8-18-2005

HIERARCHICAL FIREWALL LOAD BALANCING AND L4/L7 DISPATCHING

Stephen M. Goddard
Lincoln, NE

US 20050183140A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2005/0183140 A1

Goddard (43) Pub. Date: Aug. 18, 2005

(54) HIERARCHICAL FIREWALL LOAD BALANCING AND L4/L7 DISPATCHING

(76) Inventor: **Stephen M. Goddard**, Lincoln, NE (US)

Correspondence Address:
HARNESS, DICKEY, & PIERCE, P.L.C
7700 BONHOMME, STE 400
ST. LOUIS, MO 63105 (US)

(21) Appl. No.: 10/989,242

(22) Filed: Nov. 15, 2004

Related U.S. Application Data

(60) Provisional application No. 60/523,858, filed on Nov. 20, 2003.

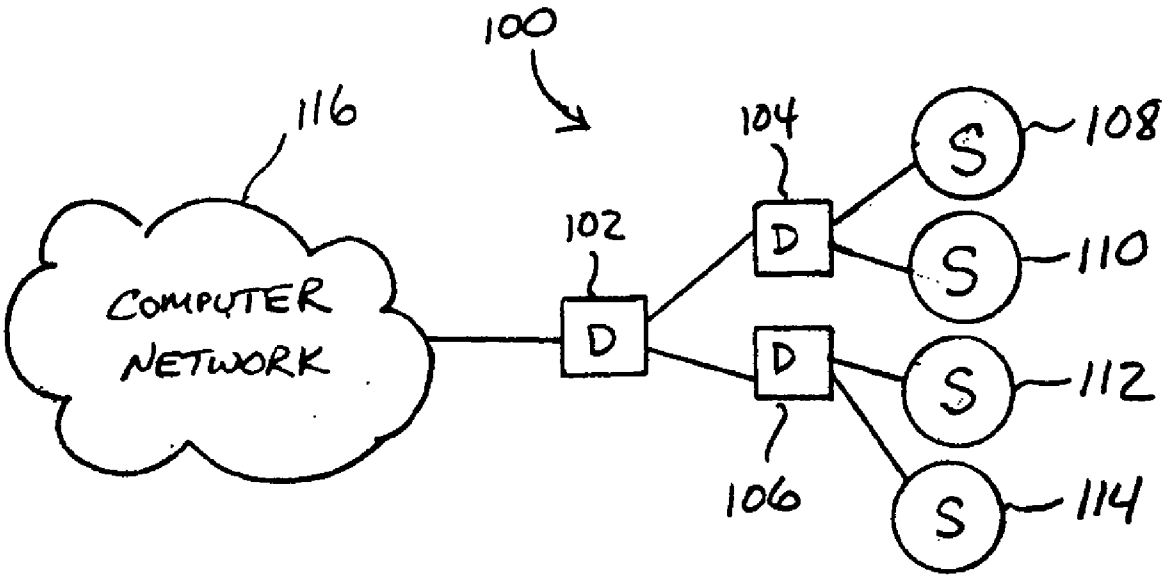
Publication Classification

(51) Int. Cl.[7] G06F 11/30

(52) U.S. Cl. 726/11

(57) ABSTRACT

A secure cluster-based server system includes a plurality of firewalls, a plurality of back-end servers, a logically external firewall dispatcher, a logically internal firewall dispatcher, and a plurality of second stage dispatchers. The external firewall dispatcher is configured for routing packets received from the external network through one or more of the firewalls to the internal firewall dispatcher, the internal firewall dispatcher is configured for dispatching packets received from the one or more firewalls to one or more of the second stage dispatchers, and the second stage dispatchers are configured for dispatching packets received from the internal firewall dispatcher to one or more of the back-end servers for processing. A computerized method of interfacing an external network to a cluster-based server includes receiving packets from a plurality of firewalls with a first stage dispatcher, dispatching each received packet from the first stage dispatcher to one of a plurality of second stage dispatchers, and dispatching each packet received by one of the second stage dispatchers to one of a plurality of servers for processing.



