

Related U.S. Application Data

continuation of application No. 16/849,813, filed on Apr. 15, 2020, now Pat. No. 11,695,800, which is a continuation-in-part of application No. 16/543,189, filed on Aug. 16, 2019, now Pat. No. 11,616,812, which is a continuation-in-part of application No. 15/383,522, filed on Dec. 19, 2016, now Pat. No. 10,599,842.

(51) **Int. Cl.**

G06F 21/56 (2013.01)

H04L 41/12 (2022.01)

H04L 61/4505 (2022.01)

H04L 61/5007 (2022.01)

H04L 61/4523 (2022.01)

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

CPC **H04L 41/12** (2013.01); **H04L 61/4505** (2022.05); **H04L 61/5007** (2022.05); **H04L 63/1416** (2013.01); **G06F 2221/2123** (2013.01); **H04L 61/4523** (2022.05)

(58) **Field of Classification Search**

CPC . H04L 61/4523; G06F 21/554; G06F 21/566; G06F 2221/2123

See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

5,754,938 A	5/1998	Herz et al.	8,204,984 B1	6/2012	Aziz
6,026,474 A	2/2000	Carter et al.	8,205,035 B2	6/2012	Reddy et al.
6,154,844 A	11/2000	Touboul et al.	8,230,505 B1	7/2012	Ahrens et al.
6,157,953 A	12/2000	Chang et al.	8,239,947 B1	8/2012	Glick et al.
6,728,716 B1	4/2004	Bhattacharya et al.	8,296,842 B2	10/2012	Singh et al.
6,804,780 B1	10/2004	Touboul	8,327,442 B2	12/2012	Herz et al.
6,836,888 B1	12/2004	Basu et al.	8,353,033 B1	1/2013	Chen et al.
7,076,696 B1	7/2006	Stringer	8,370,931 B1	2/2013	Chien et al.
7,093,239 B1	8/2006	Van der Made	8,375,444 B2	2/2013	Aziz et al.
7,181,769 B1	2/2007	Keanini et al.	8,375,447 B2	2/2013	Amoroso et al.
7,225,468 B2	5/2007	Waisman et al.	8,413,238 B1	4/2013	Sutton
7,299,294 B1	11/2007	Bruck et al.	8,413,241 B2	4/2013	Weeks et al.
7,305,546 B1	12/2007	Miller	8,418,250 B2	4/2013	Morris et al.
7,322,044 B2	1/2008	Hratar	8,438,386 B2	5/2013	Hegli et al.
7,464,407 B2	12/2008	Nakae et al.	8,438,626 B2	5/2013	Anderson et al.
7,530,106 B1	5/2009	Zaitsev et al.	8,443,442 B2	5/2013	Wang et al.
7,543,269 B2	6/2009	Krueger	8,474,044 B2	6/2013	Zawadowskiy et al.
7,546,587 B2	6/2009	Marr et al.	8,488,466 B2	7/2013	Breslin et al.
7,574,740 B1	8/2009	Kennis	8,528,057 B1	9/2013	Garrett
7,596,807 B2	9/2009	Ptacek et al.	8,528,087 B2	9/2013	Hsu et al.
7,596,808 B1	9/2009	Wilkinson et al.	8,538,578 B2	9/2013	Battles et al.
7,665,139 B1	2/2010	Szor et al.	8,539,578 B1	9/2013	Zhou et al.
7,710,933 B1	5/2010	Sundaralingam et al.	8,539,582 B1	9/2013	Aziz et al.
7,739,516 B2	6/2010	Bender et al.	8,549,643 B1	10/2013	Shou
7,832,012 B2	11/2010	Huddleston	8,555,385 B1	10/2013	Bhatkar et al.
7,882,538 B1	2/2011	Palmer	8,561,177 B1	10/2013	Aziz et al.
7,890,612 B2	2/2011	Todd et al.	8,566,946 B1	10/2013	Aziz et al.
7,937,755 B1	5/2011	Guruswamy	8,607,054 B2	12/2013	Ramarathnam et al.
7,958,549 B2	6/2011	Nakae et al.	8,607,340 B2	12/2013	Wright
7,975,018 B2	7/2011	Unrau et al.	8,627,475 B2	1/2014	Loveland et al.
7,984,129 B2	7/2011	Vaught	8,677,494 B2	3/2014	Ederly et al.
8,015,605 B2	9/2011	Yegneswaran	8,713,306 B1	4/2014	Bennett
8,024,795 B2	9/2011	Newton	8,719,937 B2	5/2014	Sundaram et al.
8,042,186 B1	10/2011	Polyakov et al.	8,725,898 B1	5/2014	Vincent
8,056,134 B1	11/2011	Ogilvie	8,726,389 B2	5/2014	Morris et al.
8,065,722 B2	11/2011	Barford et al.	8,732,296 B1	5/2014	Thomas et al.
8,078,556 B2	12/2011	Adi et al.	8,752,173 B2	6/2014	Yadav
8,082,471 B2	12/2011	Khan	8,789,135 B1	7/2014	Pani
8,131,281 B1	3/2012	Hildner et al.	8,793,151 B2	7/2014	Delzoppo et al.
8,141,154 B2	3/2012	Gruzman et al.	8,806,638 B1	8/2014	Mani
8,156,556 B2	4/2012	Krishnamurthy	8,821,242 B2	9/2014	Hinman et al.
8,171,545 B1	5/2012	Cooley et al.	8,839,369 B1	9/2014	Dai et al.
8,181,033 B1	5/2012	Paul et al.	8,844,041 B1	9/2014	Kienzle et al.
8,181,250 B2	5/2012	Rafalovich et al.	8,849,880 B2	9/2014	Thelen
			8,850,582 B2	9/2014	Endoh et al.
			8,880,435 B1	11/2014	Catlett et al.
			8,881,282 B1	11/2014	Aziz et al.
			8,893,278 B1	11/2014	Chechik
			8,898,788 B1	11/2014	Aziz et al.
			8,904,527 B2	12/2014	Dawson et al.
			8,943,594 B1	1/2015	Arrowood
			8,949,986 B2	2/2015	Ben-Shalom
			8,959,338 B2	2/2015	Snow et al.
			8,973,142 B2	3/2015	Shulman et al.
			8,984,637 B2	3/2015	Karecha et al.
			9,009,829 B2	4/2015	Stolfo et al.
			9,027,135 B1	5/2015	Aziz
			9,043,920 B2	5/2015	Gula et al.
			9,081,747 B1	7/2015	Tabieros et al.
			9,117,078 B1	8/2015	Chien et al.
			9,141,792 B2	9/2015	Baluda et al.
			9,166,993 B1	10/2015	Liu
			9,185,136 B2	11/2015	Dulkin et al.
			9,195,480 B2	11/2015	Wang et al.
			9,197,601 B2	11/2015	Pasdar
			9,213,838 B2	12/2015	Lu
			9,225,734 B1	12/2015	Hastings
			9,240,976 B1	1/2016	Murchison
			9,246,774 B2	1/2016	Mataitis et al.
			9,270,690 B2	2/2016	Kraitsman et al.
			9,305,165 B2	4/2016	Snow et al.
			9,329,973 B2	5/2016	Bhuyan
			9,330,259 B2	5/2016	Klein et al.
			9,356,942 B1	5/2016	Joffe
			9,356,950 B2	5/2016	Vissamsetty et al.
			9,369,476 B2	6/2016	Chekina et al.
			9,386,034 B2	7/2016	Cochenour
			9,398,001 B1	7/2016	Tidd
			9,407,602 B2	8/2016	Feghali et al.

(56)	References Cited					
	U.S. PATENT DOCUMENTS					
	9,413,721 B2	8/2016	Morris et al.	2003/0145225 A1	7/2003	Bruton, III et al.
	9,420,002 B1	8/2016	McGovern et al.	2003/0145226 A1	7/2003	Bruton, III et al.
	9,430,646 B1	8/2016	Mushtaq et al.	2003/0152034 A1	8/2003	Zhang et al.
	9,432,360 B1	8/2016	Triandopoulos et al.	2003/0188189 A1	10/2003	Desai et al.
	9,438,614 B2	9/2016	Herz	2003/0223367 A1	12/2003	Shay et al.
	9,495,188 B1	11/2016	Ettema et al.	2004/0083369 A1	4/2004	Erlingsson et al.
	9,503,470 B2	11/2016	Gertner et al.	2004/0172557 A1	9/2004	Nakae et al.
	9,547,516 B2	1/2017	Thakkar et al.	2004/0243699 A1	12/2004	Koclanes et al.
	9,578,045 B2	2/2017	Jarocho et al.	2004/0255157 A1	12/2004	Ghanea-Hercock
	9,591,006 B2	3/2017	Siva et al.	2005/0050353 A1	3/2005	Thiele et al.
	9,601,000 B1	3/2017	Gruss et al.	2005/0076235 A1	4/2005	Ormazabal et al.
	9,602,531 B1	3/2017	Wallace et al.	2005/0076238 A1	4/2005	Ormazabal et al.
	9,606,893 B2	3/2017	Gupta et al.	2005/0108562 A1	5/2005	Khazan et al.
	9,607,146 B2	3/2017	Sridhara et al.	2005/0138402 A1	6/2005	Yoon et al.
	9,609,019 B2	3/2017	Vissamsetty et al.	2005/0160480 A1	7/2005	Birt et al.
	9,628,498 B1	4/2017	Aziz et al.	2005/0193173 A1*	9/2005	Ring G06F 21/57 714/E11.207
	9,641,544 B1	5/2017	Treat et al.	2005/0198507 A1	9/2005	Brender et al.
	9,641,550 B2	5/2017	Kraitsman et al.	2005/0204157 A1	9/2005	Johnson
	9,705,904 B1	7/2017	Davis et al.	2005/0223239 A1	10/2005	Dotan
	9,710,648 B2	7/2017	Weingarten	2005/0240906 A1	10/2005	Kinderknecht et al.
	9,712,547 B2	7/2017	Touboul et al.	2005/0240989 A1	10/2005	Kim et al.
	9,749,349 B1	8/2017	Czarny et al.	2005/0288939 A1	12/2005	Peled et al.
	9,769,204 B2	9/2017	Vissamsetty et al.	2006/0053490 A1	3/2006	Herz et al.
	9,772,832 B2	9/2017	Rubio	2006/0085543 A1	4/2006	Hrastar
	9,781,148 B2	10/2017	Mahaffey et al.	2006/0101515 A1	5/2006	Amoroso et al.
	9,807,092 B1	10/2017	Gutzmann	2006/0126522 A1	6/2006	Oh
	9,807,115 B2	10/2017	Kolton et al.	2006/0161989 A1	7/2006	Reshef et al.
	9,813,451 B2	11/2017	Honda et al.	2006/0203774 A1	9/2006	Carrion-Rodrigo
	9,871,766 B2	1/2018	Syed et al.	2006/0209701 A1	9/2006	Zhang et al.
	9,877,210 B1	1/2018	Hildner et al.	2006/0230129 A1	10/2006	Swami et al.
	9,888,032 B2	2/2018	Dekel et al.	2006/0236401 A1	10/2006	Fosdick
	9,898,763 B1	2/2018	Vaynblat et al.	2007/0022090 A1	1/2007	Graham
	9,942,270 B2	4/2018	Vissamsetty et al.	2007/0025374 A1	2/2007	Stefan et al.
	10,025,928 B2	7/2018	Jarocho et al.	2007/0067623 A1	3/2007	Ward
	10,044,675 B1	8/2018	Ettema et al.	2007/0097976 A1	5/2007	Wood et al.
	10,102,374 B1	10/2018	Cohen et al.	2007/0100905 A1	5/2007	Masters et al.
	10,169,586 B2	1/2019	Maciejak et al.	2007/0101431 A1	5/2007	Clift et al.
	10,237,282 B2	3/2019	Nelson et al.	2007/0115993 A1	5/2007	Cohen
	10,250,636 B2	4/2019	Vissamsetty et al.	2007/0143827 A1	6/2007	Nicodemus et al.
	10,257,224 B2	4/2019	Jarocho et al.	2007/0143851 A1	6/2007	Nicodemus et al.
	10,284,591 B2	5/2019	Giuliani et al.	2007/0177499 A1	8/2007	Gavrilescu et al.
	10,375,110 B2	8/2019	Vissamsetty et al.	2007/0208822 A1	9/2007	Wang et al.
	10,382,484 B2	8/2019	Shayevitz et al.	2007/0208936 A1	9/2007	Ramos
	10,476,891 B2	11/2019	Vissamsetty et al.	2007/0209070 A1	9/2007	Yadav
	10,509,905 B2	12/2019	Vissamsetty et al.	2007/0226320 A1*	9/2007	Hager G06F 16/182 709/219
	10,542,044 B2	1/2020	Vissamsetty et al.	2007/0240215 A1	10/2007	Flores et al.
	10,567,431 B2	2/2020	Vissamsetty et al.	2007/0250930 A1	10/2007	Aziz et al.
	10,574,698 B1	2/2020	Sharifi	2007/0266422 A1	11/2007	Germano et al.
	10,599,842 B2	3/2020	Vissamsetty et al.	2007/0282782 A1	12/2007	Carey et al.
	10,599,844 B2	3/2020	Schmidtler et al.	2008/0005782 A1	1/2008	Aziz
	10,609,074 B2	3/2020	Vissamsetty et al.	2008/0018927 A1	1/2008	Martin et al.
	10,757,090 B2	8/2020	Kahol et al.	2008/0022000 A1	1/2008	Furuya et al.
	10,826,941 B2	11/2020	Jain et al.	2008/0034429 A1	2/2008	Schneider
	10,855,671 B2	12/2020	Kahol et al.	2008/0046989 A1	2/2008	Wahl
	10,938,854 B2	3/2021	Strogov et al.	2008/0060074 A1	3/2008	Okuyama
	11,032,301 B2	6/2021	Mandrychenko et al.	2008/0071728 A1	3/2008	Lim
	11,038,658 B2	6/2021	Vissamsetty et al.	2008/0082722 A1	4/2008	Savagaonkar et al.
	11,171,974 B2	11/2021	Gertner et al.	2008/0083034 A1	4/2008	Kim et al.
	11,470,115 B2	10/2022	Vissamsetty et al.	2008/0098476 A1	4/2008	Syversen
	11,481,503 B2	10/2022	Gitelman et al.	2008/0104046 A1	5/2008	Singla et al.
	11,507,663 B2	11/2022	Cohen et al.	2008/0127346 A1	5/2008	Oh et al.
	11,522,894 B2	12/2022	Weingarten et al.	2008/0162397 A1	7/2008	Zaltzman
	11,579,857 B2	2/2023	Montag et al.	2008/0168559 A1	7/2008	Touitou et al.
	11,580,218 B2	2/2023	Salem et al.	2008/0170566 A1	7/2008	Akimoto
	11,615,184 B2	3/2023	Kutt et al.	2008/0229415 A1	9/2008	Kapoor et al.
	11,734,303 B2	8/2023	Cruanes et al.	2009/0077664 A1	3/2009	Hsu et al.
	11,888,897 B2	1/2024	Vissamsetty et al.	2009/0089040 A1	4/2009	Monastyrsky et al.
	2002/0010800 A1	1/2002	Riley et al.	2009/0104046 A1	4/2009	Martin et al.
	2002/0016826 A1	2/2002	Johansson et al.	2009/0158407 A1	6/2009	Nicodemus et al.
	2002/0078382 A1	6/2002	Sheikh et al.	2009/0158418 A1	6/2009	Rao et al.
	2002/0093917 A1	7/2002	Knobbe et al.	2009/0170566 A1	7/2009	Kwon et al.
	2002/0095607 A1	7/2002	Lin-Hendel	2009/0199296 A1	8/2009	Xie et al.
	2002/0178374 A1	11/2002	Swimmer et al.	2009/0241173 A1	9/2009	Troyansky
	2002/0194489 A1	12/2002	Almogly et al.	2009/0249466 A1	10/2009	Motil et al.
	2003/0065950 A1	4/2003	Yarborough	2009/0249470 A1	10/2009	Litvin et al.
				2009/0254973 A1	10/2009	Kwan
				2009/0288158 A1	11/2009	Izatt et al.

(56)

