US006829654B1

(12) **United States Patent**
Jungck

(10) **Patent No.: US 6,829,654 B1**
(45) **Date of Patent: Dec. 7, 2004**

(54) **APPARATUS AND METHOD FOR VIRTUAL EDGE PLACEMENT OF WEB SITES**

(75) Inventor: **Peder J. Jungck**, San Carlos, CA (US)

(73) Assignee: **Cloudshield Technologies, Inc.**, Sunnyvale, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 781 days.

(21) Appl. No.: **09/ 602,129**

(22) Filed: **Jun. 23, 2000**

(51) **Int. Cl.**[7] **G06F 15/ 16**
(52) **U.S. Cl.** **709/ 246**;709/218; 370/475
(58) **Field of Search** 709/246, 216–218, 709/219, 229, 225, 238, 217; 713/201; 707/10; 370/475, 230; 379/220; 341/50; 708/204

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,805,820	A		9/1998	Bellovin et al.	395/200.55
5,831,609	A	*	11/1998	London et al.	345/746
5,938,737	A		8/1999	Smallcomb et al.	709/247
5,953,503	A		9/1999	Mitzenmacher et al.	395/200.33
5,991,713	A		11/1999	Unger et al.	704/9
6,006,264	A		12/1999	Colby et al.	709/226
6,014,660	A		1/2000	Lim et al.	707/3
6,016,512	A		1/2000	Huitema	709/245
6,046,980	A		4/2000	Packer	370/230
6,052,718	A		4/2000	Gifford	709/219
6,065,055	A	*	5/2000	Hughes et al.	709/229
6,070,191	A		5/2000	Narendran et al.	709/226
6,073,168	A		6/2000	Mighdoll et al.	709/217
6,084,878	A		7/2000	Crayford et al.	370/389
6,101,549	A	*	8/2000	Baugher et al.	709/238
6,108,703	A		8/2000	Leighton et al.	709/226
6,167,438	A	*	12/2000	Yates et al.	709/216
6,167,441	A	*	12/2000	Himmel	709/217
6,256,671	B1		7/2001	Strentzsch et al.	709/227
6,256,739	B1	*	7/2001	Skopp et al.	713/201
6,289,095	B1	*	9/2001	Buttitta et al.	379/220.01
6,330,561	B1	*	12/2001	Cohen et al.	707/10
6,389,462	B1	*	5/2002	Cohen et al.	709/218
6,480,508	B1	*	11/2002	Mwikalo et al.	370/475
6,502,135	B1	*	12/2002	Munger et al.	709/225
6,578,073	B1	*	6/2003	Starnes et al.	709/219
6,581,090	B1		6/2003	Lindbo et al.	

FOREIGN PATENT DOCUMENTS

EP	0 865 180 A2	3/1998
EP	WO 98/17039	4/1998
EP	WO 00/14938	3/2000
EP	WO 00/27092	5/2000
EP	WO 00/28713	5/2000
WO	WO 99/05584	2/1999
WO	WO 99/09725	2/1999
WO	WO 99/27684	6/1999
WO	WO 99/60459	11/1999

OTHER PUBLICATIONS

JISC JTAP Report—Network Delivery ;www.jtap.ac.uk/reports/pdf/jtap–036.pdf.*
Proxy PNNI augmented routing (proxy PAR); 1st IEEE International Conference on, Jun. 22–24, 1998.*
Client–Server Interactions in Multi–Server Operating Systems: Mark Stevenson (1994); ftp.cs.cuhk.hk/pub/mach3/src/mach_us/src/doc/us_client_server.ps.*

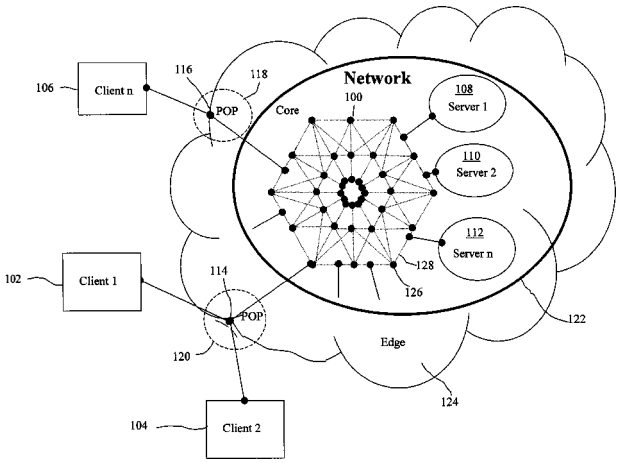
(List continued on next page.)

Primary Examiner—Thong Vu
(74) *Attorney, Agent, or Firm*—Brinks Hofer Gilson & Lione

(57) **ABSTRACT**

An apparatus and method for enhancing the infrastructure of a network such as the Internet is disclosed. Multiple edge servers and edge caches are provided at the edge of the network so as to cover and monitor all points of presence. The edge servers selectively intercept domain name translation requests generated by downstream clients, coupled to the monitored points of presence, to subscribing Web servers and provide translations which either enhance content delivery services or redirect the requesting client to the edge cache to make its content requests. Further, network traffic monitoring is provided in order to detect malicious or otherwise unauthorized data transmissions.

30 Claims, 6 Drawing Sheets



OTHER PUBLICATIONS

John Pescatore, Gartner Analyst, "Commentary: Digging into the DNS foundation," obtained at internet address, http://news.cnet.com/news/0–1005–202–2080091.html, Jun. 15, 2000.
Rainbow Technologies Products, "CryptoSwift eCommerce Accelerator," obtained at internet address, http://isg.rainbow.com/products/cs_1.html, Aug. 5, 2000.
FlowWise Networks, Inc., "AutoRoute™ Automatic Configuration of Layer 3 Routing," www.flowwise.com.
FlowWise, "Router Accelerator—RA 7000 from FlowWise" obtained at internet address http://www.flowise.com/products/ra7000.htm.
Intel® IXP 1200 Network Processor, obtained at internet address, http://developer.intel.com/design/network/ixp1200.htm.
Marshall Brain, How Stuff Works, "How Web Servers and the Internet Work," obtained at internet address http://www.howstuffworks.com/web–server.htm.
Marshall Brain, How Stuff Works, "How Domain Name Servers Work," obtained at internet address http://www.howstuffworks.com/dns.htm.
Curt Franklin, How Stuff Works, "How Routers Work," obtained at internet address http://www.howstuffworks/com.router.htm.
Microsoft Corporation, Sep. 1998 "Introduction to TCP/IP," obtained at internet address http://msdn.microsoft.com/library/backgrnd/html/tcpipintro.htm.
Robert Stone, "Center Track: An IP Overaly Network for Tracking DoS Floods," Article Oct. 1, 1999, pp. 1–9.
Chapter 1 TCP/IP Fundamentals, obtained at internet address http://webdocs.sequent.com/docs/tcpoac01/ch_1.htm, pp. 1–28.
Cheng Wu, "Web Switching: A New Generation of Networking," pp 1–3.
ArrowPoint Communications™ Article, "A Comparative Analysis of Web Switching Architectures" pp. 1–11.
ArrowPoint Communications™, Brochure, "The Top 12 Benefits of Content Intelligence."
L. Peter Deutsch, "DEFLATE Compressed Data Format Specificaton," May 1996.
Antaeus Feldspar, Article, "An Explanation of the Deflate Algorithm," Sep. 11, 1997.
ArrowPoint Communications™ CDDCenter Vendor Listing, "ArrowPoint CS–50 Highlights" obtained at internet address http:www.cddcenter.com/arrowpoint.htm, May 21, 2000.
Peter Christy, Analyst Commentary, "When to Distribute Content—The Peters't Principles," obtained at internet address http://www.cddcenter.com/index.html, May 21, 2000.
Content Delivery 101: An Introduction to Content Distribution & Delivery.
CDDCenter, "How Do Caching and Content Delivery Really Differ?" obtained at internet address http://www.cddcenter.com/cachingvcontent.htm, pp. 1–4, May 21, 2000.
Internet Research Group "Infrastructure Application Service Providers," Feb. 2000, pp. 1–7.
Peter Christy, Internet Research Group, "Content Delivery Architectures: Why Doesn'One Size Fit All?" pp. 1–12.
Steven Vonder Haar, Inter@ctive Week, Feb. 14, 2000, "Content Delivery Shifts To Edge of Net," obtained at internet address http://www.zdnet.com/intweek/stories/news/0,4164,2436865,00.html, Dated May 22, 2000.
David Willis, Network Computing, "The Content–Delivery Edge," obtained at internet address http://www.networkcomputing.com/1103/1103colwillis.html, Dated May 22, 2000.
Phrack Magazine, "IP–spoofing Demystified (Trust–Relationship Exploitation)" vol. Seven, Issue Forty–Eight, File 14 of 18. pp. 1–9, obtained at internet address http:www.fc.net/phrack/files/p48/p48–14.html, Dated Jun. 5, 2000.
Eddie Mission, "What is Eddie?", obtained at internet address http://www.eddieware.org/what.html, Dated Apr. 21, 2000.
Cisco Enterprise Solutions, "Quality of Service," obtained at internet address http://www.cisco.com/warp/public/779/largeent/learn/technologies/qos/.
Cisco White Paper, "Delivering End–to–End Security in Policy–Based Networks," obtained at internet address, http://www.cisco.com/warp/public/cc/pd/nemnsw/cap/tech/deesp_wp.htm.
Technology Packeteer, obtained at internet address, http://www.packeteer.com/technology/index.cfm.
Overview Cisco Content Networking, obtained at internet address http://www.cisco.com/warp/public/cc/so/neso/ienesv/cxne/ccnov_ov.htm.
Overview Cisco Secure Policy Manager 2.0, obtained at internet address http://www.cisco.com/warp/public/cc/pd/sqsw/sqppmn/prodlit/secmn_ov.htm.
Alteon Web Systems, White Paper "Optimizing ISP Networks and Services with DNS Redirection," Aug. 1999.
Alteon Web Systems, White Paper "Virtual Matrix Architecture Scaling Web Services for Performance and Capacity," Apr. 2000.
Alteon Web Systems, White Paper, Questions and Answers, pp. 1–3.
3Com Technical Ppaers, Layer 3 Switching, 5/98.
Web Cache Communication Protocol Version 2, pp. C–1 to C–54.
RFC2267 Working Group– Denial of Service Counter Measures, Tele–conference Meeting Aug. 25, 2000, Moderator, Henry Teng of eBay.
Track–back Architecture General Requirements Version 0.1, Initial Draft submitted to Counter–DoS Solutions Working Group, Jul. 31, 2000, Edited by Bob Geiger, Recourse Technologies.
SwitchOn Networks, Inc., ClassiPI™ At–a–Glance.
C–Port™ A Motorola Company, C–5™ Digital Communications Processor, Product Brief, pp. 1–8, May 4, 2000.
Peder Jungck, "Building a Faster Cache Server" A Theoretical Whitepaper, Silicon Valley Internet Capital , pp. 1–19.
IXF 1002 Dual Port Gigabit Ethernet MAC, Product Brief, Levon One™ an Intel Company.
NetLogic Microsystems Product Overview.
Agere, Inc. "The Challenge for Next Generation Network Processors", Sep. 10, 1999.
Phillips Semiconductors' VMS747 Security Processor Overview.
Cisco Systems, Cisco 12000 Series GSR, "Performing Internet Routing and Switching at Gigabit Speeds," obtained at internet address, http://www.cisco.com/warp/public/cc/pd/rt/12000/.
Cisco Systems, "Cisco 10000 Edge Service Router," obtained at internet address, http://www.cisco.com/warp/public/cc/pd/rt/10000/.

Nortel Networks™ "Passport 8600 Routing Switch," obtained at internet address, http://www.nortelnetworks.com/products/01/passport/8600/index.html.
Lucent Technologies, "InterNetworking Systems," obtained at internet address, http://www.lucent.com/ins/products/grf/.
Lucent Technologies, "InterNetworking Systems," obtained at internet address, http://www.lucent.com/ins/products/grf1600.html.
Juniper Networks, "M20 Internet Backbone Router," Datasheet, obtained at internet address, http://www.juniper.net/products/dsheet/100009.html.
Juniper Networks, "M40 Internet Backbone Router," Datasheet, obtained at internet address, http://www.juniper.net/products/dsheet/100001.html.
Juniper Networks, Inc., "M160 Internet Backbone Router" Datasheet, obtained at internet address, http://www.juniper-.net/products/dsheet/10012.

Rajeev Kumar, Intel Confidential, "IXP 1200 Overview".

Intel "IXP 1200 Network Processor," Datasheet, pp 1–109 (out of 146 pages), May 2000.

Cisco 7500 Series Routers, pp. 1–2, obtained at internet address http://www.cisco.com/warp/public/779/largeent/learn/technologies/qos/.

* cited by examiner

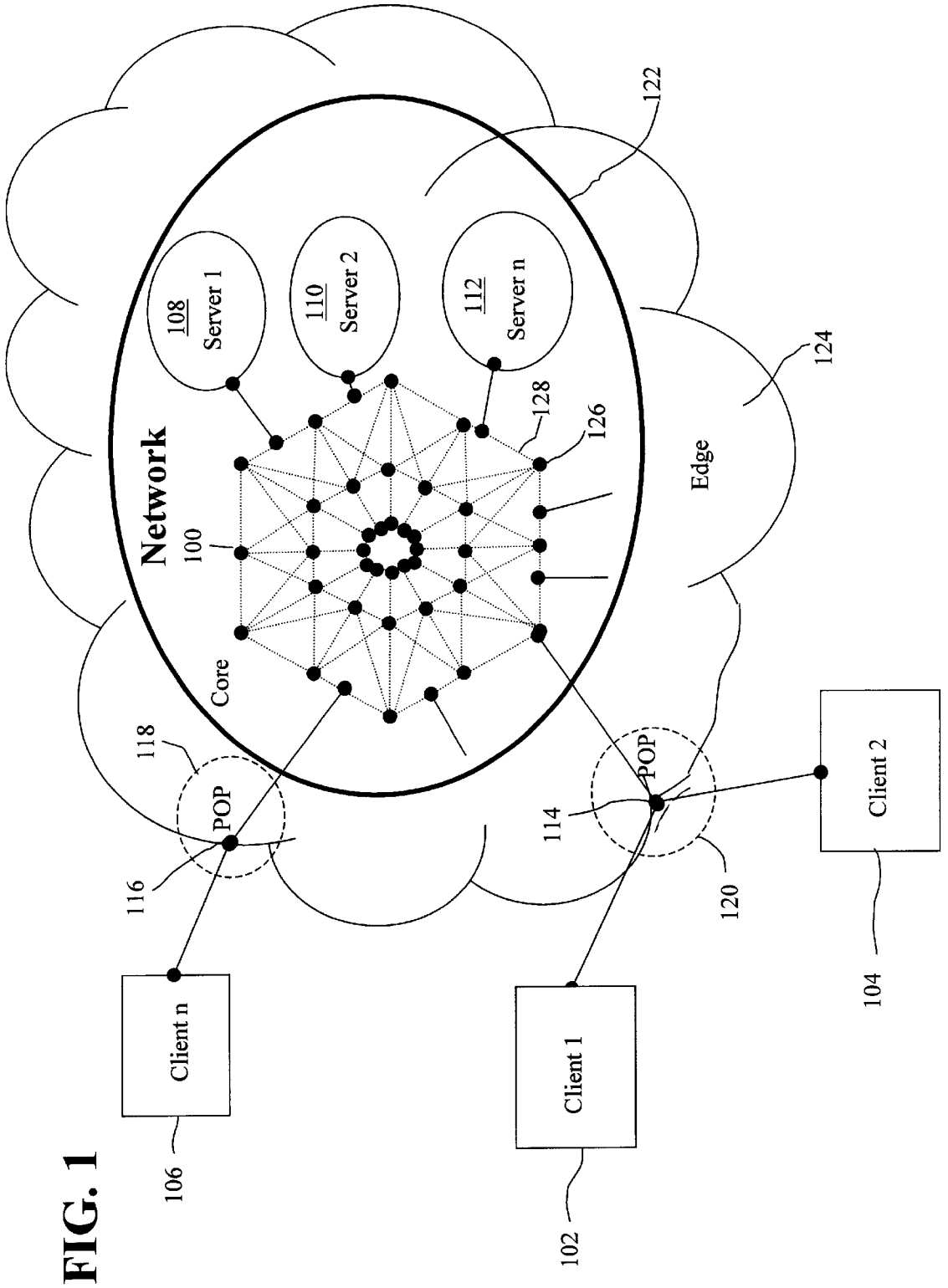

Network
100
Core
108
Server 1
110
Server 2
112
Server n
122
124
Edge
126
128
118
POP
116
114
POP
120
Client n
106
Client 1
102
Client 2
104

