	2022	OMNET++5	End to end packets delay Packet loss Throughput Reliability	AGEM TPGF GPSR AODV	-Enhance reliability -Reduce end to end delay -Reduce packet loss ratio -reduce energy consumption -Low packet loss -Lowrouting paths load balancing
Priority based data collection	QoS requirements	2022	MATLAB	Packets dropping rate End to end delay QoS	RT-TPC RPKAC	Reduce all of: -rate of packet dropping -E2E delay -ratio of noise
EGFMDR	Multipath & dynamic routing	2021	OMNET++5	E2E delay Ratio of Packets loss Throughput Energy consumption Network life time	AODV DYMO	-Increase energy -Increase efficiency -Reduce end to end delay -Decrease packet loss ratio
LQLB-MGR	Multipath & geographical routing	2021		QoS metrics	Traditional protocols	Provide better performance
OCSRP	optimization	2021		QoS metrics Security metrics	LEACH algorithm	-Process high level of --QoS -High level of security
CCP	QoS requirements	2021		Energy consumption Delay Composite	CRAFT EPSICA	Reduce energy & delay
ESLC-WSN	Clustering & swarm optimization	2020	Localization algorithms	Energy consumption Transmission data		-Reduce energy consumption -Improve data transmission
Improved AODV	Reactive routing	2020	OMNET++	Quality of deliver image No. of delivered data packets Network overhead &life time Packets loss rate	AODV	-Increase quality of delivers images -Better in all parameter metrics
LEACH-CS	Clustering & swarm optimization	2019	MATLAB	Node energy per messaging round Network life time	LEACH	-Maximize overall network energy -Improve network life time -Minimize the cost at increasing nodes
A-OLSR	Proactive &optimization routing	2018	NS2	Delay Energy Consumption Throughput	OLSR	A-OLSR is better than standard OLSR in all performance metrics
EMRP	Multipath & QoS requirements	2019	NS2	QoS: (delay, bandwidth, and hop count)	QAMR RA-MDC	Better on: E2E Delay, PDR, PSNR
4 Routing protocols for UAVs communications	Route discovery (proactive & reactive) routing	2018	OPNET	Routing traffic Throughput Delay		-AODV less load then DSR & GRP - OLSR lowest delay then AODV & GRP -OLSR highest routing overhead
Heterogeneous WMSNs prototype	Network architecture	2017	Libelium waspmote	Power consumption Battery life (network life time)	Single tier	-Simple power model -Increase life time
Evaluated AODV	Reactive routing	2017	OPNET	Rout Discovery Time Routing Traffic Send & Received		Differences between traffic types depending on QoS for each one
PRRP	Priority & QoS requirements	2017	His own C++ simulator	Queue delay Packet loss Throughput	PCCP PBRC-SD	Better in all metrics parameters

EETM RP	Multi path routing	2017		Energy consumption Node failure		Reduce energy consumption Highest energetic path
Novel protocol for local service discovery	Multi-tiers architecture	2015	DHTs	Energy efficiency		-Achieve energy efficiency -Success rate of serving request
AODV &OLSR	Route discovery (proactive & reactive) routing	2015	OPNET	E2E delay Throughput Retransmission attempts		OLSR very efficient for real time transmission
BHC	Clustering & multi path routing	2013	NS2	Energy efficiency Network delay Communication overhead	Other protocols	Ensure energy efficiency Reasonable delay
AODV, OLSR, and TORA	Route discovery (proactive & reactive) routing	2012	OPNET	E2E delay Throughput Network load		OLSR is better in vedio traffic than AODV &TORA
Two tiered WSN	Multi-tiers architecture	2012	OPNET	Real-time communication Energy consumption Network performance	IEEE802.11 IEEE802.15.4	Reduce end-to-end delay Reduce energy consumption
LEAR	QoS requirements & reactive routing	2011	NS2	Throughput	AODV	Find possible faster disjoint paths for multimedia traffics
AODV, DSR, and OLSR	Route discovery (proactive & reactive) routing	2011	NS2	E2E delay PDR Jitter Routing overhead		DSR better than others in transmission data of Wireless Ad hoc Networks
MHDMwTS	Multi path routing	2011	OMNET++	PRR-network life time	MHC and flooding	Ensure reliability to transport multimedia data
REP	QoS requirements	2010		Energy consumption Reliability	No compared	Prove efficiency on energy Increase reliability