References Cited**U.S. PATENT DOCUMENTS**

2009/0296641	A1	12/2009	Bienas et al.	2013/0231084	A1	9/2013	Raleigh
2009/0327688	A1	12/2009	Li et al.	2013/0239192	A1	9/2013	Linga et al.
2009/0328196	A1	12/2009	Bovee	2013/0242743	A1	9/2013	Thomas et al.
2010/0005339	A1	1/2010	Hooks	2013/0247190	A1	9/2013	Spurlock
2010/0077483	A1	3/2010	Stolfo et al.	2013/0290662	A1	10/2013	Teal
2010/0122317	A1	5/2010	Yadav	2013/0290729	A1	10/2013	Pettigrew et al.
2010/0122343	A1	5/2010	Ghosh et al.	2013/0291111	A1	10/2013	Zhou et al.
2010/0169973	A1	7/2010	Kim et al.	2013/0298192	A1	11/2013	Kumar et al.
2010/0269175	A1	10/2010	Stolfo et al.	2013/0298244	A1	11/2013	Kumar et al.
2010/0293615	A1	11/2010	Ye	2013/0305377	A1	11/2013	Herz
2010/0299430	A1	11/2010	Powers et al.	2013/0329732	A1	12/2013	Vyas et al.
2010/0332498	A1	12/2010	Svore et al.	2013/0333040	A1	12/2013	Diehl et al.
2011/0023118	A1	1/2011	Wright et al.	2013/0340033	A1	12/2013	Jones et al.
2011/0067107	A1	3/2011	Weeks et al.	2013/0346472	A1	12/2013	Wheeldon
2011/0078309	A1	3/2011	Bloch	2013/0347052	A1	12/2013	Choudrie
2011/0099633	A1	4/2011	Aziz	2014/0020046	A1	1/2014	Heitzman
2011/0113427	A1	5/2011	Dotan	2014/0046645	A1	2/2014	White et al.
2011/0138456	A1	6/2011	Ormazabal et al.	2014/0053267	A1	2/2014	Klein et al.
2011/0141937	A1	6/2011	Breslin et al.	2014/0059525	A1	2/2014	Jawa et al.
2011/0145920	A1	6/2011	Mahaffey et al.	2014/0068326	A1	3/2014	Quinn
2011/0167494	A1	7/2011	Bowen	2014/0068779	A1	3/2014	Tan et al.
2011/0178930	A1	7/2011	Scheidt et al.	2014/0090061	A1	3/2014	Avasarala et al.
2011/0185430	A1	7/2011	Sallam	2014/0096229	A1	4/2014	Burns et al.
2011/0209219	A1	8/2011	Zeitlin et al.	2014/0108794	A1	4/2014	Barton et al.
2011/0214176	A1	9/2011	Burch et al.	2014/0114609	A1	4/2014	Maurer et al.
2011/0214182	A1	9/2011	Adams et al.	2014/0123280	A1	5/2014	Kedma
2011/0219443	A1	9/2011	Hampel	2014/0137246	A1	5/2014	Baluda
2011/0219449	A1	9/2011	St. Neitzel	2014/0150094	A1	5/2014	Rao et al.
2011/0225655	A1	9/2011	Niemelä et al.	2014/0157366	A1	6/2014	Ko et al.
2011/0247071	A1	10/2011	Hooks et al.	2014/0165203	A1	6/2014	Friedrichs et al.
2011/0252434	A1	10/2011	Stokes	2014/0215617	A1	7/2014	Smith et al.
2011/0271341	A1	11/2011	Satish et al.	2014/0215621	A1	7/2014	Xaypanya et al.
2011/0276597	A1	11/2011	Little	2014/0215625	A1	7/2014	Paul et al.
2011/0288940	A1	11/2011	Hordan et al.	2014/0237562	A1	8/2014	Nandakumar
2012/0023572	A1	1/2012	William, Jr. et al.	2014/0237595	A1	8/2014	Sridhara et al.
2012/0030745	A1	2/2012	Bauer	2014/0237599	A1	8/2014	Gertner et al.
2012/0030750	A1	2/2012	Bhargava et al.	2014/0245376	A1	8/2014	Hibbert et al.
2012/0079596	A1	3/2012	Thomas et al.	2014/0250524	A1	9/2014	Meyers et al.
2012/0084866	A1	4/2012	Stolfo	2014/0259092	A1	9/2014	Boucher et al.
2012/0106377	A1	5/2012	Sommers et al.	2014/0270157	A1	9/2014	Youd et al.
2012/0124363	A1	5/2012	Dietrich et al.	2014/0280864	A1	9/2014	Yin et al.
2012/0137342	A1	5/2012	Hartrell et al.	2014/0282816	A1	9/2014	Xie et al.
2012/0137367	A1	5/2012	Dupont et al.	2014/0283038	A1	9/2014	Call
2012/0144488	A1*	6/2012	Sankruthi H04L 63/1425 726/24	2014/0283076	A1	9/2014	Muttik
2012/0151565	A1	6/2012	Fiterman	2014/0289851	A1	9/2014	Klein et al.
2012/0185563	A1	7/2012	Sugiyama et al.	2014/0298419	A1	10/2014	Boubez et al.
2012/0240182	A1	9/2012	Marayanaswamy et al.	2014/0349611	A1	11/2014	Kant et al.
2012/0254995	A1*	10/2012	Sallam G06F 21/52 726/22	2014/0373091	A1	12/2014	Kirner et al.
2012/0255003	A1	10/2012	Sallam	2015/0006384	A1	1/2015	Shaikh
2012/0255004	A1	10/2012	Sallam	2015/0007312	A1	1/2015	Pidathala et al.
2012/0255012	A1*	10/2012	Sallam G06F 21/554 726/23	2015/0013006	A1	1/2015	Shulman et al.
2012/0291090	A1	11/2012	Srinivasan et al.	2015/0013008	A1	1/2015	Lukacs et al.
2012/0297486	A1	11/2012	Turbin	2015/0033341	A1	1/2015	Schmidtdler et al.
2012/0297488	A1	11/2012	Kapoor et al.	2015/0039513	A1	2/2015	Adjaoute
2012/0324094	A1	12/2012	Wyatt et al.	2015/0067763	A1	3/2015	Dalcher et al.
2012/0331553	A1*	12/2012	Aziz H04L 63/145 726/23	2015/0074810	A1	3/2015	Saher et al.
2013/0052992	A1	2/2013	Lee et al.	2015/0082430	A1	3/2015	Sridhara et al.
2013/0054682	A1	2/2013	Malik et al.	2015/0089655	A1	3/2015	Choi et al.
2013/0061097	A1	3/2013	Mendel et al.	2015/0096048	A1	4/2015	Zhang et al.
2013/0080641	A1	3/2013	Lui et al.	2015/0113616	A1	4/2015	Sampas
2013/0086684	A1	4/2013	Mohler	2015/0121524	A1	4/2015	Fawaz et al.
2013/0091573	A1	4/2013	Herz et al.	2015/0121529	A1	4/2015	Quinlan et al.
2013/0097706	A1	4/2013	Titonis et al.	2015/0128206	A1	5/2015	Haim et al.
2013/0111547	A1	5/2013	Kraemer	2015/0128246	A1	5/2015	Feghali et al.
2013/0133072	A1	5/2013	Kraitsman et al.	2015/0143496	A1	5/2015	Thomas et al.
2013/0152200	A1	6/2013	Alme et al.	2015/0150125	A1	5/2015	Dulkin et al.
2013/0167236	A1	6/2013	Sick	2015/0150130	A1	5/2015	Fiala
2013/0191924	A1	7/2013	Tedesco et al.	2015/0156214	A1	6/2015	Kaminsky
2013/0198842	A1	8/2013	Klein et al.	2015/0161024	A1	6/2015	Gupta et al.
2013/0212658	A1	8/2013	Amaya et al.	2015/0163121	A1	6/2015	Mahaffey et al.
2013/0219217	A1	8/2013	Seren et al.	2015/0172300	A1	6/2015	Cochenour
				2015/0195291	A1	7/2015	Zuk et al.
				2015/0199512	A1	7/2015	Kim et al.
				2015/0200928	A1	7/2015	Burch et al.
				2015/0200955	A1	7/2015	Martin
				2015/0205962	A1	7/2015	Swidowski et al.
				2015/0220735	A1	8/2015	Paithane et al.
				2015/0254161	A1	9/2015	Baril et al.
				2015/0257194	A1	9/2015	Cho

(56)

References Cited

U.S. PATENT DOCUMENTS

2015/0264068	A1	9/2015	Beauchesne	2017/0302665	A1	10/2017	Zou et al.
2015/0264077	A1	9/2015	Berger et al.	2017/0302696	A1	10/2017	Schutz et al.
2015/0268947	A1	9/2015	Ionescu	2017/0318054	A1	11/2017	Vissamsetty et al.
2015/0268989	A1	9/2015	Busch et al.	2017/0322959	A1	11/2017	Tidwell et al.
2015/0271200	A1	9/2015	Brady et al.	2017/0324774	A1	11/2017	Ohayon et al.
2015/0281267	A1	10/2015	Danahy et al.	2017/0324777	A1	11/2017	Ohayon et al.
2015/0286820	A1	10/2015	Sridhara et al.	2017/0331849	A1	11/2017	Yu et al.
2015/0288706	A1	10/2015	Marshall	2017/0331856	A1	11/2017	Vissamsetty et al.
2015/0310196	A1	10/2015	Turgeman et al.	2017/0346802	A1	11/2017	Gruskin et al.
2015/0326587	A1	11/2015	Vissamsetty et al.	2017/0346853	A1	11/2017	Wyatt et al.
2015/0326588	A1*	11/2015	Vissamsetty H04L 63/1491 726/23	2017/0359370	A1	12/2017	Humphries et al.
2015/0326592	A1	11/2015	Vissamsetty et al.	2018/0013788	A1	1/2018	Vissamsetty et al.
2015/0326599	A1	11/2015	Vissamsetty et al.	2018/0020005	A1	1/2018	Beiter et al.
2015/0346066	A1	12/2015	Dutta et al.	2018/0027006	A1	1/2018	Zimmermann et al.
2015/0350213	A1	12/2015	Varadarajan et al.	2018/0027009	A1	1/2018	Santos et al.
2015/0350236	A1	12/2015	Klinghofer et al.	2018/0027017	A1	1/2018	Touboul et al.
2015/0358345	A1	12/2015	Clark et al.	2018/0039776	A1	2/2018	Loman et al.
2015/0370560	A1	12/2015	Tan et al.	2018/0048665	A1	2/2018	Shulman et al.
2015/0373039	A1	12/2015	Wang	2018/0063187	A1	3/2018	St Pierre
2015/0379371	A1	12/2015	Yoon et al.	2018/0089430	A1	3/2018	Mayo
2015/0381376	A1	12/2015	Wardman et al.	2018/0089431	A1	3/2018	Nalluri et al.
2016/0028750	A1	1/2016	Di Pietro et al.	2018/0124096	A1	5/2018	Schwartz et al.
2016/0042179	A1	2/2016	Weingarten	2018/0143915	A1	5/2018	Gonzalez et al.
2016/0042180	A1	2/2016	Sayre et al.	2018/0146008	A1	5/2018	Vissamsetty et al.
2016/0055334	A1	2/2016	Herwono et al.	2018/0173876	A1	6/2018	Vissamsetty et al.
2016/0055337	A1	2/2016	El-Moussa	2018/0183815	A1	6/2018	Enfinger
2016/0065675	A1	3/2016	Brand	2018/0191593	A1	7/2018	De et al.
2016/0072838	A1	3/2016	Kolton et al.	2018/0225592	A1	8/2018	Ponnuswamy
2016/0078365	A1	3/2016	Baumard	2018/0248896	A1	8/2018	Challita et al.
2016/0080414	A1	3/2016	Kolton et al.	2018/0359272	A1	12/2018	Mizrachi et al.
2016/0127352	A1	5/2016	Xu et al.	2018/0359278	A1	12/2018	Rusakov et al.
2016/0127413	A1	5/2016	Kraitsman et al.	2019/0042745	A1	2/2019	Chen et al.
2016/0142399	A1	5/2016	Pace et al.	2019/0052659	A1	2/2019	Weingarten et al.
2016/0191554	A1	6/2016	Kaminsky	2019/0068642	A1	2/2019	Araujo et al.
2016/0212225	A1	7/2016	Smith et al.	2019/0073475	A1	3/2019	Vissamsetty et al.
2016/0261631	A1	9/2016	Vissamsetty et al.	2019/0114426	A1	4/2019	Cohen et al.
2016/0285914	A1	9/2016	Singh et al.	2019/0138639	A1	5/2019	Pal et al.
2016/0315909	A1	10/2016	Von Gravrock et al.	2019/0138725	A1	5/2019	Gupta
2016/0323300	A1	11/2016	Boss et al.	2019/0199736	A1	6/2019	Howard et al.
2016/0323316	A1	11/2016	Kolton et al.	2019/0253453	A1	8/2019	Vissamsetty et al.
2016/0335110	A1	11/2016	Paithane et al.	2019/0258807	A1	8/2019	Dimaggio et al.
2016/0381023	A1	12/2016	Dulce et al.	2019/0294485	A1	9/2019	Kukreja et al.
2017/0009391	A1	1/2017	Fu et al.	2019/0294614	A1	9/2019	Brodt et al.
2017/0019425	A1	1/2017	Ettema et al.	2019/0312904	A1	10/2019	Stevens, IV et al.
2017/0026387	A1	1/2017	Vissamsetty et al.	2019/0318100	A1	10/2019	Bhatia et al.
2017/0032122	A1*	2/2017	Thakar G06F 21/566	2019/0340353	A1	11/2019	Mitelman
2017/0054754	A1	2/2017	Saher et al.	2019/0349369	A1	11/2019	Bengtson et al.
2017/0093910	A1	3/2017	Gukal et al.	2019/0354355	A1	11/2019	Jacobson et al.
2017/0126718	A1	5/2017	Baradaran et al.	2019/0379697	A1	12/2019	Vissamsetty et al.
2017/0134405	A1	5/2017	Ahmadzadeh et al.	2019/0392260	A1	12/2019	Pang et al.
2017/0141980	A1	5/2017	Palanciuc et al.	2020/0050586	A1	2/2020	Pal et al.
2017/0147796	A1	5/2017	Sardesai et al.	2020/0051697	A1	2/2020	Krishnamurti et al.
2017/0149787	A1*	5/2017	Niemela G06F 21/566	2020/0076853	A1	3/2020	Pandian et al.
2017/0149795	A1	5/2017	Day, II	2020/0133865	A1	4/2020	Mannava et al.
2017/0149832	A1	5/2017	Touboul et al.	2020/0143054	A1	5/2020	Cohen et al.
2017/0171244	A1	6/2017	Vissamsetty et al.	2020/0143061	A1	5/2020	Kim et al.
2017/0180421	A1	6/2017	Shieh et al.	2020/0201620	A1	6/2020	Beard
2017/0201545	A1	7/2017	Nicodemus et al.	2020/0218806	A1	7/2020	Cho
2017/0206142	A1	7/2017	Pawar et al.	2020/0244677	A1	7/2020	Abbaszadeh et al.
2017/0206357	A1	7/2017	Gorelik et al.	2020/0252429	A1	8/2020	Vissamsetty et al.
2017/0230384	A1	8/2017	Touboul et al.	2020/0274894	A1	8/2020	Argoeti et al.
2017/0230402	A1	8/2017	Greenspan et al.	2020/0374087	A1	11/2020	Vissamsetty et al.
2017/0235967	A1	8/2017	Ray et al.	2021/0029153	A1	1/2021	Sugimoto et al.
2017/0244729	A1	8/2017	Fahrny et al.	2021/0073374	A1	3/2021	Mookken et al.
2017/0244749	A1	8/2017	Shulman et al.	2021/0073658	A1	3/2021	Poole et al.
2017/0244755	A1	8/2017	Tsao	2021/0117232	A1	4/2021	Sriharsha et al.
2017/0250855	A1	8/2017	Patil et al.	2021/0232291	A1	7/2021	Abdulaal et al.
2017/0257375	A1	9/2017	Dulkin et al.	2021/0263945	A1	8/2021	Siebel et al.
2017/0264639	A1	9/2017	Sama et al.	2021/0397710	A1	12/2021	Cohen et al.
2017/0279839	A1	9/2017	Vasseur et al.	2022/0050895	A1	2/2022	Yu et al.
2017/0279846	A1	9/2017	Osterweil et al.	2022/0070256	A1	3/2022	Singh et al.
2017/0286676	A1	10/2017	Weingarten et al.	2022/0086142	A1	3/2022	Hecht
2017/0302458	A1	10/2017	Berger et al.	2022/0101096	A1	3/2022	Singer et al.
2017/0302653	A1	10/2017	Ortner et al.	2022/0164444	A1	5/2022	Prudkovskij
				2022/0253526	A1	8/2022	Sanders
				2022/0391496	A9	12/2022	Salem et al.
				2023/0007025	A1	1/2023	Weingarten et al.
				2023/0007026	A1	1/2023	Weingarten et al.
				2023/0007027	A1	1/2023	Weingarten et al.

(56)

References Cited**U.S. PATENT DOCUMENTS**

2023/0007028	A1	1/2023	Weingarten et al.
2023/0007029	A1	1/2023	Weingarten et al.
2023/0007030	A1	1/2023	Weingarten et al.
2023/0007031	A1	1/2023	Weingarten et al.
2023/0247046	A1	8/2023	Peters et al.
2023/0247048	A1	8/2023	Samosseiko et al.
2023/0319089	A1	10/2023	Chesla et al.

FOREIGN PATENT DOCUMENTS

CN	113297584	A	8/2021
CN	113434858	A	9/2021
EP	3 171 568		5/2017
EP	3472746	A1	4/2019
EP	3968197	A1	3/2022
ES	2785350	T3	10/2020
JP	2006-106939	A	4/2006
JP	2008-252625	A	10/2008
JP	2013-168141	A	8/2013
JP	2015-534690	A	12/2015
JP	2016-512631		4/2016
JP	2017-504102		2/2017
KR	10-2015-0101811		9/2015
KR	10-1969572		4/2019
KR	10-2021-0079494	A	6/2021
WO	WO 02/27440	A2	4/2002
WO	WO 2010/030169	A2	3/2010
WO	WO 2012/027669		3/2012
WO	WO 2013/014672		1/2013
WO	2013/121951	A1	8/2013
WO	WO 2015/171780	A1	11/2015
WO	WO 2015/171789	A1	11/2015
WO	WO 2016/024268		2/2016
WO	WO 2016/081561	A1	5/2016
WO	2017/068889	A1	4/2017
WO	WO 2017/064710		4/2017
WO	2017/218872	A1	12/2017
WO	WO 2019/092530		5/2019
WO	WO 2019/032728		3/2020
WO	2020/108357	A1	6/2020
WO	2022/076234	A1	4/2022

OTHER PUBLICATIONS

Dini et al., "Probabilistic Contract Compliance for Mobile Applications", Eighth International Conference on Availability, Reliability and Security (ARES) IEEE, Sep. 2-6, 2013, pp. 599-606.

Gu et al., "Malicious Shellcode Detection with Virtual Memory Snapshots," 2010 Proceedings IEEE INFOCOM, San Diego, CA, 2010, pp. 1-9, accessed Mar. 6, 2019.

Installing a Tanium Client—distributed also using user/password (not encrypted) from a hosted Module server, downloaded from https://docs.tanium.com/client/client/deployment.html#client_management on Apr. 1, 2021.

IBM Software, "Stepping up the battle against advanced threats", IBM Trusteer Apex Thought Leadership White Paper, Dec. 2013, WGW03043-USEN-00.

IBM Security Qradar Solution Brief "Visibility, detection, investigation and response" printed from <https://www.ibm.com/downloads/cas/OP62GKAR>, printed on May 26, 2021, in 11 pgs.

"IBM Security Trusteer Apex Advanced Malware Protection (SaaS) delivers an enterprise endpoint security solution to help protect organizations from advanced malware and targeted attacks" downloaded from https://www-01.ibm.com/common/ssi/rep_ca/0/877/ENUSZP14-0390/ENUSZP14-0390.PDF, printed Aug. 5, 2014, in 9 pgs.

IBM Guardium Documentation "Components and Topology", downloaded from <https://www.ibm.com/docs/en/qsip/7.4?topic=deployment-qradar-architecture-overview>, printed on Jun. 8, 2021, in 3 pages.

IBM Software "Stepping up the battle against advanced threats", downloaded from <https://citrixready.citrix.com/content/dam/ready/>

partners/ib/ibm-global-services/ibm-security-trusteer-apex-advanced-malware-protection/wgw03043usen.pdf, Printed Dec. 2013 in 12 pages.

Laureano et al., M., "Intrusion detection in virtual machine environments. In Euromicro Conference, 2004. Proceedings." 30th (pp. 520-525). IEEE Sep. 30, 2004.

Liu et al., "Detecting Trojan Horses Based on System Behavior Using Machine Learning Method", International Conference on Machine Learning and Cybernetics (ICMLC), IEEE, Jul. 11-14, 2010, pp. 855-860.

IBM, "Qradar Architecture overview", downloaded from <https://www.ibm.com/docs/en/qsip/7.4?topic=deployment-qradar-architecture-overview> printed May 28, 2021, in 6 pgs.

Moussaileb et al., "Ransomware's Early Mitigation Mechanisms," Proceedings ARES 2018 Proceedings of the 13th International Conference on Availability, Reliability and Security Article No. 2, pp. 1-10 (2018).

Ornaghi et al., "Man in the middle attacks." Blackhat Conference Europe (2003).

Ramachandran et al., "Detecting ARP spoofing: An active technique." International Conference on Information Systems Security, Springer, Berlin, Heidelberg (2005).

Rüdiger Schollmeier, A Definition of Peer-to-Peer Networking for the Classification of Peer-to-Peer Architectures and Applications, Proceedings of the First International Conference on Peer-to-Peer Computing, IEEE (2002).

Shosha et al., A.F., "Evasion-resistant malware signature based on profiling kernel data structure objects." In 2012 7th International Conference on Risks and Security of Internet and Systems (CRISIS) (pp. 1-8). IEEE., Oct. 31, 2012.

Tanium™ Client Management 1.6 User Guide, downloaded from https://docs.tanium.com/client_management/client_management/index.html on Apr. 1, 2021.

Xu, J-Y; Sung, A.H.; Chavez, P; Mukkamala, S.; "Polymorphic Malicious Executable Scanner by APISequence Analysis", Fourth International Conference on Hybrid Intelligent Systems, IEEE Dec. 5-8, 2004, pp. 378-383.

