

Swarm Based Cross Layer Optimization Protocol for WMSN

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ABSTRACT

Wireless Multimedia Sensor Network (WMSN) is comprised of tiny, low cost multimedia devices such as video cameras and microphones. These networks can transfer scalar as well as multimedia data into real time as well as non-real time applications. However addition of such devices exposes additional challenges on both QoS assurance and energy efficiency for efficient use of resources. This paper presents cross layer based AntSenseNet protocol to meet various QoS requirements such as throughput, jitter, lifetime and packet delivery ratio in order to improve network lifetime. Cross layer routing protocol utilizes scheduling algorithm and AntSenseNet protocol builds hierarchical structure and able to use multipath routing protocol. Simulation results shows Cross layer based AntSenseNet protocol outperforms Ant Sense routing protocol and cross layer routing protocol in terms of throughput and packet delivery ratio.

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1. INTRODUCTION

Advancement in wireless sensor network has shifted focus from typical wireless sensor network to Multimedia sensor network. Wireless multimedia sensor network consist of a set of low cost, multifunctional, autonomous sensors. The main objective of wireless sensor network is to detect the event (sensing) and data communication through node coordination and conservation of energy to maximize lifetime. Major area of applications of WMSN is video surveillance, telemedicine and in traffic control.

Introduction of video and imaging data has revealed additional challenges such as bounded delay, packet loss, minimum bandwidth, achievable data rate, cross layer coupling functionalities and strict multimedia communication time constraints. These problems are essentially examined for WMSN in order to optimize the QoS parameters like delay, jitter, throughput and packet loss.

In sensor network, Sensor nodes communicate with each other to detect events, aggregate and process data depending on the application, and to transmit the sensed information to the base station by hopping the data from node to node [3]. The sensor nodes are deployed either randomly or according to statistical distribution which is predefined, over a geographic region of interest (ROI). Wireless sensor network consists of various sensor nodes that are used to monitor any target area like forest fire detection by our army person and monitoring any industrial activity by industry manager [4].

When network scales up, routing becomes more challenging and critical. Careful resource management and delivering the collected multimedia data in WMSN is most important in WMSN. Swarm intelligence based routing protocol can be used for efficient resource management. One of the most

successful swarm intelligence techniques is the ACO (Ant colony optimization) in which Ants uses reinforcement learning to find the most efficient path.

Most of the existing routing protocols follow the traditional layered protocol but for better performance and efficient communication interaction between the different layers and their interdependencies cannot be neglected. Cross layer protocol is one of the best solution to improve the network efficiency and its lifetime in terms of QoS parameters.

This paper proposes Ant based QoS aware cross layer optimization protocol. AntSenseNet routing protocol is introduced to satisfy the QoS metrics while cross layer scheme exploits the interdependence of the layer in order to increase network lifetime. The Network simulator helps the developer to create and simulate new models on an arbitrary network by specifying both the behavior of the network nodes and the communication channels. It provides a virtual environment for an assortment of desirable features such as modeling a network based on a specific criteria and analyzing its performance under different scenarios [9]. Hence Network Simulator2 (NS2) is used as a simulator while doing experimentation.

The remainder of this paper is organized as follows: Section 2 provides brief review of the related work. In section 3 Cross layer based AntSenseNet protocol is presented. Section 4 discusses the results and in section 5 concluding remarks are presented.

2. RELATED WORK

In wireless sensor networks most routing protocols consider energy saving as the main objective. But due to addition of audio, video and imaging sensors additional challenges are exposed. Luis Cobo, Quintero and Samuel have proposed ant based routing protocol for WMSN. Here they have used ant based multi QoS routing metric. It is stated that this algorithm has better convergence and provides better QoS for multiple types of QoS.[1]

Abazeed and Saleem have proposed that improved ACO to search for best path that are satisfied with multimedia traffic requirement. To make best decision the weightage is given to energy consumption and queuing delay. At MAC layer dynamic duty cycle assignment is proposed to satisfy its goals. Result shows that it has achieved better delivery ratio and energy consumption has been reduced. [2]

