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Review Article

Routing Protocols for Wireless Multimedia Sensor Network: A Survey

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Multimedia applications have become an essential part of our daily lives, and their use is flourishing day by day. The area of wireless sensor network is not an exception where the multimedia sensors are attracting the attention of the researchers increasingly, and it has shifted the focus from traditional scalar sensors to sensors equipped with multimedia devices. The multimedia sensors have the ability to capture video, image, audio, and scalar sensor data and deliver the multimedia content through sensors network. Due to the resource constraints nature of WSN introducing multimedia will add more challenges, so the protocols designed for multimedia wireless sensor network should be aware of the resource constraints nature of WSN and multimedia transmission requirement. This paper discusses the design challenges of routing protocols proposed for WMSN. A survey and comprehensive discussion are given for proposed protocols of WMSN followed by their limitations and features.

1. Introduction

Wireless multimedia sensor networks (WMSNs) are a newly developed type of sensor network which has the sensor nodes equipped with cameras, microphones, and other sensors producing multimedia data content. The development towards the wireless multimedia sensor network has been the result of progress in the CMOS technology which leads to development of single chip camera modules that could be easily integrated with senor nodes. This integration between multimedia sources and cheap communication devices motivates the researches in wireless sensor network. WMSN enhances existing WSN applications and enables a new large range of applications, like multimedia surveillance, traffic management, automated assistance, environmental monitoring, and industrial process control. WMSNs have more additional features and requirements than WSN, such as high bandwidth demand, bounded delay, acceptable jitter, and low packet loss ratio. These characteristics impose more resource constraints that involve energy consumption, memory, buffer size, bandwidth, and processing capabilities [1]. Meeting the quality of service requirements for multimedia data within aforementioned constraints is a real challenge. These mentioned characteristics, challenges, and requirements of designing WMSNs open many research issues and future research directions to develop protocols, algorithms, architectures, devices, and test beds to maximize the network lifetime while satisfying the quality of service requirements of the various applications. Routing protocols designed for WSMN must take into consideration the requirements and resource constraints nature of WMSN, in order to meet the tight QoS requirements. Designing routing protocol for WMSN is still an open research area in spite of many routing protocols proposed for WSN. According to the direction of current research we can classify the routing protocols into different categories, for example, depending on the type and the number of constrained QoS they consider [2]. A classification of different routing protocols for WMSNs is shown in Figure 1.

2. Design Challenge and Resource Constraints

WMSN requirements impose more challenge and resource constraints to the routing protocols design. In this section the main challenges we need to deal with to improve communication efficiency in WMSN are discussed.

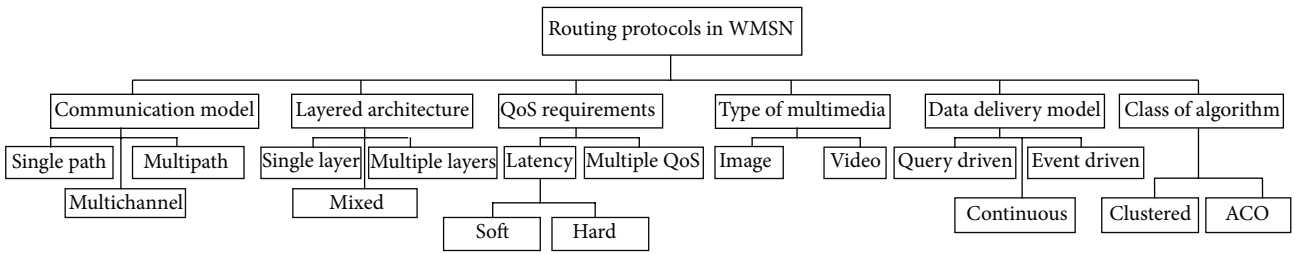

Figure 1: Classification of routing protocols for WMSN.

2.1. Energy Consumption. Multimedia applications produce high volume of traffic which requires high transmission rate and processing capabilities which lead to consuming more energy than WSN. While energy consumption is one of the most important performance metrics in WMSN the routing protocols designed for WMSN should be aware of energy consumption to prolong the network lifetime [3].

2.2. QoS Requirements. QoS requirements differ according to different types of multimedia applications. QoS metrics such as delay, bandwidth, reliability, and jitter must be disparately taken into account as needed. For example many multimedia applications are time critical: need to be reported with a limited time [4].

2.3. Multimedia Coding Techniques. Transmission of multimedia content has for long been associated with multimedia source coding techniques because of the large amounts of traffic generated by multimedia sources such as cameras. The compression techniques certainly decrease the information to be transmitted. This compression, however, comes at the cost of degradation of the multimedia quality that is usually referred to as distortion. Effective compression techniques which developed so far result in good rate-distortion levels to efficient multimedia transmission. Despite their significant compression capabilities and good rate-distortion performance, traditional source coding techniques are not directly applicable to resource constrained WMSNs. This is mainly related to the fact that predictive encoding requires complex encoders and powerful processing algorithms, which significantly increase the energy consumption. Multimedia encoding techniques focus on two main goals for efficient transmission of multimedia data. Firstly, the correlation between pixels of an image/frame or between frames of a video stream can be exploited to significantly reduce the information content to be transmitted without major quality degradation. This is usually referred to as source coding. Secondly, the compressed data should be efficiently represented to allow reliable transmission over bad channels. This is usually referred to as channel coding or error-resilient coding [3]. consequently, the main design objectives of a multimedia encoder for WMSNs are as follows.