In TABLE II, a new comprehensive comparison is provided between different routing protocols. Examples of each type of routing protocol covered in this section, including Flat Routing (Topology Based), Hierarchical protocols, Geographic Position (Information Assisted), Power Power-Aware, Energy-Efficiency, and Multicast Routing depending on Structure/Route Computation, Routes, Stored Information, Update Period, and Update Information were all included in the comparison. In this work it was discovered that the distributed routing algorithms AODV, OLSR, and TORA from the Flat-routing approach are strong, highly adaptive, efficient, and scalable. For various applications, especially real-time applications, these protocols are effective and flexible. GRP and GPSR are scalable geographic routing protocols for WMSN. Low communication overhead and advantages in large-scale deployments are provided by the power-aware and multicast routing systems.

III. CONCLUSION

This paper provides a comprehensive overview of WMSNs, with an emphasis on key research issues and current state of the art enabling technologies for WMSN construction. The work of this paper proposed a survey of various existing routing protocols for dealing with WMSNs. The features and constraints of current WMSNs routing protocols, as well as future research challenges, have been thoroughly investigated in the literature. Routing algorithms for WMSNs should be able to accommodate a variety of application-imposed Quality of Service (QoS) criteria.

A comparative analysis that can assist a researcher in choosing the best routing protocols for particular requirements or for particular network contexts. This inspires us to further research multimedia data transmission over routing protocols in the future, when the network enlarges due to rapid topology change and mobility speed.

REFERENCES

[1] F.L. Benmansour, N. Labraoui, "A Comprehensive Review on Swarm Intelligence-Based Routing Protocols in Wireless Multimedia Sensor Networks". Int J Wireless INF Networks 28, 175–198 (2021). https://doi.org/10.1007/s10776-021-00508-9.

[2] S. Ambareesh, A.N. Madheswari, "HRDSS-WMSN: A Multi-objective Function for Optimal Routing Protocol in Wireless Multimedia Sensor Networks using Hybrid Red Deer Salp Swarm algorithm". Wireless Pers Commun 119, 117–146 (2021). https://doi.org/10.1007/s11277-021-08201-z.

[3] A. Chikh, & M. Lehsaini, ." Multipath routing protocols for wireless multimedia sensor networks: A survey". International Journal of Communication Networks and Distributed Systems. 20. 60. 10.1504/IJCNDS.2018.088500. DOI:10.1504/IJCNDS.2018.088500.

[4] S. Li, J. G. Kim, D. H. Han, and K. S. Lee, "A survey of energy-efficient communication protocols with QoS guarantees in wireless multimedia sensor networks," Sensors, vol. 19, no. 1, p. 199, 2019. https://doi.org/10.3390/s19010199

[5] I. T. Almalkawi, M. G. Zapata, J. N. Al-Karaki, and J. Morillo-Pozo, "Wireless multimedia sensor networks: current trends and future directions," Sensors, vol. 10, no. 7, pp. 6662–6717, 2010. DOI: 10.3390/s100706662

[6] A. Srivastava, & P. K. Mishra,."A Survey on WSN Issues with its Heuristics and Meta-Heuristics Solutions". Wireless Personal Communications.2021. doi:10.1007/s11277-021-08659-x.

[7] R. Chiwariro, "Wireless Multimedia Sensor Networks based Quality of Service Sentient Routing Protocols: A Survey," Int. J. Adv. Comput. Sci. Appl., vol. 10, no. 9, 2019.

[8] H. Kasban, S. Nassar, & El-Bendary, M.A.M."Medical images transmission over Wireless Multimedia Sensor Networks with high data rate". Analog Integr Circ Sig Process 108, 125–140 (2021). https://doi.org/10.1007/s10470-021-01854-7

[9] P. C. Luigi Alfredo Grieco , Gennaro Boggia, Sabrina Sicari, "Secure wireless multimedia sensor networks: a survey," in 2009 third international conference on Mobile ubiquitous computing, systems, services and technologies, 2009, pp. 194–201. DOI: 10.1109/UBICOMM.2009.27

[10] M. B. Sedrati, A., "Multipath Routing to Improve Quality of Service for Video Streaming Over Mobile Ad Hoc Networks," Wireless Personal Communications- Springer US, vol. Volume (99), pp. 999–1013, 2018.

