US00RE47019E

(19) **United States**

(12) **Reissued Patent**

Thornewell et al.

(10) **Patent Number: US RE47,019 E**

(45) **Date of Reissued Patent: Aug. 28, 2018**

(54) **METHODS FOR DNSSEC PROXYING AND DEPLOYMENT AMELIORATION AND SYSTEMS THEREOF**

(71) Applicant: **F5 Networks, Inc.**, Seattle, WA (US)

(72) Inventors: **Peter M. Thornewell**, Seattle, WA (US); **Christopher R. Baker**, Seattle, WA (US)

(73) Assignee: **F5 Networks, Inc.**, Seattle, WA (US)

(21) Appl. No.: **15/286,436**

(22) Filed: **Oct. 5, 2016**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **8,856,898**
Issued: **Oct. 7, 2014**
Appl. No.: **13/687,826**
Filed: **Nov. 28, 2012**

U.S. Applications:

(63) Continuation of application No. 12/836,053, filed on Jul. 14, 2010, now Pat. No. 8,347,100.

(51) **Int. Cl.**

G06F 21/31	(2013.01)
H04L 9/32	(2006.01)
H04L 29/12	(2006.01)
H04L 29/06	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 9/3247*** (2013.01); ***H04L 61/1511*** (2013.01); ***H04L 63/08*** (2013.01); ***H04L 63/126*** (2013.01)

(58) **Field of Classification Search**

CPC . H04L 9/3247; H04L 61/1511; H04L 63/126; H04L 63/08

USPC 726/6; 713/176

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,950,735	A	4/1976	Patel
4,644,532	A	2/1987	George et al.
4,897,781	A	1/1990	Chang et al.
4,965,772	A	10/1990	Daniel et al.
4,993,030	A	2/1991	Krakauer et al.

(Continued)

FOREIGN PATENT DOCUMENTS

AU	2003300350	A1	7/2004
CA	2080530		4/1994

(Continued)

OTHER PUBLICATIONS

Laurie, et. al., "DNS Security (DNSSEC) Hashed Authenticated Denial of Existence", Mar. 2008, pp. 1-52, The IETF Trust.

(Continued)

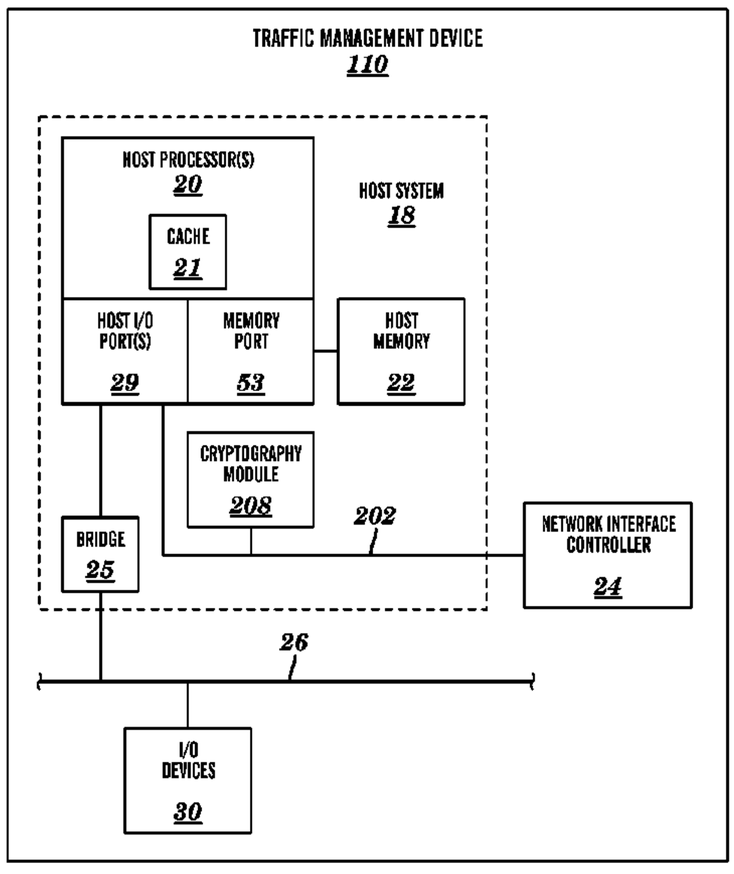
Primary Examiner — Jalatee Worjloh

(74) *Attorney, Agent, or Firm* — LeClairRyan PLLC

(57) **ABSTRACT**

A method, computer readable medium, and device for providing authenticated domain name service includes forwarding at a traffic management device a request for a domain name from a client device to one or more servers coupled to the traffic management device. The traffic management device receives a first response comprising at least a portion of the domain name from the one or more servers. The traffic management device attaches a first signature to the first response when the first response is determined by the traffic management device to be an unauthenticated response, and provides the first response with the first signature to the client device.

36 Claims, 3 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,023,826	A	6/1991	Patel
5,053,953	A	10/1991	Patel
5,167,024	A	11/1992	Smith et al.
5,218,695	A	6/1993	Noveck et al.
5,282,201	A	1/1994	Frank et al.
5,299,312	A	3/1994	Rocco, Jr.
5,303,368	A	4/1994	Kotaki
5,327,529	A	7/1994	Fults et al.
5,367,635	A	11/1994	Bauer et al.
5,371,852	A	12/1994	Attanasio et al.
5,406,502	A	4/1995	Haramaty et al.
5,473,362	A	12/1995	Fitzgerald et al.
5,475,857	A	12/1995	Dally
5,511,177	A	4/1996	Kagimasa et al.
5,517,617	A	5/1996	Sathaye et al.
5,519,694	A	5/1996	Brewer et al.
5,519,778	A	5/1996	Leighton et al.
5,521,591	A	5/1996	Arora et al.
5,528,701	A	6/1996	Aref
5,537,585	A	7/1996	Blickenstaff et al.
5,548,724	A	8/1996	Akizawa et al.
5,550,965	A	8/1996	Gabbe et al.
5,581,764	A	12/1996	Fitzgerald et al.
5,583,995	A	12/1996	Gardner et al.
5,586,260	A	12/1996	Hu
5,590,320	A	12/1996	Maxey
5,596,742	A	1/1997	Agarwal et al.
5,606,665	A	2/1997	Yang et al.
5,611,049	A	3/1997	Pitts
5,623,490	A	4/1997	Richter et al.
5,649,194	A	7/1997	Miller et al.
5,649,200	A	7/1997	Leblang et al.
5,659,619	A	8/1997	Sudia
5,663,018	A	9/1997	Cummings et al.
5,668,943	A	9/1997	Attanasio et al.
5,692,180	A	11/1997	Lee
5,721,779	A	2/1998	Funk
5,724,512	A	3/1998	Winterbottom
5,752,023	A	5/1998	Choucri et al.
5,761,484	A	6/1998	Agarwal et al.
5,768,423	A	6/1998	Aref et al.
5,774,660	A	6/1998	Brendel et al.
5,790,554	A	8/1998	Pitcher et al.
5,802,052	A	9/1998	Venkataraman
5,806,061	A	9/1998	Chaudhuri et al.
5,812,550	A	9/1998	Sohn et al.
5,825,772	A	10/1998	Dobbins et al.
5,832,283	A	11/1998	Chou et al.
5,832,496	A	11/1998	Anand et al.
5,832,522	A	11/1998	Blickenstaff et al.
5,838,970	A	11/1998	Thomas
5,862,325	A	1/1999	Reed et al.
5,875,296	A	2/1999	Shi et al.
5,884,303	A	3/1999	Brown
5,892,914	A	4/1999	Pitts
5,892,932	A	4/1999	Kim
5,893,086	A	4/1999	Schmuck et al.
5,897,638	A	4/1999	Lasser et al.
5,905,990	A	5/1999	Inglett
5,917,998	A	6/1999	Cabrera et al.
5,919,247	A	7/1999	Van Hoff et al.
5,920,873	A	7/1999	Van Huben et al.
5,936,939	A	8/1999	Des Jardins et al.
5,937,406	A	8/1999	Balabine et al.
5,941,988	A	8/1999	Bhagwat et al.
5,946,690	A	8/1999	Pitts
5,949,885	A	9/1999	Leighton
5,951,694	A	9/1999	Choquier et al.
5,958,053	A	9/1999	Denker
5,959,990	A	9/1999	Frantz et al.
5,974,460	A	10/1999	Maddalozzo, Jr. et al.
5,983,281	A	11/1999	Ogle et al.
5,988,847	A	11/1999	McLaughlin et al.
5,991,302	A	11/1999	Beri et al.
5,995,491	A	11/1999	Richter et al.
5,999,664	A	12/1999	Mahoney et al.
6,006,260	A	12/1999	Barrick, Jr. et al.
6,006,264	A	12/1999	Colby et al.
6,012,083	A	1/2000	Savitzky et al.
6,026,452	A	2/2000	Pitts
6,028,857	A	2/2000	Poor
6,029,168	A	2/2000	Frey
6,029,175	A	2/2000	Chow et al.
6,038,233	A	3/2000	Hamamoto et al.
6,041,365	A	3/2000	Kleinerman
6,044,367	A	3/2000	Wolff
6,047,129	A	4/2000	Frye
6,051,169	A	4/2000	Brown et al.
6,067,558	A	5/2000	Wendt et al.
6,072,942	A	6/2000	Stockwell et al.
6,078,929	A	6/2000	Rao
6,078,956	A	6/2000	Bryant et al.
6,085,234	A	7/2000	Pitts et al.
6,088,694	A	7/2000	Burns et al.
6,092,196	A	7/2000	Reiche
6,104,706	A	8/2000	Richter et al.
6,108,703	A	8/2000	Leighton et al.
6,111,876	A	8/2000	Frantz et al.
6,118,784	A	9/2000	Tsuchiya et al.
6,119,234	A	9/2000	Aziz et al.
6,128,279	A	10/2000	O'Neil et al.
6,128,627	A	10/2000	Mattis et al.
6,128,657	A	10/2000	Okanoya et al.
6,128,717	A	10/2000	Harrison et al.
6,154,777	A	11/2000	Ebrahim
6,160,874	A	12/2000	Dickerman et al.
6,161,145	A	12/2000	Bainbridge et al.
6,161,185	A	12/2000	Guthrie et al.
6,170,022	B1	1/2001	Linville et al.
6,178,423	B1	1/2001	Douceur et al.
6,181,336	B1	1/2001	Chiu et al.
6,182,139	B1	1/2001	Brendel
6,192,051	B1	2/2001	Lipman et al.
6,202,156	B1	3/2001	Kalajan
6,223,206	B1	4/2001	Dan et al.
6,233,612	B1	5/2001	Fruchtman et al.
6,233,648	B1	5/2001	Tomita
6,237,008	B1	5/2001	Beal et al.
6,246,684	B1	6/2001	Chapman et al.
6,253,226	B1	6/2001	Chidambaran et al.
6,253,230	B1	6/2001	Couland et al.
6,256,031	B1	7/2001	Meijer et al.
6,259,405	B1	7/2001	Stewart et al.
6,260,070	B1	7/2001	Shah
6,263,368	B1	7/2001	Martin
6,282,610	B1	8/2001	Bergsten
6,289,012	B1	9/2001	Harrington et al.
6,289,345	B1	9/2001	Yasue
6,292,832	B1	9/2001	Shah et al.
6,298,380	B1	10/2001	Coile et al.
6,304,913	B1	10/2001	Rune
6,308,162	B1	10/2001	Ouimet et al.
6,324,581	B1	11/2001	Xu et al.
6,327,622	B1	12/2001	Jindal et al.
6,330,574	B1	12/2001	Murashita
6,338,082	B1	1/2002	Schneider
6,339,785	B1	1/2002	Feigenbaum
6,343,324	B1	1/2002	Hubis et al.
6,347,339	B1	2/2002	Morris et al.
6,349,343	B1	2/2002	Foody et al.
6,353,848	B1	3/2002	Morris
6,360,270	B1	3/2002	Cherkasova et al.
6,363,056	B1	3/2002	Beigi et al.
6,367,009	B1	4/2002	Davis et al.
6,370,527	B1	4/2002	Singhal
6,374,263	B1	4/2002	Bunger et al.
6,374,300	B2	4/2002	Masters
6,389,433	B1	5/2002	Bolosky et al.
6,389,462	B1	5/2002	Cohen et al.
6,393,581	B1	5/2002	Friedman et al.
6,396,833	B1	5/2002	Zhang et al.
6,397,246	B1	5/2002	Wolfe
6,412,004	B1	6/2002	Chen et al.
6,430,562	B1	8/2002	Kardos et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,434,081	B1	8/2002	Johnson et al.
6,438,595	B1	8/2002	Blumenau et al.
6,446,108	B1	9/2002	Rosenberg et al.
6,466,580	B1	10/2002	Leung
6,469,983	B2	10/2002	Narayana et al.
6,477,544	B1	11/2002	Bolosky et al.
6,480,476	B1	11/2002	Willars
6,484,261	B1	11/2002	Wiegel
6,487,561	B1	11/2002	Ofek et al.
6,490,624	B1	12/2002	Sampson et al.
6,493,804	B1	12/2002	Soltis et al.
6,510,135	B1	1/2003	Almulhem et al.
6,510,458	B1	1/2003	Berstis et al.
6,513,061	B1	1/2003	Ebata et al.
6,514,085	B2	2/2003	Slattery et al.
6,516,350	B1	2/2003	Lumelsky et al.
6,516,351	B2	2/2003	Borr
6,519,643	B1	2/2003	Foulkes et al.
6,542,936	B1	4/2003	Mayle et al.
6,549,916	B1	4/2003	Sedlar
6,553,352	B2	4/2003	Delurgio et al.
6,556,997	B1	4/2003	Levy
6,556,998	B1	4/2003	Mukherjee et al.
6,560,230	B1	5/2003	Li et al.
6,578,069	B1	6/2003	Hopmann et al.
6,580,717	B1	6/2003	Higuchi et al.
6,601,084	B1	7/2003	Bhaskaran et al.
6,601,101	B1	7/2003	Lee et al.
6,606,663	B1	8/2003	Liao et al.
6,612,490	B1	9/2003	Herrendoerfer et al.
6,615,267	B1	9/2003	Whalen et al.
6,636,503	B1	10/2003	Shiran et al.
6,636,894	B1	10/2003	Short et al.
6,650,640	B1	11/2003	Muller et al.
6,650,641	B1	11/2003	Albert et al.
6,654,346	B1	11/2003	Mahalingaiah et al.
6,654,701	B2	11/2003	Hatley
6,661,802	B1	12/2003	Homberg et al.
6,683,873	B1	1/2004	Kwok et al.
6,690,669	B1	2/2004	Tsuchiya et al.
6,691,165	B1	2/2004	Bruck et al.
6,694,517	B1	2/2004	James et al.
6,701,415	B1	3/2004	Hendren, III
6,708,187	B1	3/2004	Shanumgam et al.
6,718,380	B1	4/2004	Mohaban et al.
6,721,794	B2	4/2004	Taylor et al.
6,728,704	B2	4/2004	Mao et al.
6,738,357	B1	5/2004	Richter et al.
6,738,790	B1	5/2004	Klein
6,742,035	B1	5/2004	Zayas et al.
6,742,045	B1	5/2004	Albert et al.
6,744,776	B1	6/2004	Kalkunte et al.
6,748,420	B1	6/2004	Quatrano et al.
6,751,663	B1	6/2004	Farrell et al.
6,754,215	B1	6/2004	Arikawa et al.
6,754,228	B1	6/2004	Ludwig
6,754,699	B2	6/2004	Swildens et al.
6,757,706	B1	6/2004	Dong et al.
6,760,337	B1	7/2004	Snyder, II et al.
6,760,775	B1	7/2004	Anerousis et al.
6,772,219	B1	8/2004	Shobatake
6,775,672	B2	8/2004	Mahalingam et al.
6,775,673	B2	8/2004	Mahalingam et al.
6,775,679	B2	8/2004	Gupta
6,779,039	B1	8/2004	Bommareddy et al.
6,781,986	B1	8/2004	Sabaa et al.
6,782,450	B2	8/2004	Arnott et al.
6,795,860	B1	9/2004	Shah
6,798,777	B1	9/2004	Ferguson et al.
6,801,960	B1	10/2004	Ericson et al.
6,804,542	B1	10/2004	Haartsen
6,816,901	B1	11/2004	Sitaraman et al.
6,816,977	B2	11/2004	Brakmo et al.
6,826,613	B1	11/2004	Wang et al.
6,829,238	B2	12/2004	Tokuyo et al.
6,839,761	B2	1/2005	Kadyk et al.
6,839,850	B1	1/2005	Campbell et al.
6,847,959	B1	1/2005	Arrouye et al.
6,847,970	B2	1/2005	Keller et al.
6,850,997	B1	2/2005	Rooney et al.
6,865,593	B1	3/2005	Reshef et al.
6,868,082	B1	3/2005	Allen, Jr. et al.
6,868,447	B1	3/2005	Slaughter et al.
6,871,221	B1	3/2005	Styles
6,871,245	B2	3/2005	Bradley
6,876,629	B2	4/2005	Beshai et al.
6,876,654	B1	4/2005	Hegde
6,880,017	B1	4/2005	Marce et al.
6,883,137	B1	4/2005	Girardot et al.
6,888,836	B1	5/2005	Cherkasova
6,889,249	B2	5/2005	Miloushev et al.
6,907,037	B2	6/2005	Tsuchiya et al.
6,912,219	B2	6/2005	Tsuchiya et al.
6,914,881	B1	7/2005	Mansfield et al.
6,920,136	B2	7/2005	Tsuchiya et al.
6,920,137	B2	7/2005	Tsuchiya et al.
6,920,138	B2	7/2005	Tsuchiya et al.
6,922,688	B1	7/2005	Frey, Jr.
6,928,077	B2	8/2005	Tsuchiya et al.
6,928,082	B2	8/2005	Liu et al.
6,934,706	B1	8/2005	Mancuso et al.
6,938,039	B1	8/2005	Bober et al.
6,938,059	B2	8/2005	Tamer et al.
6,947,985	B2	9/2005	Hegli et al.
6,950,434	B1	9/2005	Viswanath et al.
6,954,780	B2	10/2005	Susai et al.
6,957,272	B2	10/2005	Tallegas et al.
6,959,373	B2	10/2005	Testardi
6,959,394	B1	10/2005	Brickell et al.
6,961,815	B2	11/2005	Kistler et al.
6,970,924	B1	11/2005	Chu et al.
6,973,455	B1	12/2005	Vahalia et al.
6,973,490	B1	12/2005	Robertson et al.
6,973,549	B1	12/2005	Testardi
6,975,592	B1	12/2005	Seddigh et al.
6,985,936	B2	1/2006	Agarwalla et al.
6,985,956	B2	1/2006	Luke et al.
6,986,015	B2	1/2006	Testardi
6,986,040	B1	1/2006	Kramer et al.
6,987,763	B2	1/2006	Rochberger et al.
6,990,074	B2	1/2006	Wan et al.
6,990,114	B1	1/2006	Erimli et al.
6,990,547	B2	1/2006	Ulrich et al.
6,990,667	B2	1/2006	Ulrich et al.
6,996,841	B2	2/2006	Kadyk et al.
7,003,533	B2	2/2006	Noguchi et al.
7,003,564	B2	2/2006	Greuel et al.
7,006,981	B2	2/2006	Rose et al.
7,007,092	B2	2/2006	Peiffer
7,010,553	B2	3/2006	Chen et al.
7,013,379	B1	3/2006	Testardi
7,020,644	B2	3/2006	Jameson
7,020,699	B2	3/2006	Zhang et al.
7,023,974	B1	4/2006	Brannam et al.
7,024,427	B2	4/2006	Bobbitt et al.
7,028,182	B1 *	4/2006	Killcommons 713/161
7,039,061	B2	5/2006	Connor et al.
7,051,112	B2	5/2006	Dawson
7,054,998	B2	5/2006	Arnott et al.
7,058,633	B1	6/2006	Gnagy et al.
7,065,482	B2	6/2006	Shorey et al.
7,072,338	B2	7/2006	Tsuchiya et al.
7,072,339	B2	7/2006	Tsuchiya et al.
7,072,917	B2	7/2006	Wong et al.
7,075,924	B2	7/2006	Richter et al.
7,076,689	B2	7/2006	Atkinson
7,080,314	B1	7/2006	Garofalakis et al.
7,088,726	B1	8/2006	Hamamoto et al.
7,089,286	B1	8/2006	Malik
7,089,491	B2	8/2006	Feinberg et al.
7,111,115	B2	9/2006	Peters et al.
7,113,962	B1	9/2006	Kee et al.
7,113,993	B1	9/2006	Cappiello et al.
7,113,996	B2	9/2006	Kronenberg