2.3.1. High Compression Efficiency. It is necessary to achieve a high ratio of compression to effectively limit bandwidth and energy consumption.

2.3.2. Low Complexity. The resource constraints of multimedia sensors in terms of processing and energy consumption require encoder techniques to be of low complexity to reduce cost and form factors and low power to prolong the lifetime of the sensor nodes.

2.3.3. Error Resiliency. Low-power wireless communication increases the errors in the channel. As a result, the encoders should be designed to account for these effects and provide robust and error-resilient coding [1, 5].

2.4. Multimedia In-Network Processing. WMSN perform multimedia in-network processing algorithm on the raw data transmitted from environment. In-network processing requires new network architecture resource constrained processing that makes filtering and extract the useful information at the edge of network. The scalability will increase by reducing redundant data transmission and combined data coming from different sensors. It is important to enhance the applications independently and self-organizing architecture to perform flexibly in-network processing.

2.5. High Bandwidth Demand. Multimedia traffic demands high bandwidth which requires new transmission techniques to provide the required bandwidth with acceptable energy consumption level to optimize the resource constraints nature of WMSN. Anyhow, using multipath or multichannel can be a solution to this issue.

3. Routing Protocols for WMSNS

The network layer is important to QoS support for multimedia application because it is responsible for providing energy efficient path that meets QoS requirements and it serves as intermediate for the exchange of performance parameters between application and MAC layer [6].

In this section various routing protocols proposed for WMSN are surveyed and the features and limitations of each are discussed. Then a general comparison between them is made. These protocols, in fact, lie under the following categories.

3.1. Swarm Intelligence Routing Protocol. ASAR [7] is a QoS routing protocol for multimedia wireless sensor network

based on traditional ant algorithm. The ASAR selects optimal paths to meet QoS requirements for different types of services. These services are called

(i) R: event driven service mode, where delay and error are intolerant; this requires less bandwidth and high signal to noise ratio path;

(ii) D: query driven service mode, where the error is intolerant, while delay is tolerant; a congestion and high signal to noise ratio path may be used for this service;

(iii) S: stream query service mode, where delay is intolerant but error is tolerant so the less traffic and low signal-to-noise ratio path will be acceptable for this service.

The proposed protocol is a cluster based architecture and only addresses the routing scheme between the cluster heads and the sink node. Each cluster head generates ants for each type of service (R/D/S) to find different service aware paths, from source to destination, which meet QoS requirements and is suitable for the traffic type. A probabilistic rule depending on the pheromone value of the paths is defined to determine the moving from a current node to the next. The pheromone value is calculated based on delay, rate of packet loss, bandwidth, and energy consumption. All cluster heads will have three optimal path tables for different services, three pheromone tables for the three kinds of services, and also a real time pheromone value and a transition probability of the next hop. The simulation results show that the efficiency of the proposed protocol depends on the service type where some types perform well in some QoS metrics while other types are still suffering specially in delay and energy consumption. There are also some drawbacks, like the bottleneck problem of hierarchical model and the optimal path setup due to congestion which requires extra calculations that affect the network performance.

Rahman et al. [8] propose biologically inspired routing protocol which is a swarm-intelligent-based algorithm exploiting the concept of ant colony optimization to optimize the QoS metrics like delay, jitter, energy consumption, and packet survival rate. The protocol does not need to maintain the global state of the sensor nodes. The routing decision is based on neighborhood information only. The effects of both the distance from the current node to the next hop and the remaining distance from next hop to sink are considered in the routing decision. The proposed protocol uses two types of ants to find the shortest path with QoS requirements and the forwarding decision to next hop based on probability equation. The node with high probability is chosen as a forwarding node. At first the source node sends forward ant which uses probability equation to find the probabilities of each neighbor and the packet forwards to neighbor with high probability. Same steps are repeated till reaching the destination. The forward ant will be killed if it visits more than half of the number of nodes which means that the path has a loop or is nonconvergent. When the forward ant reaches the destination successfully, the backward ant is created to reinforce the visited nodes by increasing the probability value. The proposed protocol can be configured for both acknowledgment-based and non-acknowledgment-based approach. The backward ant will acknowledge the path which is chosen by forward ant. The source node will send a new forwarding node if the earlier packet is lost or the acknowledgment does not reached the source within a certain period of time. The simulation results of the proposed protocol were not compared with related protocols, while it shows good performance in jitter and delay and for the most time it finds the shortest path which leads to consuming less energy. The load balancing between nodes is not considered, which causes holes when energy of some nodes is depleted earlier than others. The protocol requires accurate geographic information of the node which increases the cost of deployment. In addition, while the network scales increase the overhead is also increased making the protocol inefficiently scalable.

