# Broadband Bonding

## Effects on Speed and Latency

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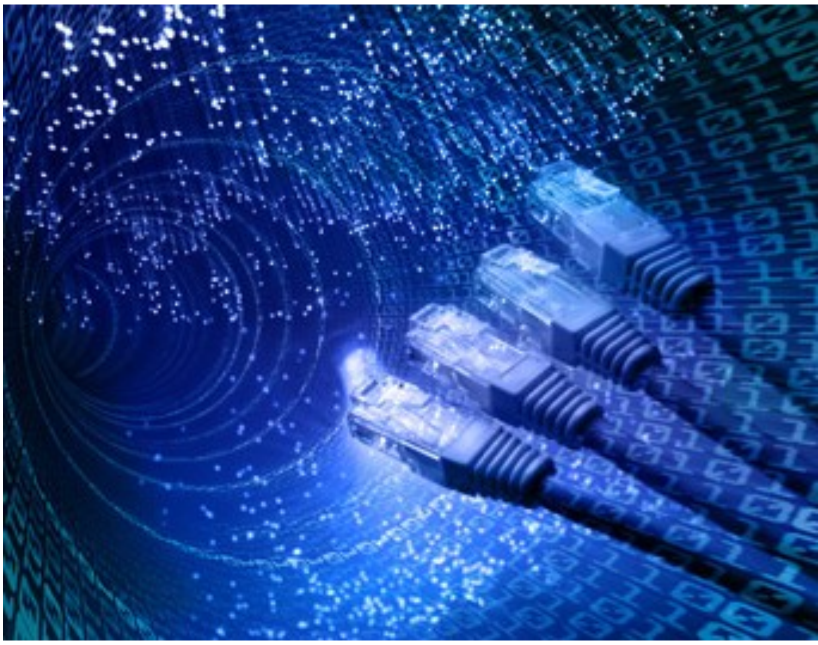


## How does bonding effect Speed and Latency?
## We address both in this technical brief.

### What is Network Latency?

Outside of speed, Latency is perhaps the most common measure that determines the user perception the quality of the service they are using across a private network or surfing the Internet.

Latency is the measure of the time it takes for data (transported in an IP packet) to travel from its source to its destination; there is a finite speed (the speed of light) at which it can travel.

There are a number of tools that can be used to measure latency on your network. The most commonly used tool to measure this time is the *ping* command. Running simple broadband speed tests like www.speedtest.net will perform a simple ping test on the connection and display the results.

The Ping command is a very simple test that tests the latency between you to the destination AND back again. Sometimes called RTT ( Round Trip Time).

### Causes of Latency in the Network

Latency can be caused by many factors on a connection. Generally the most common cause is network overload. A completely unloaded network will show Latency or a Ping test at close to the lowest physical time (effectively the speed of light). Once network elements or devices start to experience load or their connections experience load you will see the Latency grow. You can never avoid the effects of network load but how well it is managed is critical for a quality connection and is the main differentiator between a lower quality service and a higher quality service.

*A simple way to view Latency and network load is to imagine a line at the checkout counter at your local supermarket, The people in the queue are the packets, the checkout person is the network element, there comes a point that the checkout person has reached their limit of customers per hour, in this situation the queuing occurs and latency grows.*

Not all networks are created equal. Higher grade broadband services usually are built on networks with more capacity and the ability to deal more efficiently with high loads. Generally speaking, better quality connections cost more as they are more expensive to build and maintain.

### Overcoming Latency

Since we have already established that there is a finite limit to the speed of the network (that is we can't make light go faster), then how do we overcome issues related to Latency? One approach is to optimise the network with compression or optimisation devices. This is a very widely accepted practice but requires a device in the source and destination to be effective. There are proxying techniques; storing Internet or private data on a server closer to the user for frequently requested web pages and network resources that will improve the user experience.

But one of the most effective techniques is to increase the bandwidth. Increasing the available bandwidth removes the bottlenecks and allows the data to flow as quickly as possible without the impact packets being queued at the various network elements.

### How Fusion Broadband Bonding Helps with Latency

Fusion Broadband is the most cost-effective and simple way to increase your bandwidth. We combine broadband connections regardless of ISP into one single Internet connection. In short, we are ISP- and technology-agnostic solution.