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,120,128	B2	10/2006	Banks et al.	
7,120,746	B2	10/2006	Campbell et al.	
7,127,556	B2	10/2006	Blumenau et al.	
7,133,863	B2	11/2006	Teng et al.	
7,133,944	B2	11/2006	Song et al.	
7,133,967	B2	11/2006	Fujie et al.	
7,139,792	B1	11/2006	Mishra et al.	
7,143,146	B2	11/2006	Nakatani et al.	
7,146,524	B2	12/2006	Patel et al.	
7,152,184	B2	12/2006	Maeda et al.	
7,155,466	B2	12/2006	Rodriguez et al.	
7,158,526	B2	1/2007	Higuchi et al.	
7,162,529	B2	1/2007	Morishige et al.	
7,165,095	B2	1/2007	Sim	
7,167,821	B2	1/2007	Hardwick et al.	
7,171,496	B2	1/2007	Tanaka et al.	
7,173,929	B1	2/2007	Testardi	
7,185,359	B2	2/2007	Schmidt et al.	
7,191,163	B2	3/2007	Herrera et al.	
7,193,998	B2	3/2007	Tsuchiya et al.	
7,194,579	B2	3/2007	Robinson et al.	
7,209,759	B1	4/2007	Billing et al.	
7,228,359	B1	6/2007	Monteiro	
7,228,422	B2	6/2007	Morioka et al.	
7,234,074	B2	6/2007	Cohn et al.	
7,236,491	B2	6/2007	Tsao et al.	
7,240,100	B1	7/2007	Wein et al.	
7,248,591	B2	7/2007	Hamamoto et al.	
7,251,247	B2	7/2007	Hamamoto et al.	
7,280,536	B2	10/2007	Testardi	
7,280,971	B1	10/2007	Wimberly et al.	
7,283,540	B2	10/2007	Hamamoto et al.	
7,284,150	B2	10/2007	Ma et al.	
7,287,082	B1	10/2007	O'Toole, Jr.	
7,292,541	B1	11/2007	C S	
7,293,097	B2	11/2007	Borr	
7,293,099	B1	11/2007	Kalajan	
7,293,133	B1	11/2007	Colgrove et al.	
7,295,827	B2	11/2007	Liu et al.	
7,296,263	B1	11/2007	Jacob	
7,299,491	B2 *	11/2007	Shelest et al.	726/4
7,305,480	B2	12/2007	Oishi et al.	
7,308,475	B1	12/2007	Pruitt et al.	
7,308,703	B2	12/2007	Wright et al.	
7,308,709	B1	12/2007	Brezak et al.	
7,310,339	B1	12/2007	Powers et al.	
7,315,543	B2	1/2008	Takeuchi et al.	
7,319,696	B2	1/2008	Inoue et al.	
7,321,926	B1	1/2008	Zhang et al.	
7,324,533	B1	1/2008	DeLiberato et al.	
7,328,009	B2	2/2008	Takeda et al.	
7,328,281	B2	2/2008	Takeda et al.	
7,333,999	B1	2/2008	Njemanze	
7,343,398	B1	3/2008	Lownsbrough	
7,343,413	B2	3/2008	Gilde et al.	
7,346,664	B2	3/2008	Wong et al.	
7,349,391	B2	3/2008	Ben-Dor et al.	
7,383,288	B2	6/2008	Miloushev et al.	
7,383,570	B2	6/2008	Pinkas et al.	
7,385,989	B2	6/2008	Higuchi et al.	
7,394,804	B2	7/2008	Miyata et al.	
7,398,552	B2	7/2008	Pardee et al.	
7,400,645	B2	7/2008	Tsuchiya et al.	
7,400,646	B2	7/2008	Tsuchiya et al.	
7,401,220	B2	7/2008	Bolosky et al.	
7,403,520	B2	7/2008	Tsuchiya et al.	
7,406,484	B1	7/2008	Srinivasan et al.	
7,409,440	B1	8/2008	Jacob	
7,415,488	B1	8/2008	Muth et al.	
7,415,608	B2	8/2008	Bolosky et al.	
7,433,962	B2	10/2008	Janssen et al.	
7,437,478	B2	10/2008	Yokota et al.	
7,440,982	B2	10/2008	Lu et al.	
7,441,429	B1	10/2008	Nucci et al.	
7,454,480	B2	11/2008	Labio et al.	
7,457,982	B2	11/2008	Rajan	
7,467,158	B2	12/2008	Marinescu	
7,475,241	B2	1/2009	Patel et al.	
7,477,796	B2	1/2009	Sasaki et al.	
7,490,162	B1	2/2009	Masters	
7,500,243	B2	3/2009	Huetsch et al.	
7,500,269	B2	3/2009	Huotari et al.	
7,505,795	B1	3/2009	Lim et al.	
7,509,322	B2	3/2009	Miloushev et al.	
7,512,673	B2	3/2009	Miloushev et al.	
7,516,492	B1	4/2009	Nisbet et al.	
7,519,813	B1	4/2009	Cox et al.	
7,522,581	B2	4/2009	Acharya et al.	
7,526,541	B2	4/2009	Roese et al.	
7,558,197	B1	7/2009	Sindhu et al.	
7,562,110	B2	7/2009	Miloushev et al.	
7,571,168	B2	8/2009	Bahar et al.	
7,574,433	B2	8/2009	Engel	
7,577,141	B2	8/2009	Kamata et al.	
7,577,723	B2	8/2009	Matsuda et al.	
7,580,971	B1	8/2009	Gollapudi et al.	
7,587,471	B2	9/2009	Yasuda et al.	
7,590,732	B2	9/2009	Rune	
7,590,747	B2	9/2009	Coates et al.	
7,599,941	B2	10/2009	Bahar et al.	
7,610,307	B2	10/2009	Havewala et al.	
7,610,390	B2	10/2009	Yared et al.	
7,620,733	B1 *	11/2009	Tzakikario et al.	709/245
7,624,109	B2	11/2009	Testardi	
7,624,424	B2	11/2009	Morita et al.	
7,639,883	B2	12/2009	Gill	
7,644,109	B2	1/2010	Manley et al.	
7,644,137	B2	1/2010	Bozak et al.	
7,653,077	B2	1/2010	Hamamoto et al.	
7,653,699	B1	1/2010	Colgrove et al.	
7,668,166	B1	2/2010	Rekhter et al.	
7,689,596	B2	3/2010	Tsunoda	
7,689,710	B2	3/2010	Tang et al.	
7,694,082	B2	4/2010	Golding et al.	
7,701,952	B2	4/2010	Higuchi et al.	
7,711,771	B2	5/2010	Kirnos	
7,724,657	B2	5/2010	Rao et al.	
7,725,093	B2	5/2010	Sengupta et al.	
7,734,603	B1	6/2010	McManis	
7,743,035	B2	6/2010	Chen et al.	
7,746,863	B2	6/2010	Tsuchiya et al.	
7,752,294	B2	7/2010	Meyer et al.	
7,761,597	B2	7/2010	Takeda et al.	
7,769,711	B2	8/2010	Srinivasan et al.	
7,778,187	B2	8/2010	Chaturvedi et al.	
7,788,335	B2	8/2010	Miloushev et al.	
7,788,408	B2	8/2010	Takeda et al.	
7,801,978	B1	9/2010	Susai et al.	
7,808,913	B2	10/2010	Ansari et al.	
7,822,939	B1	10/2010	Veprinsky et al.	
7,831,639	B1	11/2010	Panchbudhe et al.	
7,831,662	B2	11/2010	Clark et al.	
7,849,112	B2	12/2010	Mane et al.	
7,870,154	B2	1/2011	Shitomi et al.	
7,877,511	B1	1/2011	Berger et al.	
7,885,970	B2	2/2011	Lacapra	
7,908,245	B2	3/2011	Nakano et al.	
7,908,314	B2	3/2011	Yamaguchi et al.	
7,913,053	B1	3/2011	Newland	
7,921,211	B2 *	4/2011	Larson et al.	709/226
7,925,908	B2	4/2011	Kim	
7,930,365	B2	4/2011	Dixit et al.	
7,933,946	B2	4/2011	Livshits et al.	
7,941,517	B2	5/2011	Migault et al.	
7,941,563	B2	5/2011	Takeda et al.	
7,945,908	B1	5/2011	Waldspurger et al.	
7,953,701	B2	5/2011	Okitsu et al.	
7,957,405	B2	6/2011	Higuchi et al.	
7,958,347	B1	6/2011	Ferguson	
7,965,724	B2	6/2011	Hamamoto et al.	
7,984,141	B2	7/2011	Gupta et al.	
8,005,953	B2	8/2011	Miloushev et al.	
8,031,716	B2	10/2011	Tsuchiya et al.	
8,069,225	B2	11/2011	McCanne et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,103,781	B1	1/2012	Wu et al.
8,107,471	B2	1/2012	Nakamura et al.
8,130,650	B2	3/2012	Allen, Jr. et al.
8,131,863	B2	3/2012	Takeda et al.
8,189,567	B2	5/2012	Kavanagh et al.
8,199,757	B2	6/2012	Pani et al.
8,205,246	B2	6/2012	Shatzkamer et al.
8,239,954	B2	8/2012	Wobber et al.
8,266,427	B2	9/2012	Thubert et al.
8,274,895	B2	9/2012	Rahman et al.
8,281,383	B2	10/2012	Levy-Abegnoli et al.
8,289,968	B1	10/2012	Zhuang
8,321,908	B2	11/2012	Gai et al.
8,351,333	B2	1/2013	Rao et al.
8,379,640	B2	2/2013	Ichihashi et al.
8,380,854	B2	2/2013	Szabo
8,417,817	B1	4/2013	Jacobs
8,437,345	B2	5/2013	Takeda et al.
8,447,871	B1	5/2013	Szabo
8,447,970	B2	5/2013	Klein et al.
8,464,265	B2	6/2013	Worley
8,468,267	B2	6/2013	Yigang
8,477,804	B2	7/2013	Yoshimoto et al.
8,488,465	B2	7/2013	Solis et al.
8,539,224	B2	9/2013	Henderson et al.
8,566,474	B2	10/2013	Kanode et al.
8,578,050	B2	11/2013	Craig et al.
8,582,599	B2	11/2013	Hamamoto et al.
8,594,108	B2	11/2013	Tsuchiya et al.
8,601,161	B2	12/2013	Takeda et al.
8,606,921	B2	12/2013	Vasquez et al.
8,615,022	B2	12/2013	Harrison et al.
8,646,067	B2	2/2014	Agarwal et al.
8,665,868	B2	3/2014	Kay
8,665,969	B2	3/2014	Kay
8,701,179	B1	4/2014	Penno et al.
8,725,836	B2	5/2014	Lowery et al.
8,726,336	B2	5/2014	Narayanaswamy et al.
8,726,338	B2	5/2014	Narayanaswamy et al.
8,737,304	B2	5/2014	Karuturi et al.
8,788,665	B2	7/2014	Glide et al.
8,804,504	B1	8/2014	Chen
8,819,109	B1	8/2014	Krishnamurthy et al.
8,819,419	B2	8/2014	Carlson et al.
8,819,768	B1	8/2014	Koeten et al.
8,830,874	B2	9/2014	Cho et al.
8,873,753	B2	10/2014	Parker
8,875,274	B2	10/2014	Montemurro et al.
8,886,981	B1	11/2014	Baumann et al.
8,908,545	B1	12/2014	Chen et al.
8,954,080	B2	2/2015	Janakiriman et al.
9,037,166	B2	5/2015	de Wit et al.
9,077,554	B1	7/2015	Szabo
9,083,760	B1	7/2015	Hughes et al.
9,088,525	B2	7/2015	Takeda et al.
9,106,699	B2	8/2015	Thornewell et al.
2001/0007560	A1	7/2001	Masuda et al.
2001/0009554	A1	7/2001	Katseff et al.
2001/0014891	A1	8/2001	Hoffert et al.
2001/0023442	A1	9/2001	Masters
2001/0047293	A1	11/2001	Waller et al.
2001/0051955	A1	12/2001	Wong
2002/0010783	A1	1/2002	Primak et al.
2002/0012352	A1	1/2002	Hansson et al.
2002/0032777	A1	3/2002	Kawata et al.
2002/0035537	A1	3/2002	Waller et al.
2002/0038360	A1	3/2002	Andrews et al.
2002/0049842	A1	4/2002	Huetsch et al.
2002/0059263	A1	5/2002	Shima et al.
2002/0059428	A1	5/2002	Susai et al.
2002/0065810	A1	5/2002	Bradley
2002/0065848	A1	5/2002	Walker et al.
2002/0073105	A1	6/2002	Noguchi et al.
2002/0083067	A1	6/2002	Tamayo et al.
2002/0083118	A1	6/2002	Sim
2002/0087571	A1	7/2002	Stapel et al.
2002/0087744	A1	7/2002	Kitchin
2002/0087887	A1	7/2002	Busam et al.
2002/0099829	A1	7/2002	Richards et al.
2002/0103823	A1	8/2002	Jackson et al.
2002/0103916	A1	8/2002	Chen et al.
2002/0112061	A1	8/2002	Shih et al.
2002/0133330	A1	9/2002	Loisey et al.
2002/0133491	A1	9/2002	Sim et al.
2002/0138615	A1	9/2002	Schmeling
2002/0143819	A1	10/2002	Han et al.
2002/0143909	A1	10/2002	Botz et al.
2002/0147630	A1	10/2002	Rose et al.
2002/0150253	A1	10/2002	Brezak et al.
2002/0156905	A1	10/2002	Weissman
2002/0160161	A1	10/2002	Misuda
2002/0161911	A1	10/2002	Pinckney, III et al.
2002/0161913	A1	10/2002	Gonzalez et al.
2002/0162118	A1	10/2002	Levy et al.
2002/0174216	A1	11/2002	Shorey et al.
2002/0188667	A1	12/2002	Kirnos
2002/0194112	A1	12/2002	dePinto et al.
2002/0194342	A1	12/2002	Lu et al.
2002/0198956	A1	12/2002	Dunshea et al.
2002/0198993	A1	12/2002	Cudd et al.
2003/0005172	A1	1/2003	Chessell
2003/0009429	A1	1/2003	Jameson
2003/0009528	A1	1/2003	Sharif et al.
2003/0012382	A1	1/2003	Ferchichi et al.
2003/0018450	A1	1/2003	Carley
2003/0018585	A1	1/2003	Butler et al.
2003/0028514	A1	2/2003	Lord et al.
2003/0033308	A1	2/2003	Patel et al.
2003/0033535	A1	2/2003	Fisher et al.
2003/0037070	A1	2/2003	Marston
2003/0046291	A1	3/2003	Fascenda
2003/0055723	A1	3/2003	English
2003/0061240	A1	3/2003	McCann et al.
2003/0065951	A1	4/2003	Igeta et al.
2003/0065956	A1	4/2003	Belapurkar et al.
2003/0067923	A1 *	4/2003	Ju H04L 29/12066 370/395.3
2003/0069918	A1	4/2003	Lu et al.
2003/0069974	A1	4/2003	Lu et al.
2003/0070069	A1	4/2003	Belapurkar et al.
2003/0074301	A1	4/2003	Solomon
2003/0074434	A1	4/2003	Jason et al.
2003/0086415	A1	5/2003	Bernhard et al.
2003/0105846	A1	6/2003	Zhao et al.
2003/0105983	A1	6/2003	Brakimo et al.
2003/0108052	A1	6/2003	Inoue et al.
2003/0115218	A1	6/2003	Bobbitt et al.
2003/0115439	A1	6/2003	Mahalingam et al.
2003/0128708	A1	7/2003	Inoue et al.
2003/0130945	A1	7/2003	Force et al.
2003/0139934	A1	7/2003	Mandera
2003/0140140	A1	7/2003	Lahtinen
2003/0145062	A1	7/2003	Sharma et al.
2003/0145233	A1	7/2003	Poletto et al.
2003/0149781	A1	8/2003	Yared et al.
2003/0156586	A1	8/2003	Lee et al.
2003/0159072	A1	8/2003	Bellinger et al.
2003/0163576	A1	8/2003	Janssen et al.
2003/0171978	A1	9/2003	Jenkins et al.
2003/0177364	A1	9/2003	Walsh et al.
2003/0177388	A1	9/2003	Botz et al.
2003/0179755	A1	9/2003	Fraser
2003/0191812	A1	10/2003	Agarwalla et al.
2003/0195813	A1	10/2003	Pallister et al.
2003/0204635	A1	10/2003	Ko et al.
2003/0212954	A1	11/2003	Patrudu
2003/0220835	A1	11/2003	Barnes, Jr.
2003/0221000	A1	11/2003	Cherkasova et al.
2003/0225485	A1	12/2003	Fritz et al.
2003/0229665	A1	12/2003	Ryman
2003/0236995	A1	12/2003	Fretwell, Jr.
2004/0003266	A1	1/2004	Moshir et al.
2004/0003287	A1	1/2004	Zissimopoulos et al.
2004/0006575	A1	1/2004	Visharam et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0006591 A1 1/2004 Matsui et al.
2004/0010654 A1 1/2004 Yasuda et al.
2004/0015783 A1 1/2004 Lennon et al.
2004/0017825 A1 1/2004 Stanwood et al.
2004/0025013 A1 2/2004 Parker et al.
2004/0028043 A1 2/2004 Maveli et al.
2004/0028063 A1 2/2004 Roy et al.
2004/0030627 A1 2/2004 Sedukhin
2004/0030740 A1 2/2004 Stelting
2004/0030857 A1 2/2004 Krakirian et al.
2004/0043758 A1 3/2004 Sorvari et al.
2004/0054777 A1 3/2004 Ackaouy et al.
2004/0059789 A1 3/2004 Shum
2004/0064544 A1 4/2004 Barsness et al.
2004/0064554 A1 4/2004 Kuno et al.
2004/0072569 A1 4/2004 Omae et al.
2004/0093474 A1 5/2004 Lin et al.
2004/0098383 A1 5/2004 Tabellion et al.
2004/0103283 A1 5/2004 Hornak
2004/0111523 A1 6/2004 Hall et al.
2004/0111621 A1 6/2004 Himberger et al.
2004/0117493 A1 6/2004 Bazot et al.
2004/0122926 A1 6/2004 Moore et al.
2004/0123277 A1 6/2004 Schrader et al.
2004/0133605 A1 7/2004 Chang et al.
2004/0133606 A1 7/2004 Miloushev et al.
2004/0138858 A1 7/2004 Carley
2004/0139355 A1 7/2004 Axel et al.
2004/0148380 A1 7/2004 Meyer et al.
2004/0141185 A1 8/2004 Akama
2004/0151186 A1 8/2004 Akama
2004/0153479 A1 8/2004 Mikesell et al.
2004/0167967 A1 8/2004 Bastian et al.
2004/0181605 A1 9/2004 Nakatani et al.
2004/0192312 A1 9/2004 Li et al.
2004/0199547 A1 10/2004 Winter et al.
2004/0213156 A1 10/2004 Smallwood et al.
2004/0215665 A1 10/2004 Edgar et al.
2004/0236798 A1 11/2004 Srinivasan et al.
2004/0236826 A1 11/2004 Harville et al.
2004/0264472 A1 12/2004 Oliver et al.
2004/0264481 A1 12/2004 Darling et al.
2004/0267920 A1 12/2004 Hydrie et al.
2004/0267948 A1 12/2004 Oliver et al.
2004/0268358 A1 12/2004 Darling et al.
2005/0004887 A1 1/2005 Igakura et al.
2005/0021615 A1 1/2005 Arnott et al.
2005/0021703 A1 1/2005 Cherry et al.
2005/0021736 A1 1/2005 Carusi et al.
2005/0027841 A1 2/2005 Rolfe
2005/0027869 A1 2/2005 Johnson
2005/0028010 A1 2/2005 Wallman
2005/0044158 A1 2/2005 Malik
2005/0044213 A1 2/2005 Kobayashi et al.
2005/0050107 A1 3/2005 Mane et al.
2005/0052440 A1 3/2005 Kim et al.
2005/0055435 A1 3/2005 Gbadegesin et al.
2005/0078604 A1 4/2005 Yim
2005/0091214 A1 4/2005 Probert et al.
2005/0108575 A1 5/2005 Yung
2005/0114291 A1 5/2005 Becker-Szendy et al.
2005/0114701 A1 5/2005 Atkins et al.
2005/0117589 A1 6/2005 Douady et al.
2005/0122977 A1 6/2005 Lieberman
2005/0125195 A1 6/2005 Brendel
2005/0154837 A1 7/2005 Keohane et al.
2005/0165656 A1 7/2005 Frederick et al.
2005/0175013 A1 8/2005 Le Pennec et al.
2005/0187866 A1 8/2005 Lee
2005/0188220 A1 8/2005 Nilsson et al.
2005/0188423 A1 8/2005 Motsinger et al.
2005/0189501 A1 9/2005 Sato et al.
2005/0198234 A1 9/2005 Leib et al.
2005/0198310 A1 9/2005 Kim et al.
2005/0213587 A1 9/2005 Cho et al.
2005/0234928 A1 10/2005 Shkvarchuk et al.
2005/0240664 A1 10/2005 Chen et al.
2005/0246393 A1 11/2005 Coates et al.
2005/0256806 A1 11/2005 Tien et al.
2005/0262238 A1 11/2005 Reeves et al.
2005/0277430 A1 12/2005 Meisi
2005/0289109 A1 12/2005 Arrouye et al.
2005/0289111 A1 12/2005 Tribble et al.
2006/0010502 A1 1/2006 Mimatsu et al.
2006/0031374 A1 2/2006 Lu et al.
2006/0031520 A1 2/2006 Bedekar et al.
2006/0045096 A1 3/2006 Farmer et al.
2006/0047785 A1 3/2006 Wang et al.
2006/0059267 A1 3/2006 Cugi et al.
2006/0075475 A1 4/2006 Boulos et al.
2006/0077902 A1 4/2006 Kannan et al.
2006/0080353 A1 4/2006 Miloushev et al.
2006/0095573 A1 5/2006 Carle
2006/0106882 A1 5/2006 Douceur et al.
2006/0112151 A1 5/2006 Manley et al.
2006/0112176 A1 5/2006 Liu et al.
2006/0112272 A1 5/2006 Morioka et al.
2006/0112367 A1 5/2006 Harris
2006/0123062 A1 6/2006 Bobbitt et al.
2006/0129684 A1 6/2006 Datta
2006/0135198 A1 6/2006 Lee
2006/0140193 A1 6/2006 Kakani et al.
2006/0153201 A1 7/2006 Hepper et al.
2006/0156416 A1 7/2006 Huotari et al.
2006/0161577 A1 7/2006 Kulkarni et al.
2006/0167838 A1 7/2006 Lacapra
2006/0171365 A1 8/2006 Borella
2006/0179261 A1 8/2006 Rajan
2006/0184589 A1 8/2006 Lees et al.
2006/0190496 A1 8/2006 Tsunoda
2006/0200470 A1 9/2006 Lacapra et al.
2006/0209853 A1 9/2006 Hidaka et al.
2006/0212746 A1 9/2006 Amegadzie et al.
2006/0224687 A1 10/2006 Popkin et al.
2006/0230148 A1 10/2006 Forecast et al.
2006/0230265 A1 10/2006 Krishna
2006/0233106 A1 10/2006 Achlioptas et al.
2006/0242179 A1 10/2006 Chen et al.
2006/0242300 A1 10/2006 Yumoto et al.
2006/0259320 A1 11/2006 LaSalle et al.
2006/0259949 A1 11/2006 Schaefer et al.
2006/0268692 A1 11/2006 Wright et al.
2006/0271598 A1 11/2006 Wong et al.
2006/0277225 A1 12/2006 Mark et al.
2006/0282442 A1 12/2006 Lennon et al.
2006/0282461 A1 12/2006 Marinescu
2006/0282471 A1 12/2006 Mark et al.
2006/0288413 A1 12/2006 Kubota
2007/0005807 A1 1/2007 Wong
2007/0006293 A1 1/2007 Balakrishnan et al.
2007/0016613 A1 1/2007 Foresti et al.
2007/0016662 A1 1/2007 Desai et al.
2007/0024919 A1 2/2007 Wong et al.
2007/0027929 A1 2/2007 Whelan
2007/0027935 A1 2/2007 Haselton et al.
2007/0028068 A1 2/2007 Golding et al.
2007/0058670 A1 3/2007 Konduru et al.
2007/0064661 A1 3/2007 Sood et al.
2007/0083646 A1 4/2007 Miller et al.
2007/0088702 A1 4/2007 Fridella et al.
2007/0088822 A1 4/2007 Coile et al.
2007/0106796 A1 5/2007 Kudo et al.
2007/0107048 A1 5/2007 Halls et al.
2007/0118879 A1 5/2007 Yeun
2007/0124502 A1 5/2007 Li
2007/0124806 A1 5/2007 Shulman et al.
2007/0130255 A1 6/2007 Wolovitz et al.
2007/0136308 A1 6/2007 Tsirigotis et al.
2007/0136312 A1 6/2007 Shulman et al.
2007/0162891 A1 7/2007 Burner et al.
2007/0168320 A1 7/2007 Borthakur et al.
2007/0174491 A1 7/2007 Still et al.
2007/0208748 A1 9/2007 Li
2007/0209075 A1 9/2007 Coffman

