

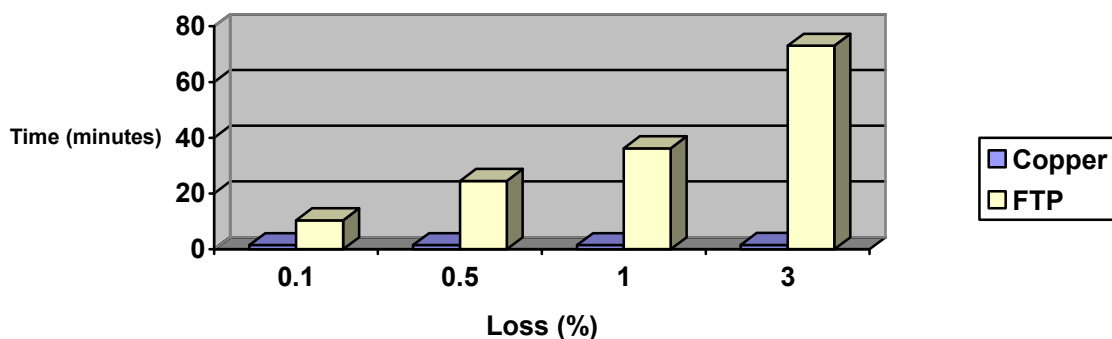
## Digital Rapids Copper: Copper Speed Compared to TCP

TCP must receive all of the data packets in the correct order, so as each packet is received an acknowledgement must be sent back before the sender can transmit the next packet. This round trip takes time, and is known as latency. If a packet is lost it must be re-sent before other packets can be received, further slowing the transmission. Increasing the bandwidth available will not help, since it will not reduce the loss or latency which is responsible for slowing down the transmission.

Copper uses Digital Fountain's patented Meta-data technology to overcome the problems associated with latency and loss. Each Copper data packet contains some information that can be used to re-assemble the entire data file. If the file requires 100 data packets, you can receive any 100 packets in any order, so you never have to wait for an acknowledgement before sending the next packet. If one data packet is lost Copper simply sends 101 data packets, which will provide all of the information needed to assemble the original data file. Increasing the bandwidth will increase the speed of the transmission, since Copper can use all of the available bandwidth.

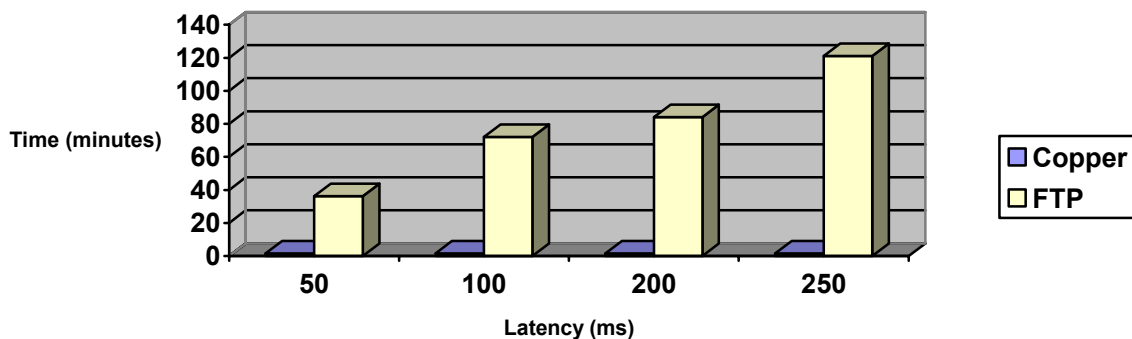
The time needed to transmit a file using TCP goes up as the loss goes up. The time remains almost unchanged for Copper.

**Copper at 45Mbps vs. FTP for 500 MB file, 50 ms Latency**



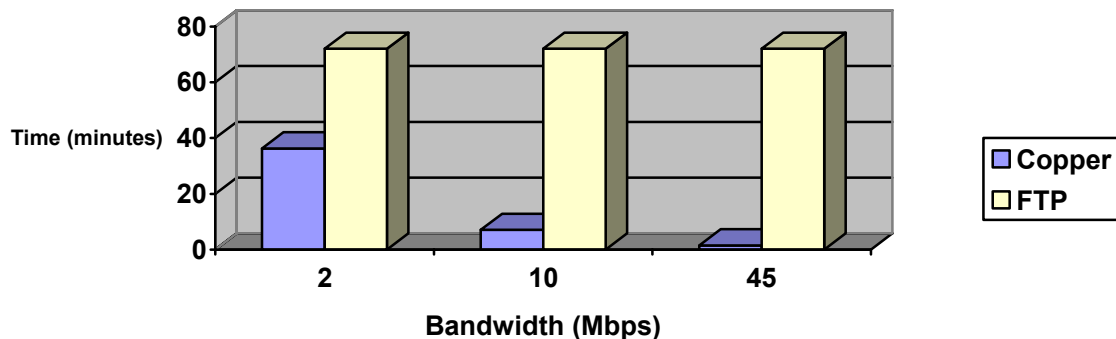
The time needed to transmit a file using TCP goes up drastically as the latency goes up. The time remains unchanged for Copper.

**Copper at 45Mbps vs. FTP for 500 MB file, 1% Loss**



The time needed to transmit a file using Copper goes down as the available bandwidth goes up. This is not the case for TCP, which is limited by loss and latency.

### Copper vs. FTP for 500 MB file, 100 ms Latency, 1% Loss



At low bandwidths (under 2 Mbps) or when latency is low (short distance with few router hops) and loss is low (no network congestion), FTP may be a reasonable choice. However, the longer the distance (and thus latency) and busier the network (and thus loss) and higher the bandwidth, the bigger the Copper speed advantage will become.

### Testing Latency

One way to test latency is through an application called Ping. To perform a Ping test:

1. Open a Command Prompt (a DOS window).
2. Type: ping www.yahoo.com (or any well-known site).

A successful test would produce something like the following:

```
Command Prompt
C:\>ping www.knto.or.kr
Pinging www.knto.or.kr [211.178.9.106] with 32 bytes of data:
Reply from 211.178.9.106: bytes=32 time=263ms TTL=47
Reply from 211.178.9.106: bytes=32 time=295ms TTL=47
Reply from 211.178.9.106: bytes=32 time=272ms TTL=47
Request timed out.

Ping statistics for 211.178.9.106:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 263ms, Maximum = 295ms, Average = 276ms
C:\>_
```

If the packet was not received, you will see "Request timed out" in the results.

Try pinging these international sites:

- NewZealand: www.wcc.govt.nz
- United States: www.lacity.org
- Great Britain: www.visitlondon.com
- Korea: www.knto.or.kr

Note that this test is not particularly useful for testing Loss, since it only sends 4 packets. Since loss is typically less than 1% to 6% you will see either an abnormally low loss (0%) or an abnormally high loss (25% if just one of the 4 packets is lost). Check <http://www.internettrafficreport.com/main.htm> for more latency and loss information.