Energy-Efficient Reliable Routing in Wireless Multimedia Sensor Networks

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Abstract — ***Wireless Multimedia Sensor Networks (WMSN) can handle different traffic classes of multimedia content (video, audio streams and still images) as well as scalar data over the network. Use of general and efficient routing protocols for WMSN is of crucial significance. Similar to other traditional networks, in WMSN a noticeable proportion of energy is consumed due to communications. Many routing protocols have been proposed for WMSN. The design of more efficient protocols in terms of energy awareness, video packet scheduling and QoS in terms of checkpoint arrangement still remains a challenge. This paper proposes the actuation of sensor on demand basis and routing protocol based on cost function which efficiently utilizes the network resources such as the intermediate nodes energy and load. Cost function is introduced to improve the route selection and control congestion. Simulation results, using the NS-2 simulator show that the proposed protocol prolongs the network lifetime, increase the reliability and decrease the network load.***

Keywords— WMSN, Energy efficiency, Reliability, Qos, Video packet scheduling.

I. INTRODUCTION

Wireless Multimedia Sensor Network (WMSN) are a new and emerging type of sensor network [1]. The sensor nodes in WMSN are equipped with cameras, microphones and other sensors producing multimedia content. During the survey of routing protocols, it is observed that routing protocols for WMSN are found to be concentrated on communication between the nodes using single path.

Single path routing algorithms in Wireless Sensor Networks (WSN) focus on picking up an energy efficiency path from interconnect sensor nodes network, e.g. Directed Diffusion [2], Minimum Cost Forwarding [3]. They make sure data transmitted on optimized path and prolong the lifetime of the network. Besides energy efficiency, multipath routing take advantage of interconnect nodes network to reduce network load and enhance data throughput and packet delivery ratio. Many multipath routing protocols have been proposed in the field of WSN [4]. However, almost all the routing protocols in WSN considered energy efficiency as the ultimate objective in order to maximize the whole network lifetime [5]. The transmission of video and image data requires both energy and QoS aware routing in order to ensure efficient usage of the sensors and effective access to the gathered measurements. In WMSN, video sensors are used to enhance the capability of event description [6]. Video sensors can generate image and video streaming data, which with heavy load require higher transmitting capability. Since high transmit rate is required for multimedia packages, congestion in WMSN is more prone to happen. So, congestion control is also of prime importance in WMSN.

The problem of congestion control has been addressed in many works e.g. Priority Based Congestion Control Protocol [7], Queue Based Congestion Control Protocol with Priority Support [8]. They analyzed how to detect and control congestion but mainly on transport layer. For addressing multimedia packets transmitting congestion problem and assure energy efficiency and reliability an energy efficient reliable video routing protocol for WMSN is proposed.

The paper is organized as follows. Section 2 introduces related works in this area; Section 3 presents the proposed solution. Some simulation results are presented in Section 4. Section 5 concludes the work.

II. RELATED WORK

Many routing protocols have been proposed in the field of WMSN. However, the design of more efficient protocols still remains a challenge.

In [9] the authors determined closed form expressions for the required number of cluster heads and the required battery energy of the nodes for both single-hop and multi-hop modes. They proposed a hybrid communication mode which is a combination of single hop and multi-hop modes and which is more cost-effective than either of the two modes. They considered the overall design problem through a data aggregation model. Aimed at the problem of unbalanced energy consumption of cluster heads caused by inter-cluster communications in WSN clustering routing protocols, a novel algorithm named Cluster Head Load Balanced Clustering (CHLBC) is presented work [10].

In [11] the author's proposed new algorithm called MPDT: Multipath Data Transfer protocol. It provides simultaneous

multiple paths for communication between any two nodes and distributes the work among the nodes uniformly, prolonging the life of the WMSN. It is observed that the packet drop reduces as the number of paths selected for the data transmission.

Routing techniques based on ant intelligence are inspired by the biological phenomenon that helps the ant in finding the shortest path among the explored routes and attracts more ants to reinforce the shortest path. Multimedia enables Improved Adaptive Routing (M-IAR) algorithm is based on ants cluster optimization algorithm [12]. M-IAR provided a shortest path of delay and delay jitter for transmission of multimedia data of single source node to single sink node.

The Decentralized QoS-Aware Middleware for Checkpointing Arrangement in Mobile Grid (MoG) computing systems was proposed in [13]. The authors determined the globally optimal checkpoint arrangement to be NP-complete and so considered Reliability Driven (ReD) middleware, employing decentralized QoS-aware heuristics, to construct superior check pointing arrangements efficiently. ReD works to maximize the probability of check pointed data recovery during job execution, increasing the likelihood that a distributed application executed on the MoG, completes without sustaining an unrecoverable failure. It allows collaborative services to be offered practically and autonomously by the MoG.