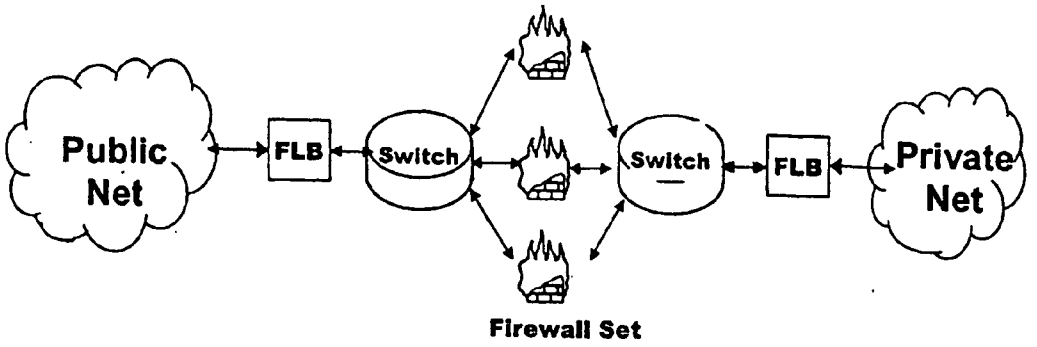


Figure 1: Typical firewall sandwich.
Prior Art

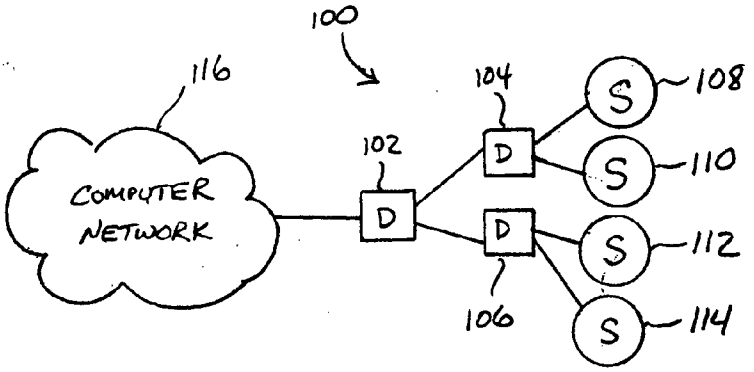


FIG. 2

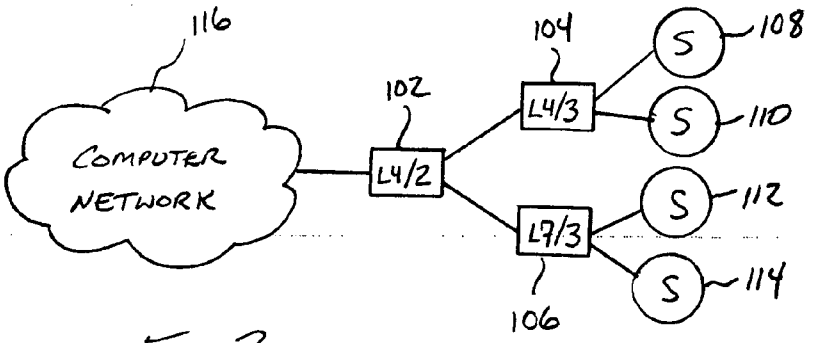


FIG. 3

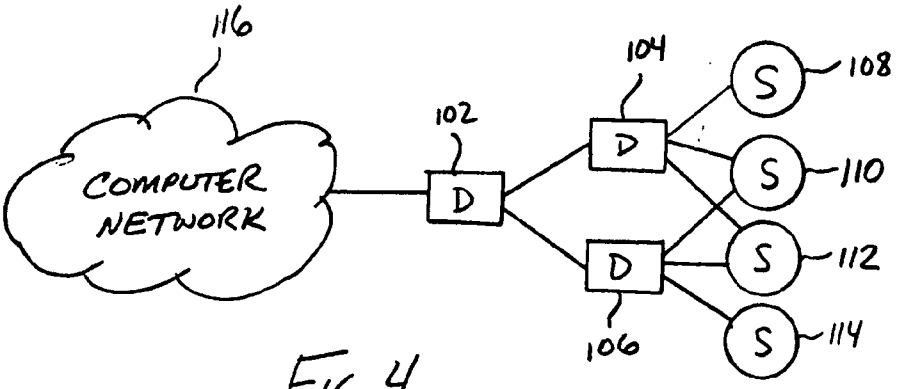


FIG. 4

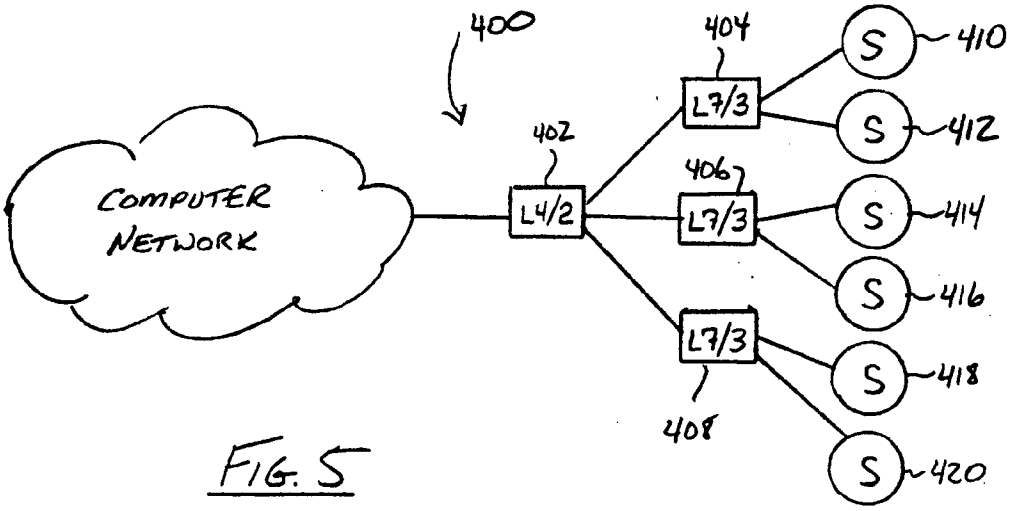


FIG. 5

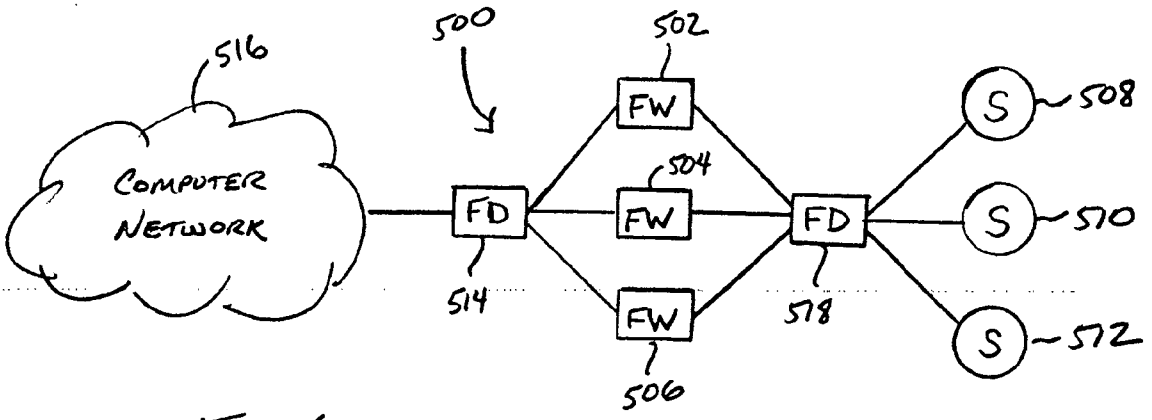


FIG. 6

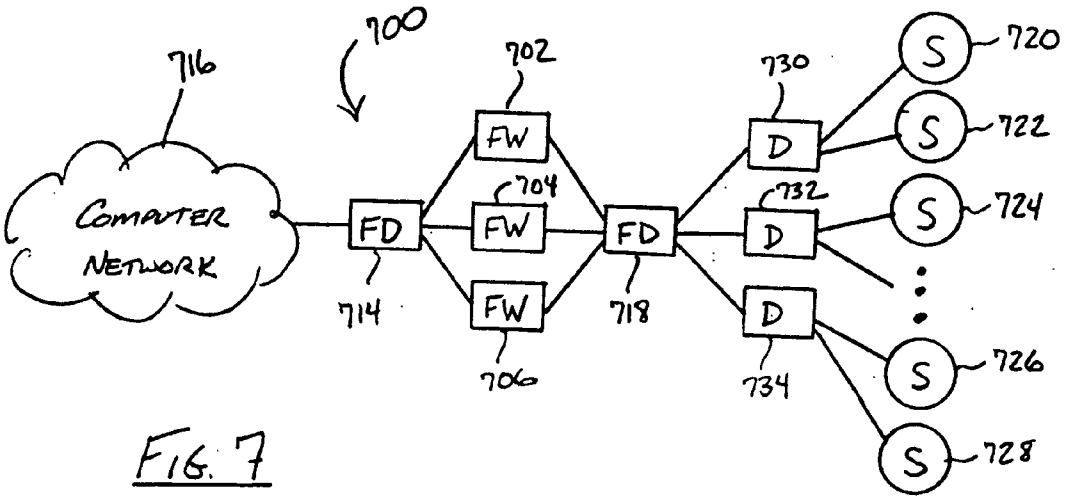

700
716
COMPUTER NETWORK
FD
714
702
FW
704
FW
706
FW
FD
718
730
D
732
D
734
D
S
720
S
722
S
724
S
726
S
728

FIG. 7

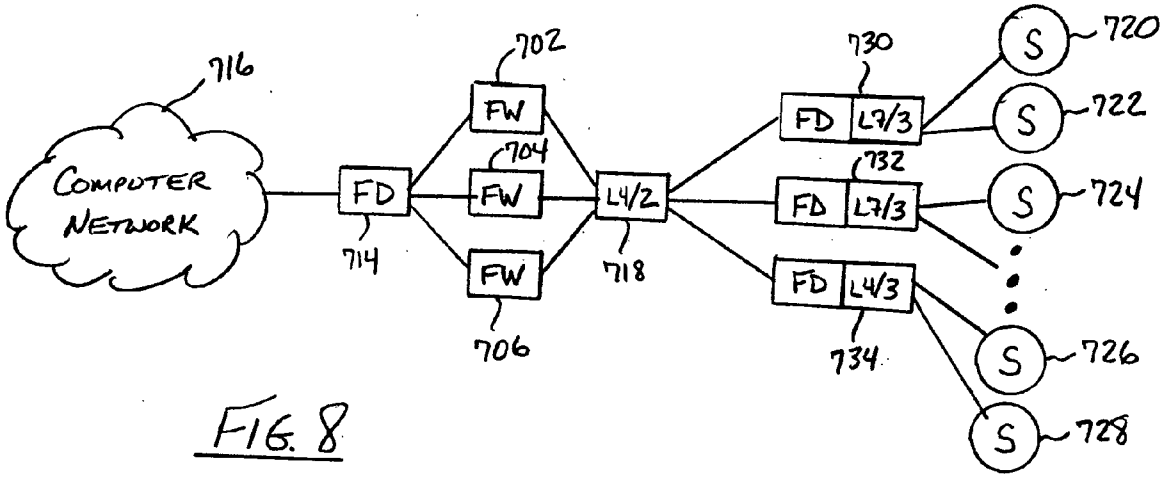

716
COMPUTER NETWORK
FD
714
702
FW
704
FW
706
FW
L4/2
718
730
FD L7/3
732
FD L7/3
734
FD L4/3
S
720
S
722
S
724
S
726
S
728

FIG. 8

HIERARCHICAL FIREWALL LOAD BALANCING AND L4/L7 DISPATCHING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 60/523,858 filed on Nov. 20, 2003, the entire disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] A variety of servers are known in the art for serving the needs of millions of computer network users. More recently, cluster-based servers have been developed, where a pool of "back-end" servers are tied together to act as a single unit, typically in conjunction with a dispatcher that shares or balances the load across the server pool. While useful for a variety of server applications, cluster-based servers are often configured as Web servers for providing requested resources to users over the Internet.

[0003] Server clustering technologies are broadly classified as: OSI layer four switching with layer two packet forwarding (L4/2); OSI layer four switching with layer three packet forwarding (L4/3); and OSI layer seven (L7) switching with either layer two packet forwarding (L7/2) or layer three packet forwarding (L7/3) clustering. These terms refer to the techniques by which the servers in the cluster are tied together. An overview of these clustering technologies is presented in Schroeder, T., S. Goddard and B. Ramamurthy, *Scalable Web Server Clustering Technologies*, IEEE Network, Vol. 14, No. 3 pp.38-45, 2000.

