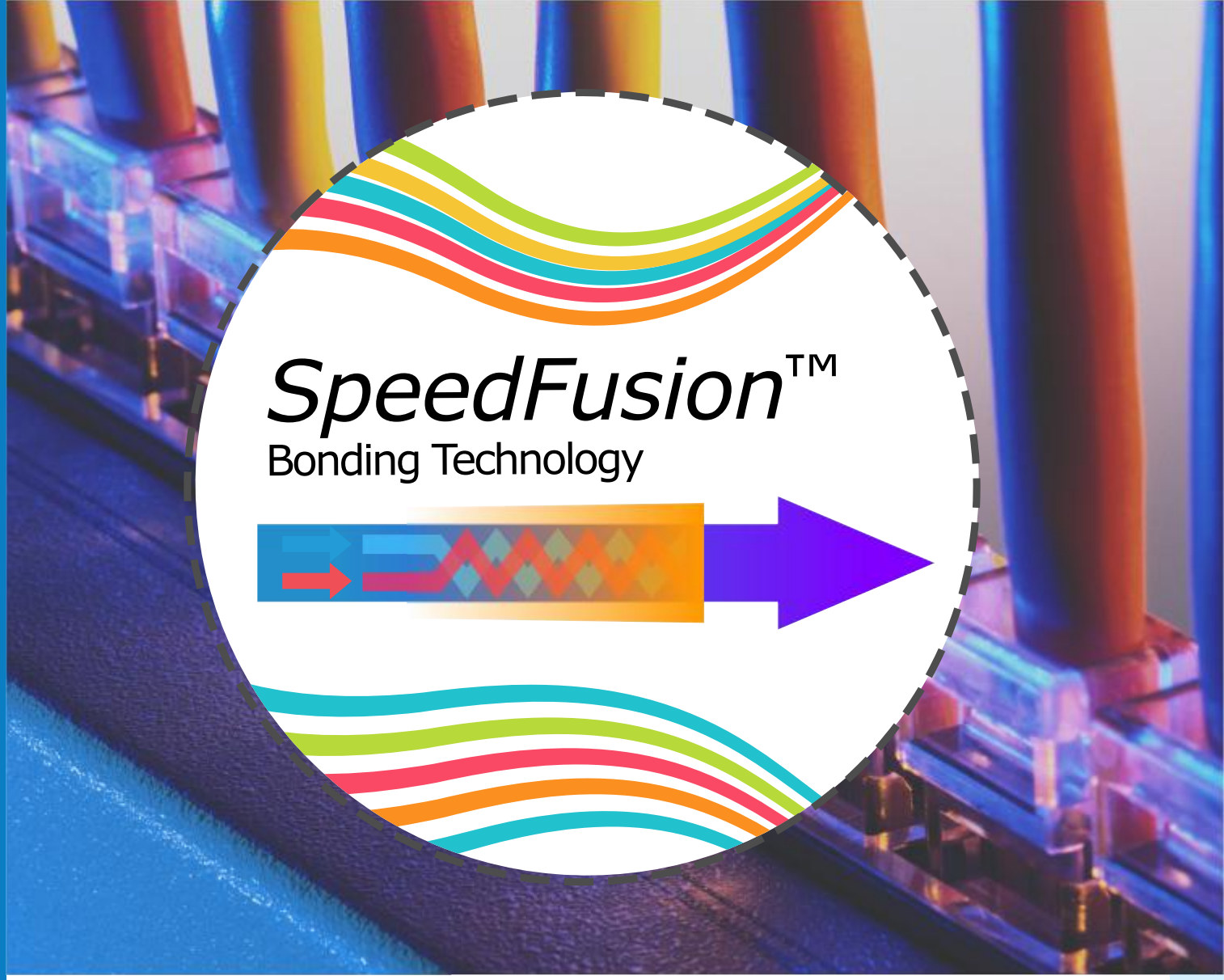


peplink

SpeedFusion : Best Practices

How to get the most out of SpeedFusion VPN bonding

Version 1.2 04/2013

Introduction to SpeedFusion

The purpose of this whitepaper is to explain how SpeedFusion works and to detail best practices for SpeedFusion VPN bonding deployment so that partners and end users can get the most out of SpeedFusion-enabled Peplink and Pepwave devices.

The intended audience is current customers and value added resellers who are deploying and integrating SpeedFusion-enabled devices in their networks.

Technology Overview

SpeedFusion is a proprietary, patent pending VPN bonding technology. Considering its complexity, it is arguably the world's easiest to setup and use site-to-site VPN technology.

Since this is a VPN technology and VPN is a point-to-point protocol, two or more SpeedFusion-enabled devices are required, just as you'd expect.

One of SpeedFusion's most powerful features is that it can use multiple WAN links to create a single logical VPN tunnel between devices. This allows SpeedFusion bonding to provide two key functions: bandwidth aggregation and VPN reliability.