Communication Pursuant to Article 94(3) EPC dated Dec. 11, 2018, for European Application 15 760 520.5, in 7 pages.

Extended European Search Report dated May 9, 2019, for Application No. 16855062.2, in 7 pages.

European Search Report dated Apr. 29, 2021, in European Patent Application No. 18844671 in 38 pages.

Extended European Search Report dated Jan. 25, 2021, for European Patent Application No. 20181537.0, in 10 pages.

Reaqa Hive, A.I. Based Endpoint Threat Response, Whitepaper, 27 pages (Apr. 6, 2017).

International Search Report and Written Opinion dated Feb. 18, 2016, for International Application No. PCT/IL2015/050802, in 10 pages.

International Preliminary Report on Patentability dated Feb. 14, 2017, for International Application No. PCT/IL2015/050802, in 7 pages.

International Search Report and Written Opinion dated Apr. 20, 2017, for International Application No. PCT/IL2016/051110, in 10 pages.

International Search Report and Written Opinion dated Dec. 11, 2018, for International Application No. PCT/US2018/045850, in 12 pages.

International Search Report and Written Opinion dated Aug. 24, 2020, for International Application No. PCT/US2020/033872, in 8 pages.

International Search Report issued in application No. PCT/US2021/050129 on Dec. 21, 2021.

International Search Report in corresponding International Patent Application No. PCT/US2015/29490, dated Aug. 7, 2015, in 2 pages.

Written Opinion in corresponding International Patent Application No. PCT/US2015/29490, dated Aug. 7, 2015, in 6 pages.

International Preliminary Report on Patentability in corresponding International Patent Application No. PCT/US2015/29490, dated Nov. 8, 2016, in 7 pages.

(56)

References Cited**OTHER PUBLICATIONS**

International Search Report in corresponding International Patent Application No. PCT/US2015/29501, dated Aug. 7, 2015, in 2 pages.

Written Opinion in corresponding International Patent Application No. PCT/US2015/29501, dated Aug. 7, 2015, in 6 pages.

International Preliminary Report on Patentability in corresponding International Patent Application No. PCT/US2015/29501, dated Nov. 8, 2016, in 7 pages.

International Search Report in corresponding International Patent Application No. PCT/US2015/61271, dated Feb. 2, 2016, in 2 pages.

Written Opinion in corresponding International Patent Application No. PCT/US2015/61271, dated Feb. 2, 2016, in 6 pages.

International Preliminary Report on Patentability in corresponding International Patent Application No. PCT/US2015/61271, dated May 23, 2017, in 7 pages.

Office Action dated Jul. 24, 2019, in European Patent Application No. 15760520.5, in 8 pages.

Office Action dated May 31, 2022, in Japanese Patent Application No. 2020-503272, in 7 pages.

Extended European Search Report dated Aug. 25, 2021, for European Patent Application No. 21162973.8, in 5 pages.

Notice of Allowance dated Jan. 30, 2024, in related U.S. Appl. No. 18/183,022, in 10 pages.

Office Action dated Aug. 1, 2023, in related U.S. Appl. No. 18/183,022, in 16 pages.

Bert Abrath • Bart Coppens • Stijn Volckaert • Bjorn De Sutter; Obfuscating Windows DLLs; 2015 IEEE/ACM 1st International Workshop on Software Protection (2015, pp. 24-30); (Year: 2015). International Search Report and Written Opinion received for PCT Patent Application No. PCT/US24/44217, mailed on Jan. 15, 2025, 24 pages.

U.S. Appl. No. 61/989,965, filed May 7, 2014, "Distributed System for Bot Detection", 54 pages.

AEfficient Virus Detection Using Dynamic Instruction Sequences—May 2009 (Year: 2009).

IBM Security Guardium Insights for IBM Cloud Park for Security, printed from <https://www.ibm.com/downloads/cas/QY1RYRLP>, printed May 26, 2021 in 12 pages.

"IBM Security Qradar SIEM Installation Guide" downloaded from http://www.siem.su/docs/ibm/Installation_andupdating/IBM_SecurityQRadar_installation_Guide.pdf, printed 2013, vol. 7.2 in 54 pages.

Abdelhameed, M.U., et al. Portable executable automatic protection using dynamic infection and code redirection; 2009 International Conference on Computer Engineering & Systems (pp. 501-507); (Year: 2009).

Abrath, Bert et al. Obfuscating Windows DLLs; 2015 IEEE/ACM 1st International Workshop on Software Protection (pp. 24-30); (Year: 2015).

Barbhuiya et al., "Detection of neighbor solicitation and advertisement spoofing in IPV6 neighbor discovery protocol." Proceedings of the 4th international conference on Security of information and networks. (2011).

Birrer, B., et al., "Using qualia and hierarchical models in malware detection", Journal of Information Assurance and Security, Dec. 29, 2009, pp. 247-255.

Chakraborty et al., "Hierarchical learning for automated malware classification", MILCOM 2017-2017 IEEE Military Communications Conference (MILCOM), Oct. 23-25, 2017, pp. 1-6.

Installing a Tanium Client—distributed also using user/password (not encrypted) from a hosted Module server, downloaded from https://docs.tanium.com/client/client/deployment.html#client_management on Apr. 2021.

Jack Ullrich, Detecting Manual Syscalls from User Mode, Winternl, Cybersecurity Research & Development, Feb. 10, 2021, 11 pages, <https://winternl.com/detecting-manual-syscalls-from-user-mode/>.

Mahler, "A New Methodology for Information Security Risk Assessment for Medical Devices and Its Evaluation," 2020, the Department of Software and Information Systems Engineering, Ben-Gurion University of the Negev, Israel.

Matsuda, Wataru et al. "Real-Time Detection System Against Malicious Tools by Monitoring DLL on Client Computers;" 2019 IEEE Conference on Application, Information and Network Security (AINS) (pp. 36-41); (Year: 2019).

Moussaileb et al., "Ransomware's Early Mitigation Mechanisms," Proceedings ARES 2018 Proceedings of the 13th International Conference on Availability, Reliability and Security Article No. 2, 02:S 1-10 (2018).

Nisslmueller, U., "LOLBin detection through unsupervised learning an approach based on explicit featurization of the command line and parent-child relationships", University of Twente, Student Theses, Sep. 27, 2022, 72 pages.

Pandian, "Security Challenges of IoT and Medical Devices in Healthcare," Internet of Things, 1st Edition, 2020, Chapter 6, pp. 87-106.

Shun-Wen Hsiao et al., "Sequence Feature Extraction for Malware Family Analysis via Graph Neural," Network, arXiv:2208.05476v1, Aug. 10, 2022, pp. 1-12.

Stine, "A cyber risk scoring system for medical devices," International Journal of Critical Infrastructure Protection, Dec. 2017, vol. 19, pp. 32-46.

Ullrich et al., "IPv6 Security: Attacks and Countermeasures in a Nutshell." 8th USENIX Workshop on Offensive Technologies (2015). Zaldivar, "Investigating the Security Threats on Networked Medical Devices," 2020, 10th Annual Computing and Communication Workshop and Conference, Jan. 2020.

