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(54) **ADAPTIVE ROUTE AND MOTION PLANNING BASED ON LEARNED EXTERNAL AND INTERNAL VEHICLE ENVIRONMENT**

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(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,361,202	A	11/1982	Minovitch
4,476,954	A	10/1984	Johnson et al.
4,754,255	A	6/1988	Sanders et al.
4,875,391	A	10/1989	Leising et al.
5,035,302	A	7/1991	Thangavelu
5,136,498	A	8/1992	McLaughlin et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN	1417755	5/2003
CN	1847817	10/2006

(Continued)

OTHER PUBLICATIONS

Official Action for U.S. Appl. No. 15/408,143, dated Jun. 15, 2018, 9 pages.

(Continued)

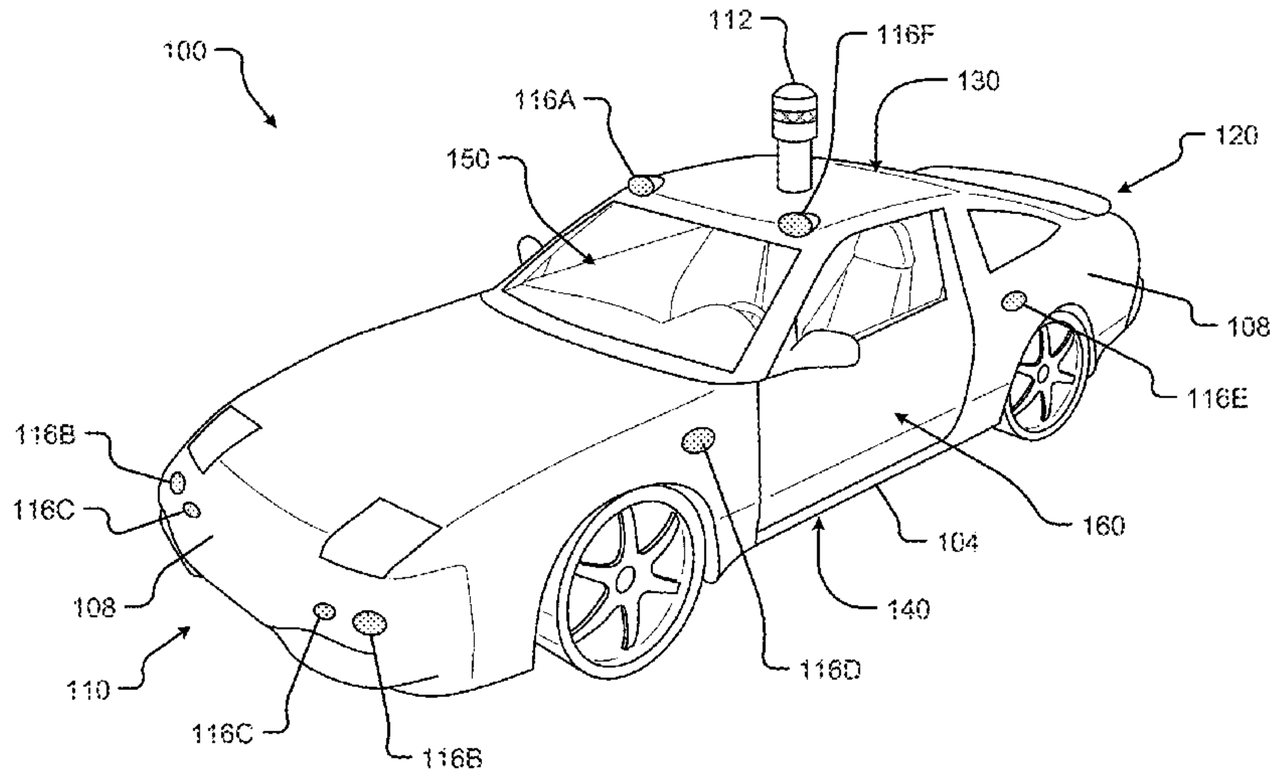
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(57) **ABSTRACT**

The systems and methods described herein can be applied to a vehicle equipped with a sensor suite that can observe information about a location, for example, a traffic light duration. The system can record information, e.g., the traffic light colors, duration of color changes, and location of the traffic lights and can upload this information to the cloud. Then, the system can augment or learn about the location, e.g., learning of traffic patterns, and store the augmented data as database-based information, where available. The learned information can help a requesting vehicle to better estimate an estimated time of arrival (ETA) for common routes taken, provide more accurate ETAs based on historical knowledge, and/or calculate or provide alternative route information.