All WAN links connected to a SpeedFusion-enabled device can simultaneously work together as a single logical VPN connection. If a link fails, SpeedFusion can detect this failure and seamlessly redirect traffic, at a packet level, across other available links. This WAN link failure detection at the packet level allows SpeedFusion to provide VPNs with highly reliable and resilient site-to-site connectivity.

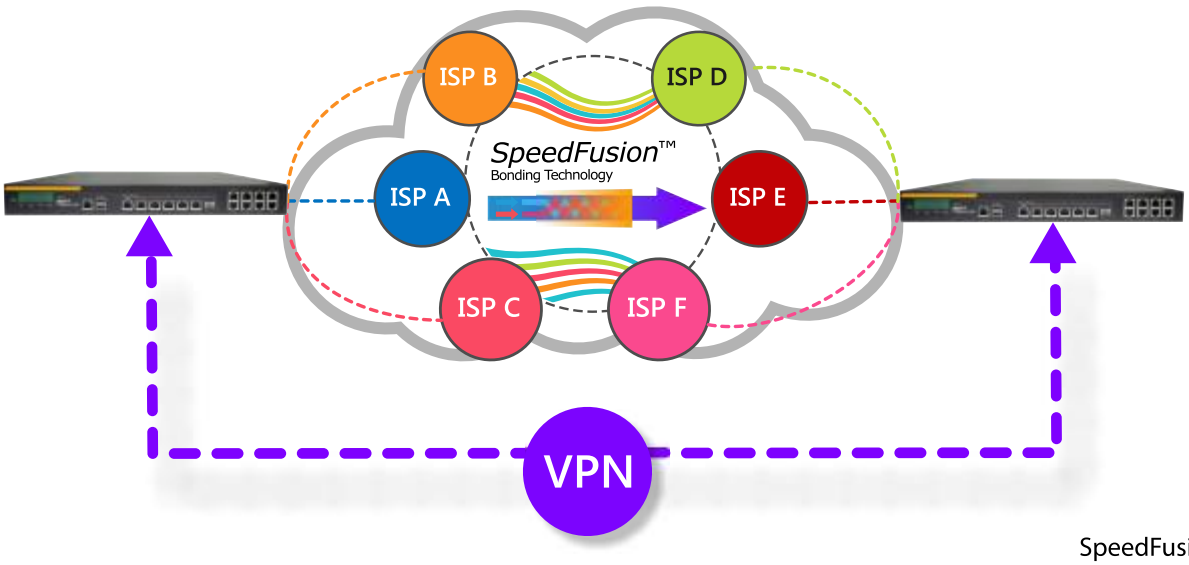
Probably the worlds easiest VPN

How to set up a site to site VPN using SpeedFusion on Peplink Balance Routers

ONLY 8 STEPS

1. Login to device A
2. Click **Network** > **SpeedFusion** > **New Profile**
3. Give the profile a name & enter device B's ID
4. Click Save and Apply.
5. Login to device B
6. Click **Network** > **SpeedFusion** > **New Profile**
7. Give the profile a name, enter device A's ID and one of device A's external IPs.
8. Click Save and Apply.

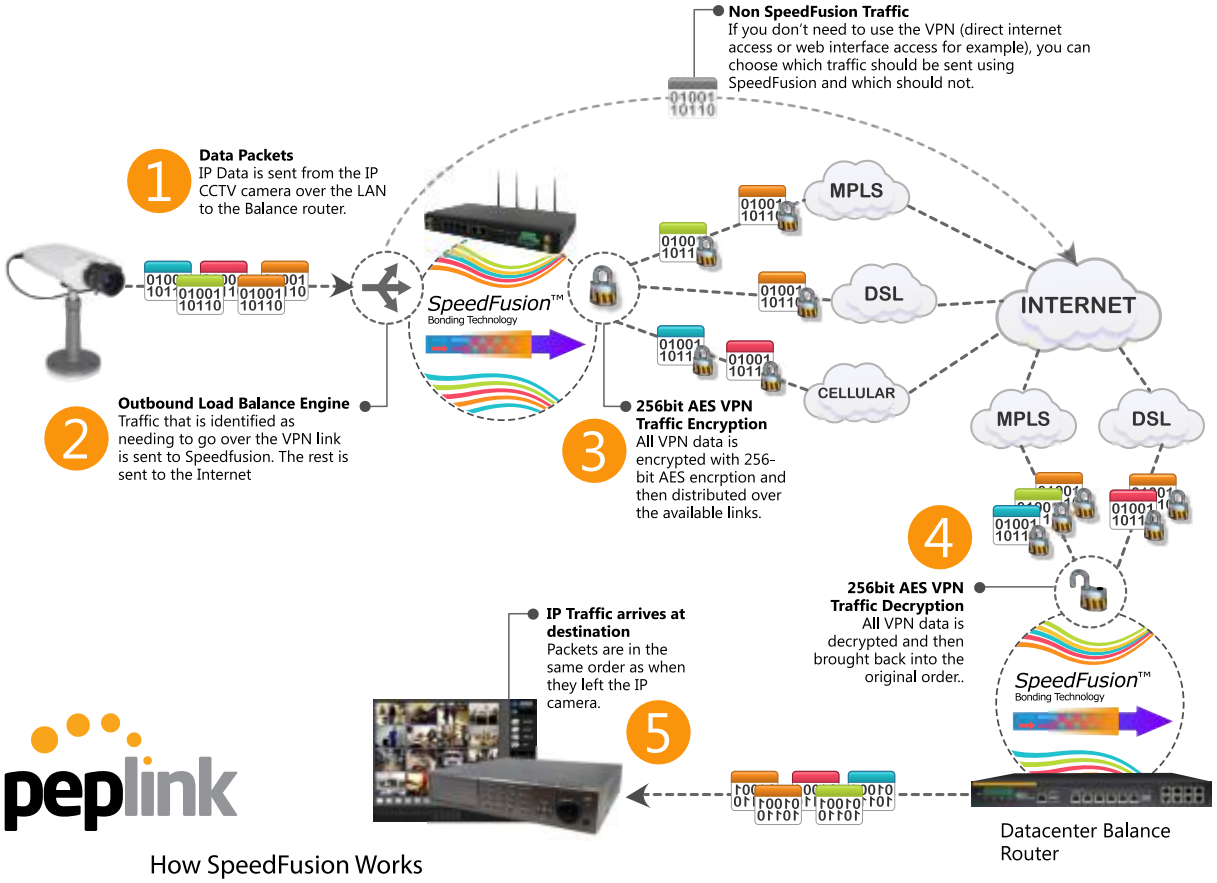
In just eight easy steps, you now have a bonded VPN connection between your devices and locations.