In CRWMSN proposed by Zara Hamid, Faisal Bashir and Jae Young Pyun many challenges related to delay and errors are presented. The protocol uses a routing metric based packet service time, channel utilization, hop count and energy of a node. Results shows that end to end packet latency has been decreased and throughput of the system is increased. [5]

Matteo Cesana, Nestro Tigliano, Jose M., Petia Todorova has presented the main characteristics and requirements of real time multimedia monitoring applications and then highlighted key research directions. It is suggested that application centric cross layer optimization is essential to achieve the required QoS in most energy efficient way.[6]

Islam Almalkawi, Manel Zapaa and Jamal Al-Karaki has exploited the hierarchical structure of powerful cluster heads and the optimized multiple paths along with the adaptive scheduling to support reliable, high throughput and energy efficient multimedia transmission in WMSN.

Correlation characteristics and functionalities between two layers have been exploited to maximize the network performance with minimum energy consumption. [7]

An Ant based protocol designed for WMSN is ASAT (An ant based service aware routing algorithm for WMSN) is presented by Y. Sun, Lui, Tung. This protocol defines three different parameters of services as event driven, data query and stream query services. ASAT achieves better performance in terms of better convergence and provides better QoS for multiple types of services. [8]

3. CROSS LAYERED AntSenseNet PROTOCOL

Ant based cross layer routing protocol is implemented to optimize the QoS parameters. AntSenseNet protocol is hierarchical protocol based on ant colony optimization protocol. Ant Sense Net algorithm is divided into three steps: In first step it clusters the nodes in colonies. Then it finds the route between clusters that meet the requirements and lastly it forwards network traffic over the previously discovered route.

WMSN Model: Network is created with multimedia sensor nodes with three types of sensors including audio, video and temperature sensor nodes.

Network simulator 2 is used to develop and simulate the performance of the Ant based Cross layer protocol. Throughput, lifetime, jitter and packet delivery ratio are used as the performance measures to evaluate the performance.

The following assumptions are made for this sensor network:

- a. Nodes are randomly placed and uniformly distributed over the two dimensional plane.
- b. Sensor nodes and sink both are not mobile.
- c. There are three types of sensor nodes: Audio, Video and scalar (Temperature sensor nodes).
- d. Isotropic propagation model is followed for communication between the nodes.
- e. Nodes are unaware of their location.

Once network is created with multimedia sensors nodes, then the network is partitioned into clusters. Clustering process is fully distributed among all sensor nodes. Clustering algorithm aims to achieve saving of network resources by selecting the nodes which are rich in resources also ensures network connectivity resulting in maximizing network lifetime.

In order to form the cluster, each node needs to calculate the probability and pheromone value of its own. Available memory of a node and remaining energy of node is used to compute the pheromone value of the node.

```
double re = node_>energy_model()->energy() / node_>energy_model()->initialenergy();
pheromone_ = pow(ma(),a) * pow(re,b);
```

Table 1. Network Parameters to simulate Routing Mechanism

Parameter	Description
Simulator	Network Simulator 2
Number of Nodes	Random
Topology	Grid
Interface Type	Phy/WirelessPhy
MAC Layer	802.11
Queue Type	Droptail/Priority Queue
Queue Length	50 Packets
Antenna Type	Omni Antenna
Propagation Type	Two ray Ground
Routing Protocol	AODV
Transport Agent	UDP
Application Agent	CBR
Initial Energy	100Joules
Simulation Time	50seconds

Once pheromone value is computed then it is broadcasted among all of its neighbour with the hello message. Neighbour nodes receive the pheromone value and stores in its neighbor table and the probability of the node is estimated as the ratio between own pheromone/total pheromone value of its neighbor. After calculating probability value of the node, each node initiated to form cluster by invoking clustering function. It will check the probability value of neighbor with own probability, if own probability is maximum among all the neighbours then that node become cluster head (CH).

CH node send cluster message to all of its neighbour node with energy, pheromone and probability value. Receiver node, updates the status of the head as CH in the neighbor table. If it is already member of the another cluster, then it checks the maximum probability of heads and initiates the join timer to send join message to the maximum probability cluster head node and sends leave message to old cluster head. If the current node is cluster head and probability value of own is greater than neighbour node then CH node send resign message to its one hop neighbour nodes.