20 Claims, 15 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,204,817	A	4/1993	Yoshida
5,363,306	A	11/1994	Kuwahara et al.
5,508,689	A	4/1996	Rado et al.
5,521,815	A	5/1996	Rose
5,529,138	A	6/1996	Shaw et al.
5,531,122	A	7/1996	Chatham et al.
5,572,450	A	11/1996	Worthy
5,610,821	A	3/1997	Gazis et al.
5,648,769	A	7/1997	Sato et al.
5,710,702	A	1/1998	Hayashi et al.
5,794,164	A	8/1998	Beckert et al.
5,797,134	A	8/1998	McMillan et al.
5,812,067	A	9/1998	Bergholz et al.
5,825,283	A	10/1998	Camhi
5,838,251	A	11/1998	Brinkmeyer et al.
5,847,661	A	12/1998	Ricci
5,890,080	A	3/1999	Coverdill et al.
5,928,294	A	7/1999	Zelinkovsky
5,949,345	A	9/1999	Beckert et al.
5,983,161	A	11/1999	Lemelson et al.
5,986,575	A	11/1999	Jones et al.
6,038,426	A	3/2000	Williams, Jr.
6,081,756	A	6/2000	Mio et al.
D429,684	S	8/2000	Johnson
6,128,003	A	10/2000	Smith et al.
6,137,425	A	10/2000	Oster et al.
6,141,620	A	10/2000	Zyburt et al.
6,148,261	A	11/2000	Obradovich et al.
6,152,514	A	11/2000	McLellen
6,157,321	A	12/2000	Ricci
6,198,996	B1	3/2001	Berstis
6,199,001	B1	3/2001	Ohta et al.
6,202,008	B1	3/2001	Beckert et al.
6,252,544	B1	6/2001	Hoffberg
6,267,428	B1	7/2001	Baldas et al.
6,302,438	B1	10/2001	Stopper, Jr. et al.
6,310,542	B1	10/2001	Gehlot
6,317,058	B1	11/2001	Lemelson et al.
6,339,826	B2	1/2002	Hayes, Jr. et al.
6,356,838	B1	3/2002	Paul
6,388,579	B1	5/2002	Adcox et al.
6,480,224	B1	11/2002	Brown
6,502,022	B1	12/2002	Chastain et al.
6,519,519	B1	2/2003	Stopczynski
6,557,752	B1	5/2003	Yacoob
6,563,910	B2	5/2003	Menard et al.
6,587,739	B1	7/2003	Abrams et al.
6,598,227	B1	7/2003	Berry et al.
6,607,212	B1	8/2003	Reimer et al.
6,617,981	B2	9/2003	Basinger
6,633,800	B1	10/2003	Ward et al.
6,662,077	B2	12/2003	Haag
6,675,081	B2	1/2004	Shuman et al.
6,678,747	B2	1/2004	Goossen et al.
6,681,176	B2	1/2004	Funk et al.
6,690,260	B1	2/2004	Ashihara
6,690,940	B1	2/2004	Brown et al.
6,724,920	B1	4/2004	Berenz et al.
6,754,580	B1	6/2004	Ask et al.
6,757,593	B2	6/2004	Mod et al.
6,762,684	B1	7/2004	Camhi
6,765,495	B1	7/2004	Dunning et al.
6,778,888	B2	8/2004	Cataldo et al.
6,782,240	B1	8/2004	Tabe
6,785,531	B2	8/2004	Lepley et al.
6,816,783	B2	11/2004	Hashima et al.
6,820,259	B1	11/2004	Kawamata et al.
6,944,533	B2	9/2005	Obradovich et al.
6,950,022	B2	9/2005	Breed
6,958,707	B1	10/2005	Siegel
6,992,580	B2	1/2006	Kotzin et al.
7,019,641	B1	3/2006	Lakshmanan et al.
7,020,544	B2	3/2006	Shinada et al.