SpeedFusion VPN

How SpeedFusion Works

Below is an example of how SpeedFusion can be used to transmit IP video from a remote location to a central datacenter over multiple WAN Links.



How SpeedFusion Works

An Example of How SpeedFusion Works

1. Data from the remote site is sent to a SpeedFusion enabled device.
2. Outbound traffic rules dictating which traffic should go over the VPN are applied.
3. SpeedFusion encrypts and encapsulates incoming traffic insides a UDP stream and then distributes it over available links.
4. SpeedFusion receives the UDP stream at the datacenter location, then decrypts it and reassembles traffic packets back into the same order as it was originally transmitted.
5. The device at the datacenter receives the traffic exactly as it was sent by the remote location

The Power of Outbound Policies combined with SpeedFusion

Separately, both outbound policies and SpeedFusion are very powerful tools. Together, they form a versatile traffic management solution that enables you to design and deliver complex rule- and logic-based traffic management solutions.

With this combined solution, you can decide which traffic should go over the VPN connection and which should go direct. When traffic is routed directly, you can also make outbound traffic decisions based on WAN link availability, as well as WAN link characteristics, such as lowest latency or least used.

Using SpeedFusion Behind a Firewall

If a Peplink Balance is placed behind a firewall, simply define firewall rules and inbound port forwarding policy in order to allow VPN traffic to pass through the firewall.

By default, SpeedFusion uses **TCP port 32015** and **UDP port 4500** for establishing VPN connections and transmit data. However, you can change the Data Port assignment in your SpeedFusion profile to another value.

The SpeedFusion Bandwidth Overhead

SpeedFusion bonded VPN requires all transmitted data to be encapsulated in a special UDP stream. This stream contains additional packet headers with all the information needed to reconstruct the original data stream in the correct order at the remote location.

SpeedFusion adds **an additional 80 bytes** of data to each packet sent over a SpeedFusion connection, no matter what size the original data packet is. This compares well to the 58 bytes of overhead required by IPsec, especially considering that SpeedFusion is not only providing advanced routing and load balancing but 256 bit AES encryption within the tunnel too.

SpeedFusion and The Internet Mix (IMIX)

Internet Mix (IMIX) is a measurement of typical Internet traffic passing through network equipment, such as routers, switches, or firewalls. When measuring equipment performance using an IMIX of packets, performance is assumed to resemble what can be seen in real life.

