Bandwidth Estimation in Mobile Ad-hoc Network (MANET)

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Abstract

In this paper we presents bandwidth estimation scheme for MANET, which uses some components of the two methods for the bandwidth estimation: 'Hello Bandwidth Estimation' & 'Listen Bandwidth Estimation'. This paper also gives the advantages of the proposed method. The proposed method is based on the comparison of these two methods.

Bandwidth estimation is an important issue in the Mobile Ad-hoc Network (MANET) because bandwidth estimation in MANET is difficult, because each host has imprecise knowledge of the network status and links change dynamically. Therefore, an effective bandwidth estimation scheme for MANET is highly desirable.

Ad hoc networks present unique advanced challenges, including the design of protocols for mobility management, effective routing, data transport, security, power management, and quality-of-service (QoS) provisioning. Once these problems are solved, the practical use of MANETs will be realizable.

Keywords: *Bandwidth Estimation, Mobile Ad Hoc NETwork (MANET), "Hello" Bandwidth Estimation Method, "Listen" Bandwidth Estimation Method, QoS.*

1. Introduction

Bandwidth estimation is a basic function that is required to provide QoS in MANETs [1]. It is a way to determine the data rate available on a network route. It is of interest to users wishing to optimize end-to-end transport performance, overlay network routing, and peer-to-peer file distribution [1].

Techniques for accurate bandwidth estimation are also necessary for traffic engineering and capacity planning support [1]. Having information existing can help to develop better methods for e.g. gateway selection, channel selection, routing, etc. [2].

Literally, ad-hoc means in Latin, ad-hoc means is "for this," meaning "for this special purpose". An ad-hoc network is a local area network (LAN) that is built spontaneously as devices connect [3] and autonomous self-organized wireless and mobile networks [4]. They do not require any fixed infrastructure for instance a base station to work. The nodes themselves address topology changes due to the mobility, the entrance or the exits of nodes. These networks use a radio medium [4].

MANET is a group of two or more devices or nodes or terminals with wireless communications and networking competence that communicate with each other without the help of any centralized administrator also the wireless nodes that can form a network to exchange information according to their need at that time [5], [6] and [7]. It is an independent system in which mobile hosts connected without wire and are free to move dynamically and sometimes they act as routers at the same time [5], [6] and [7].

There are two types of mobile network namely Mobile IP and MANET [8]. MANET consists of nodes that are cable to communicate wirelessly among themselves [7] and [8]. MANETs consist of a group of wireless mobile nodes which dynamically exchange data among themselves [7] without the reliance on a fixed base station or a wired backbone network [6].

MANET nodes are typically differentiated by their limited power, processing, and memory resources as well as high degree of mobility [6]. In MANETs, the wireless mobile nodes may dynamically enter in the network as well as leave the network. Because of the limited transmission range of wireless network nodes, multiple hops are generally required for a node to exchange information with any other node in the network [6].

Multipath routing permits the formation of multiple paths between one source node and one destination node. It is basically proposed in order to enhance the reliability of data transmission (i.e., fault tolerance) or to provide load balancing [6].

Available bandwidth estimation techniques can be divided in two major approaches [2]:

1. Intrusive Bandwidth Estimation Techniques:

   The intrusive approaches techniques are based on end-to-end probe packets to estimate the available bandwidth along a path.

2. Passive Bandwidth Estimation Techniques:

   The passive approaches techniques uses local information on the used bandwidth and that may exchange this information via local broadcasts**.**

Till date much of the research work is targeted at finding a possible path from a source to a destination without considering current network traffic or usage requirements. Such QoS support can be accomplished by either finding a path to fulfill the application requirements or offering network response to the application, when the requirements cannot be met. This paper is also about a QoS-aware routing protocol that incorporates a feedback scheme and an admission control scheme to meet the QoS requirements (provides better than best-effort service) of real-time applications using IEEE 802.11. The novel work of this QoS-aware routing protocol is the use of the approximate bandwidth estimation to response to the network traffic.

The rest of the paper is organized as: the Section II contains the Literature Review Discussion is in Section III and the Conclusion is in Section IV.

2. Literature review

In an ad hoc network, a host's available bandwidth refers to amount of bandwidth available to the node to send packets to the network [5]. Whole channel will not be used for packet transmission. Bandwidth estimation can be done using various methods; for example, bandwidth estimation is a cross-layer design of the routing and MAC layers and the available bandwidth is estimated in the MAC layer and is sent to the routing layer for admission control. Therefore, bandwidth estimation can be carried out in various network layers [1].