Once cluster formation completes, ant procedure is invoked in all sensor. AntSenseNet protocol is based on Ant colony optimization protocol used to discover and maintain the path between source and sink. There are three phases of AntSenseNet protocol: Forward ant phase, Backward ant phase and route maintenance phase. Once the cluster process ends route discovery process starts. Each sensor waits for announcement from the base station. Once announcement is received from the base station then it checks for route to reach base station in the routing table. If the route is not present in the routing table, then Node sends FANT message with energy, delay, packet loss, memory to all of its neighbours.

Neighbour nodes receives the FANT message, and update all required field and then calculates the following field such as energy, delay, packetloss and memory as:

```
rh->ek_i=row_e * rh->ek_i + (1-row_e) * rh->ek[i-1];
rh->dk_i=row_d * rh->dk_i + (1-row_d) * rh->dk[i-1];
rh->ep_i=row_p * rh->ep_i + (1-row_p) * rh->ep[i-1];
rh->mu_i=row_m * rh->mu_i + (1-row_m) * rh->mu[i-1];
```

FANT is rebroadcasted until message reaches the base station. When the forward ant reaches the base station evaluation of the path is carried out. Once it reaches the base station then base station computes path parameter such as delay energy, packet loss. These parameters are compared with standard parameters set for the particular application. If these values did not match with the standard values then that path is discarded. If FANT values fulfill the requirement of particular application, base station generates backward ants and sends these BANT message in the reverse direction. BS calculates the pheromone value of the route and unicast with the BANT in the reverse route. Intermediate nodes receive and unicast the message to source node and also it updates the pheromone value of the ant nodes in the path. Intermediate nodes create the route in the routing table to reach the base station via ant nodes. Base station maintains Ant release timer to release the ants in the network.

Whenever this timer expires, BS calculates the number of ants to be released in the network. Each node maintains maintenance timer, and checks for traffic load, if it reaches the threshold then it send MANT message with pheromone value.

Receiver node updates the pheromone value with the new pheromone value. From the interface-queue, mac layer and linklayer, packet delay in terms of queue_delay, transmission_delay, network_delay and mac_delay are estimated, From these values, packet service time is estimated.

$$T_PST = T_net + T_queue + T_mac + T_trans;$$

From MAC idle time and last transmission time, T_PST value is updated.

$$T_Pst = Tr - Tl$$

During data transmission, based on the packet service class, delay for each hop is calculated as

$$d_hop = ch->PST / ch->s_PST * ch->pkt_class;$$

$$di = (CURRENT_TIME - ch->enq_time);$$

$$eta_i = di / d_hop;$$

In order to maintain the route, FANTS are generated periodically in order to update the path periodically. During route maintenance congestion and lost link problem are also taken into consideration in order to minimize the packet loss and to improve the throughput.

In this protocol cluster head forwards the data following the maximum pheromone value. In this protocol sensor data is in various forms such as audio data, video data, scalar data. Hence packet scheduling policy is considered for different types of data. Here each CH classifier checks the type of data packet and then it is sent to the appropriate queue and scheduler organizes this data according to type and priority.

4. RESULTS& ANALYSIS

Here, Different QoS parameters are analyzed for AntSenseNet protocol and Cross layer based AntSenseNet protocol. There are two types of nodes: scalar sensor nodes and multimedia sensor nodes. Radio range of the nodes is 100m. Nodes are randomly distributed in the network having size of 500m X 500m. Modified version of 802.11 MAC protocol is used which uses priority queue and handles multimedia traffic very efficiently. Cross layering between routing, MAC and physical layer is done in order to consider multi priority traffic. 100 nodes are randomly distributed in a square area. Simulation is carried out for 50 Seconds. Initial energy of the nodes was 100 Joules. Simulation is carried out after clustering. Different performance metrics are taken into consideration: Packet delivery ratio, Throughput and Number of packets dropped. Routing packets includes control packets which are used for rout discovery, route maintenance and pheromone updation.

Network is moderately loaded. Two traffic classes are produced: multimedia traffic with a size of 1024 byte packets and scalar traffic having size of 32 byte packets. Multimedia traffic has higher priority than scalar traffic.