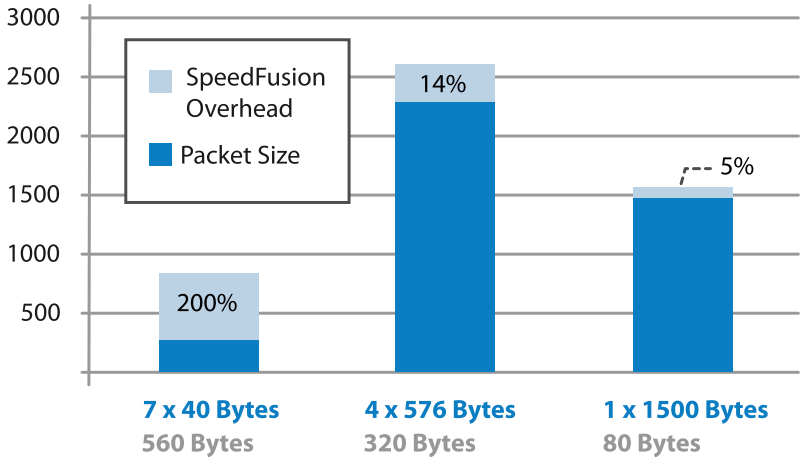
The IMIX traffic profile is used in the industry to simulate real-world traffic patterns and packet distributions. IMIX profiles are based on statistical sampling done on Internet routers. More information about IMIX can be found here:

http://en.wikipedia.org/wiki/Internet_Mix

Packet Size	Packets #	Distribution in Packets	Bytes	Distribution in Bytes
40	7	58%	280	7%
576	4	33%	2304	56%
1500	1	8%	1500	37%

A Packet level breakdown of the IMIX Standard (Total of 4084 Bytes)

The IMIX standard and SpeedFusion Overhead



Graph showing the effect of SpeedFusion overhead against the different packet sizes and quantities of the IMIX standard

As the chart on the left shows, when a SpeedFusion VPN tunnel is used to transmit IMIX data (4084 bytes), an additional 960 bytes of SpeedFusion overhead is required.

The SpeedFusion overhead is 19% of the total transmitted data (IMIX + overhead). Since it uses a fixed number of bytes per packet transmitted (an additional 80 bytes), SpeedFusion is much more efficient when transmitting larger packet sizes.

At packet sizes of 1500 bytes, SpeedFusion adds just 5% bandwidth overhead, but at packet sizes of 40 bytes, SpeedFusion overhead rises to 200%.

Calculating & Comparing VPN Overhead

SpeedFusion (80 Bytes)

$$\frac{7x80 + 4x80 + 1x80}{(7x80 + 4x80 + 1x80) + (280 + 2304 + 1500)} = 19\%$$

IPsec (58 bytes)

$$\frac{7x58 + 4x58 + 1x58}{(7x58 + 4x58 + 1x58) + (280 + 2304 + 1500)} = 14.6\%$$

In Summary...

For **only 4% of additional overhead** compared to IPsec, SpeedFusion includes bandwidth aggregation & WAN resilience.

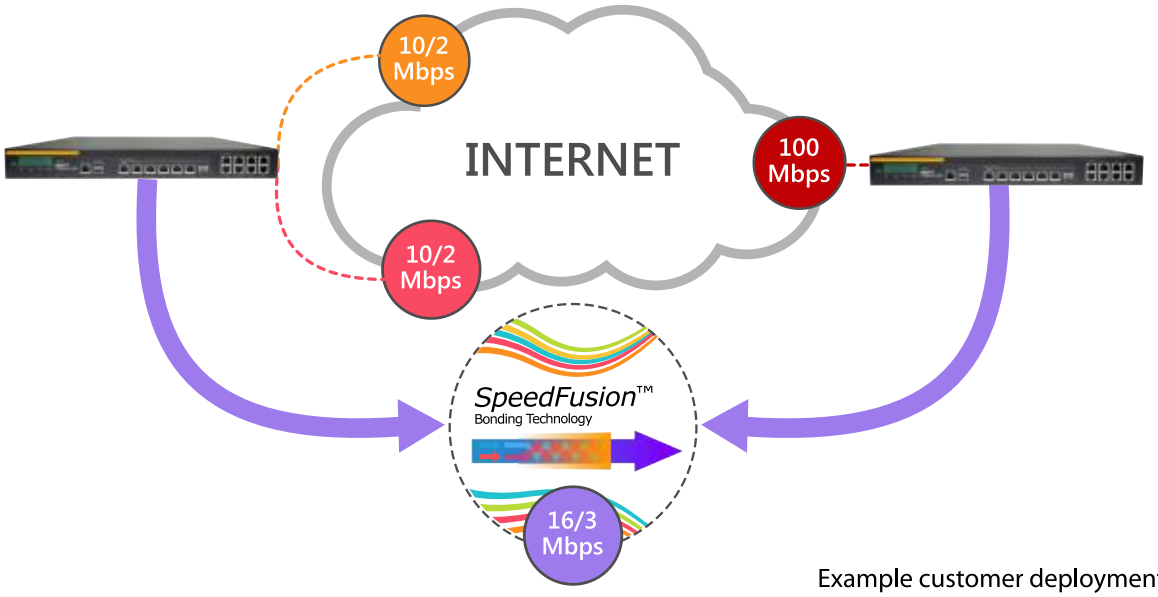
Calculating SpeedFusion Bandwidth Overhead

Using SpeedFusion for Bandwidth Aggregation across Multiple Links

SpeedFusion is often deployed to new customers who have just a single Internet connection but want more bandwidth. So, they buy an additional connection with the intention of using SpeedFusion to bond the two links.