Our customers can connect to the Internet via any combination of ADSL, BDSL, and SHDSL. None of the individual Internet connections are required to have the same bandwidth. We can even add 3G to the mix and overcome wired broadband outages.

## Effects of bonding on Speed and Latency

With a standard ADSL service there is little to regulate, control or influence the induced latency caused by overloading a link. Typically when a Ping / Latency test is performed this is done on an unloaded link. Simple tests like many available through online services send a small amount of packets over the link under test to see the "physical" Latency, however they do not provide the user an understanding of how the link will perform when under load.

Many broadband connections are subjected to packet queuing and network element overload (as mentioned above).

As the load on a given broadband connection increases there comes a point where packet scheduling / queuing starts to occur; at this point latency starts to grow. This usually happens within about 5-10% of the total capacity of the given broadband link. So it would be ideal to:

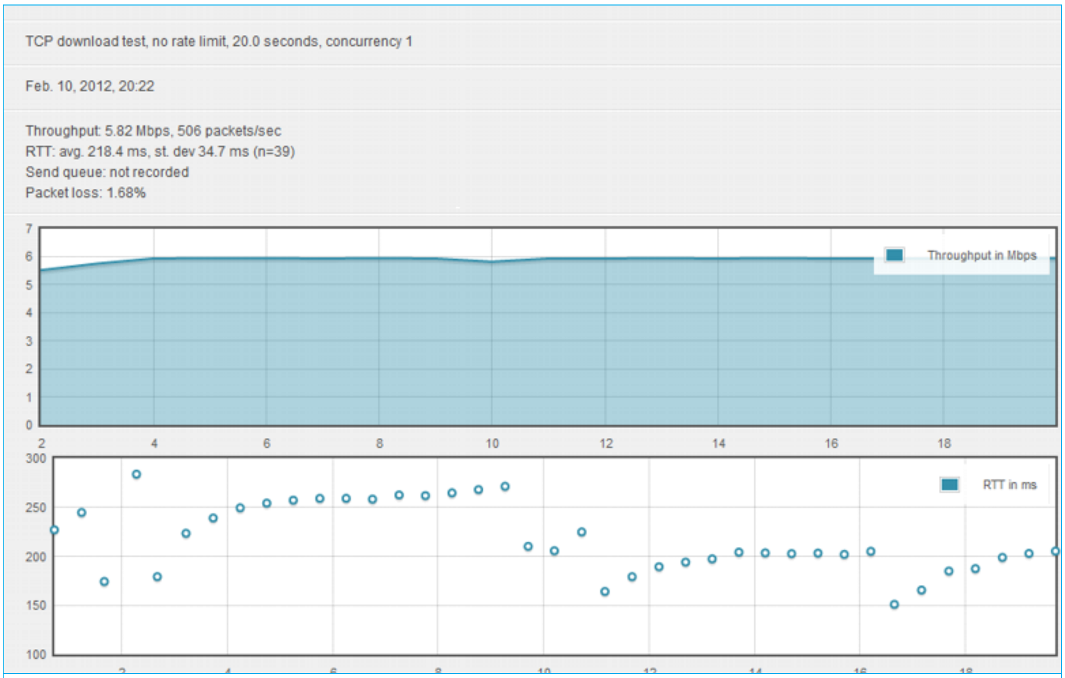
1. Be able to understand when the packet queuing occurs (latency grows); and
2. Be able to regulate the connection speed to reduce the occurrence **or** prevent this.

This is particularly important for connections that carry interactive services, VOIP, Video, terminal services etc. Basically the unloaded Ping time is important but not critical. Loaded ping time is critical as this impacts the user experience when your broadband connection is being used. In a live case study (examples below) we have a site with two ADSL2+ connections, the site is a considerable distance from the exchange so speeds in both directions are less than ideal. Each connection is supplied from a different provider with different network elements and different back haul paths and routing infrastructure.

In the graphs below (and on the following pages) we have performed a number of our broadband tuning tests on the two connections that are bonded.

