Packet Analyzer and Measurement Too l

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Abstract

In a packet network, the term bandwidth often characterizes the amount of data that the network can transfer per unit of time. Measuring an accurate network bandwidth is important to a variety of network applications so the techniques for accurate bandwidth estimation are important to optimize end-to-end transport performance, overlay network routing, peer-to-peer file distribution and capacity planning support. Existing bandwidth estimation tools such as using throughput, Pathchar, and Packet Pair measure one or more of three related metrics: capacity, available bandwidth, and bulk transfer capacity. Currently available bandwidth estimation tools employ a variety of strategies to measure these metrics.

Current bandwidth measurement techniques have many problems: poor accuracy, poor scalability, lack of statistical robustness, poor agility in adapting to bandwidth changes, lack of flexibility in deployment. In this paper we propose a solution for these problems through a simple tool for actively measuring available bandwidth along a network path. This tool uses a mechanism that exploits data packets transmitted in a TCP connection. The sender adjusts the transmission intervals of data packets, and then estimates available bandwidth of the network path between sender and receiver utilizing the arrival ACK from the receiver.

Keywords: Network, Bandwidth, Packet Analyzer, Packet Builder, Ack packet.

1. Introduction

A common complaint about the Internet is that it is slow. Some of this slowness is due to properties of the end points, like slow servers, but some is due to properties of the network, like propagation delay and limited bandwidth. Propagation delay can be measured using widely deployed and well understood algorithms implemented in tools like ping and trace route. Unfortunately, tools to measure bandwidth are neither widely deployed nor well understood although, the bandwidth is central to digital communication, and specifically to packet networks, as it relates to the amount of data that a link or network path can deliver per unit of time. For many data intensive applications, such as file transfers or multimedia streaming, the bandwidth available to the application directly impacts application performance. Even interactive applications, which are usually more sensitive to lower latency rather than higher throughput, can benefit from the lower end-to-end delays associated with high bandwidth links and low packet transmission latencies.

This work attempts to develop further understanding of how to measure bandwidth. A simple tool for actively measuring available bandwidth along a network path is proposed, it uses a mechanism that exploits data packets transmitted in a TCP connection. The receiver adjusts the transmission intervals of data packets, and then estimates available bandwidth of the network path between sender and receiver utilizing the arrival ACK from the receiver.

Available bandwidth can be measured at routers within a network [3]. This approach may require a considerable change to network hardware and is suitable for network administrators only. Some measurement tools can collect traffic information at some end hosts for performance measurements [4], but this approach requires a relatively long time for data collection and bandwidth estimation. Exchanging probe traffic between two end hosts to find the available bandwidth along a path seems the more realistic approach and has attracted much recent research.

The proposed tool divided into two parts: packet analyzer at both sender and receiver and packet builder at the sender side. The bandwidth measurement will take place at the receiver by receiving a stream of determined size packet from the sender then computing the consumed time before sending an acknowledgement to the sender, which contains the available bandwidth in that network which is measured by (total size of packets/ unit of time). The sender thus collects more information for a measurement and improved accuracy can be expected.

2. MOTIVATION

In this section, we describe the motivation for examining bandwidth measurement techniques.

A.*Applications*

Several applications could benefit from knowing the bottleneck bandwidth of a route. Developers of network protocols and applications need to know the bottleneck bandwidth to judge the efficiency of their protocols and applications. For example, if an HTTP server is delivering data at close to the bottleneck bandwidth, then increasing the bandwidth of that link may increase application performance. However if the bottleneck link already has plenty of bandwidth to spare, increasing its bandwidth will probably not improve application performance. Network clients could dynamically choose the “best” server for an operation based on the highest bottleneck bandwidth. This has been suggested as a way to choose a web server or proxy [4] [15]. In addition, accurate and timely bandwidth measurement is useful for mobile computing.

Mobile computers frequently have more than one network interface, often with very different bandwidths (e.g. 10Mb/s Ethernet and 28 Kb/s wireless). Knowing the bandwidth would allow the mobile host to pick the highest bandwidth interface as the default interface and to degrade service gracefully when it detects that it is operating on a low bandwidth link. Another application is congestion control. TCP already implicitly measures the bandwidth of the network so that it will not send packets faster than the network can handle, but this has certain disadvantages described in the next section. Finally, we could use bandwidth information to build multicast routing trees more efficiently and dynamically. Ideally, multicast routing trees would be built so that packets travel along a tree that minimizes duplicate packets and latency while maximizing bandwidth. Currently, multicast routing trees are built either without bandwidth information or with only static information.