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0214503	A1	9/2007	Shulman et al.	
2007/0220598	A1	9/2007	Salowey et al.	
2007/0226331	A1	9/2007	Srinivasan et al.	
2007/0233809	A1	10/2007	Brownell et al.	
2007/0233826	A1	10/2007	Tindal et al.	
2007/0297410	A1	12/2007	Yoon et al.	
2007/0297551	A1	12/2007	Choi	
2008/0004022	A1	1/2008	Johannesson et al.	
2008/0010372	A1	1/2008	Khedouri et al.	
2008/0022059	A1	1/2008	Zimmerer et al.	
2008/0025297	A1	1/2008	Kashyap	
2008/0034136	A1	2/2008	Ulenas	
2008/0046432	A1	2/2008	Anderson et al.	
2008/0070575	A1	3/2008	Claussen et al.	
2008/0072303	A1	3/2008	Syed	
2008/0104443	A1	5/2008	Akutsu et al.	
2008/0120370	A1	5/2008	Chan et al.	
2008/0133518	A1	6/2008	Kapoor et al.	
2008/0134311	A1	6/2008	Medvinsky et al.	
2008/0137659	A1	6/2008	Levy-Abegnoli et al.	
2008/0148340	A1	6/2008	Powell et al.	
2008/0159145	A1	7/2008	Muthukrishnan et al.	
2008/0178278	A1	7/2008	Grinstein et al.	
2008/0201599	A1	8/2008	Ferraiolo et al.	
2008/0205415	A1	8/2008	Morales	
2008/0205613	A1	8/2008	Lopez	
2008/0208933	A1	8/2008	Lyon	
2008/0209073	A1	8/2008	Tang	
2008/0222223	A1	9/2008	Srinivasan et al.	
2008/0222646	A1	9/2008	Sigal et al.	
2008/0225710	A1	9/2008	Raja et al.	
2008/0229415	A1	9/2008	Kapoor et al.	
2008/0243769	A1	10/2008	Arbour et al.	
2008/0253395	A1	10/2008	Pandya	
2008/0256224	A1	10/2008	Kaji et al.	
2008/0270578	A1	10/2008	Zhang et al.	
2008/0271132	A1	10/2008	Jokela et al.	
2008/0275843	A1	11/2008	Lal	
2008/0282047	A1	11/2008	Arakawa et al.	
2008/0288661	A1	11/2008	Galles	
2008/0301760	A1	12/2008	Lim	
2008/0304457	A1	12/2008	Thubert et al.	
2008/0320093	A1	12/2008	Thorne	
2009/0007162	A1	1/2009	Sheehan	
2009/0028337	A1	1/2009	Balabine et al.	
2009/0037975	A1	2/2009	Ishikawa et al.	
2009/0041230	A1	2/2009	Williams	
2009/0049230	A1	2/2009	Pandya	
2009/0055607	A1	2/2009	Schack et al.	
2009/0070617	A1	3/2009	Arimilli et al.	
2009/0077097	A1	3/2009	Lacapra et al.	
2009/0077619	A1	3/2009	Boyce	
2009/0089344	A1	4/2009	Brown et al.	
2009/0094252	A1	4/2009	Wong et al.	
2009/0094610	A1	4/2009	Sukirya	
2009/0100518	A1	4/2009	Overcash	
2009/0103524	A1	4/2009	Mantripragada	
2009/0106255	A1	4/2009	Lacapra et al.	
2009/0106263	A1	4/2009	Khalid et al.	
2009/0119504	A1	5/2009	van Os et al.	
2009/0125496	A1	5/2009	Wexler et al.	
2009/0125532	A1	5/2009	Wexler et al.	
2009/0125625	A1	5/2009	Shim et al.	
2009/0125955	A1	5/2009	DeLorme	
2009/0132616	A1	5/2009	Winter et al.	
2009/0138749	A1	5/2009	Moll et al.	
2009/0141891	A1	6/2009	Boyen et al.	
2009/0187649	A1	7/2009	Migault et al.	H04L 29/12066 709/223
2009/0196282	A1	8/2009	Fellman et al.	
2009/0204649	A1	8/2009	Wong et al.	
2009/0204650	A1	8/2009	Wong et al.	
2009/0204705	A1	8/2009	Marinov et al.	
2009/0210431	A1	8/2009	Marinkovic et al.	
2009/0228956	A1	9/2009	He et al.	
2009/0254592	A1	10/2009	Marinov et al.	
2009/0265396	A1	10/2009	Ram et al.	
2009/0271865	A1	10/2009	Jiang	
2009/0287935	A1	11/2009	Aull et al.	
2009/0296624	A1	12/2009	Ryu et al.	
2009/0300161	A1	12/2009	Pruitt et al.	
2009/0300407	A1	12/2009	Kamath et al.	
2010/0011434	A1	1/2010	Kay	
2010/0017846	A1	1/2010	Huang et al.	
2010/0023582	A1	1/2010	Pedersen et al.	
2010/0034381	A1*	2/2010	Trace et al.	380/255
2010/0036959	A1	2/2010	Trace et al.	
2010/0061380	A1	3/2010	Barach et al.	
2010/0064001	A1	3/2010	Daily	
2010/0071048	A1	3/2010	Novak et al.	
2010/0077462	A1	3/2010	Joffe et al.	
2010/0115236	A1	5/2010	Bataineh et al.	
2010/0122091	A1	5/2010	Huang et al.	
2010/0142382	A1	6/2010	Jungck et al.	
2010/0150154	A1	6/2010	Viger et al.	
2010/0161774	A1*	6/2010	Huang et al.	709/221
2010/0165877	A1	7/2010	Shukla et al.	
2010/0179984	A1	7/2010	Sebastian	
2010/0211547	A1	8/2010	Kamei et al.	
2010/0217890	A1	8/2010	Nice et al.	
2010/0228813	A1	9/2010	Suzuki et al.	
2010/0242092	A1	9/2010	Harris et al.	
2010/0251330	A1	9/2010	Kroeselberg et al.	
2010/0274885	A1	10/2010	Yoo et al.	
2010/0322250	A1	12/2010	Shetty et al.	
2010/0325264	A1	12/2010	Crowder et al.	
2010/0325277	A1	12/2010	Muthiah et al.	
2011/0038377	A1	2/2011	Haddad	
2011/0040889	A1	2/2011	Garrett et al.	
2011/0047620	A1	2/2011	Mahaffey et al.	
2011/0055921	A1	3/2011	Narayanaswamy et al.	
2011/0066718	A1	3/2011	Susai et al.	
2011/0066736	A1	3/2011	Mitchell et al.	
2011/0087696	A1	4/2011	Lacapra	
2011/0153822	A1	6/2011	Rajan et al.	
2011/0154132	A1	6/2011	Aybay	
2011/0154443	A1	6/2011	Thakur et al.	
2011/0173295	A1	7/2011	Bakke et al.	
2011/0184733	A1	7/2011	Yu et al.	
2011/0208714	A1	8/2011	Soukal et al.	
2011/0211553	A1	9/2011	Haddad	
2011/0246800	A1	10/2011	Accpadi et al.	
2011/0273984	A1	11/2011	Hsu et al.	
2011/0282997	A1	11/2011	Prince et al.	
2011/0283018	A1	11/2011	Levine et al.	
2011/0292857	A1	12/2011	Sarikaya et al.	
2011/0295924	A1	12/2011	Morris	
2011/0307629	A1	12/2011	Haddad	
2011/0321122	A1	12/2011	Mwangi et al.	
2012/0005372	A1	1/2012	Sarikaya et al.	
2012/0016994	A1	1/2012	Nakamura et al.	
2012/0039341	A1	2/2012	Latif et al.	
2012/0041965	A1	2/2012	Vasquez et al.	
2012/0047571	A1	2/2012	Duncan et al.	
2012/0054497	A1	3/2012	Korhonen	
2012/0059934	A1	3/2012	Rafiq et al.	
2012/0063314	A1	3/2012	Pignataro et al.	
2012/0066489	A1	3/2012	Ozaki et al.	
2012/0071131	A1	3/2012	Zisapel et al.	
2012/0101952	A1	4/2012	Raleigh et al.	
2012/0110210	A1	5/2012	Huang et al.	
2012/0117379	A1	5/2012	Thornewell et al.	
2012/0174217	A1	7/2012	Ormazabal	
2012/0191847	A1	7/2012	Nas et al.	
2012/0259998	A1	10/2012	Kaufman	
2012/0284296	A1	11/2012	Arifuddin et al.	
2012/0311153	A1	12/2012	Morgan	
2012/0317266	A1	12/2012	Abbott	
2013/0007870	A1	1/2013	Devarajan et al.	
2013/0029726	A1	1/2013	Berionne et al.	
2013/0091002	A1	4/2013	Christie et al.	
2013/0100815	A1	4/2013	Kakadia et al.	
2013/0103805	A1	4/2013	Lyon	
2013/0110939	A1	5/2013	Yang et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0120168	A1	5/2013	Kumar et al.
2013/0151725	A1	6/2013	Baginski et al.
2013/0166715	A1	6/2013	Yuan et al.
2013/0198322	A1	8/2013	Oran et al.
2013/0201999	A1	8/2013	Savolainen et al.
2013/0205035	A1	8/2013	Chen
2013/0205040	A1	8/2013	Naor et al.
2013/0335010	A1	12/2013	Wu et al.
2013/0336122	A1	12/2013	Barush et al.
2013/0340079	A1	12/2013	Gottlieb
2014/0025823	A1	1/2014	Szabo et al.
2014/0040478	A1	2/2014	Hsu et al.
2014/0095661	A1	4/2014	Knowles et al.
2014/0269484	A1	9/2014	Dankberg et al.
2014/0317404	A1	10/2014	Carlson et al.

FOREIGN PATENT DOCUMENTS

CA	2512312	A1	7/2004
EP	0 605 088		7/1994
EP	0 738 970		10/1996
EP	0744850	A2	11/1996
EP	1 081 918		3/2001
EP	2 244 418		10/2010
GB	2 448 071		10/2008
JP	63010250	A	1/1988
JP	06-205006		7/1994
JP	06-332782		12/1994
JP	8021924		3/1996
JP	08-328760		12/1996
JP	08-339355		12/1996
JP	9016510	A	1/1997
JP	11282741	A	10/1999
JP	2000183935		6/2000
JP	2005-010913		1/2005
JP	2008-257738	A	10/2008
JP	2009-124113		6/2009
JP	2011-188071		9/2011
JP	2011-238263		11/2011
NZ	566291		12/2008
WO	WO 91/14326		9/1991
WO	WO 95/05712		2/1995
WO	WO 97/09805		3/1997
WO	WO 97/45800		12/1997
WO	WO 99/05829		2/1999
WO	WO 99/06913		2/1999
WO	WO 99/10858		3/1999
WO	WO 99/39373		8/1999
WO	WO 99/64967		12/1999
WO	WO 00/04422		1/2000
WO	WO 00/04458		1/2000
WO	WO 00/58870		10/2000
WO	WO 02/39696		5/2002
WO	WO 02/056181	A2	7/2002
WO	WO 2004/061605	A2	7/2004
WO	WO 2006/091040		8/2006
WO	WO 2009/052668		10/2007
WO	WO 2008/130983		10/2008
WO	WO 2008/147973	A2	12/2008

OTHER PUBLICATIONS

Arends R., et al., "DNS Security Introduction and Requirements", Network Working Group, RFC 4033, Mar. 2005, pp. 1-20.

Arends R., et al., "Protocol Modifications for the DNS Security Extensions", Network Working Group, RFC 4035, Mar. 2005, pp. 1-50.

Arends R., et al., "Resource Records for the DNS Security Extensions", Network Working Group, RFC 4034, Mar. 2005, pp. 1-28.

Forrester Research, Inc., "DNSSEC Ready for Prime Time", Forrester Research, Inc. Cambridge, MA (Jul. 2010).

Thomson, et al., "DNS Extensions to Support IP Version 6", The Internet Society (Oct. 2003).

Wikipedia, "List of DNS record types", retrieved from Internet URL: http://en.wikipedia.org/wiki/List_of_DNS_record_types (Jun. 2010).

Wikipedia, "IPv6", retrieved from Internet URL: http://en.wikipedia.org/wiki/IPv6 (Jun. 2010).

Wikipedia, "Domain Name System Security Extensions", retrieved from Internet URL: http://en.wikipedia.org/wiki/DNSSEC (Jun. 2010).

Dan Kaminsky, (slideshow presentation) "Black Ops of Fundamental Defense: Introducing the Domain Key Infrastructure", retrieved from Internet URL: http://www.slideshare.net/RecursionVentures/dki-2, (Aug. 2010).

Bau et al., "A Security Evaluation of DNSSEC with NSEC3," Mar. 2, 2010; updated version corrects and supersedes a paper in the NDSS' 10 proceedings, pp. 1-17.

"BIG-IP® Global Traffic Manager," <http://www.f5.com/products/bigip/product-modules/global-traffic-manager.html>, last accessed Jul. 6, 2010, 2 pages.

"BIG-IP® Global Traffic Manager™ and BIG-IP Link Controller™: Implementations,".

"DNSSEC Functional Spec," TMOSDnsSECFS<TMOS<TWiki, last accessed on Mar. 31, 2010, p. 1-10.

"DNSX; DNSX Secure Signer; DNSSEC Management Solution," <http://www.xelerance.com/dnssec>. pp. 1-9.

"F5 and Infoblox Provide Customers with Complete DNS Security Solution," <http://www.f5.com/news-press-events/press/2010/20100301.html>, Mar. 1, 2010, 2 pages, F5 Networks, Inc. Seattle and Santa Clara, California.

"F5 Solutions Enable Government Organizations to Meet 2009 DNSSEC Compliance,"<http://www.f5.com/news-press-events/press/2009/20091207.html>, Dec. 7, 2009, 2 pages, F5 Networks, Inc., Seattle, California.

Higgins, Kelly Jackson, "Internet Infrastructure Reaches Long-Awaited Security Milestone," Tech Center: Security Services, <http://www.darkreading.com/securityservices/securtiy/management/showArticle.jhtml?article>, Jul. 28, 2010. pp. 1-4.

Macvittie, Lori, "It's DNSSEC Not DNSSUX," DevCentral>Weblogs, <http://devcentral.f5.com/weblogs/macvittie/archive/2009/11/18/itrsquos-dnssec-notdnssux.aspx>, posted on Nov. 18, 2009, accessed on Jul. 6, 2010, pp. 3-7.

Meyer et al., "F5 and Infoblox DNS Integrated Architecture: Offering a Complete Scalable, Secure DNS Solution, "F5 Technical Brief, Feb. 2, 2010, 18 pages, URL: http://web.archive.prg/web/20100326145019/http://www.f5.com/pdf/white-papers/infoblox-wp.pdf.

Weiler et al., "Minimally Covering NSEC Records and DNSSEC On-line Signing, "Network Working Group, RFC 4470, Apr. 2006, 8 pages, The Internet Society.

"Who is Xelerance," <http://www.xelerance.com>, slides 1-6 (2007).

"A Process for Selective Routing of Servlet Content to Transcoding Modules," Research Disclosure 422124, Jun. 1999, pp. 889-890, IBM Corporation.

"A Storage Architecture Guide," Second Edition, 2001, Auspex Systems, Inc., www.auspex.com, last accessed on Dec. 30, 2002.