ALCOLBR [9] is a routing protocol based on ant colony optimization for load balancing and addressing the QoS requirements for WMSN. The intracluster routing is built by minimum spanning tree then intercluster routing which is built by proposed ant colony optimization algorithm to find optimal and suboptimal paths. Constructing hierarchical routing tree to cluster head with cluster members is done by using MST algorithm. Intercluster routing is to find optimal and suboptimal paths using ACO algorithm. Suboptimal paths will be used when the amount of data exceeds path flow threshold. Forward ants and backward ants are used. The forward ants will die when reaching its limit. While moving from one node to the next the forward nodes update the pheromone using local pheromone update rule. The highest probability node will be chosen as next hope node. The same process is repeated till second and third suboptimal paths are found. To reinforce the optimal paths the backward ant releases more pheromone in these paths based on global pheromone rule. Then the transmission will start from source to destination. In case of node failure, the neighbor node will set the pheromone value to zero and send an error message to source node. Then the source node will stop transmission in this path and enable an alternate path for transmission. The protocol determines the congestion occurred by monitoring the end to end delay from source to destination. If it exceeds the threshold a congestion message will be sent to the source node. When the source node gets this message it will reduce the data amount sent in this path and enable an alternate path which increases the reliability. The simulation results show that the performance of the protocol is better than relevant protocols such as AGRA and MIAR, in delay, nodes life time, and scalability and reliability. The draw backs of the proposed work are the hierarchical model which introduces bottleneck problem and the optimal path selection that requires extra calculation which may decrease network performance.

Ke et al. [10] propose a routing protocol using game theory and ant colony algorithm to meet QoS challenge in wireless multimedia sensor network. The standard game theory has three elements: players, payoff, and strategies. The authors assume the players to try to maximize their payoff with minimum cost. The sensor node uses local information to build a routing path depending on the game result and

the residual energy. Ant routing algorithm is used based on [11]. The forward ants are sent to explore the path to destination node. The routing decision takes place based on the pheromone trails left by ants. The probability calculation for forward decision uses residual energy, delay, and bandwidth. When the forward ants successfully reach the sink, a backward ant is generated and takes the path found by forward ants toward the source.

3.2. Geographic Routing Protocol. TPGF [12] is a two-phase geographic greedy forwarding algorithm for WMSN. The first phase is responsible for exploring the possible routing paths while the second phase is responsible for optimizing the found routing paths with the least number of hops. The protocol assumes that each node is aware of its location and its one hop neighbor node location. Each node has three states: (1) active and available, (2) active but unavailable, and (3) dead. The links have two states: available and unavailable. The routing paths should be through active and available nodes and available links to avoid the holes and then optimize the found routing paths with least number of hops. For these two phases' geographic forwarding and path optimization is proposed. The geographic forwarding is responsible of finding routing paths with bypassing holes and consists of two methods: (1) greedy forwarding chooses the next hop node which is the closest to the sink among all neighbor nodes; (2) step back and mark: if the node has no next node except its previous node, then it will mark itself as a block node and the previous node will try to find other available node. The path optimization is to optimize the routing paths with least number of nodes and eliminate the path circle. The label based optimization is used to add other functions to the forwarding phase. Each node chosen for forwarding will have a label including path number and a digressive node number. An acknowledgment will be sent back when the routing path reaches the destination. The acknowledgment will be sent to the node which has the same path number and the largest node number. The results show that the average numbers of paths found by TPGF are more and shorter than the number of paths found by relevant protocols like GG and RNG. The drawback of TPGF is that it needs to build a complete map of the network topology which limits its scalability.

GEAMS [13] is a geographical multipath routing protocol designed to prolong the network lifetime. The proposed protocol is an enhancement of the GPSR protocol [14] where the feature of load balancing is added, to reduce the queue size and increase the life time of the network. The forwarding decision policy is taken based on the remaining energy, number of hops, distance between node and its neighbors, and the history of the packet forwarded belonging to the same stream. There are two modes used by the proposed protocol, the smart greedy forwarding and the walking back forwarding. The first mode is used when there is always a neighbor closer to the destination than the current node. The second mode is used to deal with blocking situation, where the forwarding node cannot find the next hop node toward the destination. Each sensor node stores some information about it on hop neighbor, which includes distance, link rate, and remaining energy. The simulation results show that the GEAMS is more suitable for WMSN than GPSR protocol. It ensures uniform energy consumption and meets QoS constraints.