[0004] By definition, the dispatcher in a cluster-based server manages multiple back-end servers. There are, however, practical limits on just how many back-end servers any given dispatcher can manage.

[0005] Firewalls are also known in the art, and are commonly used by organizations and, increasingly, individuals to protect computer networks from external threats including "hackers" coming from other networks, such as the Internet. A typical firewall inspects packets flowing across a network boundary and allows or denies access to internal/external servers according to defined policies. It thus forms a line of defense in securing internal or private networks from, e.g., the Internet. However, in a single firewall system, the firewall represents a single point of failure; if the firewall is down, all access is lost. The single firewall may also create a throughput bottleneck.

[0006] Firewall sandwiches can be used to remove the single point of failure as well as the potential bottleneck of a single firewall. A typical firewall sandwich is illustrated in **FIG. 1**, and includes two or more (e.g., three) firewalls configured in parallel with firewall load balancers (FLBs) on opposite sides of the firewalls. The FLBs are logically positioned at network boundaries and ensure that TCP/IP traffic specific to a particular connection passes through the same firewall in both directions. Since connection requests may originate and terminate in either internal or external networks (illustratively labeled private network and public network, respectively, in **FIG. 1**), the two FLBs perform symmetric operations, especially if the firewalls do not perform network address translation (NAT).