Without understanding SpeedFusion bandwidth overhead, a user might be confused by bandwidth availability using SpeedFusion bonding across links.

Consider the following configuration:



Example customer deployment

Accounting for SpeedFusion bandwidth overhead and assuming the traffic passing across the links is similar to the IMIX standard mentioned previously, we can calculate available real-world bandwidth at the remote site:

Download: 10Mb + 10Mb = 20Mbps - 19% = 16.2Mbps
Upload : 2Mb + 2Mb = 4Mbps - 19% = 3.24Mbps

It is important to explain SpeedFusion bandwidth overhead to your end users so that they understand why they will not get full 20Mbps/4Mbps bandwidth when using VPN bonding.

Remember, conventional VPN technology such as IPsec has an overhead of 14.6%. For only 4% of additional overhead, SpeedFusion provides **bandwidth aggregation** & **WAN** resilience.

SpeedFusion is a great MPLS complement / alternative

Customers with existing expensive MPLS & Leased Line circuits can take advantage of SpeedFusion's ability to bond lines from any provider, to complement or completely replace these circuits.

The SpeedFusion Solution can provide

1) ISP/Carrier Diversity & Redundancy
2) Lower cost per Mbps

SpeedFusion Isn't Just about Bandwidth Aggregation

The big benefit of SpeedFusion is VPN reliability and the highly available connection it provides (with packet level fail-over).

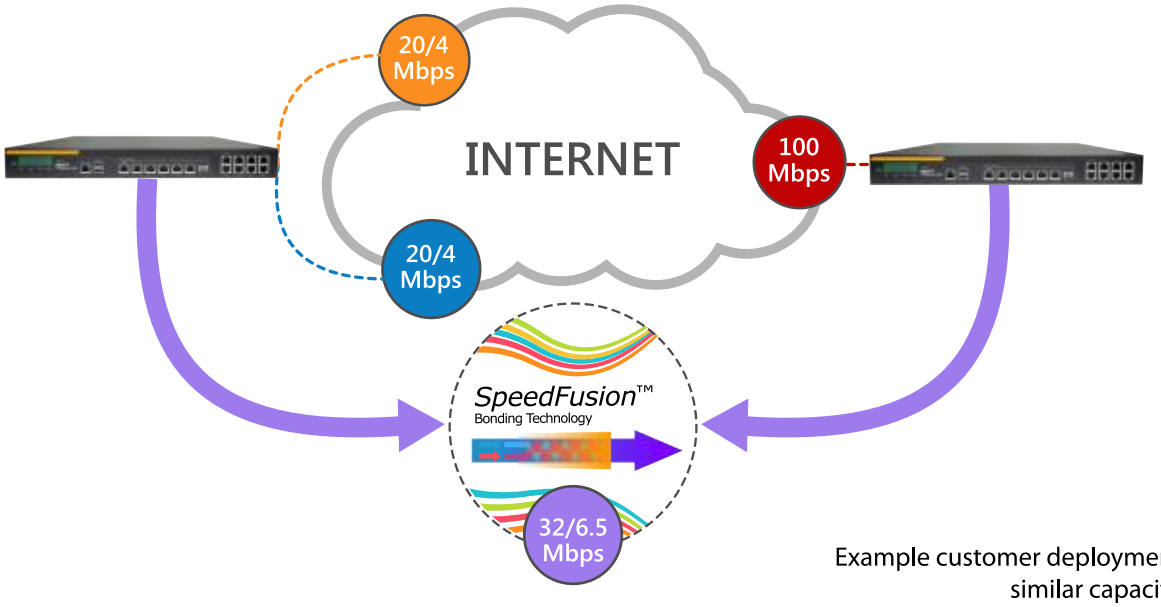
Customers can take advantage of this reliability and use a pair (or more) of low-cost DSL circuits to achieve higher reliability and throughput than comparable private circuits – often at up to 80% less cost.

Our Recommendation

Use SpeedFusion for Bandwidth Aggregation across Multiple Links with Similar Capacities

We always recommend the use of WAN links with similar bandwidth profiles from different ISPs to allow for the best possible SpeedFusion throughput.

Using at least two different ISPs offers the benefit of provider diversity, which means less chance of a technical (or even accounting/billing) error causing a network outage. Provider diversity also lessens the impact of bandwidth sharing, a common problem when using multiple circuits from a single provider.



Example customer deployment with similar capacity links

Download : 20 + 20 = 40 - 19% = 32.4Mbps
Upload : 4 + 4 = 8 - 19% = 6.48Mbps

The above configuration example uses two DSL circuits from two different ISPs, each circuit having a similar bandwidth profile, as the best use case for fixed line SpeedFusion bonding.

Remember that SpeedFusion Provides Seamless Failover, too.

SpeedFusion is not just about bandwidth aggregation. Customers can achieve seamless packet level failover across all WAN links of any bandwidth capacity.

