



The effects of latency and bandwidth on actual broadband performance

Background

Nowadays, broadband is becoming the de-facto method for connecting to the Internet. It brings with it a significant performance boost from the 56Kbps dial up analog modem technology but in most cases it delivers considerably less than high-speed local connections such as Ethernet. The most common broadband connection means is DSL and the G.Lite ADSL standard is almost ubiquitous providing up to 1.5 M downstream and 512K upstream.

If you compare the analog modem and DSL transfer rates in bytes per second they are 6,600 and over 180,000 respectively, under ideal circumstances. Even though the capacity of the DSL connection is close to 30 times that of the modem connection, the actual time taken to communicate between the subscriber and a distant web site has not reduced by a similar factor (see latency later).

All traffic traveling through the Internet is based on the IP protocol and most applications use TCP as the transport protocol. This protocol in particular provides a reliable byte stream channel between nodes. It has built in mechanisms to guarantee delivery by changing its transmission characteristics to cater for packet loss and slow packet acknowledgement responses from the receiver.

Latency and TCP Window Size

Latency is basically the delay or time consumed sending a packet from a node and receiving a response from the recipient. This value is also referred to as the round trip time (RTT). Why is this important? It is extremely important as TCP uses it and the TCP Window Size to determine it's sending rate. Therefore even if you exchange a modem connection for a DSL connection transit delays between the consumer and a target web site may not change at all because of the routers and switches in the Internet that have to forward the packets from the source to the destination.

The TCP Window Size is the amount of buffering allowed by the receiver before an acknowledgement is required. Most server-class operating systems have this value set at a large multiple of the IP packet size (1500 bytes) usually in the range 32 Kbytes to 128 Kbytes. This allows for the reception of 20 to 40 packets before an acknowledgement is required. This assumes that the local and destination systems negotiated the larger window size.

Optimum TCP Window Size

The formula that governs the optimum window size is: - TCP Window Size \geq Bandwidth (in bytes) x Latency (RTT)

You can see from this that the window size can vary greatly depending on the communications link type and the bandwidth. For example a 10M LAN, with 1 millisecond latency, only needs a TCP Window Size of 1250 bytes. In contrast, a T-1 1.544M WAN link, through the Internet, with a latency of 200 milliseconds to a web site, needs TCP Window Size of 38,600 bytes in order to ensure the connection achieves full bandwidth.

Microsoft Windows and TCP Window Size

Although server class operating systems (Solaris, AIX, UnixWare, Linux, xBSD) have a generous default window size, this is not the case with consumer desktop operating systems such as Windows 2000, XP, etc. Their default TCP Window Size is only 8760 bytes, which means that less than six packets can be outstanding before an acknowledgement is required. This value is adequate on a private high-speed, low latency LAN connection or a low speed dialup modem connection but is too small for many Internet/broadband applications.

To achieve full speed transfers across an ADSL G.Lite connection, the path to the destination cannot introduce more than 50 milliseconds RTT. If you require twice the bandwidth and do not change the window size you can only incur 25 milliseconds. If you need 3 times the bandwidth and don't change the window size then you can only incur 17 milliseconds. These are unrealistically small RTT values. Therefore the default window size needs to be increased from 8760 bytes to something more in line with the bandwidth and latency expectations (16K, 32K, etc.).

In extreme situations such as satellite communications, the RTT can reach a second or over. Normally TCP has a maximum window size of 64K; however new additions (RFC 1323) have allowed TCP window scaling allowing multiples of 64 K up to 4G. Most modern operating systems support setting TCP window scaling on or off for large buffering on very high latency links

Effects of increasing DSL bandwidth with ML-IP

ML-IP allows you to aggregate 3 to 4 IP-capable connections (DSL, cable, leased line, etc.) into a single logical connection. If the customer's network has systems with a TCP window size that is at its limit for a single broadband link with particular latency characteristics, then the value needs to be doubled, trebled or quadrupled for faster connections. In the case of ML-IP, it increases the bandwidth almost linearly through the extra links so the window size should go up proportionally.

Although changing TCP configuration on a system is somewhat intrusive, all nodes are subject to the latency, bandwidth and TCP rate control characteristics when it comes to network data transfers. However server class operating systems perform better across a wide range of speeds and latencies because they have reasonable default TCP window sizes. On the other hand, for most Microsoft Windows desktops the value must be changed in the 'Registry' from 8760 bytes to at least 32 Kbytes. For complete details on how to make these changes, see the references below. If the window size is already large, no changes are necessary.

ePipe may investigate methods of shielding systems from the real RTT of the connection within ML-IP. One method is to supply TCP acknowledgements to the local system on behalf of the end node. The ML-IP device could buffer up the extra packets ensuring that the TCP stack on the local system does not adjust its transfer rate. As far as the local system is concerned, the RTT is now based on the local LAN connection, not the Internet link.

References

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