[11] H. Shen, G. Bai, Z. Tang, and L. Zhao, "QMOR: QoS-aware multi-sink opportunistic routing for wireless multimedia sensor networks," Wireless Personal Communications, vol. 75, no. 2, pp. 1307–1330, 2014.

[12] M. Deb and A. Choudhury, " A Review of Wireless Multimedia Sensor Network and existing Routing Protocols", International Journal of Computer Sciences and Engineering, Volume-6, Issue-3,p: 343-358, 2018.

[13] A. O. Bang and P. L. Ramteke, "MANET: history, challenges and applications," International Journal of Application or Innovation in Engineering & Management (IJAIEM), vol. 2, pp. 249-251, 2013.

[14] S. Durai, S.K., Duraisamy, B. & Thirukrishna, J.T. "Certain Investigation on Healthcare Monitoring for Enhancing Data Transmission in WSN". Int J Wireless Inf Networks (2021). https://doi.org/10.1007/s10776-021-00530-x

[15] W. A. Hussein, B. M. Ali, M. F. A. Rasid, and F. Hashim, "Smart geographical routing protocol achieving high QoS and energy efficiency based for wireless multimedia sensor networks," Egypt. Informatics J., 2022 .https://doi.org/10.1016/j.eij.2021.12.005.

[16] R. Jawwharlal and L. Nirmala Devi, " Quality and Energy Aware Multipath Routing in Wireless Multimedia Sensor Networks",Journal of Communications vol. 17, no. 8, August 2022.

[17] M. Z. Ghawy et al., "An Effective Wireless Sensor Network Routing Protocol Based on Particle Swarm Optimization Algorithm," Wirel. Commun. Mob. Comput., vol. 2022, 2022 https://doi.org/10.1155/2022/8455065.

[18] Mohammed Falah Abbood, Mohammed Falih Kadhim, Ahmed Raheem Kadhim," Improving multimedia data transmission quality in wireless multimedia sensor networks though priority-based data collection", International Journal of Electrical and Computer Engineering (IJECE), Vol. 12, No. 4, August 2022, pp. 3595~3606.

[19] H. A. Abed AL ‐ Asadi, "An optimal algorithm for better efficiency in WMSN for multimedia applications," IET Wirel. Sens. Syst., vol. 11, no. 6, pp. 248–258, 2021. https://doi.org/10.1049/wss2.12030

[20] A. Chikh and M. Lehsaini, "Link Quality and Load Balancing Multipath Geographic Routing for Wireless Multimedia Sensor Networks," Int. J. Wirel. Networks Broadband Technol., vol. 10, no. 1, pp. 45–58, 2021. DOI: 10.4018/IJWNBT.2021010103

[21] S. Ramesh, C. Yaashuwanth, and K. Prathibanandhi, "Design of optimized compressed sensing routing protocol for wireless multimedia sensor networks," Int. J. Commun. Syst., vol. 34, no. 11, p. e4887, 2021. https://doi.org/10.1002/dac.4887

[22] C.N.Vanitha, and Malathy.S, "Optimizing Wireless Multimedia Sensor Networks Path Selection using Resource Levelling Technique in Transmitting Endoscopy Biomedical data", IOP Conf. Series: Materials Science and Engineering, 1055 (2021) 012071, doi:10.1088/1757-899X/1055/1/012071.

[23] M. A. Tamtalini, A. E. B. El Alaoui, and A. El Fergougui, "ESLC-WSN: a novel energy efficient security aware localization and clustering in wireless sensor networks," in 2020 1st International Conference on Innovative Research in Applied Science, Engineering and Technology (IRASET), 2020, pp. 1–6. DOI: 10.1109/IRASET48871.2020.9092203

[24] R. J. M. MUHSIN ATTO, "Improving AODV routing protocol for image transmission over mobile video sensor networks," IEEE Access, vol. 8, pp. 169396–169407, 2020. DOI: 10.1109/ACCESS.2020.3024093

[25] T. W. Tukisi, T. N. D. Mathaba, and M. O. Odhiambo, "Multi-hop PSO based routing protocol for wireless sensor networks with energy harvesting," in 2019 Conference on Information Communications Technology and Society (ICTAS), 2019, pp. 1–6. DOI: 10.1109/ICTAS.2019.8703638

[26] H. R. Hussen, S.-C. Choi, J.-H. Park, and J. Kim, "Performance Analysis of MANET Routing Protocols for UAV Communications," in 2018 Tenth International Conference on Ubiquitous and Future Networks (ICUFN), 2018, pp. 70-72. DOI: 10.1109/ICUFN.2018.8436694