The authors in [14] considered the design of more efficient protocols in terms of energy awareness, video packet scheduling and QoS in terms of check point arrangement. The proposed architecture Actuation Sensor Adaptive Routing With Checkpoint (ASARC) provides power aware, reliable routing and has low latency in delivering the sensing data from source or sink node to the destination node. ASARC provides actuation of sensor on demand basis and selection of path for communication between any two nodes such as sensor or relay node without video distortion**.**

Energy and Delay Aware Dynamic Source Routing (ED-DSR) efficiently utilizes the network resources such as the intermediate mobile nodes energy and load [15]. It ensures both timeliness and energy efficiency by avoiding low-power and overloaded intermediate mobile node. The route selection is done according to energy consumption and queue load of intermediate nodes. Cost function is defined based on residual energy, queue length, processing and transmission time of intermediate nodes. This protocol prolongs the network lifetime, increases the volume of packets delivered while meeting the data flows real-time constraints and shortens the end-to-end delay.

In existing WMSN routing protocols, there is no actuation of the multimedia sensors in on demand basis, congestion control techniques are not used to select the least cost path to the base station and no checkpoint arrangement done for comparing the quality of the original sensed data.

III. PROPOSED SOLUTION

In this section an Energy Efficient Reliable Video Routing Protocol in WMSN is proposed.

A. Multimedia Sensor Network Model

WSN usually consist of sensors, a sink and a control center. In WMSN, common sensors are mostly or totally replaced by multimedia sensors. Clustering technique is used to reduce energy consumption in proposed protocol. When triggered by the event happened in the monitoring environment, the source node collects multimedia information such as image and video of the object and then send the information to base station via cluster heads in a multi-hop way. The information will be transmitted to the base station at last as shown in Fig. 1.

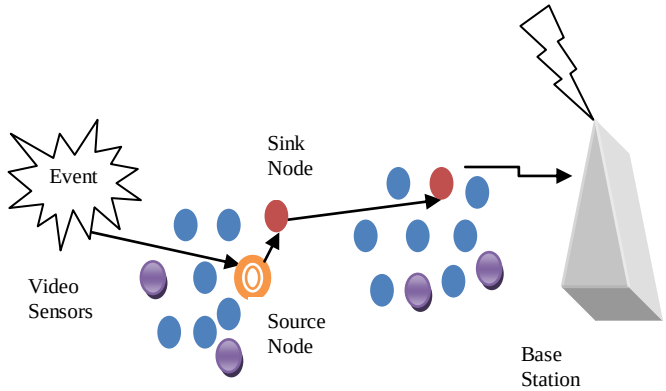

Fig.1. Model of a wireless multimedia sensor network.

B. Distributive Cluster Arrangement

In distributive cluster arrangement, wireless sensor nodes (WSn) only are used as source node, relay or sink node to avoid more loading given to wirelesss multimedia sensor nodes (WMSn). WSn may be in sense mode and in relay mode. High power node is chosen to act in both the modes. Otherwise it acts in either of the modes. In sense mode it senses the data and in relay mode it acts merely as a relay route. In relay mode the node is called sink or relay node. It acts in the relay mode when the request is given to it accordingly from the other nodes. The mode of the node is decided by the energy in the vicinity to act as sink or relay.

In the cluster arrangement the following assumptions are made:

- All the nodes are homogeneous with same battery power and architecture. .
- We assume that the network is noise and error free.

- Each node is aware of its location via some GPS system or by using some localization algorithm also each node has information about their neighbors.
- Each node also has information regarding its area coverage.

C. *Actuation of sensor nodes*

In actuation of sensor nodes, only the nodes with highest residual energy are actuated. The actuated nodes are considered as the cluster heads through which the data is disseminated to other cluster heads.

D. *Cost Function Based Multipath Routing*

In cost function based multipath routing the route request, route reply, the route selection process and data dissemination are described as follows:

The source node broadcasts the RREQ packet to the clusterheads. On receiving the RREQ packet, the clusterhead broadcast the RREP packets based on the cost function which considers the residual energy of the node and queue length. The cost of each available route is calculated according to the following equation:

$$C = C^{i}_{renergy} + C^{i}_{queue} \quad (1)$$

Where C is the cost of the route and $C^{i}_{renergy}$, C^{i}_{queue} are the costs of node *i* considering the residual energy and queue length respectively. The residual energy is obtained by considering the distance of the node and the remaining energy. An application level queue is maintained to get the queue length. The RREP is generated for the available routes to the sink out of which three least cost routes to the sink is considered to transmit the data.

In the source wireless sensor node (SWSn) each frame is coded into a number of video packets according to the size. The packets are numbered with sequence number and sent from the source node which is reassembled at the sink. The packets which are received from the network are buffered. When the buffer is full, the entire packets from it are taken and buffer is emptied.

The checkpoint arrangement is done at each intermediate nodes based on the sequence number. Each intermediate node checks the previous sequence number with the current sequence number, if the current sequence number is greater than the previous sequence number then the data is forwarded to the next node else it is discarded.