* cited by examiner

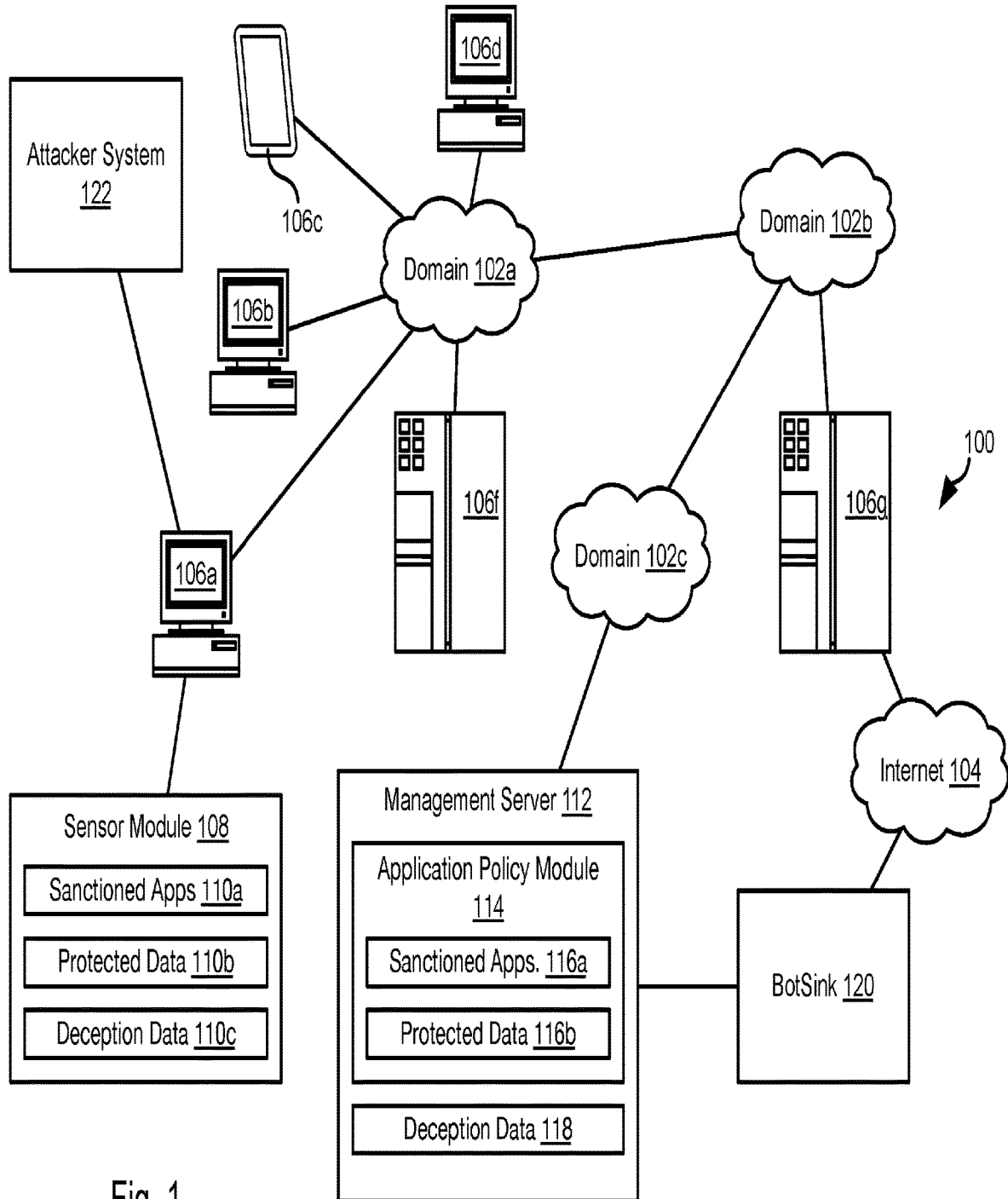


Fig. 1

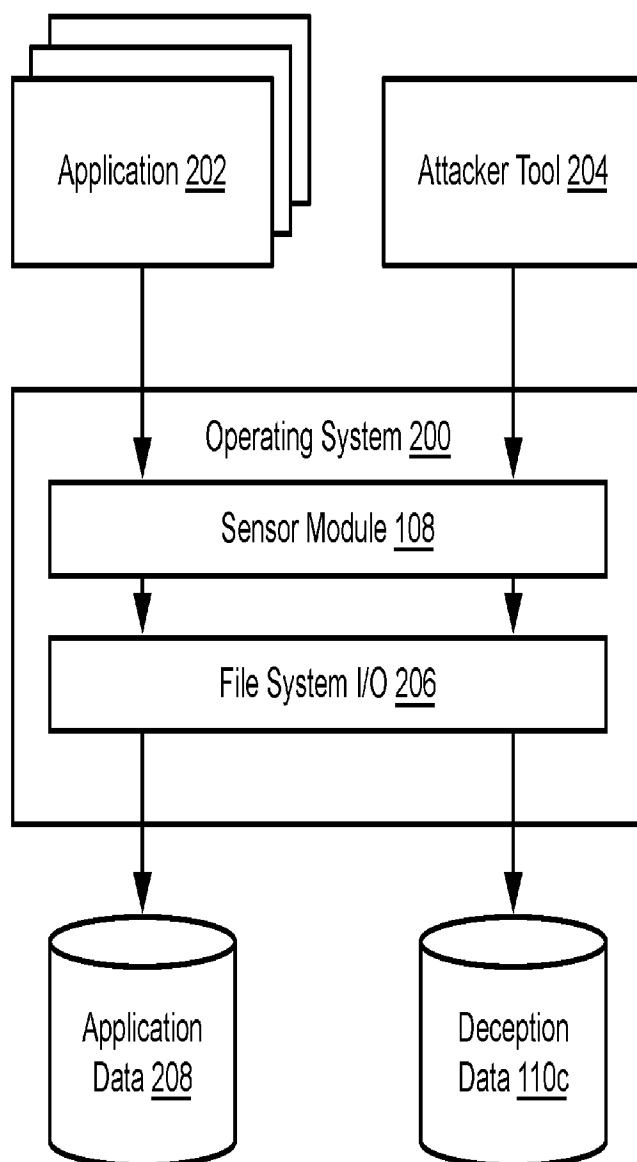


Fig. 2

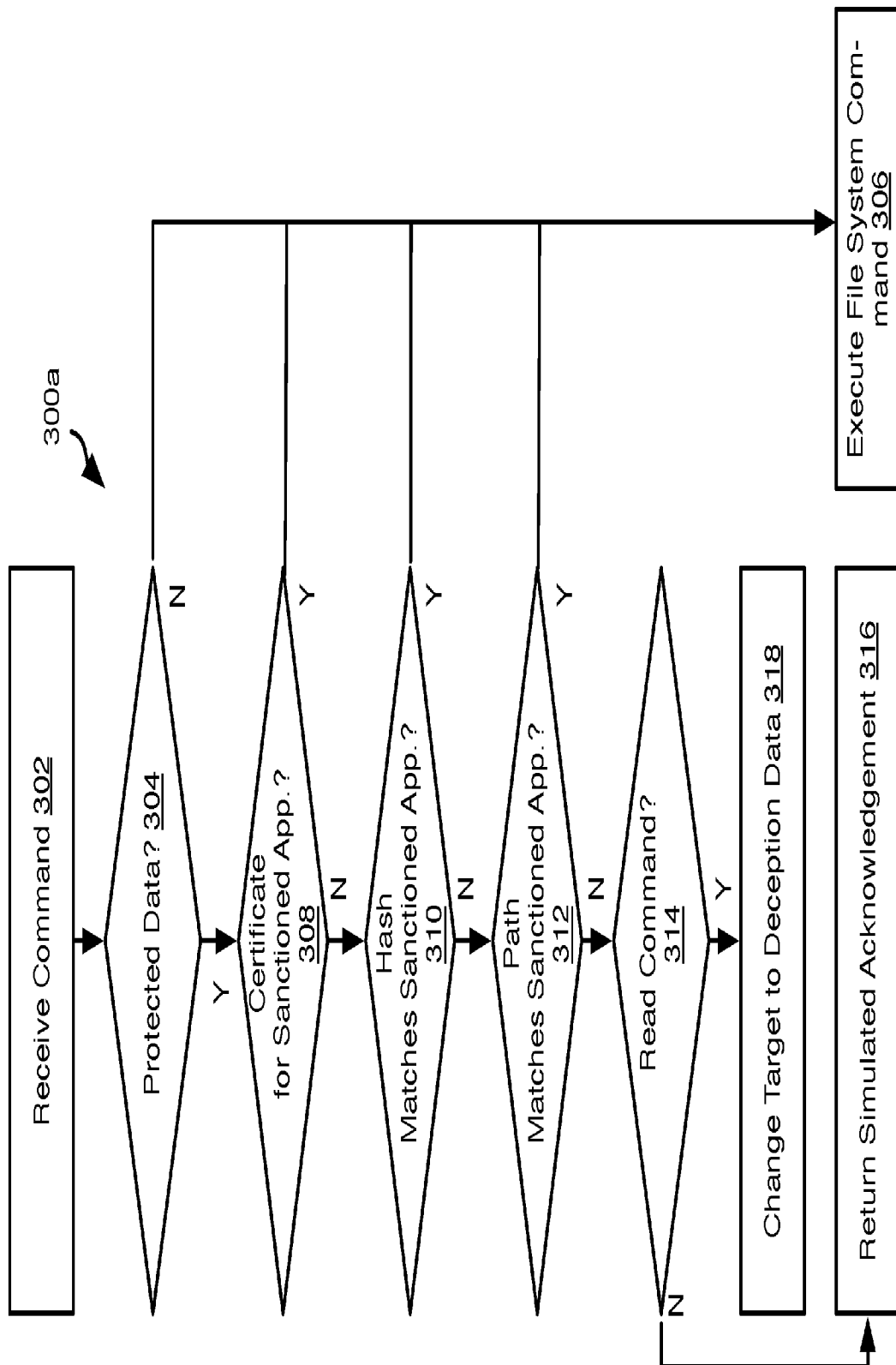


Fig. 3A

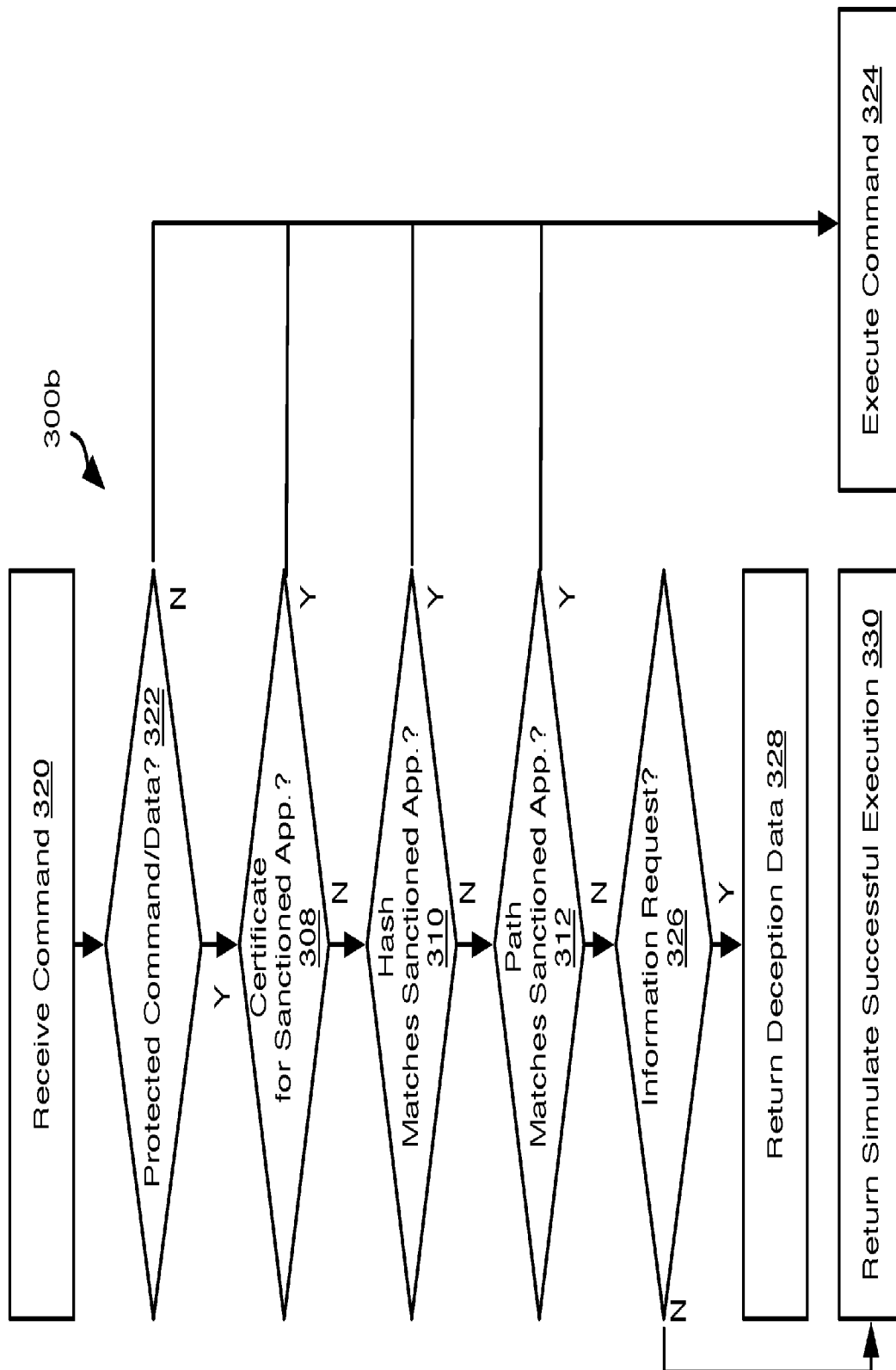


Fig. 3B

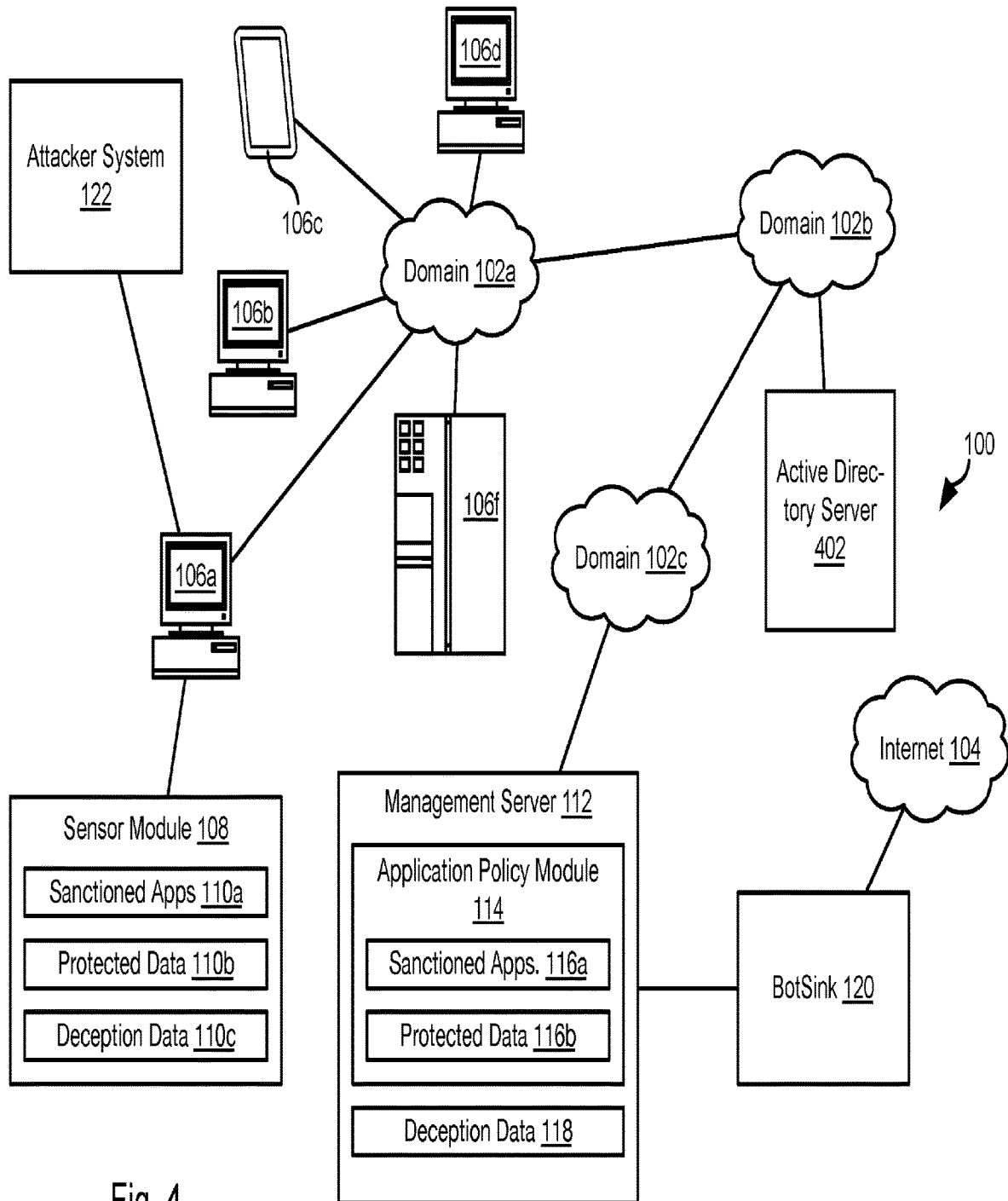


Fig. 4

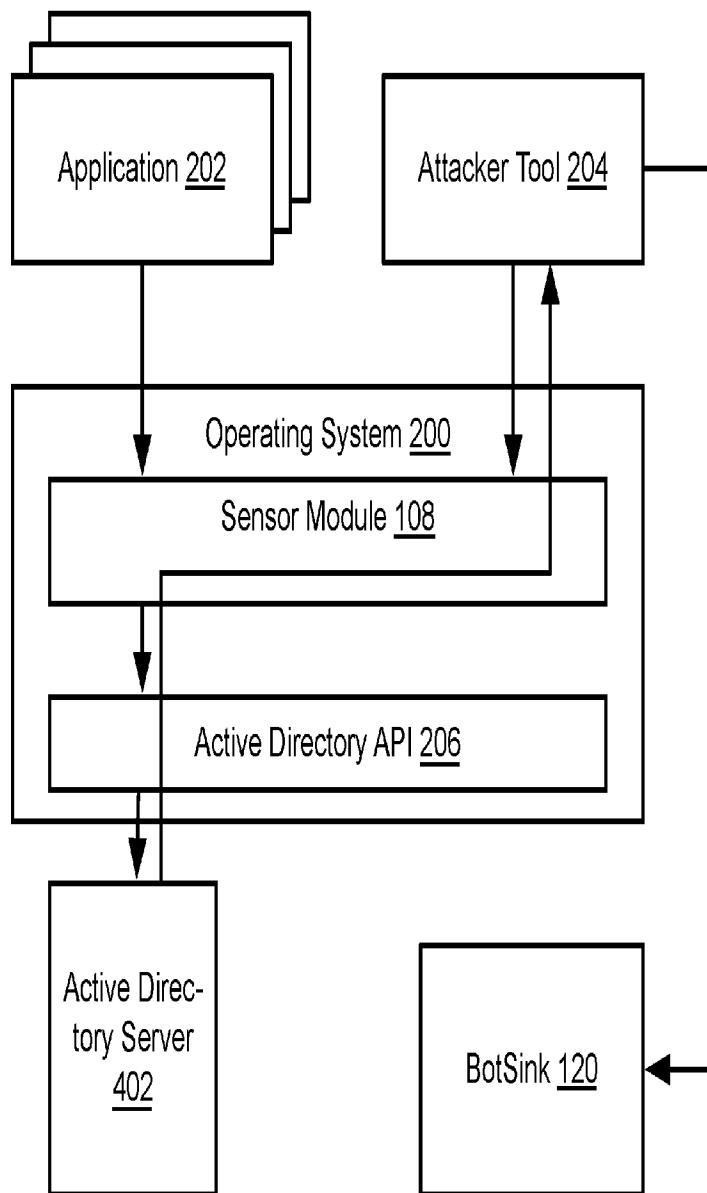


Fig. 5

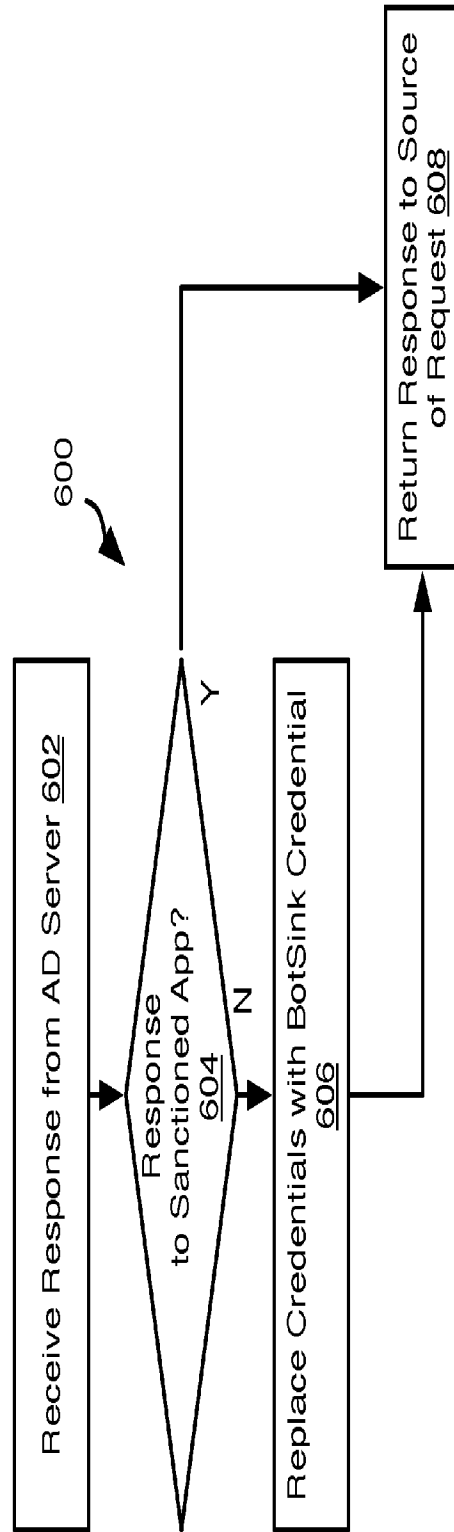


Fig. 6

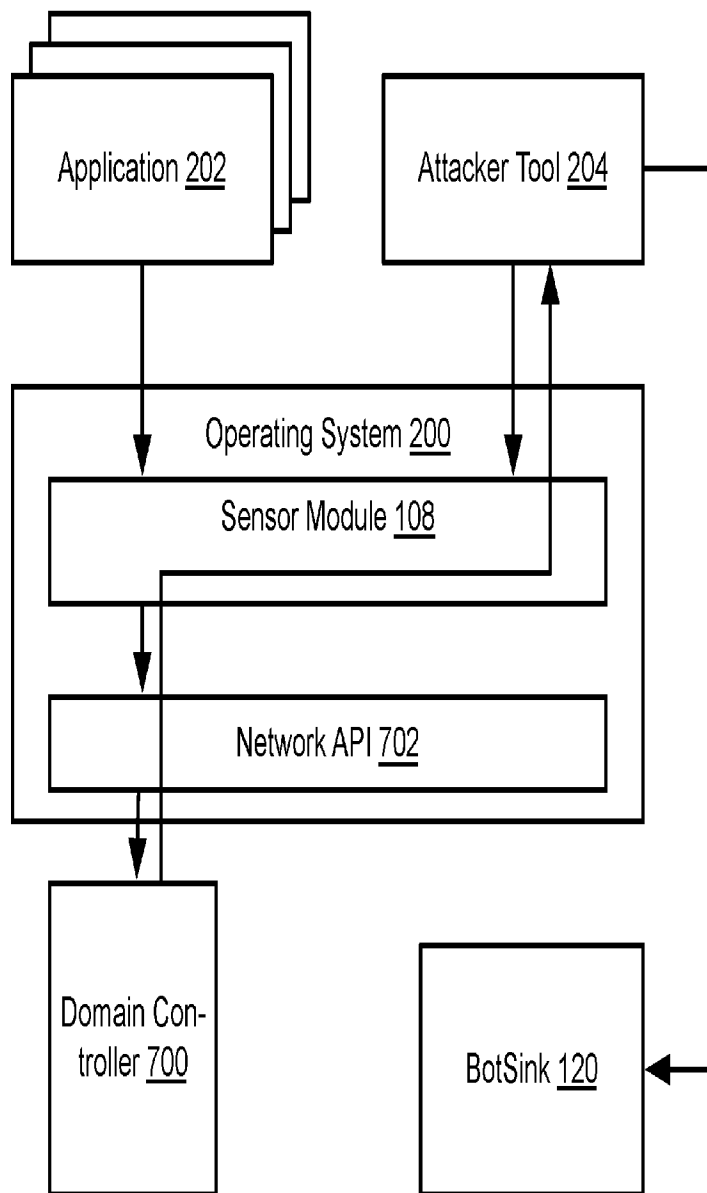


Fig. 7

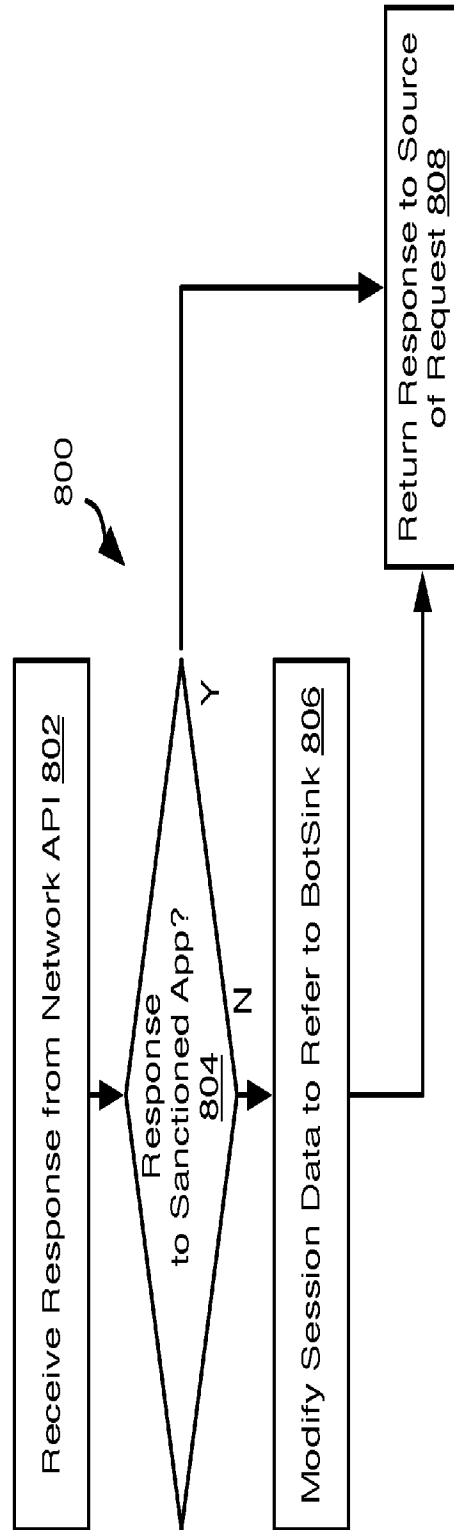


Fig. 8

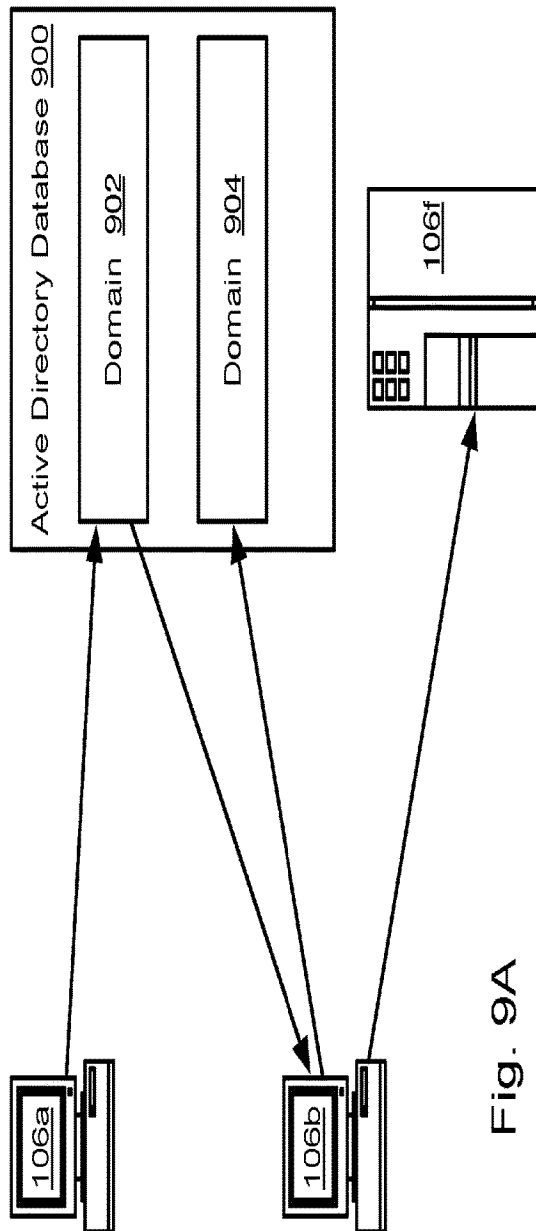


Fig. 9A

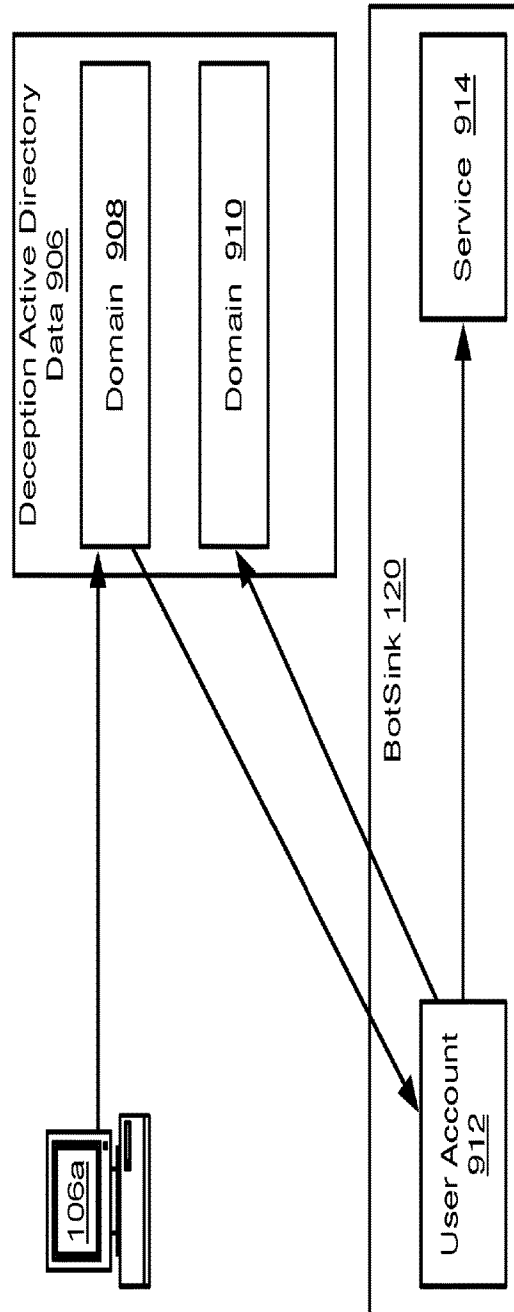


Fig. 9B

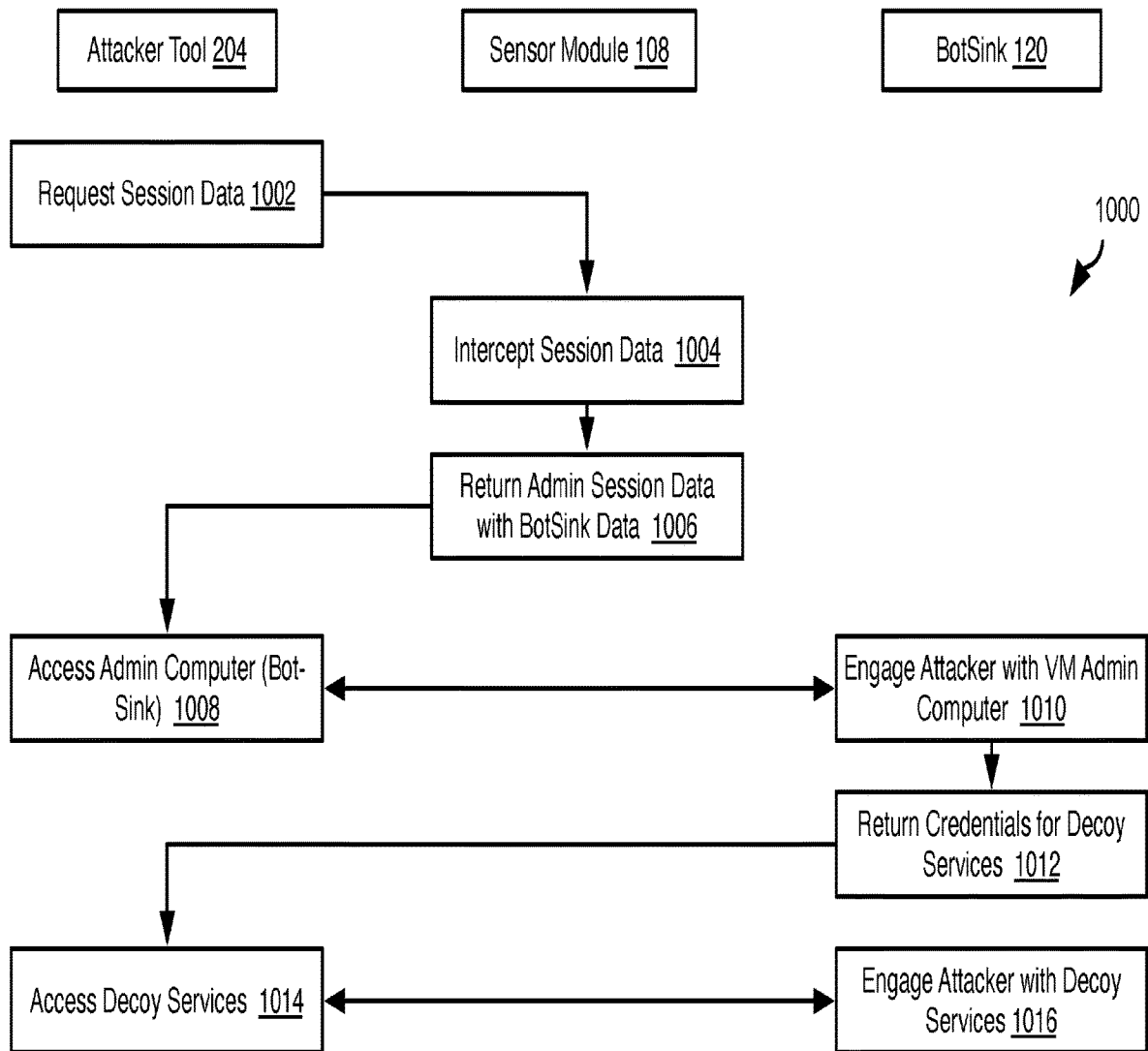


Fig. 10

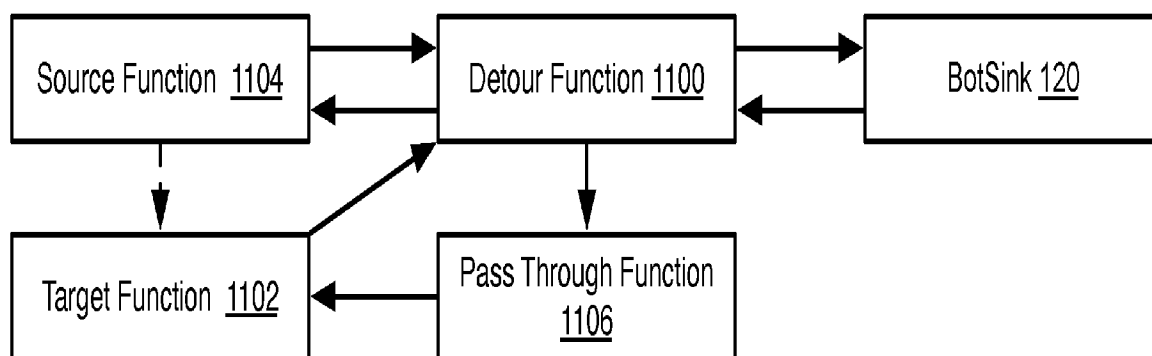


Fig. 11

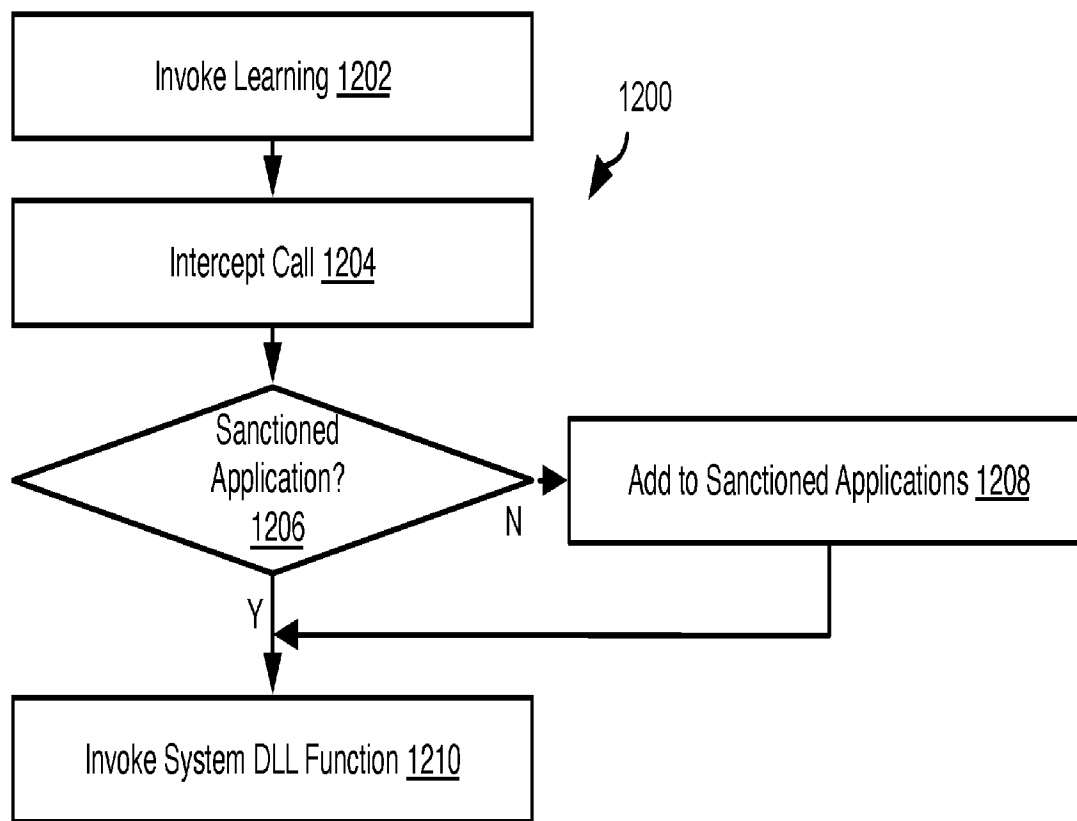


Fig. 12

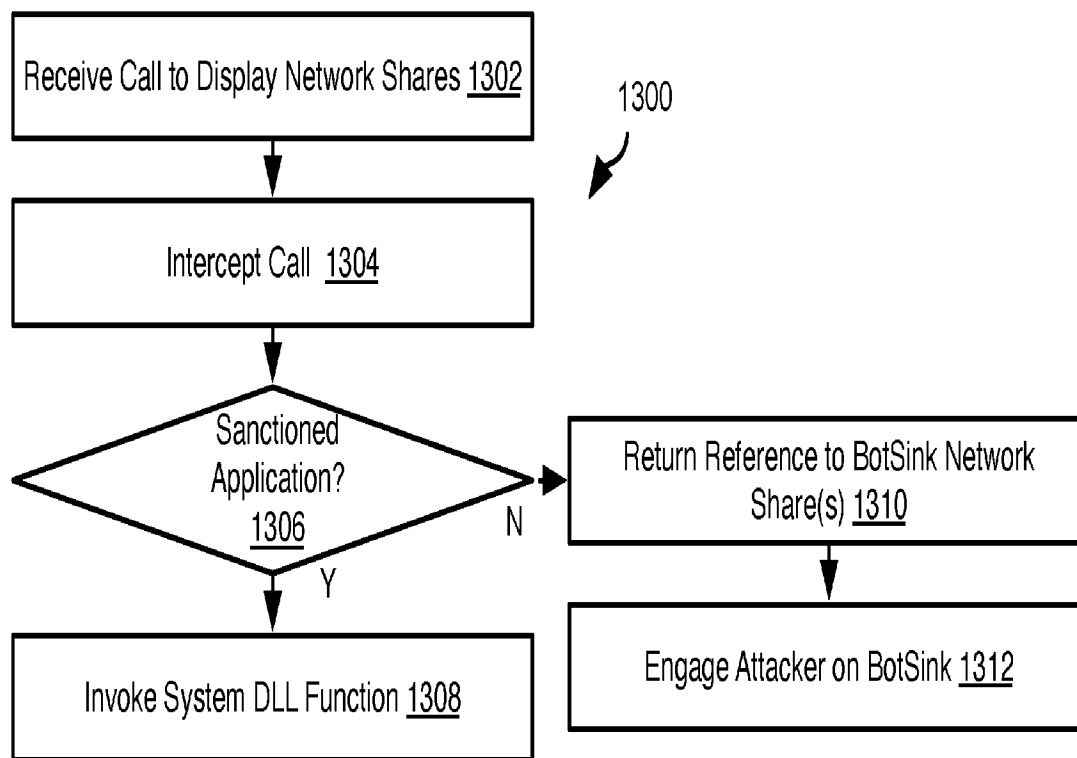


Fig. 13

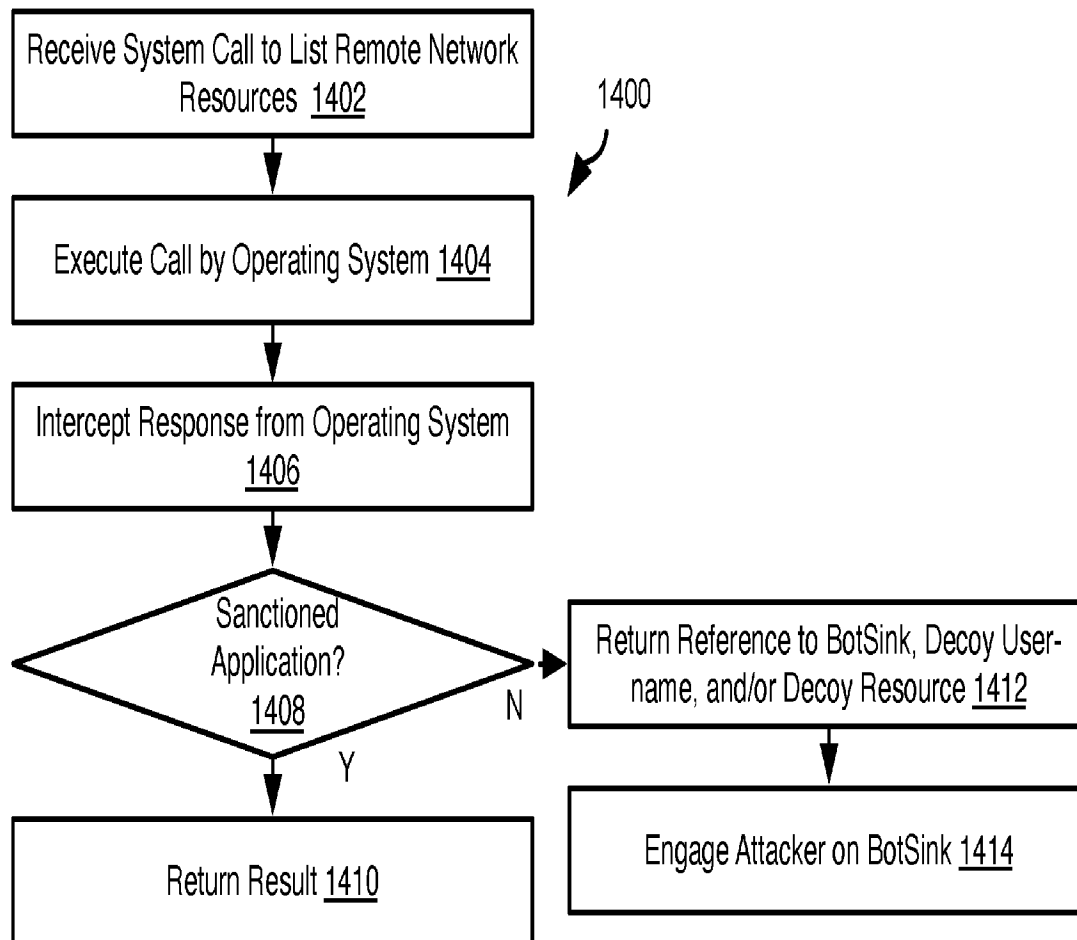


Fig. 14

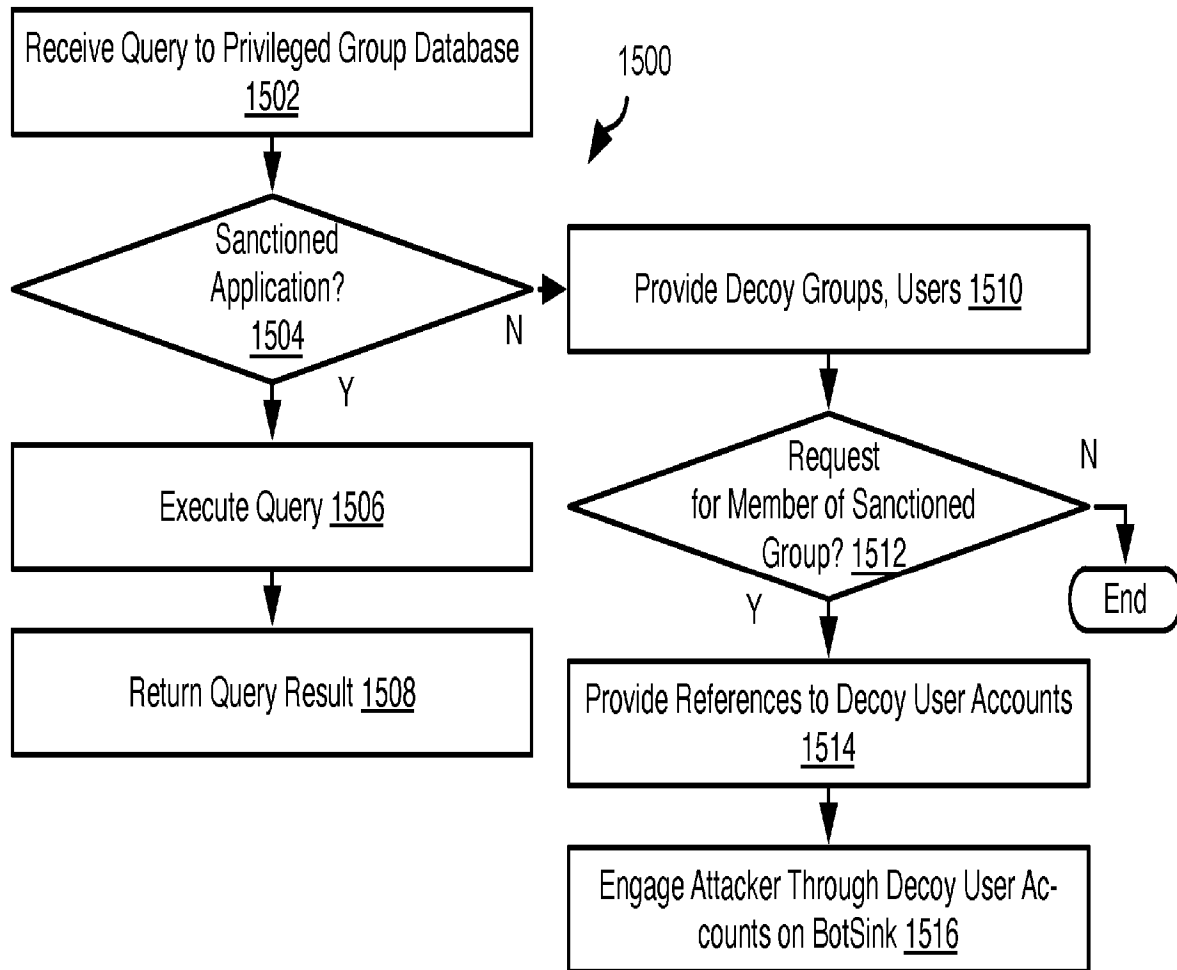


Fig. 15

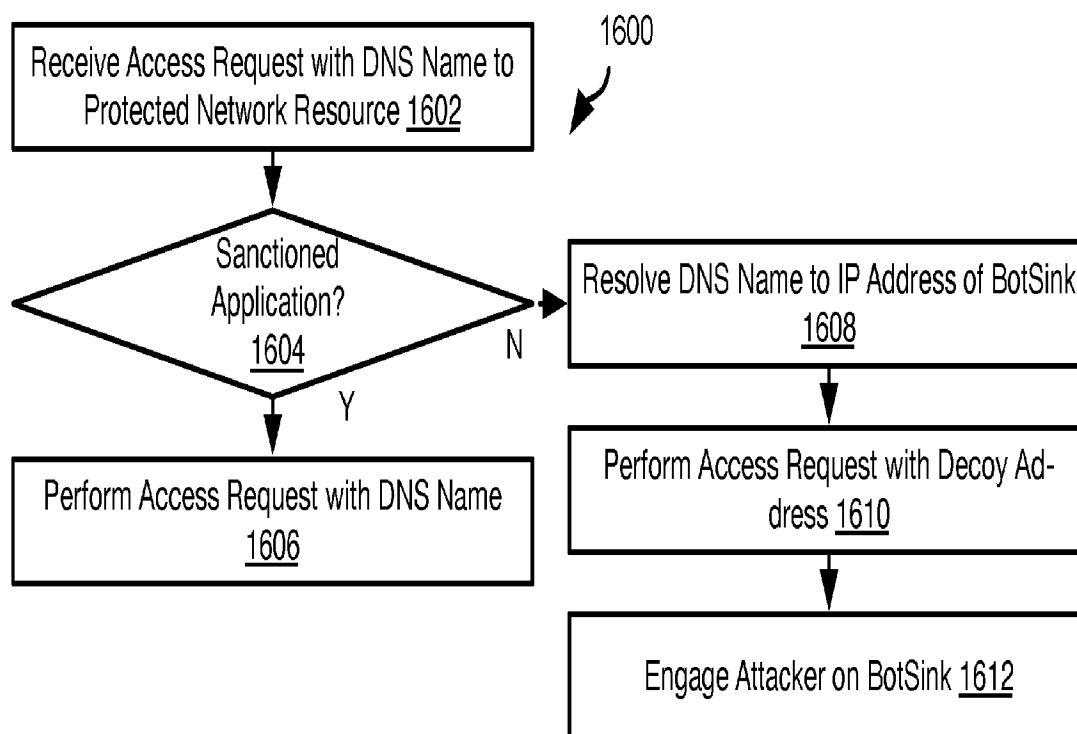


Fig. 16

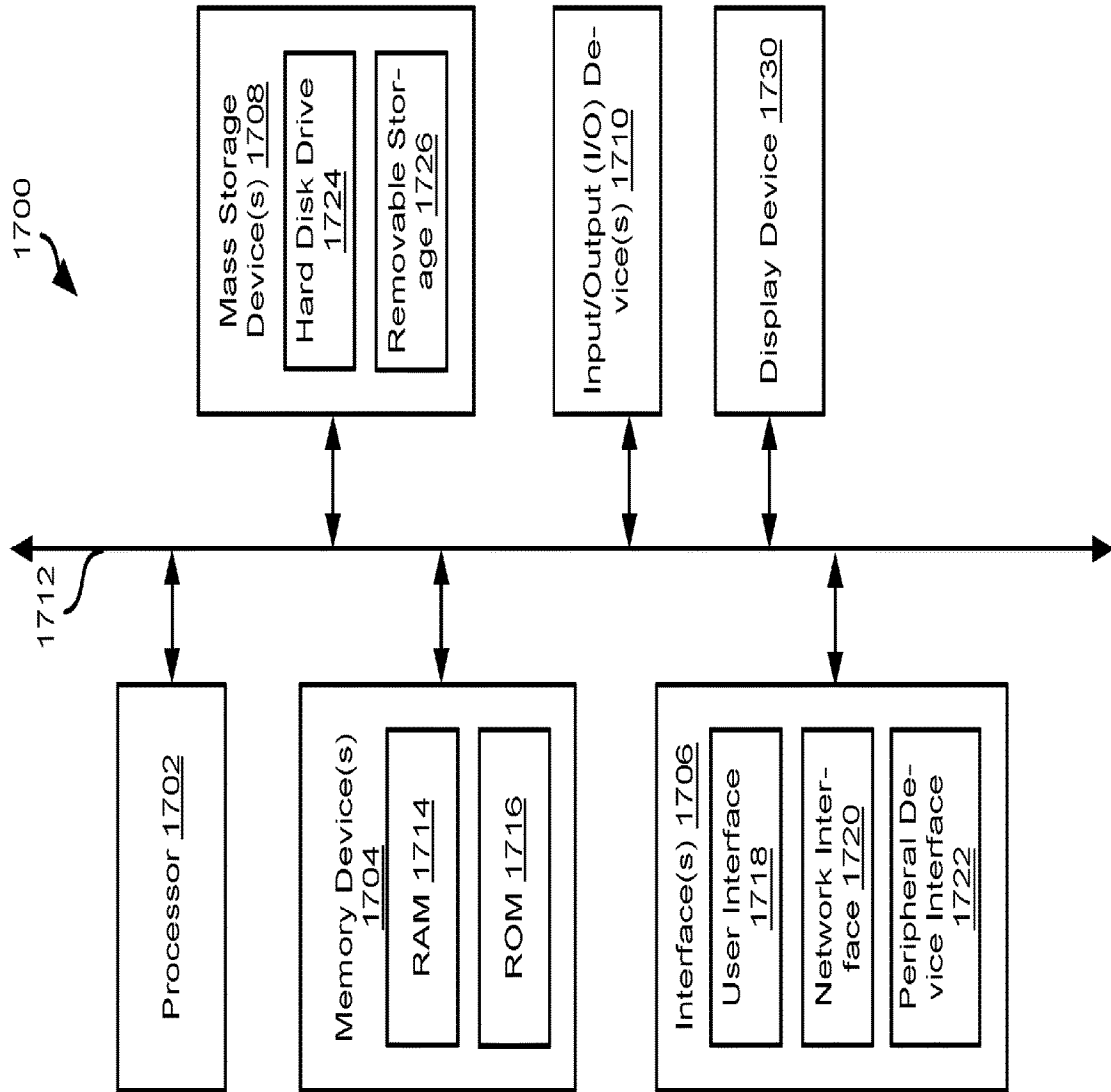


Fig. 17

1

DECEIVING ATTACKERS ACCESSING NETWORK DATA

CROSS-REFERENCE TO RELATED APPLICATION(S)

Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 CFR 1.57.

This application is a continuation of U.S. application Ser. No. 18/183,022, filed Mar. 13, 2023, and entitled “Deceiving Attackers Accessing Network Data”, which is a continuation of U.S. application Ser. No. 16/849,813, filed Apr. 15, 2020, and entitled “Deceiving Attackers Accessing Network Data”, which is a continuation-in-part of U.S. application Ser. No. 16/543,189, filed Aug. 16, 2019, and entitled “Deceiving Attackers Accessing Active Directory Data”, which is hereby incorporated herein by reference in its entirety. U.S. patent application Ser. No. 16/543,189 is a continuation-in-part of U.S. application Ser. No. 15/383,522, filed Dec. 19, 2016, and entitled “Deceiving Attackers in Endpoint Systems”, which is hereby incorporated herein by reference in its entirety for all purposes.

BACKGROUND

Once an end point system is compromised, attackers try to move laterally in the network. Attackers harvest data from end point systems and then use that information to move laterally. The systems and methods disclosed herein provide an improved approach for preventing unauthorized access to application data on endpoint systems.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the advantages of the invention will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered limiting of its scope, the invention will be described and explained with additional specificity and detail through use of the accompanying drawings, in which:

FIG. 1 is a schematic block diagram of a network environment for performing methods in accordance with an embodiment of the present invention;

FIG. 2 is a diagram illustrating components for preventing unauthorized access to application data in accordance with an embodiment of the present invention;

FIGS. 3A and 3B are process flow diagrams of methods for preventing unauthorized access in accordance with an embodiment of the present invention;

FIG. 4 is a schematic block diagram of an alternative network environment for performing methods in accordance with an embodiment of the present invention;

FIG. 5 is a diagram illustrating components for preventing unauthorized access to active directory data in accordance with an embodiment of the present invention;

FIG. 6 is a process flow diagram of a method for preventing unauthorized access to active directory data in accordance with an embodiment of the present invention;

FIG. 7 is a diagram illustrating components for preventing unauthorized access to domain data in accordance with an embodiment of the present invention;

2

FIG. 8 is a process flow diagram of a method for preventing unauthorized access to domain data in accordance with an embodiment of the present invention;

FIG. 9A is a schematic block diagram illustrating exploitation of an active directory server using an infected endpoint;

FIG. 9B is a schematic block diagram illustrating prevention of exploitation of an active directory server using an infected endpoint in accordance with an embodiment of the present invention;

FIG. 10 is a process flow diagram illustrating the use of decoy session data in accordance with an embodiment of the present invention;

FIG. 11 is a schematic block diagram of configuration of dynamic link libraries in accordance with an embodiment of the present invention;

FIG. 12 is a process flow diagram of a method for intercepting system calls in accordance with an embodiment of the present invention;

FIG. 13 is a process flow diagram of a method for intercepting calls to list network shares in accordance with an embodiment of the present invention;

FIG. 14 is a process flow diagram of a method for intercepting calls to list remote network resources in accordance with an embodiment of the present invention;

FIG. 15 is a process flow diagram of a method for intercepting calls to a database for a privileged group in accordance with an embodiment of the present invention;

FIG. 16 is a process flow diagram of a method for intercepting access requests with DNS names in accordance with an embodiment of the present invention; and

FIG. 17 is a schematic block diagram of a computer system suitable for implementing methods in accordance with embodiments of the present invention.

DETAILED DESCRIPTION

It will be readily understood that the components of the invention, as generally described and illustrated in the Figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the invention, as represented in the Figures, is not intended to limit the scope of the invention, as claimed, but is merely representative of certain examples of presently contemplated embodiments in accordance with the invention. The presently described embodiments will be best understood by reference to the drawings, wherein like parts are designated by like numerals throughout.

Embodiments in accordance with the invention may be embodied as an apparatus, method, or computer program product. Accordingly, the invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.), or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “module” or “system.” Furthermore, the invention may take the form of a computer program product embodied in any tangible medium of expression having computer-usable program code embodied in the medium.

Any combination of one or more computer-usable or computer-readable media may be utilized. For example, a computer-readable medium may include one or more of a portable computer diskette, a hard disk, a random access memory (RAM) device, a read-only memory (ROM) device, an erasable programmable read-only memory (EPROM or Flash memory) device, a portable compact disc read-only