7,021,691	B1	4/2006	Schmidt et al.
7,042,345	B2	5/2006	Ellis
7,047,129	B2	5/2006	Uotani
7,058,898	B2	6/2006	McWalter et al.
7,096,431	B2	8/2006	Tambata et al.
7,142,696	B1	11/2006	Engelsberg et al.
7,164,117	B2	1/2007	Breed et al.
7,187,947	B1	3/2007	White et al.
7,203,598	B1	4/2007	Whitsell
7,233,861	B2	6/2007	Van Buer et al.
7,239,960	B2	7/2007	Yokota et al.
7,277,454	B2	10/2007	Mocek et al.
7,284,769	B2	10/2007	Breed
7,289,645	B2	10/2007	Yamamoto et al.
7,295,921	B2	11/2007	Spencer et al.
7,313,547	B2	12/2007	Mocek et al.
7,333,012	B1	2/2008	Nguyen
7,343,148	B1	3/2008	O'Neil
7,386,376	B2	6/2008	Basir et al.
7,386,799	B1	6/2008	Clanton et al.
7,432,829	B2	10/2008	Poltorak
7,474,264	B2	1/2009	Bolduc et al.
7,493,140	B2	2/2009	Michmerhuizen et al.
7,526,539	B1	4/2009	Hsu
7,548,815	B2	6/2009	Watkins et al.
7,566,083	B2	7/2009	Vitito
7,606,660	B2	10/2009	Diaz et al.
7,606,867	B1	10/2009	Singhal et al.
7,643,913	B2	1/2010	Taki et al.
7,650,234	B2	1/2010	Obradovich et al.
7,671,764	B2	3/2010	Uyeki et al.
7,680,596	B2	3/2010	Uyeki et al.
7,683,771	B1	3/2010	Loeb
7,711,468	B1	5/2010	Levy
7,734,315	B2	6/2010	Rathus et al.
7,748,021	B2	6/2010	Obradovich et al.
RE41,449	E	7/2010	Krahnstoever et al.
7,791,499	B2	9/2010	Mohan et al.
7,796,190	B2	9/2010	Basso et al.
7,802,832	B2	9/2010	Carnevali
7,821,421	B2	10/2010	Tamir et al.
7,832,762	B2	11/2010	Breed
7,864,073	B2	1/2011	Lee et al.
7,872,591	B2	1/2011	Kane et al.
7,873,471	B2	1/2011	Gieseke
7,881,703	B2	2/2011	Roundtree et al.
7,891,004	B1	2/2011	Gelvin et al.
7,891,719	B2	2/2011	Carnevali
7,899,610	B2	3/2011	McClellan
7,966,678	B2	6/2011	Ten Eyck et al.
7,969,290	B2	6/2011	Waeller et al.
7,969,324	B2	6/2011	Chevion et al.
8,060,631	B2	11/2011	Collart et al.
8,064,925	B1	11/2011	Sun et al.
8,066,313	B2	11/2011	Carnevali
8,098,170	B1	1/2012	Szczerba et al.
8,113,564	B2	2/2012	Carnevali
8,131,419	B2	3/2012	Ampunan et al.
8,157,310	B2	4/2012	Carnevali
8,162,368	B2	4/2012	Carnevali
8,175,802	B2	5/2012	Forstall et al.
8,233,919	B2	7/2012	Haag et al.
8,245,609	B1	8/2012	Greenwald et al.
8,306,514	B1	11/2012	Nunally
8,334,847	B2	12/2012	Tomkins
8,346,233	B2	1/2013	Aaron et al.
8,346,432	B2	1/2013	Van Wiemeersch et al.
8,350,721	B2	1/2013	Carr
8,352,282	B2	1/2013	Jensen et al.
8,369,263	B2	2/2013	Dowling et al.
8,417,449	B1	4/2013	Denise
8,428,843	B2	4/2013	Lee et al.
8,432,260	B2	4/2013	Talty et al.
8,442,389	B2	5/2013	Kashima et al.
8,442,758	B1	5/2013	Rovik et al.
8,467,965	B2	6/2013	Chang
8,497,842	B2	7/2013	Tomkins et al.
8,498,809	B2	7/2013	Bill
8,509,982	B2	8/2013	Montemerlo et al.