Fig 1 shows simulation time vs packet delivery ratio of AntSenseNet protocol and Ant based cross layer protocol. It is constant for different simulation time as well as for different coverage ranges. Packet delivery ratio is better for ant based cross layer protocol than the AntSenseNet protocol.

This result is obtained due to two level scheduling that has been used. This two level scheduling avoids collisions and minimizes the interference also. Also due to the multipath transmission this ratio is improved. Due to the clustering process link failure is minimized and coverage has been increased.

Small variation in the packet delivery ratio is observed if the number of nodes is increased due to the increased network overhead. Packet delivery ratio of Ant based cross layer routing protocol is improved compared to AntSenseNet protocol. This can be observed from Figure 1, 2 and 3.

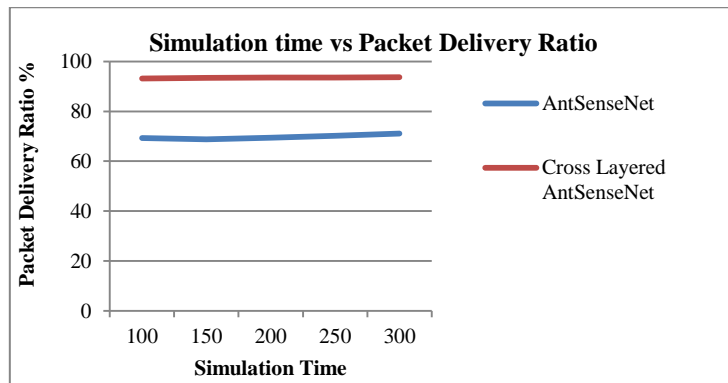


Figure 1. Simulation vs Packet Delivery Ratio

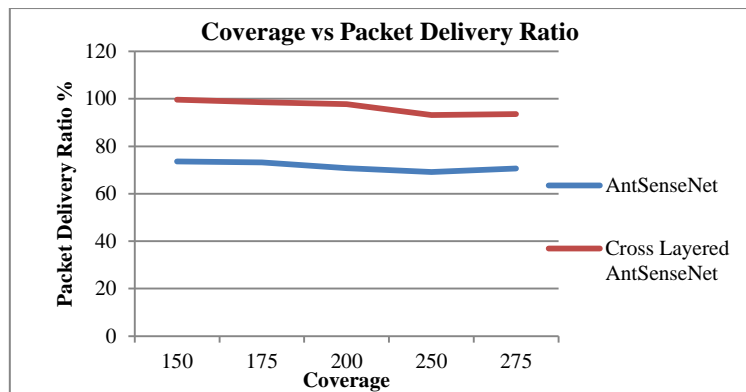


Figure 2. Coverage vs Packet Delivery Ratio

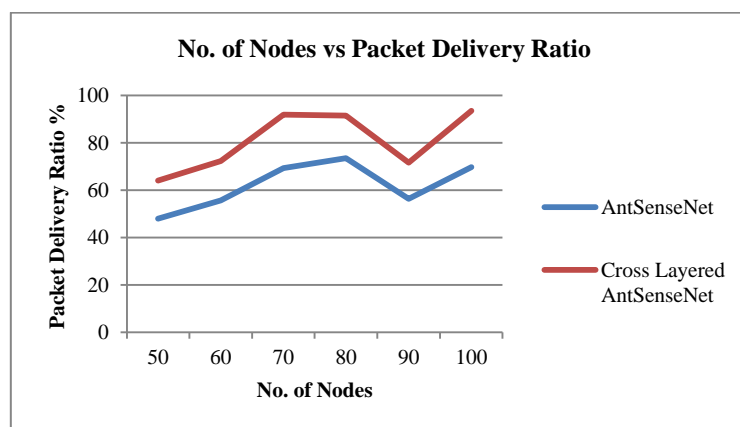


Figure 3. Node vs Packet Delivery Ratio

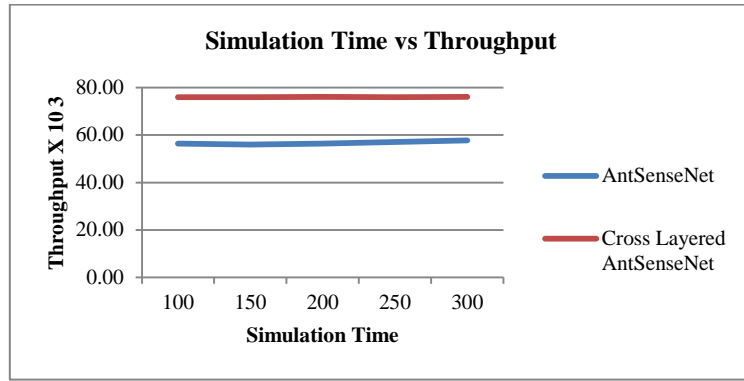


Figure 4. Simulation time vs Throughput

Our proposed protocol achieves higher throughput as shown in the figure 4, 5 and 6. This is due to the multipath scheduling algorithm that has been used in the protocol. Multiple paths were discovered when path to destination breaks. Packets could reach to destination without new path discovery process. Due to this packet delivery ratio increases and number of packets dropped decreases.

