Design & Analysis of BWCM Model for Wireless Ad hoc Networks

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Abstract- Quality of Service (QoS) support in Mobile Ad-hoc NETworks (MANETs) is a challenging task. The major challenge in ad hoc networks lies in adapting multicast communication to environments, where mobility is unlimited and failures are frequent. Such problems increase the delays and decrease the throughput. To meet these challenges, to provide QoS, and hence to improve the performance, Bandwidth Control Management BWCM model can be used.

In this paper, to provide the BWCM model that decrease MAC delay for real and non-real time application in wireless ad hoc network. In order to enhance the control of congestion, a BWCM model has been proposed for bandwidth management in mobile ad hoc networks that has a significant influence on the performance on network in term of delay. The proposed model achieves a reduction in terms of average delay by about 60-70% in comparison to the original model at a cost of about 15% decrease in throughput. The average delay obtained is quite stable and low under different channel conditions, mobility scenarios, and traffic scalability. The performance of this model is studied using NS2 simulator under different load and speed condition and DSDV as a routing protocol has been used. The proposed model to be an efficient tool for reducing the delay of real and non-real time application in MANET.

Index Terms—NS2, DSDV, BWCM, MANET

1. INTRODUCTION

A collection of nodes that communicate with each other by forming a multihop radio network and maintaining connectivity in a decentralized manner is called an ad hoc network. There is no static infrastructure for the network, such as a server or a base station. These types of networks have many advantages, such as self-reconfiguration and adaptability to highly variable mobile characteristics like the transmission conditions, propagation channel distribution characteristics and power level. They are useful in many situations such as military applications, conferences, lectures, emergency search, rescue operations and law enforcement. The idea of such networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality into mobile nodes. Quality of Service (QoS) support in Mobile Ad-hoc Networks (MANETs) is a challenging task. This model supports both real time UDP traffic and best-effort UDP and TCP traffic. In the BWCM model as shown in Fig.1, the mobility of nodes and the error prone nature of the wireless medium pose many challenges like frequent route changes and packet losses. Such problem increases packet delay and decrease throughput. Also the absence of a base station and forwarding of packets across multiple broadcast regions makes it difficult to satisfy a flow's end to end QoS target. The model includes a set of mechanisms: regulation schemes in order to assure the control of real-time traffic, and an BWCM control mechanism to support real-time and non-real time traffic. This paper is organized as follows: in Section 2, describe related work and routing protocol. In Section 3, the description of the proposed model under different network conditions and traffic loads. Section 4, indicate the performance evaluation of proposed model. Finally we draw our conclusions in Section 5.

2. Routing Protocol & Related Work

Destination Sequenced Distance Vector (DSDV) [1] is a Proactive routing protocol that solves the major problem associated with the Distance Vector routing of wired. The DSDV protocol requires each mobile station to advertise, to each of its current neighbours, its own routing table (for instance, by broadcasting its entries). The entries in this list may change fairly dynamically over time, so the advertisement must be made often enough to ensure that every mobile computer can almost always locate every other mobile computer. In addition, each mobile computer agrees to relay data packets to other computers upon request. At all instants, the DSDV protocol guarantees loop-free paths to each destination. Kumar et al. [2] improves the quality of QoS parameter for MANET. C. Gomathy et al. [3] has been design a fuzzy based priority scheduler to determine the priority of the packets. Improve the end-to-end QoS target in MANET. L. Khoukhi et. Al [4], have proposed a flexible QoS routing protocol (AQOPC) based on multi-service classes and multi-path schemes. It provides information about the state of bandwidth, end-to-end delay and hop count in the network. AQOPC performs an accurate

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admission control and a good use of network resources by calculating multiple paths and generating the needed service classes to support different QoS user requirements. In [5], a core-extraction distributed ad hoc routing (CEDAR) algorithm is proposed that uses core extraction, link state propagation, and route computation to support QOS in wireless ad hoc networks. In [6], the authors have addressed the problem of supporting real-time communications in a multihop mobile network using QoS routing that permits bandwidth calculation and slot reservation. This protocol can be applied to two main scenarios: multimedia ad hoc wireless networks and multihop extensions of wireless ATM networks. The ad hoc QoS on-demand routing (AQOR) is discussed in [7], which integrates signaling functions for resource reservation and QoS maintenance at per-flow granularity. A link-state QoS routing protocol for ad hoc networks (QOLSR) was proposed in [8] with the aim of implementing QoS functionality while dealing with limited available resources in a dynamic environment.