3.3. Routing Protocols Addressing Different Types of Algorithms. Yao et al. [15] propose a routing protocol that uses metadata to construct multipath routing to meet QoS metrics. The proposed protocol uses advanced Dijkstra algorithm and cost function to make routing decision. The advanced Dijkstra algorithm reduces the number of neighbor nodes by excluding the nodes with insufficient remaining energy and uses more than one factor such as delay, bandwidth, and remaining energy. The cost function is calculated based on delay and energy consumption for multipath, and then the optimized path will be selected. End to end delay calculation depends not only on the distance between nodes but also on the processing and queuing delay of relay nodes. To reduce queue delay, a classified queue model is introduced at each node to classify real time data and nonreal time data. The metadata is used to describe the packet. Ordinary data packet is described by ID and time stamp, while the multimedia data is described by ID, time, and location coordinator to avoid repeating the same data, which consumes more energy. The proposed protocol is simulated and the result shows that it is better than SAR protocol in delaying and energy consuming. The protocol does not consider reliability and bandwidth. The metadata is inappropriate for multimedia data because it increases the overhead and energy consumption.

Guannan et al. [16] propose a routing protocol for wireless multimedia sensor network using multipath and load balancing, aiming to increase the reliability, save more energy, and control the congestion situation. The proposed protocol is flat and event driven. No global topology is required, and the sensor node is only aware of its neighbor nodes which reduce the overhead. Three full disjoint paths are built from source node to sink called primary, alternate, and backup paths. The primary path is the least delay path, then the alternate and backup paths. By default the backup path will be used in case the primary or alternative paths fail. The transmission on these paths will be on stable rate and in round robin fashion but with specific time control called time slice control. Each sensor node will use two paths for transmission. As the primary path has less time delay it will get more time than the alternate path. The congestion control mechanism is designed for the major node (joint node) which is a node used by two paths as a relay node and is done by monitoring the queue of this node if the receiver queue reaches the threshold. A congestion notification is sent back to the source then it will stop transmitting in this path and switch to the another path. The simulation result shows that the protocol enhances the life time and throughput but under higher transmission rate the receiving rate and the network life time drop fast. The redundancy is low which affects the reliability. The work did not discuss the delay and bandwidth which have more impact on multimedia transmission.

Mande and Yuanyan [17] propose multipath routing protocol to support hole bypassing, load balancing, and congestion control. The proposed algorithm consists of two phases. The first one determines a set of multiple paths while the second selects a routing path from the found paths.

During exploring the path, the node that belonged to FCS (set of nodes that is nearer to destination and farther from the source than the current node) with less DEF (Decisive Energy Factor) (energy consumption for transmitting data packet) value is selected as next forwarding node. The proposed protocol uses amazing search algorithm which consists of wave front expansion and path back tracking. In wave front all valid nodes from source to destination are labeled in a decreasing tag number till reaching the destination. During path backtracking, the algorithm starts from destination to source and selects the node whose tag number is greater than the current node. When the source node is successfully reached, then the path is built. After multiple paths are determined, selecting paths randomly and independently from different sources increases the congestion and energy consumption in some nodes. To overcome these problems a path selection strategy is designed. To manage energy consumption, a Decisive Energy Ratio Change Request (DERCR) message is introduced which is sent by node to source to update the energy consumption value on the path. For congestion avoidance a control message is introduced which contains node and path ID; when the queue exceeds threshold specified by user the node sends this message to all nodes in routing tables; then two adjustment strategies are used, (1) gradual increase strategy based on the path and (2) gradual increase strategy based on flows. The work was not simulated to show the protocol performance. Delay, bandwidth, and jitter, which are tight requirements of multimedia transmission in wireless sensor network, are not considered.

Hamid et al. [18] present multichannel multipath QoS aware routing protocol. The routing decision in the proposed protocol is made according to dynamic adjustment of the required bandwidth and proportional delay differentiation for real time data. To efficiently utilize the bandwidth using multiple frequencies a Mutual Orthogonal Latin Square (MOLS) based scheduling is applied to assign transmission and reception activities. Packet scheduling policy is introduced, where every node has a classifier to send data into different queues according to their bandwidth and delay requirement. Initially, the sink node will specify the bandwidth value depending on delay of time critical packets and send this value to all nodes, and then all nodes will dynamically calculate their bandwidth value considering the distance to sink. The PPDD will calculate the delay for each packet in queue along the path. The PPDD (path-length-based proportional delay differentiation) schedulers service packets in classes and realize proportional average hop queuing delays among them locally at each node in the path. The proposed work defines that the packet has less number of hops to sink; it will allow higher delay than the packet coming away from the sink. To maximize the bandwidth of nonreal time traffic the sink will observe the delay; if it is increased it will increase the bandwidth for real time traffic and vice versa. The routing from source to destination will be done through the paths and channels that meet the bandwidth and delay requirements. Packets that do not meet the QoS requirements are discarded. The best effort traffic will be routed through alternative paths for balancing the distribution of remaining traffic. The simulation result shows that the proposed protocol has a good performance in delay, throughput, and lifetime compared to single r and multi-r proposed in [19] while reliability and energy are still not studied well. In addition switching between different frequencies introduces more delay.

