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TRUFFLE Broadband Bonding Network Appliance

A Frequently Asked Question on

Link Bonding

vs.

Load Balancing

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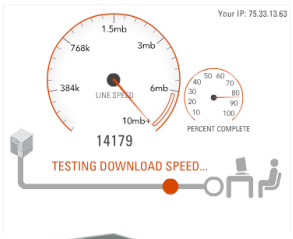
Question: What's the difference between a Truffle Broadband Bonding Network Appliance and a load balancer or load balancing router?

Short answer: Try downloading a file from behind the Truffle - you will see a big difference. With the Truffle, all of your access lines will be used to transfer the file and therefore the file download speed will be equal to the sum of all the lines. With a load balancer or load balancing router, only one of your access lines will be used to transfer the file. Truffle combines the functionality of load balancing with *link bonding* to give unparalleled performance and reliability of Internet access at low cost for small and medium sized businesses and large enterprises.



Long answer: Several load balancing devices are available on the market. Some of these were specifically designed to manage multiple Internet access links – we call these load balancers. Other devices were originally designed as Internet routers but include a load balancing feature - we call these load balancing routers. The main distinction between any of these load balancing devices and the Truffle is that Truffle provides *link bonding* for HTTP-based data transfers in the downlink direction. With link bonding, the access links are effectively combined together into a single virtual pipe so that the data transfer rate of the virtual pipe is the sum of the data transfer rates of the access links that are being combined. Load balancing devices simply distribute load at the granularity of session. For example, if a user within the local network downloads a file, it generates a server request that is sent out over a single Internet access line. As a result, the file download will only use a single Internet access line, even though the other available Internet access lines may be idle. This is primarily how the load-balancers and load balancing routers operate.

Consider the following comparison table. We consider the Truffle versus a load balancing device for a number of scenarios. Also in the comparison is Multi-link PPP – this is a link bonding approach that was originally developed many years ago. The availability of multilink PPP for Internet access is quite limited (e.g. it is generally not available in most countries including USA), but it is useful to compare for illustrative purposes.

Scenario\Solution	TRUFFLE	Load Balancing Device	MultiLink PPP Modems
File download speed with eight 6Mbps DSL lines from same ISP	48 Mbps	6 Mbps	48 Mbps
File download speed with eight DSL lines, 4@6Mbps, 4@1.5Mbps, all from same ISP	30 Mbps	6Mbps or 1.5Mbps	12 Mbps
Adapts load on each link during file transfer	Yes	No	No
Recovers from link failures during file transfers	Yes	No	Implementation dependent
File download speed with eight 6 Mbps DSL lines from different ISPs	48 Mbps	6 Mbps	Not possible requires all lines form same ISP
Ability to peer for uplink bonding	Yes	No	Yes
Inbound traffic load balancing via external DNS	Yes	Yes	N/A
Outbound traffic load balancing	Yes	Yes	N/A

In the first comparison, in the top row of the table, we consider the scenario where the DSL lines are used. It is assumed in this scenario that each of the eight DSL lines is from the same ISP and has a potential downlink data rate of 6Mbps. In this case, with a Truffle, the potential data rate of a file download is 48 Mbps, which is the sum of the available data rates.

In the second scenario with the Truffle, in the second row of the table, again there are eight DSL lines from the same ISP but they have different capabilities. Four of the DSL lines can have downlink data rates of up to 6 Mbps each, and four of the DSL lines can have downlink data rates of up to 1.5 Mbps each. In this case, the Truffle is able to realize downlink data rates

of 30 Mbps, which is the sum of potential data rates. This is indicated by the entry in the second row of the table. Indeed, the data rates available may fluctuate with time according to network congestion variations. With the Truffle, the traffic load is automatically adapted in real-time in an intelligent matter to maximize data throughput. This is indicated by the "Yes" in the third row of the table.

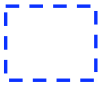
In fact, even during a file transfer if one or more links fail, Truffle automatically adapts and continues to intelligently manage traffic to maximize data throughput. If a failed link should recover in the midst of a file transfer, Truffle can utilize the available bandwidth on the recovered link. This is indicated by the "Yes" in the fourth row of the table.