[0007] The general operation of the firewall sandwich shown in **FIG. 1** will now be described. For simplicity, assume that Ethernet is used for the physical network, the firewalls (FWs) do not perform network address translation, and all traffic is TCP/IP. Under these assumptions, the processing performed by the FLBs is symmetric with respect to the flow of traffic from the public network to the private network, and vice versa.

[0008] When the FLB positioned at the public network boundary receives a SYN packet from the public network (indicating a new TCP/IP session), the FLB selects a FW through which the session traffic will flow. Common algorithms for selecting a FW include predefined (static) selection based on IP and port numbers, Round Robin, Weighted Round Robin, Least Connections, and Least-Packet Throughput. The FLB forwards the packet to the selected FW by changing the Ethernet destination MAC address of the packet to the address of the selected FW. The FLB then changes the source MAC address to its own address and places the packet onto the subnet connecting the FLB to the set of FWs.

[0009] The selected FW receives the SYN packet and decides whether the packet (and the session) is allowed to pass based on defined security policies. Assuming the packet is allowed to pass through the FW, it is forwarded to the FLB on the other side of the sandwich. This is achieved by identifying such FLB as a network gateway for the subnet it shares with the FWs.

[0010] For connection-oriented protocols, such as TCP/IP, all packets for a given session are forwarded to the same FW (in both directions), unless the FWs share state information. Assuming the FWs do not share state information (as is the case for most commercially available FWs), when the SYN packet passes through the second FLB, the FLB recognizes it as having come from a FW, records the FW through which the packet passed and forwards the packet to its destination or to its next hop in the network. (Note that when static FW selection algorithms are used, the processing performed by the second FLB is reduced and may be bypassed completely in some cases.)

