

Performance Analysis on Mobile Agent Based Congestion Control Using AODV Routing Protocol Technique with Hop by Hop Algorithm for Mobile Ad-hoc Network

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Abstract :

In Mobile Ad hoc Networks (MANETs) congestion occurs due to the packet loss and it can be successfully reduced by involving congestion control scheme which includes routing algorithm and a flow control at the network layer. In this paper, we propose to agent based congestion control technique for MANETs. In our technique, the information about network congestion is collected and distributed by mobile agents (MA) A mobile agent based congestion control AODV routing protocol is proposed to avoid congestion in ad hoc network. Some mobile agents are added in ad hoc network, which carry routing information and nodes congestion status. When mobile agent travels through the network, it can select a less-loaded neighbor node as its next hop and update the routing table according to the node's congestion status. With the aid of mobile agents, the nodes can get the dynamic network topology in time. By simulation results, we show that our proposed technique attains high delivery ratio and throughput with reduced delay when compared with the existing technique.

Keywords:

AODV routing protocol, Congestion control Mobile Ad hoc Networks (MANETs), Mobile Agents (MA), Total Congestion Metric (TCM), Enhanced Distributed Channel Access (EDCA), Transmission opportunity limit (TXOP).

1. Introduction

1.1 Mobile Ad Hoc Networks

The mobile ad hoc network is capable of forming a temporary network, without the need of a central administration or standard support devices available in a conventional network, thus forming an infrastructure-less network. In order to guarantee for the future, the mobile ad hoc

networks establishes the networks everywhere. To avoid being an ideal candidate during rescue and emergency operations, these networks do not depend on the irrelevant hardware. These networks build, operate and maintain with the help of constituent wireless nodes. Since these nodes have only a limited transmission range, it depends on its neighboring nodes to forward packets [1].

Congestion control is a key problem in mobile ad-hoc networks. The standard TCP congestion control mechanism is not able to handle the special properties of a shared wireless multihop channel well. In particular the frequent changes of the network topology and the shared nature of the wireless channel pose significant challenges.

Many approaches have been proposed to overcome these difficulties[3] Ad hoc network is a wireless and with no fixed equipment (such as base stations) distributed network which is component of mobile terminals [27] , each mobile terminal is not only host computer but also router.

As power and bandwidth limitations, ad hoc network routing protocols should distribute routing tasks fairly in the mobile nodes. At present, AODV routing protocol is often used in ad hoc network. But its biggest shortcoming is delay. In routing discovery and maintenance, a large number of data is transmitted through a small number of nodes is bound to lead to network congestion and bottleneck. At the same time, imbalanced data load will be exhaust nodes energy rapidly. With the increase of brownout nodes, network connectivity will be weakened and network overall survival time will be shorten subsequently. Therefore, In order to balance the network load and maintain network continuous, efficient and stable operation, it is necessary to take into account the routing nodes load and congestion in network [28]. In mobile ad hoc wireless network, mobile agent has mobility and autonomy. Therefore, it can be used to solve the ad hoc network congestion[26]

Ad hoc networks are characterized by a lack of infrastructure, and by a random and quickly changing network topology; thus the need for a robust dynamic routing protocol that can accommodate such an environment. Consequently, many routing algorithms have come into existence to satisfy the needs of communications in such networks. performance comparison between two routing algorithms, AODV, from the reactive family and DSDV, from the proactive family. Both protocols were simulated using the ns-2 package and were compared in terms of average throughput, packet loss ratio, and routing overhead, while varying number of nodes, speed and pause time. Simulation revealed that although DSDV perfectly scales to small networks with low node speeds, AODV is preferred due to its more efficient use of bandwidth [31]

1.2 Congestion Control in MANETs

Congestion takes place in MANETs with limited resources. In these networks, shared wireless channel and dynamic topology leads to interference and fading during packet transmission. Packet losses and bandwidth degradation are caused due to congestion, and thus, time and energy is wasted during its recovery. Congestion can be prevented using congestion-aware protocol through bypassing the affected links [2]. Severe throughput degradation and massive fairness problems are some of the identified congestion related problems. These problems are incurred from MAC, routing and transport layers [3].