MCRA [20] is a multiconstrained routing protocol designed to provide end to end delay, packet loss ratio guarantee, and balance the energy consumption in sensor nodes. The proposed protocol is query driven and query flooding data mode. The interest message is sent from source node to all neighbors. When a certain node receives the message and can meet the QoS requirements, it will broadcast the interest to all of its neighbors, otherwise it will be discarded. Same steps are repeated till the interest reaches the source node. When the source node receives multiple interests from different paths it will choose the optimum path. The differentiation service in MAC layer can be used to classify the real-time data and best effort data into different priorities. To decrease the redundancy and retransmission caused by collision, the proposed work introduces message suppression technique, which consists of two aspects: restraining forwarding and deferring one. The idea in restraining forwarding is to reduce the number of interests by restraining some nodes from forwarding, while the idea of deferring forwarding involves deferring forwarding action, so these nodes have enough time to collect and merge interests from different sources. The authors design a localization approach based on hop-count information attained from the routing process and supposing that the network nodes are distributed on a plane of rectangle "m" units in length and "n" units in width or any other known shapes. The simulation result shows that the packet loss ratio in MCRA is the best compared to DD and speed protocols. End to end delay is closest to speed, while the energy consumption is shown to be better than speed protocol, in case that the numbers of nodes are more than 70. The proposed work does not consider the reliability and bandwidth while still there is broadcasting in every node from source to destination which increases energy consumption.

Poojary and Pai [21] propose a routing protocol designed to be power aware, reliable, and having low latency. The routing algorithm consists of two steps: route setup phase and data transmission phase. In route setup phase a discovery message is sent by source node to all neighbors to explore different paths. When the neighbor nodes receive the message it will forward it to next hop, in case that the number of paths built through this node are less than threshold and the residual energy of the node is more than required energy; otherwise the node will send negative acknowledgment message. The same procedures are repeated till the message reaches the destination. Then if the destination node is ready to receive data it will send "ok" message to the source node. When "ok" message is received by the source node it will add "ok" message sender node ID to multipath set which consists of the nodes which are used as next hop nodes in transmission. In data transmission phase subset of paths is selected based on the residual energy. The data split into "m" parts and send it in multiple paths. To achieve reliability, the proposed protocol uses Reed-Solomon encoding to encode the transmitted data. Simulation results show that the energy consumption is less

than the conventional protocols. Packet loss ratio is decreased in case that the number of transmission paths is increased. The main drawbacks in the proposed work are use of Reed-Solomon for reliability which increases energy consumption and no consideration for end to end delay and bandwidth requirements. Splitting data into different paths increases the overload of data collection.

Li et al. [22] propose a multipath routing protocol based on directed diffusion. The protocol tries to find multiple disjoint paths with high throughput and low end to end delay. For this purpose the protocol uses the path metric cost, which is based on delay and expected transmission account, (ETX), and modifying directed diffusion protocol by (1) using cost path as a metric instead of pure delay; (2) reinforcing multiple paths at the sink to obtain disjoint paths from the source. When the source receives interest from the sink, exploratory data packets are flooded. When receiving exploratory data, the relay nodes will read SNR from the packet. EXT of the previous three upstream links is calculated from SNR and inserted into the packet header of ETX field. The cost of each subpath is kept in local table at intermediate nodes in ascending order. Only the one with lowest cost is forwarded to the next hop. For delay, the protocol only considers the packets whose time stamps from source to sink before the deadline. The results show that the proposed protocol works better than EDGE and directed diffusion protocols in throughput and delay aspects, while there is still flooding in exploring time which increases energy consumption. The other QoS metrics are not considered, like reliability, bandwidth, and energy consumption.

Kai and Min [23] propose reliable routing protocol based on energy prediction of WMSN. This mechanism makes the sensors predict the energy level of other nodes, and then depending on this, the protocol can balance the energy consumption of nodes by power allocation mechanism. The main goal of the proposed protocol is to increase the reliability and balance the energy consumption. The increasing of reliable transmission rate is done by increasing the power transmission level which leads to consuming more energy. For saving energy the authors use the power control algorithm presented in [24] which guarantees the reliability by gradually increasing the power level. If the maximum power level still does not meet the reliable transmission request, it has to rebuild the other route. The energy prediction mechanism is achieved by designing a state conversation model for intracluster nodes, by assuming that there are seven working states for sensors: sleep, sense, idle, receive, transmit, process, and access. Then a Markov chain is used to simulate the working state. To make sure that all sensory data reaches the sink, the network is divided into many concentric coronas. The coronas width is equal to communication distance when using the lowest transmission power level. At the beginning, the power level is set to 1 for all nodes; if the node fails to find the next hop or does not meet the reliability requirements it will increase the power level gradually till reaching the maximum power level. If it is still failed, it will stop the processing and try to find other route. For balancing the network energy consumption the transmit power level is adjusted dynamically according to the remaining energy. The simulation results show that the energy prediction mechanism increases the node life time and enhances the reliability. The results are not compared to relevant protocols. The energy prediction calculations increase the power consumption. There is no consideration for delay and bandwidth.

