IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper Volume-6, Issue-3 E-ISSN: 2347-2693

A Review of Wireless Multimedia Sensor Network and existing Routing Protocols

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Available online at: www.ijcseonline.org

Received: 20/Feb//2018, Revised: 26/Feb2018, Accepted: 19/Mar/2018, Published: 30/Mar/2018

***Abstract*—** Growing popularity of multimedia data give birth to a new field in sensor network, called wireless multimedia sensor network (WMSN) that can handle multimedia data along with the normal scalar data. Advances in CMOS (Complementary Metal Oxide Semiconductor), help sensor nodes to gather, process and transport multimedia data along with the textual data. But resource constraint nature of sensor network makes the implementation of multimedia sensor network very difficult and traditional approaches fail to deal with the consequences generated from transmitting multimedia data. Yet its popularity is increasing as it has potential civilian and military applications. Multimedia data has stringent Quality of Service requirement (QoS) such as delay, jitter, packet loss rate, energy etc. and to satisfy those criteria, routing protocols needs to modify. The critical problem to handle by the routing protocols are managing the energy while maintaining QoS requirement and handling the unreliable error prone communication medium. Here we have studied existing routing protocols used for multimedia data transmission and figure out some problems need to be addressed for future research.

***Keywords*—** Quality of Service(QoS), Hole Bypassing, Bio-inspired, Cross Layer.

I. INTRODUCTION

Multimedia means multiple media, so it is a combination of different forms of media such as text, audio, still images, video and/or animations. Multimedia wireless sensor network has become active focus area of research. Availability of inexpensive CMOS cameras and microphones with efficient signal processing and compression techniques makes it possible to deliver multimedia content in wireless manner. However in general, sensor nodes are having limited bandwidth, storage restriction, limited computational power and limited power supply. Transmitting multimedia data which require huge storage and high bandwidth makes sensor network infeasible. Along with this, multimedia data has quality of service requirement and needs high in network processing capability to compress the data during transmission. Successfully achieving these goals is not an easy task. Ideal WMSNs are supposed to be able to sense, store, process, retrieve and communicate scalar data (i.e. pressure, temperature, humidity, etc.) as normal WSNs plus image, video and audio as and when require. Figure 1 depicts the general architecture of WMSN. The architecture is pretty much same as normal sensor network which includes a sensing unit, processing unit (CPU), communication module, co-ordination sub-system, storage unit and an optional mobility/actuation unit. Sensors can sense both scalar and multimedia data; an analogue to digital converters (ADCs) is equipped with it to feed CPU digital data. Only the difference is, CPU is capable of doing signal processing and it is interfaced with a storage device. Harvested energy like solar cell can be source of energy supply apart from normal battery. A coordination sub-system coordinates the operation of different network devices such as network synchronization and location management etc. and finally mobility actuation unit is capable of handling moving and tracking objects.

A. Application of WMSN

WMSN has a wide range of application starting from surveillance, monitoring to entertainment. We have listed here few of them. Some of them are as follows:

- In **surveillance and traffic monitoring**, video and audio sensors are used along with the existing architecture of sensor network to enhance surveillance capability. It can be applied for crime and terrorist attack or it can be applied to protect public and private properties for example in battlefield it can take the pictures of the enemy and also do a recording of the activities. Video sensors can be deployed to monitor the enemy zone. Base station can collect those data through replay nodes and ultimately it sends the data to the controlling canter to take proper decision and to build strategies. Likewise, now-a-day's on road traffic has been monitored to protect accidents and to catch over-speeding people. Multimedia sensors can record potentially relevant activities (thefts, car accidents)

and make video/audio streams which prove to be an evidence for taking necessary actions. Smart parking system [1] can also be built from WMSN by identifying available spaces and guiding driver. Additionally smart cities can provide traffic routing advice to avoid congestion or it may direct the driver to reach the destination in shortest time. To monitor areas, public events, private properties and borders, large-scale network of video sensors are used by law enforcement agencies.

- In **health monitoring and health care**, WMSN can play a big role. Telemedicine sensor networks [2] are integrated with 3G multimedia networks for providing health care services. The behavior of the elderly person can be monitored through camera and thus it can help to identify his/her disease. In recent times devices act as personal assistance also like body area sensor network that basically deals with sensors can be implanted on body. Blood pressure, electrocardiogram, pulse activity of the patients having wearable sensors can be monitored remotely. Remote medical centers can also get advanced suggestions for their patients via video and audio sensors.
- In **Gaming, entertainment and industrial** area also WMSN has may things to do. Today's gaming industry laid on the concept of 3D, 4D vision and virtual reality. Virtual reality [3] is basically computer-generated simulation of a three-dimensional image of any object or any environment that can interact with, in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside which gives 3D view every object or gloves fitted with sensors. Another example can be, whenever a person is doing jugging, the surrounding of that person seem to keep moving with other people running also, it gives motivation to the person.
- In **Environmental monitoring,** WMSN plays an important role. Habitat monitoring projects are going worldwide. Earthquake detection, rise in ocean or sudden storm detection etc. falls under habitat monitoring. Acoustic and video sensors are used and they are investigated in a time-critical fashion, so that any catastrophic event can be detected. For example, arrays of video sensors are already used by oceanographers to determine the evolution of sandbars via image processing techniques [4].
- In **Industrial process control.** Several multimedia content such as temperature, imaging, and pressure can be used for time-critical industrial process control. In modern day's technology, information gathered from different kind of sensors can be directly controlled and analyzed with the help of some expert system to support a manufacturing process such as those used in automobiles, semiconductor chips, pharmaceutical food or products. In quality control industry also the details of the final product is being analyzed by using some artificial intelligence technique, if found faulty then the information is being conveyed to take necessary step. The incorporation of machine vision systems with multimedia, add flexibility to systems for visual inspections and also simplify the overall working so that a layman can also work on.