Congestion control is the major problem in mobile ad hoc networks. Congestion control is related to controlling traffic entering into a telecommunication network. To avoid congestive collapse or link capabilities of the intermediate nodes and networks and to reduce the rate of sending packets congestion control is used extensively [4]. Congestion control and reliability mechanisms are combined by TCP to perform the congestion control without explicit feedback about the congestion state and without the intermediate nodes being directly interrupted [4]. Their principles include packet conservation, additive increase/multiplicative decrease in sending rate, stable network. End system flow control, network congestion control, network based congestion avoidance, and resource allocation includes the basic techniques for congestion control [5].

Packet loss in MANETs is mainly caused due to congestion. The packet loss can be reduced by involving congestion control over a mobility and failure adaptive routing protocol at the network layer. The congestion non-adaptive routing protocols, leads to the following difficulties:

- Long delay: The congestion control mechanisms takes much time for detecting congestion. Usage of new routes in some crucial situations is advisable. In an on-demand routing protocol, the major problem is the delay occurring for route searching.
- High overhead: It takes effort in new routes for processing and communication for discovering it. It also takes effort in multipath routing for maintaining the multi-paths, though there is an alternative protocol.
- Many packet losses: The packets may be lost when the congestion is detected. To reduce the traffic load, a congestion control solution is applied either by decreasing the sending rate at the sender, or dropping packets at the intermediate nodes or by both methods. But high packet loss rate or a small throughput occurs at the receiver [6].

1.3 Problem Identification and Proposed Protocol Overview

Problem Identification. As explained in section 2, congestion adaptive routing has been examined in several studies. Estimating or reviewing the level of activity in the intermediate nodes using load or delay measurement, is the common approach in all the studies mentioned. The favorable path is established based upon the collected information, which helps in avoiding the existing and developing congested nodes. The performance of routing protocols is affected by the service type of the traffic carried by the intermediate nodes. But no research has stated this so far.

Before presenting themselves as aspirant to route traffic to the destination, the MANETs do not take the status of the queues into account, for the route discovery process. Because of this, the newly arriving traffic face long delays, packet drops, and fail to be transmit ahead of the already queuing traffic.

The mobile ad hoc networks performances are subjective to the congestion problem. A routing algorithm and a flow control scheme, includes the congestion control scheme. Enhanced performance and better congestion control can be achieved only by considering the routing and the flow control together. This was not done in earlier researches [12].

AODV routing protocol [30] is a distance vector routing protocol based on demand. The main characteristic is using a serial number to identify the routing is new or old and avoid routing loop. AODV routing protocol has the advantages of each intermediate node saves a routing request and

response result implicitly to adapt to dynamic link rapidly .AODV protocol has two main components: routing discovery and routing maintenance.

Protocol Overview. In this paper, we propose to design and develop an agent based congestion control technique. In our technique, the information about network congestion is collected and distributed by mobile agents (MA). Each node has a routing table that stores routing information for every destination. MA starts from every node and moves to an adjacent node at every time. The MA updates the routing table of the node it is visiting.

In our technique, the node is classified in one of the four categories depending on whether the traffic belongs to background, best effort, video or voice AC respectively. Then MA estimates the total congestion metric by calculating the queue length and the channel contention and it is applied to the routing protocol to select the minimum congested route.

2. Related Work

Yao-Nan Lien et al [7] proposed a new TCP congestion control mechanism by router-assisted approach. Their proposed TCP protocol, called TCP Muzha uses the assistance provided by routers to achieve better congestion control. To use TCP Muzha, routers are required to provide some information allowing the sender to estimate more accurately the remaining capacity over the bottleneck node with respect to the path from the sender to the receiver. With this information, TCP Muzha will be able to enhance the performance of both TCP and network.