"BIG-IP® Global Traffic Manager," <http://www.f5.com/products/big-ip/product-modules/global-traffic-manager.html>, last accessed Jul. 6, 2010, 2 pages.

"CSA Persistent File System Technology," A White Paper, Jan. 1, 1999, p. 1-3, http://www.cosoa.com/white_papers/pfs.php, Colorado Software Architecture, Inc.

"Detail Requirement Report: RQ-GTM-0000024," <http://fpweb/fptopic.asp?REQ=RQ-GTM-0000024>, F5 Networks, Inc., 1999, printed Mar. 31, 2010, 2 pages.

"Detail Requirement Report: RQ-GTM-0000028," <http://fpweb/fptopic.asp?REQ=RQ-GTM-0000028>, F5 Networks, Inc., 1999, printed Mar. 31, 2010, 2 pages.

"Diameter MBLB Support Phase 2: Generic Message Based Load Balancing (GMBLB)", last accessed Mar. 29, 2010, pp. 1-10, (http://peterpan.f5net.com/twiki/bin/view/TMOS/TMOSDiameterMBLB).

"Distributed File System: A Logical View of Physical Storage: White Paper," 1999, Microsoft Corp., www.microsoft.com, <http://

(56) **References Cited**

OTHER PUBLICATIONS

www.eu.microsoft.com/TechNet/prodtechnol/windows2000serv/maintain/DFSnt95>, pp. 1-26, last accessed on Dec. 20, 2002.
"DNSSEC Functional Spec," TMOSDnsSECFS<Tmos<TWiki, last accessed on Mar. 31, 2010, pp. 1-10.
"DNSX; DNSX Secure Signer; DNSSEC Management Solution," <http://www.xelerance.com/dnssec>.pp. 1-9, Aug. 2009.
"F5 Solutions Enable Government Organizations to Meet 2009 DNSSEC Compliance," .<http://www.f5.com/news-press-events/press/2009/20091207.html>, Dec. 7, 2009, 2 pages, F5 Networks, Inc., Seattle, California.
"Market Research & Releases, CMPP PoC documentation", last accessed Mar. 29, 2010, (http://mainstreet/sites/PD/Teams/ProdMgmt/MarketResearch/Universal).
"Market Research & Releases, Solstice Diameter Requirements", last accessed Mar. 29, 2010, (http://mainstreet/sites/PD/Teams/Prod/Mgmt/MarketResearch/Unisversal).
"NERSC Tutorials: I/O on the Cray T3E, 'Chapter 8, Disk Striping'," National Energy Research Scientific Computing Center (NERSC), http://hpcfnersc.gov, last accessed on Dec. 27, 2002.
"Respond to Server Depending on TCP::Client_Port", DevCentral Forums iRules, pp. 1-6, last accessed Mar. 26, 2010, (http://devcentral.f5.com/Default/aspx?tabid=53&forumid=5&tpage=1&v).
"Scaling Next Generation Web Infrastructure with Content-Intelligent Switching: White Paper," Apr. 2000, p. 1-9 Alteon Web Systems, Inc.
"Secure64 DNS Signer", <http://www.secure64.com>, Data sheet, Jun. 22, 2011, V.3.1., 2 pages.
"Servlet/Applet/HTML Authentication Process With Single Sign-On," Research Disclosure 429128, Jan. 2000, pp. 163-164, IBM Corporation.
"The AFS File System in Distributed Computing Environment," www.transarc.ibm.com/Library/whitepapers/AFS/afsoverview.html, last accessed on Dec. 20, 2002.
"Traffic Surges; Surge Queue; Netscaler Defense," 2005, PowerPoint Presentation, slides 1-12, Citrix Systems, Inc.
"UDDI Overview", Sep. 6, 2000, pp. 1-21, uddi.org, (http://www.uddi.org/).
"UDDI Technical White Paper," Sep. 6, 2000, pp. 1-12, uddi-org, (http://www.uddi.org/).
"UDDI Version 3.0.1", UDDI Spec Technical Committee Specification, Oct. 14, 2003, pp. 1-383, uddi.org, (http://www.uddi.org/).
"Veritas SANPoint Foundation Suite(tm) and SANPoint Foundation Suite(tm) HA: New Veritas Volume Management and File System Technology for Cluster Environments," Sep. 2001, Veritas Software Corp.
"Who is Xelerance," <http://www.xelerance.com>, slides 1-6.
"Windows Clustering Technologies —An Overview," Nov. 2001, Microsoft Corp., www.microsoft.com, last accessed on Dec. 30, 2002.
"Windows Server 2003 Kerberos Extensions," Microsoft TechNet, 2003 (Updated Jul. 31, 2004), http://technet.microsoft.com/en-us/library/cc738207, Microsoft Corporation.
Abad, C., et al., "An Analysis on the Schemes for Detecting and Preventing ARP Cache Poisoning Attacks", IEEE, Computer Society, 27th International Conference on Distributed Computing Systems Workshops (ICDCSW'07), 2007, pp. 1-8.
Aguilera, Marcos K. et al., "Improving recoverability in multi-tier storage systems," International Conference on Dependable Systems and Networks (DSN-2007), Jun. 2007, 10 pages, Edinburgh, Scotland.
Anderson et al., "Serverless Network File System," in the 15th Symposium on Operating Systems Principles, Dec. 1995, Association for Computing Machinery, Inc. (18 pages).
Anderson, Darrell C. et al., "Interposed Request Routing for Scalable Network Storage," ACM Transactions on Computer Systems 20(1): (Feb. 2002), pp. 1-24.
Anonymous, "How DFS Works: Remote File Systems," Distributed File System (DFS) Technical Reference, retrieved from the Internet on Feb. 13, 2009: URL<:http://technetmicrosoft.com/en-us/library/cc782417WS.10,printer).aspx> (Mar. 2003).
Apple, Inc., "Mac OS X Tiger Keynote Intro. Part 2," Jun. 2004, www.youtube.com <http://www.youtube.com/watch?v=zSBJwEmRJbY>, p. 1.
Apple, Inc., "Tiger Developer Overview Series: Working with Spotlight," Nov. 23, 2004, www.apple.com using www.archive.org <http://web.archive.org/web/20041123005335/developer.apple.com/macosx/tiger/spotlight.html>, pp. 1-6.
Arends et al., "DNS Security Introduction and Requirements", Network Working Group, RFC 4033, Mar. 2005, pp. 1-20.
Arends et al., "Protocol Modifications for the DNS Security Extensions," Network Working Group, RFC 4035, Mar. 1, 2005, 54 pages, The Internet Society.
Arends et al., "Resource Records for the DNS Security Extensions", Network Working Group, RFC 4034, Mar. 2005, pp. 1-28.
Aura T., "Cryptographically Generated Addresses (CGA)", Network Working Group, RFC 3972, Mar. 2005, pp. 1-21.
Baer, T., et al., "The Elements of Web Services" ADTmag.com, Dec. 1, 2002, pp. 1-6, (http://www.adtmag.com).
Bagnulo et al., "DNS 64: DNS extensions for Network Address Translation from IPv6 Clients to IPv4 Servers," Internet draft, Jul. 2010, pp. 1-31, IETF Trust.
Basney et al., "Credential Wallets: A Classification of Credential Repositories Highlighting MyProxy," Sep. 19-21, 2003, pp. 1-20, 31st Research Conference on Communication, Information and Internet Policy (TPRC 2003), Arlington, Virginia.
Bau et al., "A Security Evaluation of DNSEC with NSEC3," Mar. 2, 2010; updated version corrects and supersedes a paper in the NDSS' 10 proceedings, pp. 1-18.
BIG-IP® Access Policy Manager®: Implementations, Version 12.0, F5 Networks, Inc., 2015, pp. 1-108.
Blue Coat, "Technology Primer: CIFS Protocol Optimization," Blue Coat Systems Inc., 2007, pp. 1-3, (http://www.bluecoat.com).
Botzum, Keys, "Single Sign On—A Contrarian View," Aug. 6, 2001, pp. 1-8, Open Group Website, http://www.opengroup.org/security/topics.htm.
Cabrera et al., "Swift: A Storage Architecture for Large Objects," In Proceedings of the-Eleventh IEEE Symposium on Mass Storage Systems, Oct. 1991, pp. 123-128.
Cabrera et al., "Swift: Using Distributed Disk Striping to Provide High I/O Data Rates," Fall 1991, pp. 405-436, vol. 4, No. 4, Computing Systems.
Cabrera et al., "Using Data Striping in a Local Area Network," 1992, technical report No. UCSC-CRL-92-09 of the Computer & Information Sciences Department of University of California at Santa Cruz.
Callaghan et al., "NFS Version 3 Protocol Specifications" (RFC 1813), Jun. 1995, The Internet Engineering Task Force (IETN), www.ietf.org, last accessed on Dec. 30, 2002.
Carns et al., "PVFS: A Parallel File System for Linux Clusters," in Proceedings of the Extreme Linux Track: 4th Annual Linux Showcase and Conference, Oct. 2000, pp. 317-327, Atlanta, Georgia, USENIX Association.
Cavale, M. R., "Introducing Microsoft Cluster Service (MSCS) in the Windows Server 2003", Microsoft Corporation, Nov. 2002.
Crescendo Networks, "Application Layer Processing (ALP)," 2003-2009, pp. 168-186, Chapter 9, CN-5000E/5500E, Foxit Software Company.
Dan Kaminsky, (slideshow presentation) "Black Ops of Fundamental Defense: Introducing the Domain Key Infrastructure", retrieved from Internet URL: http://www.slideshare.net/RecursionVentures/dki-2, (slides 1-116) (Aug. 2010).
English Translation of Notification of Reason(s) for Refusal for JP 2002-556371 (Dispatch Date: Jan. 22, 2007).
F5 Networks Inc., "3-DNS® Reference Guide, version 4.5", F5 Networks Inc., Sep. 2002, pp. 2-1-2-8, 3-1-3-12, 5-1-5-24, Seattle, Washington.
F5 Networks Inc., "Big-IP® Reference Guide, version 4.5", F5 Networks Inc., Sep. 2002, pp. 11-1-11-32, Seattle, Washington.
F5 Networks Inc., "Case Information Log for 'Issues with BoNY upgrade to 4.3'", as early as Feb. 2008.

(56) **References Cited**

OTHER PUBLICATIONS

F5 Networks Inc., "Configuration Guide for Local Traffic Management", F5 Networks Inc., Jan. 2006, version 9.2.2, 406 pgs.
F5 Networks Inc., "Deploying the BIG-IP LTM for Diameter Traffic Management" F5® Deployment Guide, Publication date Sep. 2010, Version 1.2, pgs. 1-19.
F5 Networks Inc., "F5 Diameter RM", Powerpoint document, Jul. 16, 2009, pp. 1-7.
F5 Networks Inc., "F5 WANJet CIFS Acceleration", White Paper, F5 Networks Inc., Mar. 2006, pp. 1-5, Seattle, Washington.
F5 Networks Inc., "Routing Global Internet Users to the Appropriate Data Center and Applications Using F5's 3-DNS Controller", F5 Networks Inc., Aug. 2001, pp. 1-4, Seattle, Washington, (http://www.f5.com/f5producs/3dns/relatedMaterials/UsingF5.html).
F5 Networks Inc., "Using F5's 3-DNS Controller to Provide High Availability Between Two or More Data Centers", F5 Networks Inc., Aug. 2001, pp. 1-4, Seattle, Washington, (http://www.f5.com/f5products/3dns/relatedMaterials/3DNSRouting.html).
F5 Networks, Inc., "BIG-IP ASM 11.2.0", Release Notes, Sep. 19, 2012, Version 11.2.0, F5 Networks, Inc.
F5 Networks, Inc., "BIG-IP Controller with Exclusive OneConnect Content Switching Feature Provides a Breakthrough System for Maximizing Server and Network Performance," Press Release, May 8, 2001, 2 pages, Las Vegas, Nevada.
F5 Networks, Inc., "BIG-IP Systems: Getting Started Guide," Manual 0300-00, Feb. 4, 2010, pp. 1-102, version 10.1, F5 Networks, Inc.
F5 Networks, Inc., "BIG-IP® Access Policy Manager®: Application Access," version 12.1, published May 9, 2016 (66 pages).
F5 Networks, Inc., "BIG-IP® Access Policy Manager®: Authentication and Single Sign-On," version 12.1, published May 9, 2016 (332 pages).
F5 Networks, Inc., "BIG-IP® Access Policy Manager®: Implementations," version 12.1, published May 9, 2016 (168 pages).
F5 Networks, Inc., "BIG-IP® Access Policy Manager®: Network Access," version 12.1, published May 9, 2016 (108 pages).
F5 Networks, Inc., "BIG-IP® Access Policy Manager®: Portal Access," version 12.1, published May 9, 2016 (82 pages).
F5 Networks, Inc., "BIG-IP® Access Policy Manager®: Secure Web Gateway", version 12.1, published May 9, 2016 (180 pages).
F5 Networks, Inc., "BIG-IP® Application Security Manager™: Getting Started Guide", Version 11.2, May 7, 2012, F5 Networks, Inc.
F5 Networks, Inc., "BIG-IP® Application Security Manager™: Implementations", Version 11.2, May 7, 2012, F5 Networks, Inc.
F5 Networks, Inc., "BIG-IP® TMOS®: Implementations", Manual, May 5, 2015, Version 11.2, F5 Networks, Inc.
F5 Networks, Inc., "Configuration Guide for BIG-IP® Application Security Manager™", Manual, May 7, 2012, Version 11.2, F5 Networks, Inc.
F5 Networks, Inc., "F5 TMOS Operations Guide", Manual, Mar. 5, 2015, F5 Networks, Inc.
F5 Networks, Inc., "Release Note: BIG-IP APM 12.1.0," published Jun. 6, 2016 (13 pages).
Fajardo V., "Open Diameter Software Architecture," Jun. 25, 2004, pp. 1-6, Version 1.0.7.
Fan et al., "Summary Cache: A Scalable Wide-Area Protocol", Computer Communications Review, Association Machinery, New York, USA, Oct. 1998, vol. 28, Web Cache Sharing for Computing No. 4, pp. 254-265.
Farley, M., "Building Storage Networks," Jan. 2000, McGraw Hill, ISBN 0072120509.
Fielding et al., "Hypertext Transfer Protocol—HTTP/1.1," Network Working Group, RFC: 2068, Jan. 1997, pp. 1-162.
Fielding et al., "Hypertext Transfer Protocol—HTTP/1.1," Network Working Group, RFC: 2616, Jun. 1999, pp. 1-176, The Internet Society.
Floyd et al., "Random Early Detection Gateways for Congestion Avoidance," Aug. 1993, pp. 1-22, IEEE/ACM Transactions on Networking, California.
Forrester Research, Inc., "DNSSEC Ready for Prime Time", Forrester Research, Inc. Cambridge, MA, 23 pages (Jul. 2010).
Gibson et al., "File Server Scaling with Network-Attached Secure Disks," in Proceedings of the ACM International Conference on Measurement and Modeling of Computer Systems (Sigmetrics '97), Association for Computing Machinery, Inc., Jun. 15-18, 1997.
Gibson et al., "NASD Scalable Storage Systems," Jun. 1999, USENIX99, Extreme Linux Workshop, Monterey, California.
Gupta et al., "Algorithms for Packet Classification", Computer Systems Laboratory, Stanford University, CA, Mar./Apr. 2001, pp. 1-29.
Hagino J., et al., "An IPv6-to-IPv4 Transport Relay Translator", Network Working Group, RFC 3142, Jun. 2001, pp. 1-11.
Harrison, C., May 19, 2008 response to Communication pursuant to Article 96(2) EPC dated Nov. 9, 2007 in corresponding European patent application No. 02718824.2.
Hartman, J., "The Zebra Striped Network File System," 1994, Ph.D. dissertation submitted in the Graduate Division of the University of California at Berkeley.
Haskin et al., "The Tiger Shark File System," 1996, in proceedings of IEEE, Spring Compcon, Santa Clara, CA, www.research.ibm.com, last accessed on Dec. 30, 2002.
Heinz G., "Priorities in Stream Transmission Control Protocol (SCTP) Multistreaming", Thesis submitted to the Faculty of the University of Delaware, Spring 2003, pp. 1-35.
Higgins, Kelly Jackson, "Internet Infrastructure Reaches Long-Awaited Security Milestone," Tech Center: Security Services, <http//www.darkreading.com/securityservices/security/management/showArticle.jhtml?article>, Jul. 28, 2010. pp. 1-4.
Hochmuth, Phil, "F5, CacheFlow pump up content-delivery lines," Network World Fusion, May 4, 2001, 1 page, Las Vegas, Nevada.
Howarth, Fran, "Investing in security versus facing the consequences," White Paper by Bloor Research, Sep. 2010, pp. 1-15.
Hu, J., Final Office action dated Sep. 21, 2007 for related U.S. Appl. No. 10/336,784.
Hu, J., Office action dated Feb. 6, 2007 for related U.S. Appl. No. 10/336,784.
Hwang et al., "Designing SSI Clusters with Hierarchical Checkpointing and Single 1/0 Space," IEEE Concurrency, Jan.-Mar. 1999, pp. 60-69.
Ilvesmaki M., et al., "On the Capabilities of Application Level Traffic Measurements to Differentiate and Classify Internet Traffic", Presented in SPIE's International Symposium ITcom, Aug. 19-21, 2001, pp. 1-11, Denver, Colorado.
International Search Report and Written Opinion for International Patent Application No. PCT/US2011/058469 (dated May 30, 2012).
International Search Report and Written Opinion for PCT/US2011/054331, dated Mar. 13, 2012, 13 pages.
International Search Report for International Patent Application No. PCT/US2008/083117 (dated Jun. 23, 2009).
International Search Report for International Patent Application No. PCT/US2008/060449 (dated Apr. 9, 2008).
International Search Report for International Patent Application No. PCT/US2008/064677 (dated Sep. 6, 2009).
International Search Report for International Patent Application No. PCT/US02/00720, dated Mar. 19, 2003.
International Search Report for International Patent Application No. PCT/US2012/071648 (dated May 27, 2013).
International Search Report from International Application No. PCT/US03/41202, dated Sep. 15, 2005.
Internet Protocol,"Darpa Internet Program Protocol Specification", (RFC:791), Information Sciences Institute, University of Southern California, Sep. 1981, pp. 1-49.
Karamanolis et al., "An Architecture for Scalable and Manageable File Services," HPL-2001-173, Jul. 26, 2001. p. 1-14.
Katsurashima et al., "NAS Switch: A Novel CIFS Server Virtualization, Proceedings," 20th IEEE/11th NASA Goddard Conference on Mass Storage Systems and Technologies, 2003 (MSST 2003), Apr. 2003.
Kawamoto, D., "Amazon Files for Web Services Patent", CNET News.com, Jul. 28, 2005, pp. 1-2, last accessed May 4, 2006, (http://news.com).