Present bandwidth estimation tools measure one or more of three related metrics: capacity, available bandwidth, and bulk transfer capacity [9]. Currently available bandwidth estimation tools utilize a various strategies to measure these metrics [9].

The issues of multipath routing in MANETs were specifically examined [6]. They also discuss the application of multipath routing to support application constraints such as reliability, load-balancing, energy-conservation, and QoS [6].

An improved mechanism was proposed to estimate the available bandwidth in IEEE 802.11-based ad hoc networks [10]. In 802.11-based ad hoc networks, few works deal with solutions for bandwidth estimation [4].

In a distributed ad hoc network, a host's available bandwidth cannot decided only by the raw channel bandwidth, but also by its neighbour's bandwidth usage and interference caused by other sources, each of which reduces a host's available bandwidth for transmitting data. Therefore, applications cannot properly optimize their coding rate without knowledge of the status of the entire network [1].

An incorporating QoS into routing, and introduce bandwidth estimation by propagating bandwidth information through "Hello" messages [11] and [12]. A cross-layer approach, including an adaptive feedback scheme and an admission scheme to give information to the application about the network position, are implemented [11] and [12].

According to the simulations show that their QoS-aware routing protocol can improve packet delivery ratio greatly without impacting the overall end-to-end throughput, while also decreasing the packet delay and the energy consumption significantly [11].

The problem in available bandwidth estimation was rethink in IEEE 802.11 based ad hoc networks [12]. According to them estimation accuracy is increased by improving the calculation accuracy of the probability for two adjacent nodes idle period to overlap.

All the information of MANET which include the History of ad hoc, wireless ad hoc, wireless mobile approaches and types of MANETs, and then they present more than 13 types of the routing Ad Hoc Networks protocols were proposed [7]. They give description of routing protocols, analysis of individual characteristics and advantage and disadvantages to collect and compare, and present all the applications or the Possible Service of Ad Hoc Networks [7].

2.1 Characteristics of MANET

The intention of the MANET is to standardize IP routing protocol functionality is appropriate for the wireless routing application within both dynamic and static topologies with raised dynamics because of node motion and other factors:

- **Dynamicity**: Every host can randomly change position. The topology is generally unpredictable, and the network status is imprecise.
- **Non-centralization:** There is no centralized control in the network and, thus, network resources cannot be assigned in a predetermined manner.
- **Radio properties:** The wireless channel can suffer fading, multipath effects, time variation, etc.

With these constraints, Hard QoS (e.g., guaranteed constant bit rate and delay) is difficult to achieve. The reasons are as follows [11] and [12]:

- To support QoS the end host should have knowledge of the worldwide position of the network. The dynamic nature of MANETs makes it difficult for hosts to determine information about their local neighborhood, much less the global status of the network.
- It is hard to establish cooperation between neighboring hosts to determine a transmit schedule for guaranteed packet delivery without centralized control. In MANETs, each host's transmissions will interfere with neighboring hosts' transmissions.
- The wireless channel's main deficiency is its unreliability caused by various reasons such as fading and interference.

Thus if the topology changes too frequently, the source host cannot detect the network status changes and cannot make the corresponding adjustment to meet the specific QoS requirements. Therefore, combinatorial stability must first be met before we can consider providing QoS to real-time applications. Solution is a QoS-aware routing protocol that either **provides feedback about the available bandwidth** to the application (feedback scheme), or admits a flow with the requested bandwidth **(admission scheme)** [11]**.** Both the feedback scheme and the admission scheme require knowledge of the *end-to-end bandwidth* available along with the *route from the source to the destination*. Thus, bandwidth estimation is important to support QoS.

2.2 Bandwidth Estimation Methods

Estimating accurate available bandwidth allows a node to make optimal decision before transmitting a packet in networks. It is therefore clear that the available bandwidth estimation enhances the QoS in wired and wireless Networks. Measuring available bandwidth in ad hoc networks is challenging issue in MANET and calculating the residual bandwidth using the IEEE 802.11 MAC is still a challenging problem, because the bandwidth is shared among neighboring hosts, and an individual host has no knowledge about other neighboring hosts' traffic status. Two methods for estimating bandwidth are used below [11] and [12]:

1. **"Listen" bandwidth estimation:** For hosts to listen to the channel and estimate the available bandwidth every second based on the ratio of free and busy times. The IEEE 802.11 MAC utilizes both a physical carrier sense and a virtual carrier sense [via the network allocation vector (NAV)], which can be used to find out the free and busy times. The MAC detects that the channel is free when the following three requirements are met [11] and [12]:

   - NAV's value is less than the current time;
   - Receive state is idle;
   - Send state is idle.