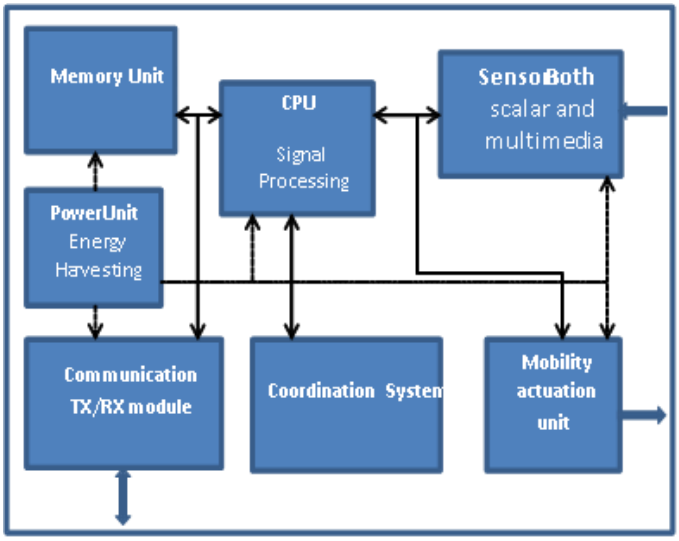

Figure 1. General architecture of wireless multimedia sensor network

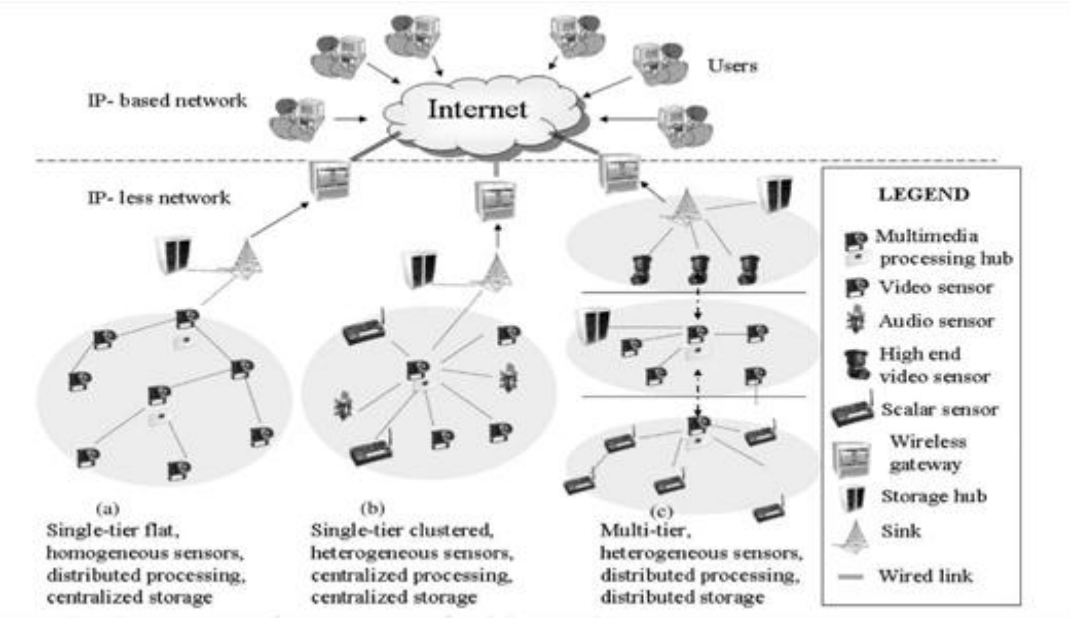

Figure 2. Wireless Multimedia sensor network reference architecture

B. Architecture of WMSN

Architecture of WMSN can be classified based on its composition (**homogeneous or heterogeneous**), architecture (**single-tier or multi-tier**).

A **homogeneous WMSN** consists of the sensors having same capability, same energy and storage. But a **heterogeneous WMSN** consists of different types of nodes having different sensing, energy, storage and processing capability. Nodes having better configuration can act as a coordinator responsible for most of the communication and processing task in order to improve the network performance.

To maintain scalability, network architecture of multimedia wireless sensor network can be single layer or multi-layer. Every node can do anything starting from image sensing, processing, coding etc. However they can communicate with the sink either in single hop manner or multi hop manner. Single layer architecture can also be clustered architecture, where various kinds of sensors are grouped according to their working principle and cluster heads are only responsible for forwarding the data to the sink. But if the data generated by multimedia sensor is large then flat architecture may not be suitable. So, the concept multi-layer comes here. Multi-layer architecture basically deals with heterogeneous sensors. An example can be, scalar sensors are placed in the first layer like for motion detection. Then some complex sensors are placed in the second tier which can do more complex task like object detection and third tier consists of more intelligent sensor which can do something like object tracking etc. Figure 2 depicts the general architecture of multimedia sensor network [5]. Nodes are normally grouped into clusters. Cluster heads are responsible for collecting and sending the data of the member of the clusters to the base station. Sometimes not all the data are transmitted only important information's are extracted and send. A low energy node can do only sensing and small distance communication whereas high energy nodes can act as a cluster head. However deciding the cluster head is a tricky job, several strategies are in the literature to deal with the problem.

C. Challenges for WMSN routing

Routing protocols designed for WMSN has to face several challenges generated by the multimedia traffic itself. Several conflicting objectives and constraints, imposed by technologies and user has to handle by the routing policies.

- Energy consumption: Multimedia applications are energy hungry as they require high transmission rate and processioning capability. Main constraint in designing WMSN is energy. So nodes will have to equipped with huge amount of energy may be in the form of battery or super capacitor or may be equipped with some solar cell which can harvest solar energy.
- QoS requirement: Quality of service is another consideration in multimedia data. Various QoS parameters are there and they vary from application to application like delay, jitter, phase difference, bandwidth, path loss etc. Maintaining the QoS requirement is important because the data may be unusable otherwise.