FIG. 1

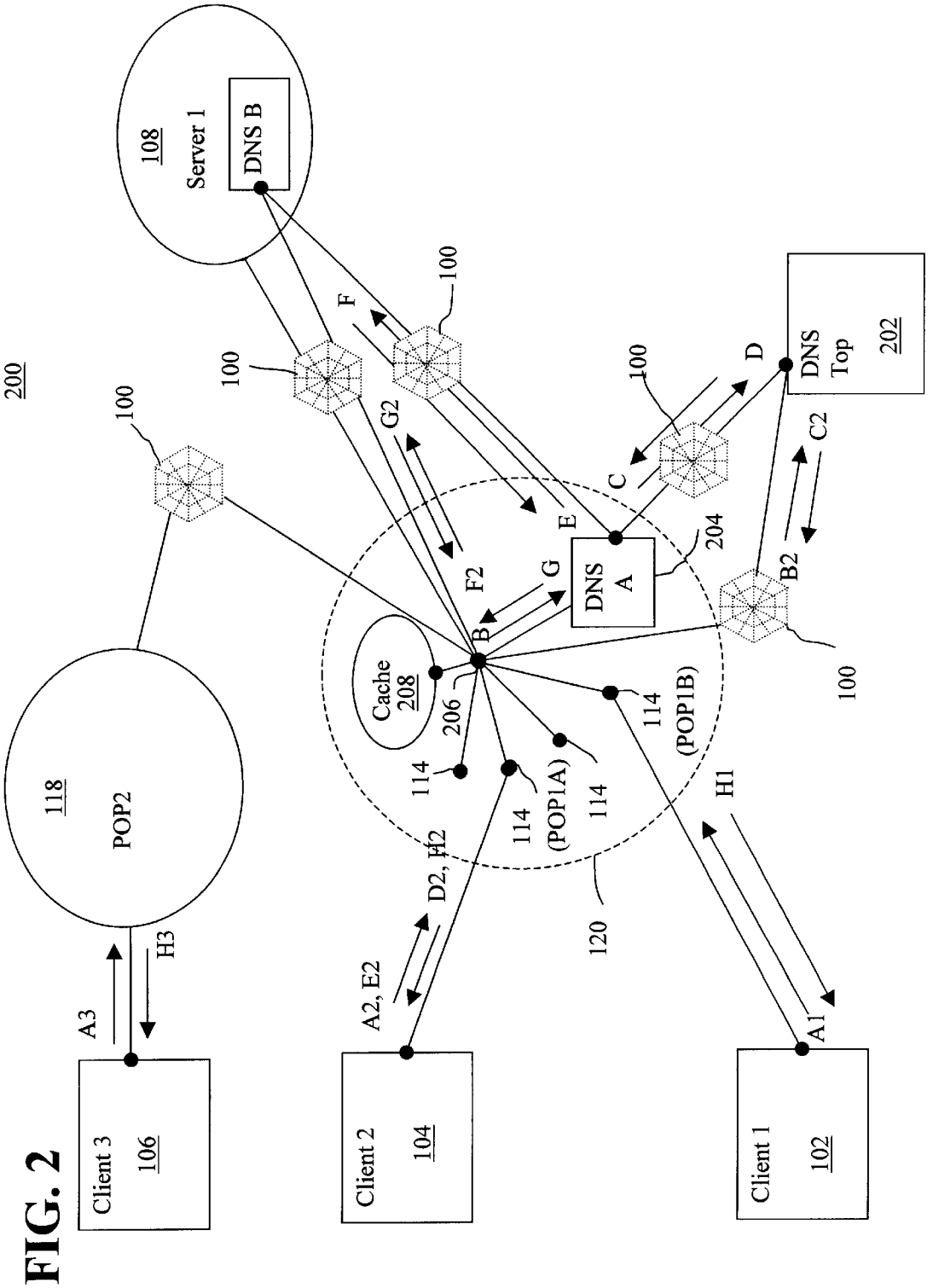

200
108
Server 1
DNS B
100
F
G2
E
C
D
DNS
Top
202
C2
B2
204
DNS
A
G
F2
B
Cache
208
206
114
(POP1A)
114
(POP1B)
120
118
POP2
H3
A3
D2, H2
A2, E2
H1
A1
Client 3
106
Client 2
104
Client 1
102

FIG. 2

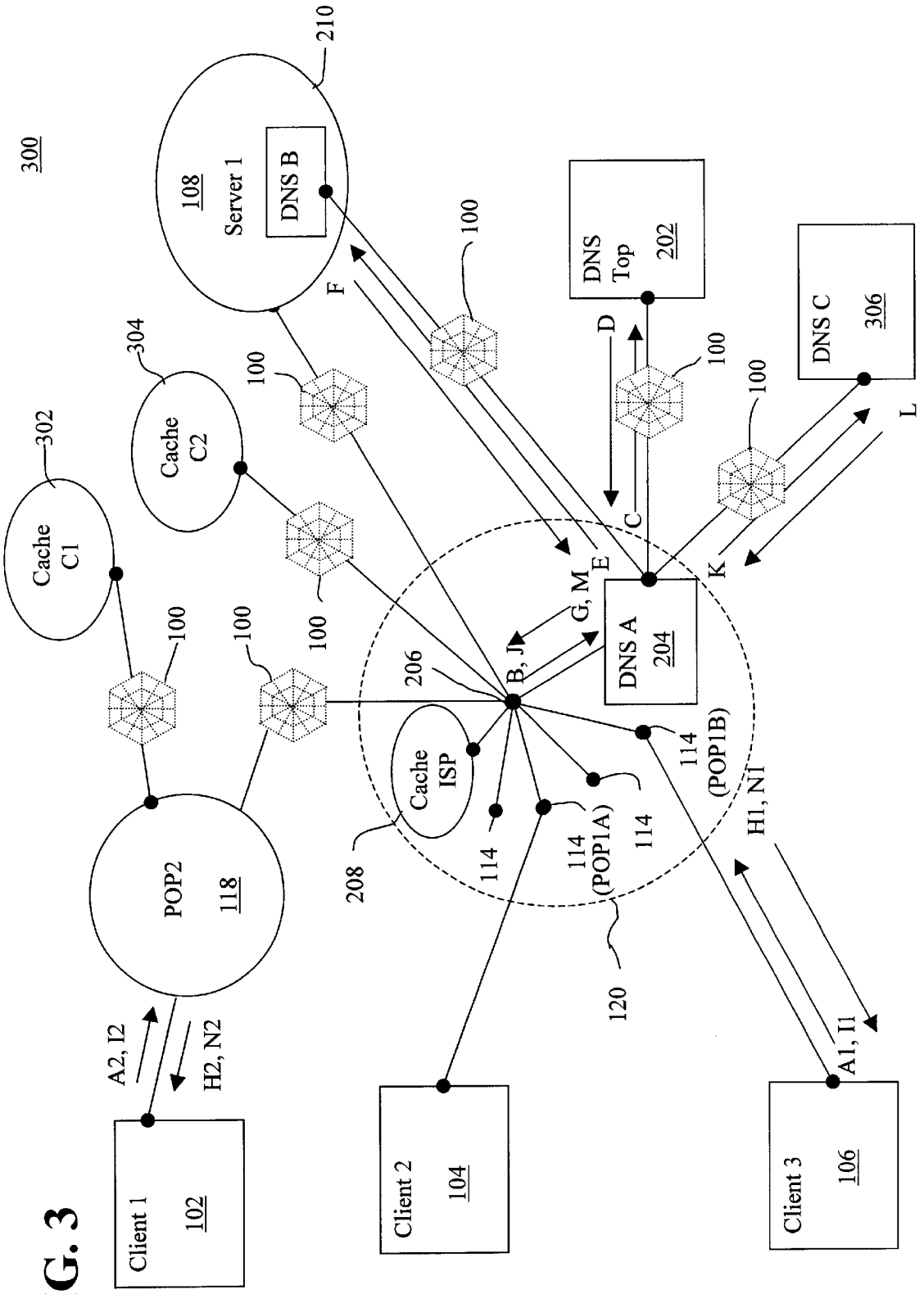

300
108
Server 1
DNS B
210
DNS Top
202
DNS C
306
Cache C1
302
Cache C2
304
100
F
D
C
E
G, M
B, J
K
L
DNS A
204
206
Cache ISP
208
114
114 (POP1A)
114 (POP1B)
120
H1, N1
A1, I1
A2, I2
H2, N2
POP2
118
Client 1
102
Client 2
104
Client 3
106

FIG. 3

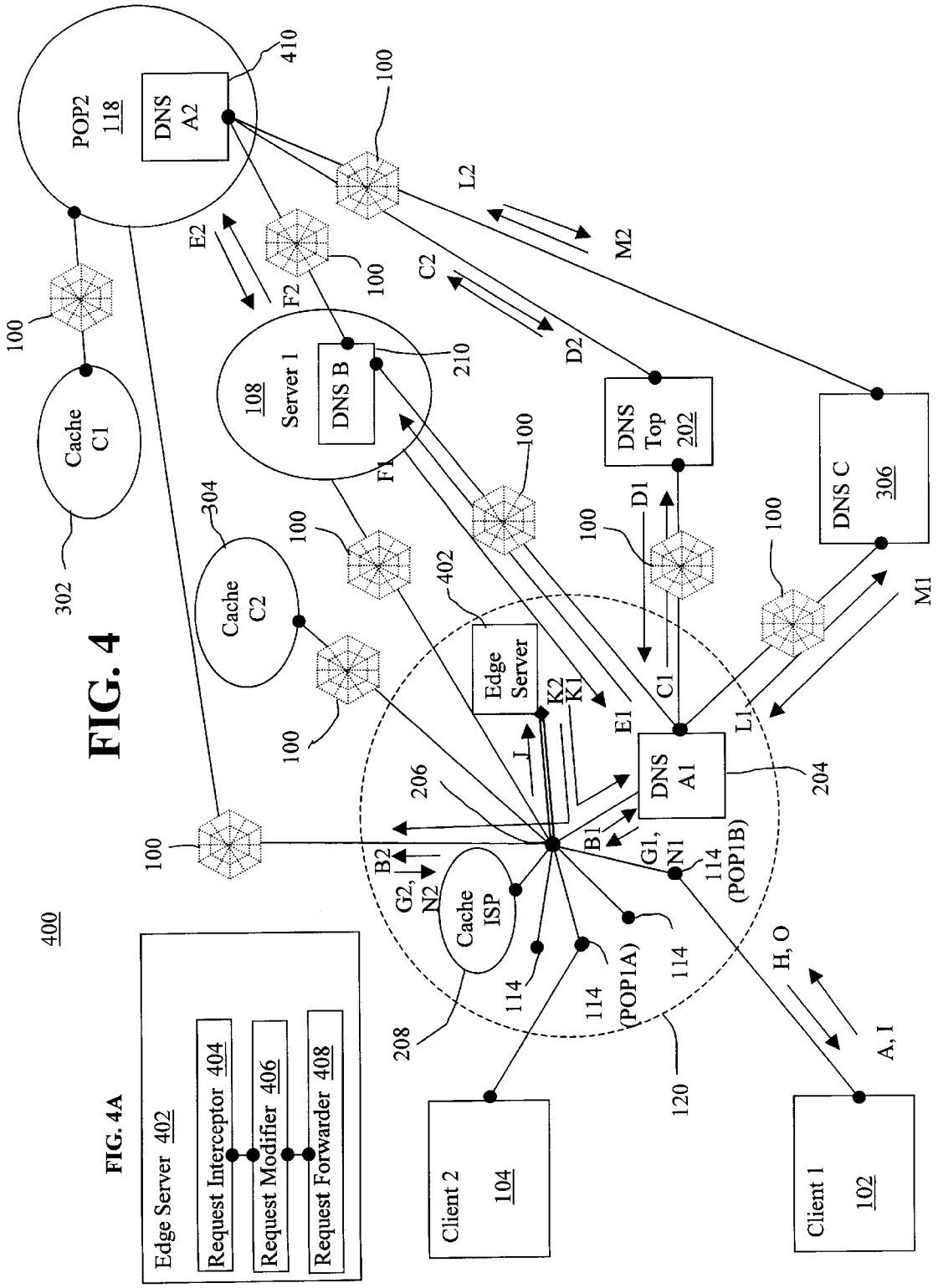

400
POP2
118
DNS
A2
410
100
L2
M2
E2
F2
C2
D2
Cache
C1
302
108
Server 1
DNS B
210
F1
DNS
Top
202
D1
DNS C
306
M1
304
Cache
C2
402
Edge
Server
K2
K1
E1
C1
L1
I
DNS
A1
204
206
B1
G1,
N1
114
(POP1B)
B2
G2,
N2
Cache
ISP
208
114
114
(POP1A)
114
H, O
A, I
120
Client 2
104
Client 1
102
Edge Server 402
Request Interceptor 404
Request Modifier 406
Request Forwarder 408

FIG. 4

FIG. 4A

FIG. 5

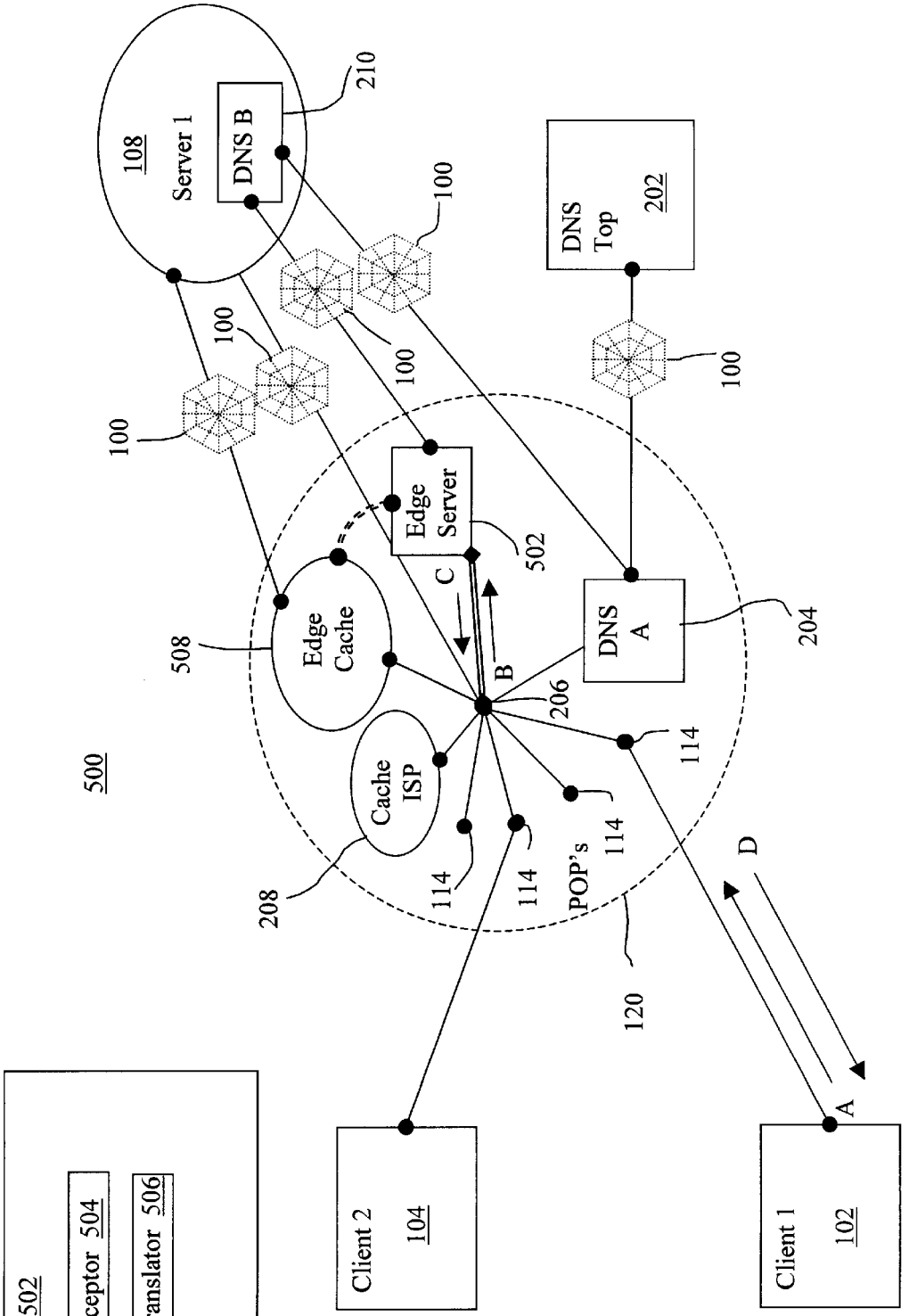
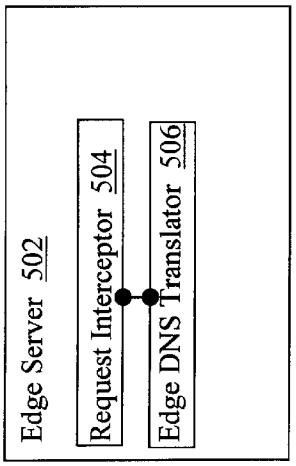