Wei Sun et al [8] have compared the general AIMD-based congestion control mechanism (GAIMD) with Equation-based congestion control mechanism (TFRC TCP-Friendly Rate Control) over a wide range of MANET scenario, in terms of throughput fairness and smoothness. Their results have shown that TFRC and GAIMD are able to maintain throughput smoothness in MANET, but at the same time, they require only a less throughput than the competing TCP flows. Also their results show that TFRC changes its sending rate more smoothly than GAIMD does, but it gets the least throughput compares with TCP and GAIMD.

Yung Yi et al [9] have developed a fair hop-by-hop congestion control algorithm with the MAC constraint 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 their algorithm is globally stable using a Lyapunov-function-based approach. Next, in the presence of delay, they have shown that the hop-by-hop control algorithm has the property of spatial spreading. Also they have derived bounds on the “peak load” at a node, both with hop-by-hop control, as well as with end-to-end control, show that significant gains are to be had with the hop-by-hop scheme, and validate the analytical results with simulation.

Umut Akyol et al [10] have studied the problem of jointly performing scheduling and congestion control in mobile adhoc networks so that network queues remain bounded and the resulting flow rates satisfy an associated network utility maximization problem. They have defined a specific network utility maximization problem which is appropriate for mobile adhoc networks. They have described a wireless Greedy Primal Dual (wGPD) algorithm for combined congestion control and scheduling that aims to solve this problem. They have shown how the wGPD algorithm and its associated signaling can be implemented in practice with minimal disruption to existing wireless protocols.

S.Karunakaran et al [11] have presented a Cluster Based Congestion Control (CBCC) protocol that consists of scalable and distributed cluster-based mechanisms for supporting congestion control in mobile ad hoc networks. The distinctive feature of their approach is that it is based on the self-organization of the network into clusters. The clusters autonomously and proactively monitor congestion within its localized scope.

S.Venkatasubramanian et al [19] proposed the QoS architecture for Bandwidth Management and Rate Control in MANETs. The bandwidth information in the architecture can be used for QoS capable routing protocols to provide support to admission control. The traffic is balanced and the network capacity is improved as the weight value assists the routing protocol to evade routing traffic through congested area. The source nodes then perform call admission control for different priority of flows based on the bandwidth information provided by the QoS routing. In addition to this, a rate control mechanism is used to regulate best-effort traffic, whenever network congestion is detected. In this mechanism, the packet generation rate of the low-priority traffic is adjusted to incorporate the high-priority traffic.

R.Mynuddin Sulthani et al [20] proposed a joint design of reliable QoS architecture for mobile adhoc networks. In the reliable multipath routing protocol, dispersion and erasure code techniques are utilized for producing replicated fragments for each packet, to enhance reliability. Then messages with good delivery probability are identified and transmitted through the paths with high average node delivery index. While it receives an assured number of fragments, destination can recover the original packet. Next, a call admission control (CAC) scheme has been developed, in which, the calls are admitted based on the bandwidth availability of the path. Once congestion occurs, the best effort traffic is rate controlled, to free bandwidth for the real-time flows.

Lijun Chen et al [21] proposed the joint design of congestion control, routing and scheduling for ad hoc wireless networks. They formulate resource allocation in the network with fixed wireless channels or single-rate wireless devices as a utility maximization problem with schedulability and rate constraints arising from contention for the wireless channel. We also extend the dual algorithm to handle the network with time-varying channel and adaptive multi-rate devices, and surprisingly show that, despite stochastic channel variation, it solves an ideal reference system problem which has the best feasible rate region at link layer. In future, they will extend the results to networks with more general interference models and/or node mobility and further will enhance the performance gain from cross-layer design involving link layer.