- Multimedia in- network processing: WMSN require multimedia in network processing to filter out redundant information and to handle heterogeneous data coming out from separate sensors. Along with this, it also requires database and efficient indexing to store and retrieve data.
- Multimedia coding technique: Coding is an important consideration as it is directly related to the size of the data. The size of the data collected through video sensors has to be reduced to transmit it through the channel. Compression techniques reduce the amount of traffic generated however it comes in the cost of information degradation also known as distortion. Compression techniques should have high compression ratio, low error rate and fewer complexities.
- Demand of high bandwidth: Transmitting multimedia data through the communication channel require high bandwidth which is difficult to get in wireless channel. So modification in the hardware and communication techniques has to be incorporated. Multi-channel or multi path can be an option.
- Reliability and Timeliness: Reliability and Timeliness comes as a quality of service requirement, but they have been pointed out here because usefulness of multimedia data heavily depends on them. Applications like Video on demand are less error tolerant so reliability has to be high. On the other hand for live streaming or video conferencing timeliness has to be maintained strictly.

The contribution of the paper are:

a. Detail study of the issues related with routing protocol used for wireless multimedia sensor network and discussion of the existing routing approaches.

b. Extensive performance analysis of the routing protocols has been done.

c. A handful of open research areas are identified.

The rest of the paper is organized as follows, Section II contain classification of existing routing protocol along with their working principle, merits and demerits. Followed by Section III which represents future research directions and Section IV concludes survey work with comparative study of all existing routing protocols.

II. EXISTING ROUTING PROTOCOLS

Routing layer aims to deliver sensed data to the sink taking into account several design considerations. All these considerations come from the multimedia content handling and their QoS requirement like delay, jitter and other than that congestion control, hole bypassing, delay tolerance etc. Many routing protocols have been proposed in the literature. They can be categorized in many ways. Based on the network architecture routing protocols can designed as flat, hierarchical, clustered routing protocol [6]. Again based on the approach they can be data centric or cross layer. As discussed multimedia data has several QoS requirement, so to address those, protocols are also designed. Again some routing protocols are Bio-inspired, for example they are using swarm intelligence, ant colony optimization or bee colony optimization. However all this categorization is not a hard core one, as the approaches are related to each other, like biologically inspired routing approaches can also fall under the category of QoS based approach. Figure 3. depicts the classification of routing protocols used for multimedia data transmission over wireless medium. We have classified the protocols according to A. architecture based, B. Biologically Inspired, C. QoS based and D. Cross layer. Protocols fall under each category has been listed in the figure also.

A. Architecture based routing protocol

WMSN can have flat, hierarchical and clustered architecture. All the nodes in the flat routing protocol has the same responsibility, anyone can do anything from sensing to transmission. They may follow single or multiple path for transmission. These algorithms are also called data centric protocols. However they may suffer from delay, congestion and high overhead. To avoid these problems, most of the algorithms follow hierarchical architecture. In both architecture nodes may be grouped into clusters. Out of them mostly all the algorithm use the location information. So, architecture based algorithms are broadly partitioned into location based and flat architecture based routing protocol.

A.1. Location Based Routing Protocol

This type of protocol require location information of all the nodes to take routing decisions. Based on this information it can select the best possible way to reach the destination. GPS is used primarily to collect location information of all the nodes. Following are the description of some location based routing protocols.

TPGF [7] is a two phase greedy forwarding algorithm. It is a pure geographic greedy forwarding algorithm which takes care of three features (1) Hole bypassing. (2) Shortest path transmission and (3) Multipath transmission. It does not include any face routing e.g. face hand rule which is different from many geographic routing like GPSR [8]. It finds one shortest path per execution but can be applied repeatedly to find more node disjoint paths. It does not require any computation or preservation of planner graph. The main

advantage of TPGF is that it avoids the local minima problem. The basic assumption is that only the source node

It does use the whole network information which makes it scalable, but it cannot handle mobility so it is unsuitable for multimedia transmission.

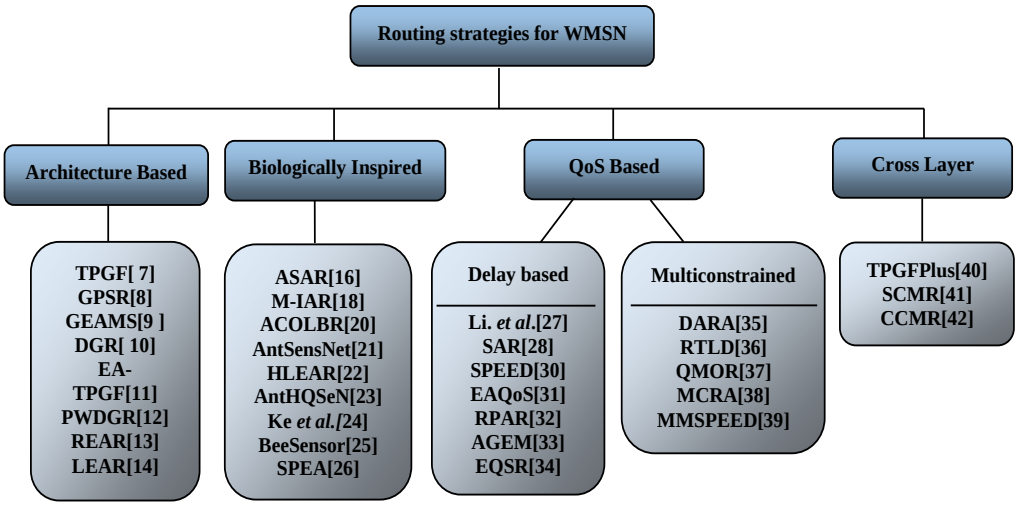

Figure 3. Classification of WMSN routing protocols

Knows the location of the base station and other nodes can only know when it receives a packet from the source. Each sensor node can work in three different mode (1) active and available (2) active but unavailable and (3) dead. Similarly each link can have two different states (1) available and (2) unavailable. The process starts with the source node chooses next hop among its neighbors which is close to the sink and so on. This way greedy forwarding goes on but only when the next hop does not have any further neighbor than it set back and mark the sender as a block node. The next step is path optimization. In this phase path circles are eliminated and number of nodes in the path is also minimized. Simulation results showed that it performs better than GPSR.

TPGF works well when the network topology is known, but when it is changing frequently then TPGF may not be that useful.