(56) **References Cited**

OTHER PUBLICATIONS

Kimball, C.E. et al., "Automated Client-Side Integration of Distributed Application Servers," 13Th LISA Conf., 1999, pp. 275-282 of the Proceedings.
Klayman, J., response filed by Japanese associate to office action dated Jan. 22, 2007 in corresponding Japanese patent application No. 2002-556371.
Klayman, J., Nov. 13, 2008 e-mail to Japanese associate including instructions for response to office action dated May 26, 2008 in corresponding Japanese patent application No. 2002-556371.
Klayman, J., Jul. 18, 2007 e-mail to Japanese associate including instructions for response to office action dated Jan. 22, 2007 in corresponding Japanese patent application No. 2002-556371.
Kohl et al., "The Kerberos Network Authentication Service (V5)," RFC 1510, Sep. 1993. (http://www.ietf.org/rfc/rfc1510.txt?number=1510).
Korkuzas, V., Communication pursuant to Article 96(2) EPC dated Sep. 11, 2007 in corresponding European patent application No. 02718824.2-2201.
LaMonica M., "Infravio Spiffs Up Web Services Registry Idea", CNET News.com, May 11, 2004, pp. 1-2, last accessed Sep. 20, 2004, (http://www.news.com).
Laurie et al., "DNS Security (DNSSEC) Hashed Authenticated Denial of Existence," Network Working Group, RFC 5155, Feb. 2008, pp. 1-51.
Lelil, S., "Storage Technology News: AutoVirt adds tool to help data migration projects," Feb. 25, 2011, last accessed Mar. 17, 2011, <http://searchstorage.techtarget.com/news/article/0,289142,sid5_gci1527986,00.html >.
Long et al., "Swift/RAID: A distributed RAID System", Computing Systems, Summer 1994, vol. 7, pp. 333-359.
Mac Vittie, L., "Message-Based Load Balancing: Using F5 Solutions to Address the Challenges of Scaling Diameter, RADIUS, and Message-Oriented Protocols", F5 Technical Brief, 2005, pp. 1-9, F5 Networks Inc., Seattle, Washington.
MacVittie, Lori, "It's DNSSEC Not DNSSUX," DevCentral>Weblogs, <http://devcentral.f5.com/weblogs/macvittie/archive/2009/11/18/itrsquos-dnssec-not-dnssux.aspx>, posted on Nov. 18, 2009, accessed on Jul. 6, 2010, pp. 3-7.
MacVittie, Lori, "Message-Based Load Balancing," Technical Brief, Jan. 2010, pp. 1-9, F5 Networks, Inc.
Meyer et al., "F5 and Infoblox DNS Integrated Architecture: Offering a Complete Scalable, Secure DNS Solution," F5 Technical Brief, Feb. 2, 2010, 18 pages, URL: http://web.archive.prg/web/20100326145019/http://www.f5.com/pdf/white-papers/infoblox-wp.pdf.
Modiano E., "Scheduling Algorithms for Message Transmission Over a Satellite Broadcast System", MIT Lincoln Laboratory Advanced Network Group, Nov. 1997, pp. 1-7.
Nichols K., et al., "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", (RFC:2474) Network Working Group, Dec. 1998, pp. 1-19, last accessed Oct. 8, 2012, (http://www.ietf.org/rfc/rfc2474.txt).
Noghani et al., "A Novel Approach to Reduce Latency on the Internet: 'Component-Based Download'," Proceedings of the Computing, Las Vegas, NV, Jun. 2000, pp. 1-6 on the Internet: Intl Conf. on Internet.
Norton et al., "CIFS Protocol Version CIFS-Spec 0.9," 2001, Storage Networking Industry Association (SNIA), www.snia.org, last accessed on Mar. 26, 2001.
Notice of Reasons for Rejection and Its English Translation for corresponding Japanese Patent Application No. 2014-550426 (Apr. 13, 2016) (3 pages).
Novotny et al., "An Online Credential Repository for the Grid: MyProxy," 2001, pp. 1-8.
Office Action for corresponding Chinese Application No. 201280070784.4 (dated Dec. 6, 2016) (15 pages).
Office Action for corresponding Taiwan Patent Application No. 101145417 (dated May 11, 2016) (11 pages).
Ott D., et al., "A Mechanism for TCP-Friendly Transport-level Protocol Coordination", USENIX Annual Technical Conference, 2002, University of North Carolina at Chapel Hill, pp. 1-12.
OWASP, "Testing for Cross site scripting", OWASP Testing Guide v2, Table of Contents, Feb. 24, 2011, pp. 1-5, (www.owasp.org/index.php/Testing_for_Cross_site_scripting).
Padmanabhan V., et al., "Using Predictive Prefetching to Improve World Wide Web Latency", SIGCOM, 1996, pp. 1-15.
Pashalidis et al., "A Taxonomy of Single Sign-On Systems," 2003, pp. 1-16, Royal Holloway, University of London, Egham Sunray, TW20, 0EX, United Kingdom.
Pashalidis et al., "Impostor: A Single Sign-On System for Use from Untrusted Devices," Global Telecommunications Conference, 2004, GLOBECOM '04, IEEE, Issue Date: Nov. 29-Dec. 3, 2004.Royal Holloway, University of London.
Patterson et al., "A case for redundant arrays of inexpensive disks (RAIFD)", Chicago, Illinois, Jun. 1-3, 1998, in Proceedings of ACM Sigmod conference on the Management of Data, pp. 109-116, Association for Computing Machinery, Inc., www.acm.org, last accessed on Dec. 20, 2002.
Pearson, P.K., "Fast Hashing of Variable-Length Text Strings," Comm. of the ACM, Jun. 1990, pp. 1-4, vol. 33, No. 6.
Peterson, M., "Introducing Storage Area Networks," Feb 1998, InfoStor, www.infostor.com, last accessed on Dec. 20, 2002.
Preslan et al., "Scalability and Failure Recovery in a Linux Cluster File System," in Proceedings of the 4th Annual Linux Showcase & Conference, Atlanta, Georgia, Oct. 10-14, 2000, pp. 169-180 of the Proceedings, www.usenix.org, last accessed on Dec. 20, 2002.
Response filed Jul. 6, 2007 to Office action dated Feb. 6, 2007 for related U.S. Appl. No. 10/336,784.
Response filed Mar. 20, 2008 to Final Office action dated Sep. 21, 2007 for U.S. Appl. No. 10/336,784.
Rodriguez et al., "Parallel-access for mirror sites in the Internet," InfoCom 2000. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings. IEEE Tel Aviv, Israel Mar. 26-30, 2000, Piscataway, NJ, USA, IEEE, US, Mar. 26, 2000 (Mar. 26, 2000), pp. 864-873, XP010376176 ISBN: 0-7803-5880-5 p. 867, col. 2, last paragraph—p. 868, col. 1, paragraph 1.
Rosen E., et al., "MPLS Label Stack Encoding", (RFC:3032) Network Working Group, Jan. 2001, pp. 1-22, last accessed Oct. 8, 2012, (http://www.ietf.org/rfc/rfc3032.txt).
RSYNC, "Welcome to the RSYNC Web Pages," Retrieved from the Internet URL: http://samba.anu.edu.ut.rsync/. (Retrieved on Dec. 18, 2009).
Savage, et al., "AFRAID—A Frequently Redundant Array of Independent Disks," Jan. 22-26, 1996, pp. 1-13, USENIX Technical Conference, San Diego, California.
Schaefer, Ken, "IIS and Kerberos Part 5—Protocol Transition, Constrained Delegation, S4U2S and S4U2P," Jul. 18, 2007, 21 pages, http://www.adopenstatic.com/cs/blogs/ken/archive/2007/07/19/8460.aspx.
Schilit B., "Bootstrapping Location-Enhanced Web Services", University of Washington, Dec. 4, 2003, (http://www.cs.washington.edu/news/colloq.info.html).
Seeley R., "Can Infravio Technology Revive UDDI?", ADTmag.com, Oct. 22, 2003, last accessed Sep. 30, 2004, (http://www.adtmag.com).
Shohoud, Y., "Building XML Web Services with VB.NET and VB 6", Addison Wesley, 2002, pp. 1-14.
Silva, Peter, "DNSSEC: The Antidote to DNS Cache Poisoning and Other DNS Attacks," F5 Technical Brief, 2009, pp. 1-10.
Sleeper B., "The Evolution of UDDI" UDDI.org White Paper, The Stencil Group, Inc., Jul. 19, 2002, pp. 1-15, San Francisco, California.
Sleeper B., "Why UDDI Will Succeed, Quietly: Two Factors Push Web Services Forward", The Stencil Group, Inc., Apr. 2001, pp. 1-7, San Francisco, California.
Soltis et al., "The Design and Performance of a Shared Disk File System for IRIX," Mar. 23-26, 1998, pp. 1-17, Sixth NASA Goddard Space Flight Center Conference on Mass Storage and Technologies in cooperation with the Fifteenth IEEE Symposium on Mass Storage Systems, University of Minnesota.

(56) **References Cited**

OTHER PUBLICATIONS

Soltis et al., "The Global File System," Sep. 17-19, 1996, in Proceedings of the Fifth NASA Goddard Space Flight Center Conference on Mass Storage Systems and Technologies, College Park, Maryland.
Sommers F., "Whats New in UDDI 3.0—Part 1", Web Services Papers, Jan. 27, 2003, pp. 1-4, last accessed Mar. 31, 2004, (http://www.webservices.org/index.php/articleprint/871/-1/24).
Sommers F., "Whats New in UDDI 3.0—Part 2", Web Services Papers, Mar. 2, 2003, pp. 1-8, last accessed Nov. 1, 2007, (http://www.web.archive.org/web/20040620131006/).
Sommers F., "Whats New in UDDI 3.0—Part 3", Web Services Papers, Sep. 2, 2003, pp. 1-4, last accessed Mar. 31, 2007, (http://www.webservices.org/index.php/article/articleprint/894/-1/24/).
Sorenson, K.M., "Installation and Administration: Kimberlite Cluster Version 1.1.0, Rev. Dec. 2000," Mission Critical Linux, http://oss.missioncriticallinux.corn/kimberlite/kimberlite.pdf.
Stakutis, C., "Benefits of SAN-based file system sharing," Jul. 2000, pp. 1-4, InfoStor, www.infostor.com, last accessed on Dec. 30, 2002.
Tatipamula et al., "IPv6 Integration and Coexistence Strategies for Next-Generation Networks", IEEE Communications Magazine, Jan. 2004, pp. 88-96.
Thekkath et al., "Frangipani: A Scalable Distributed File System," in Proceedings of the 16th ACM Symposium on Operating Systems Principles, Oct. 1997, pp. 114, Association for Computing Machinery, Inc.
Thomson et al., "DNS Extensions to Support IP Version 6," The Internet Society, Network Working Group, RFC 3596, Oct. 2003, pp. 1-8.
Tulloch, Mitch, "Microsoft Encyclopedia of Security," 2003, pp. 218, 300-301, Microsoft Press, Redmond, Washington.
Uesugi, H., Nov. 26, 2008 amendment filed by Japanese associate in response to office action dated May 26, 2008 in corresponding Japanese patent application No. 2002-556371.
Uesugi, H., English translation of office action dated May 26, 2008 in corresponding Japanese patent application No. 2002-556371.
Uesugi, H., Jul. 15, 2008 letter from Japanese associate reporting office action dated May 26, 2008 in corresponding Japanese patent application No. 2002-556371.
Wallace, "Delegating Identity Using X.509 Certificates", IETF Trust, Jul. 29, 2015, 8 pgs.
Wang B., "Priority and Realtime Data Transfer Over the Best-Effort Internet", Dissertation Abstract, 2005, ScholarWorks@UMASS.
Weiler et al., "Minimally Covering NSEC Records and DNSSEC On-line Signing," Network Working Group, RFC 4470, Apr. 2006, 8 pages, The Internet Society.
Wikipedia, "Diameter (protocol)", pp. 1-11, last accessed Oct. 27, 2010, (http://en.wikipedia.org/wiki/Diameter_(protocol)).
Wikipedia, "Domain Name System Security Extensions," <http://en.wikipedia.org/wiki/DNSSEC>, accessed Jun. 3, 2010, pp. 1-20.
Wikipedia, "IPv6", <http://en.wikipedia.org/wiki/IPv6>, accessed Jun. 3, 2010, 20 pages.
Wikipedia, "List of DNS record types," <http://en.wikipedia.org/wiki/List_of_DNS_record_types>, Jun. 2010, pp. 1-6.
Wilkes, J., et al., "The HP AutoRAID Hierarchical Storage System," Feb. 1996, vol. 14, No. 1, ACM Transactions on Computer Systems.
Williams et al., "Forwarding Authentication," The Ultimate Windows Server 2003 System Administrator's Guide, 2003, 2 pages, Figure 10.7, Addison-Wesley Professional, Boston, Massachusetts.
Woo T.Y.C., "A Modular Approach to Packet Classification: Algorithms and Results", Bell Laboratories, Lucent Technologies, Mar. 2000, pp. 1-10.
Xelerance, "DNSX; DNSX Secure Signer; DNSSEC Management Solution," <http://www.xelerance.com/dnssec>.pp. 1-9, Aug. 2009.
Zayas, E., "AFS-3 Programmer's Reference: Architectural Overview," Transarc Corp., version 1.0 of Sep. 2, 1991, doc. No. FS-00-D160.
Peter Silva, Securing Web Presence with DNSSEC, ISSA Preeminent Trusted Global Information Security Community, ISSA Journal, Mar. 2010), pp. 32-36.*
Carpenter, B., "Transmission of IPv6 over IPv4 Domains Without Explicit Tunnels", Network Working Group, RFC 2529, Mar. 1999, pp. 1-10.
Eastlake D., "Domain Name System Security Extensions", Network Working Group, RFC 2535, Mar. 1999, pp. 1-44.
"BIG-IP® Global Traffic Manager™ and BIG-IP Link Controller™: Implementations," Manual 0304-00, Dec. 3, 2009, pp. 1-161, version 10.1, F5 Networks, Inc.
"BIG-IP® Systems: Getting Started Guide," Manual 0300-00, Feb. 4, 2010, pp. 1-102, version 10.1, F5 Networks, Inc.
"Detail Requirement Report: RQ-GTM-0000024," <http://fpweb/fptopic.asp?REQ:RQ-GTM-0000024>, F5 Networks, Inc., 1999, printed Mar. 31, 2010, 2 pages.
"DNS DDOS Protection Functional Spec," BigipDNSDDOSProtectionFS<TMO<TWiki, last accessed Mar. 31, 2010, 2 pages.
"DNS Security (DNSSEC) Solutions," <http://www.f5.com/solutions/security/dnssec>, F5 Networks, Inc., printed Aug. 23, 2010, pp. 1-4.
"F5 and Infoblox Provide Customers with Complete DNS Security Solution," <http://www.f5.com/news-press-events/press/2010/20100301.html>, Mar. 1, 2010, 2 pages, F5 Networks, Inc., Seattle and Santa Clara, California.
"PDR/CDR for RQ-GTM-0000028," BigipDNSDDOSProtectionPDR<TMOS<TWiki, last accessed on Mar. 31, 2010, pp. 1-14.
"Secure64 DNS Signer," <www.secure64.com>, 2 pages, Apr. 2010.
Silva, Peter, "DNSSEC: The Antidote to DNS Cache Poisoning and Other DNS Attacks,"F5 Technical Brief, 2009, pp. 1-10.
"Who is Xelerance," <http://www.xelerance.com>, slides 1-6, Jul. 2007.
Bagnulo, et al., "DNS extensions for Network Address translation from IPv6 Clients to IPv4 Servers", IETF Trust (Jul. 2010).

* cited by examiner

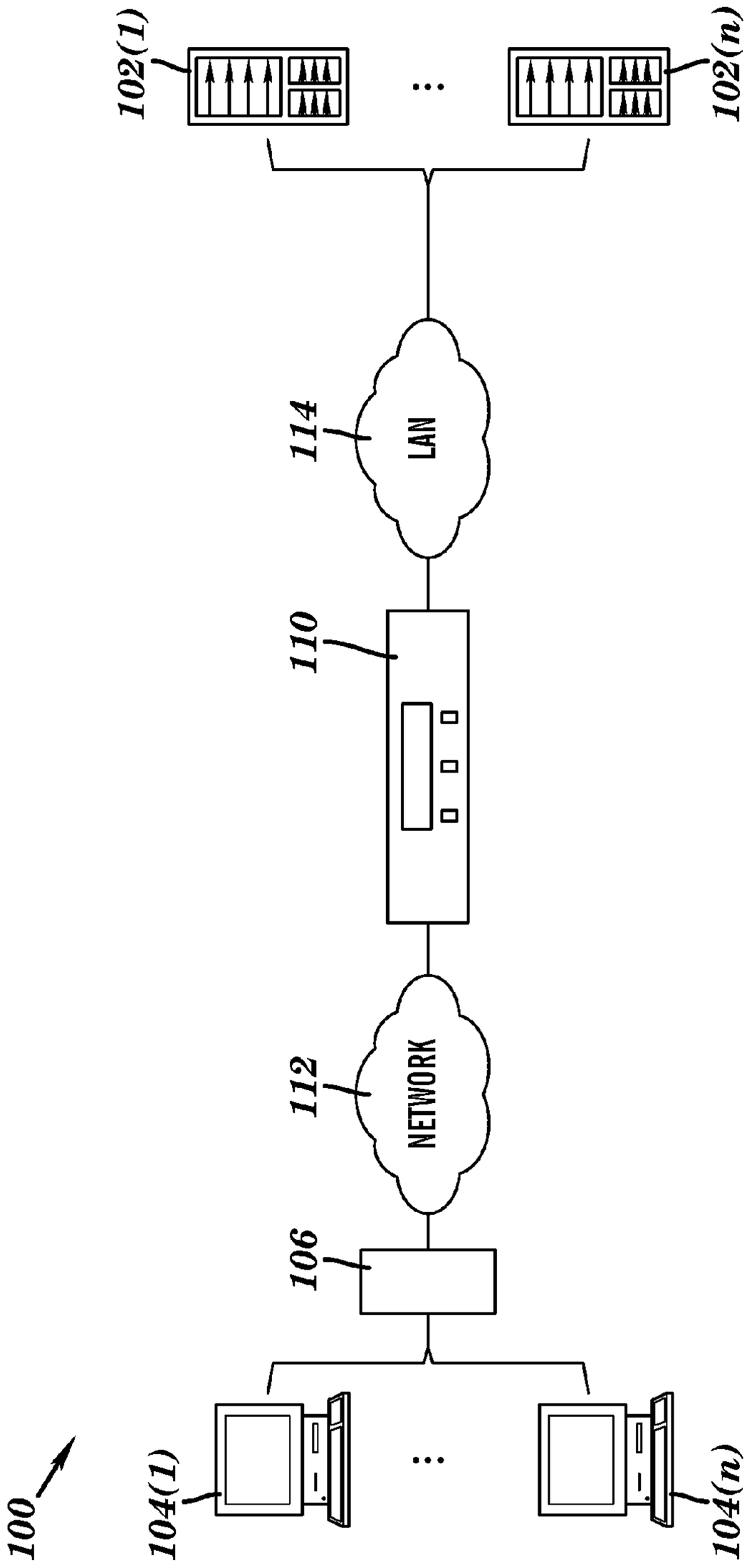


FIG. 1

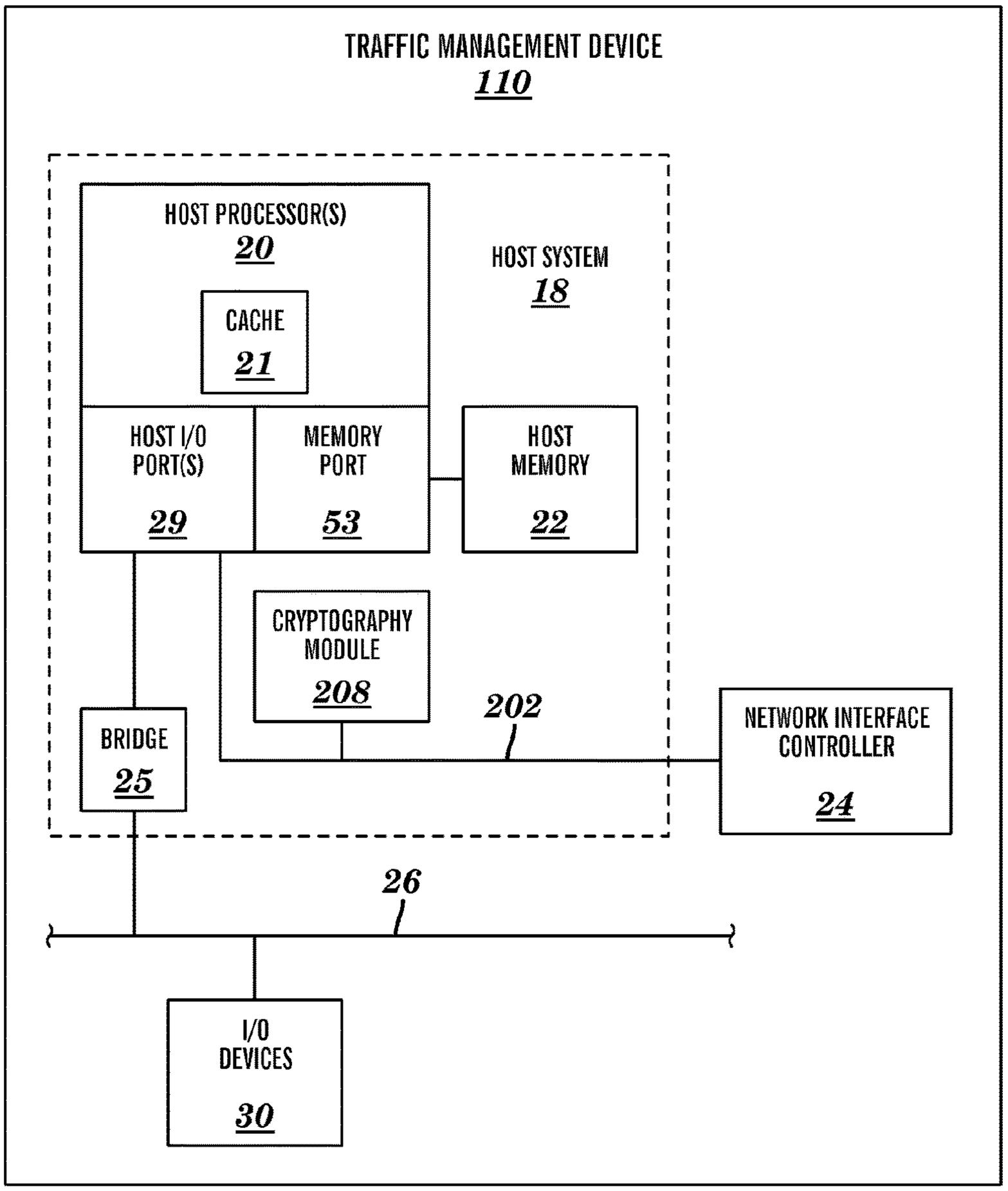

TRAFFIC MANAGEMENT DEVICE
110
HOST PROCESSOR(S)
20
CACHE
21
HOST SYSTEM
18
HOST I/O PORT(S)
29
MEMORY PORT
53
HOST MEMORY
22
CRYPTOGRAPHY MODULE
208
202
BRIDGE
25
NETWORK INTERFACE CONTROLLER
24
26
I/O DEVICES
30