[27] V. Saritha, P. V. Krishna, I. Alagiri, V. M. Viswanatham, and M. S. Obaidat, "Efficient Multipath Routing Protocol with Quality of Service for Mobile Ad Hoc Networks," in 2018 IEEE International Conference on Communications (ICC), 2018, pp. 1-6. DOI: 10.1109/ICC.2018.8422385

[28] T. Mekonnen, P. Porambage, E. Harjula, and M. Ylianttila, "Energy consumption analysis of high quality multi-tier wireless multimedia sensor network," IEEE Access, vol. 5, pp. 15848–15858, 2017. DOI: 10.1109/ACCESS.2017.2737078

[29] F. Hazzaa and S. Yousef, "Performance Analysis for Traffics in Mobile Ad Hoc Network," in International Conference on Global Security, Safety, and Sustainability,2017, pp. 342-350.

[30] L. Tshiningayamwe, G.-A. Lusilao-Zodi, and M. E. Dlodlo, "A priority rate-based routing protocol for wireless multimedia sensor networks," in Advances in nature and biologically inspired computing, Springer, 2016, pp. 347–358.

[31] A. Yousefiankalareh, A. Najari, and M. Hosseynzadeh, "Tree-based routing protocol in wireless sensor networks using optimization algorithm batch particles with a mobile sink," in 2020 IEEE 17th International Conference on Smart Communities: Improving Quality of Life Using ICT, IoT and AI (HONET), 2020, pp. 1–5. DOI:10.1109/HONET50430.2020.9322844

[32] R. Helal and A. ElMougy, "An energy-efficient service discovery protocol for the IoT based on a multi-tier WSN architecture," in 2015 IEEE 40th Local Computer Networks Conference Workshops (LCN Workshops), 2015, pp. 862–869. DOI: 10.1109/LCNW.2015.7365939

[33] H. J. Alqaysi and G. A. QasMarrogy, "Performance Analysis Of Video Streaming Application Over MANETS Routing Protocols". INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATIONS AND ROBOTICS, vol. 3, pp. 22-28, 2015.

[34] T. T. Huynh, A.-V. Dinh-Duc, and C. H. Tran, "Energy efficient delay-aware routing in multi-tier architecture for wireless sensor networks," in 2013 International Conference on Advanced Technologies for Communications (ATC 2013), 2013, pp. 603–608. DOI: 10.1109/ATC.2013.6698186

[35] S. Naseer, S. Hussain, I. Raza, S. Chaudry, J. Mirza, and M. Raza, "Mobile ad-hoc network routing protocols: A simulation and performance analysis using multimedia traffic," Journal of Basic and Applied Scientific Research, vol. 2, pp. 9925-9930, 2012.

[36] Y. Zhou, S. Liu, and S. Tang, "A Two-Tiered Architecture of Wireless Sensor Network using Multitier Protocols for Structural Health Monitoring," in Advanced Materials Research, 2012, vol. 468, pp. 42–45. https://doi.org/10.4028/www.scientific.net/AMR.468-471.42

[37] U.-U.-R. Ayesha Nayyar, Faisal Bashir Hussain, "Load based energy aware multimedia routing protocol-(LEAR)," in 2011 3rd International Conference on Computer Research and Development, 2011, vol. 2, pp. 427–430. DOI: 10.1109/ICCRD.2011.5764166

[38] G. Adam, C. Bouras, A. Gkamas, V. Kapoulas, G. Kioumourtzis, and N. Tavoularis, "Performance evaluation of routing protocols for multimedia transmission over mobile ad hoc networks," in Wireless and Mobile Networking Conference (WMNC), 2011 4th Joint IFIP, 2011, pp. 1-6.

[39] G. Sun, J. Qi, Z. Zang, and Q. Xu, "A reliable multipath routing algorithm with related congestion control scheme in wireless multimedia sensor networks," in 2011 3rd International Conference on Computer Research and Development, 2011, vol. 4, pp. 229–233 DOI: 10.1109/ICCRD.2011.5763902.

[40] K. Lin and M. Chen, "Reliable routing based on energy prediction for wireless multimedia sensor networks," in 2010 IEEE Global Telecommunications Conference GLOBECOM 2010, 2010, pp. 1–5. DOI: 10.1109/GLOCOM.2010.5683858