This allows the use of multiple inexpensive, high-capacity WAN links in place of a single very expensive private circuit, with the added benefit of being able to easily and quickly add additional inexpensive circuits to provide extra bandwidth as needed.

Multiple WAN links from multiple ISPs offer **higher levels of resilience** than single (or even multiple) circuits from a single provider.

Not All Internet Connections Are Created Equal

The Effect of WAN Link Characteristics on SpeedFusion VPN Connections

Another important factor to consider is the quality of the WAN links connecting SpeedFusion-enabled devices. Let's consider some of the typical drivers for using SpeedFusion in the first place:

1. **Internet Connection Bandwidth Availability** – SpeedFusion is often deployed by customers who are limited to slow DSL or cellular connections at a given location. Typically, these customers want to combine these slow links to create a faster aggregate connection between locations.

2. **Internet Connection Reliability** – We often see poor physical line quality at customer locations, particularly DSL using old copper (and sometimes even lead) cable over a long run from the nearest exchange or POP. These connections are inherently unreliable and can sometimes be affected by rain ingress into the physical circuits, as well as temperature changes.

   We also see customers who have no physical lines and want to use cellular connectivity. Naturally, the quality, bandwidth availability, and reliability of cellular connections vary depending on location.

3. **Flexibility** – One of the benefits of SpeedFusion is that it is connection agnostic, so we often see customers who want to use it to bond WAN links of different technology types, such as 3G/4G, VSAT, DSL, and leased lines. Obviously, the characteristics of these connections are very different (VSAT has high latency, cellular connections have variable latency/bandwidth depending on their location/signal strength, etc.).

4. **ISP Diversity** – This is a big driver for customers who want to make sure that even if an ISP has a service issue, they can still connect using a WAN link from another ISP. The same DSL product from different ISPs can have quite different characteristics, with everything from variable contention, latency, and bandwidth availability being factors.

The two main WAN link characteristics that are important are;

1. **Packet Loss** – This is the number of data packets lost in transit.

2. **Connection Latency** – This is the time it takes a packet to travel to a destination and to be acknowledged. Closely related is jitter, or the variation in latency.

Any variation of these characteristics has an effect on the amount of WAN link bandwidth that is available for use by SpeedFusion.

Packet Loss

When the SpeedFusion engine detects packet loss on a WAN link, it reacts in a couple of different ways: First, if packet loss is excessive, the link will fail its health test and will not be used by SpeedFusion as an active link until it passes a subsequent health test.

If packet loss is low enough that the health test is green, SpeedFusion will use the link for sending and receiving data. SpeedFusion will spot when packets have been lost in transit and limit the amount of data it attempts to send down that particular link while continually checking the link for stability.

If packet loss is caused by temporary link saturation, SpeedFusion will later attempt to increase the amount of data it sends down the link. If packet loss was caused by a faulty WAN connection, SpeedFusion will detect additional packet loss on the link and further reduce the amount of data it tries to transmit on the link until the link stabilizes.

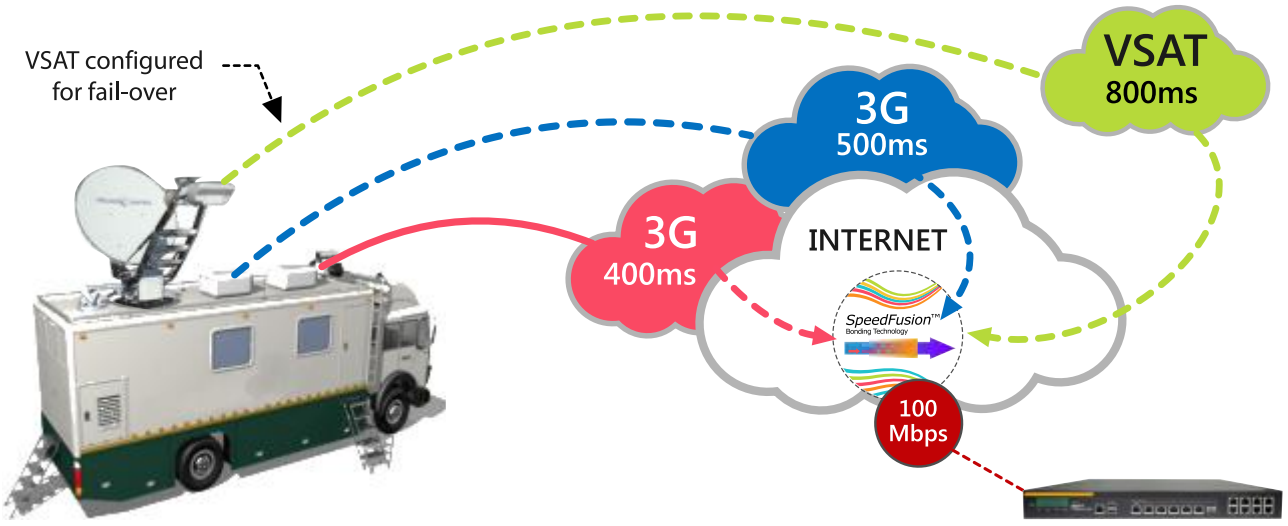
Packet loss on a link results in reduced bandwidth throughput, as traffic sent via the link is reduced until it stabilizes or SpeedFusion determines that the link cannot be used. Packet loss also causes increased latency across the VPN link, as the end SpeedFusion device waits for lost packets in an attempt to reconstruct the data stream in the correct order.