memory (CDROM), an optical storage device, and a magnetic storage device. In selected embodiments, a computer-readable medium may comprise any non-transitory medium that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

Computer program code for carrying out operations of the invention may be written in any combination of one or more programming languages, including an object-oriented programming language such as Java, Smalltalk, C++, or the like and conventional procedural programming languages, such as the “C” programming language or similar programming languages, and may also use descriptive or markup languages such as HTML, XML, JSON, and the like. The program code may execute entirely on a computer system as a stand-alone software package, on a stand-alone hardware unit, partly on a remote computer spaced some distance from the computer, or entirely on a remote computer or server. In the latter scenario, the remote computer may be connected to the computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

The invention is described below with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions or code. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a non-transitory computer-readable medium that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable medium produce an article of manufacture including instruction means which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

Referring to FIG. 1, the methods disclosed herein may be practiced in a network environment **100** including a plurality of domains **102a-102c**. The domains **102a-102c** may be any network division, such as a subnet, local area network (LAN), virtual local area network (VLAN), or the like. The domains **102a-102c** may be distributed within a same building or over a large geographic area with interconnecting links including the Internet **104**. The illustrated domains **102a-102c** may represent one or more network components, such as routers, switches, servers, and the like that imple-

ment routing of traffic within the domains **102a-102c** and control traffic flowing into and out of the domains **102a-102c**.

Each domain may include one or more endpoints **106a-106g**. The endpoints **106a-106g** are production computing devices that operate as personal computers for users or servers providing production services to other endpoints or to external computers accessing the network environment by way of the Internet **104**. The endpoints **106a-106g** may be desktop or laptop computers, mobile phones, tablet computers, server computers, and any other type of computing device. Some endpoints **106a-106g** may include internet-enabled devices, i.e. so-called Internet of things (IoT) devices that are often a vulnerability.

The endpoints **106a-106g** are not dedicated honeypots, but rather perform non-decoy functions and process legitimate production data and legitimate production tasks of an enterprise, such as functioning as user computers executing applications such as word processors, browsers, graphics programs etc. The endpoints **106a-106g** may also function as web servers, database servers, remote login servers, application servers, and the like.

Some or all of the endpoints **106a-106g** execute a sensor module **108**. The sensor module **108** stores or accesses a list of sanctioned applications **110a** and may also store or access a listing or description of protected data **110b**. The endpoints **106a-106g** may execute one or more instances of one or more of the sanctioned applications **110a** and store data generated or used by these applications that corresponds to the protected data. The sanctioned applications **110a** are production applications for performing any of the production tasks and functionality mentioned above. Accordingly, the protected data **110b** may also be production data for use in performing the production tasks and functionality mentioned above, as opposed to decoy or deceptive data.

The sensor module **108** may store or access deception data **110c** stored locally on the endpoint **106a-106g** or accessed from another location. The deception data **110c** may mimic the format of production data in the form of web pages, word processor documents, spreadsheets, databases, etc. The deception data **110c** may also mimic other files used by applications such as credentials for authenticating the application with a remote server, configuration files, browser histories, a listing of recently accessed files, configuration files, and the like.

In the case of credentials or other files that are used to access a remote server or provide a record of accessing a remote server, the deception data **110c** may reference a BotSink **120**. The BotSink **120** may function as a honey pot programmed to engage an attacker while preventing access to production data or computer systems. For example, the BotSink **120** may execute one or more virtual machines implementing network services that engage and monitor malicious code while preventing access to other endpoints **106a-106g** of the network. The BotSink **120** may implement any of the method methods for detecting and engaging malicious code disclosed in the following applications (herein after “the incorporated applications”), which are hereby incorporated herein by reference in their entirety:

U.S. application Ser. No. 14/458,026, filed Aug. 12, 2014, and entitled DISTRIBUTED SYSTEM FOR BOT DETECTION;

U.S. application Ser. No. 14/466,646, filed Aug. 22, 2014, and entitled EVALUATING URLS FOR MALICIOUS CONTENT;

U.S. application Ser. No. 14/549,112, filed Nov. 20, 2014, and entitled METHOD FOR DIRECTING MALICIOUS ACTIVITY TO A MONITORING SYSTEM;

U.S. application Ser. No. 15/157,082, filed May 17, 2016, and entitled EMULATING SUCCESSFUL SHELLCODE ATTACKS;

U.S. application Ser. No. 14/805,202, filed Jul. 21, 2015, and entitled MONITORING ACCESS OF NETWORK DARKSPACE;

U.S. application Ser. No. 14/965,574, filed Dec. 10, 2015, and entitled DATABASE DECEPTION IN DIRECTORY SERVICES;

U.S. application Ser. No. 15/142,860, filed Apr. 29, 2016, and entitled AUTHENTICATION INCIDENT DETECTION AND MANAGEMENT;

U.S. application Ser. No. 15/153,471, filed May 12, 2016, and entitled LURING ATTACKERS TOWARDS DECEPTION SERVERS;

U.S. application Ser. No. 15/204,779, filed Jul. 7, 2016, and entitled DETECTING MAN-IN-THE-MIDDLE ATTACKS; and

U.S. application Ser. No. 15/360,117, filed Nov. 23, 2016, and entitled IMPLEMENTING DECOYS IN NETWORK ENDPOINTS.

In some embodiments, the data **110a-110c** is provided to the endpoints **106a-106g** by a management server **112**. The management server **112** may implement an application policy module **114**. The application policy module **114** stores or accesses a listing **116a** of sanctioned applications and may provide an interface for an administrator to specify what applications are included in the listing **116a**. The listing **116a** may indicate which applications are sanctioned for particular endpoints **106a-106g** or for endpoints in a particular domain **102a-102c**. The listing **116a** may be automatically updated to include applications as they are installed on endpoints **106a-106g** by an administrator.