LEAR [25] is energy aware multimedia routing protocol which makes modification on AOVD protocol and offers QoS by assigning routes according to data type; these routes are less congested and have maximum power. The protocol also offers a hole bypassing technique. The protocol assumes that the network consists of scalar sensors and multimedia sensors. The scalar data is treated as the best effort data while for multimedia data special care must be taken. A bit is inserted into request message to distinguish between scalar data and multimedia data. When event occurs a request message is broadcasted to all neighbors of the source node. The node receiving this message again sends it to their neighbors till it reaches the destination. The destination replies by sending a request reply message to the source. When the source receives this message the transmission will start in this path. The path selection is based on route selection factor. The node with high selection factor value will be chosen as a forwarding node. The selection factor calculation is based on remaining energy and active routes used by the node. When the node reaches 25% of its total energy it will be labeled as a swap node and will not participate in the routing. The scalar data is routed like AODV protocol. The simulation results show that the number of paths is increasing as multimedia data is increasing. The hop distance will increase but with high throughput and the congestion will be reduced. The protocol still uses broadcasting in all forwarding steps which increases energy consumption. Delay, bandwidth, and reliability are not considered in the proposed protocol.

Data dissemination phase is used as the first step in many different routing protocols designed for WMSN. Mohajerzadeh et al. [26] propose data dissemination protocol for WMSN named MLAF. The protocol aims to reduce the redundancy, prioritize the data according to their importance, and give attention to delay and energy consumption. MLAF considers the network as a virtual grid and every node is aware of its geographical position. There are two types of nodes defined in each cell: internal nodes where all their neighbors are inside the cell and edge ones which have at least one neighbor in another cell. Each packet has a field which registers the ID of the received nodes. If any node receives the packet and finds its ID in the list the packet is destroyed. The proposed protocol uses two mechanisms for routing directional forwarding and delay sensitive forwarding. In directional forwarding there are two priorities: low priority data where each grid cell should receive data from southern cell; the packet comes from other direction will be destroyed; For high priority data, each grid cell receives data from all its neighbors. In delay sensitive forwarding we have also two different priorities but the forwarding way is different. For high priority traffic MLAF will decrease the number of hops by increasing the transmission power while the low priority traffic will follow the normal routes. Simulation result shows that the performance of the proposed protocol is better compared to LAF protocol but the broadcasting at

Table 1: Comparison of routing protocols for WMSNs.

Protocol	Architecture		Data deliver model			Methodology						Congestion control	Classification service	Energy efficiency	QoS parameters are considered
	Flat	Hierarchical	Query driven	Event driven	Stream query	Location awareness	Hole bypassing	Multipath	Multichannel	Geographic	Other				
Yao et al. [15]	√		√					√			Metadata + advanced Dijxtra		√	√	Delay
Guannan et al. [16]	√			√				√				√		√	Reliability
Mande and Yuanyan [17]	√		√				√	√			Amazing algorithm	√	√	√	Reliability
Hamid et al. [18]	√		√					√	√				√		Delay-bandwidth
MCRA [20]	√		√			√					Flooding		√	√	Reliability
Poojary and Pai [21]	√		√					√						√	Reliability
Li et al. [22]	√		√					√			Based on direct diffusion				Delay
Kai and Min [23]	√		√								Energy prediction mechanism			√	Reliability
LEAR [25]	√			√			√	√			Based on AODV		√	√	Reliability
MLAF [26]	√		√			√		√			Based on LAF		√	√	Reliability-delay
ASAR [7]		√	√	√	√			√			ACO		√	√	Delay, packet loss ratio-bandwidth
Rahman et al. [8]	√		√								ACO			√	Delay-jitter
ALCOLBR [9]		√	√					√			ACO	√			Reliability
Ke et al. [10]	√		√								ACO and game theory			√	Delay-bandwidth
TPGF [12]	√		√			√	√	√		√					Delay-reliability
GEAMS [13]	√		√				√			√	Based on GPSR			√	Delay-reliability

Table 2: Simulation scenario of proposed routing protocols for WMSNs.

Protocol	Verified method		Simulator type	Performance metrics	Compared to	Comparison result
	Simulator	Testbed				
Yao et al. [15]	√		Not specified	Energy consumption-delay-distance	SAR	The REAR algorithm prolongs the network liftme and performs much better than SAR
Guannan et al. [16]	√		OMNet++	PRR-network life time	MHC and flooding	Achieveing higher data rate and longer network life time. But under higher package transmitting rate from source, receiving rate, and network life time will drop fast
Mande and Yuanyan [17]	—	—	—	—	—	—
Hamid et al. [18]	√		NS-2	Delay-node life time-throughput	Single-r and multi-r mechanisms	Providing significant performance improvements in terms of average delay, average lifetime, and network throughput
MCRA [20]	√		NS-2	Delay-packet loss ratio-control message overhead	SPEED-DD	Showing that it has a good overall performance
Poojary and Pai [21]	√		Qualnet network simulator	Energy consumption-PRR	Not specified	Prolonging the network life time and the packet drop reduces as the number of paths selected for the data transmission is increased
Li et al. [22]	√		NS-2	Throughput-delay-goodput	EDGE and basic diffusion	Achieving high throughput and desirable delay to meet the QoS requirement of multimedia streaming
Kai and Min [23]	√		Not specified	Energy consumption-reliability	Not compared	The energy consumption is reduced by using the proposed energy prediction mechanism
LEAR [25]	√		NS-2	Throughput	AODV	The protocol finds possible disjoint paths or partial disjoint paths for multimedia traffic faster than AODV
MLAF [26]	√		Opnet	Energy consumption-PRR	LAF	Showing good result in energy consumption, reliability, and end to end delay
ASAR [7]	√		NS-2	queuing delay, PRR, and dropped rate	Traditional ant-based-Dijkstra-DD	Select the optimal paths to meet their individual QoS requirements. Thus improving network performance
Rahman et al. [8]	√		Java	Delay-jitter	Not compared	M-IAR shows good performance which achieves acceptable delay, jitter, and energy consumption