[0011] When the FLB positioned at the public network boundary receives a packet other than a SYN packet, it determines whether it is part of an existing TCP session. This is often done using the source and destination IP addresses and the respective port numbers. Assuming the packet belongs to an existing TCP session, the FLB forwards it to the correct FW. The FW then forwards the packet to the second FLB, and so on. If the packet does not belong to an existing TCP session, the first FLB either discards the packet, or discards the packet and replies with an RST packet, or forwards the packet to one of the FWs for deciding the packet's fate.

[0012] As is known, the private computer network shown in **FIG. 1** may include one or more computer servers, including a cluster-based server of the type described above. In such a case, the overall network would include the firewalls, the FLBs, a dispatcher, and multiple back-end servers.

SUMMARY OF THE INVENTION

[0013] A secure cluster-based server system constructed according to one embodiment of the present invention

includes a plurality of firewalls, a plurality of back-end servers, a logically external firewall dispatcher, a logically internal firewall dispatcher, and a plurality of second stage dispatchers. The external firewall dispatcher is configured for routing packets received from the external network through one or more of the firewalls to the internal firewall dispatcher, the internal firewall dispatcher is configured for dispatching packets received from the one or more firewalls to one or more of the second stage dispatchers, and the second stage dispatchers are configured for dispatching packets received from the internal firewall dispatcher to one or more of the back-end servers for processing.

[0014] According to another embodiment of this invention, a computerized method of interfacing an external network to a cluster-based server includes receiving packets from a plurality of firewalls with a first stage dispatcher, dispatching each received packet from the first stage dispatcher to one of a plurality of second stage dispatchers, and dispatching each packet received by one of the second stage dispatchers to one of a plurality of servers for processing.

[0015] According to other aspects of the present invention, various computer devices and system components can (but need not) be implemented in application-space on commercially-off-the-shelf (COTS) computer devices executing COTS operating system software.

[0016] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating certain exemplary embodiments of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0018] **FIG. 1** is a block diagram of a prior art firewall sandwich interposed between public and private networks;

[0019] **FIG. 2** is a block diagram of a multi-stage cluster-based server system according to the present invention;

[0020] **FIG. 3** is a block diagram of a multi-stage cluster-based server system employing L4 and L7 dispatchers;

[0021] **FIG. 4** is a block diagram of a multi-stage cluster-based server system having back-end servers each connected to multiple dispatchers;

[0022] **FIG. 5** is a block diagram of one preferred multi-stage cluster-based server for supporting cookies;

[0023] **FIG. 6** is a block diagram of a cluster-based server system having a firewall dispatcher configured for clustering back-end servers;

[0024] **FIG. 7** is a block diagram of a multi-stage cluster-based server system having a firewall dispatcher configured for clustering subsequent stage dispatchers and back-end servers; and

[0025] **FIG. 8** is a block diagram of a multi-stage cluster-based server system having second stage dispatchers that are firewall aware.

[0026] Like reference numerals indicate like elements or features throughout the several drawings.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0027] A cluster-based server system according to a first embodiment of the present invention is indicated generally as **100** in **FIG. 2**. As shown in **FIG. 2**, the system **100** includes multiple dispatchers **102**, **104**, **106** and multiple computer servers **108**, **110**, **112**, **114** (also referred to as "back-end servers"). In this embodiment, dispatcher **102** is configured for sending packets received by the dispatcher **102** (e.g., packets received from the computer network **116** shown in **FIG. 1**) to one of the dispatchers **104**, **106**. Further, dispatchers **104**, **106** are configured for forwarding packets received from the dispatcher **102** to one or more of the servers **108-114** for processing. In this manner, a highly scalable and configurable system **100** is advantageously provided, as further explained below.

[0028] In the embodiment of **FIG. 2**, dispatcher **104** manages a first set of servers **108**, **110**, and dispatcher **106** manages a second set of servers **112**, **114**, with dispatcher **102** forwarding packets received from the computer network **116** to the dispatchers **104**, **106** according to a predetermined load distribution scheme (which may include load balancing). The dispatcher **102** is a first stage dispatcher, and dispatchers **104**, **106** are second stage dispatchers, with the overall system **100** constituting a multi-stage, hierarchical cluster-based server system. Although the system **100** of **FIG. 2** employs only two dispatching stages, it should be understood that a greater number of stages can be employed in any given application of this invention. Additionally, while two second stage dispatchers are employed in the embodiment of **FIG. 2**, it should be understood that a greater or lesser number of dispatchers can be utilized in the second stage and any subsequent stages.

[0029] When scaled up, the system **100** can support a "farm" of second stage dispatchers under management of the first stage dispatcher **102**, with each second stage dispatcher managing a farm of back-end servers and/or third stage dispatchers.