   The MAC declares that the channel is busy when one of following occurs:

   - NAV sets a new value;
   - Receive state changes from idle to any other state;
   - Send state changes from idle to any other state.

   $\Rightarrow$ <u>Channel BW*free time/over all time</u>

   Weight factor

2. ***"Hello" bandwidth estimation:*** The sender's current bandwidth consumption as well as the sender's one-hop neighbours' (from its two-hop neighbours) current bandwidth consumption is piggybacked onto the standard "Hello" message. Each host estimates its available bandwidth based on the information provided in the "Hello" messages and knowledge of the frequency reuse design [11] and [12].

   The second neighboring host's information was proposed by using hop relay to propagate [11]. **AODV** uses the

"Hello" messages to update the neighbor caches. The "Hello" message used in AODV only keeps the address of the host who initiates this message. Modify the "Hello" message, including two fields. The first field includes host address, consumed bandwidth, timestamp, and the second field includes neighbor's addresses, consumed bandwidth, timestamp, as shown in Figure 1. Each host finds out its used bandwidth by monitoring the packets it supplies into the network. This value is recorded in a bandwidth-consumption register at the host and is updated periodically.

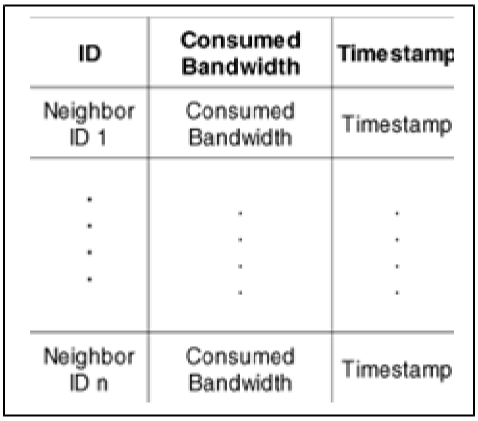

Figure 1. Hello structure [11]

3. Discussion

By using the "Listen" method the host cannot release the bandwidth immediately when a path breaks, because it does not know how much bandwidth each node in the broken path consumes. The time interval between claiming a path break and setting up the path is only several milliseconds. In such a small time interval, it is almost impossible for the hosts to automatically and correctly update their bandwidth registers in the "Listen" bandwidth estimation method because the consumed bandwidth estimation is based on averaging bandwidth consumption every 1s interval and the hosts in the broken path were transmitting data in the previous second [11].

If the topology is static Hello or Listen be used e.g. listen or Hello. But the problem is when the topology is not static that is mobile topology. But bandwidth estimation is difficult, because each host has imprecise knowledge of the network status and links change dynamically. Therefore, an effective bandwidth estimation scheme is highly desirable [1].

Therefore, the "Listen" bandwidth estimation approach has difficulty correctly estimating the residual bandwidth. Even if some forced update schemes can be adopted, the hosts still cannot release the bandwidth correctly; since the hosts do not know how much bandwidth each node in the broken path consumes [11].

The "Hello" bandwidth estimation method and the "Listen" bandwidth estimation method in [11] and [12] we compare these two methods which are summarized as follows in the form of Table 1.

Table 1. Comparison of the "Hello" bandwidth estimation & the "Listen" bandwidth estimation methods

	Listen Bandwidth Estimation	**Hello Bandwidth Estimation**
Counts	It counts the used bandwidth	It counts the transmitted packets only
Performance	The host cannot release the bandwidth immediately when a path breaks, because it does not know how much bandwidth each node in the broken route consumes.	It is better when releasing the bandwidth immediately is important.
Performance in mobile topology	It performs better in term of packet delivery ratio.	It performs better in term of end-to-end throughput
Performance in Static topology	The "Hello" and "Listen" schemes work equally well, using large weight factors to reduce the congestion and minimize the chance of lost "Hello" messages incorrectly signalling a broken route.	
Overhead	It does not add extra overhead	It adds overhead by attaching neighbor's bandwidth consumption information.