GPSR (Greedy Perimeter Stateless Routing) [8], is a well excised routing protocol use for wireless sensor network. It uses the position of the router and destination node in routing decision. Greedy forwarding and perimeter forwarding are the two forwarding mode use in the algorithm. A flag in the packet identifies the current forwarding mode. Greedy forwarding is done generally which forwards a packet, but if it is found that no suitable neighbor of the path exist then it changes the forwarding mode and follow perimeter forwarding where the packet is forwarded along the perimeter of the network, thus it can avoid hole problem.

It provides good packet delivery ratio in case of a dense network.

GEAMS [9], geographic energy aware multipath stream based routing protocol, is best suited for WMSNs'. No global knowledge of the topology is required only the decisions are taken based on the local information. Energy consumption is reduced by using a two-fold policy (1) Greedy forwarding and (2) walking back forwarding. It adds the load balancing functionality with the famous GPSR [8] protocol to enhance the lifetime of the network and to reduce the queue size of popular nodes. Each intermediate node forward the data packet based on some policy which takes care of (1) Remaining energy (2) Actual distance between node and its neighbor (3) No of hops (4) History of the packets forwarded belonging to the same stream. It basically provides three features shortest path transmission, multipath transmission and load balancing. Greedy forwarding is applied to select the neighbor close to the sink to forward the data and when it is found there is no way to reach the sink, then walking back forwarding is used.

GEAMS work without using global topology, thus it can increase lifetime of the network while maintaining QoS requirement. But it can cause congestion and sometimes packet loss.

DGR (Directional Geographic Routing) [10], is a protocol use especially designed for video transmission. It provides better video transmission quality while maintaining the lifetime of the network. It considers that any node can send

video packet at any time. A video stream is first partitioned into smaller parts then they are sent through multiple disjoint paths using low bandwidth, in parallel. It use forward error coding for improving the reliability of the transmission. Packet delivery rate and signal to noise ratio are use as routing metric. DGR transmits video, utilizing the full network resources and provide less end-to-end delay.

However it is not applicable for wireless multimedia sensor as it has additional overhead which will result delay in wireless transmission.

Energy-Aware TPGF (EA-TPGF) [11] is an extension of TPGF algorithm, which uses label based optimizations of path. A distance-energy formula is used to calculate the score of each neighbor. It also use an energy cost transmission formula for the calculation of energy consumption by the transmitter. Greedy forwarding helps to discover multiple routes to destination. The basic focus of the algorithm is to provide energy efficiency.

But EA-TPGF increases the average delay than TPGF as it use the same discovered path again and again.

Another geographic routing **PWDGR** (Pairwise directional geographic routing) [12] is used to solve the bottleneck problem. It's a multi-path routing protocol which is based on DGR [10]. So, rather than finding an individual node around the sink, PWDGR searches for a pair of node around the sink for data transmission. It is applicable for video transmission and is reliable and fault tolerant.

Use of pairwise nodes around the sink helps PWDGR to make full use of the nodes within 360 degree and thus increase the network life time. However it may suffer from hole problem.

A.2. Flat routing Protocol

Real time energy aware routing protocol **REAR** [13], uses multipath transmission to reduce energy consumption of a link. A special metadata is used to find routing paths. The use of metadata, reduce the bandwidth radically as it avoids retransmission of the packets also. It uses optimized Dijkstra to select a link having least cost. A classified queue model is hosted in each node to handle real time data transmission. Remaining energy, queuing delay and estimated distance are used as cost factor.

However the use of metadata increases energy consumption. It does not consider reliability also.

LEAR [15], is a location base, self-organizing, energy aware routing protocol use for multimedia transmission. It's a reactive routing protocol works as AODV [14]. A special factor called route selection factor which is dependent on the energy of the node, is used by forwarding nodes. If the energy of a node is lower than 25% of its total power then it cannot take part in the data forwarding. In this way it can avoid hole problem also. It tries to find node disjoint paths, but if not available then it will go for partial node disjoint paths. Use of multiple path make it suitable for multimedia transmission.

However it does not consider delay, reliability and bandwidth into consideration.

B. Biologically inspired

Biologically inspired algorithms can be swarm intelligent based, evolutionary based or bee colony based. Some approaches are there which combine swarm intelligence with game theory. Ant colony optimization is also used.

ASAR (Ant-based service-aware routing) [16], an Ant-colony based QoS routing basically deals with the routing scheme between the cluster head and the sink. It selects optimal path to meet QoS requirements for different types of services. In general there exist two different service models, (i) event driven service mode: event driven service (R) mode is delay intolerant and error intolerant. (ii) Query driven service mode: query driven service is of two types data query service (D) and stream query service. D service is error intolerant, while delay is tolerant; On the other hand, stream query service (S) is delay is intolerant but error is tolerant. Each cluster head generates ants for each type of service (R/D/S) to find different service aware paths, from source to destination then depending on the objective function of each type of data and pheromone value of each path, different paths are chosen to meet the different QoS requirements. A probabilistic rule is used to determine the progress from current node to the next. Delay, bandwidth, rate of packet loss and energy consumption decides the amount of pheromone value. The pheromone value is quantified at the sink to decrease the sending frequency of reverse ants or control messages and thus optimize network resources and quicken the convergence of the algorithm.

Simulation results shows that it perform better than Direct Diffusion [17] and Dijkstra.

M-IAR (Multimedia-Enabled Improved Adaptive Routing) [18], is swarm intelligent based algorithm which use the concept of ant colony optimization for optimizing different QoS requirement like end-to-end delay, latency, jitter, energy consumption, packet survival rate etc. It is an extension to the Improved Adaptive Routing (IAR) [19], which was specifically used for WSN. It is a flat multi hop routing protocol which use geographic location of the nodes to generate the best possible route. When deciding the route it considers not only the closeness of a neighbor from sink but also consider the closeness of the node among themselves. Location based services with ant based intelligence help to

find the optimum path in minimum time. Two different types of ants are used here, Forward ant and backward ant. First the source node sends a forward ant to find the optimum path. It uses some predefined criteria to decide the probability of each neighbor to become next forwarder. The one with the highest probability is chosen. When it reaches to the destination then a backward ant is created which uses global information gathered from the forward ant to update the probability values and emphasize the searched path. An attractive feature of M-IAR is, it use piggybacks end-to-end acknowledgement to guarantee successful delivery of packet. This play an important role in multimedia transmission as suppose an I-Frame of a video stream did not reach to the destination, then it can be resend later on within a pre-defined duration.