Ant based crosslayer protocol has less number of packets dropped due to multipath routing protocol. Due to clustered network architecture it has less communication overhead as most of the nodes in the network have to communicate with their cluster heads and cluster head communicates with other group heads. Due to this energy required is less which results in increase in lifetime. Also data aggregation takes place at cluster heads which results in decrease in energy consumption

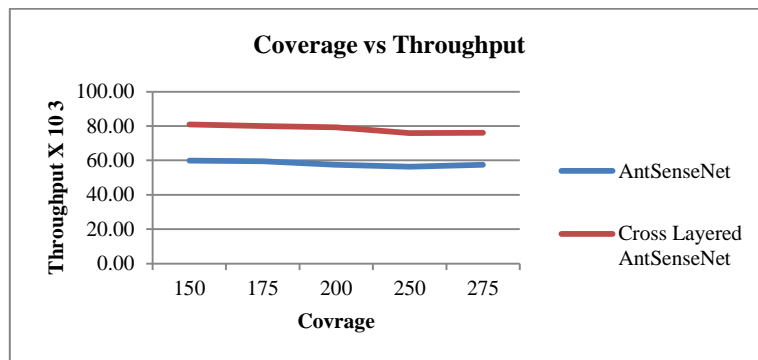


Figure 5. Coverage vs Throughput

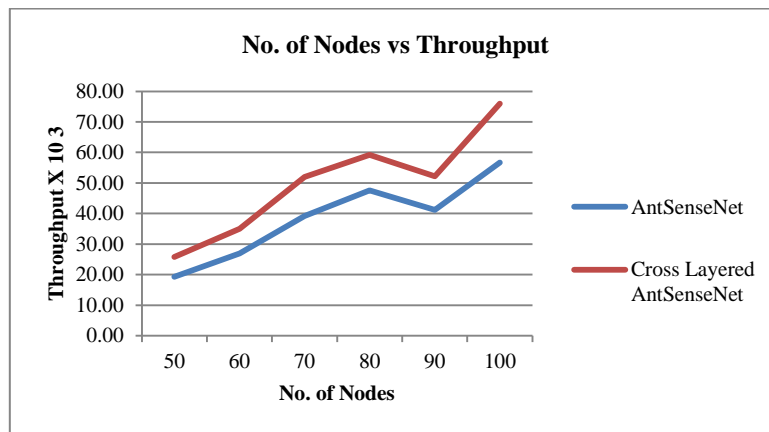


Figure 6. Node vs Throughput

5. CONCLUSION




WMSN has issues such as coverage, connectivity, network lifetime and scheduling & data aggregation. In this paper ant based cross layer protocol is presented. Cross layering between routing and MAC layer is done in order to exploit the correlation and functionality between different layers. Also multipath routing protocol has been implemented along with scheduling and queuing model to improve network lifetime and overall throughput of the network. Our proposed protocol uses scheduling protocol which maintains the minimum end to end delay suitable for different data. It achieves high throughput and packet delivery ratio by avoiding collisions and interference. The simulation results shows that proposed protocol achieves better performance than AntSenseNet protocol.

In future we will focus on the clustering of the nodes in order to optimize end to end delay. Also we will concentrate on the on the routing model we have used in proposed protocol in order to improve the energy efficiency and network lifetime.

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