500
108
Server 1
DNS B
210
100
DNS Top
202
Edge Server
502
Edge Cache
508
C
B
DNS A
204
206
Cache ISP
208
114
POP's
120
D
A
Client 2
104
Client 1
102

FIG. 5A


Edge Server 502
Request Interceptor 504
Edge DNS Translator 506

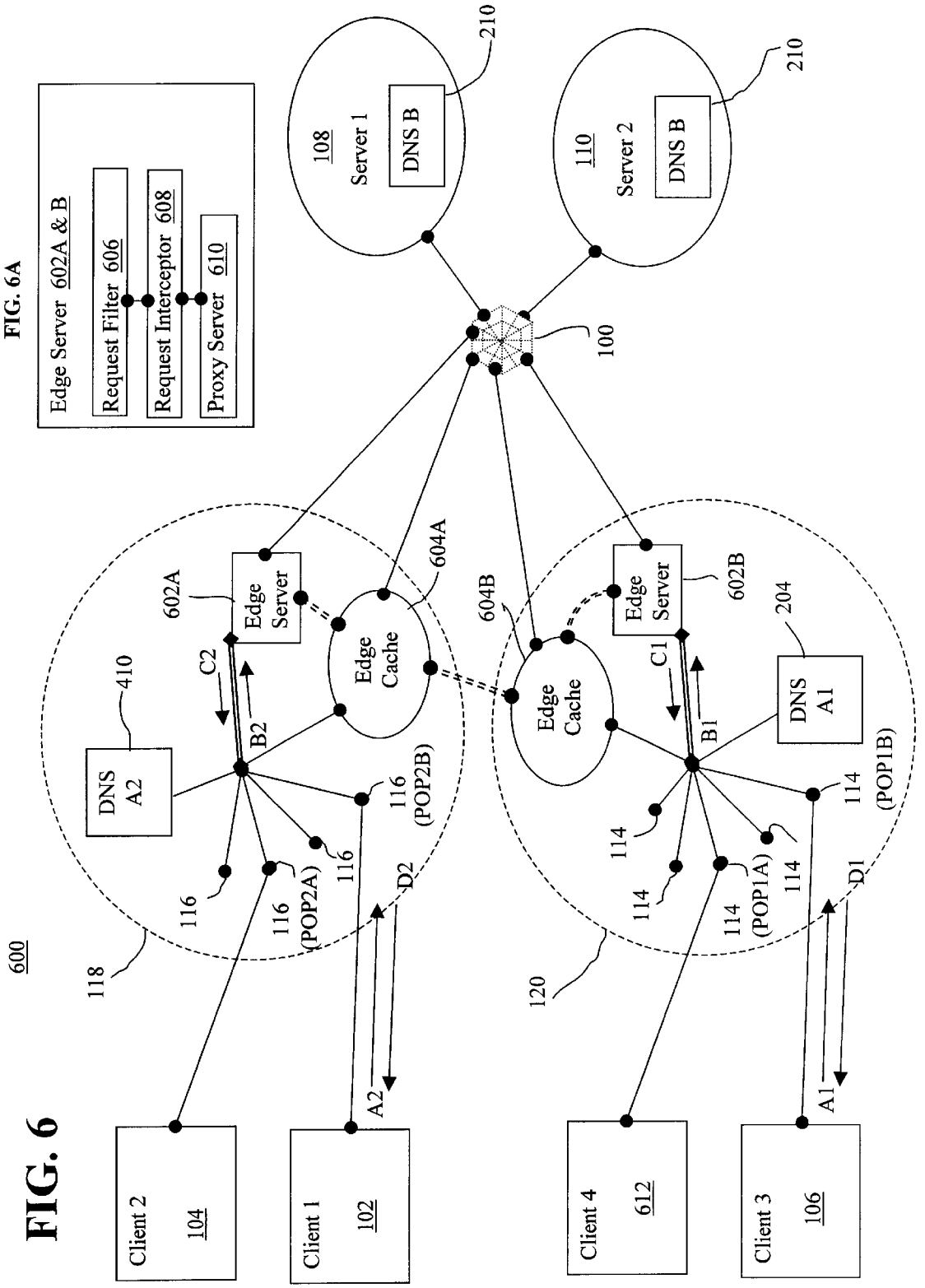


FIG. 6A
Edge Server 602A & B
Request Filter 606
Request Interceptor 608
Proxy Server 610
108
Server 1
DNS B
210
110
Server 2
DNS B
210
100
600
602A
Edge Server
604A
Edge Cache
410
DNS A2
C2
B2
116
116 (POP2A)
116 (POP2B)
D2
A2
118
604B
Edge Cache
602B
Edge Server
204
DNS A1
C1
B1
114
114 (POP1A)
114 (POP1B)
D1
A1
120
Client 2
104
Client 1
102
Client 4
612
Client 3
106

FIG. 6

APPARATUS AND METHOD FOR VIRTUAL EDGE PLACEMENT OF WEB SITES

RELATED APPLICATIONS

The following co-pending and commonly assigned U.S. Patent Application has been filed on the same date as the present application. This application relates to and further describes other aspects of the embodiments disclosed in the present application and is herein incorporated by reference.

U.S. Pat. application Ser. No. 09/602,286, entitled "APPARATUS AND METHOD FOR DOMAIN NAME RESOLUTION", filed concurrently herewith.

BACKGROUND

The Internet is growing by leaps and bounds. Everyday, more and more users log on to the Internet for the first time and these, and existing users are finding more and more content being made available to them. Whether it be for shopping, checking stock prices or communicating with friends, the Internet represents a universal medium for communications and commerce.

Unfortunately, the growing user base along with the growing content provider base is causing ever increasing congestion and strain on the infrastructure, the network hardware and software plus the communications links linking it all together, which makes up the Internet. While the acronym "WWW" is defined as "World Wide Web", many users of the Internet have come to refer to it as the "World Wide Wait."

These problems are not limited to the Internet either. Many companies provide internal networks, known as intranets, which are essentially private Internets for use by their employees. These intranets can become overloaded as well. Especially, when a company's intranet provides connectivity to the Internet. In this situation, the intranet is not only carrying internally generated traffic but also Internet traffic generated by the employees.

Furthermore, more and more malicious programmers are setting there sights on the Internet. These "hackers" spread virus programs or attempt to hack into Web sites in order to steal valuable information such as credit card numbers. Further, there have been an increasing number of Denial of Service attacks where a hacker infiltrates multiple innocent computers connected to the Internet and uses them, unwittingly, to bombard a particular Web site with an immense volume of traffic. This flood of traffic overwhelms the servers and literally shuts the Web site down.

Accordingly, there is a need for an enhanced Internet infrastructure to more efficiently deliver content from providers to users and provide additional network security and fault tolerance.

SUMMARY

The present invention is defined by the following claims, and nothing in this section should be taken as a limitation on those claims. By way of introduction, the preferred embodiments described below relate to an apparatus for facilitating communications between a client and a first server over a network, where the network comprises a first sub-network comprising the client. The apparatus comprises a request interceptor coupled with the first sub-network and operative to selectively intercept a first request generated by the client to the first server prior to receipt by the first server. The apparatus also includes a request transmitter operative to transmit the intercepted first request to the first server as if originated by the apparatus. In addition, the apparatus includes a response receiver operative to receive a response from the first server in response to the originated intercepted first request. In addition, the apparatus includes a response transmitter operative to transmit said response to said client. Finally, the apparatus includes a request filter coupled between the request interceptor and the request transmitter and operative to selectively filter the intercepted first request prior to the request transmitter acting on the request.

The preferred embodiments further relate to a method for facilitating communications between a client and a first server over a network where the network comprises a first sub-network comprising the client. The method comprises: intercepting, selectively, a first data transmission generated by the client to the first server prior to receipt by the first server; filtering the selectively intercepted first data transmission; originating the filtered selectively intercepted first data transmission to the first server; receiving a response from the first server in response to the originated filtered selectively intercepted first data transmission; and transmitting the response to the client.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts an exemplary network for use with the preferred embodiments.

FIG. **2** depicts the operations of the Domain Name System of the exemplary network of FIG. **1**.

FIG. **3** depicts an exemplary content delivery system for use with the exemplary network of FIG. **1**.

FIG. **4** depicts a content delivery system for use with the network of FIG. **1** according to a first embodiment.

FIG. **4**A depicts a block diagram of the edge server of FIG. **4**.

FIG. **5** depicts a content delivery system for use with the network of FIG. **1** according to a second embodiment.

FIG. **5**A depicts a block diagram of the edge server of FIG. **5**.

FIG. **6** depicts a content delivery system for use with the network of FIG. **1** according to a third embodiment.

FIG. **6**A depicts a block diagram of the edge server of FIG. **6**.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Referring now to the figures, and in particular, FIG. **1**, there is shown an exemplary network **100** for use with the presently preferred embodiments. It is preferred that the network **100** be a publicly accessible network, and in particular, the Internet. While, for the purposes of this disclosure, the disclosed embodiments will be described in relation to the Internet, one of ordinary skill in the art will appreciate that the disclosed embodiments are not limited to the Internet and are applicable to other types of public networks as well as private networks, and combinations thereof, and all such networks are contemplated.

I. Introduction

As an introduction, a network interconnects one or more computers so that they may communicate with one another, whether they are in the same room or building (such as a Local Area Network or LAN) or across the country from each other (such as a Wide Area Network or WAN). A network is series of points or nodes **126** interconnected by communications paths **128**. Networks can interconnect with other networks and can contain sub-networks. A node **126** is a connection point, either a redistribution point or an end

point, for data transmissions generated between the computers which are connected to the network. In general, a node **126** has a programmed or engineered capability to recognize and process or forward transmissions to other nodes **126**. The nodes **126** can be computer workstations, servers, bridges or other devices but typically, these nodes **126** are routers.

A router is a device or, in some cases, software in a computer, that determines the next network node **126** to which a piece of data (also referred to as a "packet" in the Internet context) should be forwarded toward its destination. The router is connected to at least two networks or sub-networks and decides which way to send each information packet based on its current understanding of the state of the networks it is connected to. A router is located at any juncture of two networks, sub-networks or gateways, including each Internet point-of-presence (described in more detail below). A router is often included as part of a network switch. A router typically creates or maintains a table of the available routes and their conditions and uses this information along with distance and cost algorithms to determine the best route for a given packet. Typically, a packet may travel through a number of network points, each containing additional routers, before arriving at its destination.

The communications paths **128** of a network **100**, such as the Internet, can be coaxial cable, fiber optic cable, telephone cable, leased telephone lines such as T1 lines, satellite links, microwave links or other communications technology as is known in the art. The hardware and software which allows the network to function is known as the "infrastructure." A network **100** can also be characterized by the type of data it carries (voice, data, or both) or by the network protocol used to facilitate communications over the network's **100** physical infrastructure.

The Internet, in particular, is a publicly accessible worldwide network **100** which primarily uses the Transport Control Protocol and Internet Protocol ("TCP/IP") to permit the exchange of information. At a higher level, the Internet supports several applications protocols including the Hypertext Transfer Protocol ("HTTP") for facilitating the exchange of HTML/World Wide Web ("WWW") content, File Transfer Protocol ("FTP") for the exchange of data files, electronic mail exchange protocols, Telnet for remote computer access and Usenet for the collaborative sharing and distribution of information. It will be appreciated that the disclosed embodiments are applicable to many different applications protocols both now and later developed.

Logically, the Internet can be thought of as a Web of intermediate network nodes **126** and communications paths **128** interconnecting those network nodes **126** which provide multiple data transmission routes from any given point to any other given point on the network **100** (i.e. between any two computers connected to the network). Physically, the Internet can also be thought of as a collection of interconnected sub-networks wherein each sub-network contains a portion of the intermediate network nodes **126** and communications paths **128**. The division of the Internet into sub-networks is typically geographically based, but can also be based on other factors such as resource limitations and resource demands. For example, a particular city may be serviced by one or more Internet sub-networks provided and maintained by competing Internet Service Providers ("ISP's") (discussed in more detail below) to support the service and bandwidth demands of the residents.

Contrasting the Internet with an intranet, an intranet is a private network contained within an enterprise, such as a corporation, which uses the TCP/IP and other Internet protocols, such as the World Wide Web, to facilitate communications and enhance the business concern. An intranet may contain its own Domain Name Server ("DNS") (described in more detail below) and may be connected to the Internet via a gateway, i.e., an intra-network connection, or gateway in combination with a proxy server (described in more detail below) or firewall, as are known in the art.

Referring back to FIG. **1**, clients **102**, **104**, **106** and servers **108**, **110**, **112** are shown coupled with the network **100**. Herein, the phrase "coupled with" is defined to mean directly connected to or indirectly connected with through one or more intermediate components. Such intermediate components may include both hardware and software based components. The network **100** facilitates communications and interaction between one or more of the clients **102**, **104**, **106** and one or more of the servers **108**, **110**, **112** (described in more detail below). Alternatively, the network **100** also facilitates communications and interaction among one or more of the clients **102**, **104**, **106**, e.g. between one client **102**, **104**, **106** and another client **102**, **104**, **106** or among one or more of the servers **108**, **110**, **112**, e.g. between one server **108**, **110**, **112** and another server **108**, **110**, **112**.

A client **102**, **104**, **106** may include a personal computer workstation, mobile or otherwise, wireless device such as a personal digital assistant or cellular telephone, an enterprise scale computing platform such as a mainframe computer or server or may include an entire intranet or other private network which is coupled with the network **100**. Typically, a client **102**, **104**, **106** initiates data interchanges with other computers, such as servers **108**, **110**, **112** coupled with the network **100**. These data interchanges most often involve the client requesting data or content from the other computer and the other computer providing that data or content in response to the request. Alternatively, the other computer coupled with the network can "push" data or content to the client **102**, **104**, **106** without it first being requested. For example, an electronic mail server **108**, **110**, **112** may automatically push newly received electronic mail over the network **100** to the client **102**, **104**, **106** as the new electronic mail arrives, alleviating the client **102**, **104**, **106** from first requesting that new mail be sent. It will be apparent to one of ordinary skill in the art that there can be many clients **102**, **104**, **106** coupled with the network **100**.

A server **108**, **110**, **112** may include a personal computer workstation, an enterprise scale computing platform or other computer system as are known in the art. A server **108**, **110**, **112** typically responds to requests from clients **102**, **104**, **106** over the network **100**. In response to the request, the server **108**, **110**, **112** provides the requested data or content to the client **102**, **104**, **106** which may or may not require some sort of processing by the server **108**, **110**, **112** or another computer to produce the requested response. It will be apparent to one of ordinary skill in the art that a client **102**, **104**, **106** may also be a server **108**, **110**, **112** and vice versa depending upon the nature of the data interchange taking place. For purposes of this disclosure, a client **102**, **104**, **106** requests or receives content and is separate from a server **108**, **110**, **112** which provides content (whether requested or not, i.e. pushed). Preferably, servers **108**, **110**, **112** are World Wide Web servers serving Web pages and/or Web content to the clients **102**, **104**, **106** (described in more detail below). It will be apparent to one of ordinary skill in the art that there can be many servers **108**, **110**, **112** coupled with the network **100**.

Clients **102**, **104**, **106** are each coupled with the network **100** at a point of presence ("POP") **114**, **116**. The POP **114**, **116** is the connecting point which separates the client **102**,

104, 106 from the network 100. In a public network 100, such as the Internet, the POP 114, 116 is the logical (and possibly physical) point where the public network 100 ends, after which comes the private hardware or private network of the client 102, 104, 106. A POP 114, 116 is typically provided by a service provider 118, 120, such as an Internet Service Provider ("ISP") 118, 120, which provides connectivity to the network 100 on a fee for service basis. A POP 114, 116 may actually reside in rented space owned by telecommunications carrier such as AT&T or Sprint to which the ISP 118, 120 is connected. A POP 114, 116 may be coupled with routers, digital/analog call aggregators, servers 108, 110, 112, and frequently frame relay or ATM switches. As will be discussed below, a POP 114, 116 may also contain cache servers and other content delivery devices.

