Improving Ad Hoc Network Performances by Estimating Available Bandwidth

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Abstract: The term bandwidth refers to the data rate that a network link or a network path can transfer. Bandwidth is one of the guarantee attribute to measure the performance of the network. Measuring available bandwidth in ad hoc networks is a challenging issue in Mobile Ad hoc Network (MANET). In this paper, the new technique is proposed to evaluate the accurate available bandwidth in ad hoc networks. This technique considers reducing backoff time, node's and link's capability. By these network flows, the amount of bandwidth is wasted. Estimating accurate available bandwidth allows a node to make an optimal decision before sending a packet in networks.

Keywords –Available Bandwidth, backoff, MANET

I. INTRODUCTION

MANET is an autonomous and decentralized system of mobile nodes which are connected by wireless links. They do not need any infrastructure. This kind of networks are very flexible and suitable for several situations and applications, thus they allow the establishing of temporary communication without pre-installed infrastructure. IEEE has defined for wireless technology called IEEE 802.11 standard. This standard provides an ad hoc mode, allowing mobiles to communicate directly. No standardized mechanism has been developed to measure the remaining resources in ad hoc networks [1]. Utilizing resources in systematic way without wastage will increase the network throughput. Bandwidth is one of the main resources in network traffic. So it is ardent fact that estimating accurate available bandwidth improves the network performance and Quality of Service automatically.

The term Quality of Service (QoS) refers to resource reservation control mechanisms rather than the achieved service quality. QoS is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow [2]. For example in video conferencing which needs to send millions of bits per second to refresh a color screen while the total number of bits in an e-mail may not reach even a million. The efficient QoS should provide support for these types of applications. Although resource estimation is challenging task in ad hoc networks, it should be taken into account to improve the QoS of networks. The network is expected to guarantee a set of measurable pre-specified service attributes to the users in terms of end-to-end performance such as delay, bandwidth, probability of packet loss, delay variance, etc. Estimating accurate bandwidth increases overall network performance.

Available bandwidth is estimated in ad hoc networks based on the IEEE 802.11 Media Access Control (MAC) Layer. Bandwidth Estimation is an important action that is needed to provide QoS in MANETs. However, bandwidth estimation is extremely difficult [3]; because each host has imprecise knowledge of the network status and links change dynamically in ad hoc networks. Therefore, an effective bandwidth estimation scheme is highly desirable. The proposed algorithm achieves higher throughput and which allows estimating accurate available bandwidth for successful transmission without more collision.

The section II describes the proposed approach. In section III, the estimation of available bandwidth is presented. In the section IV, experimental settings and its results are discussed. The section V has the conclusion part.

II. PROPOSED APPROACH

Available bandwidth is the amount of bandwidth left over after the cross traffic. It can be determined by finding the time period for which the link is not utilized for transmitting data. In recent years, mainly focused research area is ad hoc network. In ad hoc network, a host's available bandwidth refers to amount of bandwidth available to the node to transmit packets to the network. Whole channel will not be used for packet transmission. The amount of bandwidth needs to further communication such as initiating communication, neighbor's interferences etc which reduces the node's available network. So every node should know the status of network for taking optimum decision. Some of the characteristics have an influence on the available bandwidth from a node to one of its neighbors. These are node's emission capability, link's capability, and collision and backoff time.

The MAC layer uses a Carrier Sense Multiple Access and Collision Avoidance (CSMA/CA) algorithm for shared use of the medium. An important function of DCF is a random Backoff timer [9]. A station must wait for random period of time before attempting to access the medium again. This ensures that multiple stations wanting to send data and don't transmit at the same time. The random delay makes the mobile stations to wait different periods of time and avoid collision, channel idle, transmitting with each other. In IEEE 802.11 standard MAC protocol used Binary Exponential Backoff (BEB) algorithm to reduce collision, when the channel becomes busy, the silence periods become shorter and the Backoff process has a greater impact on the available bandwidth: when the sender detects a silence period long enough on the link to be considered, the medium may not be available long enough to send one whole packet due to this extra Backoff time. A solution to cope with this situation should be to consider a mean value for the Backoff in the estimation methods. So that in our work, instead of BEB algorithm the Fibonacci Backoff (FB) algorithm is used.