3. BWCM Model for Control Management

A. BWCM Model

The schematic BWCM model is presented in Fig.1 that includes a set of functionalities and mechanisms. In the model, includes a temporary resource reservation process, co-ordination, and control management is name as BWCM controller. The controller is to determine whether the available resources in a network can meet the requirements of a new flow while maintaining bandwidth levels for existing flows, co-ordination among the packets. Accordingly, the decision is performed on the acceptance or rejection of a flow. This function is conducted together by the source node and other intermediate nodes mechanisms. In the controller, the source node has a final decision to accept or reject the user QoS requirements based on the feedback information about the state of the network. This feedback measure is the packet delay measured by the MAC layer, which is calculated by the difference between the time of receiving an acknowledge packet (from the next-hop) and the time of sending a packet to the MAC layer (from the upper layer). The minimum bandwidth requirement for real and non-real time applications as shown in table 1. This allows the controller to measure the local available bandwidth at each node in the network. The measured available bandwidth is then used by the controller to decide if the flow can be admitted for a particular service. The real-time traffic measured by the BWCM controller is in terms of bits per second. The estimation of the end-to-end available bandwidth is performed by sending a request from source node toward the destination. For that purpose, an UDP control packet is exploited by using an additional field "BW" that contains initially the value of the requested bandwidth “BW_{req}”. At each intermediate node, a comparison is performed between the value of BW and the available bandwidth “BW_{avai}” of the current node. The value of the field BW is updated if it is bigger than the value BW_{avai} of the current node. When the destination receives the UDP control packet, BW represents the minimum bandwidth available along the path, and it is copied from UDP to a newly generated short replay message (SRM). The latter packet is transmitted back to the source node and at the same time the temporary resource reservation process (TRP) is performed. Additional fields are used during TRP mechanism, which are stored in each intermediary node in order to specify the "temporary reservation status" of the node, the "status duration" and the "flow identifier". The first field is set to value of the reserved bandwidth and the status duration is set to a certain value "T". T indicates the period of time within which the temporary reservation is performed. Note that even when the temporary reservation is performed by a flow, other flows can also exploit the available resources of the node. The reserved bandwidth is released just after the expiration of T duration. The evaluation of the right status duration to be set at a particular node is explained in the following. The computation of the right status duration needs to take into account the number of hops between the source and the particular node, and also the delays between the intermediate nodes. Let consider Δt the temporary reservation interval of a flow in a given intermediate node. During Δt, other flows originating from other source nodes can also use the available resources. Let λ, be the target delivery rate which defines the desired percentage of packets to be sent within the QoS constraint, where $\lambda = 1$ corresponds to best QoS guaranty and $\lambda = 0$ corresponds to the best-effort transmission. Then, (1) verifies the probability that Δt is lower than a given time value δ and the flow request to be accepted.

$$P[\Delta t \le \delta] \ge \lambda --- (1)$$

A good evaluation of (1) requires the destination to be acquainted with the statistical descriptions of delay of each node along the path. However, in many cases, the statistical distribution of such parameter can be approximated by a Gaussian distribution. Under this hypothesis, and assuming independency among nodes statistics, the temporary reservation time among the nodes turns out to be a Gaussian variable. If we consider x_{Tr} and σ^2_{Tr} the statistical average and variance of the random variable T_r, respectively (T_r is the temporary reservation time in a given node), then the temporary reservation interval statistics can be expressed as in (2)

$$P[\Delta t \le \delta] = 1 - Q\left(\frac{\delta - m_{T_x}}{\sigma_{T_x}}\right) --- (2)$$

Q represents the complementary distribution function of a Gaussian variable with mean 0 and variance 1. Let υ be the actual time satisfaction provided by the intermediate node as given by (2). Hence, the flow request would be satisfied even if the average temporary reservation time was increased to the value m_{Tr} given by (3)

$$m_{T_x} = \upsilon - \sigma_{T_r} Q^{-1}[1 - \lambda] --- (3)$$

The satisfaction of the requested target delivery rate for a given flow is met if the temporary reservation time is greater than m_{Tr} (m_{Tr}, is the time bound of the temporary reservation interval). After the expiration of $m_{Tr,}$ the temporary reservation status of a node is set to zero. Thus, the released resources could be used by other flows, this permits a good utilization of available resources in the network.

