Fast Estimation of Network Bandwidth

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ABSTRACT
There are several tools on the Internet that measure the bandwidth of an Internet link. These tools, however, have been shown to be a bit slow in regards to measuring the bandwidth. This is a direct result of the large amount of probe packets that these programs use in order to determine the bandwidth link, but is also affected by the tendency for these programs to find out more information about the characteristics of the link itself. These tools send only a fixed number of probe packets, which can result in inaccurate results. Here, we use a regression-based, iterative technique to filter out queue delays from all measured RTTs. Our tests, which use the existing ICMP (Internet Control Message Protocol) based tools, are done along an Internet path and show that the proposed scheme is faster and similarly accurate.

SIGNIFICANCE
• Network Bandwidth is an Important Resource, knowledge of link bandwidths along a path can:
  • Avoid excessive packet loss, delay, and congestion
  • Plan delivery or data on a path for time-sensitive data
  • Many tools currently available are not adaptive to network conditions such as congestion since they send a fixed amount of probe packets.

NETWORK MODEL
Notations Used for the Network Model are:
p(i): Propagation delay over link Li
q(i): Upstream random queue delay at node i
q(i)': Downstream random queue delay at node i
b(i): Upstream bandwidth of link Li
bd(i): Downstream bandwidth of link Li
f(i): Processing or forwarding delay at node i

METHODLOGY
First, let us consider a path from node N1 to node N7 and let us suppose node N1 sends a packet of size r to node N6 and node N7 returns a packet of size r in response. The roundtrip time, T(i, j), of this communication as seen by node N1 is given by the following compressed equation:

\[ T(i,j) = \sum_{k=1}^{n} \frac{1}{m_k(i)} \sum_{j=1}^{n} \frac{1}{m_j(j)} + C(i) + C(j) + f(i,j) \]

Where C(i) can be regarded as a constant and is:

\[ C(i) = \sum_{k=1}^{n} C(k) + \sum_{j=1}^{n} C(j) - (i) \]

And C(i,j) is regarded as a total random queue delay and is:

\[ C(i,j) = \sum_{k=1}^{n} q_k(k) + q_j(j) - q_{i,j} \]

The minimum roundtrip time can be calculated with the formula:

\[ T(i,j) = \sum_{k=1}^{n} m_k(i) + C(i,j) \]

Where m(i) is the hop formula:

\[ m(i) = \sum_{k=1}^{n} \frac{1}{b_k(k)} \]

And G(i) is the constant or intercept formula:

\[ G(i) = \sum_{k=1}^{n} \frac{1}{g_k(k)} + C(i) \]

EXPERIMENTAL RESULTS
In order for our proposed technique to fairly be compared against the other programs we are using, we use the same ICMP protocol for probing and messaging as used in pathchar, nettimer, and pchar.


REFERENCES

FAST ADAPTIVE BANDWIDTH ESTIMATION
1) Measuring roundtrip times: Send probe packets of size \( r_1, r_2, \ldots, r_n \) to the remote host and measure the corresponding RTTs as \( T_1, T_2, \ldots, T_n \) from the responses of the remote node. Let \( T = T_1 + T_2 + \cdots + T_n \) be the corresponding measured RTT vector. The probe packets of different sizes can be sent in some random order with sufficient time interval in between them. It is important that the packetsize must not exceed the maximum transmission unit (MTU) of the path to the remote node.

2) Calculating regression line: Interpolate a regression line for points \((T_1, r_1), (T_2, r_2), \ldots, (T_n, r_n)\) with their corresponding weights \(w_1, w_2, \ldots, w_n\), where \(w_i = 1\) for \(i = 1\) and then obtain the corresponding interpolated RTTs on the regression line as \(y_1, y_2, \ldots, y_n\). Let \(T = y_1 + y_2 + \cdots + y_n\) represent the corresponding vector. Find the slope of the line for the iteration with \(i = 0\).

3) Filtering and selective probing: For \(i = 1, 2, \ldots, n\), if \( r_i > y_i \) (i.e. the point is above the regression line) then discard \(r_i\) and send a probe packet of size \(r_i\) to the remote node to obtain a new RTT value. Let \(r_i\) as the minimum of the previous RTT and the new RTT.

4) Iterating for convergence: For \(i = 1, 2, \ldots\) such that \(s_i = T_i - T_i\) and let us observe that the constant \(s\) has been chosen carefully to ensure termination of the process without sacrificing accuracy too much.

FAST ADAPTIVE BANDWIDTH ESTIMATION

1. Fast and adaptive filtering of queue delays from roundtrip times measured on variable sized probe packets sent from a host to two successive nodes along a path for a link produced accurate results.

2. Fast filtering of queue delays is achieved through a weighted linear regression fit of the RTT data in an iterative manner.

CONCLUSION

• Produces similar results as other programs with less probe packets needed. (i.e. – Less intrusive)