But the authors of the paper have not compare the approach with any existing protocol.

ACOLBR (Ant Colony Optimization-based Load-Balancing Routing Algorithm) [20] is a QoS based routing algorithm used for load balancing. It uses ant colony based optimization. Intra-cluster routing is built with the help of minimum spanning tree and ant colony is used to build the inter-cluster communication. The objective of ant colony optimization is to find the optimal and the sub-optimal paths for inter-cluster routing. Optimal path will be used for data transfer and if the amount of data exceeds from the path flow threshold then, sub-optimal path are used. Use of maximum and minimum pheromone density value, helps ACOLBR to explore more paths. When one node forward its data to the next node the pheromone value is updated. The node with highest pheromone value is chosen as the next forwarder. Similarly sub-optimal path will also be selected based on the pheromone value. To select an optimal path the backward ant release more pheromone on selected path by using the global pheromone rule. In case of any node failure the pheromone value becomes zero and the source node will choose some sub-optimal path of transmission. If the protocol finds that the end-to-end delay of a path from source to destination exceeds thresholds then it will inform the source to reduce the data transmission rate. When the source node will get such a message then, it will reduce the data transmission rate on that path and enables an alternate path for the current transmission, thus it will provide congestion control and load-balancing.

Simulation results show that it performs better than ASAR and M-IAR.

AntSensNet [21] is a hybrid routing protocol which combines the features of hierarchical network structure and ant colony optimization. It operates in rounds. Each round is again divided into cluster setup and steady state phase. A special type ant is used over here called cluster ants (CANTS). The nodes with the CANTS can only become the cluster head based on the clustering pheromone value. A tunable factor cluster radius is used to maintain the minimum distance between two cluster heads to avoid signal interference. Forwards ants are used to generate the route to the sink and the reverse ants are used to generate the reverse path to the source, if the path generated by forwarded ant meets the quality of service requirement.

Simulation finds that AntSensNet is scalable and able to handle congestion better than ASAR and TPGF.

HLEAR (Hop and load based energy-aware routing protocol) [22], is a load balanced, swarm based, self-organizing routing protocol use to avoid holes while increasing network lifetime. It tries to find complete node disjoint paths, if not possible then at least partially disjoint paths. Rate of forwarding, hop count and residual energy are used to find an optimal path. It does not allow a node having energy less than 0.5J to take part in the route discovery phase, thus holes are avoided. It spawns another routing metric β based on the previously mentioned routing metrics. For route discovery, route request packets are broadcast but in controlled manner. When it reaches to the sink then the reverse path is created by sending the route reply packet. Minimum distant node disjoint path is generated form the algorithm.

Simulation result shows it performs better than AODV [14] but it cannot handle congestion.

AntHQSeN [23] is a stochastic, reactive routing protocol which works in two phase's a. route discovery and b. route maintenance. Forward ants are generated to find multiple paths from source to destination. Network information is also carried by these ants to maintain the QoS. Selection of a route is dependent on the values of the pheromone. Packets are forwarded stochastically. The route setup phase is completed when the destination sends the backward ant to the source. Pheromone calculation is done using residual energy, bandwidth, pheromone concentration etc. In AntHQSeN, hello ants are also used for neighborhood discovery, they also exchange the QoS related information.

It performs better than AODV [14], but setup time is more.

In [24], ke *et al.* propose an ant colony and game theoretic based algorithm is proposed to meet the quality of service requirement of wireless multimedia sensor network. The elements of the game are player, payoff and strategy. The player always tries to maximize their payoff with minimum cost. The algorithm builds the routing path using the local information and the residual energy. Then ant colony optimization is used to optimize the routing path. Forward ants use the residual energy, delay and bandwidth to calculate the amount of pheromone to be left on the path to

the destination. When the forward ant reaches to the sink it dies and backward ant is created to generate the reverse path.

A Bee Colony based optimization called **Beesensor** [25], is also used in multimedia sensor. It's a reactive, scalable, energy efficient protocol. Four agents are used: packers, foragers, scouts and swarms. Packers are like food storage bee, they gather packets from upper layer and look for suitable forager. Forager is responsible for carrying packets to the sink. Scouts explore the network. Packets look for apt forager to transfer data. During the transmission foragers also collect the network information and piggy back those to other forager. Foragers waiting at the sink node, after getting the information build a swarm of forager and send it back to the source. It works in stochastic manner. Source node maintains a routing table and a probability distribution table. Probability distribution helps a packet to select appropriate forager.

SPEA (Strength Pareto Evolutionary algorithm) [26], is genetic algorithm (GA) based routing protocol use to optimize QoS parameters like delay, traffic, hop count and bandwidth. Multi objective GA is used here as the QoS parameters are contradictory in nature. It works in two module QoS routing module and GA module. QoS service module searches for the route to destination, if there is no route then route discovery process is created by sending smart agents. Route reply message is sent in the reverse path. If there is any error in the route then it called the GA module. GA module generate new route by combining existing routes and destination. Available routes become initial population and a fitness function is generated by combining the QoS requirements.

Simulation result shows it perform better than AODV [14]. However use of GA requires high computational power.

C. Quality of Service Based

QoS routing protocols can be categories into probabilistic and deterministic protocol, which can further be divided into soft real time and hard real time. In probabilistic routing protocols, nodes transmit message of known probability and it is dependent on hop-distance from source to destination, time of last forwarded packet, the number of hops a packet has already travelled and number of neighbour. On the other hand, deterministic protocols keep the complete information of network like node trajectories, period in which a decision is forwarded and encounter probability of nodes. Soft real time protocol can withstand few bit error, but hard real time system cannot. Reliability, latency, bandwidth, and Jitter are the QoS requirement for WMSNs. Based on type of constraints, QoS based protocols can be broadly classified into **latency based** and **multi-constraint based** routing protocols. Latency Based Constrained Routing deals with latency only hard or soft and multi-constrained based deals with more than one QoS requirement. Here we have taken the latency and multi-constrained based classification. All other classifications are included herewith. In [43], QoS based algorithms for WSMN's is studied.