Our Recommendation

The Effect of WAN Link Characteristics on SpeedFusion VPN Connections, Continued

Latency

When latency characteristics are the same across connected WAN links, it has very little effect on SpeedFusion bandwidth throughput. However, when the latency of WAN links varies considerably, bandwidth throughput is affected.



Managing High Latency Links

In cases of high variation in WAN link latency, the best approach (assuming there is enough bandwidth on low latency links) is to allocate lower latency links for SpeedFusion while setting higher latency links as failover connections.

Another approach is to use higher latency links for specific direct traffic types that are not as latency sensitive (like direct Internet access) while reserving lower latency links for other important corporate traffic that needs to transit the VPN, such as VoIP and Citrix.

***Note**: Using UDP traffic over SpeedFusion can provide higher throughput than TCP which has restrictive flow control.*

The effect of Latency on SpeedFusion

1. A TCP stream is transmitted from the remote site
2. SpeedFusion encapsulates the stream and sends the data across all links
3. The datacenter must wait for slower packets to arrive over the satellite link in order to decrypt them and recreate the stream in the same order as it was sent.
4. The end result is higher latency and lower bandwidth throughput, as the buffering at the datacenter end will equalize the SpeedFusion VPN's latency to around the 800ms (or the highest link latency).

Recommended latency difference = Less than 150ms

Packet Loss in high latency environments

In the example above, there is a 3G connection which is highly susceptible to packet loss. Because the latency across the SpeedFusion link is equalized to the highest latency link (800ms), if a packet is lost on the 3G link, SpeedFusion will take longer to spot the packet loss (800ms+).

In certain conditions, such as regular timed packet loss on the above 3G link, combined with typically high latency found on these types of links, the TCP protocol method of retransmitting lost packets can have a drastic effect on available bandwidth over the VPN. This is another reason why we recommend that, whenever possible, high latency links be used for failover and not as an active SpeedFusion WAN link.

External Factors that Affect WAN Link Quality

WAN Link Testing – Use Speedtest.net

Whatever WAN connections you are using, it is always a good idea to test each individually and repeatedly to discover its maximum throughput in both directions. Remember, bandwidth availability can vary throughout the day, especially if using cellular or fixed lines with variable contention.

Customers are often surprised by how bandwidth availability can vary between links from the same ISP and how different actual bandwidth availability can be from that advertised by the ISP.

Cellular and Satellite Bandwidth Availability

The amount of bandwidth available on a 3G/4G or satellite data connection is dependent on a number of factors:

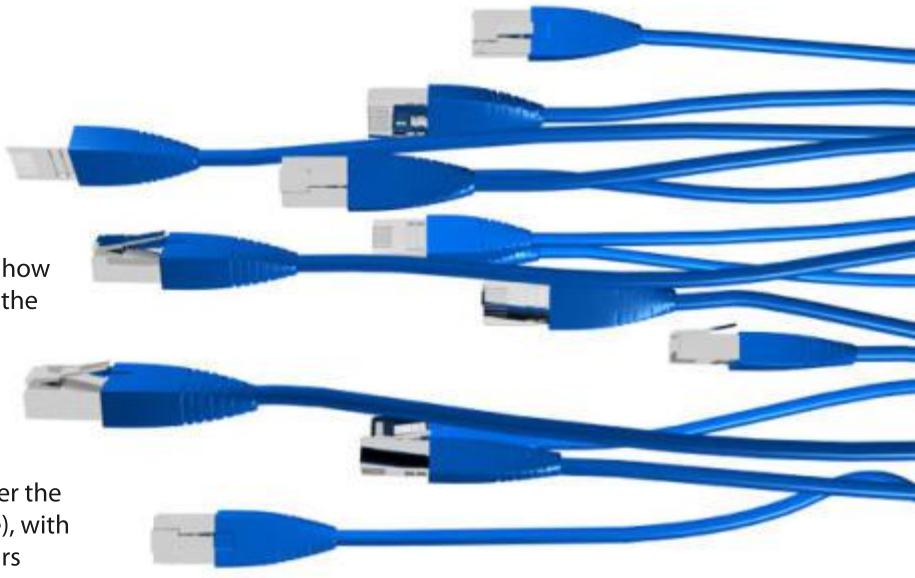
- **Signal Strength** – Determined by the distance to the nearest cellular tower (or visibility of the satellite) and the subsequent signal quality received.
- **Backhaul Bandwidth Availability** – From the cellular tower to the ISP's core network or from the satellite ground station to the ISP's core network.
- **Device Contention** – At the tower or satellite you are connected to (determined by the number of active subscribers on a tower or satellite at any given moment).

