A Certain Investigation on Cluster Based Medium Access Control and QoS Aware Routing Protocol for Heterogeneous Networks

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Abstract— Clustering is a process to subdivide the sensing field of sensor network into number of clusters. Each cluster selects a leader called cluster head. A cluster head may be elected by the sensor node in the cluster or pre assigned by the network designer. Optimized Clustering can save lot of energy in the network. In our paper we have surveyed various clustering protocols for wireless sensor networks and compared on various parameters. The performance of the IEEE 802.11 MAC protocol has been shown to degrade considerably in an ad hoc network with nodes that transmit at heterogeneous power levels. We conclude that the schemes together offer a simple yet effective and viable means of performing medium access control and QOS scheduling techniques in heterogeneous networks.

Key words: Cluster, MAC Layer, Het Net, QOS scheduling, Routing protocol

I. INTRODUCTION

Clustering is an approach used to reduce traffic during the routing process. Clustering is division of the network into different virtual groups based on rules in order to discriminate the nodes allocated to different sub-networks. The goal of clustering is to achieve scalability in presence of large networks and high mobility. QoS provisioning is challenging due to the key characteristics of MANETs i.e. lack of central coordination, mobility of hosts and limited availability of resources. QoS support for MANETs encompasses four major functionally interdependent areas i.e. QoS models, QoS resource reservation signaling, QoS Routing and QoS Medium Access Control (MAC). A QoS model defines the service architecture of the overall QoS framework. QoS routing focuses on identification of network paths with sufficient capacity to meet end-user service requirements. QoS MAC provides mechanisms for resolving medium contention and supports reliable unicast links.

Providing QoS is more difficult for MANETs due to at least two reasons. First, unlike wired networks, radios have broadcast nature. Thus, each link's bandwidth will be affected by the transmission/receiving activities of its neighboring links. Second, unlike cellular networks where only one-hop wireless communication is involved, MANETs need to guarantee QoS on a multi-hop wireless path. Further, mobile hosts may join, leave, and rejoin at any time and at any location; existing links may disappear and new links may be formed "on-the-fly". All these raise challenges to QoS-aware routing in MANETs. Next, we discuss some the challenges in designing routing protocols.

II. LITERATURE REVIEW

Xiaoqin Chen et al. [2] have proposed a congestion-aware routing metric which was employed data-rate, MAC overhead, and buffer queuing delay, with preference given to less congested high throughput links to improve channel utilization also they have proposed the Congestion Aware Routing protocol for Mobile ad hoc networks (CARM). CARM has applied a link data-rate categorization approach to prevent routes with mismatched link data-rates. CARM was only discussed and simulated in relation IEEE 802.11b networks; however, it was applied to any multi-rate ad hoc network.

Ming Yu et al. [3] have proposed a link availability-based QoS-aware (LABQ) routing protocol for mobile ad hoc networks based on mobility prediction and link quality measurement, in addition to energy consumption estimate. They have provided highly reliable and better communication links with energy-efficiency.

Yung Yi and Sanjay Shakkottai [4] have developed a fair hop-by-hop congestion control algorithm with the MAC constraint was being imposed in the form of a channel access time constraint, using an optimization-based framework. In the absence of delay, they have shown that this algorithm was globally stable using a Lyapunov-function-based approach and in the presence of delay, they have shown that the hop-by-hop control algorithm has the property of spatial spreading.

R.Asokan et al. [5] were being extended the scope to QoS routing procedure, to inform the source about QoS available to any destination in the wireless network. However, existing QoS routing solutions were dealt with only one or two of the QoS parameters. It was important that MANETs was provided QoS support routing, such as acceptable delay, jitter and energy in the case of multimedia and real time applications. They have proposed a QoS Dynamic Source Routing (DSR) protocol using Ant Colony Optimization (ACO) called Ant DSR (ADSR).

Lei Chen and Wendi B. Heinzelman [6] have proposed a QoS-aware routing protocol that were incorporated an admission control scheme and a feedback scheme to meet the QoS requirements of real-time applications. The novel part of this QoS-aware routing protocol was the use of the approximate bandwidth estimation to react to network traffic. They have implemented these schemes by using two bandwidth estimation methods to find the residual bandwidth available at each node to support new streams.

Chenxi Zhu and M. Scott Corson [7] have developed a QoS routing protocol for ad hoc networks using TDMA. Their object was to establish bandwidth guaranteed QoS routes in small networks whose topologies were changed at low to medium rate. The protocol was based on AODV, and built QoS routes only as needed. They have started with the problem of calculating the available bandwidth on a given route and develop an efficient algorithm and then they were used the algorithm in conjunction with AODV to perform QoS routing.