C.1. Latency Based

In [27], Li *et al.* proposed a modification of Direct Diffusion to support multipath routing for WMSN based on link quality and latency metrics. The multiplication of ETX (Expected transmission count) and delay is used as a cost factor to judge a link. Use of ETX is an important consideration as it can include the cost of retransmission also. It select node disjoint multiple paths for sending the data to increase the reliability.

But it does not distinguish between real time and non-real time traffic and does not also prioritize the data stream, so often it may not be useful for real time data delivery. However it achieve high throughput compared to EDGE.

Sequential access routing (**SAR**) [28] is a deterministic and hard real time approach. It considers three factors for routing, a. energy level b. QoS of each path and c. precedence level of each packet. Basically it assigns a priority to every packet of the network and then calculates the weighted QoS metric, which is the product of the additive QoS metric and a weight coefficient which is associated with the priority level of each packet. Each node keeps information about its neighbor in a table. The objective is to keep track of the multiple paths from the neighbors to sink so that it can avoid single path failure problem. The appropriate path is selected by taking the minimum average weighted QoS path.

Scalability can be an issue of this approach as it is a table based approach.

SPEED (Stateless Protocol for Real-Time Communication) [30] is a stateless soft real time based QoS routing protocol for wireless sensor network. Stateless in the sense that it does not maintain any table for storing routing information, rather keeps on the information about one hop neighbor and geographic location is used to find the local routing decisions. A stateless non deterministic greedy forwarding (SNGF) routing is used for taking routing decision. Four module works side by side, Beacon exchange, Delay estimation, Rerouting and Neighborhood feedback loop. Beacon exchange is responsible for sharing the location related information. Delay estimation is used calculate the round trip single hop delay across every node and thus help SNFG to select a node meeting the speed requirement. SNFG is used to maintain desired delivery speed yet reduce the network congestion. MAC layer helps SNFG to drop the packet in case of congestions. If there is congestion in a route, then it is

redirected. Neighborhood feedback loop is used for maintain system performance by checking the single hop relay speed. It checks whether the packet has been relayed with the desired speed or dropped and finally back pressure rerouting module is used for sending a message to the source informing that a route is congested or a node fails to find the next hop. In this case, the source reroute the next set of packets. The disadvantage of the algorithm is that it does not distinguish between real time and non-real time data packets.

It is not scalable as it tries to maintain the flow reservation concept, so when there are holes in the network or sudden congestion, then it perform poorly.

Energy-aware QoS (**EAQoS**) [31] is a routing strategy where a cost function is used to judge each link. The cost function includes residual energy, transmission energy and end-to-end delay. The optimal path is found by considering the energy consumption and end to end delay. An extended version of Dijkstra is used to generate k-least cost path from source to destination. The cost of each path is stored in a table. Only the paths meeting the QoS requirement is chosen. The algorithm stops when k shortest path is discovered. If a new path is to be generated, then only the disjoint node path is selected so that the old data traffic cannot interfere the traffic of the newly created path. The algorithm can handle both the real time traffic and non-real time traffic.

It basically does not treat different real time traffic individually, thus it is not applicable for the situation where several multimedia traffic coexist.

Real-time Power-Aware Routing (**RPAR**) [32] protocol has some distinctive feature called power adjustment. It can provide application specific delay by adjusting the transmission power. It is a power aware, location dependent routing protocol which takes care of the network scalability, memory and bandwidth requirement. It works in four different modules: neighborhood manager, delay estimator, forwarding policy, and velocity assignment policy. Neighborhood manager helps to find all probable neighbors to the sink meeting end-to-end delay. The searching is better than periodic beacon as SPEED [30]. The delay estimator use Jacobson's algorithm to estimate contention delay and count estimation. By using dynamic transmission power adjustment and routing decisions it minimize the miss ratios. It better handles the properties of WMSNs, as it integrated power efficiencies and support real time traffic.

But it cannot handle sudden congestion and large holes and also the working of neighborhood manager is pretty time consuming.

AGEM [33] is an adaptive greedy energy aware multipath routing protocol which uses location based services. It can be considered as an extension of GPSR [8] with load balancing feature to increase the lifetime of the network. Adaptive greedy forwarding selects a subset of neighbors for forwarding based on the residual energy, distance between current node and neighbors, hop count and forwarded packet history for the same stream. Data stream is forwarded through different paths, so reduce the energy consumption. Greedy forwarding and walking back forwarding are the modules of the approach. Each node has a database of one hop neighbors.

Simulation shows it perform better than GPSR but because of GF mean energy consumption appear to be high for small networks.

EQSR [34] is energy efficient QoS based routing tries to minimize energy consumption to increase lifetime and maximize reliability. Reliability is increased through the use of XOR-based forward error correction. Residual energy, SNR and buffer size are used as routing metric. It tries to find node-disjoint paths. The algorithm is divided into primary path setup phase and alternate path setup. Primary setup phase searches for available next hop based on the link cost. It can distinguish between real and non-real time traffic as it implements queuing model. Before sending any data packet, it divide the packet into smaller segment, then adds error correction code and send. Weighted traffic allocation scheme is used to distribute the data along different paths.

In case of node failure it avoids to flood the route discovery packet but the use of error correction increases the data redundancy.

C.2. Multi- constrained

DARA (Distributed aggregate routing algorithm) [35], a distributed multi QoS constrained, location aware routing protocol. Providing les delay and high path reliability while using less energy, is the motto of the algorithm. Nodes broadcast beacon message dynamically rather than periodic, thus saves energy also enables to handle both static and dynamic topology. Nodes only take decision based on the local available information, no need to keep the global network information. To increase reliability it sends duplicate packet to the sink as well as reduces the retransmission cost.

It uses power control scheme to reduce the data transmission energy. But it cannot handle hole problem.