In the third scenario, there are eight 6 Mbps DSL lines available again, but they are from different ISPs. In this case, a file download speed of 48 Mbps is again realizable with the Truffle, since the Truffle does not require all of the Internet access lines to be from the same ISP. Indeed, no coordination with the ISP is necessary to install the Truffle. No new equipment or software is necessary to install in order to use the Truffle.

The Truffle supports bonding of all types of traffic (including non-http) both inbound and outbound when peered with another Truffle unit or with Broadband Bonding service. In case the Truffle is installed in standalone, all http downlink traffic will be bonded and other traffic will be load balanced, as described next.

Link load balancing. Traffic can be classified as "Inbound" or "Outbound". Inbound traffic is initiated from within the public Internet and is between a host in the Internet and a local host, usually a server, located on a company's premises. Inbound traffic can be primarily in one direction or another - uplink or downlink. For example, a user within the Internet may request an object from the company's server. Since the request originates from the Internet, it is inbound traffic. However, since fulfilling the request involves transfer of data to the user, most of the traffic will be in the uplink direction. Similarly, inbound traffic can be primarily in the downlink direction if an outside user initiates uploading a file to the company's server from a remote location.

In order to provide inbound link load balancing, the BGP (Border Gateway Protocol) may be used together with equal cost multi-path forwarding. This involves configuring peering routers that are external to the company. This is an expensive solution and requires a



level of coordination that will be prohibitive to most businesses. Such businesses that need to provide high traffic public servers are usually better off outsourcing and using a server hosting service from a third party.

Other inbound link load balancers use the DNS (Domain Name Service) to provide link load balancing. In this method, on a slow time scale, inbound server requests are distributed among the available links by providing different IP address translations as a result of requests to resolve an IP address from a domain name using DNS. Truffle supports inbound link load balancing using this method.

A number of relatively low cost load balancing routers that provide *outbound* link load balancing are available on the market. Generally, these routers will distribute outbound requests on the access links in a round robin manner. Here, one must be careful, or certain applications will not work correctly. In particular, many such load balancing routers will blindly distribute sessions on the access links, even though some applications require that sessions belonging to the same task be routed over the same access link to work correctly. Usually these are low bandwidth applications that do not require multiple access links. However, they are important to support and a load balancing router must be cognizant of these issues in order for the applications to work. Truffle has been designed with this in mind, and is capable of supporting such applications in a seamless manner. Moreover, the Truffle provides this sophisticated form of load balancing even in the presence of access line failures. When an access line fails, it is automatically bypassed by the Truffle, and only available access lines are used to support data communications.

Link Bonding. As discussed above, an important difference between load balancing devices and the Truffle is that the Truffle also provides link bonding. A load balancing router provides load balancing only at the session level. In other words, traffic is distributed at the granularity

of a session. When there are a large number of sessions present concurrently, they will be distributed over the available access links. However, in the case of a file transfer, a load balancing router will use only one of the available access lines to transfer the file. With link bonding, in contrast, even a single file transfer will be able to simultaneously use all of the available access lines.

Specifically, with Truffle, HTTP-based traffic may be bonded across the available access lines at a granularity that is smaller than a single session. This means that *all* active access lines can be used *simultaneously* to support even a single application. In comparison, a load balancing router will not be able to efficiently use all the resources available. This is a unique feature of the Truffle - to be able to combine the available access links into a single virtual high-speed link. Truffle when peered with another Truffle (or with the Broadband bonding Service) can bond any type of traffic both in uplink and downlink directions. In standalone mode, i.e. by itself, however, it will bond only HTTP downlink traffic. For the other traffic types, the Truffle has functionality similar to a load balancing router in standalone mode.