B. *Metrics*

We distinguish between the bottleneck bandwidth and the available bandwidth of a route. The bottleneck bandwidth of a route is the ideal bandwidth of the lowest bandwidth link (the bottleneck link) on that route between two hosts. In most networks, as long as the route between the two hosts remains the same, the bottleneck bandwidth remains the same. The bottleneck bandwidth is not affected by other traffic. In contrast, the available bandwidth of a route is the maximum bandwidth at which a host can transmit at a given point in time along that route. Available bandwidth is limited by other traffic along that route. The question of which is the better metric can only be answered by the application. Some applications want to know which route will give them the minimum delay or want to use an estimate taken longer than a few seconds ago. For these applications bottleneck bandwidth is probably the best metric. Some applications are only interested in the best average throughput. For these applications, available bandwidth is probably the best metric. We are interested in both metrics, but have chosen to investigate bottleneck bandwidth first because it is a more stable metric and is therefore useful over a longer period of time, and because it bounds the available bandwidth and can therefore be used later to more accurately compute available bandwidth.

3. Related work

Researchers have been trying to create end-to-end measurement algorithms for available bandwidth since too many years. From Keshav’s packet pair [5] to Carter and Crovella’s cprobe [6], the objective was to measure end-to-end available bandwidth accurately, quickly, and without affecting the traffic in the path, i.e., non-intrusively. What makes the measurement of available-bandwidth hard is, first, that there is no consensus on how to precisely define it, second that it varies with time and third, that it exhibits high variability in a wide range of timescales. Although there are several bandwidth estimation tools, most of them measure capacity rather than available bandwidth [8, 10], for more information refer to [7], [9].

The most popular technique is to use throughput as an approximation of bandwidth. Throughput is the amount of data a transport protocol like TCP can transfer per unit of time. One problem with throughput is that other metrics (e.g. packet drop rate) may have a significant effect on TCP throughput, while not affecting bandwidth. Another problem with measuring throughput is that an application’s throughput to a host implies nothing about other transfers, even from the same application to the same host. For example, a web browser sending a request to a web server may experience low throughput because that request involved running a slow CGI script. The same browser sending a different request could experience high throughput because the latter request did not involve running a CGI script. Correlating the throughput of different applications (like telnet and http) is even more inaccurate.

TCP uses another technique to estimate bandwidth. It sends more and more packets until one is dropped. It estimates the bandwidth to be somewhere between the sending rate when the packet was dropped and half that rate. This has several problems: 1) TCP is measuring the bottleneck router's buffer size in addition to the bottleneck bandwidth, 2) TCP wastes network resources by forcing a dropped packet and filling the router's buffers, and 3) TCP has to increase its sending rate slowly, or else it will overshoot the real bandwidth and cause massive packet loss. The last problem is particularly acute on high bandwidth, high latency links, such as satellite connections, because TCP needs time to reach the maximum transmission rate.

4. Proposed Solution

4.1 Design & Implementation

Two techniques were combined with each other to produce the proposed solution to measure the network bandwidth. First technique is depending on sending number of data packets created by the packet builder over the network, and measure the time needed to receive all the sent packets by calculating the difference between the arrival ACK times for the first and last packets sequentially. Since the size of the sent packets is known the network bandwidth can be measured using equation (1). The second technique is depending on sending packets of varying sizes and measuring their round trip time, then correlating the round trip times with the packet sizes to calculate bandwidth.

Bandwidth = Size of Sent packets /Received Time … (1)

This approach was applied to different types of networks with different speeds and in different times of the day. Below are the measurements that have been done over both LAN and WAN networks in the different times of the day (Early Morning, Afternoon and Midnight).

4.2 Measuring Bandwidth in 10Mbps LAN

A LAN network was put under test in several different times of the day (Early Morning, Afternoon and Midnight) to measure the bandwidth, refer to section (5) to see the result.

4.3 Measuring Bandwidth in 2Mbps WAN

A WAN network was put under test in several different times of the day (Early Morning, Afternoon and Midnight) to measure the bandwidth, refer to section (5) to see the result.