FIG. 2

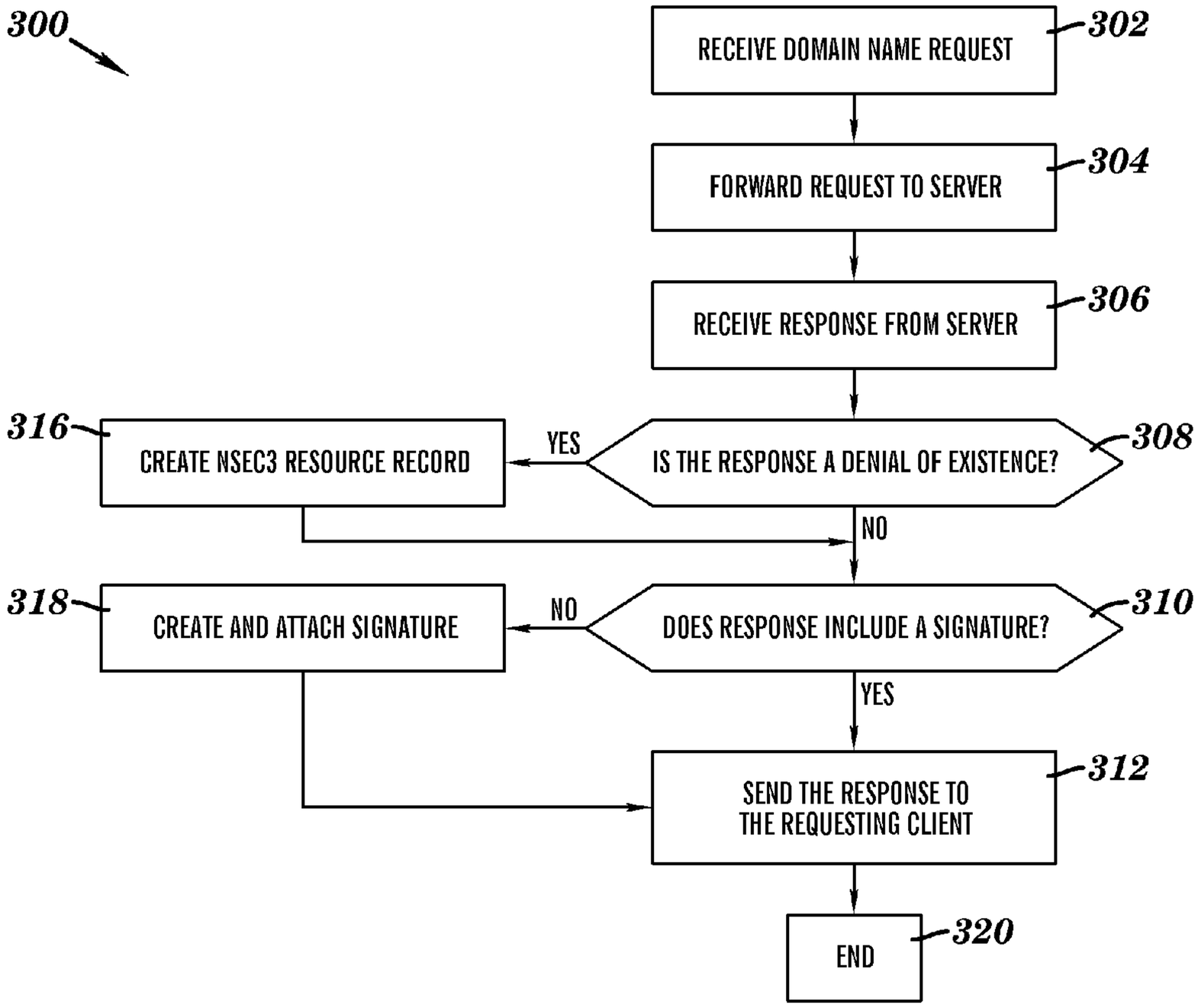

300
RECEIVE DOMAIN NAME REQUEST
302
FORWARD REQUEST TO SERVER
304
RECEIVE RESPONSE FROM SERVER
306
IS THE RESPONSE A DENIAL OF EXISTENCE?
308
YES
CREATE NSEC3 RESOURCE RECORD
316
NO
DOES RESPONSE INCLUDE A SIGNATURE?
310
NO
CREATE AND ATTACH SIGNATURE
318
YES
SEND THE RESPONSE TO THE REQUESTING CLIENT
312
END
320

FIG. 3

METHODS FOR DNSSEC PROXYING AND DEPLOYMENT AMELIORATION AND SYSTEMS THEREOF

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/836,053, filed Jul. 14, 2010, which is hereby incorporated by reference in its entirety.

TECHNOLOGICAL FIELD

This technology generally relates to securing network applications, and more particularly, to systems and methods for Domain Name System Security Extensions (DNSSEC) proxying and deployment amelioration.

BACKGROUND

Global Internet Domain Name System, also referred to as the Domain Name System (DNS), defines a tree of names starting with root, ".", immediately below which are top level domain names such as ".com" and ".us". Below top level domain names there are normally additional levels of names. Domain Name System (DNS) was invented as a technology for enabling humans to identify computers, services, and resources connected to a network (e.g., Internet) by corresponding names rather than network addresses (e.g., Internet Protocol (IP) addresses) in a number format. DNS translates human readable names into unique binary information of network devices to enable users to find the devices they need. Unfortunately, conventional DNS is not secure and is highly prone to malicious interception. The insecure nature of DNS has been known to cause substantial loss of privacy, data, and identity theft, among many other problems. For example, one of the ways in which DNS can be exploited is called DNS cache poisoning. When a client device inputs a Uniform Resource Locator (URL) into a client browser, a DNS resolver checks the Internet for the proper name/number translation and location. Typically, DNS will accept the first response or answer obtained without question and direct the client device to the site referred to in the response. The server receiving the DNS response will also cache that information for a period of time until it expires, so upon the next request for that name/number, the site is immediately delivered to the requesting client device. Since users at client devices assume they are getting the correct information, when a malicious system responds to the DNS query first with modified, false information, security of the client device is breached. Not only does that single computer get sent to the wrong place, but if the malicious server is answering for a service provider, then thousands of users can get sent to a rogue system. This misdirection of a URL request can last for hours to days, depending on how long the server stores the information, and all the other DNS servers that propagate the information can also be affected. The imminent dangers posed by a rogue site include delivering malware, committing fraud, and stealing personal or sensitive information.

To overcome some of the drawbacks of conventional DNS systems, Domain Name System Security Extensions (DNSSEC) were introduced as an attempt to add security to DNS while maintaining the backward compatibility needed to scale with the Internet as a whole. DNSSEC adds a digital signature to ensure the authenticity of certain types of DNS transactions and, therefore, the integrity of the information. DNSSEC is a series of DNS protocol extensions, described in Request for Comments (RFCs) 4033, 4034, and 4035, hereby incorporated by reference in their entireties, that ensures the integrity of data returned by domain name lookups by incorporating a chain of trust into the DNS hierarchy. The chain is built using public key infrastructure (PKI), with each link in the chain consisting of a public/private key pair. Deploying DNSSEC involves signing zones with public/private key encryption and returning DNS responses with signatures. A client's trust in the signatures is based on the chain of trust established across administrative boundaries, from parent to child zone, using a Domain Name System Key (DNSKEY) and delegation signer (DS) resource records, which were not defined in DNS specifications. In DNSSEC, since an unbroken chain of trust is established from the root at the top through the top-level domain (TLD) and down to individual registrants, the client device's answer always receives an authenticated response. All zones are authenticated by "signing," in that a publisher of a zone signs that zone prior to publication, and the parent of that zone publishes the keys of that zone. With millions of zones, it is likely that the keys expire before the DNS records are updated. As a result, zone operators require techniques to automatically allocate keys to DNS records before these keys expire. Unfortunately, conventional systems are unable to handle management of keys for DNSSEC. Further, conventional DNS systems are unable to translate non-DNSSEC responses to DNSSEC responses.

Furthermore, conventional network systems are unable to handle DNSSEC signatures when zone names are dynamically updated. For example, consider a zone name that was previously signed statically. Subsequently, when the zone name is updated or changed, the DNSSEC signature for the earlier version of the zone is rendered invalid, and since the new zone is unsigned, there is no method for conventional systems to automatically enable DNSSEC for the dynamic update to the zone in real time.

In another related scenario, for global server load balancing (GSLB)-type DNS responses in which the Internet Protocol (IP) answer in a response to a request from a client device can change depending on the requesting client device, conventional systems are unable to provide DNSSEC for such dynamically changing domain names while at the same time performing global load balancing. Since GSLB can provide different answers to different clients for the same domain name, GSLB and DNSSEC are fundamentally at odds in the original design specifications. DNSSEC, as originally conceived, was focused solely on traditional static DNS and never considered the requirements of GSLB, or intelligent DNS. Unfortunately it is difficult for conventional systems to provide DNSSEC for dynamic DNS, and to provide DNSSEC for GSLB-type DNS responses in a load balancing scenario where there might be two different answers for the same request and the GSLB has to forward a signed response to the client device.

SUMMARY

One example of the technology is a method for providing authenticated domain name service. The method includes

forwarding at a traffic management device a request for a domain name from a client device to one or more servers coupled to the traffic management device. The traffic management device receives a first response comprising at least a portion of the domain name from the one or more servers. The traffic management device attaches a first signature to the first response when the first response is determined by the traffic management device to be an unauthenticated response, and provides the first response with the first signature to the client device.

Another example includes a computer readable medium having stored thereon instructions for providing authenticated domain name service, which when executed by at least one processor, causes the processor to perform a number of steps. The steps include forwarding at a traffic management device a request for a domain name from a client device to one or more servers coupled to the traffic management device. The traffic management device receives a first response comprising at least a portion of the domain name from the one or more servers. The traffic management device attaches a first signature to the first response when the first response is determined by the traffic management device to be an unauthenticated response, and provides the first response with the first signature to the client device.

Another example is that of a traffic management device, which includes one or more processors executing one or more traffic management applications, a memory coupled to the one or more processors by a bus, a network interface controller coupled to the one or more processors and the memory and configured to receive data packets from a network that relate to the executing traffic management applications, and provide authenticated domain name service. In this example, at least one of the one or more processors is configured to execute programmed instructions stored in the memory and the network interface controller including logic capable of being further configured to implement forwarding at a traffic management device a request for a domain name from a client device to one or more servers coupled to the traffic management device. The traffic management device receives a first response comprising at least a portion of the domain name from the one or more servers. The traffic management device attaches a first signature to the first response when the first response is determined by the traffic management device to be an unauthenticated response, and provides the first response with the first signature to the client device.

The examples offer numerous advantages. By way of example only, technology disclosed enables signing DNS responses in real time and deploying DNSSEC quickly and easily in an existing network environment, thereby ensuring that answers to domain name requests received by the client devices when asking for name resolution come from a trusted name server, and not a hacker. The examples support Federal Information Processing Standard (FIPS) storage of the private keys, and are able to securely synchronize the keys between multiple FIPS devices. Additionally, examples of the disclosed technology use a cryptographic module or storage chip on a motherboard of a traffic management device to secure a unique hardware key as part of the multi-layer encryption process. When a response from a non-DNSSEC server is returned, the response is signed in real time to ensure continuous signing. The potential attacker cannot forge the signed response without the corresponding private key.

Further, the examples enable compliance with federal DNSSEC mandates and help protect valuable domain names and web properties from rogue servers sending invalid responses. Furthermore, the examples of the technology enable global server load balancing (GSLB)-type DNSSEC responses in which the IP answer can change depending on the requesting client by signing answers at the time the traffic management device (with load balancing functionality) decides what the answer to a request should be. These and other advantages, aspects, and features will become more apparent from the following detailed description when viewed in conjunction with the accompanying drawings. Non-limiting and non-exhaustive examples are described with reference to the following drawings. Accordingly, the drawings and descriptions below are to be regarded as illustrative in nature, and not as restrictive or limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an exemplary network system environment using traffic management device for DNSSEC proxying and deployment amelioration;

FIG. **2** is a partly schematic and partly functional block diagram of traffic management device in the exemplary network environment of FIG. **1**; and

FIG. **3** is a flow chart of an exemplary process and method for DNSSEC proxying and deployment amelioration when a DNSSEC request is to be serviced using non-DNSSEC server devices.

DETAILED DESCRIPTION

Various examples of the technology disclosed enable a traffic management device **110** to handle mismatches between non-DNSSEC and DNSSEC environments. For example, client devices operating in a DNSSEC environment need to communicate with servers operating in a non-DNSSEC environment. Traffic management device **110** provides secure conversion from one environment to another and prevents malicious "man-in-the-middle" attacks.

Referring to FIG. **1**, an exemplary network system **100** including traffic management device **110** that is configured to provide authenticated domain name service, for example, to requesting client computers **104**(**1**) to **104**(n) is illustrated. By way of example only, a network **112** can provide responses and requests according to the Hyper-Text Transfer Protocol (HTTP) based application, request for comments (RFC) document guidelines or the Common Internet File System (CIFS) or network file system (NFS) protocol in this example, although the principles discussed herein are not limited to these examples and can include other application protocols and other types of requests (e.g., File Transfer Protocol (FTP) based requests). The exemplary network system **100** can include a series of one or more client devices such as client computers **104**(**1**) to **104**(n). Client computers **104**(**1**)-**104**(n) are coupled to traffic management device **110** via a local domain name server (LDNS) **106**. In some examples, LDNS **106** is optional and client computers **104**(**1**)-**104**(n) are coupled to traffic management device **110** directly or via a network **112**. Traffic management device **110** is interposed in between servers **102**(**1**) to **102**(n) and the client devices **104**(**1**) to **104**(n) for providing one or more communication channels through network **112** and a Local Area Network (LAN) **114**, although other communication channels may be directly established between various devices in network system **100** without network **112** and/or LAN **114**. For clarity and brevity, in FIG. **1** two server devices **102**(**1**) and **102**(n) are shown, but it should be understood that any number of server devices can use the exemplary network system **100**. Likewise, two client

devices **104**(**1**)-**104**(n), one LDNS **106**, and one traffic management device **110** are shown in FIG. **1**, but any number of client devices, LDNSs, and traffic management devices can also use the exemplary network system **100** as well. Although network **112** and LAN **114** are shown, other numbers and types of networks could be used. The ellipses and the designation "n" denote an unlimited number of server devices and client devices, respectively.

Servers **102**(**1**)-**102**(n) comprise one or more server computing machines or devices capable of operating one or more Web-based applications that may be accessed by network devices in the network **112**, such as client computers **104**(**1**)-**104**(n) (also referred to as client devices **104**(**1**)-**104**(n)), via traffic management device **110**, and may provide other data representing requested resources, such as domain name services and zones, particular Web page(s) corresponding to URL request(s), image(s) of physical objects, and any other objects, responsive to the requests, although the servers **102**(**1**)-**102**(n) may perform other tasks and provide other types of resources. It should be noted that while only two servers **102**(**1**) and **102**(n) are shown in the network system **100** depicted in FIG. **1**, other numbers and types of servers may be coupled to the traffic management device **110**. It is also contemplated that one or more of the servers **102**(**1**)-**102**(n) may be a cluster of servers managed by a network traffic management device such as traffic management device **110**. In one example, servers **102**(**1**)-**102**(n) are DNS servers in a DNS environment. In another example, servers **102**(**1**)-**102**(n) are DNSSEC servers in a DNSSEC environment. In yet another example, servers **102**(**1**)-**102**(n) are a mix of DNS and DNSSEC servers, as can be understood by those of ordinary skill in the art upon reading this disclosure. In some examples, servers **102**(**1**)-**102**(n) are Berkeley Internet Name Domain (BIND) servers.

The client computers **104**(**1**)-**104**(n) in this example (also interchangeably referred to as client devices **104**(**1**)-**104**(n), client computing devices **104**(**1**)-**104**(n), clients **104**(**1**)-**104**(n), and client computing systems **104**(**1**)-**104**(n)) can run interface applications such as Web browsers that can provide an interface to make requests for and send data, including DNS and DNSSEC requests, to different Web server-based applications via LDNS **106** connected to the network **112** and/or via traffic management device **110**. A series of network applications can run on the servers **102**(**1**)-**102**(n) that allow the transmission of data that is requested by the client computers **104**(**1**)-**104**(n). Servers **102**(**1**)-**102**(n) can provide data or receive data in response to requests directed toward the respective applications on the servers **102**(**1**)-**102**(n) from the client computers **104**(**1**)-**104**(n). For example, as per the Transmission Control Protocol (TCP), packets can be sent to the servers **102**(**1**)-**102**(n) from the requesting client computers **104**(**1**)-**104**(n) to send data, although other protocols (e.g., FTP) may be used. It is to be understood that the servers **102**(**1**)-**102**(n) can be hardware or software executing on and supported by hardware, or can represent a system with multiple servers, which can include internal or external networks. Servers **102**(**1**)-**102**(n) can be domain name servers with DNS capabilities hosting one or more website zones. Alternatively, servers **102**(**1**)-**102**(n) can be DNSSEC servers in a DNSSEC environment hosting one or more website zones. For example, the servers **102**(**1**)-**102**(n) can be any BIND version of Microsoft Domain Controllers provided by Microsoft Corporation of Redmond, Wash., although other types of servers can be used. Further, additional servers can be coupled to the network **112** and/or LAN **114** and many different types of applications can be available on servers coupled to the network **112** and/or LAN **114**.

Generally, the client devices such as the client computers **104**(**1**)-**104**(n) can include virtually any computing device capable of connecting to another computing device to send and receive information, including Web-based information. The set of such devices can include devices that typically connect using a wired (and/or wireless) communications medium, such as personal computers (e.g., desktops, laptops), mobile and/or smart phones and the like. In this example, the client devices can run browsers and other types of applications (e.g., web-based applications) that can provide an interface to make one or more requests to different server-based applications via network **112**, although requests for other types of network applications and resources, for example URLs, may be made by client computers **104**(**1**)-**104**(n). Client computers **104**(**1**)-**104**(n) can be configured to make DNSSEC and non-DNSSEC requests to servers **102**(**1**)-**102**(n), or other types of traffic management devices (e.g., routers, load balancers, application delivery controllers, and the like).

Client computers **104**(**1**)-**104**(n) can submit requests to LDNS **106**. LDNS **106** can respond to the requests when resources are locally stored on LDNS **106**, for example, in a local cache memory. For example, a client computer may request for a URL www.example.com. If LDNS **106** has a valid copy of www.example.com, it can directly provide this URL to the requesting client computer. In other scenarios, LDNS **106** forwards the requests to traffic management device **110** via network **112**. LDNS **106** can be configured to expedite requests for network resources (e.g., URLs) based upon a history of requests from one or more client computers **104**(**1**)-**104**(n). In one example, LDNS **106** can provide an initial response to a requesting one of client computers **104**(**1**)-**104**(n) while additional resources are being fetched from severs **102**(**1**)-**102**(n) resulting in a faster initial response for a request from client computers **104**(**1**)-**104**(n). By way of example only, LDNS **106** can be a proxy server, or a server similar to servers **102**(**1**)-**102**(n) but located between client computers **104**(**1**)-**104**(n) and traffic management device **110**.