[0030] Each dispatcher **102-106** is preferably configured to implement OSI layer four switching (L4), OSI layer seven switching (L7), or any other suitable dispatching technology. In one exemplary embodiment, illustrated generally in **FIG. 3**, the first stage dispatcher **102** employs layer four switching with layer two packet forwarding (L4/2), one of the second stage dispatchers **104** employs layer four switching with layer three packet forwarding (L4/3), and the other second stage dispatcher **106** employs layer seven switching with layer three packet forwarding (L7/3). Among other benefits, this arrangement allows return traffic from the servers **108-114** to bypass the first stage dispatcher **102**.

[0031] Each back-end server can be configured flexibly. For example, some servers can (but need not) be dedicated HTTP Web servers, dedicated FTP servers, dedicated SSL-supported Web servers, etc. Thus, packets of one type, such as HTTP packets, can be sent to one server, while packets of another type, such as those requesting FTP files, can be sent to another server, if desired. It is not necessary, however, for all same-service-providing servers (e.g., all dedicated HTTP Web servers) to be managed by the same dispatcher, as they

can instead be managed by different dispatchers. Multi-service-providing servers may also be employed.

[0032] Additionally, it is not necessary for each server to be connected to only one dispatcher. Instead, each back-end server can be connected to multiple dispatchers at the same time, as illustrated generally in **FIG. 4**. As shown therein, dispatcher **104** is connected to servers **108-112**, and dispatcher **106** is connected to servers **110-114**. Thus, servers **110, 112** are connected to both second stage dispatchers **104, 106** in this exemplary embodiment. Alternatively, dispatchers **104, 106** can be connected to a greater or lesser number of the back-end servers **108-114**. When one or more back-end servers are connected to multiple dispatchers, server configuration information can be established and shared with dispatcher modules via administration modules. Server configuration information can also be static or dynamic. For example, all HTTP traffic could be routed to server **110** and all FTP traffic to server **112**, or each server may receive a fraction of the connection requests to a dispatcher and that fraction may vary over time based on a load allocation algorithm.

[0033] While no direct connections are shown between the first stage dispatcher **102** and one or more of the back-end servers **108-114** in **FIGS. 2-4**, it should be understood that the dispatcher **102** can be so configured. That is, in addition to forwarding packets received from the computer network **116** to the second stage dispatchers **104, 106**, the dispatcher **102** may be configured to forward some packets received from the network **116** to one or more of the back-end servers **108-114** directly and thus bypass the second stage dispatchers **104, 106**, if desired. In other words, the dispatcher **102** can be configured to function both as a conventional dispatcher for a cluster-based server system, and as a first stage dispatcher in a hierarchical multi-stage dispatching arrangement. Similarly, one or more of the second stage dispatchers may be directly connected to one or more back-end servers as well as one or more third stage dispatchers, etc.

[0034] The connections between the dispatchers and the back-end servers are preferably (but need not be) persistent TCP connections. Additional information regarding persistent TCP connections is disclosed in International Publication No. WO 02/037799, the entire disclosure of which is incorporated herein by reference.

[0035] One preferred embodiment for supporting cookies will now be described with reference to **FIG. 5**. The multi-stage hierarchical cluster-based server system **400** of **FIG. 5** includes a first stage L4/2 dispatcher **402**, multiple second stage L7/3 dispatchers **404-408**, and multiple back-end servers **410-420**. In this embodiment, each cookie contains information identifying the back-end server that created it. When a client initiates a TCP request, the L4/2 dispatcher **402** forwards the SYN packet to one of the L7/3 dispatchers, such as dispatcher **408**. Therefore, a TCP connection is established between the client and the L7/3 dispatcher **408** (note that return traffic bypasses the L4/2 dispatcher **402**). When the client subsequently sends an HTTP request packet with a cookie header, dispatcher **408** will examine the packet to determine which server created the cookie. For this example, assume that server **414** created the cookie. If every L7/3 dispatcher is connected to each back-end server, the dispatcher **408** will simply forward the cookie packet to the server **414** via a persistent TCP connection therebetween.

[0036] Alternatively, if there is no connection between the L7/3 dispatcher **408** and the server **414** (as is the case for the system **400** illustrated in **FIG. 5**), the dispatcher **408** must determine which of the other L7 dispatchers are connected to the server **414**. For this purpose, the system **400** can maintain a central configuration file containing information about all connections between the L7 dispatchers and the back-end servers. By sharing this file with all L7 dispatchers, dispatcher **408** can query the file to identify an L7 dispatcher that is connected to the server **414** (which, in this example, is dispatcher **406**). Alternatively, the system **400** can implement a broadcast mechanism among the L7 dispatchers, thus allowing dispatcher **408** to broadcast a message "who is connected to this server?" to the other L7 dispatchers. The L7 dispatcher **406** will then respond accordingly.