8,521,410	B2	8/2013	Mizuno et al.
8,527,143	B2	9/2013	Tan

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,527,146	B1	9/2013	Jackson et al.
8,532,574	B2	9/2013	Kirsch
8,543,330	B2	9/2013	Taylor et al.
8,547,340	B2	10/2013	Sizelove et al.
8,548,669	B2	10/2013	Naylor
8,559,183	B1	10/2013	Davis
8,577,600	B1	11/2013	Pierfelice
8,578,279	B2	11/2013	Chen et al.
8,583,292	B2	11/2013	Preston et al.
8,589,073	B2	11/2013	Guha et al.
8,600,611	B2	12/2013	Seize
8,613,385	B1	12/2013	Hulet et al.
8,621,645	B1	12/2013	Spackman
8,624,727	B2	1/2014	Saigh et al.
8,634,980	B1	1/2014	Urmson et al.
8,634,984	B2	1/2014	Sumizawa
8,644,165	B2	2/2014	Saarimaki et al.
8,660,735	B2	2/2014	Tengler et al.
8,671,068	B2	3/2014	Harber et al.
8,688,372	B2	4/2014	Bhogal et al.
8,698,639	B2	4/2014	Fung et al.
8,705,527	B1	4/2014	Addepalli et al.
8,706,143	B1	4/2014	Elias
8,718,797	B1	5/2014	Addepalli et al.
8,718,910	B2	5/2014	Gueziec
8,725,311	B1	5/2014	Breed
8,730,033	B2	5/2014	Yarnold
8,737,986	B2	5/2014	Rhoads et al.
8,761,673	B2	6/2014	Sakata
8,774,842	B2	7/2014	Jones et al.
8,779,947	B2	7/2014	Tengler et al.
8,782,262	B2	7/2014	Collart et al.
8,793,065	B2	7/2014	Seltzer et al.
8,798,918	B2	8/2014	Onishi et al.
8,805,110	B2	8/2014	Rhoads et al.
8,812,171	B2	8/2014	Fillev et al.
8,817,761	B2	8/2014	Gruberman et al.
8,825,031	B2	9/2014	Aaron et al.
8,825,277	B2	9/2014	McClellan et al.
8,825,382	B2	9/2014	Liu
8,826,261	B1	9/2014	Anand et al.
8,838,088	B1	9/2014	Henn et al.
8,862,317	B2	10/2014	Shin et al.
8,972,090	B2	3/2015	Weslati et al.
8,977,408	B1	3/2015	Cazanas et al.
9,043,016	B2	5/2015	Filippov et al.
9,163,952	B2	10/2015	Viola et al.
9,229,905	B1	1/2016	Penilla et al.
9,299,251	B2	3/2016	Scofield et al.
9,360,342	B2	6/2016	Ignatin
9,581,460	B1	2/2017	McNew et al.
9,663,118	B1	5/2017	Palmer et al.
9,969,404	B2	5/2018	McNew
1,007,705	A1	9/2018	Fields et al.
2001/0010516	A1	8/2001	Roh et al.
2001/0015888	A1	8/2001	Shaler et al.
2002/0009978	A1	1/2002	Dukach et al.
2002/0023010	A1	2/2002	Rittmaster et al.
2002/0026278	A1	2/2002	Feldman et al.
2002/0045484	A1	4/2002	Eck et al.
2002/0065046	A1	5/2002	Mankins et al.
2002/0077985	A1	6/2002	Kobata et al.
2002/0095249	A1	7/2002	Lang
2002/0097145	A1	7/2002	Tumey et al.
2002/0103622	A1	8/2002	Burge
2002/0105968	A1	8/2002	Pruzan et al.
2002/0126876	A1	9/2002	Paul et al.
2002/0128774	A1	9/2002	Takezaki et al.
2002/0143461	A1	10/2002	Burns et al.
2002/0143643	A1	10/2002	Catan
2002/0152010	A1	10/2002	Colmenarez et al.
2002/0154217	A1	10/2002	Ikeda
2002/0169551	A1	11/2002	Inoue et al.
2002/0174021	A1	11/2002	Chu et al.
2003/0004624	A1	1/2003	Wilson et al.