In a similar manner, the management server **112** may store or access protected data **116b** that lists data files, folders, or other descriptors of data that are protected. The protected data **116b** may be obtained automatically from configuration files for applications. For example, an application on installation will often create directories for files used by the application. Accordingly, these directories and files may be observed by analyzing the configuration files for instructions to create these directories and files or by observing how the file system changes following installation of the application on a sample endpoint.

The management server **112** may also store or access deception data **118**. As noted above, this deception data may mimic production data for one or more applications and may reference the BotSink **120** in order to lure attackers into engagement with the BotSink **120**.

The management server **112** distributes some or all of the data **116a-116b**, **118** to the endpoints **106a-106g**. For example, deception data **118** provided to an endpoint may mimic files generated or used by one or more production applications actually installed on that endpoint. Likewise, the listing of sanctioned applications **116a** provided to the endpoint may include only those applications that were installed by an administrator or authorized user on that endpoint. The deception data **118** provided to the endpoint may then include deception data mimicking the production data of those applications. The management server **112** may periodically update the data **116a-116b**, **118** and distribute updated data to the endpoints **106a-106g**.

The methods disclosed herein are invoked in response to an attacker system **122** attempting to access production

application data on an endpoint **106a-106g**. This may include the attacker system **122** issuing commands to the endpoint **106a-106g** or uploading malicious code to the endpoint **106a-106g**, which then attempts to access the production application data. However, unauthorized access may be prevented using the methods disclosed herein in either case.

Referring to FIG. 2, the sensor module **108** may be incorporated into the operating system **200**, such as by modifying the functions of one or more libraries for performing access to a file system. The sensor module **108** intercepts file system command from instances of applications **202** installed on the endpoint as well as file system commands from an attacker, such as an attacker tool **204** executing on the endpoint. The file system commands that are intercepted may include write commands, read commands, delete commands, or instructions to list the contents of a directory or other commands to navigate through a directory.

The sensor module **108** evaluates a source of each command, e.g. the binary instance executing on the endpoint that issued the command to the operating system. If the source of the command is an application listed in the sanctioned applications **110a**, the command is passed to the file system I/O (input output) functions **206** of the operating system **200**, which then executes the command with respect to the production application data **208**.

If the source of the command is not found to be in the sanctioned applications **110a**, the command may be modified such that it refers to deception data **110c**. The modified command may then be input to the file system I/O functions **206**. In the case of a write or delete command, the sensor module **108** may suppress execution of the command and return an acknowledgment to the source of the command indicating that the command was executed successfully.

In the embodiment of FIG. 2, the modified commands are executed by the same file system I/O functions **206** as other commands. Accordingly, the deception data **110c** may be stored in the file system and accessible to such functions **206**. However, the deception data **110c** may be hidden such that it is not viewable by users or applications executing on the endpoint.

In other embodiments, the sensor module **108** itself may access and return the deception data **110c**, in which case the deception data **110c** may be stored anywhere, including remotely from the endpoint and referenced by the sensor module **108**. The deception data **110c** could, for example, be encrypted such that only the sensor module **108** can decrypt the deception data **110c** in order to return it in response to a read command from the attacker tool **204** or other unauthorized source.

In still other embodiments, the sensor module **108** may automatically generate deception data **110c** in response to file system commands, such as based on templates that are populated with random data in order to mimic a type of file requested by the file system command from the attacker tool **204**.

Referring to FIG. 3A, the sensor module **108** may include any executable code programmed to execute the illustrated method **300a**. The method **300a** may include receiving **302** a file system command, such as by intercepting a command made to the operating system **200** of the endpoint in which the sensor module **108** is embedded.

The method **300a** may include evaluating **304** whether the data (file, directory, type of file, etc.) is protected data, such as might be indicated by the listing **110b** of protected data on the endpoint. If not, the method **300a** may include executing

306 the file system command without modification, i.e. passing it to the operating system **200** for execution. In some embodiments, only the sanctioned applications **110a** are permitted to issue file system commands, which may include operating system utilities. Accordingly, in some embodiments, step **304** may be omitted.

The method **300a** may further include evaluating a source of the file system command according to some or all of steps **308-312**. For example, if the source of the file system command is found **308** to have a certificate matching that of a sanctioned application **110a**, then file system command may be executed **306** with respect to the data referenced in the command.

If a hash, e.g. the SHA-1 (secure hash algorithm) hash of the binary code that issued the file system command is found **310** to match a hash of the binary executable for one of the sanctioned applications **110a**, then the file system command may be executed **306** with respect to the data referenced in the command.