[0037] Upon determining that dispatcher **406** is connected to the server **414** that created the cookie (using the above methods or otherwise), dispatcher **408** can send the packet to the dispatcher **406** using layer two packet forwarding. After receiving this packet, dispatcher **406** can add an entry into a matching table (preferably dedicated for this purpose) that matches a persistent TCP connection between it and the server **414** to the source MAC address of the packet (i.e., the MAC address of the sending L7 dispatcher **408**), and send the cookie packet to the server **414** for processing. Upon receiving a reply from the server **414**, dispatcher **406** can query the matching table and send the reply back to the dispatcher **408** using layer two packet forwarding. Dispatcher **408** then sends the reply back to the client (again, bypassing the L4/2 dispatcher **402**). Alternatively, other approaches can be employed for supporting cookies in a multi-stage hierarchical cluster-based server system according to the present invention.

[0038] All of the dispatchers shown in **FIGS. 2-5** can be and preferably are implemented in application-space. As is known, software on a computer is generally characterized as either operating system (OS) software or applications. The OS software typically includes a kernel and one or more libraries. The kernel is a set of routines for performing basic, low-level functions of the OS such as interfacing with hardware. Applications are typically high-level programs that interact with the OS software to perform functions. The applications are said to Attorney Docket No. **2186-000008**/US execute in application-space. The functionality of the dispatchers of this invention can be implemented in the kernel, in applications, or in hardware. Moreover, the dispatchers can be implemented in application-space using commercially-off-the-shelf (COTS) hardware and COTS OS software. This is in contrast to custom hardware and/or OS software, which is typically more expensive and less flexible. Additional information regarding application-space implementations is disclosed in International Publication No. WO 02/43343, the entire disclosure of which is incorporated herein by reference.

[0039] **FIG. 6** illustrates a cluster-based server system **500** according to another embodiment of this invention. As shown in **FIG. 5**, the system **500** includes a plurality of firewalls **502-506**, a plurality of back-end servers **508-512**, a logically external firewall dispatcher **514** for dispatching packets from an external computer network **516** to the firewalls **502-506** (and vice versa), and a logically internal firewall dispatcher **518** for interfacing the firewalls **502-506**

to the cluster of back-end servers **508-512**. Similar to the FLBs shown in **FIG. 1**, the firewall dispatchers **514**, **518** send packets to and receive packets from the firewalls **502-506** via switches (not shown).

[**0040**] In operation, the external firewall dispatcher **514** functions much like the logically external FLB shown in **FIG. 1**, and the internal firewall dispatcher **518** functions much like the logically internal FLB shown in **FIG. 2**. Additionally, in the system of **FIG. 6**, the internal firewall dispatcher **518** is configured to function as a dispatcher for managing the cluster of back-end servers **508-512**. Thus, rather than receiving packets from an FLB, the internal firewall dispatcher **518** receives packets directly from the firewalls **502-506** (via a switch), and dispatches these packets to the back-end servers **508-512** according to a predetermined load distribution scheme (which may include load balancing). In other words, the internal firewall dispatcher **518** operates as a firewall load balancer in a firewall sandwich comprising the external firewall dispatcher **514** and the multiple firewalls **502-506**, and also as a dispatcher in a cluster-based server comprising the back-end servers **508-512**. While three firewalls **502-506** and three back-end servers **508-512** are shown in **FIG. 6**, it should be understood that a greater or lesser number of firewalls and/or servers may be employed in any given implementation.

[**0041**] In one preferred embodiment, the internal firewall dispatcher **518** and the external firewall dispatcher **514** both execute in application-space on COTS hardware running COTS operating system software. Thus, no special hardware or software modifications are required. Additionally, both firewall dispatchers **514**, **518** can execute on the same machine, if desired. Further, the logically external firewall dispatcher **514** is preferably configured to monitor the internal firewall dispatcher **518** and take over for the internal firewall dispatcher upon detecting a failure. Conversely, the internal firewall dispatcher **518** is preferably configured to monitor and take over for the external firewall dispatcher **514** upon detecting a failure therein. In this manner, the firewall dispatchers **514**, **518** provide redundancy for one another, thereby increasing system reliability.

[**0042**] The firewall dispatchers **514**, **518** can be configured to implement any suitable dispatching technology, including L4/2, L4/3 and L7 clustering. They can also function solely as a firewall load balancer, or solely as a network-clustering dispatcher. Therefore, the firewall dispatchers of the present invention provide great flexibility in system design and operation.

[**0043**] **FIG. 7** illustrates a cluster-based server system **700** according to another embodiment of the present invention. As shown in **FIG. 7**, the system **700** includes multiple firewalls **702-706**, a logically external firewall dispatcher **714** for dispatching packets from an external computer network **716** to the firewalls **702-706** (and vice versa), and a logically internal firewall dispatcher **718** for interfacing the firewalls **702-706** to a cluster of back-end servers **720-728** via multiple second stage dispatchers **730-734**. Thus, the system **700** is similar to the system **500** of **FIG. 6** except that the firewall dispatcher **718** also serves as the first stage dispatcher of a multi-stage, hierarchical cluster-based server of the type described above with reference to **FIGS. 2-5**.

[**0044**] As with the embodiments of **FIGS. 2-5**, in the embodiment of **FIG. 7**, a greater or lesser number of dispatchers may be employed, as can a greater number of dispatching stages. Further, each dispatcher can be connected to one or more dispatchers in a subsequent stage as well as to one or more back-end servers directly, and each back-end server can be connected to multiple dispatchers at the same time, if desired. The system of **FIG. 7** can also employ a greater or lesser number of firewalls, as apparent to those skilled in the art.