We frequently see users who have 100% signal strength yet get only a small percentage of the bandwidth they would normally expect from their cellular or satellite data connection. This can be because there simply isn't enough backhaul bandwidth at a cell tower or ground station to the ISP's backbone, and what is available is saturated. Or it may be that there are a large number of devices connected to a cell tower or satellite. As such, the share of tower/satellite time allocated to the device limits the amount of bandwidth that can be transmitted and received.

When it is a matter of contention of the service, the easiest way to improve your chances of getting more bandwidth is to create another connection using an additional vSAT or cellular modem connection. This allows you to get twice as much of the time allocated to your devices, and the amount of bandwidth shared with you for your SpeedFusion connection is increased. However, very little can be done if the bottleneck is the backhaul from the tower or satellite to the ISP's core network, apart from complaining to the ISP in the hope that they will upgrade the core network.

Fixed Line Contention

Most internet connections are provided as a contended service. This means that although your provider has advised you will get up to 24Mbps broadband over DSL for example, depending on how oversubscribed your DSL service is (literally how many people in your area are connected to the ISP's service), the bandwidth that's actually available at any given moment could be considerably less.



The amount of bandwidth available on a contented service can vary considerably over the period of a day (and even minute to minute), with higher speeds possible during working hours compared to the evenings when your neighbours are home and using the same internet service heavily.

Adding an additional fixed line service from the same ISP can give you a 'bigger share' of the bandwidth that's available.

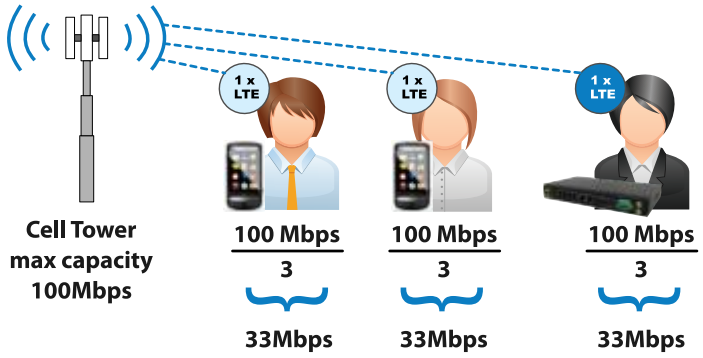
1:1 contended services are available from ISPs to counter this issue but are naturally more expensive than 20:1 or 50:1 services.

Application Considerations

The Benefits of Using Multiple Verizon LTE Connections on Contended Cell Towers

Verizon and other LTE providers use a process called windowing/time-slicing when multiple subscribers connect to their LTE services.

Single Cellular Connection



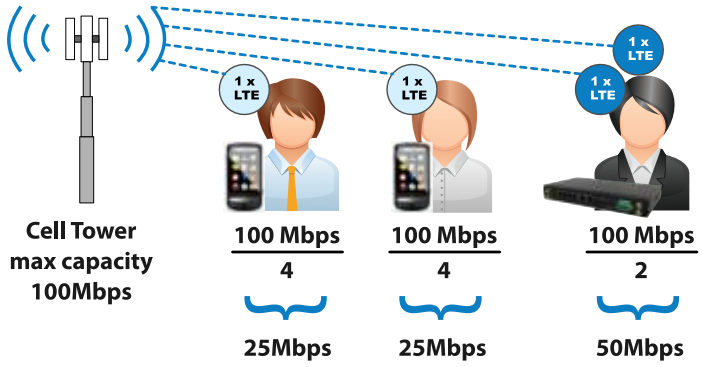
Three users and devices connected to a single tower.

In this example, three users with three LTE-enabled devices connect to a cell tower. Each gets 33Mbps, which is a third of the available bandwidth at the tower.

100Mbps / 3 =

33Mbps

Dual Cellular Connections



Three users and devices (but four LTE connections) connected to a single tower.

In this example, the third user is using a Pepwave MAX device and has installed an additional LTE data SIM.

There are now three devices with four LTE connections connected to the cell tower.

The first two users get one quarter of the available bandwidth (25Mbps), but
the third user gets two quarters (or half) of the available bandwidth using his two LTE connections.

100Mbps /2 =

50Mbps

Multiple Cellular Connections Deliver a Larger Share of Available Bandwidth

As the above diagrams show, adding an additional cellular connection does not always mean a doubling of available bandwidth, especially if both connections are from the same ISP.

However, an additional cellular connection can provide the end user with a larger share of the available bandwidth at a tower.

www.peplink.com Follow us on twitter @peplink

United States Office

T: +1 (650) 450 9668
E: sales@peplink.com