If a path to the binary code that issued the file system command is found **312** to match the path to the binary executable of one of the sanctioned applications **110a**, then the file system command may be executed **306** with respect to the data referenced in the command.

Steps **308-312** are just examples of checks that may be used to verify whether binary code issuing a command is in fact an instance of a sanctioned application. In some embodiments, all of steps **308-312** must be satisfied before step **306** will be executed with respect to the data referenced in the command. In other embodiments, other checks may be used as alternatives or as additional requirements before step **306** will be executed with respect to the data referenced in the command.

In some embodiments, certain protected data may be bound to a particular sanctioned application **110a**. Accordingly steps **308-312** may be evaluated only for those applications that are bound to the protected data **110b** referenced in the file system command, i.e. the command will be executed with respect to the data referenced in the command only if one of **308-312** (or each and every one of **308-312** in some embodiments) is satisfied for at least one sanctioned application **110a** that is also bound to the protected data **110b** referenced in the file system command.

If the tests of steps **308-312** are not sufficient to invoke execution of step **306** for the data referenced in the file system command according to any of the embodiments mentioned above, then the source of the file system command may be determined not to be one of the sanctioned applications **110a** and processing continues at steps **314**, **318**.

If the file system command is found **314** to be a read command, then file system command may be changed **318** to refer to the deception data **110c** of the endpoint. Step **306** may be executed with respect to the modified file system command, which will include returning the deception data referenced by the modified file to the source of the file system command, such as to the attacker tool **204**.

If the file system command is found **316** not to be a read command, such as in the case of a write or a delete command, then the file system command is ignored and a simulated acknowledgment of the command is returned **316** to the source of the file system command.

Referring to FIG. 3B, in some embodiments, the sensor module **108**, or a different sensor module **108** may execute the illustrated method **300b** with respect to commands other than file system commands. In some embodiments, a plurality of sensor modules **108** execute on the endpoint and

each sensor module **108** may intercept a different types of command. Each sensor module will then execute the method **300a** or **300b** upon intercepting that type of command. For example, requests to modify, delete, or read information regarding processes executing on the endpoint, the registry of the endpoint, or an application programming interface (API) available to applications executing on the endpoint. The method **300b** may include receiving **320** a command and evaluating **322** whether the command references protected data or is a protected command. If not, then the command may be executed **324**. For example, the protected data **110b** may indicate which commands are restricted to sanctioned applications **110a** in addition to data or types of data that are protected. In some embodiments, only sanctioned applications are permitted to access any data or invoke execution of any command. Accordingly, step **322** may be omitted as a path to execution **324** of a command.

The method **300b** may further include evaluating the source of the command of step **320** according to steps **308-312** in the same manner as for the method **300a**. If the conditions of steps **308-312** are met, then the command may be executed in the same form it was received. As for the method **300a**, all of steps **308-312** must have a positive result before the command is executed **324** and one or more additional tests may be required to be satisfied before the command is executed **324** without modification.

If the steps **308-312** indicate that the source is a sanctioned application, then the method **300b** may include evaluating **326** whether the command is a request for information, such as a request for information regarding executing processes, the registry, available APIs, or other system information. If so, then deception data is returned **328** to the source of the command. As for other embodiments disclosed herein, the deception data that is returned may mimic the legitimate data that is requested but not correspond to actual system data.

If the command is not a request for information, the method **300b** may include returning **330** a result that simulates successful execution of the command. As for the method **300a**, a delete command may indicate that data was successfully deleted, a modify command may indicate that the system data or process or operating parameter referenced in the command was modified as requested.

An example of the use of the method **300a** may include the browser history for a browser. For example, the FIREFOX browser history may be stored at C:\Users\<user name>\AppData\Roaming\Mozilla Firefox\Profiles\<some profile number>.default\formhistory.sqlite. Ordinarily, only the FIREFOX browser should access this file inasmuch as it will include functions for displaying the browser history on request. Accordingly, any other application attempting to access this file or its directory may be blocked by the sensor module **108** and instead receive a simulated browser history file including decoy data.

In another example, in Windows, the "shadowcopy delete" command deletes the volume shadow copies. Malware often deletes this to accessing of backup volumes. Accordingly, this file may be listed as protected data **110b** and sensor module **108** will detect attempts to delete the volume shadow copies by non-sanctioned applications and prevent their execution. As noted above, acknowledgments of such commands may be returned indicating that the volume shadow copies were in fact deleted.

In an example of the use of the method **30b**, an attacker, e.g. attacker tool **122**, tries to access the registry, which may be in a listing of protected data **110b**. For example, the attacker may attempt to read the registry to determine a

registry key for one or more antivirus application (e.g., McAfee, SYMANTEC, or the like) is present in the registry. No legitimate application would generally need to access the registry to determine whether an antivirus application is installed. In some embodiments, the sensor module **108** may intercept such attempts and return a result including a registry key for the antivirus tool, regardless of whether the antivirus application is installed. In many cases, this will cause the attacker tool to refrain from installing itself or otherwise attempting to perform malicious activities.

In another example, the attacker, e.g. attacker tool **122**, seeks to determine whether the endpoint is a virtual machine (VM), such as by evaluating the registry to determine whether a hypervisor is installed and/or executing on the endpoint. The sensor module **108** intercepts these requests and returns an output indicating that the endpoint is executing a VM, e.g. indicate that the current operating environment in which the command was received is a VM or that a hypervisor is installed and/or executing on the endpoint. In another example, the attacker, e.g. attacker tool **122**, seeks to view a list of processes executing on the endpoint. In response, the sensor module **108** will return a "correct list of processes list" to the attacker.

Referring to FIG. 4, the network environment **100** may further include an active directory server **402** in one or more of the domains **102a-102c**. The active directory server **402** may implement a directory service. A directory service functions as databases that map and store the names of network resources to their respective network addresses. Users referencing network objects need not remember the physical address of the object. The directory may store network resources and those resources may or may not have a name. The directory can also store user identifiers (very common), departments of user identifiers, access level of user identifiers, hosts accessible by user identifiers, the access level associated with each user identifier. The directory may further store organizational details, a network topology, an IT policy, and the like. Although Active Directory, the most popular directory server, depends on DNS very heavily, it is distinct therefrom and provides much more than a simple mapping between domain names and IP addresses. In particular, directory services may perform authentication for access to resources as well. LDAP (Lightweight Directory Access Protocol) is one of the popular methods available to access the data in directory services. LDAP also provides authentication and authorization to let user access resources in directory services.

The directory service implemented by the active directory server **402** may provide authorization and access to key assets in corporate networks. Attackers may use various methods of exploitation to get unauthorized access to directory services. Once an attacker obtains access to a directory service, the attacker can easily log into key servers, databases etc. by impersonating credentials stored in directory services. The attacker may then exfiltrate data. For example, confidential data may be disclosed. In some instances, unauthorized modifications could be made (such as new account creation, access control modifications, document forgery, backup corruption, unauthorized financial transactions etc.) or data may be made unavailable (such as crypto malware, bank account takeover, bringing down or defacement of corporate web servers).

The systems and methods disclosed herein incorporate database deception into directory services so that attackers cannot differentiate between real production assets with respect to fake assets. Once an attacker access fake creden-

tials pointing to a BotSink **120**, the system prevents outbound access and simulates access to actual enterprise assets. This enables the identification and analysis of attackers for use in preventing data breaches.

"Active Directory" (AD) is one of the directory services supported by WINDOWS operating systems. The AD domain controller is a server that provides authentication services within a domain whereby it provides access to computer resources. AD provides a database storing information about objects. Each object can be a user, computer, or a group of users. Although the systems and methods disclosed herein are described for use with an Active Directory system, they may be applied with equal effectiveness to any directory service.

The systems and methods described herein returns simulated responses to requests to an active directory server **402**. These responses reference the BotSink **120** and may include credentials for authenticating with respect to the BotSink **120**, such as a user account defined on the BotSink **120** or a service executing on the BotSink **120**. These responses lure an attacker to use the service or to attempt to use the user account. However, use of such services or accounts results in engagement of the attacker with the BotSink **120** and other resources described herein. This enables early detection of malicious intent and account misuse and diverts attention from real targets and resources.

Referring to FIG. 5, in some embodiments, the sensor module **108** on an endpoint **106a-106g** may detect responses from an active directory server **402**. These responses may be the result of requests issued to the active directory server **402** by an application **202** or attacker tool **204** executing on that endpoint **106a-106g**. For example, the sensor module **108** may operate in conjunction with substituted or modified functions in an active directory API (application programming interface) in the operating system **200** of an endpoint **106a-106g**. The substituted or modified functions may route responses from the active directory server **402** to the sensor module **108** prior to return of the response to the application that requested it. The sensor module **108** may then determine whether to return the response to an application **202** to which the response is addressed without modification or with modification. In particular, if the response is addressed to an attacker tool **204** that is not a sanctioned application, the response may be modified such that any system, user account, or credential included in the response is replaced with corresponding references to the BotSink **120**, decoy computer on the BotSink **120**, a credential or user account for authenticating with the BotSink **120** (e.g., logging in, accessing a particular service, etc.).

The manner in which the application to which the response is addressed is determined to be sanctioned or not may be according to the approach described in either of FIGS. 3A and 3B. In particular, the response from the active directory server **402** may be received on a port with respect to which an application is registered by the operating system **200**. Accordingly, the sensor module **108** may evaluate that application to determine whether it is sanctioned according to the approach of either of FIGS. 3A and 3B. If not, the response is modified at step **606** to replace references to addresses, actual user accounts, services, computer systems, or other production resources with corresponding references to the BotSink **120**, i.e. an address of the BotSink **120**, a decoy user account, decoy service, decoy virtual machine, or other decoy resource executing on the BotSink **120**.

Referring to FIG. 6, the sensor module **108** may execute the illustrated method **600** with respect to responses from the active directory server **402**. The method **600** includes receiv-

11

ing **602** a response from the active directory server **402** by the sensor module **108**. The sensor module **108** evaluates **604** whether the application to which the response is addressed is sanctioned. For example, this may include evaluating an application listening to a port to which the response was addressed. Alternatively, the response may include some other identifier that is sufficient to identify the application (i.e. instance of an application executing on operating system **200** to which the response is addressed. As noted above, receiving the response may be performed by interfacing with an API programmed to interface with the active directory server **402** such that response are intercepted before they are returned to the requesting application. For example, the sensor module **108** may interface with substituted or modified versions of the Power Shell such that commands input to the Power Shell are intercepted and possibly modified by the sensor module **108**. Commands that may be intercepted may include commands such as 'net group/domain "domain users"' will return list of domain users present in Active Directory. Other example commands include 'Get-ADComputer-Filter*' will return all computer accounts in Active Directory, "nltest/dclist: domain name" will return domains in the network.

The modified response is then returned **608** to the application to which it is addressed, i.e. the application that requested the information included in the response from the active directory server **402**. Where the application is found **604** to be sanctioned, the original response, or data from the response, is returned **608** to the source of the request without substituting references to the BotSink **120**.

Note that FIG. 6 illustrates the case where a response from the active directory service is received and modified. In other embodiments, a request from an application that is not sanctioned that is addressed to the active directory service is intercepted and simulated response is generated that references the BotSink **120**, i.e. a response that has an expected format corresponding to the request but with names of systems, addresses, credentials, services, etc. referencing such entities as implemented by the BotSink **120**.

In some embodiments, the active directory server **402** may host decoy information describing a configuration of the BotSink **120**, such as decoy information describing decoy users accounts, addresses of decoy systems (virtual machines), decoy services, and decoy credentials for accessing any of these accounts, systems, and services. Accordingly, modifying a request by the sensor module may include modifying the request such that it is a request for decoy information on the active directory server (e.g., references the BotSink **120**) such that the response from the active directory server **402** includes only the decoy information rather than the information actually requested.

In some embodiments, authenticated users of an endpoint **106a-106g** are added to a whitelist accessed by the sensor module **108** such that requests to the active directory server **402** and responses received are not substituted according to the method **600**.

Referring to FIG. 7, in some embodiments, the sensor module **108** intercepts responses to requests to a domain controller **700**. In some embodiments, the function of the domain controller **700** is performed by a domain joined computer. For example, the sensor module **108** may monitor one or both of requests to a network API **702** of the operating system **200** to the domain controller **700** and responses to such requests.

For example, referring to the method **800** of FIG. 8, the responses may be responses to requests for session data issued received **802** from a network API **702**. A response

12

determined **804** to be to a non-sanctioned application may be modified at step **806** to refer to the BotSink **120** and returned **808** to the non-sanctioned application. In one scenario, an attacker tool **204** executing on an infected endpoint (e.g., endpoint **106a**) requests session data from the domain controller **700** or domain joined computer **700** using information learned via earlier active directory queries.

Responses determined **804** to be in response to requests from sanctioned applications **202** may be returned **808** to them without replacing a reference to a computer system in the response with a reference to the BotSink **120**. The manner in which an application is determined **804** to be sanctioned may be performed in the same manner described above with respect to either of FIGS. 3A and 3B.

FIGS. 9A and 9B illustrate how the methods **600** and **800** may be used to redirect and occupy an attacker. In an unprotected case shown in FIG. 9A, an attacker tool **204** on an infected endpoint **106a** uses the active directory API on the infected system to access an active directory database **900** through the active directory server **402**. Using this information, the attacker tool **204** uses the network API to request session data in order to identity of an endpoint **106b** logged in to the domain account for a domain to which infected endpoint **106a** belong. The attacker tool may infect the administrator endpoint **106b** and access the active directory database **900** and discover that the admin user account is referenced in domain data **904** defining another group, e.g. an administrator group. The endpoint **106b** may further store credentials enabling the endpoint **106b** to access a service hosted by server **106f**.

Accordingly, the attacker tool **204** on the infected system **106a** may attempt to move laterally by requesting information from the active directory server **402** in order to discover the endpoint **106b** of the admin user account, infect it, and use it to access the service on server **106f** as an administrator.

FIG. 9B illustrates an alternative view seen by an attacker tool **204** on the infected endpoint **106a** when the methods according to FIGS. 4 through 6 are implemented. The attacker tool **204** requests information from the active directory server **402**. The responses to these requests are modified to reference decoy information, such as decoy active directory data **906** having a same format as the active directory database **900** but with references to computer systems and services being replaced with references to the BotSink **120** (e.g. virtual machines executing on the BotSink **120**) and services executing on the BotSink **120**.

A response to a request to obtain the identity of an administrator of a domain to which the endpoint **106a** belongs using the network API is intercepted and modified to reference to a decoy domain **908**. A request for the identity of the administrator of the decoy domain **908** may include a reference to a user account **912** or virtual machine logged in to a user account **912** on the BotSink **120**. That user account **912** may be defined as part of an admin domain **910** and that user account **912** may include credentials (e.g., VM for which the user account **912** is logged in may store or reference credentials) that are sufficient to authenticate a user with respect to a service **914** executing on the BotSink **120**.

Accordingly, the attacker tool **204** may attempt to move laterally as in the case of FIG. 9A but only engage the BotSink **120**. The activities of the attacker tool **204** may be monitored and logged by the BotSink **120** in order to characterize the attacker tool **204** and alerts may be generated to alert and administrator to remove the attacker tool **204** from the infected endpoint **106a**. Engaging, monitoring, logging, characterizing, and generation of alerts may be

13

performed according to any of the approaches described in the incorporated applications.

FIG. 10 illustrates a method 1000 that may be implemented using the system shown in FIG. 9B. An attacker tool 204 executing on an infected endpoint (e.g., endpoint 106a) requests 1002 session data using a network API for the domain of the infected endpoint, the session data indicating computers (e.g., computers in the same domain) that are connected to the active directory server 402. For example, a network API command for requesting such session data may be used. The sensor module 108 intercepts 1004 a response to this request and determines that the attacker tool 204 is a non-sanctioned application attempting to access restricted data (see FIG. 6). In response, the sensor module 108 returns 1006 the session data with references to one or more computers in the session data replaced with one or more addresses assigned to the BotSink 120. In the alternative, the sensor module 108 intercepts the request for session data and creates a decoy response referencing the BotSink 120 rather than modifying a response from the active directory server 402.

In particular, the IP address of the computer logged in to the administrator account of the domain may be replaced with an IP address assigned to the BotSink 120. For example, the BotSink 120 may acquire IP addresses in various domains as described in the incorporated applications. Each address added to the session data may be assigned to a virtual machine (VM) executing on the BotSink 120.

The attacker tool 204 may then attempt to access 1008 the computer logged in to the administrator account, which is in fact the BotSink 120. The BotSink 120 (e.g., the VM assigned the IP address represented as that of the administrator's computer at step 1006 ("the admin VM")) may then engage 1010 the attacker tool. The activities of the attacker tool 204 with respect to the BotSink 120 may be monitored and stored in order to characterize the attacker tool 204 as described in the incorporated applications.

In particular, the attacker tool 204 may attempt to obtain credentials or identifiers of services cached or stored by the admin VM. In response, these credentials may be returned 1012 to the attacker tool. However, these credentials or identifiers of services may reference services implemented by the BotSink 120, such as by other VMs being executed by the BotSink 120. The attacker tool 204 receives the credentials or identifiers and attempts to access 1014 the services represented by them.

In response, the BotSink 120 authenticates the attacker tool 204 and engages 1016 with the attacker tool 204 using the service, i.e. executes commands from the attacker tool in accordance with the service. Actions of the attacker tool 204 may be monitored and used to characterize the attacker tool 204 as described in the incorporated applications. In addition or as an alternative, interaction with the BotSink 120 at steps 1010, 1012, and 1016 by the attacker tool may trigger an alert or remedial action such as removing the attacker tool 204 from the infected endpoint 106a or isolating (disconnecting) the infected endpoint 106a from a network.

Note that in some embodiments, one of the services implemented on the BotSink 120 may be a decoy active directory service that implements an interface for responding to commands in the active directory API and is programmed to respond to these commands with decoy data referencing decoy computers, user accounts, and services implemented on the BotSink 120.

Referring to FIG. 11, in some implementations, intercepting of system calls according to the foregoing and subse-

14

quent embodiments may be implemented by substituting a reference to a detour function 1100 in the place of a target function 1102 in source function 1104 such that when the source function 1104 executes code that would have called the target function 1102, the detour function 1100 is called instead. For example, this reference replacement may be made in dynamic link libraries (DLL) of the operating system on the endpoint 106a-106g or other files of the operating system.

The detour function 1100 may perform evaluations described herein to determine whether the call should be handled in cooperation with the BotSink 120 or should be passed on to the target function. The detour function 1100 may also perform actions described herein relating to substituting decoy information in a response to a call to the target function 1102. Where it is determined that the call should be routed to the target function 110 this may be performed by way of a pass through function 1106 or "trampoline" function, which invokes the target function 1102 using arguments passed to the detour function 1100 by the source function 1104. The target function 1102 may return its result to the detour function 1100, which then returns the result to the source function 1104. Alternatively, the result may be routed to the detour function 1100 by way of the pass through function 1106. Where the function call is routed to the BotSink 120, a result from the BotSink 120 may be routed to the source function 1104 by the detour function 1100.

The processing of system calls according to the methods disclosed herein may be preceded by modifying source functions making the system calls on the endpoint 106a-106g to refer to one or more detour functions as described above.