Table 1. QoS classes and application

QoS class	Bandwidth Requirement	Application Type
1	256 Kbps	Non-real-time flow with normal service
2	512 Kbps	Non-real-time flow with preference service
3	2 Mbps	Real-time flow with normal service
4	4 Mbps	Real-time flow with preference service

B. Analysis of MAC Delay

Assume there are two classes of mobile devices in the shared channel environment. Class 1 and Class 2 represent real-time UDP traffic and best effort TCP traffic, respectively. Each of the n_1 *Class* 1 mobile devices has an active UDP session, and each of the n_2 Class 2 mobile devices has an active TCP session. We define an idle mobile device as a mobile device whose MAC layer is idle and interface queue empty. If a mobile device is not idle then it is busy. Denote the portion of time that a class i mobile device is busy as $P_{on,i.}$ From [10] a busy class *i* mobile device's transmission probability in each time slot is represented as,

$$\tau_1 = \frac{2.(1-2p_i)}{(1-2p_i)(W+1) + p_i W\left(1-(2p_i)^m\right)} --- (1)$$

Where p_i is the collision probability for a class i mobile device at each time slot. W is the initial back-off window, and $W2^m$ is the maximum back-off window in the IEEE 802.11 protocol. By following the procedure in [10], the collision probability can be represented as,

$$p_1 = 1-\left(1-p_{on,1}\tau_1\right)^{n_1-1}\left(1-p_{on,2}\tau_2\right)^{n_2}$$

$$p_2 = 1-\left(1-p_{on,2}\tau_1\right)^{n_1}\left(1-p_{on,2}\tau_2\right)^{n_2-1} --- (2)$$

The probability that one or more packets are sent to the channel at each slot is then,

$$p_{tr} = 1-\left(1-p_{on,1}\tau_1\right)^{n_1}\left(1-p_{on,2}\tau_2\right)^{n_2} --- (3)$$

and the probability of a successful transmission each slot is,

$$P_s = n_1 p_{on,1}\tau_1\left(1-p_{on,1}\tau_1\right)^{n_1-1}\left(1-p_{on,2}\tau_2\right)^{n_2} +$$

$$\frac{n_2 p_{on,2}\tau_1\left(1-p_{on,1}\tau_1\right)^{n_1}\left(1-p_{on,2}\tau_2\right)^{n_2-1}}{P_{tr}} --- (4)$$

The total throughput of the system (in packets/sec) can be represented as,

$$S = \frac{P_s P_{tr}}{(1-P_{tr})\sigma + P_{tr}\left(P_s T_s + (1-P_s)T_c\right)} --- (5)$$

Where σ is the length of a time slot, which is 20μs in all our simulations. Ts and Tc are the times needed to send un-collided and collided packets, respectively, on the channel. Ts and Tc are calculated from the packet length distribution, taking into account the overhead of the MAC and physical layers. The length of collided packets is approximated as the maximum length of two collided packets. The overall average MAC delay can be simply calculated using little's formula as,

$$d = \frac{P_{on,1}n_1 + P_{on,2}n_2}{S} --- (6)$$

In this simulation, video sessions are modeled as CBR sources and the FTP sessions have an infinitely long file sizes that lasts for the whole simulation period. It is observed that uncontrolled system as the original system, and the system with the proposed feedback control as the proposed system. Because it is difficult to use a simple model to characterize the flow control of TCP/IP, coupled with a queuing system on top of the MAC layer, and the MAC layer and traffic shaper (for the proposed model), we evaluate the quantity $P_{on,1}$ and $P_{on,2}$ during the simulation as an approximation of this complex system. With $P_{on,1}$,$P_{on,2}$, n_1,n_2 known, we jointly solve (1), (2) for p_1,p_2,τ_1, τ_2 then from (3), (4), (5), (6), the overall average delay is computed.

4. PERFORMANCE EVALUATION

The performance evaluation of the proposed model is studied with the NS2 simulator. The performance of BWCM model with the 'original model' [9] has been compared. The word 'original model' to refer to IEEE 802.11 wireless network. Each mobile host has a transmission range of 100meters and shares a 5.5Mbps radio channel with its neighboring nodes. In order to better understand the properties of the BWCM model, the simulation considers a multiple scenarios of real and non real time and TCP best-effort traffic. The video and voice flows representing real-time traffic and data flow representing the non-real time traffic. Video traffic is modeled as 200Kbps constant rate traffic with a packet size of 512bytes. Voice traffic is modeled as 32Kbps constant rate traffic with a packet size of 80bytes and data traffic is modeled as 16Kbps constant rate traffic with a packet size of 1024bytes. The simulation considers a multihop network of 40 mobile nodes. The DSDV protocol is chosen as the routing protocol referred to in Figure 1.