Xuyang Wang et al [22] proposed a cross layer hop by hop congestion control scheme to improve TCP performance in multihop wireless networks which coordinates the congestion response across the transport, network, and transport layer protocols. The proposed scheme attempts to determine the actual cause of a packet loss and then coordinates the appropriate congestion control response among the MAC network, and transport protocols. The congestion control efforts are invoke at all intermediate and source node along the upstream paths directed from the wireless link experiencing the congestion induced packet drop.

Kazuya Nishimura et al [23] proposed a routing protocol that reduces network congestion for MANET using multi-agents. They use two kinds of agents: Routing Agents to collect information about congestion and to update the routing table at each node, and Message Agents to move using this information. In the future, they will investigate a better evaluation function and discuss the

limits of its effectiveness. The evaluation function itself may change depending on the environment. Incorporating learning into the function is also an interesting issue.

Bhadauria, Sharma [24] proposed the information about network congestion is collected and distributed by mobile agents (MA). The MA measures the queue length of the various traffic classes and the channel contention and estimates the total congestion metric to find the minimum congestion level in the network. The congestion metric is applied in the routing protocol to select the minimum congested route.

P.K. Suri et al [29] proposed a bandwidth-efficient power aware routing protocol "QEPAR". The routing protocol is presented to minimize the bandwidth consumption as well as delay. QEPAR will help in increasing the throughput by decreasing the packet loss due to non availability of node having enough battery power to retransmit the data packet to next node. The proposed protocol is also helpful in finding out an optimal path without any loop.

Vinay Rishiwal et al [30] proposed QoS based power aware routing protocol (Q-PAR). The selected route is energy stable and satisfies the bandwidth constraint of the application. The protocol Q-PAR is divided in to two phases. In the first route discovery phase, the bandwidth and energy constraints are built in into the DSR route discovery mechanism. In the event of an impending link failure, the second phase, a repair mechanism is invoked to search for an energy stable alternate path locally. Moreover the local repair mechanism was able to find an alternate path in most of the cases enhanced the network lifetime and delayed the repair and reconstruction of the route.

3. Agent Based Congestion Control

3.1 EDCA Mechanism of 802.11e

The Hybrid Coordination Function (HCF) which has been sketched by 802.11e labels two new MAC methods. The PCF and DCF modes have been replaced with HCF controlled channel access (HCCA), and enhanced distributed channel access (EDCA) which provides distributed access supplying service differentiation [13].

An extended version of the legacy DCF mechanism is EDCA. Access Categories (AC) or traffic priority classes like voice, video, best effort and background are defined by EDCA [14]. The access categories prioritize themselves from AC3 to AC0. In general, best effort and background traffic are maintained by AC1 and AC0 and real-time applications like voice or video transmission are maintained by AC2 and AC3 [15]. For the purpose of service differentiation, many MAC constraints vary with priority level chosen for each AC.

For the implementation of the EDCA contention algorithm the four transmission queues are applied with each AC being communicated with the others. The minimum idle delay before contention (AIFS), the Contention Windows (CW_{min} and CW_{max}), and the Transmission opportunity limit (TXOP) are the various parameters described here. The default values of each parameter are listed in Table 1.

Table 1. IEEE 802.11e EDCA MAC System Parameters

Access Category	AIFSN	CWmin	CWmax	Queue length	Max. retry limit
AC3	2	7	15	25	8
AC2	2	15	31	25	8
AC1	3	31	1023	25	4
AC0	7	31	1023	25	4

In the MAC layer, voice traffic is conveyed through AC3 and the video traffic is conveyed through AC2 in accordance with 802.11e EDCA standard. The AC class differentiation in EDCA is very much useful in providing services to the traffic. Superior servicing is done for high-priority traffic and not much importance is given for low-priority traffic. The contention parameters of EDCA are not able to adapt to the network conditions, in spite of the delay sensitivity of real-time traffic taken into account. This leads to limitations in the QoS improvement [16].