A typical ISP 118, 120 may provide multiple POP's 114, 116 to simultaneously support many different clients 102, 104, 106 connecting with the network 100 at any given time. A POP 114, 116 is typically implemented as a piece of hardware such as a modem or router but may also include software and/or other hardware such as computer hardware to couple the client 102, 104, 106 with the network 100 both physically/electrically and logically (as will be discussed below). The client 102, 104, 106 connects to the POP 114, 116 over a telephone line or other transient or dedicated connection. For example, where a client 102, 104, 106 is a personal computer workstation with a modem, the ISP 118, 120 provides a modem as the POP 114, 116 to which the client 102, 104, 106 can dial in and connect to via a standard telephone line. Where the client 102, 104, 106 is a private intranet, the POP 114, 116 may include a gateway router which is connected to an internal gateway router within the client 102, 104, 106 by a high speed dedicated communication link such as Ti line or a fiber optic cable.

A service provider 118, 120 will generally provide POP's 114, 116 which are geographically proximate to the clients 102, 104, 106 being serviced. For dial up clients 102, 104, 106, this means that the telephone calls can be local calls. For any client 102, 104, 106, a POP which is geographically proximate typically results in a faster and more reliable connection with the network 100. Servers 108, 110, 112 are also connected to the network 100 by POP's 114, 116. These POP's 114, 116 typically provide a dedicated, higher capacity and more reliable connection to facilitate the data transfer and availability needs of the server 108, 110, 112. Where a client 102, 104, 106 is a wireless device, the service provider 118, 120 may provide many geographically dispersed POP's 114, 116 to facilitate connecting with the network 100 from wherever the client 102, 104, 106 may roam or alternatively have agreements with other service providers 118, 120 to allow access by each other's customers. Each service provider 118, 120, along with its POP's 114, 116 and the clients 102, 104, 106 effectively forms a sub-network of the network 100.

Note that there may be other service providers 118, 120 "upstream" which provide network 100 connectivity to the service providers 118, 120 which provide the POP's 114, 116. Each upstream service provider 118, 120 along with its downstream service providers 118, 120 again forms a sub-network of the network 100. Peering is the term used to describe the arrangement of traffic exchange between Internet service providers (ISPs) 118, 120. Generally, peering is the agreement to interconnect and exchange routing information. More specifically, larger ISP's 118, 120 with their own backbone networks (high speed, high capacity network connections which interconnect sub-networks located in disparate geographic regions) agree to allow traffic from other large ISP's 118, 120 in exchange for traffic on their backbones. They also exchange traffic with smaller service providers 118, 120 so that they can reach regional end points where the POP's 114, 116 are located. Essentially, this is how a number of individual sub-network owners compose the Internet. To do this, network owners and service providers 118, 120, work out agreements to carry each other's network traffic. Peering requires the exchange and updating of router information between the peered ISP's 118, 120, typically using the Border Gateway Protocol (BGP). Peering parties interconnect at network focal points such as the network access points (NAPs) in the United States and at regional switching points. Private peering is peering between parties that are bypassing part of the publicly accessible backbone network through which most Internet traffic passes. In a regional area, some service providers 118, 120 have local peering arrangements instead of, or in addition to, peering with a backbone service provider 118, 120.

A network access point (NAP) is one of several major Internet interconnection points that serve to tie all of the service providers 118, 120 together so that, for example, an AT&T user in Portland, Oreg. can reach the Web site of a Bell South customer in Miami, Fla. The NAPs provide major switching facilities that serve the public in general. Service providers 118, 120 apply to use the NAP facilities and make their own inter-company peering arrangements. Much Internet traffic is handled without involving NAPs, using peering arrangements and interconnections within geographic regions.

For purposes of later discussions, the network 100 can be further logically described to comprise a core 122 and an edge 124. The core 122 of the network 100 includes the servers 108, 110, 112 and the bulk of the network 100 infrastructure, as described above, including larger upstream service providers 118, 120, and backbone communications links, etc. Effectively, the core 122 includes everything within the network 100 up to the POP's 114, 116. The POP's 114, 116 and their associated hardware lie at the edge 124 of the network 100. The edge 124 of the network 100 is the point where clients 102, 104, 106, whether single devices, computer workstations or entire corporate internal networks, couple with the network 100. As defined herein, the edge 124 of the network 100 may include additional hardware and software such as Domain Name Servers, cache servers, proxy servers and reverse proxy servers as will be described in more detail below. Typically, as the network 100 spreads out from the core 122 to the edge 124, the total available bandwidth of the network 100 is diluted over more and more lower cost and lower bandwidth communications paths. At the core 122, bandwidth over the higher capacity backbone interconnections tends to be more costly than bandwidth at the edge 124 of the network 100. As with all economies of scale, high bandwidth interconnections are more difficult to implement and therefore rarer and more expensive than low bandwidth connections. It will be appreciated, that even as technology progresses, newer and higher bandwidth technologies will remain more costly than lower bandwidth technologies.

II. The World Wide Web

As was discussed above, clients 102, 104, 106 engage in data interchanges with servers 108, 110, 112. On the Internet, these data exchanges typically involve the World Wide Web ("WWW"). Relative to the TCP/IP suite of protocols (which are the basis for information exchange on the Internet), HTTP is an application protocol. A technical definition of the World Wide Web is all the resources and

users on the Internet that are using the Hypertext Transfer Protocol ("HTTP"). HTTP is the set of rules for exchanging data in the form of files (text, graphic images, audio, video, and other multimedia files, such as streaming media and instant messaging), also known as Web content, between clients **102**, **104**, **106** and servers **108**, **110**, **112**. Servers **108**, **110**, **112** which serve Web content are also known as Web servers **108**, **110**, **112**.

Essential concepts that are part of HTTP include (as its name implies) the idea that files/content can contain references to other files/content whose selection will elicit additional transfer requests. Any Web server **108**, **110**, **112** contains, in addition to the files it can serve, an HTTP daemon, a program that is designed to wait for HTTP requests and handle them when they arrive. A personal computer Web browser program, such as Microsoft™ Internet Explorer, is an HTTP client program (a program which runs on the client **102**, **104**, **106**), sending requests to Web servers **108**, **110**, **112**. When the browser user enters file requests by either "opening" a Web file (typing in a Uniform Resource Locator or URL) or clicking on a hypertext link, the browser builds an HTTP request and sends it to the Web server **108**, **110**, **112** indicated by the URL. The HTTP daemon in the destination server **108**, **110**, **112** receives the request and, after any necessary processing, returns the requested file to the client **102**, **104**, **106**.

The Web content which a Web server typically serves is in the form of Web pages which consist primarily of Hypertext Markup Language. Hypertext Markup Language ("HTML") is the set of "markup" symbols or codes inserted in a file intended for display on a World Wide Web browser. The markup tells the Web browser how to display a Web page's words and images, as well as other content, for the user. The individual markup codes are referred to as elements or tags. Web pages can further include references to other files which are stored separately from the HTML code, such as image or other multimedia files to be displayed in conjunction with the HTML Web content.

A Web site is a related collection of Web files/pages that includes a beginning HTML file called a home page. A company or an individual tells someone how to get to their Web site by giving that person the address or domain name of their home page (the addressing scheme of the Internet and the TCP/IP protocol is described in more detail below). From the home page, links are typically provided to all the other pages (HTML files) located on their site. For example, the Web site for IBM™ has the home page address of http://www.ibm.com. Alternatively, the home page address may include a specific file name like index.html but, as in IBM's case, when a standard default name is set up, users don't have to enter the file name. IBM's home page address leads to thousands of pages. (But a Web site can also be just a few pages.)

Since site implies a geographic place, a Web site can be confused with a Web server **108**, **110**, **112**. As was discussed above, a server **108**, **110**, **112** is a computer that holds and serves the HTML files, images and other data for one or more Web sites. A very large Web site may be spread over a number of servers **108**, **110**, **112** in different geographic locations or one server **108**, **110**, **112** may support many Web sites. For example, a Web hosting company may provide server **108**, **110**, **112** facilities to a number of Web sites for a fee. Multiple Web sites can cross-link to files on other Web sites or even share the same files.

III. The Domain Name System

As was described above, the network **100** facilitates communications between clients **102**, **104**, **106** and servers **108**, **110**, **112**. More specifically, the network **100** facilitates the transmission of HTTP requests from a client **102**, **104**, **106** to a server **108**, **110**, **112** and the transmission of the server's **108**, **110**, **112**, response to that request, the requested content, back to the client **102**, **104**, **106**. In order to accomplish this, each device coupled with the network **100**, whether it be a client **102**, **104**, **106** or a server **108**, **110**, **112** must provide a unique identifier so that communications can be routed to the correct destination. On the Internet, these unique identifiers comprise domain names (which generally will include World Wide. Web Uniform Resource Locators or "URL's") and Internet Protocol addresses or "IP" addresses. Every client **102**, **104**, **106** and every server **108**, **110**, **112** must have a unique domain name and IP address so that the network **100** can reliably route communications to it. Additionally, clients **102**, **104**, **106** and servers **108**, **110**, **112** can be coupled with proxy servers (forward, reverse or transparent), discussed in more detail below, which allow multiple clients **102**, **104**, **106** or multiple servers **108**, **110**, **112** to be associated with a single domain name or a single IP address. In addition, a particular server **108**, **110**, **112** may be associated with multiple domain names and/or IP addresses for more efficient handling of requests or to handle multiple content providers, e.g. multiple Web sites, on the same server **108**, **110**, **112**. Further, as was discussed above, since a POP **114**, **116** provides the connecting point for any particular client **102**, **104**, **106** to connect to the network **100**, it is often satisfactory to provide each POP **114**, **116** with a unique domain name and IP address since the POP **114**, **116** will reliably deliver any communications received by it to its connected client **102**, **104**, **106**. Where the client **102**, **104**, **106** is a private network, it may have its own internal hardware, software and addressing scheme (which may also include domain names and IP addresses) to reliably deliver data received from the POP **114**, **116** to the ultimate destination within the private network client **102**, **104**, **106**.

As was discussed, the Internet is a collection of interconnected sub-networks whose users communicate with each other. Each communication carries the address of the source and destination sub-networks and the particular machine within the sub-network associated with the user or host computer at each end. This address is called the IP address (Internet Protocol address). In the current implementation of the Internet, the IP address is a 32 bit binary number divided into four 8 bit octets. This 32-bit IP address has two parts: one part identifies the source or destination sub-network (with the network number) and the other part identifies the specific machine or host within the source or destination sub-network (with the host number). An organization can use some of the bits in the machine or host part of the address to identify a specific sub-network within the sub-network. Effectively, the IP address then contains three parts: the sub-network number, an additional sub-network number, and the machine number.

One problem with IP addresses is that they have very little meaning to ordinary users/human beings. In order to provide an easier to use, more user friendly network **100**, a symbolic addressing scheme operates in parallel with the IP addressing scheme. Under this symbolic addressing scheme, each client **102**, **104**, **106** and server **108**, **110**, **112** is also given a "domain name" and further, individual resources, content or data are given a Uniform Resource Locator ("URL") based on the domain name of the server **108**, **110**, **112** on which it is stored. Domain names and URL's are human comprehensible text and/or numeric strings which have symbolic meaning to the user. For example, a company may

have a domain name for its servers **108**, **110**, **112** which is the company name, i.e., IBM Corporation's domain name is ibm.com. Domain names are further used to identify the type of organization to which the domain name belongs. These are called "top-level" domain names and include com, edu, org, mil, gov, etc. Corn indicates a corporate entity, edu indicates an educational institution, mil indicates a military entity, and gov indicates a government entity. It will be apparent to one of ordinary skill in the art that the text strings which make up domain names may be arbitrary and that they are designed to have relevant symbolic meaning to the users of the network **100**. A URL typically includes the domain name of the provider of the identified resource, an indicator of the type of resource and an identifier of the resource itself. For example, for the URL "http://www.ibm.com/index.html", http identifies this resource as a hypertext transfer protocol compatible resource, www.ibm.com is the domain name (again, the www is arbitrary and typically is added to indicate to a user that the server **108**, **110**, **112**, associated with this domain name is a world wide Web server), and index.html identifies a hypertext markup language file named "index.html" which is stored on the identified server **108**, **110**, **112**.

Domain names make the network **100** easier for human beings to utilize it, however the network infrastructure ultimately uses IP addresses, and not domain names, to route data to the correct destination. Therefore, a translation system is provided by the network **100** to translate the symbolic human comprehensible domain names into IP addresses which can then be used to route the communications. The Domain Name System ("DNS") is the way that Internet domain names are located and translated into IP addresses. The DNS is a distributed translation system of address translators whose primary function is to translate domain names into IP addresses and vice versa. Due to the ever expanding number of potential clients **102**, **104**, **106** and servers **108**, **110**, **112** coupled with the network **100** (currently numbering in the millions), maintaining a central list of domain name/IP address correspondences would be impractical. Therefore, the lists of domain names and corresponding IP addresses are distributed throughout the Internet in a hierarchy of authority. A DNS server, typically located within close geographic proximity to a service provider **118**, **120** (and likely provided by that service provider **118**, **120**), handles requests to translate the domain names serviced by that service provider **118**, **120** or forwards those requests to other DNS servers coupled with the Internet for translation.

DNS translations (also known as "lookups" or "resolutions") can be forward or reverse. Forward DNS translation uses an Internet domain name to find an IP address. Reverse DNS translation uses an Internet IP address to find a domain name. When a user enters the address or URL for a Web site or other resource into their browser program, the address is transmitted to a nearby router which does a forward DNS translation in a routing table to locate the IP address. Forward DNS translations are the more common translation since most users think in terms of domain names rather than IP addresses. However, occasionally a user may see a Web page with a URL in which the domain name part is expressed as an IP address (sometimes called a dot address) and wants to be able to see its domain name, to for example, attempt to figure the identity of who is providing the particular resource. To accomplish this, the user would perform a reverse DNS translation.

The DNS translation servers provided on the Internet form a hierarchy through which any domain name can be "resolved" into an IP address. If a particular DNS translation server does not "know" the corresponding IP address of a given domain name, it "knows" other DNS translation servers it can "ask" to get that translation. This hierarchy includes "top-level" DNS translation servers which "know" which resources (clients **102**, **104**, **106** or servers **108**, **110**, **112**) have a particular top level domain identifier, i.e. corm, gov, edu, etc. as described above. This hierarchy further continues all the way up to the actual resource (client **102**, **104**, **106** or server **108**, **110**, **112**) which is typically affiliated with a DNS translation server which "knows" about it and its IP address. A particular DNS translation server "knows" of a translation when it exists in its table of translations and has not expired. Any particular translation will typically be associated with a Time to Live ("TTL") which specifies a duration, time or date after which the translation expires. As discussed, for a given translation, if a DNS translation server does not know the translation, because it is not in its routing table or it has expired, that DNS translation server will have to inquire up the hierarchical chain of DNS translation servers in order to make the translation. In this way, new domain name and IP address translations can be propagated through the DNS translation server hierarchy as new resources are added and old resources are assigned new addresses.

Referring now to FIG. **2**, there is shown a diagram illustrating the basic operation of the Domain Name System **200**. Depicted in the figure are clients **102**, **104**, **106**, labeled "Client **1**", "Client **2**" and "Client **3**." Clients **1** and **2** are coupled with POP's **114** provided by service provider **120**, labeled "POP1A" and "POP 1B." Client **3** is coupled with a POP (not shown) provided by service provider **118**, labeled "POP2." In addition, service providers **118**, **120** may provide additional POP's **114** for other clients **102**, **104**, **106** as described above. Service provider **120** is shown further coupled with service provider **118**, a server **108**, labeled "Server **1**", preferably a Web server and more preferably an entire Web site which may comprise multiple sub-servers (not shown) as discussed above, and a top-level DNS translation server **202**, labeled "DNS Top", all via the network **100** which is preferably the Internet. Furthermore, service provider **120** further includes a DNS translation server **204**, labeled "DNS A" and routing and interconnection hardware **206**, as described above, to electrically and logically couple the POP's **114** with the network **100**. Optionally, the service provider **120** may also include a cache server **208** or proxy server (not shown) to enhance content delivery as described below.

In order for a client **102**, **104**, **106** to generate a request for content to a particular server **108**, the client **102**, **104**, **106** first determines the IP address of the server **108** so that it can properly address its request. Referring to Client **1** **102**, an exemplary DNS translation transaction where the client **102**, **104**, **106** is a single workstation computer is depicted. A user of Client **1** enters a URL or domain name of the Server **1** **108** and specific resource contained within Server **1**, such as a sub-server, into their browser program in order to make a request for content. The browser program typically handles negotiating the DNS translation transaction and typically has been pre-programmed ("bound") with the IP address of a particular DNS translation server to go to first in order to translate a given domain name. Typically, this bound DNS translation server will be DNS A **204** provided by the service provider **120**. Alternatively, where the client **102**, **104**, **106** is not bound to a particular DNS translation server, the service provider **120** can automatically route translation requests received by its POP's **114** to its DNS translation

server, DNS A **202**. The process by which a domain name is translated is often referred to as the "slow start" DNS translation protocol. This is in contrast to what is known as the "slow start HTTP" protocol which will be discussed below in more detail in relation to content delivery.