III. AVAILABLE BANDWIDTH ESTIMATION

To estimate the accurate available bandwidth, the network flow due to which, the amount of bandwidth wasted should be considered. Thus considering few phenomena which affected the channel, the bandwidth is estimated accurately.

A. Node's emission capability

The carrier sense mechanism prevents two close emitters from transmitting simultaneously, unless they draw the same Backoff counter value. Therefore, an emitter shares the channel bandwidth with all its close neighbors [5]. The channel utilization has to be monitored to evaluate the capacity of a node to emit a given traffic volume. Whenever a node needs to send a frame, it first needs to contend for medium access and it cannot emit its frame unless the medium is free. Therefore, a potential sender needs to evaluate the load of the medium, i.e., the proportion of time the medium is idle to determine the chance it has to successfully gain access to the shared resource. Such evaluation is also performed by the solutions proposed in [7]. For example, a 54-Mbps implementation of IEEE 802.11 cannot deliver throughputs higher than 33.2 Mbps. B_s is the bandwidth available to node s, i.e., the maximum throughput it can emit without degrading close flow's rate. C_{max} is the capacity of the medium. Therefore (1) is factual.

$$B_s \leq \frac{T_{idle}(S)}{\Delta}.C_{\max} \qquad (1)$$

During an arbitrary observation interval Δ, each node may monitor the radio medium in its surroundings and measure the total amount of time T_{idle} that is idle for emitting frames. To adapt the evaluation to the MAC protocol's behavior, periods of time shorter than IEEE 802.11's DIFS timing shall not be added to the total idle time count, as such intervals do not allow any backoff decrease or medium access.

B. Link's Emission capability

A radio link composed of two neighbor nodes s and r. For a transmission to take place, the receiver needs that no interference occurs during the whole transmission. Therefore, the value of the available bandwidth on a link depends on both peer channel utilization ratios and also on the idle period synchronization [6]. This synchronization needs to be evaluated. To start the communication, the medium has to be free during at least Distributed Inter Frame Space (DIFS) time on the emitter's side in order that this emitter gains access to the medium. Once the emission has started, the status of the medium at the emitter's side is irrelevant. On the receiver's side, the medium has to be free during the time required to transmit the whole data frame. A uniform random distribution of the medium occupancy over the observation period is considered. It is then possible to compute the expected delay $E(l_{(s,r)})$ before nodes s and r sense the medium idle simultaneously. $b_{(s,r)}$ is the estimated available bandwidth on link $l(s,r)$. The expected available bandwidth $E(b_{(s,r)})$ is evaluated through considering a uniform random distribution of the medium occupancy. For that purpose, expected delay is computed before nodes sense the medium idle. This evaluation is presented as detailed in [10].

C. Collision probability and Backoff time

Routing protocol uses Hello packets, regularly emitted by every node, to exchange connectivity and bandwidth-related information. A collision probability may be computed on the basis of these Hello packets. When such packets are emitted regularly, a receiver may estimate the amount of Hello packets it should receive in a given time interval. Comparing this number with the effective number of received Hello packets gives an estimation of the collision probability between both peers.

Whenever a node experiences collision, the backoff mechanism is triggered. This is an approximation, as a sender suffering a collision probably provoked a collision itself, triggering the collision avoidance mechanism at another emitter. Other emitter increases simultaneously its contention window, resulting in a reduced collision probability for successive retransmission. For every frame, the transmission is successful at the first attempt with probability (1-*p)*. It succeeds at the second attempt with probability *p*. (1-*p*). After C unsuccessful retransmission attempts, the frame should be dropped.