ACs pause for diverse values of Arbitration Interframe Space (AIFS) and AIFSi is computed by,

$$AIFSi = SIFS + AIFSNi \times SlotTime$$

where $AIFSi$ is a positive integer which is greater than one, $AIFSNi$ is the AC-specific AIFS number; SIFS and Slot Time are dependent on physical layer [14]. If the values of the subsequent parameters are small, the channel access delay will become less for the AC which leads the higher priority to approach the medium.

When a particular QoS station (QSTA) has the concession to begin transmissions, then the TXOP is expressed as the time interval in IEEE 802.11e. The initiation of the TXOP and the multiple frame transmission within an EDCA TXOP are the nodes approved by TXOP. The former occurs only when the EDCA rules allow entry to the medium. And the later occurs when an EDCA Function (EDCAF) holds the concession to contact the medium after completing a frame exchange sequence. The period of TXOP values are herewith in the EDCA parameter engraved in beacon frames. A STA is allowed to transmit multiple MAC protocol data units (MPDUs) from the same AC with a SIFS time interval between an ACK and the succeeding frame transmission. A single MPDU may be forwarded for each TXOP if the TXOP limits the value of 0 [17].

3.2 Mobile Agent (MA)

A Mobile Agent (MA) starts from every node and moves to an adjacent node at every time. A node visited next is selected at the equivalent probability. The MA brings its own history of movement and updates the routing table of the node it is visiting.

Each MA has its own history which consists of its source node S , the current time T_c , the number of hops NH from the starting node, the adjacent node AN that the MA has last visited and the number of multiple packets NP on AN at T_c . When an MA visits a node, it puts the information (S, T_c, NH, AN, NP) in the routing table of that node.

Each node has a routing table that stores k fresh routing information records from itself to every node $S : [S, \{(Tc_1, NH_1, AN_1, NP_1) \cdots (Tc_m, NH_m, AN_m, NP_m)\}]$, where $Tc_1 > Tc_2 > \cdots > Tc_m$. We call m the number of entries. For each $i (1 \leq i \leq m)$, Tc_i is a time of visiting the adjacent node AN_i , NH_i is the number of hops and NP_i is the number of MAs on AN_i . When MA with the history (S, Tc, NH, AN, NP) visits a node N , the routing information on that node $[S, \{(Tc_1, NH_1, AN_1, NP_1) \cdots (Tc_m, NH_m, AN_m, NP_m)\}]$ is updated to

$$[S; \{(Tc, NH; AN, NP), (Tc_1, NH_1, AN_1, NP_1), \dots (Tc_{m-1}, NH_{m-1}, AN_{m-1}, NP_{m-1})\}]$$

3.3 Queue Length Estimation

The traffic rate within the network has to be determined to find the level of congestion. The traffic rate is significantly affected by

- the number of new incoming flows
- the number of existing flows
- the density of the nodes in the network
- Communication abilities of nodes

Our goal is to acquire macroscopic network statistics using a heuristic approach. We compute the traffic rate as follows: Let the value L_o represent the offered load at the queue of node i and it is defined as

$$L_{oi} = \frac{AR_i}{SR_i} \quad (1)$$

where AR_i is the aggregate arrival rate of the packets produced and forwarded at node i while SR_i is the service rate at node i , i.e., $SR_i = 1/T$ where T is the computed exponentially weighted moving average of the packets' waiting time at the head of the service queue. The distribution of the queue length $PR(Q_1)$ (essentially this is the probability that there are Q_1 packets in the queue) at the node is computed as

$$PR(Q_1) = (1 - L_{oi}) L_{oi}^{Q_1} \quad (2)$$

For N distinct queues, the joint distribution is the product

$$PR(Q_{11}, Q_{12} \cdots Q_{1N}) = \prod_{i=1}^N (1 - L_{oi}) L_{oi}^{Q_{1i}} \quad (3)$$