A. Simulation Environment and Methodology

Our simulation modeled a network of mobile nodes placed randomly within 100x100meter area. Each simulation is run for 1200 seconds of simulation time. Multiple simulations run with different seed values are conducted for each scenario and collected data is averaged over those simulated results. A free space propagation model is used in our simulation. Data sessions with randomly selected sources and destinations were simulated. Each source transmits data packets at a minimum rate of 5packets/sec. and maximum rate of 80packets/sec. The traffic load is varied, by changing the number of data and the effect is evaluated with DSDV routing protocols. The following metrics are used in computing the performance:

- Average end-to-end delay
- Throughput

Figs. 2 and 3 show the impact of the increasing number of TCP flows on the average end-to-end delay and throughput of traffic. Fig. 3 shows a significant difference in terms of the average delay between the proposed model and the original model. The average delay in BWCM model grows slowly with the increasing number of TCP flows, and it remains almost less than 5msec. In contrast, the average delay in the original model grows from 5 to 23msec as the number of TCP flows increases from 15 to 80 flows. Hence, the gain achieved by the proposed model, in terms of the average delay, is by about 70-80%. The average throughput of the TCP traffic in the proposed model is about 20% less than the original model. The previous results confirm that by adopting the BWCM mechanisms, it is observed from the simulation results that can achieve a reduction in the average delay by about 60-70% in comparison to the original model at a cost of about 12-15 % decrease in throughput. When the pause timer expires, the mobile node picks another random destination and moves at another random speed. Fig 4 shows that the average end-to-end delay in the proposed model increases slowly and it grows only for the highest mobility scenarios. Whereas the average delays in the original model grows from 5 to 29 msec. This means that the proposed model achieves a reduction in terms of average delay by about 60-70%. On the other hand, it is observed in Fig 5 that the throughput of TCP best-effort traffic decreases slowly in both original and BWCM model as the mobility increases. This decrease in terms of throughput by about 12-15% when the mobility becomes high is due essentially to the congestion and the broken links in the route relaying source and destination

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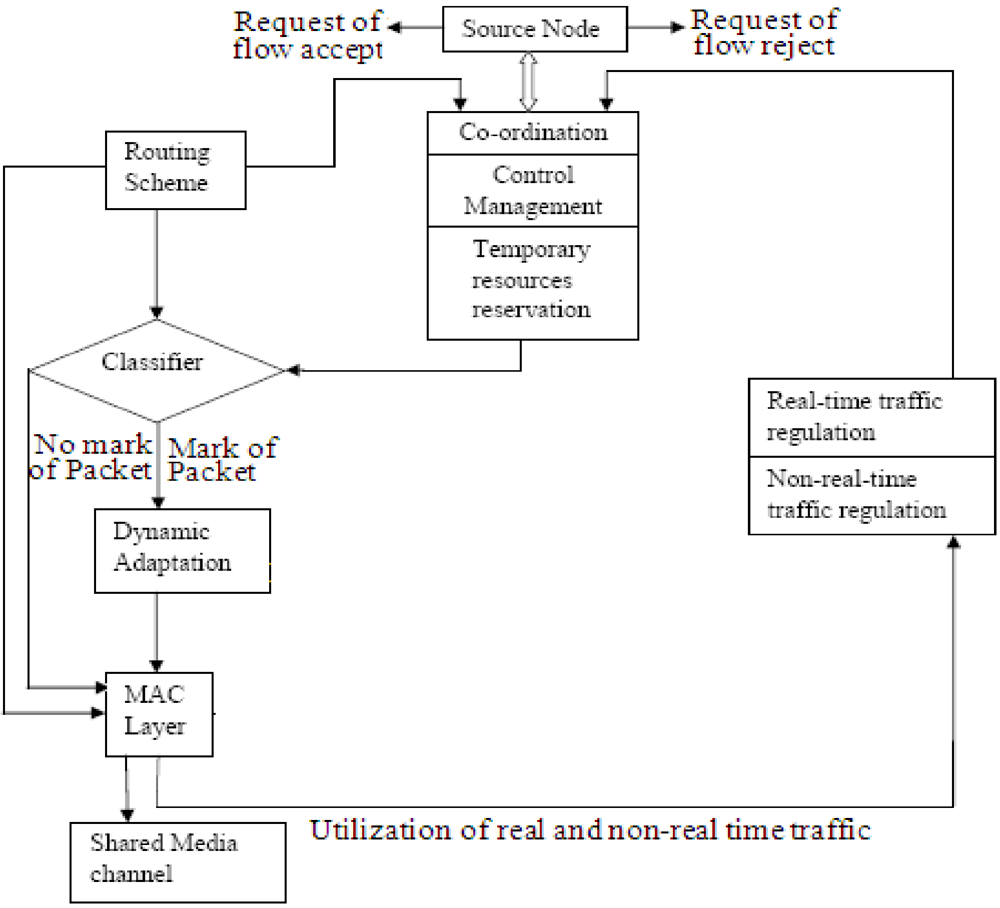