## Graph A:

Shows ADSL connection 1. This test is a simple test of the connection under full load for 20 seconds in a downlink direction. You can see that the stability of the connection is very good. Throughput is shown to be at **5.8Mbps**, which is a good result given the distance that the connection is from the local exchange. The interesting thing to note is the Latency, **218ms**, this is a lot. However if you were to perform a simple ping test over this link without any load you would see the connection show a result of around 25ms in ping time. The difference is one test is under load and the other is not.




Graph A

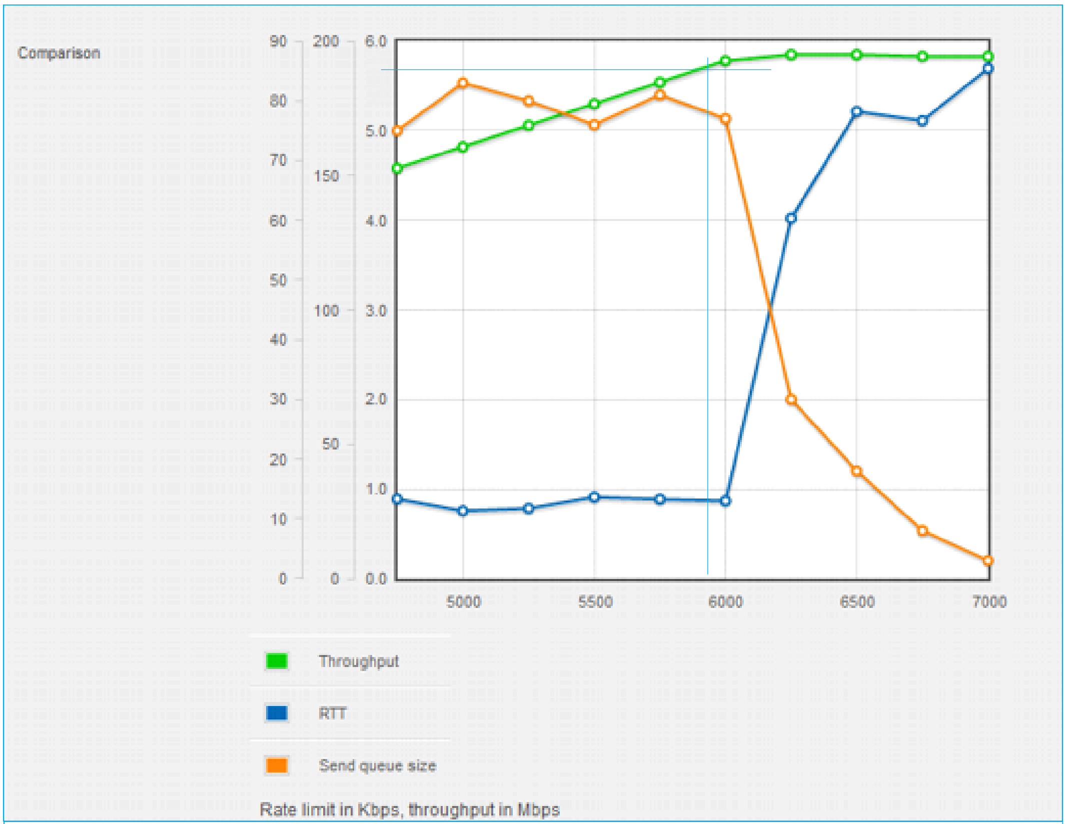
### Graph B: ( Below)

In this test, we progressively load up the link by downloading over a 20 second period, with throughput levels shown in the X-axis at the bottom of the graph (4.75, 5.00, 5.25, 5.5, 5.75, 6.0, 6.25, 6.5, 7.0 Mbps). The throughput (i.e. the rate we are actually downloading at) is shown in the Green Line. You can see this rise as we are asking for more and more data. T he Blue line is representing the Latency (ping time), here you can see that the latency is fundamentally quite stable until the throughput reached is approximately **5.8Mbps** (shown by the Red lines on the Y-axis) once we try and load up the connection beyond this point you can see the latency suddenly increases dramatically, shown in the Blue line. It very quickly increases to more than 8 times the average. In addition the Orange line shows us that packet queuing is occurring by the sudden drop of this indicator towards zero.