3.1.1 ADVANTAGE OF LISTEN METHOD:

The Listen Method does not add an extra overhead by attaching neighbor's bandwidth consumption information.

3.1.2 DISADVANTAGES OF LISTEN METHOD:

In this method the host cannot release the bandwidth immediately when a path breaks, because it does not know how much bandwidth each node in the broken path consumes.

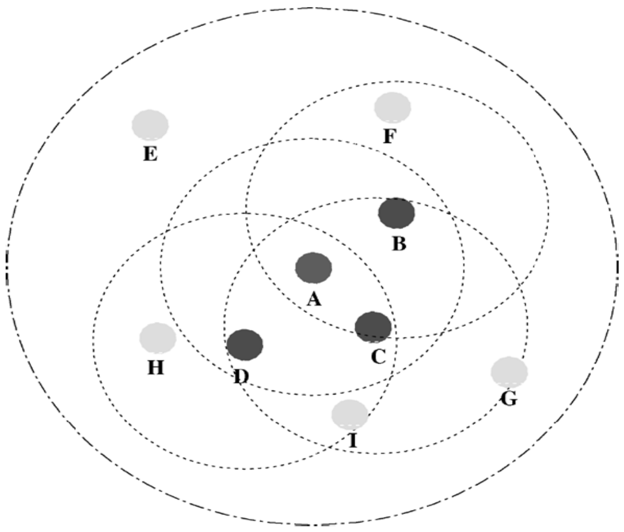

Fig. 2 Hidden node scenario. The big circle indicates host A's interference range. The small circles show host A and its first neighboring hosts' transmission range. Hosts B, C, and D are A's first neighbours of host's A and hosts F, G, H, and I are host A's second neighbors. Host E is in host A's interference range [11] and [12].

3.2.1 ADVANTAGE OF HELLO METHOD:

The "Hello" bandwidth estimation method can solve this problem easily by using the forced update scheme [11].

This approach avoids creating extra control messages by using the "Hello" messages to propagate the bandwidth information.

The first neighbouring hosts' information can be obtained directly, but there is no way to get the second neighbouring hosts' bandwidth information directly Figure 2. There are several ways to get the second neighbouring hosts' information, such as propagating the host bandwidth information using higher transmission power to reach the two-hop neighbourhood, setting up a separate signalling channel to broadcast the bandwidth information.

3.2.2 DRAWBACKS OF HELLO METHOD:

Drawbacks of Getting Second Neighbouring Hosts' Information are [11] and [12]:

1. Imprecise Information about the Hidden Hosts [11] and [12] as shown in Figure 2.
2. Overhead caused by attaching neighbour's bandwidth consumption information.
3. using higher power to propagate information consumes much more power.
4. It destroys the frequency reuse pattern and causes much more interference.
5. Using a separate channel to propagate the bandwidth information needs an additional control that is an intense burden for an ad hoc network in terms of bandwidth consumption and hardware support.

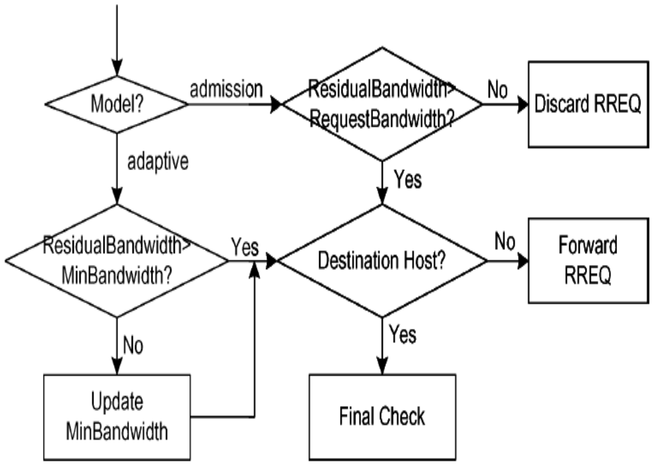

Figure 3. Host's working procedure after receiving RREQ in AODV [11]

Host's working procedure after receiving reply request RREQ in AODV is explained in Figure 3.

If SOURCE ADAPTIVE

If B.W > min B.W

ALLOW Destination host ,

Else

Reject.