Table 2: Continued.

Protocol	Verified method		Simulator type	Performance metrics	Compared to	Comparison result
	Simulator	Testbed				
ALCOLBR [9]	√		NS-2	Delay-node life time-PRR	AGRA and M-IAR	ACOLBR has a better adaptability; it can achieve load balancing, reduce the end to end delay, and prolong the network lifetime
Ke et al. [10]	—	—	—	—	—	—
TPGF [12]	√		NetTopo	Delay-no. of found paths	GPSR	Holes can be efficiently bypassed compared to (GPSR), suitable for multimedia transmission
GEAMS [13]	√		OMNeT++	Delay-lost packet-energy distribution	GPSR	More suitable for WMSNs than GPSR as it ensures uniform energy consumption and meets the delay and packet loss constraint

each node increases energy consumption, redundancy, and congestion. The protocol requires grid arrangement which is not suitable for all applications of sensor network. The results are not compared to known protocols for WMSN. Increasing the reliability and decreasing the delay by increasing the transmission power will increase energy consumption which affects the network performance.

Table 1 shows summary of comparison between aforementioned routing protocols for WMSN based on the QoS parameters considered: data delivery model, network architecture, hole bypassing, energy aware, methodology used, congestion control mechanism, location awareness, and classification service.

Table 2 shows the simulation scenario of proposed routing protocols for WMSNs.

4. Conclusion

Appearing of WMSN has opened new large applications in our life and many researches issues emerged that need different solutions. In this paper WMSN technologies are introduced. Challenges and resource constraints are discussed. Current routing protocols are classified according to the existing researches direction. Also the routing protocols proposed for multimedia transmission are surveyed and the performance issues of each routing protocol are highlighted. In our survey, we can realize that the proposed protocols for wireless multimedia sensor network have different methodologies and one goal which satisfies the multimedia transmission requirements. The proposed protocols lie under different categories as mentioned, where the first class shows the routing protocols based on ant colony optimization. The ACO displays several features that make it particularly suitable for wireless multimedia sensor networks. Additionally, ant routing has shown excellent performance to solve routing problems in WSNs and ad hoc networks. The second class is geographic routing protocols like TPGF and GPSR. These protocols achieve good performance in hole bypassing and it is suitable for WMSN as it ensures uniform energy consumption and meets the delay and packet loss constraint. The last class of the proposed protocols follows different algorithm types and addresses different QoS metrics that are required for multimedia transmission with resource constraint nature of WMSN. We believe that the researches focus will increase in this area, while developing routing protocols will attract more attention since they play the key roles behind the development of WSN.

References

[1] I. F. Akyildiz, T. Melodia, and K. R. Chowdhury, "Wireless multimedia sensor networks: applications and testbeds," *Proceedings of the IEEE*, vol. 96, no. 10, pp. 1588–1605, 2008.

[2] S. Ehsan and B. Hamdaoui, "A survey on energy-efficient routing techniques with QoS assurances for wireless multimedia sensor networks," *IEEE Communications Surveys and Tutorials*, vol. 14, no. 2, pp. 265–278, 2011.

[3] I. F. Akyildiz and C. M. Vuran, *Wireless Sensor Networks*, Ian F. Akyildiz Series in Communications and Networking, I. F. Akyildiz, Eds., John Wiley and Sons, New York, NY, USA, 2010.

[4] J. Zheng and A. Jamalipour, *Wireless Sensor Networks: A Networking Perspective*, IEEE Press Editorial Board, John Wiley & Sons, New York, NY, USA, 2009.

[5] B. Girod, A. M. Aaron, S. Rane, and D. Rebollo-Monedero, "Distributed video coding," *Proceedings of the IEEE*, vol. 93, no. 1, pp. 71–83, 2005.

[6] S. Misra, M. Reisslein, and G. Xue, "A survey of multimedia streaming in wireless sensor networks," *IEEE Communications Surveys and Tutorials*, vol. 10, no. 4, pp. 18–39, 2008.

[7] Y. Sun, H. Ma, L. Liu, and Y. Zhang, "ASAR: an ant-based service-aware routing algorithm for multimedia sensor networks," *Frontiers of Electrical and Electronic Engineering in China*, vol. 3, no. 1, pp. 25–33, 2008.