RTLD (Real-time routing protocol with load distribution) [36] is a routing protocol able to handle real time data while ensuring high throughput and minimum packet overhead. It introduces a special feature called "geodirection-cast forwarding" which is a combination of geocast and directional forwarding. It also introduces the concept of optimal forwarding for load balancing, based on remaining energy, packet reception rate and packet velocity. Location

management, routing management, power management and neighborhood management are the module constitute the algorithm. Location management gather the location of the neighbors of a node, neighborhood manager select the subset of nodes able to forward data packet, power management determines the transceiver able to forward also decide the power use for transmission and finally routing manager does the optimal forwarding. Simulation shows it provides better result than SPEED [30].

But the high deployment cost is the main disadvantage of this algorithm.

Another QoS aware opportunistic multi sink routing protocol is QMOR (QoS aware multisink opportunistic routing) [37] which specially designed for multimedia transmission. The aim of the algorithm is to increase the reliability with minimum delay. Each node maintains a forwarder list which is then prioritizes to meet QoS requirement. Multimedia data like video has a highly redundant data and the correlation among the data is also high. To reduce the redundancy, QMOR designed a correlation aware differential coding. It also uses DCISIS, differential source coding scheme to address the source and destination.

It works well in case of video transmission but perform poorly in heterogeneous network.

MCRA [38], is another multi constrained query driven routing protocol. It uses a special message called "interest" to query for an event. It does not uses any location based services rather it uses hop count to generate the logical address of all node in the network, thus it considerably reduces the amount of message flow. Also it suppresses redundant and retransmitted messages which may be generate due to failure or collision.

Simulation result shows it perform better than DD [16] and SPEED [30], but it does not consider reliability and bandwidth.

MMSPEED [39], Multi-Path and Multi-SPEED routing protocol is an extension of SPEED protocol with probabilistic QoS guarantee in wireless sensor networks. Timeliness and reliability are the two QoS factors, the algorithm tires to achieve. Reliability requirement is met by using probabilistic multi path forwarding. Multiple QoS levels are provided in the timeliness domain by guaranteeing multiple packet delivery speed options. Various reliability requirements are supported and virtual isolation among the delivery speed is done. Based on the reliability and speed packets are categorized according to their speed classes and put them in different priority queue. Localized packet delivery is done without having information about of the network topology, augmented with dynamic compensation, to reduce the inaccuracies coming from local information. It minimizes the chance of less reliable and unbounded transmissions. To remove the void area problem r hole back pressure algorithm is used. This way, MMSPEED can guarantee end-to-end timeliness in a localized way. It consider every node knows its own location, which makes it scalable and adaptability to large scale dynamic sensor networks also increase.

However it does not consider the hop count and energy consumption as routing metric which turn increase power consumption.

D. Cross Layer

Most of the communication protocols are designed based on the layered stack architecture, but with the development of networks, the layered stack architecture fail to meet several wireless network requirement. Especially in the sensor network since the nodes are energy constrained so in routing decisions to conserve the energy while maximizing the performance several layer in the protocol stack need to cooperate with each other. This is done in a cross layer architecture.

TPGFPlus [40], is an extension of TPGF [7] geographic routing protocol. It optimize cross layer factors like duty cycle and harvested energy. Greedy forwarding works in different way than TPGF. It focus on two hop for forwarding, rather than selecting the node close to the sink in 1 hop, it consider the two hop neighbor also. Energy harvesting is taken into consideration. Power adjustment is done by the each node while transmitting the data. If it has less energy then it reduce the transmission power to avoid hole problem.

It provides better results than TPGF but not applicable for large scale, mobile network.

SCMR [41], a secure cluster based multipath routing protocol provides an efficient routing technique in a secure manner. So along with routing it provides reliability also. It exploits the hierarchical structure of traditional clustering and follows single tier cluster architecture. Cluster head selects a path based on the type of data it has to forward e.g. multimedia contents are delivered through good quality and min delay path, disjoint path for multimedia streaming and less strict QoS path is suitable for scalar data transmission. First the BS sends periodic broadcast message called BS_MSG containing ID of the base station and relevant security information for authentication. Two thresholds are being kept Thr-High and Thr-Low. Nodes receiving the BS_MSG message, compares the RSSI of the received message with Thr-High. If it is greater, then the node send an acknowledgement message to the BS to inform about the joining as a child. From now, they can act as first level

cluster head and broadcast CH_MSG to their neighbors which contain ID of the cluster head, No of hops between the CH and BS in its current found path, ID of the nodes join with it through the current path and security info. Nodes receiving CH_MSG, check RSSI and compare it with Thr-High and Thr-Low. If RSSI is greater than Thr-High then it starts behaving as cluster member. If it is in between high and low then it starts acting as new second level cluster head and immediately responds back to the sender with a message stating that it can use it as a potential forwarder to base station. The process continues until all the nodes join the network. Then it optimizes the found path by eliminating the links which forms a cycle. A two level QoS aware scheduling is used to send the data. For maintaining security, nodes will only receive message from another node if they share the same security key. Three different types of keys are used unique node key, unique cluster key and pair wise key. Each of them is used in different level of security. Simulations results show it provide efficient multimedia data delivery.

In [42], **CCMR** is a cross layer based clustered multi path routing with QoS aware scheduling is proposed. Hierarchical structure is built based on hop count, RSSI without suing any coordination measurement equipment or position message exchange. Two thresholds are used for comparing RSSI. The upper threshold is used for 1st level cluster formation. Lower threshold is used to establish the links between the cluster heads. The whole network formation step is similar to SCMR. After forming the network architecture two level QoS aware scheduling is done. Based on the load condition and number of nodes in clusters the delay time is decided to avoid collision. Therefore TDMA is chosen by the author as intrinsically it has the collision resolution feature. Dynamic time slot assignment is done to avoid channel underutilization. At the lower level scheduling process cluster head sends a broadcast message asking each group member to send the type of data to be transmitted, its requirements and its amount. This broadcast message contains the time slot for each cluster member. In the request phase, cluster members send a request message to the CH at the allocated time slot informing about the data to be sent and its QoS requirements so that the node which has high QoS requirement can be outlined. After collecting all these information a schedule is sent to all members, which contain the specified time schedule for sending each type of data.