Most of the backoff algorithms suffer from the following shortcoming due to their inherent operations. Increasing the contention window in case of failure to transmit tends to rapidly increase large contention windows to even larger sizes. Reaching such large window sizes dangerously decrease the possibility of gaining access to the channel. Moreover, a large window size tends to contribute to increasing channel idle times, leading to a major waste the shared limited communication channel. In FB algorithm the difference between consecutive contention window sizes are reduced according to a Fibonacci sequence [8] and long channel idle time is reduced. So that the more channel will be available for other nodes for transmission. Contention Window (CW) is increased gradually as Fibonacci series represented in (2).

$$F(n) = F(n-1) + F(n-2).\ F(0) = 0,\ F(1) = 1,\ n >= 0 \qquad (2)$$

Backoff is waiting time for medium, which is measured by the Fibonacci Backoff algorithm. K is the proportion of bandwidth consumed by the backoff mechanism when collisions happen and by T (m) the time separating the emission of two consecutive frames. This delay essentially depends on the emission rate and on the frame size m. Then, K can be expressed by (3).

$$K = \frac{DIFS + backoff}{T(m)} \quad (3)$$

The above considerations mentioned are combined to estimate the available bandwidth on a wireless networks. This technique is called as Efficient Available Bandwidth Estimation technique. To summarize, the available bandwidth between two neighbor nodes s and r can be estimated by (4).

$$E_{final}(b_{(s,r)}) = (1-K).(1-p).E(b_{(s,r)}) \quad (4)$$

where $E(b_{(s,r)})$ is the available bandwidth on link (s, r) evaluated by monitoring the radio channel and combining emitter and receiver's values in a probabilistic manner, p is the collision probability measured on the received *Hello* packets and rescaled to the appropriate packet size, and K is the proportion of bandwidth lost due to the backoff scheme computed due to p.

IV. SIMULATION AND RESULTS

Network Simulator (NS) is a discrete event network simulator. NS is popularly used in the simulation of routing and multicast protocols, among others, and is heavily used in ad hoc networking research. NS supports an array of popular network protocols, offering simulation results for wired and wireless network alike.

From the operational point of view, the process of estimating available bandwidth in IEEE 802.11 based ad hoc network is simulated using NS2 Simulator (version 2.33). The essential parameters used for this work are given in the Table1. The simulation is run for 900ms. The simulated medium capacity can be set to 2 Mbps. The nodes involve in transmission. NS supports number of routing protocols. Among that the Ad Hoc On-Demand Distance-Vector (AODV) routing protocol has been chosen. The simulation is performed with 25 nodes, which are flooded in grid environment randomly. Randomly five nodes are chosen as source and five nodes are chosen as destination. Every node may act as source or destination. The accuracy of available bandwidth estimation is not only based on the consumed bandwidth, it also relies on the amount of bandwidth consumed by the network flows such as flow delay, flow collision. For example a 2-Mbps of total bandwidth is not utilized as whole.

TABLE 1. PARAMETERS FOR SIMULATION

Parameters	Values
Hello packet	1s
Packet Size	1000 bytes
Medium capacity	2 Mb/s
Communication range	250m
Carrier Sensing Range	550m
Grid Size	1000m X 1000m
Number of Retransmissions	6

The amount of bandwidth is consumed by network interferences. In order that, this work proposed to improved available bandwidth estimation technique for accurate bandwidth estimation. In this work, the amount of bandwidth wasted for the collision, number of retransmissions and backoff procedures are considered.

In wireless networks the radio channel of each node is shared with all its neighbors even though two nodes have no direct communication. Ad hoc networks need continuous re-evaluation of network resources. The main aim of this work is improving network performance by considering one of QoS characteristics is bandwidth. Estimation of accurate bandwidth, which allows a node to make efficient decision. Simulation is performed with random number of nodes, flow sources and destination, location of these nodes and 2Mbps capacity. The following Fig. 1, 2 and 3 describe the network performances while by means of our proposed work of one hop and two hop flows.