3.4 Channel Contention Estimation

In this network, we consider IEEE 802.11 MAC with the distributed coordination function (DCF). It has the packet sequence as request-to-send (RTS), clear-to-send (CTS), data and acknowledgement (ACK). The amount of time between the receipt of one packet and the transmission of the next is called a short inter frame space (SIFS). Then the channel occupation due to MAC contention will be

$$C_{OCC} = t_{RTS} + t_{CTS} + 3t_{SIFS} + t_{acc} \quad (4)$$

Where t_{RTS} and t_{CTS} are the time consumed on *RTS* and *CTS*, respectively and t_{SIFS} is the *SIFS* period. t_{acc} is the time taken due to access contention.

The channel occupation is mainly dependent upon the medium access contention, and the number of packet collisions. That is, C_{occ} is strongly related to the congestion around a given node.

C_{occ} can become relatively large if congestion is incurred and not controlled, and it can dramatically decrease the capacity of a congested link.

3.5 Total Congestion Metric

The Total Congestion Metric (TCM) can be estimated from the obtained queue length and the channel contention.

$$TCM = PR(Q_1) + C_{occ} \quad (5)$$

3.6 Agent Based Congestion Control Routing

The agent based congestion routing can be explained from the following figure:

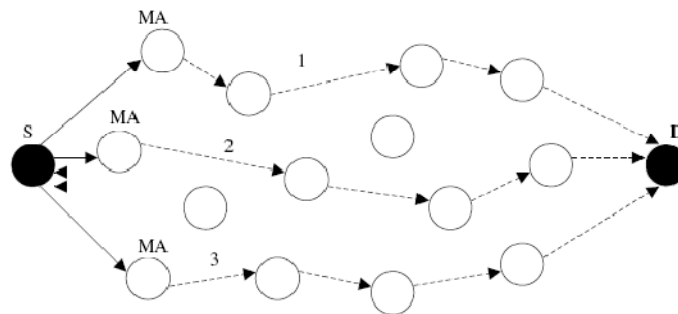


Fig. 1. Agent Based Congestion Routing

Step 1: The source S checks the number of available one hop neighbors and clones the Mobile Agent (MA) to that neighbors.

Step 2: The Mobile Agent selects the shortest path of the route to move towards the destination D as given in the Fig 1 such as P1, P2 and P3.

Step 3: The MA1 moves towards the destination D in a hop-by-hop manner in the path P1 and MA2 in P2 and MA3 in P3 respectively.

Step 4: Then the MA1 calculates the TCM1 of that path P1 and similarly MA2 calculates the TCM2 of P2 and MA3 calculates the TCM3 of P3.

Step 5: Now the destination D sends the total congestion metrics TCM1, TCM2 and TCM3 of the paths P1, P2 and P3 respectively to the source.

Step 6: Now the source selects path using min (TCM1, TCM2, and TCM3) and sends the data through the corresponding path which has the minimum congestion.

4. Simulation Results

4.1 Simulation Model and Parameters

We use NS2 [18] to simulate our proposed technique. In the simulation, the channel capacity of mobile hosts is set to the same value: 11Mbps. In the simulation, mobile nodes move in a 1000 meter x 1000 meter region for 50 seconds simulation time. Initial locations and movements of the nodes are obtained using the random waypoint (RWP) model of NS2. It is assumed that each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. The node speed is 5 m/s. and pause time is 5 seconds. In the simulation, for class1 traffic video is used and for class2 and Class3, CBR and FTP are used respectively.

The simulation settings and parameters are summarized in table 2.

Table 2. Simulation Settings

No. of Nodes	50
Area Size	1000 X 1000
Mac	802.11e
Radio Range	250m
Simulation Time	50 sec
Routing Protocol	AODV
Traffic Source	CBR and Video
Video Trace	JurassikH263-256k
Packet Size	512
Mobility Model	Random Way Point
Speed	5m/s
Pause time	5 sec
MSDU	2132
Rate	250kb, 500kb,.....1000Kb
No. of Flows	2,4,6,8 and 10

4.2 Performance Metrics

We compare the performance our Agent Based Congestion Control (ABCC) technique with the Hop by Hop algorithm [9]. The performance is evaluated mainly, according to the following metrics.