IV. SIMULATION RESULTS

A. *Simulation Setup*

The proposed protocol is simulated over NS-2 v2.34 [16]. The network size is 500 × 500 m^2 with 150 nodes at first instance. Each node is equipped with an IEEE 802.11 for the MAC layer as shown in Table.2, which lists the parameters used in our simulation.

Parameters	Values
Network Area	500 ×500 sq m
Number of Nodes	150
Clusters Formed	15
Packet Size	512 B
Initial Energy	50 Joules
Mac Layer	IEEE 802.11
Radio Model	Two Ray Ground Model
Radio Range	40 m
IFQ Length	50 Packets

Table.2. Simulation parameters.

B. *Performance Metrics*

Four important performance metrics are evaluated. They are used to compare the performance of routing protocols in simulation:

- *Routing overhead:* The ratio between the average numbers of data events relayed by a data forwarder for every distinct event delivered to the sink.
- The *energy consumption* measures the average energy dissipated to transmit a data packet from source to sink.
- The *packet delivery ratio (%)* is the number of packets generated by the source to the number of packets received by the sink node.

C. *Results and Discussions*

The simulation was carried out by comparing the proposed protocol Energy efficient reliable video routing with Actuation sensor adaptive routing with checkpoint arrangement (ASARC) and Energy and delay aware dynamic source routing (ED-DSR).

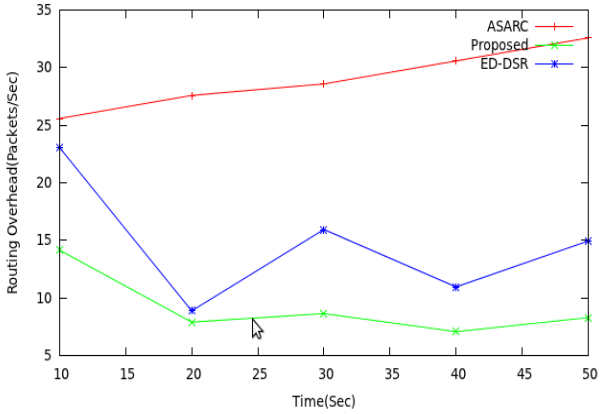

Fig.1 Routing Overhead

Fig.1 shows the routing overhead. By using the cost function based routing and checkpoint arrangement the optimum number of packets are dropped. It provides the least cost path for transmission of multimedia data and decrease the network load.

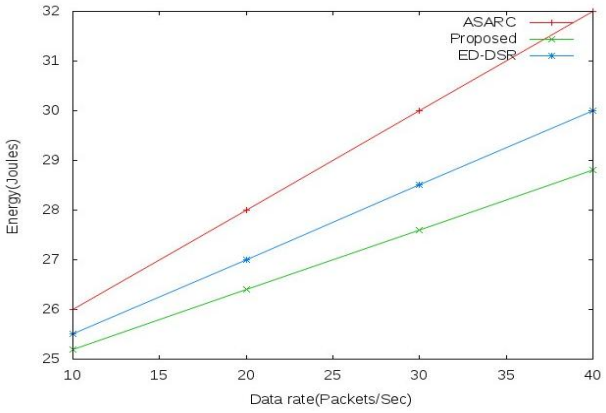

Fig.2 Energy Consumption

Fig. 2 shows the results for the energy consumption. From the figure, it is observed that there is less energy consumption by the proposed protocol. As the network load increases the energy consumption also increases.

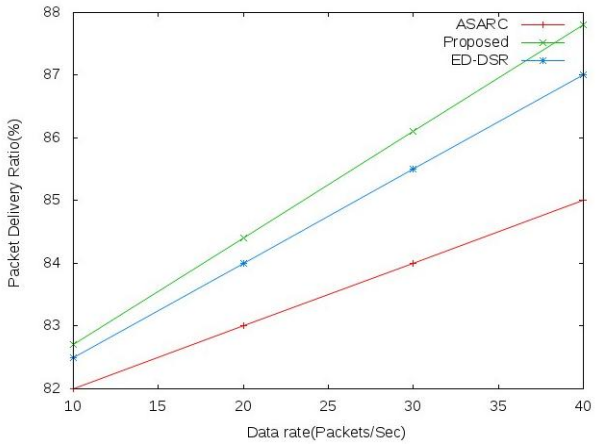

Fig.3 Packet Delivery Ratio

Fig. 3 shows the packet delivery ratio. Proposed protocol has higher delivery rate than ASARC and ED-DSR because proposed protocol disperse packets into least cost paths and with checkpoint arrangement reduce collision of packets.

V. Conclusion

This paper analyzes the energy and the reliability problem in routing transmissions based on wireless multimedia sensor network. By means of actuating the sensors on demand basis, the energy is greatly saved. In the process of QoS routing selection, a cost function based multipath routing which considers residual energy and queue length of each intermediate node is used to calculate cost. The quality of the image is compared by arranging checkpoint at intermediate nodes. An energy efficient reliable video routing is achieved. It can be enhanced by using poison model for finding the route among more than 500 nodes.

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