If SOURCE ADMISSION

If B.W > Requested B.W

ALLOW Destination host ,

Else

Reject.

After completing this checking procedure, it is not sufficient to say that the current network can offer the min-bandwidth indicated in the RREQ packet. The reason is that if the route is chosen, the chosen hosts will bring mutual interference into the network during transmission. Therefore, one final check procedure is required before transmiting the RREP packet back to the source host. We directly use the relation of the end-to-end throughput with the number of hops and the bottleneck bandwidth in the route as follows (the details can be found in [11] and [13].

If (hop num =1)

Min B.W =Min B.W

Else if (hop num =2)

Min B.W =Min B.W / 2

Else if (hop num =3)

Min B.W =Min B.W /3

Else if (hop num =4)

Min B.W =Min B.W/4

.

.

.

Else if (hop num =n)

Min B.W =Min B.W / n

This equation offers the upper limit of the available bandwidth. A more accurate estimation is studied in [14] and [15], where the interflow contention is accounted for by using the contention counter. Finally, the destination host sends the RREP with a changed header ***(min-bandwidth, AODV RREP header)*** to the source host. Once intermediate hosts receive the RREP, they enable the path and also record the min-bandwidth in their routing table, which is useful for path maintenance of QoS-aware routing with "Hello" bandwidth estimation.

3.3 PROPOSED METHOD:

The proposed approach uses some components of both: the Listen bandwidth estimation and the Hello bandwidth estimation method. The proposed method is used for the routing in MANET using ADOV protocol. The proposed is described below:

1) It estimates the bandwidth by counting the used bandwidth, as in the Listen bandwidth estimation method.
2) If there is a route break then it uses the update scheme used in Hello bandwidth estimation method to immediately release the bandwidth when the route is broken.
3) Then it reply request back to whom who send request then it sends according to the Listen bandwidth estimation method it does not add an extra overhead as it does not need to attach neighbour's bandwidth consumption information.

3.3.1 ADVANTAGES OF PROPOSED METHOD:

1) In the proposed method the host can release the bandwidth immediately when a route breaks, because it uses the Update Scheme used in the "Hello" Bandwidth estimation method.

2) No Overhead which is caused by attaching neighbour's bandwidth consumption information as in the Hello method.

3.3.2 EXAMPLE**:**

If there is no route break then it can estimate the bandwidth normally. The problem is when the route is broken. So, the following example has shown the case of the broken route.

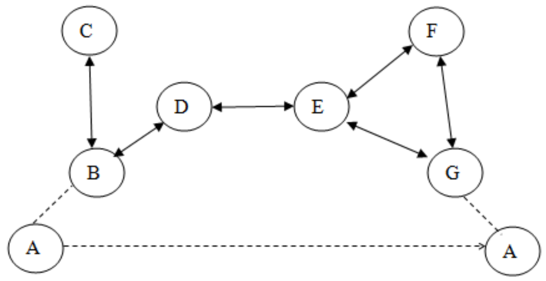

Figure 4.

Suppose that in Figure 4. 'A' moves away from 'B' towards 'G', and has active sessions with 'C' and 'D'. The following actions occur:

- 'B' notices that its link to 'A' is broken.
- 'B' checks its routing table, and finds that its link to 'A' was actively in use by 'C' and 'D'.
- 'B' unicasts ∞metric route update, with an incremented destination sequence number, to 'C' and 'D'. 'C' may subsequently issue a new RREQ (Route Request) for 'A'.
- 'D' also notes that its route to 'A' was actively in use, and forwards the ∞-metric route update to 'E'.

- The ∞-metric route update for 'A' may also be included in the next hello message issued by 'B'
- 'E' may subsequently issue a new route request for 'A'.
- Any subsequent route request for 'A' which is satisfied by a RREP (route reply) through 'B' may cause 'B' to update its route table.

The symbol of infinity '∞' means that route does not exist or the route is broken.

IV. Conclusion

In this paper we proposed a new method after comparing the "Hello" Bandwidth estimation method and the "Listen" bandwidth estimation method. The proposed method removes the problems caused by these two methods. The proposed method, immediately releasing bandwidth when the route breaks as in the "Listen" method and replace this with an "update technique" used in the "Hello" method. The proposed method also does not cause an overhead which was in the "Hello" bandwidth Estimation method due to attaching neighbours bandwidth usage information.

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