Figure. 1 A proposed BWCM model of Mobile ad hoc network

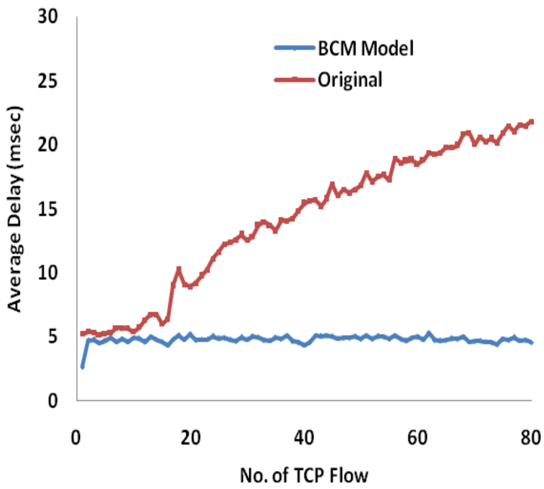

Figure 2: Average delay in the original and BWCM models vs. number of TCP flows

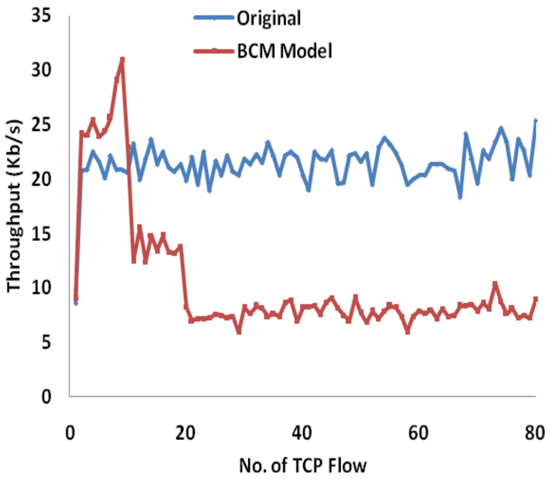

Figure 3: Average throughput in the original and BWCM models vs. number of TCP flows

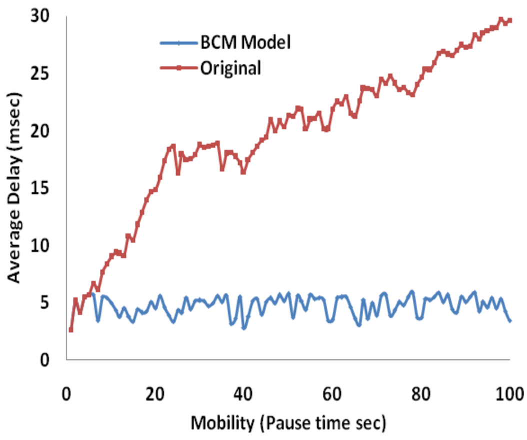

Figure 4: Average delay in the original and BWCM models vs. mobility.

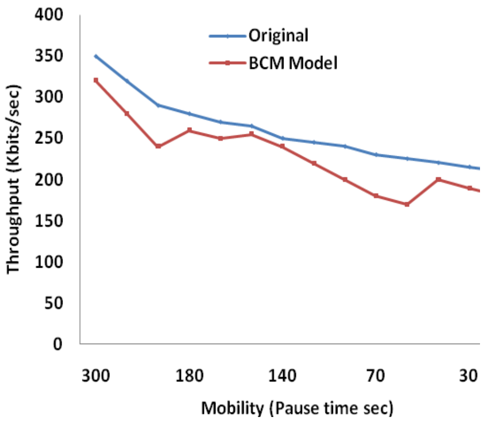

Figure 5: Average throughput in the original and BWCM models vs. mobility.

5. CONCLUSION

In this paper, a BWCM model approach for QoS support in wireless ad hoc networks. The proposed model aims to perform the service differentiation delivery with a minimum end-to-end delay and it's include a mechanism of admission control for real and non-real time traffic control, and best-effort traffic. We investigated the performances of BWCM model and IEEE 802.11 models with the simulation of a large set of scenarios. The simulation results show the benefits of using the proposed model. The average delay obtained is quite stable and low under different channel conditions, mobility scenarios, and traffic scalability. The proposed model achieves a reduction in terms of average delay by about 60-70% in comparison to the original model at a cost of about 15 percent decrease in throughput. The proposed model to be an efficient tool for reducing the delay of real and non-real time application in MANET.

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