III. OPEN RESEARCH ISSUES

WMSN is grabbing attention now days because of its applicability, but as discussed transmission of multimedia data is a cumbersome task. Routing protocols has several advantages and disadvantages, none of them can be think of as an optimum one. This section discuss about the problems need to explore for future exploration. Protocols based on swarm intelligence, ant colony optimization may overpower other approaches, but they seem to be good on pen and paper, but in actual deployment they may fail to perform well, and moreover, mapping the scenario in terms of these algorithms is also difficult.

Performance of geographic routing in good, but the main problem is in most of the cases network information has to be kept with the node, this becomes an overhead and most importantly these algorithms use the location of the node and sink collected form GPS in their routing decision. Using GPS in not a feasible option in several applications, moreover GPS receivers are also costly.

Multipath based QoS routing are most suitable for multimedia transmission as they can transmit the data in parallel, which increase throughput and reduce end-to-end delay. However designing a good multipath QoS based routing is again a difficult job as QoS parameters are contradictory in nature. If some factors are optimized, other degrades automatically. So multi objection optimization has to be used with fine parameter tuning.

Cross layer approaches has very good prospect. Most of the energy of a node, goes out in transmission, reception, idle listening or overhearing. As energy efficiency is the most important factor in multimedia transmission, so if scheduling of the nodes is done in a way so that they will be awake only when they have some data to send, then energy can be saved. Duty cycle based algorithm proved to provide better result using less energy. So, if outing decisions can be combined with application or MAC layer, they can provide better result.

Freedom from hole and freedom from looping are the two important concern in designing routing algorithm. Static and dynamic routing holes are created as a death of a node in the routing path. Path loops results extra delay. Most of the routing protocol does not consider how to overcome from these problems. Some algorithms use multiple sink instead of single sink to avoid hole near sink

IV. CONCLUSION

The growing popularity of multimedia transmission over wireless link give birth to several attractive application but the stringent QoS requirement and the size of the data transmitted over the network, are the main considerations need to be taken care by the data transmission strategies. Designing a routing protocol needs to take care several considerations and there cannot be one protocol which will provide all the services. This paper surveyed different existing routing protocol with their merits and demerits and also future scope is discussed. Table 1, lists a comparative discussion of all routing protocol discussed in this survey. Swarm intelligent based routing protocols need to be exercised in more realistic way to be applicable for multimedia transmission and future research direction should go in that. If routing protocols which deal with hole and loop bypassing can be combined with cross layer functionalities may probably would provide best result.

TABLE I
Comparison of wmsn routing protocols

Protocol	characteristic	Energy efficiency	Reliability	Not suitable for WMSN	Applicable for video transmission	Energy harvesting	Real Time	Load Balancing	Location Aware	Architecture		Hole Bypassing	Multi path
										Flat	Clustered		
TPGF	Greedy forwarding, architecture based								Yes			Yes	Yes
GPSR	Greedy Forwarding, Perimeter Forwarding,	Yes		Yes					Yes			Yes	
GEAMS	Geographic, Greedy Forwarding, Walk back Forwarding	Yes											Yes
DGR	Forward error coding	Yes		Yes	Yes		Yes	Yes	Yes			Yes	
EATPGF	Label based optimization	Yes							Yes			Yes	Yes
PWDGR	Extension of DGR	Yes			Yes		Yes						Yes
REAR	Flat, optimized differential encoding	Yes					Yes						Yes
LEAR	Reactive, use route selection factor	Yes	Yes					Yes				Yes	Yes
ASAR	ACO Based	Yes	Yes				Yes				Yes		Yes
M-IAR	ACO, Swarm intelligent Based	Yes	Yes						Yes				
ACOLBR	ACO Based						Yes				Yes	Yes	
Ant Sense Net	Hierarchical ACO	Yes					Yes				Yes		Yes
HLEAR	Swarm intelligent Based	Yes						Yes					

TABLE I
Comparison of wmsn routing protocols

Protocol	characteristic	Energy efficiency	Reliability	Not suitable for WMSN	Applicable for video transmission	Energy Harvesting	Real Time	Load Balancing	Location Aware	Architecture		Hole Bypassing	Multi path
										Flat	Clustered		
AntHQSeN	Stochastic, ACO	Yes						Yes			Yes		
[24]	Game theoretic	Yes											
BeeSensor	Bee Colony based optimization	Yes								Yes			
SPEA	Multi-objective GA	Yes								Yes			
[27]	Extension of DD						Yes						Yes
SAR	Deterministic hard real time	Yes								Yes			Yes
SPEED	Soft real time	Yes					Yes	Yes	Yes			Yes	
EAQoS	QoS based modified Dijkstra	Yes					Yes						
RPAR	Power Adjustment	Yes					Yes		Yes		Yes	Yes	
AGEM	Greedy energy aware extension of GPSR	Yes					Yes		Yes			Yes	
EQSR	QoS, Error correction	Yes	Yes										Yes
DARA	Multiconstraint QoS	Yes	Yes						Yes				Yes
RTLD	Geo direction cast forwarding	Yes					Yes	Yes	Yes			Yes	Yes

TABLE I
Comparison of wmsn routing protocols

Protocol	Characteristic	Energy Efficiency	Reliability	Not Suitable for WMSN	Applicable for video transmission	Energy Harvesting	Real Time	Load Balancing	Location Aware	Architecture		Hole Bypassing	Multi Path
										Flat	Clustered		
QMOR	Co-relation aware differentiation coding	Yes	Yes		Yes		Yes						
MCRA	Multiconstraint query driven	Yes	Yes						Yes				
MMSPEED	Multipath multispeed probabilistic QoS		Yes		Yes			Yes	Yes				Yes
TPGF Plus	Cross layer extension of TPGF					Yes			Yes			Yes	
SCMR	Hierarchical, secure										Yes		Yes
[42]	QoS aware scheduling										Yes		Yes

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