Duc A. Tran and Harish Raghavendra [8] have proposed CRP, a congestion-adaptive routing protocol for MANETs. CRP tried to prevent congestion from occurring in the first place, rather than dealing with it reactively. A key in CRP design was the bypass concept. A bypass was a sub path connecting a node and the next non congested node. If a node was aware of a potential congestion ahead, it was found a bypass that was used in case the congestion actually occurred or. Part of the incoming traffic was sent on the bypass, was being made the traffic was being come to the potentially congested node less. The congestion was avoided as a result.

RamaChandran and Shanmugavel [11] have proposed and studied three cross-layer designs among physical, medium access control and routing (network) layers, using Received Signal Strength (RSS) as cross-layer interaction parameter for energy conservation, unidirectional link rejection and reliable route formation in mobile ad hoc networks.

III. Problem Description

A. Existing System

The main challenge involved with routing protocols in Wireless Heterogeneous Networks (WSNs) is to provide the required Quality of Service (QoS) while respecting the resources limitation of the network such as severe resource constraints of Heterogeneous nodes, high node density, unreliable links and harsh environmental conditions. There are many other challenges involved with routing protocols for WHNs since different applications call for different QoS such as end-to-end delay and reliable data transmission guarantees.

Thus, the design requirements of WHNs change according to the application. Accordingly, it is difficult to propose a routing protocol that satisfies the wide range of applications while respecting the WHNs constraints. Furthermore, the inter-dependency and conflict among multiple QoS parameters make the problem difficult.

B. Proposed System

MAC layer is responsible for scheduling and allocation of the shared wireless channel, which eventually determines the link level QoS parameters specifically MAC delay. This section presents the QoS-aware scheduling parameters that reflect the performance of the routing protocol in terms of end-to-end delay and reliability of data transmission with minimum resource consumption.MAC layer coordinates the sharing of the wireless medium layer and can contribute to energy efficiency by minimizing the number of collisions, overhearing, overhead and ideal listening.

In this research work, proposed scheme extends the routing approach and considers the joint functionalities among the layers especially the routing and MAC layers. A cross-layer design is proposed between the routing and MAC layers where the end-to-end QoS requirements are enforced through Hetrogeneous decision of next hops according to the neighbors state and the required QoS.

However, the end-to-end requirement is guaranteed jointly by the local decisions of these networks and the sink decision on the used paths and the number of these paths. The proposed scheme prioritized traffic according to the requirements such that the end-to-end requirements can be improved with packet, path and queue scheduling. When the traffic load on Hetrogeneouss in some area of the network is high due to heavy communication activity, the probability of routing through this area is decreased to protect the traffic from dropping.

C. QoS Protocol Performance Issues and Factors

Even after overcoming the challenges of MANET, a number of factors have major impacts while evaluating the performance of QoS protocols. Some of these parameters are of particular interest considering the characteristics of the MANET environment. They can be summarized as follows:

D. Node mobility

This factor generally encompasses several parameters: the nodes' maximum and minimum speed, speed pattern and pause time. The node's speed pattern determines whether the node moves at uniform speed at all times or whether it is constantly varying, and also how it accelerates, for example, uniformly or exponentially with time. The pause time determines the length of time nodes remain stationary between each period of movement. Together with maximum and minimum speed, this parameter determines how often the network topology changes and thus how often network state information must be updated.

E. Network size

Since QoS state has to be gathered or disseminated in some way for routing decisions to be made, the larger the network, the more difficult this becomes in terms of update latency and message overhead. This is the same as with all network state information, such as that used in best-effort protocols;

F. Node Transmission Power

Some nodes may have the ability to vary their transmission power. This is important, since at a higher power, nodes have more direct neighbors and hence connectivity increases, but the interference between nodes increases as well. Transmission power control can also result in unidirectional links between nodes, which can affect the performance of routing protocols.

IV. Cluster Based Strategic Media Access Control and QoS Aware Routing Protocol

A. Neighbor Node Selection Mechanism

Since short delay is the major real-time QoS requirement for traffic transmission, CBMQOR incorporates the Earliest Deadline First scheduling algorithm (EDF), which is a deadline driven scheduling algorithm for data traffic scheduling in intermediate nodes. In this algorithm, an intermediate node assigns the highest priority to the packet with the closest deadline and forwards the packet with the highest priority first. Let us use $S_p(i)$ to denote the size of the packet steam from node n_i, use W_i to denote the bandwidth of node i, and $T_p(i)$ to denote the packet arrival interval from node n_i. The QoS of the packets going through node n_i can be satisfied if

$$\frac{S_p(1)}{T_a(1)}+\frac{S_P(j)}{T_a(j)}+...+\frac{S_P(m)}{T_a(m)}\leq W_i \quad .... (1)$$