2003/0007227	A1	1/2003	Ogino
2003/0055557	A1	3/2003	Dutta et al.
2003/0060937	A1	3/2003	Shinada et al.
2003/0060977	A1	3/2003	Jijina et al.
2003/0065432	A1	4/2003	Shuman et al.
2003/0101451	A1	5/2003	Bentolila et al.
2003/0109972	A1	6/2003	Tak
2003/0125846	A1	7/2003	Yu et al.
2003/0132666	A1	7/2003	Bond et al.
2003/0149530	A1	8/2003	Stopczynski
2003/0158638	A1	8/2003	Yakes et al.
2003/0182435	A1	9/2003	Redlich et al.
2003/0202683	A1	10/2003	Ma et al.
2003/0204290	A1	10/2003	Sadler et al.
2003/0230443	A1	12/2003	Cramer et al.
2004/0017292	A1	1/2004	Reese et al.
2004/0024502	A1	2/2004	Squires et al.
2004/0036622	A1	2/2004	Dukach et al.
2004/0039500	A1	2/2004	Amendola et al.
2004/0039504	A1	2/2004	Coffee et al.
2004/0068364	A1	4/2004	Zhao et al.
2004/0070920	A1	4/2004	Flueli
2004/0093155	A1	5/2004	Simonds et al.
2004/0117494	A1	6/2004	Mitchell et al.
2004/0128062	A1	7/2004	Ogino et al.
2004/0153356	A1	8/2004	Lockwood et al.
2004/0162019	A1	8/2004	Horita et al.
2004/0180653	A1	9/2004	Royalty
2004/0182574	A1	9/2004	Adnan et al.
2004/0193347	A1	9/2004	Harumoto et al.
2004/0203974	A1	10/2004	Seibel
2004/0204837	A1	10/2004	Singleton
2004/0209594	A1	10/2004	Naboulsi
2004/0217850	A1	11/2004	Perttunen et al.
2004/0225557	A1	11/2004	Phelan et al.
2004/0255123	A1	12/2004	Noyama et al.
2004/0257208	A1	12/2004	Huang et al.
2004/0260470	A1	12/2004	Rast
2005/0012599	A1	1/2005	DeMatteo
2005/0031100	A1	2/2005	Iggulden et al.
2005/0038598	A1	2/2005	Oesterling et al.
2005/0042999	A1	2/2005	Rappaport
2005/0065678	A1	3/2005	Smith et al.
2005/0065711	A1	3/2005	Dahlgren et al.
2005/0086051	A1	4/2005	Brulle-Drews
2005/0093717	A1	5/2005	Lilja
2005/0097541	A1	5/2005	Holland
2005/0114864	A1	5/2005	Surace
2005/0122235	A1	6/2005	Teffer et al.
2005/0124211	A1	6/2005	Diessner et al.
2005/0130744	A1	6/2005	Eck et al.
2005/0144156	A1	6/2005	Barber
2005/0149752	A1	7/2005	Johnson et al.
2005/0153760	A1	7/2005	Varley
2005/0159853	A1	7/2005	Takahashi et al.
2005/0159892	A1	7/2005	Chung
2005/0192727	A1	9/2005	Shostak et al.
2005/0197748	A1	9/2005	Hoist et al.
2005/0197767	A1	9/2005	Nortrup
2005/0234614	A1	10/2005	Sakurai et al.
2005/0251324	A1	11/2005	Wiener et al.
2005/0261815	A1	11/2005	Cowelchuk et al.
2005/0278093	A1	12/2005	Kameyama
2005/0283284	A1	12/2005	Grenier et al.
2006/0015819	A1	1/2006	Hawkins et al.
2006/0036358	A1	2/2006	Hale et al.
2006/0044119	A1	3/2006	Egelhaaf
2006/0047386	A1	3/2006	Kanevsky et al.
2006/0058948	A1	3/2006	Blass et al.
2006/0059229	A1	3/2006	Bain et al.
2006/0125631	A1	6/2006	Sharony
2006/0130033	A1	6/2006	Stoffels et al.
2006/0142933	A1	6/2006	Feng
2006/0173841	A1	8/2006	Bill
2006/0175403	A1	8/2006	McConnell et al.
2006/0184319	A1	8/2006	Seick et al.