Packet Delivery Fraction: It is the ratio of the number of packets received successfully and the total number of packets sent.

Throughput: It is the number of packets received successfully.

Average end-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

4.3 Results

A. Effect of Varying Rates

In the initial experiment, we measure the performance of the proposed technique by varying the rate as 250, 500, 750 and 1000Kb.

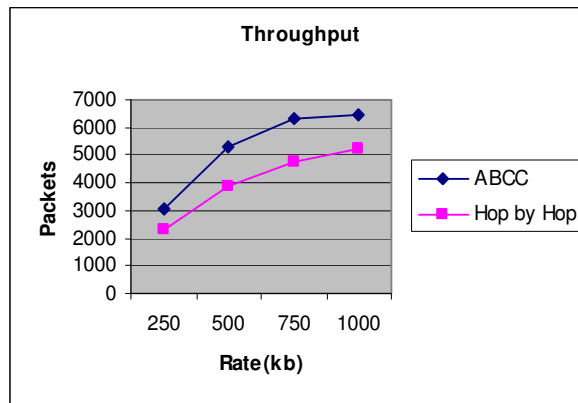


Fig. 2. Rate Vs Throughput

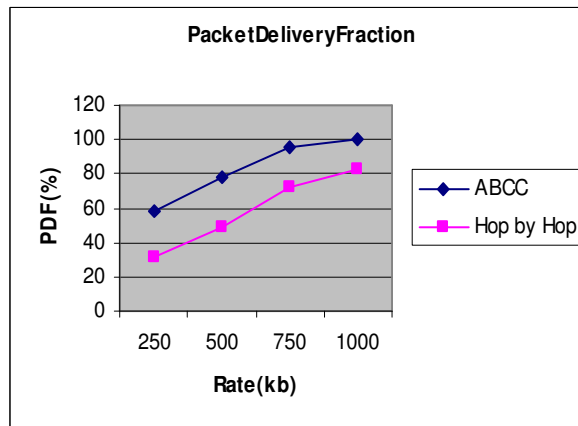


Fig. 3. Rate Vs Packet Delivery Fraction

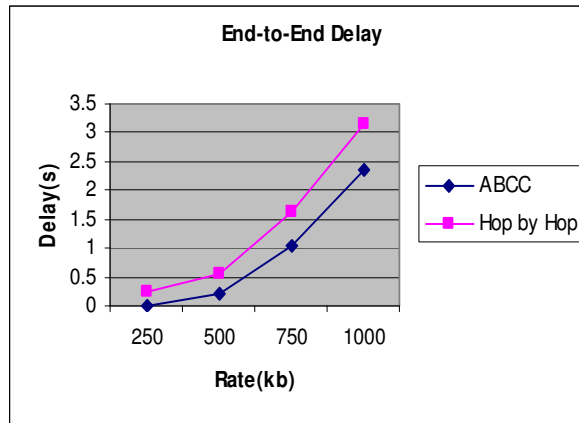


Fig. 4. Rate Vs End-to-End Delay

Fig 2 gives the throughput of the proposed technique when the rate is increased. As we can see from the figure, the throughput is more in the case of ABCC when compared to the Hop by Hop algorithm.

From Fig 3, we can see that the packet delivery fraction for ABCC is more, when compared to the Hop by Hop algorithm.

From Fig 4, we can see that the average end-to-end delay of the proposed ABCC technique is less when compared to the Hop by Hop algorithm.

B. Effect of varying Flows

In the next experiment, we compare our proposed technique by varying the number of flows as 2, 4, 6, 8 and 10.