A series of Web-based and/or other types of protected and unprotected network applications can run on servers **102**(**1**)-**102**(n) that allow the transmission of data that is requested by the client computers **104**(**1**)-**104**(n). The client computers **104**(**1**)-**104**(n) can be further configured to engage in a secure communication directly with the traffic management device **110** and/or the servers **102**(**1**)-**102**(n), via LDNS **106**, or otherwise, using mechanisms such as Secure Sockets Layer (SSL), Internet Protocol Security (IPSec), Transport Layer Security (TLS), and the like.

In this example, network **112** comprises a publicly accessible network, such as the Internet, which includes client computers **104**(**1**)-**104**(n), although network **112** may comprise other types of private and public networks that include other devices. Communications, such as requests from client computers **104**(**1**)-**104**(n) and responses from servers **102**(**1**)-**102**(n), take place over network **112** according to standard network protocols, such as the HTTP and TCP/IP protocols in this example, but the principles discussed herein are not limited to this example and can include other protocols (e.g., FTP). Further, network **112** can include local area networks (LANs), wide area networks (WANs), direct connections, other types and numbers of network types, and any combination thereof. On an interconnected set of LANs or other networks, including those based on different archi-

tectures and protocols, routers, switches, hubs, gateways, bridges, crossbars, and other intermediate network devices may act as links within and between LANs and other networks to enable messages and other data to be sent from and to network devices. Also, communication links within and between LANs and other networks typically include twisted wire pair (e.g., Ethernet), coaxial cable, analog telephone lines, full or fractional dedicated digital lines including T1, T2, T3, and T4, Integrated Services Digital Networks (ISDNs), Digital Subscriber Lines (DSLs), wireless links including satellite links, optical fibers, and other communications links known to those of ordinary skill in the relevant arts. Generally, network **112** includes any communication medium and method by which data may travel between client devices **104**(**1**)-**104**(n), servers **102**(**1**)-**102**(n), and traffic management device **110**, and these devices are provided by way of example only.

In this example, each of the servers **102**(**1**)-**102**(n), traffic management device **110**, LDNS **106**, and client computers **104**(**1**)-**104**(n) can include a central processing unit (CPU), controller or processor, a memory, and an interface system which are coupled together by a bus or other link, although other numbers and types of each of the components and other configurations and locations for the components can be used. Since these devices are well known to those of ordinary skill in the relevant art(s), they will not be described in further detail herein.

In addition, two or more computing systems or devices can be substituted for any one of the systems in the network system **100**. Accordingly, principles and advantages of cloud computing and/or distributed processing, such as redundancy, replication, virtualization, and the like, can also be implemented, as appropriate, to increase the robustness and performance of the devices and systems of the network system **100**. The network system **100** can also be implemented on a computer system or systems that extend across any network environment using any suitable interface mechanisms and communications technologies including, for example telecommunications in any suitable form (e.g., voice, modem, and the like), Public Switched Telephone Network (PSTNs), Packet Data Networks (PDNs), the Internet, intranets, combination(s) thereof, and the like.

By way of example only and not by way of limitation, LAN **114** comprises a private local area network that includes the traffic management device **110** coupled to the one or more servers **102**(**1**)-**102**(n), although the LAN **114** may comprise other types of private and public networks with other devices. Networks, including local area networks, besides being understood by those of ordinary skill in the relevant art(s), have already been described above in connection with network **112**, and thus will not be described further here.

As shown in the example environment of network system **100** depicted in FIG. **1**, the traffic management device **110** can be interposed between the network **112** and the servers **102**(**1**)-**102**(n) coupled via LAN **114** as shown in FIG. **1**. Again, the network system **100** could be arranged in other manners with other numbers and types of devices. Also, the traffic management device **110** is coupled to network **112** by one or more network communication links, and intermediate network devices, such as routers, switches, gateways, hubs, crossbars, and other devices. It should be understood that the devices and the particular configuration shown in FIG. **1** are provided for exemplary purposes only and thus are not limiting. Although a single traffic management device **110**, additional traffic management devices may be coupled in series and/or parallel to the traffic management device **110**, thereby forming a cluster, depending upon specific applications, and the single traffic management device **110** shown in FIG. **1** is by way of example only, and not by way of limitation.

Generally, the traffic management device **110** manages network communications, which may include one or more client requests and server responses, to/from the network **112** between the client computers **104**(**1**)-**104**(n) and one or more of the servers **102**(**1**)-**102**(n) in LAN **114** in these examples. These requests may be destined for one or more servers **102**(**1**)-**102**(n), and, as alluded to earlier, may take the form of one or more TCP/IP data packets originating from the network **112**, passing through one or more intermediate network devices and/or intermediate networks, until ultimately reaching the traffic management device **110**, for example.

In one example, traffic management device **110** is configured as a global server load balancing device that distributes end-user application requests based on business policies, data center conditions, network conditions, user location, and application performance, such that each request from client computers **104**(**1**)-**104**(n) is automatically directed to the closest or best-performing data center hosting one or more servers **102**(**1**)-**102**(n). In this example, traffic management device **110** provides DNSSEC signed responses even when zone names have been dynamically updated. Although in this example, traffic management device **110** has global server load balancing capabilities, in alternative examples traffic management device **110** may receive responses from a global server load balancing (GSLB) device coupled to LAN **114**. By way of example only, such a global load balancing device can be a BIG-IP® Global Traffic Manager™ provided by F5 Networks, Inc., of Seattle, Wash.

In addition, as discussed in more detail with reference to FIGS. **2**-**3**, traffic management device **110** is configured to provide authenticated domain name service. In any case, the traffic management device **110** may manage the network communications by performing several network traffic management related functions involving network communications, secured or unsecured, such as load balancing, access control, VPN hosting, network traffic acceleration, encryption, decryption, cookie, and key management and providing authenticated domain name service in accordance with the systems and processes described further below in connection with FIGS. **2**-**3**, for example.

Referring to FIG. **2**, an exemplary traffic management device **110** is illustrated. Included within the traffic management device **110** is a system bus **26** (also referred to as bus **26**) that communicates with a host system **18** via a bridge **25** and with an input-output (I/O) device **30**. In this example, a single I/O device **30** is shown to represent any number of I/O devices connected to bus **26**. In one example, bridge **25** is in further communication with a host processor **20** via host input output (I/O) ports **29**. Host processor **20** can further communicate with a network interface controller **24** via a CPU bus **202**, a host memory **22** (via a memory port **53**), and a cache memory **21**. As outlined above, included within the host processor **20** are host I/O ports **29**, memory port **53**, and a main processor (not shown separately). In this example, host system **18** includes a cryptography module **208**.

In one example, traffic management device **110** can include the host processor **20** characterized by anyone of the following component configurations: computer readable medium and logic circuits that respond to and process instructions fetched from the host memory **22**; a microprocessor unit, such as: those manufactured by Intel Corpora-

tion of Santa Clara, Calif.; those manufactured by Motorola Corporation of Schaumburg, Ill.; those manufactured by Transmeta Corporation of Santa Clara, Calif.; the RS/6000 processor such as those manufactured by International Business Machines of Armonk, N.Y.; a processor such as those manufactured by Advanced Micro Devices of Sunnyvale, Calif.; or any other combination of logic circuits capable of executing the systems and methods described herein. Still other examples of the host processor **20** can include any combination of the following: a microprocessor, a microcontroller, a central processing unit with a single processing core, a central processing unit with two processing cores, or a central processing unit with more than one processing core.

Examples of the traffic management device **110** include one or more application delivery controller devices of the BIG-IP® product family provided by F5 Networks, Inc. of Seattle, Wash., although other types of traffic management devices may be used. In an exemplary structure and/or arrangement, traffic management device **110** can include the host processor **20** that communicates with cache memory **21** via a secondary bus also known as a backside bus, while another example of the traffic management device **110** includes the host processor **20** that communicates with cache memory **21** via the system bus **26**. The local system bus **26** can, in some examples, also be used by the host processor **20** to communicate with more than one type of I/O devices **30**. In some examples, the local system bus **26** can be anyone of the following types of buses: a VESA VL bus; an ISA bus; an EISA bus; a Micro Channel Architecture (MCA) bus; a PCI bus; a PCI-X bus; a PCI-Express bus; or a NuBus. Other example configurations of the traffic management device **110** include I/O device **30** that is a video display (not shown separately) that communicates with the host processor **20** via an Advanced Graphics Port (AGP). Still other versions of the traffic management device **110** include host processor **20** connected to I/O device **30** via any one or more of the following connections: HyperTransport, Rapid I/O, or InfiniBand. Further examples of the traffic management device **110** include a communication connection where the host processor **20** communicates with one I/O device **30** using a local interconnect bus and with a second I/O device (not shown separately) using a direct connection. As described above, included within some examples of the traffic management device **110** is each of host memory **22** and cache memory **21**. The cache memory **21**, will, in some examples, be any one of the following types of memory: SRAM; BSRAM; or EDRAM. Other examples include cache memory **21** and host memory **22** that can be anyone of the following types of memory: Static random access memory (SRAM), Burst SRAM or SynchBurst SRAM (BSRAM), Dynamic random access memory (DRAM), Fast Page Mode DRAM (FPM DRAM), Enhanced DRAM (EDRAM), Extended Data Output RAM (EDO RAM), Extended Data Output DRAM (EDO DRAM), Burst Extended Data Output DRAM (BEDO DRAM), Enhanced DRAM (EDRAM), synchronous DRAM (SDRAM), JEDECSRAM, PCIOO SDRAM, Double Data Rate SDRAM (DDR SDRAM), Enhanced SDRAM (ESDRAM), SyncLink DRAM (SLDRAM), Direct Rambus DRAM (DRDRAM), Ferroelectric RAM (FRAM), or any other type of memory device capable of executing the systems and methods described herein.

The host memory **22** and/or the cache memory **21** can, in some examples, include one or more memory devices capable of storing data and allowing any storage location to be directly accessed by the host processor **20**. Such storage of data can be in a local database internal to traffic management device **110**, or external to traffic management device **110** coupled via one or more input output ports of network interface controller **24**. Further examples of traffic management device **110** include a host processor **20** that can access the host memory **22** via one of either: system bus **26**; memory port **53**; or any other connection, bus or port that allows the host processor **20** to access host memory **22**.

One example of the traffic management device **110** provides support for anyone of the following installation devices: a floppy disk drive for receiving floppy disks such as 3.5-inch, 5.25-inch disks or ZIP disks, a CD-ROM drive, a CD-R/RW drive, a DVD-ROM drive, tape drives of various formats, USB device, a bootable medium, a bootable CD, a bootable compact disk (CD) for GNU/Linux distribution such as KNOPPIX®, a hard-drive or any other device suitable for installing applications or software. Applications can, in some examples, include a client agent, or any portion of a client agent. The traffic management device **110** may further include a storage device (not shown separately) that can be either one or more hard disk drives, or one or more redundant arrays of independent disks; where the storage device is configured to store an operating system, software, programs applications, or at least a portion of the client agent. A further example of the traffic management device **110** includes an installation device that is used as the storage device.

Furthermore, the traffic management device **110** can include network interface controller **24** to communicate, via an input-output port inside network interface controller **24**, with a Local Area Network (LAN), Wide Area Network (WAN) or the Internet through a variety of connections including, but not limited to, standard telephone lines, LAN or WAN links (e.g., 802.11, T1, T3, 56 kb, X.25, SNA, DECNET), broadband connections (e.g., ISDN, Frame Relay, ATM, Gigabit Ethernet, Ethernet-over-SONET), wireless connections, optical connections, or some combination of any or all of the above. Connections can also be established using a variety of communication protocols (e.g., TCP/IP, IPX, SPX, NetBIOS, Ethernet, ARCNET, SONET, SDH, Fiber Distributed Data Interface (FDDI), RS232, RS485, IEEE 802.11, IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, CDMA, GSM, WiMax and direct asynchronous connections). One version of the traffic management device **110** includes network interface controller **24** configured to communicate with additional computing devices via any type and/or form of gateway or tunneling protocol such as Secure Socket Layer (SSL) or Transport Layer Security (TLS), or the Citrix Gateway Protocol manufactured by Citrix Systems, Inc. of Fort Lauderdale, Fla. Versions of the network interface controller **24** can comprise anyone of: a built-in network adapter; a network interface card; a PCMCIA network card; a card bus network adapter; a wireless network adapter; a USB network adapter; a modem; or any other device suitable for interfacing the traffic management device **110** to a network capable of communicating and performing the methods and systems described herein.

In various examples, the traffic management device **110** can include any one of the following I/O devices **30**: a keyboard; a pointing device; a mouse; a gesture based remote control device; a biometric device; an audio device; track pads; an optical pen; trackballs; microphones; drawing tablets; video displays; speakers; inkjet printers; laser printers; and dye sublimation printers; or any other input/output device able to perform the methods and systems described herein. Host I/O ports **29** may in some examples connect to multiple I/O devices **30** to control the one or more I/O

devices **30**. Some examples of the I/O devices **30** may be configured to provide storage or an installation medium, while others may provide a universal serial bus (USB) interface for receiving USB storage devices such as the USB Flash Drive line of devices manufactured by Twintech Industry, Inc. Still other examples of an I/O device **30** may be bridge **25** between the system bus **26** and an external communication bus, such as: a USB bus; an Apple Desktop Bus; an RS-232 serial connection; a SCSI bus; a FireWire bus; a FireWire **800** bus; an Ethernet bus; an AppleTalk bus; a Gigabit Ethernet bus; an Asynchronous Transfer Mode bus; a HIPPI bus; a Super HIPPI bus; a SerialPlus bus; a SCI/LAMP bus; a FibreChannel bus; or a Serial Attached small computer system interface bus.

According to some examples, traffic management device **110** includes cryptography module **208** integrated as part of host system **18** for carrying out various exemplary functions of storing private and public keys. Alternatively, cryptography module **208** may be a part of an autonomous application security manager module integrated with or communicating independently with the traffic management device **110**. An exemplary application security manager is the BIG-IP® Application Security Manager™ provided by F5 Networks, Inc. of Seattle, Wash. In one example, cryptography module **208** includes a crypto-storage chip on the motherboard to secure one or more unique hardware keys as part of the multi-layer encryption process employed by traffic management device **110** to secure keys.

Accordingly, components of traffic management device **110** include one or more processors (e.g., host processor **20**) executing one or more traffic management applications, memory (e.g., cache memory **21**, and/or host memory **22**) coupled to the one or more processors by a bus, network interface controller **24** coupled to the one or more processors and the host memory **22** and configured to receive data packets from a network that relate to the executing traffic management applications, and provide authenticated domain name service. In this example, at least one of the one or more processors is configured to execute programmed instructions stored in the memory (e.g., cache memory **21**, and/or host memory **22**) and the network interface controller **24** including logic capable of being further configured to implement forwarding at traffic management device **110** a request for a domain name from a client device (e.g., one or more of client computers **104**(**1**)-**104**(n)) to one or more servers (e.g., servers **102**(**1**)-**102**(n)) coupled to traffic management device **110**. The traffic management device **110** receives a first response comprising at least a portion of the domain name from the one or more servers **102**(**1**)-**102**(n). The traffic management device **110** attaches a first signature to the first response when the first response is determined by the traffic management device **110** to be an unauthenticated response, and provides the first response with the first signature to the client device (e.g., one or more of client computers **104**(**1**)-**104**(n)).

The operation of example processes for providing authenticated domain name service using traffic management device **110** shown in FIGS. **1-2**, will now be described with reference back to FIGS. **1-2** in conjunction with flow diagram or flowchart **300** shown in FIG. **3**, respectively. The flowchart **300** is representative of example machine readable instructions for implementing in dynamic real-time authenticated domain name service, for example, at the traffic management device **110**. In this example, the machine readable instructions comprise an algorithm for execution by: (a) a processor (e.g., host processor **20**), (b) a controller, and/or (c) one or more other suitable processing device(s) within host system **18**, for example. The algorithm may be implemented in software stored on tangible computer readable media such as, for example, a flash memory, a CD-ROM, a floppy disk, a hard drive, a digital video (versatile) disk (DVD), or other memory devices, but persons of ordinary skill in the art will readily appreciate that the entire algorithm and/or parts thereof could alternatively be executed by a device other than a processor and/or implemented in firmware or dedicated hardware in a well known manner (e.g., it may be implemented by an application specific integrated circuit (ASIC), a programmable logic device (PLD), a field programmable logic device (FPLD), a field programmable gate array (FPGA), discrete logic, or the like). For example, at least some of the components of the traffic management device **110** could be implemented by software, hardware, and/or firmware. Also, some or all of the machine readable instructions represented by the process of flowchart **300** of FIG. **3** may be implemented manually at the traffic management device **110**, for example, using a command line interface (CLI) prompt window operated by a system administrator. Further, although the example algorithm is described with reference to flowchart **300**, persons of ordinary skill in the art will readily appreciate that many other methods of implementing the example machine readable instructions may alternatively be used. For example, the order of execution of the blocks in flowchart **300** may be changed, and/or some of the blocks described may be changed, eliminated, or combined.

Referring now to FIG. **3**, flowchart **300** discusses a scenario where responses received from servers **102**(**1**)-**102**(n) are not signed. It is to be noted servers **102**(**1**)-**102**(n) may be able to sign some responses but are unable to sign some other responses, depending upon the request from client computers **104**(**1**)-**104**(n).

In step **302** of the flowchart **300**, traffic management device **110** receives a request from one of client computers **104**(**1**)-**104**(n). In this example, the request from the client computers **104**(**1**)-**104**(n) can be a DNSSEC request for an address record (also referred to as an 'A' record) that requires a signed response, or an authenticated response from one or more servers **102**(**1**)-**102**(n). In this example, servers **102**(**1**)-**102**(n) may not be able to provide an authenticated response to the request since the servers **102**(**1**)-**102**(n) are in a conventional DNS only environment. By way of example only, the request can include a URL for a website www.example.com, where "." is the root, ".com" is a top-level domain, and ".example" is a second level domain, and so on, as can be understood by those of ordinary skill in the art. Further by way of example only and not by way of limitation, other types of top-level domains such as ".gov," ".org," ".net," and/or country specific domains (e.g., ".us") may be a part of the request from client computers **104**(**1**)-**104**(n). The request from one of the client computers **104**(**1**)-**104**(n) can come via LDNS **106**, which may or may not have a cached copy of the requested resource for providing an initial response to the request. It is to be noted that the requests can be originating from anywhere around the earth, and are not geographically or otherwise restricted in their origin.

In step **304**, traffic management device **110** forwards the received request to one of the servers **102**(**1**)-**102**(n) after removing bits and/or headers to convert the request into a regular DNS request that can be understood by servers **102**(**1**)-**102**(n). Although in this example servers **102**(**1**)-**102**(n) are not DNSSEC enabled, they are still on a trusted network (e.g., on LAN **114**).

In step **306**, traffic management device **110** receives a response from one of servers **102**(**1**)-**102**(n). In one example, the response includes a resource record set (RRSET) including one or more address records. The RRSET includes all the records of a given type for a given domain included in the original request, as known to those of ordinary skill in the art. In this example, the response can be for the root ".". Alternatively, the response can be for the top level domain ".com" and/or second level domain ".example". The response can include a plurality of responses in succession starting from the root, which is the highest level, to the lowest level domain, and can therefore comprise building a chain of trust for signing response received from servers **102**(**1**)-**102**(n). For example, each of the responses from servers **102**(**1**)-**102**(n) for root, top level, and second level domains, can be respectively analyzed for a signature, determined by the traffic management device **110** (e.g., in step **310** below). In the example of FIG. **3**, since servers **102**(**1**)-**102**(n) are regular DNS servers that are authoritative for the requested zone but do not have the capability to sign, the responses for root, top level, and second level domains will not be signed responses. As a result, the response received from servers **102**(**1**)-**102**(n) in this example will not be DNSSEC compliant. For example, in one scenario a requested domain name, e.g., www.example.com, will not have a signature attached to it when received by the traffic management device **110**. In another scenario, there will be dynamic updates to www.example.com records. In this scenario, a previously authenticated response forwarded by the traffic management device **110** to the requesting one of client computers **104**(**1**)-**104**(n) will no more have a valid signature, and will need to be signed again at the traffic management device **110**, as discussed below for step **318**.