2006/0212909	A1	9/2006	Girard et al.
2006/0241836	A1	10/2006	Kachouh et al.
2006/0243056	A1	11/2006	Sundermeyer et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0250272 A1 11/2006 Puamau
2006/0253307 A1 11/2006 Warren et al.
2006/0259210 A1 11/2006 Tanaka et al.
2006/0274829 A1 12/2006 Siemens et al.
2006/0282204 A1 12/2006 Breed
2006/0287807 A1 12/2006 Teffer
2006/0287865 A1 12/2006 Cross et al.
2006/0288382 A1 12/2006 Vitito
2006/0290516 A1 12/2006 Muehlsteff et al.
2006/0293856 A1 12/2006 Foessel et al.
2007/0001831 A1 1/2007 Raz et al.
2007/0002032 A1 1/2007 Powers et al.
2007/0010942 A1 1/2007 Bill
2007/0015485 A1 1/2007 DeBiasio et al.
2007/0028370 A1 2/2007 Seng
2007/0032225 A1 2/2007 Konicek et al.
2007/0057781 A1 3/2007 Breed
2007/0061057 A1 3/2007 Huang et al.
2007/0067614 A1 3/2007 Berry et al.
2007/0069880 A1 3/2007 Best et al.
2007/0083298 A1 4/2007 Pierce et al.
2007/0088488 A1 4/2007 Reeves et al.
2007/0103328 A1 5/2007 Lakshmanan et al.
2007/0115101 A1 5/2007 Creekbaum et al.
2007/0118301 A1 5/2007 Andarawis et al.
2007/0120697 A1 5/2007 Ayoub et al.
2007/0135995 A1 6/2007 Kikuchi et al.
2007/0156317 A1 7/2007 Breed
2007/0182625 A1 8/2007 Kerai et al.
2007/0182816 A1 8/2007 Fox
2007/0185969 A1 8/2007 Davis
2007/0192486 A1 8/2007 Wilson et al.
2007/0194902 A1 8/2007 Blanco et al.
2007/0194944 A1 8/2007 Galera et al.
2007/0195997 A1 8/2007 Paul et al.
2007/0200663 A1 8/2007 White et al.
2007/0208860 A1 9/2007 Zellner et al.
2007/0213090 A1 9/2007 Holmberg
2007/0228826 A1 10/2007 Jordan et al.
2007/0233341 A1 10/2007 Logsdon
2007/0250228 A1 10/2007 Reddy et al.
2007/0257815 A1 11/2007 Gunderson et al.
2007/0276596 A1 11/2007 Solomon et al.
2007/0280505 A1 12/2007 Breed
2008/0005974 A1 1/2008 Delgado Vazquez et al.
2008/0023253 A1 1/2008 Prost-Fin et al.
2008/0027337 A1 1/2008 Dugan et al.
2008/0033635 A1 2/2008 Obradovich et al.
2008/0042824 A1 2/2008 Kates
2008/0051957 A1 2/2008 Breed et al.
2008/0052627 A1 2/2008 Oguchi
2008/0071465 A1 3/2008 Chapman et al.
2008/0082237 A1 4/2008 Breed
2008/0086455 A1 4/2008 Meisels et al.
2008/0090522 A1 4/2008 Oyama
2008/0104227 A1 5/2008 Birnie et al.
2008/0119994 A1 5/2008 Kameyama
2008/0129475 A1 6/2008 Breed et al.
2008/0143085 A1 6/2008 Breed et al.
2008/0147280 A1 6/2008 Breed
2008/0148374 A1 6/2008 Spaur et al.
2008/0154712 A1 6/2008 Wellman
2008/0154957 A1 6/2008 Taylor et al.
2008/0161986 A1 7/2008 Breed
2008/0164985 A1 7/2008 Iketani et al.
2008/0169940 A1 7/2008 Lee et al.
2008/0174451 A1 7/2008 Harrington et al.
2008/0212215 A1 9/2008 Schofield et al.
2008/0216067 A1 9/2008 Villing
2008/0228358 A1 9/2008 Wang et al.
2008/0234919 A1 9/2008 Ritter et al.
2008/0252487 A1 10/2008 McClellan et al.
2008/0253613 A1 10/2008 Jones et al.