A task consists of a number of jobs. It is derived that for a given set of $\overline{m}$ jobs for an operating system, the deadline-driven scheduling algorithm is feasible for the job scheduling if and only if

$$\frac{T_{cp}(1)}{T_g(1)}+\frac{T_{cp}(2)}{T_g(2)}+\frac{T_{cp}(j)}{T_g(j)}+...+\frac{T_{cp}(\overline{m})}{T_g(\overline{m})}\leq 1, \quad ....(2)$$

where $T_g(j)$ denotes the job arrival interval time period and $T_{cp}(j)$ denotes the job computing time of task j and 1 is the CPU utility when the CPU is busy all the time. Recall that space utility $U_s(i)$ is the fraction of time a node n_i is busy with packet forwarding over a unit time.

In a communication network, the transmission time of a packet in packet stream from node n_j can be regarded as the computing time $T_{cp}(j)$ of a job from task j, the packet arrival interval T_a can be regarded as T_g, and the CPU utility can be regarded as node space utility in the job scheduling model. Then, it is reduced to

$$U_s(i)=\frac{S_p(1)/W_i}{T_a(1)}+\frac{S_p(2)/W_i}{T_a(2)}+\frac{S_p(j)/W_i}{T_a(j)}+...+\frac{S_p(m)/W_i}{T_a(m)}\leq 1$$

$$\Rightarrow \frac{S_p(1)}{T_a(1)}+\frac{S_P(j)}{T_a(j)}+...+\frac{S_P(m)}{T_a(m)}\leq W_i \quad .... (3)$$

Where $W_i=(1-U_c(i)).C_i, S_p(j)$ is the size of the packet steam from node n_j.

Equation (3) indicates that the scheduling feasibility of a node is affected by packet size Sp, the number of packet streams from m neighbors, and its bandwidth W_i .A queue length threshold is set to avoid queuing congestion, we set up a space utility threshold e $\tilde{T}_{Us}$ for each node as a safety line to make the queue scheduling feasible. $U_{as}(i)$ is used to denote the available space utility and $U_{as}(i)= \tilde{T}_{Us} - U_{as}(i)$. In CBMQOR, after receiving a forward request from a source node, an intermediate node n_i with space utility less than threshold $\tilde{T}_{Us}$ replies the source node.

The replied node n_i informs the source node about its available workload rate $U_{as}(i)*W_i$, and the necessary information to calculate the queuing delay of the packets from the source node. The source node selects the replied neighbor nodes that can meet its QoS deadline for packet forwarding based on the calculated queuing delay.

After the source node determines the N_q nodes that can satisfy the deadline requirement of the source node, the source node needs to distribute its packets to the N_q nodes based on their available workload rate $U_{as}(i)*W_i$ to make the scheduling feasible in each of the neighbor nodes. Subsequently, the problem can be modeled as a linear programming process. Suppose the packet generating rate of the source node is W_g kb/s, the available workload rate of the intermediate node i is $U_{as}(i)*W_i$, and the workload rate allocation from source node to immediate node i is ,

$Ai=\frac{S_p(i)}{T_a(i)}$ where 0 <i<n. Then, we need to solve the following equations to get an allocation set

$$A=\left\{\begin{array}{l} W_g=\sum_{i=1}^{N_q} A_i \\ A_i\leq U_{as}(i)*W_i \end{array}\right\} \quad .... (4)$$

Any results that satisfy (4) can be used by the source node. If the equation cannot be solved, which means the QoS of the source node cannot be satisfied, then the source node stops generating packets based on the admission control policy. Based on $S_p(i)$, the source node can calculate the packet arrival interval for node n_i:

$$T_a(i)=\frac{S_p(i)}{Ai}.$$

For example, suppose the bandwidth W_i of the intermediate node n_i is 70 kb/s, the threshold of the workload is 80percentof the overall space utility, which is56 kb/s. Node n_i schedules the packet traffic from three different source nodes n_1, n_2, and n_3 periodically. The packet size of traffic from n_1, n_2, and n_3 are 1, 10, and 20 kb with arrival interval 0.1, 0.5, and 1 s, respectively. Then, $\frac{S_1}{T_1}+\frac{S_2}{T_2}+\frac{S_3}{T_3}=50$ kb/s.