In this situation if we control the speed of the connection to a level just before latency grows and packet queuing occurs we can have a much more stable connection and provide a much better user experience through controlling the effect of the latency increasing.

What we are able to see from this test is that we can achieve a reliable and usable **5.8Mbps** on this link with a loaded ping time of around **25ms**. If we pull data at an unregulated speed from this connection we will induce

significant latency >**200ms** into the connection and ultimately reduce throughput.

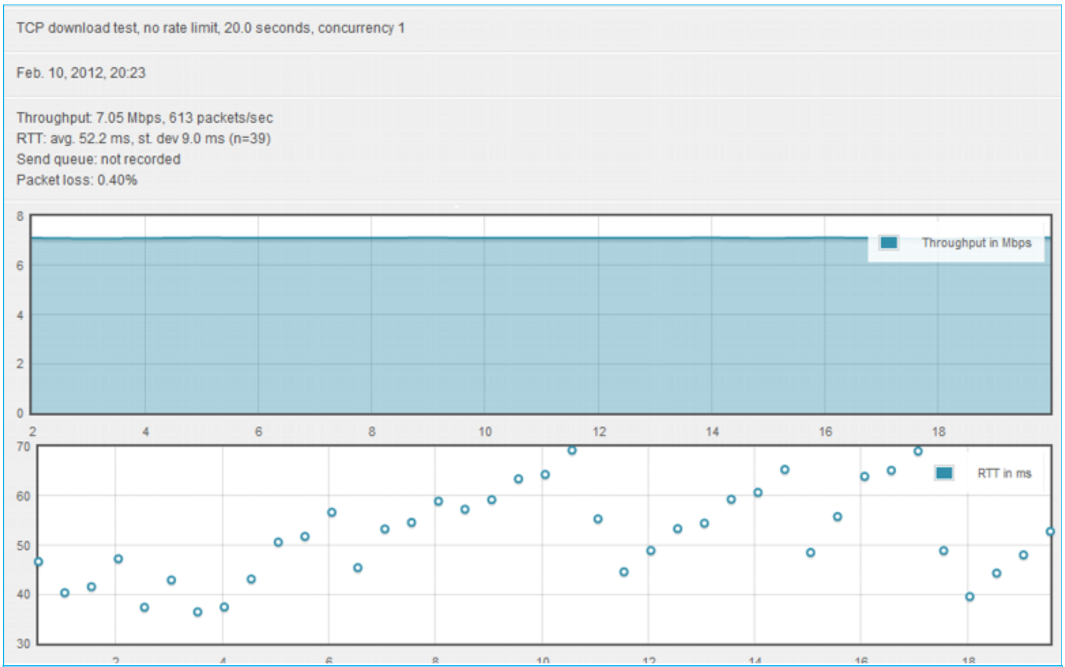



Graph B

## Graph C:

This Graph is showing the same test as **Graph A** but on the second ADSL line, Connection 2.