2008/0255721 A1 10/2008 Yamada
2008/0255722 A1 10/2008 McClellan et al.
2008/0269958 A1 10/2008 Filev et al.
2008/0281508 A1 11/2008 Fu
2008/0300778 A1 12/2008 Kuznetsov
2008/0305780 A1 12/2008 Williams et al.
2008/0319602 A1 12/2008 McClellan et al.
2009/0006525 A1 1/2009 Moore
2009/0024419 A1 1/2009 McClellan et al.
2009/0037719 A1 2/2009 Sakthikumar et al.
2009/0040026 A1 2/2009 Tanaka
2009/0055178 A1 2/2009 Coon
2009/0082951 A1 3/2009 Graessley
2009/0099720 A1 4/2009 Elgali
2009/0112393 A1 4/2009 Maten et al.
2009/0112452 A1 4/2009 Buck et al.
2009/0119657 A1 5/2009 Link, II
2009/0125174 A1 5/2009 Delean
2009/0132294 A1 5/2009 Haines
2009/0138336 A1 5/2009 Ashley et al.
2009/0144622 A1 6/2009 Evans et al.
2009/0157312 A1 6/2009 Black et al.
2009/0158200 A1 6/2009 Palahnuk et al.
2009/0180668 A1 7/2009 Jones et al.
2009/0189373 A1 7/2009 Schramm et al.
2009/0189979 A1 7/2009 Smyth
2009/0195370 A1 8/2009 Huffman et al.
2009/0210257 A1 8/2009 Chalfant et al.
2009/0216935 A1 8/2009 Flick
2009/0222200 A1 9/2009 Link et al.
2009/0224931 A1 9/2009 Dietz et al.
2009/0224942 A1 9/2009 Goudy et al.
2009/0234578 A1 9/2009 Newby et al.
2009/0241883 A1 10/2009 Nagoshi et al.
2009/0254446 A1 10/2009 Chernyak
2009/0264849 A1 10/2009 La Croix
2009/0275321 A1 11/2009 Crowe
2009/0278750 A1 11/2009 Man et al.
2009/0278915 A1 11/2009 Kramer et al.
2009/0279839 A1 11/2009 Nakamura et al.
2009/0284359 A1 11/2009 Huang et al.
2009/0287405 A1 11/2009 Liu et al.
2009/0299572 A1 12/2009 Fujikawa et al.
2009/0312998 A1 12/2009 Berckmans et al.
2009/0319181 A1 12/2009 Khosravy et al.
2010/0008053 A1 1/2010 Osternack et al.
2010/0023204 A1 1/2010 Basir et al.
2010/0035620 A1 2/2010 Naden et al.
2010/0036560 A1 2/2010 Wright et al.
2010/0042498 A1 2/2010 Schalk
2010/0052945 A1 3/2010 Breed
2010/0057337 A1 3/2010 Fuchs
2010/0066498 A1 3/2010 Fenton
2010/0069115 A1 3/2010 Liu
2010/0070338 A1 3/2010 Siotia et al.
2010/0077094 A1 3/2010 Howarter et al.
2010/0087987 A1 4/2010 Huang et al.
2010/0090817 A1 4/2010 Yamaguchi et al.
2010/0097178 A1 4/2010 Pisz et al.
2010/0097239 A1 4/2010 Campbell et al.
2010/0097458 A1 4/2010 Zhang et al.
2010/0106344 A1 4/2010 Edwards et al.
2010/0106418 A1 4/2010 Kindo et al.
2010/0118025 A1 5/2010 Smith et al.
2010/0121570 A1 5/2010 Tokue et al.
2010/0121645 A1 5/2010 Seitz et al.
2010/0125387 A1 5/2010 Sehyun et al.
2010/0125405 A1 5/2010 Chae et al.
2010/0125811 A1 5/2010 Moore et al.
2010/0127847 A1 5/2010 Evans et al.
2010/0131300 A1 5/2010 Collopy et al.
2010/0134302 A1 6/2010 Ahn et al.
2010/0134958 A1 6/2010 Disaverio et al.
2010/0136944 A1 6/2010 Taylor et al.
2010/0137037 A1 6/2010 Basir
2010/0144284 A1 6/2010 Chutorash et al.