When another node n_4 sends are quest to the intermediate n_i, n_i checks its own available workload rate and replies to the source node its available workload rate 6 kb/s. If n4 accepts the reply and sends 20 kb/s traffic to the intermediate node n_i, n_i will reject the request and inform n4 to reduce the traffic to 6 kb/s. Once the bandwidth of the intermediate node drops to 60 kb/s because of the interference, n_i's overall space utility is reduced to 48 kb/s. Then, n_i informs node n3 under scheduling that has the largest $\frac{S_p(i)}{T_a(i)}$ = 20 kb/s to change its traffic to 18 kb/s.

B. Scheduling in CBMQOR

In order to further reduce the stream transmission time, an adaptive packet scheduling algorithm is proposed for packet routing. This algorithm assigns earlier generated packets to forwarder nodes with higher queuing delays and scheduling feasibility, while assigns more recently generated packets to forwarders with lower queuing delays and scheduling feasibility, so that the transmission delay of an entire packet stream can be reduced.

t is used to denote the time when a packet is generated, and T_{QoS} is used to denote the delay QoS requirement. Let W_S and W_I denote the bandwidth of a source node and an intermediate node respectively, we use $T_{S\to I} = \frac{S_P}{W_S}$ to denote the transmission delay between a source node and an intermediate node, and $T_{I\to D} = \frac{S_P}{W_S}$ to denote the transmission delay between an intermediate node and an AP. Let T_w denote the packet queuing time and $T_w(i)$ denote the packet queuing time of n_i. Then, as Fig. 3 shows, the queuing delay requirement is calculated as $T_w < T_{QoS} = T_{S\to I} = T_{I\to D}$. As T_{QoS}, $T_{S\to I}$, and $T_{I\to D}$ are already known, the source node needs to calculate T_w of each intermediate node to select intermediate nodes that can send its packets by the deadline, i.e., that can satisfy

$$T_w < T_{QoS} = T_{S\to I} = T_{I\to D}.$$

Below is the method to calculate T_w. CBMQOR incorporates the EDF, in which an intermediate node assigns the highest priority to the packet with the closest deadline and forwards the packet with the highest priority first.

V. RESULTS AND DISCUSSION

A. Simulation Setup

The simulated traffic is Constant Bit Rate (CBR). The simulation settings are also represented in tabular format as shown in Table 5.1.

Parameter	Value
Simulator	NS-2 (Version 2.35)
Channel type	Channel/Wireless channel
Protocols	CBMQOR, RAB, QoS-SBRP
Simulation duration	120 seconds
Packet size	512 KB
Traffic rate	128 bytes
Mobility Models	Random Waypoint
Traffic Models	CBR
Network size	200 nodes
Topology	500 m x 500m

Table 1: Simulation Environment of CBMQOR, RAB, QoS-SBRP

B. Simulation Results and Discussions

The following metrics are taken into account for evaluating the proposed routing mechanism with RAB.

- Throughput
- Packet Delivery Ratio
- Packet Drop
- Overhead
- Delay

C. Analysis of Packet Delivery Ratio

Figure 5.1. shows the packet delivery ratio performance of the existing RAB QoS-SBRP protocols and the proposed CBMQOR. It is clearly seen that the proposed protocol CBMQOR achieves better packet delivery ratio than that of RAB and QoS-SBRP protocols. The numerical results are given in Table 5.2.

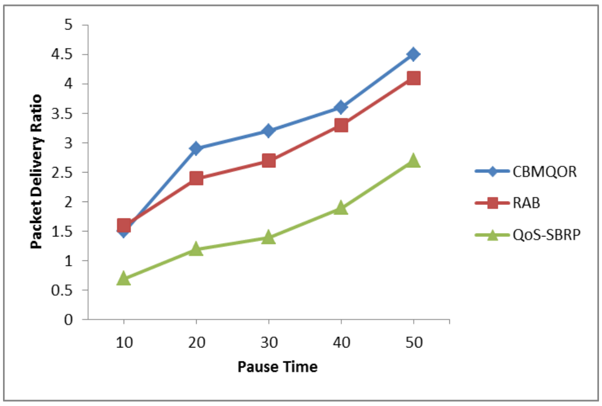

Fig. 1: Pausetime Vs Packet Delivery Ratio

D. Analysis of Packet Drop Ratio

Figure 5.2. depicts the packets drop performance of the existing RAB and QoS-SBRP protocol and the proposed CBMQOR. It is clear that the proposed protocol CBMQOR achieves lesser packet drop than that of RAB and QoS-SBRP protocols.