Returning to the comparison table, let us now reexamine the various scenarios and desired feautres with a load balancing device instead of the Truffle, as indicated by the second column in the table. For a file download over eight 6 Mbps DSL lines from the same ISP, a load balancing device will only use one of the eight available DSL lines, and thus is limited to a maximum of 6 Mbps data rate in the downlink direction, as compared to 48 Mbps for the Truffle. In the case of DSL lines from the same ISP with varying maximum data rates, again a load balancing device will use only one of the eight available DSL links. The possible data rate achievable is either 6 Mbps or 1.5 Mbps, depending on which link is selected by the load balancing device. Also, during a file transfer, since only one link is used for the entire file transfer, a load balancing device is not able to adapt to changing data rates on the different links. If the selected line for the file transfer fails during the transfer, the transfer will fail. This

explains the two "No"s in the column in the comparison table for load balancing devices.

An alternative approach to link bonding is to use a protocol like multi-link PPP. However, this requires special hardware and software installed at the premises of the ISP. Due to the high cost of deployment, multi-link PPP is rarely deployed by ISPs, and is thus largely unavailable. Multi-link PPP was designed primarily for aggregating homogeneous links.

Coming back to the comparison table, consider the hypothetical situation where multiple modems with multilink PPP are used. This would require all links to be from the same ISP, and special hardware at the ISP facilities. In this case, with eight 6 Mbps DSL links, a total data rate of 48 Mbps could hypothetically be realized with the multilink PPP modems. However, multi-link PPP was not designed to support links with time varying data rates. In the case of heterogeneous data rate capacities, multilink PPP could hypothetically allocate the load in proportion to the data rate capacities. However, with fluctuating data rates the performance can be severely degraded since the relative offered load on the links is statically allocated. If the load is equally spread on the available links, the realized data rate is equal to the number of lines times the minimum data rate. In the scenario discussed above and referred to in the second row of the comparison table, this is 8 X 1.5 Mbps = 12 Mbps.

Also indicated in the table is that with multilink PPP, the load is not dynamically adjusted on the DSL lines, since the traffic across the links is spread in a static manner. Depending on the implementation, multilink PPP may or may not have the facility for graceful recovery in the event of a link failure.

In the scenario discussed above where the DSL lines are from different ISPs, multilink PPP cannot be used. This is also indicated in the table.

Ease of Installation. The patent pending Truffle does not require any new equipment or software to be installed at the Internet Service Provider(s), or anywhere else. The link bonding performed by the Truffle is achieved without any peering device. With a peered unit, bonding capabilities enlarge to any type of traffic from http downlink.

Futhermore, the Truffle offers a configuration option whereby no changes are required to an existing Local Area Network (LAN) with a single Internet connection. In this case, typically the Truffle is installed between the firewall and the Internet access device (e.g. DSL modem or T1 access device). This means no changes are required for IP address assignment of existing devices within the company premises, and no changes are needed in the existing firewall configuration. Most load balancing routers, in contrast, require reconfiguration of the existing LAN within the company premises. Truffle is easily configured through a graphical user interface on a web browser.

Many other optional features on the Truffle can be selectively enabled through the graphical user interface. These include firewall functionality, port forwarding, support for de-militarized zone (DMZ), DHCP service, application port binding, advanced QoS, traffic monitor, traffic filtering and traffic shaping.

Summary. Truffle represents the state of the art in link aggregation solutions, and is unique in its class. It embodies over a decade of engineering effort and incorporates sophisticated algorithms for balancing traffic and optimizing use of resources. During a file transfer, for example, the Truffle automatically adapts to available link bandwidth and access line variations to use all possible resources simultaneously in order to transfer the file as quickly as possible. Unlike other load balancing routers, where support for link aggregation is almost an afterthought, the patent pending Truffle is designed specifically for link aggregation and incorporates sophisticated algorithms that dynamically optimize the use of all available resources. For example, a source of delay and unreliability in Internet access is in provision of DNS. Truffle leverages parallel paths to disjoint DNS servers, when available, and optimizes parallel DNS requests for improved latency and reliability of DNS.

In short, the Truffle is the best of breed link aggregation device designed for small and medium sized businesses and larger enterprises. While other devices often fail in the task of link aggregation, the easy to install Truffle, delivers uniquely exceptional performance and reliability for Internet access, resulting in significant cost savings as compared with obtaining Internet access through a single Internet connection.