[**0045**] In one exemplary embodiment, illustrated in **FIG. 8**, the logically internal firewall dispatcher/first stage dispatcher **714** is configured to implement L4/2 dispatching, second stage dispatchers **730**, **732** are configured as L7/3 dispatchers, and second stage dispatcher **734** is configured as an L4/3 dispatcher. Additionally, each second stage dispatcher is provided with a firewall dispatching module DF, as shown in **FIG. 8**. After receiving a SYN message from a firewall, the L4/2 dispatcher **714** embeds the firewall information into the SYN message and forwards the message to a selected or specified (e.g., IP specified) one of the second stage dispatchers **730-734** to be processed. The DF of such second stage dispatcher extracts the firewall information from the SYN message before passing it to the L7/3 (or L4/3, as applicable) module for processing. In this manner, the second stage dispatchers **730-734** are firewall aware, and can send responses directly to the firewalls (bypassing the first stage dispatcher **714**). Thus, the traffic path is such that there are no single bottlenecks for the server response traffic.

[**0046**] In the embodiments of **FIGS. 7 and 8**, the internal and external firewall (and first stage) dispatchers **714**, **718** may execute in application-space on COTS hardware running COTS operating system software. Thus, no special hardware or software modifications are required. Additionally, both firewall dispatchers **714**, **718** can execute on the same machine, if desired, and both are preferably configured to monitor and take over for the other upon detecting a failure.

[**0047**] As apparent to those skilled in the art, the computer networks shown illustratively in **FIGS. 2-8** may be, e.g., a local area network (LAN), a wide area network (WAN), the Internet, a combination of such networks, etc.

[**0048**] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed:

1. A secure cluster-based server system comprising a plurality of firewalls, a plurality of back-end servers, a logically external firewall dispatcher, a logically internal firewall dispatcher, and a plurality of second stage dispatchers, the external firewall dispatcher configured for routing packets received from the external network through one or more of the firewalls to the internal firewall dispatcher, the internal firewall dispatcher configured for dispatching packets received from said one or more firewalls to one or more of the second stage dispatchers, and the second stage dispatchers configured for dispatching packets received from the internal firewall dispatcher to one or more of the back-end servers for processing.

2. The system of claim 1 wherein the internal firewall dispatcher is configured for dispatching packets to the second stage dispatchers using L4 dispatching.

3. The system of claim 1 wherein the second stage dispatchers are configured for dispatching packets to the back-end servers using L4 or L7 dispatching.

4. The system of claim 1 wherein each back-end server is connected to at least one second stage dispatcher.

5. The system of claim 4 wherein at least one back-end server is connected to a plurality of second stage dispatchers.

6. The system of claim 1 wherein the firewalls are configured as a firewall sandwich.

7. The system of claim 1 wherein the external firewall dispatcher is embodied in a first computer device and the internal firewall dispatcher is embodied in a second computer device.

8. The system of claim 1 wherein the external firewall dispatcher and the internal firewall dispatcher are embodied in the same computer device.

9. The system of claim 1 wherein the external firewall dispatcher is configured for storing firewall path information for at least one connection.

10. The system of claim 9 wherein the external firewall dispatcher is configured for storing said firewall path information in a packet belonging to said one connection.

11. A computerized method of interfacing an external network to a cluster-based server, the method comprising:

receiving packets from a plurality of firewalls with a first stage dispatcher;

dispatching each received packet from the first stage dispatcher to one of a plurality of second stage dispatchers; and

dispatching each packet received by one of the second stage dispatchers to one of a plurality of servers for processing.

12. The method of claim 11 wherein each packet received by the first stage dispatcher is dispatched to one of the second stage dispatchers using L4 dispatching.

13. The method of claim 11 wherein each packet received by one of the second stage dispatchers is dispatched to one of the servers using L4 or L7 dispatching.

14. The method of claim 11 further comprising bypassing the first stage dispatcher when sending a response from one of the servers to the external network.

15. The method of claim 14 further comprising storing firewall path information designating one or more of the firewalls for use with one or more particular connections.

16. The method of claim 15 wherein storing includes storing the firewall path information in packets received by the first stage dispatcher.

17. The method of claim 16 wherein the stored firewall path information is retrieved from one of said packets by one of the second stage dispatchers for routing a response from said one packet to a corresponding one of the firewalls.

18. The method of claim 15 further comprising routing response traffic associated with a particular connection to a corresponding one of the firewalls using the stored firewall path information.

19. The method of claim 17 wherein routing includes routing response traffic associated with said particular connection from one of the second stage dispatchers to said corresponding one of the firewalls.

20. The method of claim 11 further comprising receiving, at one of the second stage dispatchers, a packet having a cookie created by one of the servers, and forwarding said packet having a cookie from said one of the second stage dispatchers to said server that created the cookie.

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