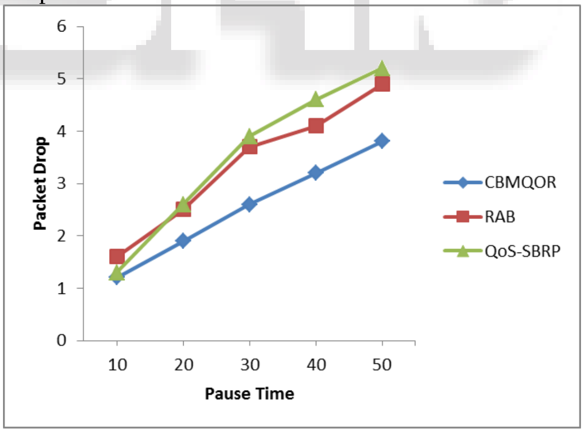

Fig. 2: Pause time Vs Packet Drop

E. Analysis of Packet Overhead Ratio

Figure 5.3. shows the overhead performance of the existing RAB, QoS-SBRP protocols and the proposed CBMQOR. It is proved that the proposed protocol CBMQOR achieves less overhead than that of RAB protocol. The numerical results are also given in Table 5.2.

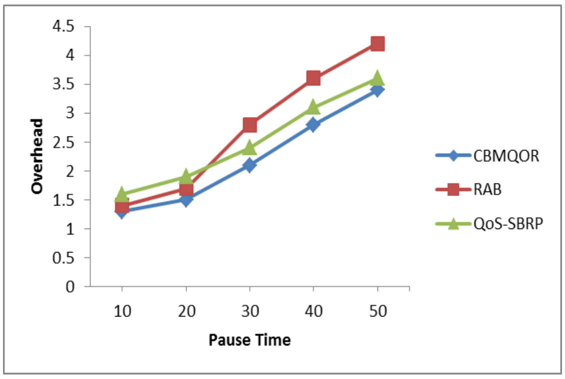

Fig. 3: Pause time Vs Overhead

F. *Analysis of End to End Delay*

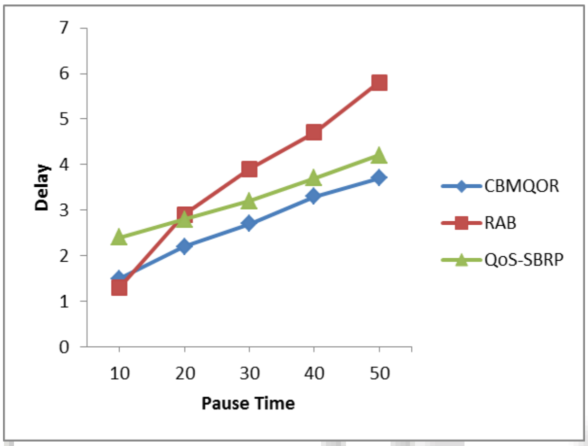

Fig. 4: Pause time Vs Delay

Figure 5.4. shows the Delay performance of the existing RAB, QoS-SBRP protocols and the proposed CBMQOR. It is proved that the proposed protocol CBMQOR protocol reducing delay than that of Existing routing protocol.

VI. CONCLUSION

The proposed a routing mechanism in order to ensure QoS through packet scheduling strategy named Strategic MAC with QoS based Routing Protocol shortly termed as CBMQOR. A Cluster based Medium Access control and QoS - aware neighbor node selection mechanism is used to meet the transmission delay requirement among the mobile nodes. A distributed packet scheduling mechanism for reducing the transmission delay of packets is also presented. Packet resizing mechanism is proposed that is capable enough to adjust the segment size of the packet in adaptive manner. The simulation is carried out based on pause time and mobility speed. Mobility speed is taken for ensuring the protocol's performance on heterogeneous ad hoc networks. Simulation results prove that the proposed mechanism attains better QoS in terms of packet delivery ratio, overhead, packets drop and delay based on both pause time and mobility speed.

Pause Time	Delay			Overhead			Packet Delivery Ratio			Packet Drop		
	CBMQOR	RAB	QoS-SBRP	CBMQOR	RAB	QoS-SBRP	CBMQOR	RAB	QoS-SBRP	CBMQOR	RAB	QoS-SBRP
10	1.5	1.3	2.4	1.3	1.4	1.6	1.5	1.6	0.7	1.2	1.6	1.3
20	2.2	2.9	2.8	1.5	1.7	1.9	2.9	2.4	1.2	1.9	2.5	2.6
30	2.7	3.9	5.2	2.1	2.8	2.4	5.2	2.7	1.4	2.6	3.7	3.9
40	3.3	4.7	3.7	2.8	3.6	3.1	3.6	3.3	1.9	5.2	4.1	4.6
50	3.7	5.8	4.2	3.4	4.2	3.6	4.5	4.1	2.7	3.8	4.9	5.2

Table 2: Pause time Vs Packet Delivery Ratio, Packets Drop, Overhead and Delay

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