Client **1 102** then sends its translation request, labeled as "A1", to its: POP **114**, POP1A. The request, A1, is addressed with a return address of Client **1** and with the IP address of the bound DNS A **204** therefore the service provider's **120** routing equipment **206** automatically routes the request to DNS A **204**, labeled as "B." Assuming DNS A **204** does not know how to translate the given domain name in the request or the translation in its routing table has expired, it must go up the DNS hierarchy to complete the translation. DNS A **204** will then forward a request, labeled "C", upstream to the top-level DNS translation server **202** associated with the top-level domain in the domain address, i.e. com, gov, edu etc. DNS A **204** has been pre-programmed with the IP addresses of the various hierarchical servers that it may need to talk to in order to complete a translation. DNS A **204** addresses request C with the IP address of the top-level DNS server **202** and also includes its own return address. DNA then transmits the request over the network **100** which routes the request to the top level DNS server **202**. The top-level DNS server **202** will then translate and return the IP address corresponding to Server **1 108** back to DNS A **204** via the network **100**, labeled "D."

As was discussed above, a particular domain name may be associated with multiple IP addresses of multiple sub-servers **108**, **110**, **112**, as in the case of a Web site which, due to its size, must be stored across multiple sub-servers **108**, **110**, **112**. Therefore, in order to identify the exact sub-server which can satisfy the request of the Client **1 102**, DNS A **204** must further translate the domain address into the specific sub-server **108**. In order to accomplish this, Server **1 108** provides its own DNS translation server **210** which knows about the various sub-servers and other resources contained within Server **1 108**. DNS A **204**, now knowing the IP address of Server **1 108**, e.g. the Web site generally, can create a request, labeled "E", to translate the domain name/URL provided by Client **1 102** into the exact sub-server/resource on Server **1 108**. DNS B **210** returns the translation, labeled "F", to DNS A **204** which then returns it to Client **1 102** via the service provider's routing equipment **206**, labeled "G", which routes the response through POP1A **114** to the Client **1**, labeled "H1." Client **1 102** now has the IP address it needs to formulate its content requests to Server **1 108**.

FIG. **2**, further depicts an exemplary DNS translation transaction wherein the client **102**, **104**, **106** is a private network such as an intranet. For example, client **2 104** may comprise its own network of computer systems. Further more, client **2 104** may provide its own DNS translation server (not shown) to handle internal routing of data as well as the routing of data over the network **100** generally for the computer systems coupled with this private network. In this case, the internal DNS translation server will either be programmed to send its unknown translations to DNS A (labeled as "A2", "B", "C", "D", "F", "G", "H2") or may be programmed to use the DNS hierarchy itself, i.e. communicate directly with the upstream DNS Top **202** and DNS B **210** (labeled as "A2", "B2", "C2", "D2", "E2", "F2", "G2", "H2"). In these cases, the internal DNS translation server simply adds another layer to the DNS hierarchy as a whole, but the system continues to function similarly as described above.

In addition, FIG. **2**, further depicts an exemplary DNS translation transaction wherein the client **102**, **104**, **106** is coupled with a POP **114** that is not associated with its bound DNS translation server **204**. For example, Client **3 106** is depicted as being coupled with POP2 provided by service provider **118**. In the exemplary situation, Client **3 106** is bound with DNS A **204** provided by service provider **120**. This situation can occur in the wireless environment, where a particular wireless client **102**, **104**, **106** couples with whatever POP **114**, **116** is available in its geographic proximity (e.g. when roaming) and is affiliated, e.g. has access sharing agreements, with the service provider **120** who generally provides connectivity services for the client **102**, **104**, **106**. In this case, client **3 106** will perform its translation requests as described above, and will address these requests to its bound DNS Server, in this case DNS A **204**. The service provider **118** will see the address of the DNS A **204** in client **3**'s **106** translation requests and appropriately route the translation request over the network **100** to service provider **120** and ultimately on to DNS A **204**. DNS A **204** will appropriately handle the request and: return it via the network **100** accordingly (labeled as "A3", "B", "C", "D", "E", "F", "G", "H3").

It will be appreciated that in each of the examples given above, if a particular DNS translation server already "knows" the requested translation, the DNS translation server does not have to go up the hierarchy and can immediately return the translation to the requester, either the client **102**, **104**, **106** or downstream DNS translation server.

It should be noted, that because a given server **108**, **110**, **112** may comprise multiple IP addresses, the DNS translation servers may be programmed to return a list of IP addresses in response to a given domain name translation request. Typically, this list will be ordered from the most optimal IP address to the least optimal IP address. The browser program can then pick one of the IP addresses to send content requests to and automatically switch to another IP address should the first requests fail to reach the destination server **108**, **110**, **112** due to a hardware failure or network **100** congestion. It will further be appreciated that the operations and structure of the existing DNS system are known to those of ordinary skill in the art.

IV. Content Delivery

As mentioned above, once the DNS translation is complete, the client **102**, **104**, **106** can initiate its requests for content from the server **108**. Typically, the requests for content will be in the form of HTTP requests for Web content as described above. In order to alleviate server **108** overload, the HTTP protocol provides a "slow start" mechanism. As was described above, a Web page consists of HTML code plus images, multimedia or other separately stored content. Typically, the amount of HTML code contained within a Web page is very small compared to the amount of image and/or multimedia data. When a client requests a Web page from the server **108**, the server **108** must serve the HTML code and the associated image/multimedia data to the client **102**, **104**, **106**. However, the client **102**, **104**, **106**, upon receipt of the HTML code, may decide, for whatever reason, that it does not want the associated image/multimedia data. To prevent the server **108** from wasting processing and bandwidth resources unnecessarily by sending unwanted data, the HTTP slow start protocol forces the client **102**, **104**, **106** to first request the HTML code and then subsequent to receipt of that HTML code, request any associated separately stored content. In this way, if after the initial request, the client **102**, **104**, **106** disconnects or otherwise switches to making requests of another server **108**, the initial server **108** is not burdened with serving the unwanted or unnecessary content.

In addition, it important to note that clients **102**, **104**, **106** may be located very far from each other, either geographically or even logically in consideration of the network topology. For example, a client **102**, **104**, **106** may be located in Chicago, Ill. while the server **108** from which it is requesting content is located in Paris, France. Alternatively, client **102**, **104**, **106** may be located in the same city as server **108** but, due to the topology of the network **100**, there may be multiple nodes **126** and interconnecting communications paths **128** between the client **102**, **104**, **106** and the server **108** necessitating a lengthy route for any data transmitted between the two. Either scenario can significantly impact the response time of a server **108** to a given request from a client **102**, **104**, **106**. Adding in the fact that the network **100** may be servicing millions of clients **102**, **104**, **106** and servers **108** at any given time, the response time may be further impacted by reduced bandwidth and capacity caused by network congestion at the server **108** or at one or more intermediate network nodes **126**.

Servers **108** and service providers **118**, **120** may attempt to alleviate this problem by increasing the speed and bandwidth capacity of the network **100** interconnections. Further, servers **108** may attempt to alleviate slow request response times by providing multiple sub-servers which can handle the volume of requests received with minimal latency. These sub-servers can be provided behind a reverse proxy server which, as described above, is "tightly coupled" with the Web site and can route content requests directed to a single IP address, to any of the multiple sub-servers. This reduces the number of individual translations that have to be made available to the DNS translation system and kept up to date for all of the sub-servers. The reverse proxy server can also attempt to balance the load across multiple sub-servers by allocating incoming requests using, for example, a round-robin routine. Reverse proxy servers can further include a cache server as described below to further enhance the Server's **108** ability to handle a high volume of requests or the serving of large volumes of data in response to any given request. It will be appreciated that reverse proxy servers and load balancing techniques are generally known to those of ordinary skill in the art.

Clients **102**, **104**, **106** and service providers **118**, **120** (and, as described above, servers **108**) may attempt to alleviate this problem by including a cache or cache server **208**. A cache server **208** is a server computer (or alternatively implemented in software directly on the client **102**, **104**, **106** or another computer coupled with the client **102**, **104**, **106** such as at the POP **114**) located, both logically and geographically, relatively close to the client **102**, **104**, **106**. The cache server **208** saves/caches Web pages and other content that clients **102**, **104**, **106**, who share the cache server, have requested in the past. Successive requests for the same content can then be satisfied by the cache server **208** itself without the need to contact the source of the content. A cache server **208** reduces the latency of fulfilling requests and also reduces the load on the content source. Further, a cache server **208** at the edge **124** of the Internet reduces the consumption of bandwidth at the core **122** of the Internet where it is more expensive. The cache server **208** may be a part of a proxy server or may be provided by a service provider **118**, **120**.

Cache servers **208** invisibly intercept requests for content and attempt to provide the requested content from the cache (also known as a "hit"). Note that a cache server **208** is not necessarily invisible, especially when coupled with a proxy server. In this case, the client **102**, **104**, **106** may need to be specially programmed to communicate its content requests to the proxy server in order to utilize the cache server. Cache servers **208**, as referred to in this disclosure then, may include these visible cache servers as well as invisible cache servers which transparently intercept and attempt to service content requests. Where the requested content is not in the cache (also known as a "miss"), the cache forwards the request onto the content source. When the source responds to the request by sending the content to the client **102**, **104**, **106**, the cache server **208** saves a copy of the content in its cache for later requests. In the case where a cache server is part of a proxy server, the cache/proxy server makes the request to the source on behalf of the client **102**, **104**, **106**. The source then provides the content to the cache/proxy server which caches the content and also forwards the requested content to the client **102**, **104**, **106**. An exemplary software based cache server is provided by SQUID, a program that caches Web and other Internet content in a UNIX-based proxy server closer to the user than the content-originating site. SQUID is provided as open source software and can be used under the GNU license for free software, as is known in the art.

Caches operate on two principles, temporal locality and spatial locality. Temporal locality is a theory of cache operation which holds that data recently requested will most likely be requested again. This theory dictates that a cache should store only the most recent data that has been requested and older data can be eliminated from the cache. Spatial Locality is a theory of cache operation which holds that data located near requested data (e.g. logically or sequentially) will be likely to be requested next. This theory dictates that a cache should fetch and store data in and around the requested data in addition to the requested data. In practice, this means that when a HTML Web page is requested, the cache should go ahead and request the separately stored content, i.e. begin the slow start process because more likely than not, the client **102**, **104**, **106** will request this data upon receipt of the HTML code.

While cache servers **208** alleviate some of the problems with net congestion and request response times, they do not provide a total solution. In particular, they do not provide a viable solution for dynamic content (content which continually changes, such as news, as opposed to static or fixed content). This type of content cannot be cached otherwise the requesting client **102**, **104**, **106** will receive stale data. Furthermore, cache servers **208** often cannot support the bandwidth and processing requirements of streaming media, such as video or audio, and must defer these content requests to the server **108** which are the source of the content. Cache servers **208**, in general, further lack the capability to service a large volume of requests from a large volume of clients **102**, **104**, **106** due to the immense capacity requirements. Typically, then general cache servers **208**, such as those provided by a service provider **118**, **120** will have high miss rates and low hit rates. This translates into a minimal impact on server **108** load, request response times and network **100** bandwidth. Moreover, as will be discussed below, by simply passing on requests which miss in the cache to the server **108** to handle, the server **108** is further subjected to increased security risks from the untrusted network **100** traffic which may comprise, for example, a denial of service attack or an attempt by a hacker to gain unauthorized access.

Referring now to FIG. **3**, there is depicted an enhanced content delivery system **300** which provides optimized caching of content from the server **108** to the client **102**, **104**, **106** utilizing the HTTP slow start protocol. The system **300** is typically provided as a pay for service by a content delivery service to which particular servers **108** subscribe to in order

to enhance requests made by clients **102**, **104**, **106** for their specific content. FIG. **3** depicts the identical DNS system of FIG. **2** but adds cache servers **302** and **304**, labeled "Cache C1" and "Cache C2" plus a special DNS translation server **306**, labeled "DNS C" affiliated with the content delivery service.

The depicted system **300** implements one known method of "Content Delivery." Content delivery is the service of copying the pages of a Web site to geographically dispersed cache servers **302**, **304** and, when a page is requested, dynamically identifying and serving the page from the closest cache server **302**, **304** to the requesting client **102**, **104**, **106**, enabling faster delivery. Typically, high-traffic Web site owners and service providers **118**, **120** subscribe to the services of the company that provides content delivery. A common content delivery approach involves the placement of cache servers **302**, **304** at major Internet access points around the world and the use of a special routing code embedded in the HTML Web pages that redirects a Web page request (technically, a Hypertext Transfer Protocol—HTTP—request) to the closest cache server **302**, **304**. When a client **102**, **104**, **106** requests the separately stored content of a Web site/server **108** that is "content-delivery enabled," the content delivery network re-directs that client **102**, **104**, **106** to makes its request, not from the site's originating server **108**, but to a cache server **302**, **304** closer to the user. The cache, server **302**, **304** determines what content in the request exists in the cache, serves that content to the requesting client **102**, **104**, **106**, and retrieves any non-cached content from the originating server **108**. Any new content is also cached locally. Other than faster loading times, the process is generally transparent to the user, except that the URL ultimately served back to the client **102**, **104**, **106** may be different than the one initially requested. Content delivery is similar to but more selective and dynamic than the simple copying or mirroring of a Web site to one or several geographically dispersed servers. It will further be appreciated that geographic dispersion of cache servers is generally known to those of ordinary skill in the art.

FIG. **3** further details a known method of re-directing the requests generated by the client **102**, **104**, **106** to a nearby cache server **302**, **304**. This method utilizes the HTTP slow start protocol described above. When a client **102**, **104**, **106** wishes to request content from a particular server **108**, it will obtain the IP address of the server **108**, as described above, using the normal DNS translation system. Once the server's **108** IP address is obtained, the client **102**, **104**, **106** will make its first request for the HTML code file which comprises the desired Web page. As given by the HTTP slow start protocol, the server **108** will serve the HTML code file to the client **102**, **104**, **106** and then wait for the client **102**, **104**, **106** to request the separately stored files, e.g., the image and multimedia files, etc. Normally, these requests are made in the same way that the initial content request was made, by reading each URL from the HTML code file which identifies the separately stored content and formulating a request for that URL. If the domain name for the URL of the separately stored content is the same as the domain name for the initially received HTML code file, then no further translations are necessary and the client **102**, **104**, **106** can immediately formulate a request for that separately stored content because it already has the IP address. However, if the URL of the separately stored content comprises a different domain name, then the client **102**, **104**, **106** must go through the DNS translation process again to translate the new domain name into an IP address and then formulate its requests with the appropriate IP address. The exemplary content delivery service takes advantage of this HTTP slow start protocol characteristic.

The exemplary content delivery service partners with the subscribing Web server **108** and modifies the URL's of the separately stored content within the HTML code file for the particular Web page. The modified URL's include data which will direct their translation requests to a specific DNS translation server **306**, DNS C provided by the content delivery service. DNS C is an intelligent translation server which attempts to figure out where the client **102**, **104**, **106** is geographically located and translate the URL to point to a cache server **302**, **304** which is geographically proximate to the client **102**, **104**, **106**. DNS C performs this analysis by knowing the IP address of the downstream DNS server **204**, DNS A which it assumes is located near the client **102**, **104**, **106**. By using this IP address and combining it with internal knowledge of the network **100** topology and assignment of IP addresses, DNS C **306** can determine the geographically optimal cache server **302**, **304** to serve the requested content to the client **102**, **104**, **106**.

An exemplary transaction is further depicted by FIG. **3**. In this exemplary transaction, Client **3 106** wishes to request content from Server **1 108**. Client **3 106** will establish the IP address of the source of the desired content using the standard DNS translation system described above, labeled "A1", "B", "C", "D", "E", "F", "G", "H1." Once Client **3 106** has the IP address of Server **1 108**, it will generate a request for the initial HTML code file of the desired Web page and Server **1 108** will respond with the data. Client **3 106** will then request a particular separately stored file associated with the Web page by reading the URL from the HTML code file and translating the domain name contained therein. As noted above, this URL comprises the domain name of the content delivery service as well as an identifier which identifies the content being requested (since the content delivery service typically handles many different servers **108**). Client **3 106** will generate another translation request to DNS A **204**, labeled "I1" and "J." DNS A **204** will attempt to translate the given domain name but will fail because the content delivery service has set all of its translations to have a TTL=0. Therefore, DNS A **204** will be required to contact DNS C **306** which is provided by the content delivery service, labeled "K" and "L." Note that DNS A **204** may be required to contact DNS top **202** in order to locate the IP address of DNS C **306**. DNS C **306** receives the translation request and knows the IP address of DNS A **204**, which was given as the return address for the translation. Using the IP address of DNS A **204**, DNS C **306** figures out which cache server **302**, **304** is geographically proximate to Client **3 106**, in this case, Cache C2 **304**. An appropriate IP address is then returned to by DNS C **306** to DNS A **204** and subsequently returned to Client **3 106**. Client **3 106** then formulates its request for the separately stored data but, unwittingly, uses the IP address of the cache server C2 **304**. Cache server C2 **304** receives the request and serves the desired content as described above.