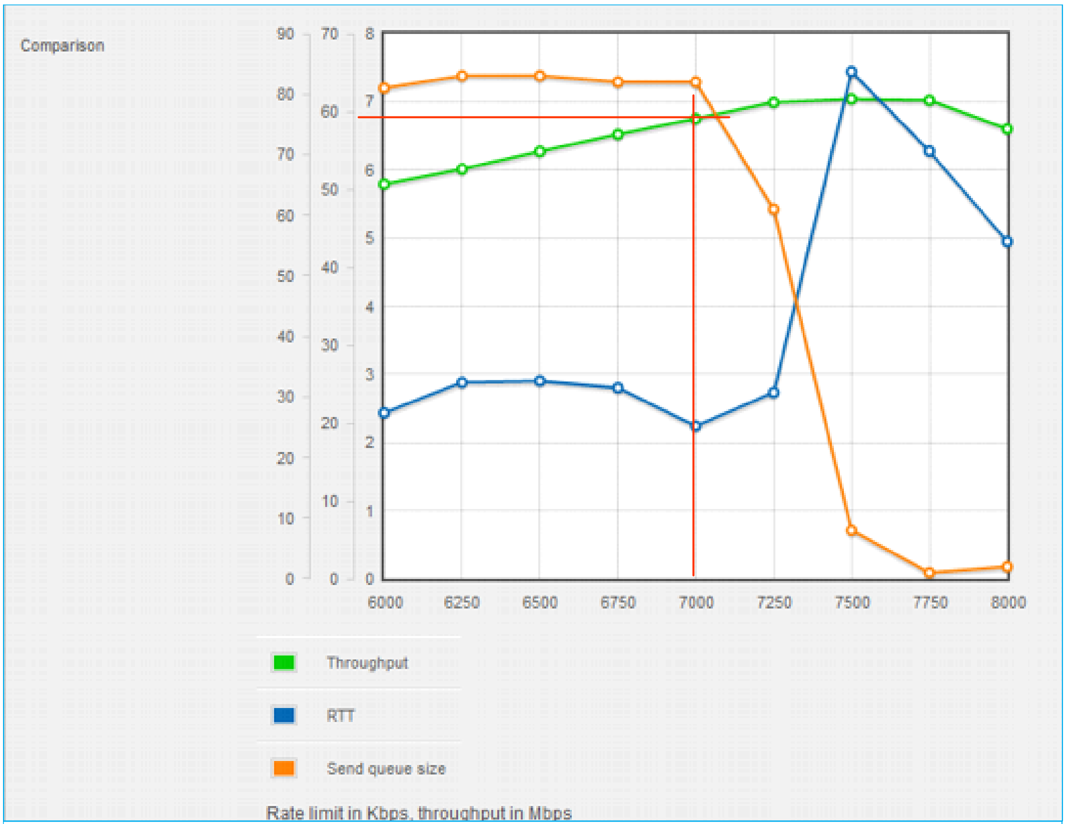
Here you will see that this is a better performing connection insofar as speed and latency. This connection is providing us with a speed of just on **7Mbps** and a loaded latency of less than **60ms**.




Graph C

## Graph D:

Like **Graph B**, this is a test showing how the link performs under a progressive load. This shows us that this connection gives us a reliable speed of up to about **6.8Mbps** (shown by the **Red Lines**). After this point we can see the latency very quickly doubles to over **60ms** and throughput starts to drop.




Graph D

## Bonding:

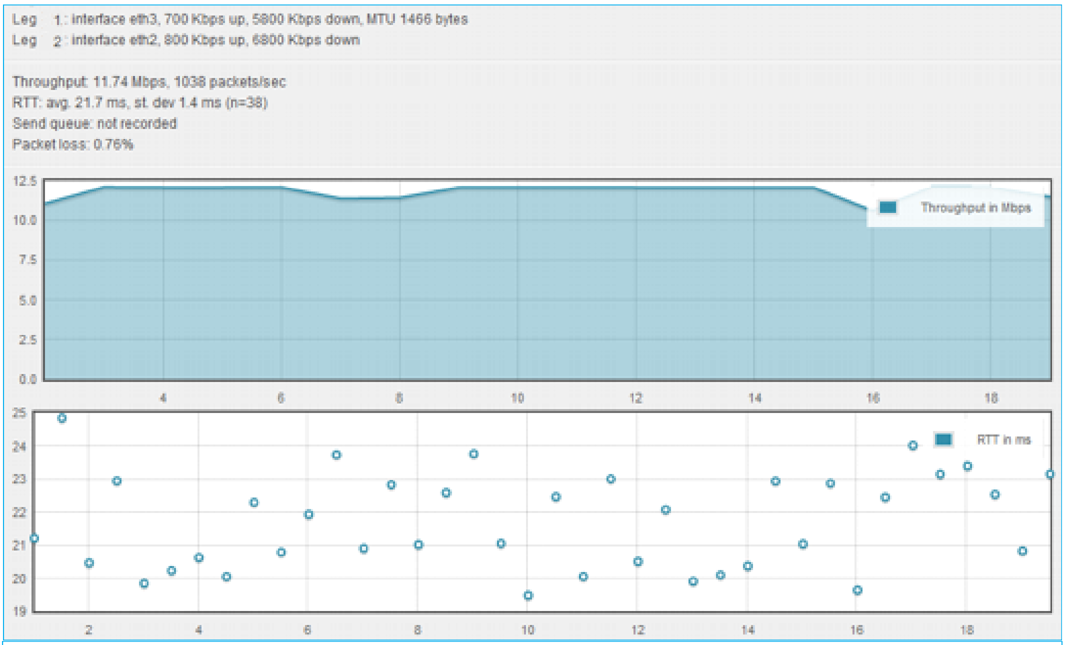
Using bonding and our link management, if we were to set a upper download limit on connection 1 of **5.8Mbps** and a limit on connection 2 of **6.8Mbps** we will see the throughput of the bonded connection close to the sum of the two connections (1+2) less about 5-10% in bonding overhead. (5.8+6.8 = 12.7 – 8% overhead = 11.6Mbps )