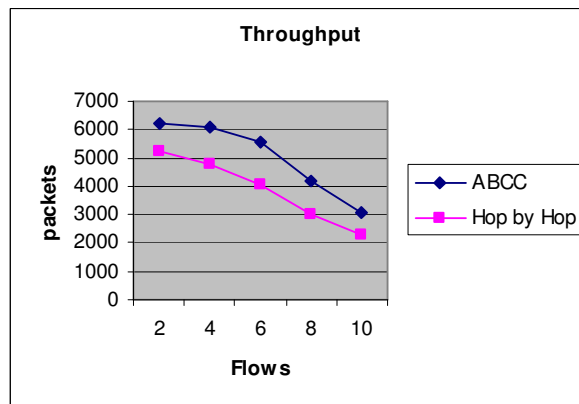


Fig. 5. Flows Vs Throughput

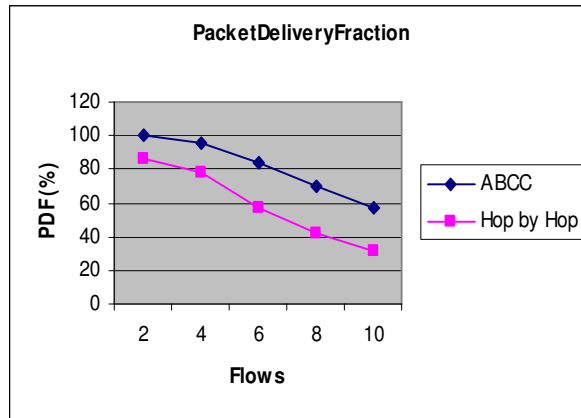


Fig. 6. Flows Vs Packet Delivery Fraction

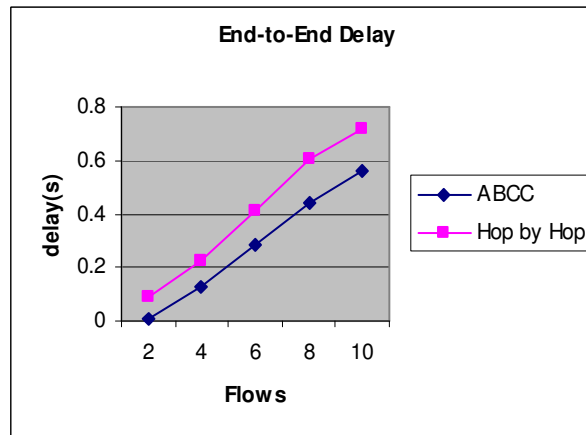


Fig. 7. Flows Vs End-to-End Delay

Fig 5 gives the throughput of the proposed technique when the flow is increased. As we can see from the figure, the throughput is more in the case of ABCC when compared to the Hop by Hop algorithm.

From Fig 6, we can see that the packet delivery fraction for ABCC is more, when compared to the Hop by Hop algorithm.

From Fig 7, we can see that the average end-to-end delay of the proposed ABCC technique is less when compared to the Hop by Hop algorithm.

5. Conclusion

In this paper, we have developed an agent based congestion control technique. In our technique, the information about network congestion is collected and distributed by mobile agents (MA). A mobile agent starts from every node and moves to an adjacent node at every time. A node visited next is selected at the equivalent probability. The MA brings its own history of movement and

updates the routing table of the node it is visiting. The MA updates the routing table of the node it is visiting. In this technique, the node is classified in one of the four categories depending on whether the traffic belongs to background, best effort, video or voice AC respectively. Then MA estimates the queue length of the various traffic classes and the channel contention of each path. Then this total congestion metric is applied to the routing protocol to select the minimum congested route in the network. , a mobile agent based congestion control AODV routing protocol reduces the end-to-end delay and the number of route discovery requests, balances the traffic load. By simulation results, we have shown that our proposed technique attains high delivery ratio and throughput with reduced delay when compared with the existing technique.

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