FIG. **3** further illustrates a second exemplary transaction sequence which discloses a flaw in the depicted content delivery method. In this example, Client **1 102** wishes to request content from Server **1 108**. Client **1 102** is a wireless or mobile client which is coupled with service provide **118** at POP2 but is bound to DNS A **204** provided by service provider **120**. In this example, all of the translation and request transactions occur as in the above example for Client **3 106**. The translation request to identify the IP address of the separately stored content will be handled by DNS A **204** which will then hand it off to DNS C **306** as described above. However, DNS C **306** will then attempt to identify a geographically proximate cache server **302**, **304** based on

the IP address of DNS A **204** which is not located near Client **1 102** in this example. Therefore DNS C **306** will return a translation directing Client **1102** to cache server C2 **304** when in fact, the optimal cache server would have been cache server C1 **302**. With more and more wireless and mobile user utilizing the Internet, mis-optimized redirection of content delivery will happen more frequently. Furthermore, there may be cases where the Client **102, 104, 106** is dynamically bound to a DNS translator associated with whatever POP **114, 116** they are connecting to. While this may appear to solve the problem, the content delivery service is still basing its redirection determination on an indirect indicator of the location of the client **102, 104, 106**. However, the IP address of the DNS translator may still fail to indicate the correct geographic location or the correct logical location (based on the, topology of the network **100**) of the client **102, 104, 106** in relation to the DNS translator. A more accurate indicator of the client's **102, 104, 106** physical geographic location and/or network logical location is needed in order to make an accurate decision on which cache server **302, 304** to redirect that client **102, 104, 106** to.

V. The First Embodiment

Referring now to FIG. **4**, there is depicted a first embodiment of an enhanced DNS system to facilitate the operation of content delivery services by eliminating the dependency on the geographic location of the downstream DNS server. In addition to what is shown in FIG. **3**, the embodiment shown in FIG. **4** further adds an edge server **402** coupled with the routing equipment **206** and POP's **114** of an affiliated service provider **120** and preferably located within the affiliated server provider's **120** facilities. In one alternative embodiment, the edge server **402** is integrated with a router. In another alternative embodiment, the edge server is integrated with a generally accessible DNS translation server such as DNS A1 **204**. The edge server **402** is capable of monitoring the network traffic stream passing between the POP's **114** and the network **100**, including the service provider's **120** hardware, such as the cache **208** and the DNS translation server **204**, DNS A. The edge server **402** is further capable of selectively intercepting that traffic and preventing it from reaching its intended destination, modifying the intercepted traffic and reinserting the modified traffic back into the general network traffic stream. It is preferred that the facilities and capabilities of the edge server **402** be provided to content delivery services and or Web servers **108** on a fee for services basis as will be described below. Further, it is preferred that an edge server **402** be provided at every major service provider **118, 120** so as to be able to selectively intercept network traffic at all possible POP's **114, 116** of the network **100**.

Referring to FIG. **4**A, the edge server **402** includes a request interceptor **404**, a request modifier **406**, and a request forwarder **408**. The edge server **402** preferably includes one or more processors, a memory coupled with the processors and one or more network interfaces or other interfaces, also coupled with the processors and operative to couple or integrate the edge server **402** with the routing equipment of the service provider **120**. Optionally, the edge server **402** may include secondary storage including a second memory such as a cache memory, hard disk or other storage medium. Further, the processors of the edge server **402** may be dedicated processors to perform the various specific functions described below. The edge server **402** preferably further includes software and/or firmware provided in a read only memory or in a secondary storage which can be loaded into memory for execution or, alternatively, executed from the secondary storage by the processors, to implement the various functions as detailed below. To further improve performance, such software functionality may also be provided by application specific integrated circuits ("ASICS"). For example, an edge server **402** can comprise a Compaq TaskSmart™ Server manufactured by Compaq Corporation, located in Austin, Tex. The TaskSmart™ Server can include an Intel I×A1000 Packet Processor manufactured by Intel Corporation, located in Santa Clara, Calif. to perform the traffic monitoring and port specific traffic interception functions as well as the security applications as detailed below. The TaskSmart™ Server can further include a PAX.port 1100™ classification adapter manufactured by Solidum Corporation, located in Scotts Valley, Calif., which can receive intercepted DNS translation requests from the packet processor and, utilizing a look up table (preferably stored in a memory providing high speed access), determine whether or not the request is associated with a subscribing server **108**, as described below. The classification adapter can attempt to resolve the DNS request or hand it off to a general processor such as an Intel Pentium III™ or other general purpose processor for further operations as detailed below. An exemplary edge server **402** may have six 9.1 GB hot pluggable hard drives preferably in a RAID or other redundant configuration, two redundant hot pluggable power supplies, five 10/100 Ethernet ports and 1 GB of main memory and capable of handling in excess of 1250 requests per second.

The request interceptor **404** listens to the network traffic passing between the POP's **114** of the affiliated service provider **120** and the network **100** and selectively intercepts DNS translation requests generated by any of the clients **102, 104** coupled with the particular affiliated service provider **120**. Such interception is preferably accomplished by identifying the destination "port" of any given data packet generated by a client **102, 104**, alternatively other methods of identifying a packet type may be used such as by matching the destination address with a list of known DNS translation server addresses. A port in programming is a "logical connection place" and specifically, within the context of the Internet's communications protocol, TCP/IP, a port is the way a client program specifies a particular applications program on a computer in a network to receive its requests. Higher-level applications that use the TCP/IP protocol such as HTTP, or the DNS translation protocol, have ports with pre-assigned numbers. These are known as "well-known ports" and have been assigned by the Internet Assigned Numbers Authority (IANA). Other application processes are given port numbers dynamically for each connection. When a service (server program) initially is started, it is said to bind to its designated port number. As any client program wants to use that server, it also must request to bind to the designated port number. Port numbers are from 0 to 65536. Ports **0** to **1024** are reserved for use by certain privileged services. For the HTTP service, port **80** is defined as a default and it does not have to be specified in the Uniform Resource Locator (URL). In an alternative embodiment, the routing equipment **206** of the service provider **120** is programmed to forward all DNS translation requests to the edge server **402**. The request interceptor **404** can then choose which DNS translation requests to intercept as described below. This alternative routing scheme may implemented through a traffic routing protocol such as a Domain Name System Translation Protocol ("DNSTP"). This protocol is implemented in similar fashion to the Web Cache Control Protocol ("WCCP") which is used to redirect HTTP requests to proxy cache servers based on the specified port in the packet.

DNS translation requests are identified by the port number **53**. The request interceptor **404** monitors for all data traffic with the specified port number for a DNS translation request. It then is capable of intercepting DNS translation requests generated by clients **102**, **104** such as computer workstations, wireless devices or internal DNS translators on a private network. The request interceptor **404** is aware of which content delivery services subscribe to the edge server **402** service and is operative to selectively intercept DNS translation requests associated with the subscribing content delivery service, i.e. contain translations intended to be translated by the DNS translator of the content delivery service or server **108**. The request interceptor **404** may provide a table or database stored in memory or other storage device where it can look up the service subscribers to determine whether the particular DNS translation request should be intercepted. It is preferred that the request interceptor **404** make this determination at "wire speed", i.e. at a speed fast enough so as not to impact the bandwidth and throughput of the network traffic it is monitoring.

When a DNS translation request is generated by a client **102**, **104** to translate a domain name associated with the content delivery service, as described above for the modified HTTP slow start protocol, to retrieve the separately stored Web page content, that DNS translation request will be selectively intercepted by the request interceptor **404** of the edge server **402**. The interception will occur before it reaches the bound/destination DNS translation server bound to or specified by the client **102**, **104**. The request interceptor **404** will then pass the intercepted DNS translation request to the request modifier **406**.

The request modifier **406** modifies the DNS translation request to include additional information or indicia related to the client **102**, **104** so that the intelligent DNS translation server of the content delivery service or server **108** can make a more optimized decision on which of the geographically dispersed cache servers **302**, **304** would be optimal to serve the requests of the client **102**, **104**. This additional information can include the geographic location of the POP **114** or the characteristics of the downstream network infrastructure, such as whether the client **102**, **104** is connecting to the POP **114** via a modem connection or a broadband connection or whether the client **102**, **104** is a wired or wireless client, etc. It will be appreciated that there may be other information or indicia that the edge server **402** can provide to enhance the DNS translation request and this may depend on the capabilities of the subscribing content delivery services, and all such additional indicia are contemplated. It is preferable that the subscribing content service providers are familiar with the indicia data types, content and possible encoding schemes which the edge server **402** can provide so as to establish a protocol by which the data is transferred to the subscribing content delivery service. Such information is then recognized and used by the content delivery service to enhance their redirection. For example, by knowing the geographic location of the POP **114** as provided by the edge server **402**, the content delivery service does not need to rely on the IP address of the bound DNS server from which it receives the translation request (described in more detail below) and therefore will make a more accurate determination of which cache server **302**, **304** to choose. Similarly, by knowing the capabilities of the downstream network infrastructure from the POP **114** to the client **102**, **104** as provided by the edge server **402**, the content delivery service can redirect content requests by the client **102**, **104** to a cache server **302**, **304** with capabilities which match. For example, where the POP **114** to client **102**, **104** connection is a broadband connection, the client **102**, **104** can be directed to make its requests to a cache server **302**, **304** capable of utilizing the available bandwidth to the client **102**, **104**. In contrast, where the client **102**, **104** connects to the POP **114** via a modem/standard telephone line connection, the content delivery service can direct that client **102**, **104** to make its requests to an appropriate low speed cache server **302**, **304** so as not to waste the resources of high bandwidth cache servers **302**, **304**.

Once the DNS translation request has been modified, the request modifier **406** passes the DNS translation request to the request forwarder **408**. The request forwarder places the modified DNS translation request back into the general stream of network traffic where it can be routed to its originally intended destination, i.e. the bound or specified DNS translation server **204**, **410** bound to or specified by the originating client. The DNS translation server **204**, **410** will translate the request as described above, by contacting the DNS translation server **306**, DNS C associated with the content delivery service. As described above, the intelligent DNS translation server **306** of the content delivery service will see the modified request and utilize the information/indicia included by the edge server **402** to make a more optimal translation and cache server **302**, **304** assignment.

FIG. **4** depicts an exemplary content delivery transaction between Client **1 102** and Server **1 108**. For the purposes of this example transaction, Client **1 102** is bound to DNS translation server **204**, labeled "DNS A1." Client **1 102** initiates the HTTP slow start protocol as described above by making its initial request for an HTML Web page from Server **1 108**. This initiation may require making several DNS translations as described above, labeled as "A", "B1", "C1", "D1", "E1", "F1", "G1", "H." Once the HTML Web page has been received by Client **1 102**, it will begin to request the separately stored content associated with the Web page. As was discussed above, where Server **1 108** has been "content enabled" and subscribes to the content delivery service, the URL's of the separately stored content will comprise the domain name of the content delivery service. As well, as discussed above, these domain names will require complete DNS translation all the way back to the DNS translation server **306**, DNS C of the content delivery service because the content delivery service ensures that all of its translations have TTL=0 and therefore cannot be stored in any given downstream DNS translation server. Therefore, Client **1 102** will initiate a DNS translation for the URL of the separately stored content, labeled "I." This DNS translation request will go through the POP **114** and to the routing equipment **206** of the service provider **120**. The edge server **402** will see this DNS translation request and identify the domain name of the content service provider as a subscriber to its service. The request interceptor **404** will then intercept the DNS translation request, labeled as "J." The request interceptor **404** will pass the intercepted DNS translation request to the request modifier **406** which will append a geographic indication representing the physical geographic location of the edge server **402** or alternatively, other downstream network characteristics. Given that the edge server **402** is located geographically proximate to the POP's **114**, this information will more accurately represent the location of Client **1 102**. Alternatively, while the edge server **402** may not be geographically proximate to the POP's **114**, it may be network proximate to the POP's **114**, i.e. there may be a minimal of network infrastructure between the POP's **114** and the edge server **402**. In some instances, while one device on a network may sit physically right next to another device on the network, the network

topology may dictate that data flowing between those devices flow over a circuitous route to get from one device to the other. In this case, while the devices are physically close to one another, they are not logically close to one another. The edge server **402** is preferably familiar, not only with its geographic location within the context of the network **100** as a whole, but also its logical location. Using this information, the edge server **402** can further include information as to this logical location so as to enable, not only a geographically optimal redirection of Client **1**'s **102** requests but also a network topology based optimized redirection.

The request modifier **406** will then pass the modified DNS translation request to the request forwarder **408** which will place the request back into the general traffic stream, and in this case, on its way to the original intended recipient, Client **1**'s **102** bound DNS translation server **204**, DNS A1, labeled as "K1." DNS A1 **204** will then translate the modified DNS translation request as described above and return the translation to Client **1 102**, labeled as "L1", "M1", "N1", "O." DNS C **306**, using the additional data provided by the edge server **402**, will supply a DNS translation redirecting Client **1**'s **102** requests to Cache C2 **304** which is the optimal cache server.

FIG. **4** further depicts a second exemplary content delivery transaction between Client **1 102** and Server **1 108**. For the purposes of this second example transaction, Client **1 102** is a wireless or mobile wired device connecting to a POP **114** provided by service provider **120** but is bound to DNS translation server **410**, labeled "DNS A2" provided by service provider **118**. Note that in the previous exemplary transaction above, Client **1 102** was bound to DNS A1 **204**, e.g., Client **1 102** was a stationary computer or private network subscribing to the network **100** connection services of service provider **120** and using the POP's **114** provided by the service provider **120** and that service provider's **120** DNS translation server **204**, DNS A1. In the current example, Client **1 102** is a subscriber to the network **100** connections services of service provider **118** but is currently roaming, i.e. geographically located in an area not serviced by a POP **116** provided by service provider **118**. Therefore Client **1 102** must use a POP **114** provided by a service provider **120**, which for example, has an agreement to allow such connections from service provider's **118** customers. However, because DNS translation servers are bound to the Client **102**, i.e. the address of the preferred DNS translation server is programmed into the Client **102**, Client **102** will still use its programmed or bound DNS translation server, typically the DNS translation server provided by its service provider **118**, in this case DNS A2 **410**.

As above, Client **1 102** initiates the HTTP slow start protocol as described above by making its initial request for an HTML Web page from Server **1 108**. This initiation may require making several DNS translations as described above but using DNS A2 **410** instead of DNS A1 **204**, labeled as transactions "A", "B2", "C2", "D2", "E2", "F2", "G2", "H." Once the HTML Web page has been received by Client **1 102**, it will begin to request the separately stored content associated with the Web page. As was discussed above, where Server **1 108** has been "content enabled" and subscribes to the content delivery service, the URL's of the separately stored content will comprise the domain name of the content delivery service. As well, as discussed above, these domain names will require complete DNS translation all the way back to the DNS translation server **306**, DNS C of the content delivery service because the content delivery service ensures that all of its translations have TTL=0 and therefore cannot be stored in any given downstream DNS translation server. Therefore, Client **1 102** will initiate a DNS translation for the URL of the separately stored content, labeled "I." This DNS translation request will go through the POP **114** and to the routing equipment **206** of the service provider **120**. The edge server **402** will see this DNS translation request and identify the domain name of the content service provider as a subscriber to its service. The request interceptor **404** will then intercept the DNS translation request, labeled as "J." The request interceptor **404** will pass the intercepted DNS translation request to the request modifier **406** which will append a geographic indication representing the physical geographic location of the edge server **402**. Given that the edge server **402** is located geographically proximate to the POP's **114**, this information will more accurately represent the location of Client **1 102**. Alternatively, while the edge server **402** may not be geographically proximate to the POP's **114**, it may be network proximate to the POP's **114**, i.e. there may be a minimal of network infrastructure between the POP's **114** and the edge server **402**. In some instances, while one device on a network may sit physically right next to another device on the network, the network topology may dictate that data flowing between those devices flow over a circuitous route to get from one device to the other. In this case, while the devices are physically close to one another, they are not logically close to one another. The edge server **402** is preferably familiar, not only with its geographic location within the context of the network **100** as a whole, but also its logical location. Using this information, the edge server **402** can further include information as to this logical location so as to enable, not only a geographically optimal redirection of Client **1**'s **102** requests but also a network optimized redirection.