5. Results & Analysis

5.1 LAN Bandwidth Measurements

Table 1: LAN 10Mbps bandwidth measurement (Morning).

No. of Packets	Total Packets size (Mega)	Required time (sec)	BW (Mb /sec)
100	100	11.63	8.59
300	300	35.71	8.40
500	500	63.29	7.90
1000	1000	123.46	8.10

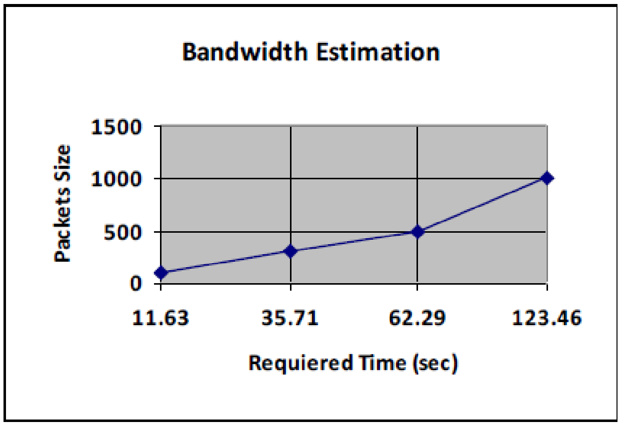

Figure1: LAN 10Mbps bandwidth measurement (Morning)

Table 2: LAN 10Mbps bandwidth measurement (Afternoon).

No. of Packets	Total Packet size (Mega)	Required time (sec)	BW (Mb /sec)
100	100	19.23	5.2
300	300	61.22	4.9
500	500	94.34	5.3
1000	1000	196.08	5.1

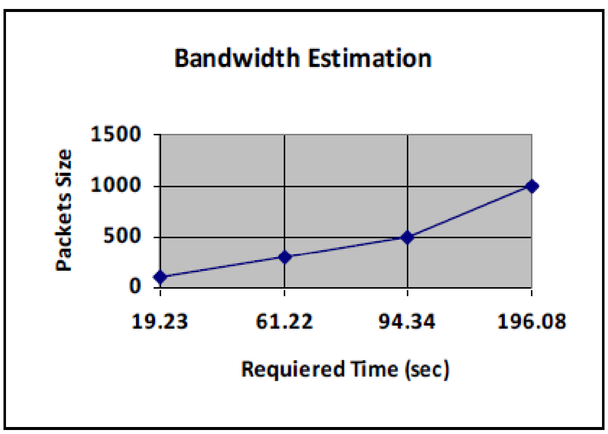

Figure2: LAN 10Mbps bandwidth measurement (Afternoon)

Table 3: LAN 10Mbps bandwidth measurement (Midnight).

No. of Packets	Total Packets size (Mega)	Required time (sec)	BW (Mb /sec)
100	100	10.98	9.11
300	300	36.01	8.33
500	500	64.05	7.81
1000	1000	124.08	8.06

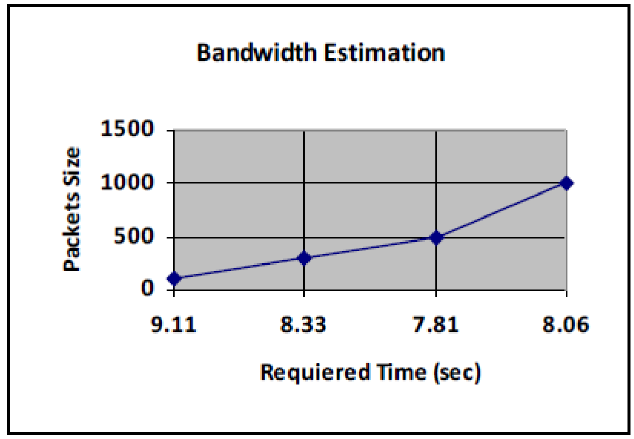

Figure3: LAN 10Mbps bandwidth measurement (Midnight)

5.2 WAN Bandwidth Measurements

Table 4: WAN 2Mbps bandwidth measurement (Morning).