[8] M. A. Rahman, R. G. Aghaei, A. El Saddik, and W. Gueaieb, "M-IAR: biologically inspired routing protocol for wireless multimedia sensor networks," in *Proceedings of the IEEE International Instrumentation and Measurement Technology Conference (IMTC '08)*, pp. 1823–1827, IEEE, May 2008.

[9] B. Junlei, L. Zhiyuan, and W. Ruchuan, "An ant colony optimization-based load balancing routing algorithm for wireless multimedia sensor networks," in *Proceedings of the IEEE 12th International Conference on Communication Technology (ICCT '2010)*, pp. 584–587, November 2010.

[10] Z. Ke, L. Li, Q. Sun, and N. Chen, "Ant-like game routing algorithm for wireless multimedia sensor networks," in *Proceedings of the 4th International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM '08)*, October 2008.

[11] G. Di Caro and M. Dorigo, "AntNet: distributed stigmergetic control for communications networks," *Journal of Artificial Intelligence Research*, vol. 9, pp. 317–365, 1998.

[12] L. Shu, Y. Zhang, L. T. Yang, Y. Wang, and M. Hauswirth, "Geographic routing in wireless multimedia sensor networks," in *Proceedings of the 2nd International Conference on Future Generation Communication and Networking (FGCN '08)*, pp. 68–73, December 2008.

[13] S. Medjiah, T. Ahmed, and F. Krief, "GEAMS: a geographic energy-aware multipath stream-based routing protocol for WMSNs," in *Proceedings of the Global Information Infrastructure Symposium (GIIS '09)*, June 2009.

[14] B. Karp and H. T. Kung, "GPSR: greedy perimeter stateless routing for wireless networks," in *Proceedings of the 6th Annual International Conference on Mobile Computing and Networking (MOBICOM '00)*, pp. 243–254, August 2000.

[15] L. Yao, W. Wen, and F. Gao, "A real-time and energy aware QoS routing protocol for multimedia wireless sensor networks," in *Proceedings of the 7th World Congress on Intelligent Control and Automation (WCICA '08)*, pp. 3304–3309, June 2008.

[16] S. Guannan, Q. Jiandong, Z. Zhe, and Q. Qiuhong, "A reliable multipath routing algorithm with related congestion control scheme in wireless multimedia sensor networks," in *Proceedings of the 3rd International Conference on Computer Research and Development (ICCRD '11)*, pp. 229–233, March 2011.

[17] X. Mande and G. Yuanyan, "Multipath routing algorithm for wireless multimedia sensor networks within expected network lifetime," in *Proceedings of the International Conference on Communications and Mobile Computing (CMC '10)*, pp. 284–287, April 2010.

[18] M. A. Hamid, M. M. Alam, and H. C. Seon, "Design of a QoS-aware routing mechanism for wireless multimedia sensor networks," in *Proceedings of the IEEE Global Telecommunications*

Conference (GLOBECOM '08), pp. 800–805, IEEE, December 2008.

[19] K. Akkaya and M. F. Younis, "Energy and QoS aware routing in wireless sensor networks," *Cluster Computing*, vol. 8, no. 2-3, pp. 179–188, 2005.

[20] Y. Xin, L. Layuan, and F. J. An, "Multi-constrained routing in wireless multimedia sensor networks," in *Proceedings of the International Conference on Wireless Communications and Signal Processing (WCSP '09)*, November 2009.

[21] S. Poojary and M. M. M. Pai, "Multipath data transfer in wireless multimedia sensor network," in *Proceedings of the 5th International Conference on Broadband Wireless Computing, Communication and Applications (BWCCA '10)*, pp. 379–383, November 2010.

[22] S. Li, R. Neelisetti, C. Liu, and A. Lim, "Delay-constrained high throughput protocol for multi-path transmission over wireless multimedia sensor networks," in *Proceedings of the 9th IEEE International Symposium on Wireless, Mobile and Multimedia Networks (WoWMoM '08)*, June 2008.

[23] L. Kai and C. Min, "Reliable routing based on energy prediction for wireless multimedia sensor networks," in *Proceedings of the 53rd IEEE Global Communications Conference (GLOBECOM '10)*, December 2010.

[24] H. Kwon, T. H. Kim, S. Choi, and B. G. Lee, "Cross-layer lifetime maximization under reliability and stability constraints in wireless sensor networks," in *Proceedings of the IEEE International Conference on Communications (ICC '05)*, vol. 5, pp. 3285–3289, May 2005.

[25] A. Nayyar, F. Bashir, and U. Ubaid-Ur-Rehman, "Load based energy aware multimedia routing protocol (LEAR)," in *Proceedings of the 3rd International Conference on Computer Research and Development (ICCRD '11)*, pp. 427–430, March 2011.

[26] A. H. Mohajerzadeh, M. H. Yagbmaee, and R. Monsefi, "A QoS based data dissemination protocol for wireless multimedia sensor networks," in *Proceedings of the 3rd International Workshop on Advanced Computational Intelligence (IWACI '10)*, pp. 670–675, August 2010.