The request modifier **406** will then pass the modified DNS translation request to the request forwarder **408** which will place the request back into the general traffic stream, and in this case, on its way to the original intended recipient, Client **1**'s **102** bound DNS translation server **410**, DNS A2, labeled as "K2." DNS A2 **410** will then translate the modified DNS translation request as described above and return the translation to Client **1 102**, labeled as "L2", "M2", "N2", "O." In this case, without the additional data provided by the edge server **402**, DNS C **306** would have made its redirection determination based on the IP address of DNS A2 **410**, as described above. This would have resulted in Client **1 102** being redirected to Cache C1 **302** instead of the optimal cache for its location. However, DNS C **306**, using the additional data provided by the edge server **402** is able to supply a DNS translation redirecting Client **1**'s **102** requests to Cache C2 **304** which is the optimal cache server.

VI. The Second Embodiment

Referring to FIG. **5**, there is depicted a second embodiment of an enhanced DNS system to facilitate content delivery which is not dependent upon the geographic location of the downstream DNS server and is capable of enhancing the HTTP slow start protocol.

FIG. **5** shows Clients **1** and **2 102**, **104** coupled with POP's **114**, POP1A and POP1B of service provider **120**. As described above, service provider **120** includes routing equipment **206**, Cache **208** and DNS translation server **204** to facilitate coupling the POP's **114** with the network **100**. In addition, service provider **120** further includes an edge server **502** and an edge cache **508**. In one alternative embodiment, the edge server **502** is integrated with a router. In another alternative embodiment, the edge server **502** is integrated with a generally accessible DNS translation server such as DNS A **204**. In still another alternative

embodiment, the edge server **502** can be integrated with the edge cache **504** or each can be provided as separate devices or the edge server **502** can utilize an existing cache server **208** provided by the service provider **120**. For clarity, a number of the components of FIG. **4** have been omitted from FIG. **5**.

Referring to FIG. **5**A, the edge server **502** further includes a request interceptor **504** and an edge DNS translation server **506**. It is preferred that the facilities and capabilities of the edge server **502** be provided to Web servers **108** on a subscription or fee for services basis as will be described below. It is further preferred that an edge server **502** and edge cache **508** be provided at every service provider **118**, **120** or at every major network **100** intersection so as to provide coverage of every POP **114**, **116** on the edge **124** of the network **100**. The edge server **402** preferably includes one or more processors, a memory coupled with the processors and one or more network interfaces or other interfaces, also coupled with the processors and operative to couple or integrate the edge server **502** with the routing equipment of the service provider **120**. Optionally, the edge server **502** may include secondary storage including a second memory such as a cache memory, hard disk or other storage medium. Further, the processors of the edge server **502** may be dedicated processors to perform the various specific functions described below. The edge server **502** preferably further includes software and/or firmware provided in a read only memory or in a secondary storage which can be loaded into memory for execution or, alternatively, executed from the secondary storage by the processors, to implement the various functions as detailed below. To further improve performance, such software functionality may also be provided by application specific integrated circuits ("ASICS"). For example, an edge server **502** can comprise a Compaq TaskSmart™ Server manufactured by Compaq Corporation, located in Austin, Tex. The TaskSmart™ Server can include an Intel I×A 1000 Packet Processor manufactured by Intel Corporation, located in Santa Clara, Calif. to perform the traffic monitoring and port specific traffic interception functions as well as the security applications as detailed below. The TaskSmart™ Server can further include a PAX.port 1100™ classification adapter manufactured by Solidum Corporation, located in Scotts Valley, Calif., which can receive intercepted DNS translation requests from the packet processor and, utilizing a look up table (preferably stored in a memory providing high speed access), determine whether or not the request is associated with a subscribing server **108**, as described below. The classification adapter can attempt to resolve the DNS request or hand it off to a general processor such as an Intel Pentium III™ or other general purpose processor for further operations as detailed below. An exemplary edge server **502** may have six 9.1 GB hot pluggable hard drives preferably in a RAID or other redundant configuration, two redundant hot pluggable power supplies, five 10/100 Ethernet ports and 1 GB of main memory and capable of handling in excess of 1250 requests per second.

As described above, the request interceptor **504** operates to selectively intercept DNS translation requests associated with its subscribing Web server **108** generated by clients **1** and **2** **102**, **104**. Alternatively, DNS translation requests can be forwarded to the request interceptor **504** by the service provider's **120** routing equipment **206** as described above. In this embodiment, however, because the request interceptor **504** is monitoring for DNS translation requests associated with the server **108** and not some separate content delivery service, the request interceptor **504** will selectively intercept all DNS translation requests, including the initial request to retrieve the HTML Web page file and begin the HTTP slow start protocol. Again, the request interceptor **504** preferably includes a database or table stored in a memory or other storage medium which indicates the domain names or other identification information of subscribing servers **108**.

The selectively intercepted DNS translation requests are passed by the request interceptor **504** to an internal edge DNS translation server **506**. The internal edge DNS translation server **506** then translates the given domain name into the IP address of the edge cache **508** and returns this translation to the client **102**, **104**, labeled "A", "B", "C", "D." This effectively redirects the client **102**, **104** to make all of its content requests from the edge cache **508**. As opposed to a proxy server, where the client **102**, **104** is not redirected but either thinks that it is communicating with the server **108** (in the case of a transparent or server side reverse proxy server) or has been specifically programmed to communicate its requests to the proxy server (in the case of a client side forward proxy server). The edge cache **508** operates as a normal cache server as described above, attempting to satisfy content requests from its cache storage. However, when the requested content is not available in the cache storage (a cache miss), the request is proxied to the server **108** by the edge cache **508** and/or edge server **502**, i.e. the edge cache **508** and/or edge server **502** make the request on behalf of the client **102**, **104**. This is in contrast to normal cache servers which forward the request from the client **102**, **104** onto the server **108** upon a cache miss.

Cache misses are handled as described above, the edge server **502** or alternatively the edge cache **508** makes its own request for the uncached content from the server **108**. Alternatively, other algorithms can be used to reduce or eliminate cache misses including mirroring the content of the server **108** coupled with periodic updates either initiated by the edge server **502** or edge cache **508** or periodically pushed to the edge cache **508** by the server **108**. In another alternative embodiment, the server **108** can update cached content when it determines that such content has changed or can provide time durations or other form of expiration notification after which the edge cache **508** purges the content. Where the content expires or is otherwise purged from the edge cache **508**, the next request for that content will miss and cause a reload of the content from the server **108**. One of ordinary skill in the art will recognize that there are many caching algorithms which may be used to maintain cache coherency. It is further, preferable that the edge cache **508** maintain a replacement policy of replacing the oldest data in the cache when the cache is full. Again, one of ordinary skill in the art will recognize that there are many different cache replacement algorithms that may be used.

In this way, the edge server **502** and edge cache **508** act similarly to a forward or reverse proxy server for all of its subscribing servers **108**. Generally, a reverse proxy server is a proxy server that hides multiple source servers behind a single address. A reverse proxy server allows a content provider to serve their content from multiple host computers without requiring users to know the addresses of each of those computers. When a user makes a request to a content provider, they use the address of the reverse proxy server. The reverse proxy server intercepts the requests for content from the source and redirects those requests to the appropriate host computer within the content provider. The redirection can be based on a which machine contains the requested content or can be used to balance the request load across multiple mirrored servers. A forward proxy server sits between a workstation user and the Internet so that the

enterprise can ensure security, administrative control and caching services. A forward proxy server can be associated with a gateway server which separates the enterprise network from an outside network such as the Internet. The forward proxy server can also be associated with a firewall server which protects the enterprise network from outside intrusion. Forward proxy servers accept requests from their users for Internet content and then request that content from the source on behalf of the user. The forward proxy server modifies the identity of the requestor (typically by altering the internet protocol address of the requestor) to be that of the forward proxy server. A user workstation typically must be configured to use a proxy server. A forward proxy server can also be a cache server (see above).

A major distinction between the edge server **502** and a proxy server is that there is no one address of the edge server **502**. The edge server **502** effectively needs no address because it intercepts the necessary network traffic. Therefore, clients **102**, **104** do not need to know of the existence of the edge server **502** and can operate as they normally do, making content requests of servers **108**. However, when they request content from a subscribing server **108**, that content will be transparently provided instead by the edge server **502** and edge cache **508**.

Effectively, the edge server **502** and edge cache **508** isolate the sub-network comprising the service provider **120**, the POP's **114** and the clients **102**, **104** from the subscribing server **108**, i.e. the clients **102**, **104** are prevented from any direct contact with server **108**. Should the client **102**, **104** request uncached content, it is the edge cache **508** and not the client **102**, **104** which will request that content from the server **108**. Furthermore, the edge server **502** and edge cache **508** can ensure that the request is valid and legitimate before communicating with the server **108**. This "trusted" relationship between the edge server **502**/edge cache **508** and the subscribing servers acts as additional security for the servers **108**. Those servers **108** can be programmed to ignore content requests from clients **102**, **104** since they know that only valid content requests can come from an edge server **502**/edge cache **508**. Furthermore, the edge server **502** alleviates the load on the server's **108** internal DNS translation server **210** because all DNS translations will be handled by the internal edge DNS translator **506**.

The effect of the edge server **502** and edge cache **508** is faster DNS translations and better response times to requests. The edge cache **508** can serve the initial HTML Web page file to the requesting client **102**, **104** and immediately begin the process of requesting the separately stored content (if not already in the cache) from the server **108** in order to speed up the HTTP slow start protocol. Furthermore, it is preferred that the edge caches **508** located through out the edge **124** of the network **100** be capable of communicating and sharing cached data. In this way, the edge caches **508** can further reduce the demands placed on the subscribing servers **108**.

Notice, however, that because the edge server **502** intercepts translation requests, a client **102**, **104** that already knows the IP address of the server **108**, can still directly communicate with that server **108** via the network **100**. In this case, the server **108** can choose to disconnect itself from the network **100** generally (or refuse to accept any inbound content requests from the network **100** that do not originate from an edge server **502**/edge cache **508**, however such origination may be forged). The edge server **502** and edge cache **508** can then connect with the server **108** using private proprietary communications links which are not available to clients **102**, **104**.

The edge server **502** and edge cache **508** can also provide load balancing and security services to the subscribing servers. For example, open source load balancing techniques available from eddieware.org can be implemented in the edge server **502**. Where a particular server **108** comprises multiple sub-servers, the edge cache **508** can be programmed to request uncached content from the sub-servers so as to spread the load on each sub-server.

Further, because the edge server **502** acts as the DNS translator server for its subscribers, it can detect and absorb any security attacks based on the DNS system, such as distributed denial of service attacks, "DDOS." A Denial of Service Attack ("DOS" or Distributed DOS "DDOS") is an incident in which a user or organization is deprived of the services of a resource they would normally expect to have. Typically, the loss of service is the inability of a particular network service, such as e-mail, to be available or the temporary loss of all network connectivity and services. In the worst cases, for example, a Web site accessed by millions of people can occasionally be forced to temporarily cease operation. A denial of service attack can also destroy programming and files in a computer system. Although usually intentional and malicious, a denial of service attack can sometimes happen accidentally. A denial of service attack is a type of security breach to a computer system that does not usually result in the theft of information or other security loss. However, these attacks can cost the target person or company a great deal of time and money.

DDOS attacks come in mainly two varieties, one attempts to shut down the DNS system in relation to the target site so that no legitimate user can obtain a valid translation and make a request from the site. Another type of DDOS attack attempts to overload the server **108** directly with a flood of content requests which exceed the capacity of the server. However, it will be appreciated that, by placing edge servers **502** and edge caches **508** so that all POP's **114**, **116** are covered and can be monitored, DDOS attacks can never reach the server **108** itself and will always be detected close to their origination by an edge server **502** where they can be stopped and isolated. It will be further apparent that where a DDOS attack cripples one edge server **502** and its associated sub-network, the remaining edge servers **502** at other service providers **118**, **120** (and their associated sub-networks) can remain operational and therefore the server **108** suffers minimal impact as a result of the DDOS attack. In addition, it is preferred that the edge server **502** and edge cache **508** provide bandwidth and processing power far in excess of that needed by the sub-network comprising the POP's **114** and service provider **120** in order to be able to absorb DDOS attacks and not be crippled by them.

It will further be appreciated, that the edge server **502** can incorporate the capabilities of the edge server **402** by providing enhanced DNS translations for subscribing content delivery services as well as the enhanced content delivery itself for subscribing servers **108**.

In addition, where client **102**, **104** is a private network such as an intranet, which has its own internal DNS translation server which is making DNS translation requests out to the network **100**, the edge server **502** can set its returned DNS translations to have a TTL=0 so that the client's **102**, **104** internal DNS server must always forward DNS translation requests to subscribing server **108** upstream where they can be intercepted by the edge server **502**. Otherwise, the caching function of the client's **102**, **104** internal DNS translation server would prevent proper DNS translations from occurring. Notice that this is not an issue in the first embodiment, because as discussed above, the content deliv-

ery service performs the DNS translations and always sets translation TTL=0 to facilitate its operation.

VII. The Third Embodiment

Referring to FIG. **6**, there is depicted an enhanced network **100** to facilitate content delivery and network **100** security. FIG. **6** depicts clients **1** and **2** **102**, **104** connected with POP's **114**, POP2A and POP2B of service provider **118** effectively forming a sub-network of the network **100**. Further, clients **3** and **4** **106**, **612** are shown connected to POP's **116**, POP1A and POP1B of service provider **120**. Further, service providers **118**, **120** each include an edge server **602**A, **602**B and an edge cache **604**A, **604**B coupled with the routing equipment **206** of the service providers **118**, **120** so as to be able to intercept all network traffic flowing between the POP's **114**, **116** and the network **100**. In one alternative embodiment, the edge server **602** is integrated with a router. In another alternative embodiment, the edge server **602** is integrated with a generally accessible DNS translation server such as DNS A1 **204** or DNS A2 **410**. In still another alternative embodiment, the edge server **602** is integrated with the edge cache **604**, or alternatively they can be implemented as separate devices or the edge server **602** can utilize a cache server **208** provided by the service provider **118**, **120** (not showing in FIG. **6**). It is preferred that the facilities and capabilities of the edge servers **602** be provided to Web servers **108** on a subscription or fee for services basis as will be described below. It is further preferred that an edge server **602** and edge cache **604** be provided at every service provider **118**, **120** or at every major network **100** intersection so as to provide coverage of every POP **114**; **116** on the edge **124** of the network **100**, i.e. to minimize the size of the sub-network downstream from the edge server **602**.

Referring to FIG. **6**A, the edge server **602** further includes a request filter **606**, a request interceptor **608** and a proxy server and/or internal DNS translation server **610**. The edge server **602** is capable of operating similarly to the edge server **402** and **502** of the previous embodiments. However, the edge server **602** is further capable of intercepting data traffic at the packet level based on the source or destination IP address contained within the packets flowing past the edge server **602**. In this way, the edge server **602** is able to provide complete isolation of its subscribing servers **108**, **110**. Any network traffic destined for a, subscribing server **108**, **110** can be intercepted by the edge server **602** and acted upon. The edge server **602** preferably includes one or more processors, a memory coupled with the processors and one or more network interfaces or other interfaces, also coupled with the processors and operative to couple or integrate the edge server **602** with the routing equipment of the service provider **120**. Optionally, the edge server **602** may include secondary storage including a second memory such as a cache memory, hard disk or other storage medium. Further, the processors of the edge server **602** may be dedicated processors to perform the various specific functions described below. The edge server **602** preferably further includes software and/or firmware provided in a read only memory or in a secondary storage which can be loaded into memory for execution or, alternatively, executed from the secondary storage by the processors, to implement the various functions as detailed below. To further improve performance, such software functionality may also be provided by application specific integrated circuits ("ASICS"). For example, an edge server **602** can comprise a Compaq TaskSmart™ Server manufactured by Compaq Corporation, located in Austin, Tex. The TaskSmart™ Server can include an Intel I×A1000 Packet Processor manufactured by Intel Corporation, located in Santa Clara, Calif. to perform the traffic monitoring and port specific traffic interception functions as well as the security applications as detailed below. The TaskSmart™ Server can further include a PAX.port 1100™ classification adapter manufactured by Solidum Corporation, located in Scotts Valley, Calif., which can receive intercepted DNS translation requests from the packet processor and, utilizing a look up table (preferably stored in a memory providing high speed access), determine whether or not the request is associated with a subscribing server **108**, as described below. The classification adapter can attempt to resolve the DNS request or hand it off to a general processor such as an Intel Pentium III™ or other general purpose processor, for further operations as detailed below. An exemplary edge server **602** may have six 9.1 GB hot pluggable hard drives preferably in a RAID or other redundant configuration, two redundant hot pluggable power supplies, five 10/100 Ethernet ports and 1 GB of main memory and capable of handling in excess of 1250 requests per second.