No. of Packets	Total Packet size (Mega)	Required time (sec)	BW (Mb /sec)
100	100	70.92	1.41
300	300	222.22	1.35
500	500	387.6	1.29
1000	1000	757.58	1.32

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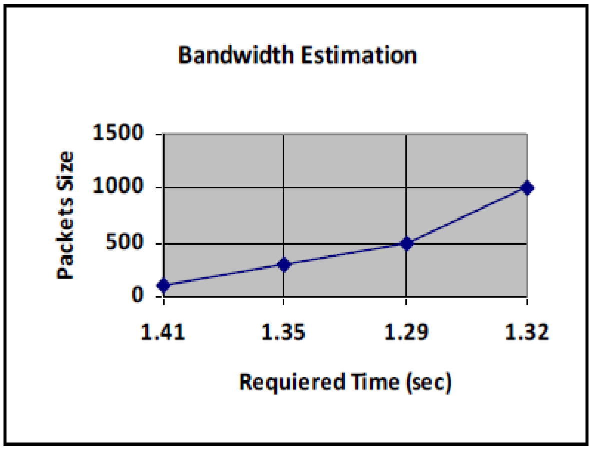

Figure4: WAN 2Mbps bandwidth measurement (Morning).

Table 5: WAN 2Mbps bandwidth measurement (Afternoon).

No. of Packets	Total Packet size (Mega)	Required time (sec)	BW (Mb /sec)
100	100	73.53	1.36
300	300	197.37	1.52
500	500	413.22	1.21
1000	1000	833.33	1.20

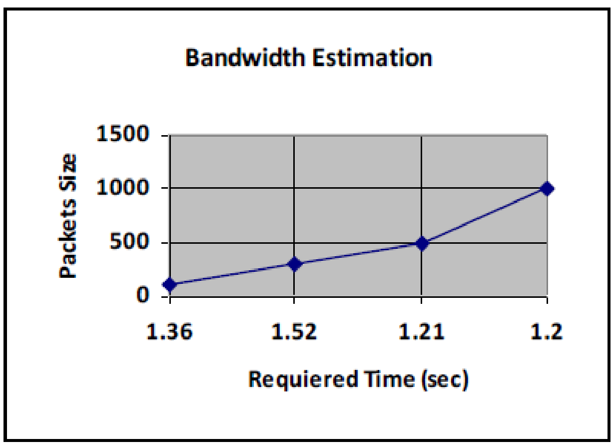

Figure5: WAN 2Mbps bandwidth measurement (Afternoon).

Table 6: WAN 2Mbps bandwidth measurement (Midnight).

No. of Packets	Total Packet size (Mega)	Required time (sec)	BW (Mb /sec)
100	100	65.79	1.52
300	300	211.27	1.42
500	500	335.57	1.49
1000	1000	735.29	1.36

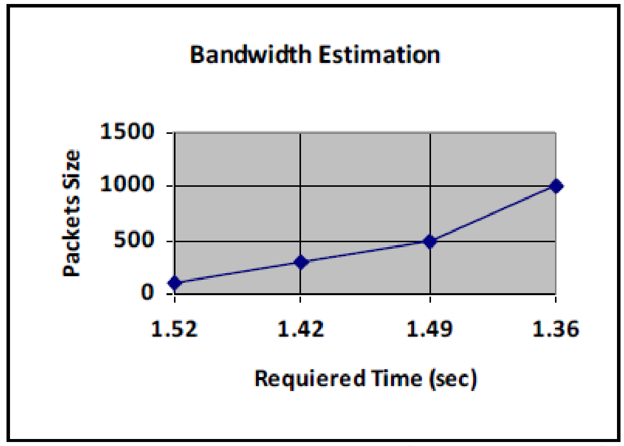

Figure6: WAN 2Mbps bandwidth measurement (Midnight).

As the figures show, the estimated bandwidth was measured and we noticed that the speed of packets transition was faster at both morning and midnight time than the afternoon time; this because no much traffics were exist in the morning and midnight comparing to the afternoon time which makes more available bandwidth in those intervals of the day.

6. Conclusion

We examined the characteristics of current bandwidth measurement techniques and found several problems. We propose statistically robust algorithms which overcome these problems by giving timely estimates, being agile in the face of bandwidth changes, giving more flexibility in deployment, and working with a variety of different traffic types.

We conclude that accurate, flexible and scalable bandwidth measurement is not only possible, but desirable in order to maintain the growth and reliability of many Internet applications.

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