In step **308**, traffic management device **110** determines whether the received response from one of the servers **102**(**1**)-**102**(n) is a denial of existence response for the requested resource. Denial of existence can occur, for example, when the original request from the client computers **104**(**1**)-**104**(n) is for a non-existent domain name. Alternatively, a denial of existence response may be received when one or more data records within a zone does not exist. For example, the name www.example.com may exist but an address record (or, 'A' record) at www.example.com may not exist and result in a denial of existence response from servers **102**(**1**)-**102**(n). Since A records are well known to those of ordinary skill in the art, they will not be described in detail here. If the received response from one of the servers **102**(**1**)-**102**(n) is a denial of existence, the flow proceeds to step **316**, and if not, the flow proceeds to step **310**.

In step **316**, when the traffic management device **110** determines the received response from one of the servers **102**(**1**)-**102**(n) is a denial of existence response, traffic management device **110** creates one or more next secure (NSEC3) resource records belonging to a cryptographically hashed domain name. Since NSEC3 resource records are known to those of ordinary skill in the art, they will not be described in detail here. In one example, traffic management device **110** dynamically manufactures the NSEC3 resource record based upon the request from the client, with no knowledge of the actual content of the relevant zone on domain name servers **102**(**1**)-**102**(n), such that the manufactured NSEC3 resource record can be used by the client to prove non-existence of the requested name. In another example, traffic management device **110** may dynamically manufacture the NSEC3 resource record based upon the request from the client with some knowledge of the actual content of the relevant zone on domain name servers **102**(**1**)-**102**(n). In yet another example, traffic management device **110** may dynamically manufacture the NSEC3 resource record based upon the request from the client with complete knowledge of the actual content of the relevant zone on domain name servers **102**(**1**)-**102**(n). By way of example only, creating the NSEC3 resource record includes utilizing one of Secure Hash Algorithms (SHAs), although other types of hashing algorithms may be used. In this example, resource records created by traffic management device **110** as a response to a denial of existence of original resource from servers **102**(**1**)-**102**(n) are trusted by client computers **104**(**1**)-**104**(n), since traffic management device **110** itself is a trusted device for client computers **104**(**1**)-**104**(n). Signatures to the created zone are then attached by traffic management device **110** as described in step **318** below.

One example of how the NSEC3 resource record is created by traffic management device **110** is by taking the requested non-existent name, say www.example.com and performing hashing using one of the DNSSEC specified secure hashing algorithms (e.g., SHA1) prior to sending the response to the requesting one of the client computers **104**(**1**)-**104**(n). Assuming, by way of example only and not by way of limitation, the resulting hash is equal to "12345". The requesting one of client computers **104**(**1**)-**104**(n) may need a "spanning" NSEC3 record for its proof of non-existence (i.e., the closest enclose proof as disclosed in RFC 5155), or it may need a "matching" NSEC3 record (i.e., the exact enclose proof as also disclosed in RFC 5155). For a spanning record, this example would take the hashed name "12345" and perform, for example, a "+1" or "−1" on the number the hash represents. Accordingly, in this case two numbers "12344" and "12346" are generated. These new hash values would span the original hashed non-existent name and would be used to create a spanning NSEC3 record at traffic management device **110**. Similarly, for a matching record, two hash values are required, however, only the "+1" is created and paired with the original name by traffic management device **110**, resulting in an NSEC3 record containing "12345" and "12346". It is to be noted that although in the examples above "+/−1" values were used, any increment method, for example "+/−N" where N is an integer, may be used and the "+/−1" is only an illustrative example and is not limiting. Additionally, this example represents a method to manufacture an NSEC3 resource record at traffic management device **110** in substantially real-time upon receipt of the response in step **306** with no knowledge of the actual set of names in the zone. As discussed above, additional scenarios where traffic management device **110** may have some or complete knowledge of contents of the zone may use this example for generating NSEC3 records. Since spanning and matching records are known to those of ordinary skill in the art, and are disclosed in RFC 5155 hereby incorporated by reference in its entirety, the will not be described in detail herein.

In step **310**, traffic management device **110** determines if the response received from one of the servers **102**(**1**)-**102**(n) was a DNSSEC response that included signatures for a top level domain, a second level domain, a sub-level domain, and/or all levels of the domain name. This determination can be made by the traffic management device **110** by checking whether or not the received response from servers **102**(**1**)-**102**(n) includes a resource record signature (RRSIG), although other methods of determining may be used. Since RRSIG records that were introduced as a part of DNSSEC are known to those of ordinary skill in the art, they will not

be described in detail here. If the received response includes an RRSIG, the flow proceeds to step **314**. If not, the traffic management device **110** determines the response is unauthenticated, and the flow proceeds to step **318**.

In step **318**, traffic management device **110** dynamically in real-time generates one or more cryptographic signatures (e.g., RRSIG records) and attaches the signatures to the response received from one or more servers **102**(**1**)-**102**(n). Attaching the signature can be performed in one or more of the following exemplary ways, although other ways of attaching signatures "on the fly" may be contemplated by those of ordinary skill in the art after reading this disclosure. For attaching a signature, traffic management device **110** is configured to allocate zone signing keys (ZSKs) and Key Signing Keys (KSKs) for the received response from servers **102**(**1**)-**102**(n). In this example, KSKs are used to sign other DNSKEY records, while ZSKs are used to sign all resource record sets (RRSETs). By way of example only, both KSKs and ZSKs can be made stronger by using more bits in the key material, and for security reasons, can be rotated at different time intervals (e.g., KSK every 12 months and the ZSK every one to two months). The public key infrastructure enables client computers **104**(**1**)-**104**(n) to validate the integrity of the response received from non-DNSSEC servers **102**(**1**)-**102**(n) signed with the private key. Since the private key of the public/private key pair could be used to impersonate a valid signer, those keys are kept secure, by way of example only, by storing them as hardware keys in cryptography module **208**. By way of example only, cryptography module **208** supports FIPS storage of the private keys. Additionally, traffic management device **110** is configured to securely synchronize the keys between multiple FIPS devices, e.g., multiple traffic management devices. In one example, cryptography module **208** includes a crypto-storage chip on the motherboard to secure a unique hardware key as part of the multi-layer encryption process employed by traffic management device **110** to secure KSKs and ZSKs. Alternatively, KSKs and ZSKs may be secured, by way of example only and not by way of limitation, using secure SSL-encrypted storage systems. Accordingly, traffic management device **110** encrypts the response using the one or more keys, as discussed above.

In step **312**, traffic management device **110** forwards the response with the signature, along with a public key to the requesting one of the client computers **104**(**1**)-**104**(n). Since traffic management device **110** signs the response from servers **102**(**1**)-**102**(n) and client computers **104**(**1**)-**104**(n) trust the traffic management device **110**, client computers **104**(**1**)-**104**(n) can use the DNSKEY to validate the RRSET using RRSIG included in the forwarded response from traffic management device **110**. The flow ends in step **320**.

Example Use Case

In one exemplary global server load balancing (GSLB)-type scenario, traffic management device **110** configured as a load balancing device can provide responses that can change depending on the requesting client out of client computers **104**(**1**)-**104**(n). Alternatively, traffic management device **110** may receive responses routed from a global load balancer connected to LAN **114**. For example, for a request www.example.com, traffic management device **110** may receive two different responses—one from a server **102**(**1**) and another from a server **102**(**2**). Out of the two responses, it is possible that the response from server **102**(**1**) may be the only one that is signed and the response from server **102**(**2**) may not be signed. However, the response from server **102**(**2**) might be the most current updated response with updated resource records. In such a scenario, traffic management device **110** will sign the response from server **102**(**2**) according to the steps of flowchart **300**, and forward the signed response to the client computers **104**(**1**)-**104**(n), instead of sending the older signed response from server **102**(**1**)-**102**(n).

Servers **102**(**1**)-**102**(n) have DNS entries that are statically signed. Each time a DNS entry is updated, signatures associated with the DNS entries become outdated and those DNS entries have to be signed again either manually or offline. A change to a DNS entry means a change to an IP address that the DNS entry is translated into. Therefore, for updates to DNS entries, traffic management device **110** signs or authenticates the new responses including updated IP addresses, and performs load balancing based on the new signed IP addresses, while discarding the outdated or older IP addresses (and hence, older DNS entries).

The examples of the technology described herein provide numerous advantages. For example, when client computers **104**(**1**)-**104**(n) are in a DNSSEC environment requiring authenticated responses, examples disclosed herein enable such client computers **104**(**1**)-**104**(n) to communicate with non-DNSSEC servers **102**(**1**)-**102**(n) on a real time basis without any upgrades to software on client computers **104**(**1**)-**104**(n). Such dynamic "on-the-fly" authentication performed by traffic management device **110** when servers **102**(**1**)-**102**(n) are unable to sign the responses, ensure that the client computers **104**(**1**)-**104**(n) receive valid resource records that are from a trusted source, and not from a rogue server or site. The technology described also enables administrators of large non-DNSSEC DNS deployments to quickly become DNSSEC compliant by interposing traffic management device **110** according to the examples disclosed in such legacy deployments resulting in an easy and fast DNSSEC compliance solution.

Having thus described the basic concepts, it will be rather apparent to those skilled in the art that the foregoing detailed disclosure is intended to be presented by way of example only and is not limiting. Various alterations, improvements, and modifications will occur and are intended to those skilled in the art, though not expressly stated herein. The order that the measures and processes for providing secure application delivery are implemented can also be altered. Furthermore, multiple networks in addition to network **112** and LAN **114** could be associated with traffic management device **110** from/to which network packets can be received/transmitted, respectively. These alterations, improvements, and modifications are intended to be suggested by this disclosure, and are within the spirit and scope of the examples. Additionally, the recited order of processing elements or sequences, or the use of numbers, letters, or other designations therefore, is not intended to limit the claimed processes and methods to any order except as can be specified in the claims.

What is claimed is:

1. A method for providing authenticated domain name service comprising:

forwarding at a traffic management device a domain name system security extension (DNSSEC) type request for a domain name received from a client device to one or more domain name system (DNS) servers;

receiving at the traffic management device a response for at least a portion of the domain name from the one or more servers, wherein the one or more servers are not domain name system security extension (DNSSEC) compliant;

creating at the traffic management device a resource record when the response is determined to be a denial of existence response for the requested domain name;

generating at the traffic management device a signature and signing the response or the resource record using the signature; and

sending at the traffic management device the signed resource record or response to the client device in response to the request.

2. The method as set forth in claim **1**, wherein the one or more servers are authoritative for a zone associated with the at least a portion of the domain name.

3. The method as set forth in claim **1**, wherein the signing further comprises encrypting the response or the resource record using a stored private key, the method further comprising performing at the traffic management device a hash of the encrypted response or resource record prior to the sending.

4. The method as set forth in claim **1**, wherein the at least a portion of the domain name comprises a top-level domain name that is known to be authenticated.

5. The method as set forth in claim **1**, wherein at least one of the first or second server is authoritative for a zone associated with the at least a portion of the domain name.

6. A non-transitory computer readable medium having stored thereon instructions for providing authenticated domain name service comprising machine executable code which when executed by at least one processor, causes the processor to perform steps comprising:

forwarding a domain name system security extension (DNSSEC) type request for a domain name received from a client device to one or more domain name system (DNS) servers;

receiving a response for at least a portion of the domain name from the one or more servers, wherein the one or more servers are not domain name system security extension (DNSSEC) compliant;

creating a resource record when the response is determined to be a denial of existence response for the requested domain name;

generating a signature and signing the response or the resource record using the signature; and

sending the signed resource record or response to the client device in response to the request.

7. The medium as set forth in claim **6**, wherein the one or more servers are authoritative for a zone associated with the at least a portion of the domain name.

8. The medium as set forth in claim **6**, wherein the signing further comprises encrypting the response or the resource record using a stored private key, the medium further having stored thereon instructions comprising machine executable code which when executed by the at least one processor causes the processor to perform steps further comprising performing a hash of the encrypted response or resource record prior to the sending.

9. The medium as set forth in claim **6**, wherein the at least a portion of the domain name comprises a top-level domain name that is known to be authenticated.

10. A traffic management device comprising:

at least one processor; and

a memory coupled to the at least one processor which is configured to be capable of executing programmed instructions stored in the memory to perform steps comprising:

forwarding a domain name system security extension (DNSSEC) type request for a domain name received from a client device to one or more domain name system (DNS) servers;

receiving a response for at least a portion of the domain name from the one or more servers, wherein the one or more servers are not domain name system security extension (DNSSEC) compliant;

creating a resource record when the response is determined to be a denial of existence response for the requested domain name;

generating a signature and signing the response or the resource record using the signature; and

sending the signed resource record or response to the client device in response to the request.

11. The device as set forth in claim **10**, wherein the one or more servers are authoritative for a zone associated with the at least a portion of the domain name.

12. The device as set forth in claim **10**, wherein the signing further comprises encrypting the response or the resource record using a stored private key, the at least one processor further configured to be capable of executing programmed instructions stored in the memory to perform steps further comprising performing a hash of the encrypted first response or resource record prior to the sending.

13. The device as set forth in claim **10**, wherein the at least a portion of the domain name comprises a top-level domain name that is known to be authenticated.

14. A method for providing authenticated domain name service comprising:

forwarding at a traffic management device a domain name system security extension (DNSSEC) type request for a domain name received from a client device to a global server load balancer coupled to at least first domain name system (DNS) server that is not DNSSEC compliant and a second DNS server that is DNSSEC compliant;

receiving at the traffic management device first and second responses for at least a portion of the domain name from the global server load balancer, wherein the first response is from the first server and the second response is from the second server;

generating at the traffic management device a signature and signing the first response using the signature when the first response is determined to be more current than the second response; and

sending at the traffic management device the signed first response to the client device in response to the request.

15. The method as set forth in claim **1**, wherein the first and second responses are denial of existence responses and the method further comprises:

creating at the traffic management device a resource record;

generating at the traffic management device a signature and signing the first or second response or the resource record using the signature; and

sending at the traffic management device the signed resource record or first or second response to the client device in response to the request.

16. The method as set forth in claim **15**, wherein the signing further comprises encrypting the first or second response or the resource record using a stored private key, the method further comprising performing at the traffic management device a hash of the encrypted first or second response or resource record prior to the sending.

17. A non-transitory computer readable medium having stored thereon instructions for providing authenticated

domain name service comprising machine executable code which when executed by at least one processor, causes the processor to perform steps comprising:

forwarding a domain name system security extension (DNSSEC) type request for a domain name received from a client device to a global server load balancer coupled to at least first domain name system (DNS) server that is not DNSSEC compliant and a second DNS server that is DNSSEC compliant;

receiving first and second responses for at least a portion of the domain name from the global server load balancer, wherein the first response is from the first server and the second response is from the second server;

generating a signature and signing the first response using the signature when the first response is determined to be more current than the second response; and

sending the signed first response to the client device in response to the request.

18. The medium as set forth in claim **17**, wherein the first and second responses are denial of existence responses and the medium further has stored thereon instructions comprising machine executable code which when executed by the at least one processor causes the processor to perform steps further comprising:

creating at the traffic management device a resource record;

generating at the traffic management device a signature and signing the first or second response or the resource record using the signature; and

sending at the traffic management device the signed resource record or first or second response to the client device in response to the request.

19. The medium as set forth in claim **18**, wherein the signing further comprises encrypting the first or second response or the resource record using a stored private key, the medium further having stored thereon instructions comprising machine executable code which when executed by the at least one processor causes the processor to perform steps further comprising performing a hash of the encrypted first or second response or resource record prior to the sending.

20. The medium as set forth in claim **17**, wherein at least one of the first or second server is authoritative for a zone associated with the at least a portion of the domain name.

21. A traffic management device comprising:

at least one processor; and

a memory coupled to the at least one processor which is configured to be capable of executing programmed instructions stored in the memory to perform steps comprising:

forwarding a domain name system security extension (DNSSEC) type request for a domain name received from a client device to a global server load balancer coupled to at least first domain name system (DNS) server that is not DNSSEC compliant and a second DNS server that is DNSSEC compliant;

receiving first and second responses for at least a portion of the domain name from the global server load balancer, wherein the first response is from the first server and the second response is from the second server;

generating a signature and signing the first response using the signature when the first response is determined to be more current than the second response; and

sending the signed first response to the client device in response to the request.

22. The device as set forth in claim **21**, wherein the first and second responses are denial of existence responses and the at least one processor is further configured to be capable of executing programmed instructions stored in the memory to perform steps further comprising:

creating at the traffic management device a resource record;

generating at the traffic management device a signature and signing the first or second response or the resource record using the signature; and

sending at the traffic management device the signed resource record or first or second response to the client device in response to the request.

23. The device as set forth in claim **22**, wherein the signing further comprises encrypting the first or second response or the resource record using a stored private key, the at least one processor further configured to be capable of executing programmed instructions stored in the memory to perform steps further comprising performing a hash of the encrypted first or second response or resource record prior to the sending.

24. The device as set forth in claim **21**, wherein at least one of the first or second server is authoritative for a zone associated with the at least a portion of the domain name.

25. A non-transitory computer readable medium having stored thereon instructions for providing authenticated domain name service comprising machine executable code which when executed by at least one processor, causes the processor to:

receive a domain name system security extension (DNSSEC) request for a domain name from a DNSSEC compliant computing device;

generate a domain name system (DNS) request corresponding to the DNSSEC request for the domain name;

send the DNS request for the domain name to one or more DNS servers that are not DNSSEC compliant;

receive a DNS compliant response for at least a portion of the domain name from the one or more DNS servers;

create a signed resource record that is DNSSEC compliant when the DNS compliant response from the one or more DNS servers is a denial of existence response for the requested domain name; and

send the signed resource record to the requesting DNSSEC compliant computing device.

26. The medium as set forth in claim 25, wherein the DNS servers are authoritative for a zone associated with the at least a portion of the domain name.

27. The medium as set forth in claim 25, wherein the executable code, when executed by the processor, further causes the processor to:

encrypt the signed resource record using a stored private key; and

perform a hash of the encrypted signed resource record prior to sending the signed resource record to the requesting DNSSEC compliant computing device.

28. The medium as set forth in claim 25, wherein the at least a portion of the domain name comprises a top-level domain name that is known to be authenticated.

29. A method for providing authenticated domain name service implemented by a system comprising one or more network traffic management devices, one or more servers, or one or more clients, the method comprising:

receiving a domain name system security extension (DNSSEC) request for a domain name from a DNSSEC compliant computing device;

generating a domain name system (DNS) request corresponding to the DNSSEC request for the domain name;

sending the DNS request for the domain name to one or more DNS servers that are not DNSSEC compliant;

receiving a DNS compliant response for at least a portion of the domain name from the one or more DNS servers;

creating a signed resource record that is DNSSEC compliant when the DNS compliant response from the one or more DNS servers is a denial of existence response for the requested domain name; and

sending the signed resource record to the requesting DNSSEC compliant computing device.

30. The method as set forth in claim 29, wherein the DNS servers are authoritative for a zone associated with the at least a portion of the domain name.

31. The method as set forth in claim 29, further comprising:

encrypting the signed resource record using a stored private key; and

performing a hash of the encrypted signed resource record prior to sending the signed resource record to the requesting DNSSEC compliant computing device.

32. The method as set forth in claim 25, wherein the at least a portion of the domain name comprises a top-level domain name that is known to be authenticated.

33. A system comprising one or more network traffic management devices, one or more servers, or one or more clients, the system comprising:

one or more processors; and

memory comprising programmed instructions stored in the memory, the one or more processors configured to be capable of executing the programmed instructions stored in the memory to:

receive a domain name system security extension (DNSSEC) request for a domain name from a DNSSEC compliant computing device;

generate a domain name system (DNS) request corresponding to the DNSSEC request for the domain name;

send the DNS request for the domain name to one or more DNS servers that are not DNSSEC compliant;

receive a DNS compliant response for at least a portion of the domain name from the one or more DNS servers;

create a signed resource record that is DNSSEC compliant when the DNS compliant response from the one or more DNS servers is a denial of existence response for the requested domain name; and

send the signed resource record to the requesting DNSSEC compliant computing device.

34. The system as set forth in claim 33, wherein the DNS servers are authoritative for a zone associated with the at least a portion of the domain name.

35. The system as set forth in claim 33, wherein the one or more processors are further configured to be capable of executing the programmed instructions stored in the memory to:

encrypt the signed resource record using a stored private key; and

perform a hash of the encrypted signed resource record prior to sending the signed resource record to the requesting DNSSEC compliant computing device.

36. The system as set forth in claim 33, wherein the at least a portion of the domain name comprises a top-level domain name that is known to be authenticated.

* * * * *