For valid content requests from clients **102**, **104**, **106**, **612**, the edge server **602** in combination with the edge cache **604** acts just like the edge server **502** and edge cache **508** in the previous embodiment. Such requests will be redirected and served from the edge cache **604**. Again an edge cache **604**A at one service provider **118** can share cached data from another edge cache **604**B located at another service provider **120**. In this way, a comprehensive content delivery service is created which completely isolates the core **122** of the network **100** from untrusted and unregulated client **102**, **104**, **106**, **602** generated network traffic. Such traffic is isolated at the edge **124** of the network **100** within the sub-network below, i.e. downstream from the edge server **602** where it can be contained, monitored and serviced more efficiently. In terms of the economics of the network **100** then, the load on the expensive high bandwidth communications resources located at the core **122** of the network **100** is reduced and maintained at the edge **124** of the network where bandwidth is less expensive.

In addition, the edge server's **602** packet level filter **606** prevents any client **102**, **104**, **106**, **612** from directly communicating with any subscribing server **108**, **110** even if that client **102**, **104**, **106**, **612** has the IP address of the server **108**, **110**. The packet level filter **608** will see the destination IP address in the network traffic and selectively intercept that traffic.

Once traffic is intercepted, the edge server **602** can perform many value added services. As described above, the edge server **602** can perform DNS translations and redirect clients **102**, **104**, **106**, **612** to make their content requests to the edge cache **604**. The edge server **602** can also monitor the data transmission being generated by clients **102**, **104**, **106**, **602** for malicious program code, i.e. program code that has been previously identified (by the server **108** or a third party such as a virus watch service) as unwanted, harmful, or destructive such as viruses or other unauthorized data being transmitted. For example, if the edge server **602**A detects a data packet whose origin address could not have come from the downstream network or POP's **114** to which it is connected, the edge server **602**A knows that this data packet must be a forgery and can eradicate it or prevent it from reaching the network **100**. For example, where a computer hacker surreptitiously installs a program on client **1** **102** to make a DDOS attack on server **1** **108** but appear as if the attack is coming from client **4** **612**, the edge server **602**A will see the packets generated by Client **1** **102** and also see that they contain a source address associated with a

client, in this case client **4 612**, which based on the address, could not have come from any POP **114** of the service provider **118** to which the edge server **602**A is connected. In this case, the edge server **602**A can eliminate that packet and then attempt to identify the actual originating client, in this case client **1 102**, so that the attack can be stopped and investigated. In addition, because general network traffic is unable to reach the subscribing servers **108**, **110**, hackers would be unable to access those servers in attempts to steal valuable data such as credit card numbers.

Furthermore, to enhance security, as described above, the connections between the edge servers **602**A, **602**B and edge caches **604**A, **604**B can alternatively be made through private communications links instead of the publicly accessible network **100**. In this way, only trusted communications over secure communications links can reach the servers **108**, **110**. This security in combination with the multiple dispersed edge servers **602**A, **602**B and edge caches **604**A, **604**B covering the edge **124** of the network **100** ensures that the subscribing servers **108**, **110** will be able to serve their content under high demand and despite security threats.

In operation, the request filter **606** pre-filters traffic before receipt by the request interceptor **608**. The request filter **606** preferably provides subscriber detection, "ingress filtering" capability, and cache hit determination. The request filter **606** first determines whether or not the traffic it is monitoring is associated with a subscribing/affiliated server **108**, **110**. If not, this traffic is ignored and allowed to proceed to its final destination. The request filter **606** preferably comprises a table or database of subscribers stored in a memory or other storage device. If the traffic is associated with a subscribing server **108**, **110**, the request filter **606** then performs ingress filtering by determining whether the packet originated downstream from the edge server **602**, i.e. from the downstream sub-network, the POP's **114**, **116** affiliated with this particular edge server **602** or from upstream which indicates that they did not originate from an affiliated POP **114**, **116** and therefore are suspect and most likely invalid. Packets originating from upstream are preferably eradicated. Valid downstream originating packets are then analyzed for the content/nature of the packet. If the packet comprises a content request, the request filter **606** can determine if the request can be satisfied by the edge cache **604**. Preferably, the request filter **606** maintains a table or database in memory or other storage medium of the edge cache **604** contents. If the packet contains a request that can be satisfied from the edge cache **604**, the request filter **606** will hand the packet/request off to the edge cache **604**. The edge cache **604** operates similarly to the edge cache **508** of the above embodiment. If the packet comprises a DNS translation request or a content request which cannot be satisfied by the edge cache **604**, the request filter **606** hands the packet/request off to the internal request transmitter/proxy server/DNS translation server **610** to proxy, e.g. transmit, the request to the intended server or provide a DNS translation. The server **108** responds with the requested content to the edge server **602** and/or edge cache **604** which then returns the response to the requesting client **102**, **104**, **106**, **612** and/or caches the response. It is preferred that the request filter **606** be able to perform its functions at "wire speed", i.e. a speed at which will have minimal impact on network **100** bandwidth and throughput. The request filter **606** then further alleviates the processing load on the internal DNS translator/proxy server **610** of the edge server **602**.

It will be appreciated that, in any of the above embodiments, additional upstream edge servers and edge caches can be provided at major peering points to provide a layered hierarchy of cache storage tiers which further enhances the response times. In addition, a hierarchy of edge servers and edge caches can be used to handle any overload of one or more downstream edge servers and edge caches or to handle spill over of capacity or even a complete failure of one or more edge servers or edge caches. By forming a hierarchy of edge servers and edge caches, the network **100** and service provider **118**, **120** fault tolerance is increased and enhanced.

The edge servers and edge caches therefore act similarly to proxy servers. However, where a forward proxy server alters the source address of a given content request (effectively making that request on behalf of a client), an edge server merely adds additional data to the source address which can then be used by upstream content delivery services for more accurate redirection or intercepts and substitutes the address translation transactions to redirect a client to make its requests from a nearby edge cache. Therefore, there is no need to intercept content requests since those requests will have been already directed to the edge cache. While a reverse proxy server is typically tightly bound with a group of servers which belong to a single entity or comprise a single Web site, the edge server performs reverse proxy functions but for any entity or Web site which subscribes to the service. Furthermore, no changes are required to the client or the subscribing servers. Once the subscriber tables are updated within the edge servers, the edge server will then start to perform its functions on the network traffic of the subscribing Web server. The subscribing Web server does not need to alter their Web site in any way and the client does not need to be pre-programmed to communicate with the edge server.

Further the network of edge servers and edge caches located at every major network intersection so as to cover every POP, thereby minimizing the size of the sub-network downstream from the edge server, forms a security barrier which isolates the core infrastructure and servers of the network/internet from the edge where the clients are located. In addition to isolation, network performance is enhanced by virtually placing the content and services of core content providers at network-logically and physically-geographic proximate locations with respect to the clients. Content is placed as close as possible to the requesters of that content resulting in enhanced response times and enhanced throughput. This results in reduced load, congestion and bandwidth consumption of the expensive high capacity backbone links which form the core of the network. Trivial network traffic is maintained at the edge of the network speeding response times and throughput. In addition, the edge caches are capable of communicating with one another and sharing cached data, thereby greatly enhancing the caching effect and further reducing the load on the core of the network.

By further making the edge servers more intelligent, such as by adding additional processing capacity, dynamic load balancing services can be provided to the subscribing servers which can respond to changing demands for content. The edge servers and edge caches are further located to minimize the number of downstream clients, thereby forming sub-networks which can isolate and contain network traffic. This allows security services to be provided by isolating security threats to the smallest possible portion of the network generally while leaving the remaining portions of the network fully operational. Further, would be hackers are prevented from being able to directly access a subscribing server an trying to break in and steal valuable data. Therefore, even where a particular server has a security hole, the data stored there will still be protected. In addition, the

edge server is aware of it physical/geographic location and its logical location within the network hierarchy allowing it to enhance content redirection services as clients go wireless or otherwise go more mobile in relation to their service providers. Finally, the provision of a decentralized DNS enhancement system, as provided by the presently preferred embodiments, reduces the load on the existing DNS system and on subscribing servers' internal DNS systems as well as provides a distributed defense against DNS based denial of service attacks. Such attacks can be isolated to the smallest portion of the network possible and closest to the attacks source while the remaining portions of the network remain unaffected. Further, by isolating the attack, the source of the attack can be more easily pinpointed and investigated. Traffic can be monitored for unauthorized or malicious program code, i.e. program code previously identified as unwanted, harmful or destructive, such as the placement of zombies or virus programs. Such programs can be detected and eradicated before they can make it to their intended destination.

In addition, the provision of the decentralized DNS enhancement system, as provided by the presently preferred embodiments, provides an infrastructure which may be used to supplant the existing DNS system and allow the creation of new domain names and a new domain name allocation service. New services such as a keyword based DNS system may also be provided to further increase the ease of use of the network **100** and which do not rely on any modifications to a users Web browser program; i.e. remain transparent to both the client and the content provider. A user's attempt to request content from a subscribing content provider using a new domain name provided by this new DNS system would be intercepted prior to reaching the existing DNS system and be properly translated so as to direct the user to the content provider. Alternatively, the request may be redirected to an edge server and edge cache which proxy's the request for the user to the content provider. Such a system allows the content provider to remain a part of the network **100**, i.e. remain connected to the Internet and maintain their access within the existing DNS system, or they may choose to completely disconnect from the network **100** altogether and utilize proprietary communications links to the network of edge servers and edge caches to provide users/clients with access to their content.

It will be further appreciated by one of ordinary skill in the art that the provision of numerous distributed edge servers and edge caches encircling the core of the network **100** provides a secure decentralized infrastructure on which service applications can be built. Through the provision of additional application and data processing capabilities within the edge servers, service applications such as user applications (for example, content monitoring/filtering, advertising filtering, privacy management and network personalization), e-commerce applications (such as regional and local electronic store fronts, distributed shopping carts or advertising distribution), distributed processing applications, database access applications (such as distributed enterprise database access), communications applications (such as electronic mail, identity authentication/digital signatures, anti-spam filtering and spam source detection, voice telephony and instant messaging), search engine applications, multimedia distribution applications (such as MP3 or MPEG distribution and content adaptation), push content applications (such as stock quotes, news or other dynamic data distribution), network applications (such as on-demand/dynamic virtual private networks and network/enterprise security), etc. can be implemented. These applications can be implemented with minimal hardware at the network **100** core **122** because much of the processing load and bandwidth demands are distributed out at the edge **124** of the network **100**. Further, any application where decentralization of the client interface from the back-end processing enhances the application can be applied on a wide scale to the edge server infrastructure to reduce the centralized demands on the service providers.

It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, that are intended to define the spirit and scope of this invention.

I claim:

1. A method of facilitating communications over a network, said network comprising first and second servers and a plurality of sub-networks coupled with said first and second servers, said network further comprising a first sub-network of said plurality of sub-networks coupled with a first translator and a first client, and a second sub-network of said plurality of sub-networks coupled with a second translator and a second client, said method comprising:

(a) monitoring said first sub-network for a first translation request generated by said first client directed to said first translator by said first client;

(b) monitoring said second sub-network for a second translation request generated by said second client directed to said second translator by said second client;

(c) intercepting, selectively, said first translation request prior to receipt by said first translator;

(d) intercepting, selectively, said second translation request prior to receipt by said second translator;

(e) isolating said first translation request from said second sub-network; and

(f) isolating said second translation request from said first sub-network.

2. The method of claim **1**, further comprising:

(g) monitoring said first sub-network for a first communications between said first client and one of said first and second servers;

(h) monitoring said second sub-network for a second communications between a second client and one of said first and second servers, said second sub-network different from said first sub-network;

(i) intercepting, selectively, said first and second communications.

3. The method of claim **2**, further comprising:

(j) preventing said first communications from being transmitted via said second sub-network; and

(k) preventing said second communications from being transmitted via said first sub-network.

4. The method of claim **2**, further comprising:

(j) mediating said first and second communications between said first and second clients and said first and second servers;

(k) diverting, selectively, said first and second communications from said first and second clients to at least one cache server.

5. The method of claim **2**, further comprising:

(j) proxying said first and second communications to said first and second servers from said first and second clients;

(k) receiving, selectively, said first and second communications from said first and second servers to at least one cache server; and

(l) transmitting said first and second communications received from said first and second servers from said at least one cache to said first and second clients.

6. An apparatus for facilitating communications between first and second clients and first and second servers over a network, said network comprising a first sub-network coupled with said first client and said first and second servers and a second sub-network coupled with said second client and said first and second servers, said apparatus comprising:

a first request interceptor coupled with said first sub-network and operative to selectively intercept a first request generated by said first client and directed by said first client to a first translator to translate a first address into a first translated address to facilitate said communications between said first client and one of said first and second servers, prior to receipt by said first translator;

a second request interceptor coupled with said second sub-network and operative to intercept a second request generated by said second client and directed by said second client to a second translator to translate a second address into second translated address to facilitate said communications between said second client and one of said first and second servers, prior to receipt by said first translator;

a first request modifier coupled with said first request interceptor and operative to modify said first address to a first modified address; and

a second request modifier coupled with said second request interceptor and operative to modify said second address to a second modified address.

7. The apparatus of claim **6**, wherein said first request modifier is further operative to leave said first request unmodified and said second request modifier is further operative to leave said second request unmodified.

8. The apparatus of claim **6**, wherein said first and second requests further comprise origination data indicating which of said first and second sub-networks from which said first and second requests originated, said first and second request interceptors being further operative to detect when said origination data of said intercepted request mismatches with said one of said first and second sub-networks that said first and second translation interceptors are coupled with.

9. The apparatus of claim **8**, wherein said first and second request modifiers are further operative to delete mismatching intercepted translation requests.

10. The apparatus of claim **8**, wherein said first and second request interceptors are further operative to determine an actual originating client of said mismatching translation request.

11. The apparatus of claim **8**, wherein said first and second request interceptors are further operative to isolate said mismatching translation requests within their corresponding sub-networks.

12. The apparatus of claim **6**, further comprising a first traffic monitor coupled with said first sub-network and a second traffic monitor coupled with said second sub-network, wherein said network is further operative to transmit data between said first and second clients and said first and second servers, said first traffic monitor operative to selectively intercept said transmitted data between said first client and said first and second servers and said second traffic monitor operative to selectively intercept said transmitted data between said second client and said first and second servers.

13. The apparatus of claim **12**, wherein said first and second traffic monitors are further operative to detect malicious program code within said transmitted data.

14. The apparatus of claim **12**, wherein said first and second traffic monitors are further operative to detect unauthorized data within said transmitted data.

15. The apparatus of claim **14**, wherein said first and second traffic monitors re further operative to prevent said unauthorized data from being communicated outside said corresponding sub-network.

16. The apparatus of claim **12**, wherein said first and second traffic monitors are further operative to detect forged communications within said transmitted data.

17. The apparatus of claim **6**, wherein said first request modifier further comprises a third address translator and said second request modifier further comprises a fourth address translator, wherein upon receipt of said first translation request, said third address translator is operative to translate said first address into a third translated address and return said third translated address to said first client, and wherein upon receipt of said second translation request, said fourth address, translator is operative to translate said third address into a fourth translated address and return said fourth translated address to said second client.

18. The apparatus of claim **17**, wherein said third translated address is associated with a first cache which is affiliated with said first and second servers and proximate to said first client and said fourth translated address is associated with a second cache which is affiliated with said first and second servers and proximate to said second client.

19. The apparatus of claim **18**, wherein said first cache is geographically proximate to said first client.

20. The apparatus of claim **18**, wherein said second cache is geographically proximate to said second client.

21. The apparatus of claim **18**, wherein said first cache is logically proximate to said first client based on a topology of said first sub-network.

22. The apparatus of claim **18**, wherein said second cache is logically proximate to said second client based on a topology of said second sub-network.

23. The apparatus of claim **18**, wherein said first cache is operative to cache data from said first and second servers and said second cache is operative to cache data from said first and second servers.

24. The apparatus of claim **23** being further operative to prevent direct communications between said first and second clients and said first and second servers.

25. The apparatus of claim **18**, wherein said first cache is coupled with said first sub-network and said second cache is coupled with said second sub-network.

26. The apparatus of claim **18**, wherein said first cache is coupled with said first translation interceptor and said second cache is coupled with said second translation interceptor.

27. The apparatus of claim **18**, further comprising said first and second caches.

28. The apparatus of claim **27**, wherein said first cache is operative to communicate with said second cache.

29. The apparatus of claim **28**, wherein said first cache is operative to communicate with said second cache via said network.

30. The apparatus of claim **28**, wherein said communication comprises sharing of cached data from said first and second servers.

* * * * *