**Bonding overhead** is effectively the administrative overhead on the packets and the connection that bonding uses. Typically it is between 5-10%

### Graph E:

Shows us a bonded result using exactly the same test as **Graph A** and **C**, which is an unlimited download test of 20 seconds.

In the graph you will see that our Bonded down load speed is **11.7Mbps** with a latency of **21ms** and a standard deviation of very low 1.4ms. This result is for completely non-compressible data and would give an excellent user experience regardless of connection load, Interesting to note is that the latency is under control and stays in an acceptable range.

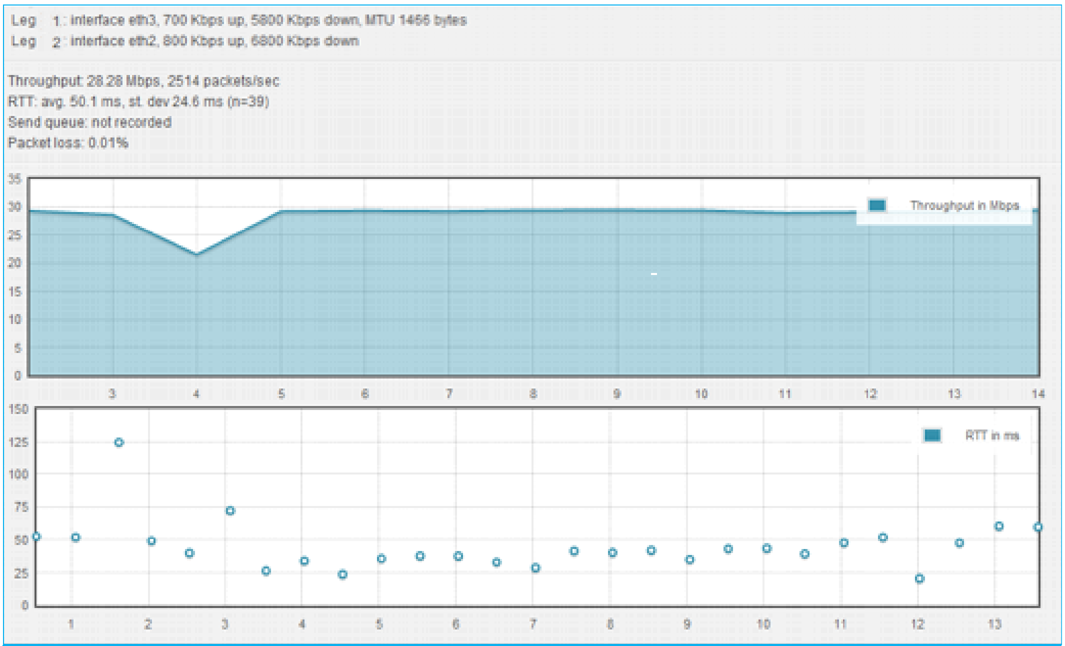



Graph E

### Graph F:

Shows us the exact same test as **Graph D**, however this time we have turned on "Compression". This allows us to compress ALL compressible data in the up- and downlink directions.

Different data is compressible to different degrees. What we are able to see here is that the actual speed of the connection is now running at over **28Mbps**, latency has grown (due to compression running) to **50ms** but the massive increase in throughput more than makes up for the increase in latency which is still less than the best of one of the connections under full load.




Graph F

**Remember this result is created from bonding two ADSL connections. Connection 1,running at 5.8Mbps with RTT under load of over 200ms. Connection 2, running at 7.0Mbps with Ping under load of over 70ms.**

### Contact

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