FIG. 12 illustrates a method 1200 for identifying whitelisted applications. For a period, e.g. 1 day, 2 days, 1 week, etc. following processing of source functions 1104 on the operating system of one or more endpoints 106a-106g to reference the detour function(s) 1100, a learning mode may be invoked 1202. During this period the detour functions 1100 may operate in a learning mode in which all calls to a target function 1102 are intercepted 1204 and the detour function 1100 invokes 1210 the target function 1102. I.e., a call to a target function 1102 will be passed to the target function 1102. The detour function 1100 may report data regarding calls during the learning period, particularly identifiers of applications or processes that issue the call, e.g., a registry key, executable name, file system path to the executable, hash of the executable, or other identifier of the calling application or process. The detour function 1100 may make this report to the BotSink 120 for each system call or make a report of each unique identifier that made a call during the learning period. Note also that in some embodiments, not all system calls are intercepted, i.e. have references thereto replaced with detour function(s) 1100. For example, either (a) only references to certain target functions 1102 are replaced with references to detour function(s) 1100 or (b) some functions 1100 simply pass a function call to a corresponding target function 1100 while others perform interception, inspection, and substitution functions as described herein.

If the application or process that issued the intercepted call is not found 1206 to be in a list of sanctioned applications, it is added 1208 to the list, i.e., the unique identifier of the application or process is added to the list. If the application or process that issued the intercepted call is found 1206 to already be in a list of sanctioned applications, then step 1210 is performed without repeating step 1208.

15

In some embodiments, each endpoint **106a-106g** creates its own list of sanctioned applications during the learning period and then sends these to the BotSink **120**, which then compiles a list of sanctioned applications that are then distributed back to the endpoints **106a-106g**. Alternatively, the endpoints **106a-106g** may coordinate with one another to share identifiers of sanctioned applications such that each endpoint **106a-106g** has the same list. In another approach, each endpoint **106a-106g** compiles its own list of sanctioned applications and uses it according to the methods described herein without obtaining identifiers of other applications identified by other endpoints **106a-106g**.

Referring to FIG. 13, the illustrated method **1300** may be executed on an endpoint **106a-106g**. For example, the method **1300** may be executed by a detour function **1104**, sensor module **108**, or other component executing on the endpoint **106a-106g** (hereinafter “the endpoint”).

The method **1300** may include receiving **1302** a call to display network shares mounted to the endpoint. Network shares are file systems on other computers remote from the endpoint that are mounted to the file system of the endpoint and accessed through the file system of the endpoint. The call may be the “net use” command in the MICROSOFT operating system. Other function calls may include GetLogicalDrives (), GetVolumeInformation (). This call may be intercepted **1304** by virtue of a reference to it being a call to a detour function **1100** substituted for a target function corresponding to the call. Interception may also be performed by a sensor module **108** or according to any interception approach described herein.

The detour function **1100** or other component performing the method **1300**, may evaluate **1306** whether the source of the call is a sanctioned application, e.g. a unique identifier of the source of the call is in the list of sanctioned applications. If so, the detour function **1100** invokes **1308** the target function **1102**, i.e. the “net use” function and returns a result of the function to the source of the call. If not, then the detour function **1100** returns **1310** a simulated result that includes a reference to a network share on the BotSink **120**. For example, the actual response to the “net use” function call. The simulated result may be obtained by the detour function **1100** issuing a call to the corresponding target function **1102**, i.e. the net use call, receiving the response, and replacing references to network shares with references to the BotSink **120**. In other approaches, the simulated result is generated without generating a call to the target function **1102**.

For example, the actual result from the “net use” function may be:

Status	Local	Remote	Network
OK	Z:	\\network426.example.com	Microsoft Windows Network

The result returned to the source of the call may be:

Status	Local	Remote	Network
OK	Z:	\\network521.example.com	Microsoft Windows Network

In this example, “network426.example.com” may be an actual server providing a network share. “network521.example.com” may be the domain name assigned to the BotSink **120**.

16

Attempts by the source of the call to access the network shares may result in the source of the call engaging **1312** the BotSink **120**. For example, the BotSink **120** may create a network share referenced by the result returned at step **1310**.

Any attempt to access the share may be responded to by providing simulated files. Attempts to access the network share may be monitored by connection attempts on BotSink **120** to host network426.example.com or by monitoring the DNS queries to the host network426.example.com. Attempts to access the BotSink **120** through the references in the modified response may invoke generation of an alert or other action to reduce risk to the endpoint or other network resources, such as blocking access to the endpoint or other network resources by the source address or executable that is the source of the call.

Referring to FIG. 14, the illustrated method **1400** may be executed on an endpoint **106a-106g**. For example, the method **1400** may be executed by a detour function **1100**, sensor module **108**, or other component executing on the endpoint.

The method **1400** may include receiving **1402** a call to list a remote network resource or request to list credentials managed by a credential manager, or a request to list of domain controllers accessible from the endpoint, or a request to enumerate remote network shares. This call may be intercepted **1304** by virtue of a reference to it being a reference to a detour function **1100** when the interception DLL was loaded into the application or process making the call. Interception may also be performed by a sensor module **108** or according to any interception approach described herein.

The detour function **1100** or other component performing the method **1400**, may execute **1404** the call on the operating system of the endpoint, such as by invoking the corresponding target function **1102**. The detour function **1100** may intercept **1406** a response to the call from the operating system. If the source of the call is found **1408** to be a sanctioned application, the result from the operating system is returned **1410** to the source of the call. The manner in which the source is determined to be sanctioned may be according to the approach of any of the methods described hereinabove.

If not, then the detour function **1100** returns **1412** a simulated result that includes a reference to a network share on the BotSink **120**. For example, response from step **1406** may be modified to include references to the BotSink **120** in the place of references to network resources.

For example, the system call may be to an API (application programming interface) of a credential manager, such as that provided by the WINDOWS CREDENTIAL MANAGER API. For example, such a call may include “CredEnumerateA(), CredReadA(), or other function call defined in Advapi32.dll. The result from the operating system received at step **1406** may be:

TERMSRV/network426. internalcorp.com, UserName rdpuser@internalcorp.com, Password: HASH1

The modified result returned to the source of the call may be TERMSRV/network521. internalcorp.com, UserName decoyuser@internalcorp.com, Password: HASH2

where network426. internalcorp.com is a server for which the credential manager has a credential and network521. internalcorp.com is a domain name assigned to the BotSink **120**. Note that the username and hash of the password are also altered in this example.

In another example, the call intercepted at step **1402** is a call to list domain controllers. Such a call may include “WNetOpenEnumA()”, “WNetEnumResourceA()”, or

17

other function call defined in Mpr.dll of the Win32 API. In another example, the call is “NetShareEnum (. . .)” in Netapi32.dll of the Win32 API.

For example, the source of the call may issue the call “net view bantestado5.” The operating system may return the result:

Shared resources at bantestad05		
Share name	Type Used as	Comment
NETLOGON	Disk	Logon server share
SYS VOL	Disk	Login server share

In particular, the domain controllers may return NETLOGON and SYSVOL shares type. A result referencing these shares would then be modified to either (a) remove them to hide them from malware or (b) replace them with references to a decoy domain controller implemented on the BotSink 120. This hinders an attacker from fingerprinting or finding the domain controllers of a network.

In another example, the call received at step 1402 is to find network shares on a remote machine using a call such as WNetOpenEnumA(), WNetEnumResourceA() in the Mpr.dll of the Win32 API or NetShareEnum () in the Netapi32.dll of the Win32 API.

For example, the result of a call such as “net view sx1.testsystem/all” may include:

Shared resources at sx1.testsystem			
Share name	Type	Used as	Comment
ADMIN\$	Disk		Remote Admin
SHARE_CIFS	Disk		
C\$	Disk		Default share
IPC\$	IPC		Remote IPC

The entries of this result indicate network shares from a remote system. These network shares may be hidden from a non-sanctioned application according to the methods described herein. For example, for a non-sanctioned application, the entries may simply be deleted, returning a response at step 1410 that does not indicate the presence of any network shares. This enables the hiding of these network shares from malware so that it cannot find these shares to exploit them or spread a ransomware-type attack. Alternatively, network shares on the BotSink 120 may be substituted in the result.

In another example, the call received at step 1402 is a request to get information about network servers and/or computers. For example, the “NetServerEnum()” call in the Netapi32.dll of the Win32 API.

For example, the input call may return “NETWORK.426” when executed by the operations, where NETWORK.426 is an identifier of an actual server on the network. The detour function 1100 may return NETWORK.521, which refers to the BotSink 120.

In another example, the call at step 1402 is a call to enumerate a registry of recently accessed servers or other computers. Such a call may include RegEnum Value() in the Advapi32.dll of the Win32 API, which enumerates a list of remote servers or computers recently accessed using a remote desktop connection.

18

The result at step 1406 may read as follow:

```
HKEY_CURRENT_USER\Software\Microsoft\Terminal server
Client\Default MRU0 REG_SZ NETWORK.426
```

The modified result returned at step 1410 may read as follows:

```
HKEY_CURRENT_USER\Software\Microsoft\Terminal server
Client\Default MRU0 REG_SZ NETWORK.521
```

where NETWORK.426 refers to a server in the network other than the BotSink 120 and NETWORK.521 refers to the BotSink 120.

As for other embodiments, attempts to access the network resources in the modified response will be received by the BotSink 120, which may then engage 1414 the source of the call in order to detect and characterize it. Attempts to access the BotSink 120 through the references in the modified response may invoke generation of an alert or other action to reduce risk to the endpoint or other network resources, such as blocking access to the endpoint or other network resources by the source address or executable that is the source of the call.

Referring to FIG. 15, the illustrated method 1500 relates to a circumstance in which malware obtains a local administrative credential for a security account manager (SAM) database, such as from a local security authority subsystem service (LSAS) process. In this case, the endpoint receives 1502 a query to obtain information regarding a privileged group database. The privileged group may be referenced by the data obtained by the malware. The query may be a call to SamEnumerateGroupsInDomain (), SamGetMembersInGroup () in the Win32 API.

If the query is found 1504 to be from a sanctioned application according to any of the approaches described herein, then the end point executes 1506 the query and returns 1508 a result of the query to the application, process, or remote computer system from which the query was received. If the query is not found 1504 to be from a sanctioned application, the endpoint provides 1510 decoy data to the source of the call, i.e. data including references to users, groups, or both users and groups that do not correspond to actual users and groups on the endpoint or in the production SAM database of the endpoint and network 100. The decoy users and/or groups may reference decoy users and groups defined on the BotSink 120, e.g., in a decoy SAM database on the BotSink 120.

If a request is found 1512 to have been received that references a decoy user or group returned at step 1510, the method 1500 may include providing decoy information from decoy accounts corresponding to the decoy user or group referenced in the request. For example, this may be performed in response to receiving a SamGetMembersInGroup () call that references a decoy group provided at step 1510. Steps 1512 and 1514 may be performed any number of times. In particular, decoy data may be generated in response to each request such that an attacker will be fed decoy data to occupy and deceive the attacker.

Further attempts to access or exploit the user accounts may be directed to the BotSink 120 that may engage 1516 the attacker, such as by implementing the user accounts on the BotSink 120 and providing access to services in the context of the user accounts on the BotSink 120. These activities may be monitored and characterized. Engaging 1516 may invoke generation of an alert or other action to

reduce risk to the endpoint or other network resources, such as blocking access to the endpoint or other network resources by the source of the call.

Referring to FIG. 16, in some embodiments an endpoint **106a-106g** may execute the illustrated method **1600**. A source may issue a call that references a DNS (domain name service) address that must be resolved to an IP (internet protocol address). Such a call may include `DNSQuery_A ( )` from the `Dnsapi.dll` of the Win32 API. This call is received **1602** by the endpoint, such as by way of a detour function **1100**, which evaluates **1604** whether the call was received from a sanctioned application according to any of the approaches described herein. If so, the endpoint invokes **1606** performing of the access request. In some embodiments, prior to performing step **1606**, the endpoint resolves the DNS address to an IP address, such as by issuing a call with the DNS address to a DNS server and receiving a response including the IP address. The endpoint may then invoke performing of the access request with the IP address by the operating system of the endpoint, i.e. invoke the target function **1102** corresponding to the call. Alternatively, the arguments of the call, including the DNS address may be passed to the target function **1102** without first resolving the DNS address to an IP address. The target function **1102** may then execute with respect to the IP address. For example, if the functions **1104**, **1106** are a “ping” command, the target function **1102** will ping the BotSink **120** and return a result of that function, i.e. when and whether replies to ping messages were received, a delay between a ping message and a reply, and the IP address of the destination of the ping message.

If the source of the call is not found **1604** to be a sanctioned application, the DNS address may be resolved **1608** to an address that does not actually correspond to the DNS address. Instead, the DNS address is resolved **1608** to one of one or more IP addresses assigned to the BotSink **120**. The access request may be performed **1610**, e.g. target function **1102** invoked, with the arguments from the call received at step **1602** except that the DNS address is replaced with the IP address from step **1608**. The result of the access request is then returned to the source of the access request. For example, where the access request is a ping command, the result of pinging the BotSink **120** may be returned to the source. As for other embodiments disclosed herein, attempts to communicate using the information returned may result in engaging **1612** the attacker as described above.

FIG. 17 is a block diagram illustrating an example computing device **1700** which can be used to implement the system and methods disclosed herein. The endpoints **106a-106g**, management server **112**, BotSink **120**, attacker system **122**, and active directory server **402** may also have some or all of the attributes of the computing device **1700**. In some embodiments, a cluster of computing devices interconnected by a network may be used to implement any one or more components of the invention.

Computing device **1700** may be used to perform various procedures, such as those discussed herein. Computing device **1700** can function as a server, a client, or any other computing entity. Computing device can perform various monitoring functions as discussed herein, and can execute one or more application programs, such as the application programs described herein. Computing device **1700** can be any of a wide variety of computing devices, such as a desktop computer, a notebook computer, a server computer, a handheld computer, tablet computer and the like.

Computing device **1700** includes one or more processor(s) **1702**, one or more memory device(s) **1704**, one or more interface(s) **1706**, one or more mass storage device(s) **1708**, one or more Input/Output (I/O) device(s) **1710**, and a display device **1730** all of which are coupled to a bus **1712**. Processor(s) **1702** include one or more processors or controllers that execute instructions stored in memory device(s) **1704** and/or mass storage device(s) **1708**. Processor(s) **1702** may also include various types of computer-readable media, such as cache memory.

Memory device(s) **1704** include various computer-readable media, such as volatile memory (e.g., random access memory (RAM) **1714**) and/or nonvolatile memory (e.g., read-only memory (ROM) **1716**). Memory device(s) **1704** may also include rewritable ROM, such as Flash memory.

Mass storage device(s) **1708** include various computer readable media, such as magnetic tapes, magnetic disks, optical disks, solid-state memory (e.g., Flash memory), and so forth. As shown in FIG. 17, a particular mass storage device is a hard disk drive **1724**. Various drives may also be included in mass storage device(s) **1708** to enable reading from and/or writing to the various computer readable media. Mass storage device(s) **1708** include removable media **1726** and/or non-removable media.

I/O device(s) **1710** include various devices that allow data and/or other information to be input to or retrieved from computing device **1700**. Example I/O device(s) **1710** include cursor control devices, keyboards, keypads, microphones, monitors or other display devices, speakers, printers, network interface cards, modems, lenses, CCDs or other image capture devices, and the like.

Display device **1730** includes any type of device capable of displaying information to one or more users of computing device **1700**. Examples of display device **1730** include a monitor, display terminal, video projection device, and the like.

Interface(s) **1706** include various interfaces that allow computing device **1700** to interact with other systems, devices, or computing environments. Example interface(s) **1706** include any number of different network interfaces **1720**, such as interfaces to local area networks (LANs), wide area networks (WANs), wireless networks, and the Internet. Other interface(s) include user interface **1718** and peripheral device interface **1722**. The interface(s) **1706** may also include one or more user interface elements **1718**. The interface(s) **1706** may also include one or more peripheral interfaces such as interfaces for printers, pointing devices (mice, track pad, etc.), keyboards, and the like.

Bus **1712** allows processor(s) **1702**, memory device(s) **1704**, interface(s) **1706**, mass storage device(s) **1708**, and I/O device(s) **1710** to communicate with one another, as well as other devices or components coupled to bus **1712**. Bus **1712** represents one or more of several types of bus structures, such as a system bus, PCI bus, IEEE 1394 bus, USB bus, and so forth.

For purposes of illustration, programs and other executable program components are shown herein as discrete blocks, although it is understood that such programs and components may reside at various times in different storage components of computing device **1700**, and are executed by processor(s) **1702**. Alternatively, the systems and procedures described herein can be implemented in hardware, or a combination of hardware, software, and/or firmware. For example, one or more application specific integrated circuits (ASICs) can be programmed to carry out one or more of the systems and procedures described herein.

21

We claim:

1. A computer-implemented method for deceiving a source attempting to access target data, the method comprising:

configuring, by a computer system, a system call to refer to a detour function;

receiving, by the computer system from a source, a request to access target data via the system call;

determining, by the computer system via the detour function, whether the source is sanctioned; and

returning, by the computer system in response to determining that the source is not sanctioned, decoy data to the source, wherein the decoy data is different from the target data, the decoy data configured to mimic the target data,

wherein the computer system comprises a computer processor and an electronic storage medium.

2. The computer-implemented method of claim 1, wherein the decoy data is configured to mimic a format of the target data.

3. The computer-implemented method of claim 2, wherein the format comprises one or more of a word processor document, spreadsheet, database, credential, configuration file, browser history, or a listing of recently accessed files.

4. The computer-implemented method of claim 1, wherein the source comprises an attacker system.

5. The computer-implemented method of claim 1, wherein the target data comprises production data.

6. The computer-implemented method of claim 1, wherein the computer system comprises an endpoint.

7. The computer-implemented method of claim 6, wherein the endpoint comprises a production device.

8. The computer-implemented method of claim 1, wherein the decoy data does not comprise production data.

9. The computer-implemented method of claim 1, wherein the request to access target data comprises a read command or information request.

10. The computer-implemented method of claim 1, wherein whether the source is sanctioned is determined by determining whether the source comprises a sanctioned application.

22

11. The computer-implemented method of claim 1, wherein the decoy data is stored locally on the computer system.

12. The computer-implemented method of claim 1, wherein the decoy data is stored on another location and is accessed by the computer system.

13. A system for deceiving a source attempting to access target data, the system comprising:

one or more computer readable storage devices configured to store a plurality of computer executable instructions; and

one or more hardware computer processors in communication with the one or more computer readable storage devices and configured to execute the plurality of computer executable instructions in order to cause the system to:

configure a system call to refer to a detour function;

receive a request to access target data via the system call;

determine, via the detour function, whether the source is sanctioned; and

return, in response to determining that the source is not sanctioned, decoy data to the source, wherein the decoy data is different from the target data, the decoy data configured to mimic the target data.

14. The system of claim 13, wherein the decoy data is configured to mimic a format of the target data.

15. The system of claim 14, wherein the format comprises one or more of a word processor document, spreadsheet, database, credential, configuration file, browser history, or a listing of recently accessed files.

16. The system of claim 13, wherein the target data comprises production data.

17. The system of claim 13, wherein the decoy data does not comprise production data.

18. The system of claim 13, wherein whether the source is sanctioned is determined by determining whether the source comprises a sanctioned application.

19. The system of Claim 13, wherein the decoy data is stored locally.

20. The system of Claim 13, wherein the decoy data is stored on another location and is accessed by the system.

* * * * *