Nodes arrival, bandwidth, throughput and end-to-end delay are calculated to represent the results and accuracy. The efficiency of network is examined with simulating is performed with 25 randomly nodes. Five Constant Bit Rate (CBR) traffics are generated with random throughputs. Nodes move according to a random waypoint mobility model with maximum speed of 10 or 20 m/s. Physical rate is of 2 Mbps.

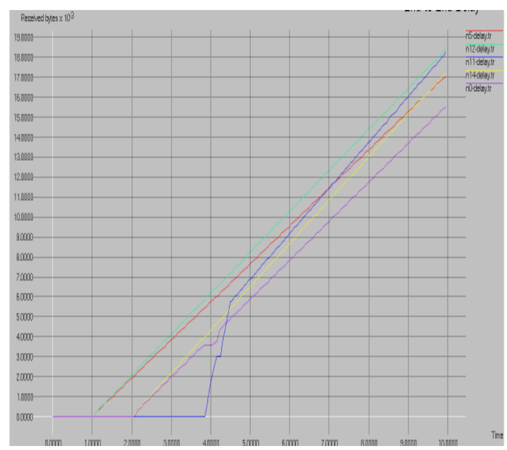

Figure 1. End-to-End delay

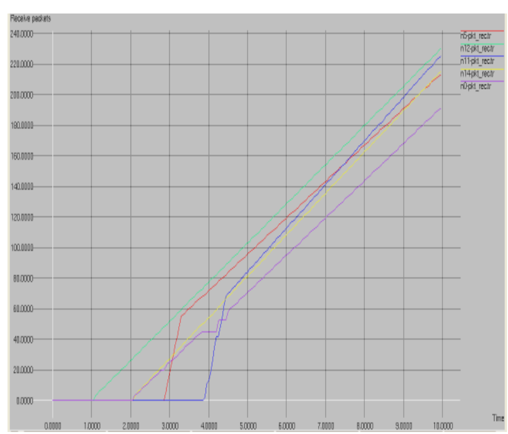

Figure 2. Number of Packets Received at Sink

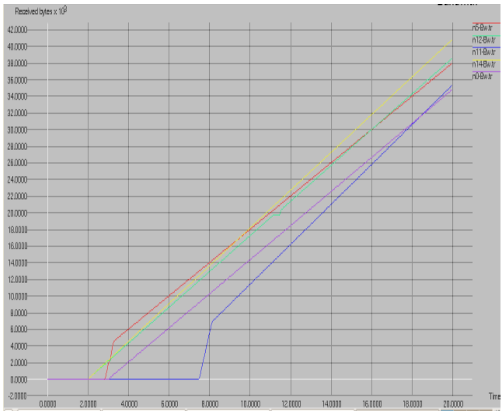

Figure 3. Available Bandwidth

V. CONCLUSION

The new technique is presented for accurate bandwidth estimation between neighbor nodes. This method considers the each node's medium occupancy, probabilistic combination of these values to account for synchronization between nodes, estimation of the collision probability and additional overhead by the retransmissions and backoff time. By these considerations the accuracy of bandwidth estimation is improved. The proposed technique uses the Fibonacci Backoff algorithm for increasing contention window size gradually when the channel is busy. It reduces the collision and channel idle time. It allows fast medium contention for other nodes. Accurate bandwidth estimation enables the node to know the traffic of network.

The available bandwidth is evaluated in IEEE 802.11 based ad hoc network. This standard provides an ad hoc mode, allowing mobiles to communicate directly. The network performance for one hop and two hop neighbors is shown by the simulation results. From the above simulation there is no doubt for high network performance. Simply computing the available bandwidth is not sufficient to decide about the network ability to convey a flow in Ad Hoc networks. Additional QoS metrics delay variance will be considered to further enhancement in QoS for ad hoc networks.

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