2010/0145700 A1 6/2010 Kennewick et al.
2010/0145987 A1 6/2010 Harper et al.
2010/0152976 A1 6/2010 White et al.
2010/0169432 A1 7/2010 Santori et al.
2010/0174474 A1 7/2010 Nagase

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0179712 A1 7/2010 Pepitone et al.
2010/0185341 A1 7/2010 Wilson et al.
2010/0188831 A1 7/2010 Ortel
2010/0197359 A1 8/2010 Harris
2010/0202346 A1 8/2010 Sitzes et al.
2010/0211259 A1 8/2010 McClellan
2010/0211282 A1 8/2010 Nakata et al.
2010/0211300 A1 8/2010 Jaffe et al.
2010/0211304 A1 8/2010 Hwang et al.
2010/0211441 A1 8/2010 Sprigg et al.
2010/0217458 A1 8/2010 Schweiger et al.
2010/0222939 A1 9/2010 Namburu et al.
2010/0228404 A1 9/2010 Link et al.
2010/0234071 A1 9/2010 Shabtay et al.
2010/0235042 A1 9/2010 Ying
2010/0235744 A1 9/2010 Schultz
2010/0235891 A1 9/2010 Oglesbee et al.
2010/0250071 A1 9/2010 Pala et al.
2010/0253493 A1 10/2010 Szczerba et al.
2010/0256836 A1 10/2010 Mudalige
2010/0265104 A1 10/2010 Zlojutro
2010/0268426 A1 10/2010 Pathak et al.
2010/0274410 A1 10/2010 Tsien et al.
2010/0280751 A1 11/2010 Breed
2010/0287303 A1 11/2010 Smith et al.
2010/0289632 A1 11/2010 Seder et al.
2010/0289643 A1 11/2010 Trundle et al.
2010/0291427 A1 11/2010 Zhou
2010/0295676 A1 11/2010 Khachaturov et al.
2010/0304640 A1 12/2010 Sofman et al.
2010/0305807 A1 12/2010 Basir et al.
2010/0306080 A1 12/2010 Trandal et al.
2010/0306309 A1 12/2010 Santori et al.
2010/0306435 A1 12/2010 Nigoghosian et al.
2010/0315218 A1 12/2010 Cades et al.
2010/0321151 A1 12/2010 Matsuura et al.
2010/0325626 A1 12/2010 Greschler et al.
2010/0332130 A1 12/2010 Shimizu et al.
2011/0015853 A1 1/2011 DeKock et al.
2011/0018736 A1 1/2011 Carr
2011/0021213 A1 1/2011 Carr
2011/0021234 A1 1/2011 Tibbits et al.
2011/0028138 A1 2/2011 Davies-Moore et al.
2011/0035098 A1 2/2011 Goto et al.
2011/0035141 A1 2/2011 Barker et al.
2011/0040438 A1 2/2011 Kluge et al.
2011/0050589 A1 3/2011 Yan et al.
2011/0053506 A1 3/2011 Lemke et al.
2011/0077808 A1 3/2011 Hyde et al.
2011/0078024 A1 3/2011 Messier et al.
2011/0080282 A1 4/2011 Kleve et al.
2011/0082615 A1 4/2011 Small et al.
2011/0084824 A1 4/2011 Tewari et al.
2011/0090078 A1 4/2011 Kim et al.
2011/0092159 A1 4/2011 Park et al.
2011/0093154 A1 4/2011 Moinzadeh et al.
2011/0093158 A1 4/2011 Theisen et al.
2011/0093438 A1 4/2011 Poulsen
2011/0093846 A1 4/2011 Moinzadeh et al.
2011/0105097 A1 5/2011 Tadayon et al.
2011/0106375 A1 5/2011 Sundaram et al.
2011/0112717 A1 5/2011 Resner
2011/0112969 A1 5/2011 Zaid et al.
2011/0117933 A1 5/2011 Andersson
2011/0119344 A1 5/2011 Eustis
2011/0130915 A1 6/2011 Wright et al.
2011/0134749 A1 6/2011 Speks et al.
2011/0137520 A1 6/2011 Rector et al.
2011/0145331 A1 6/2011 Christie et al.
2011/0172873 A1 7/2011 Szwabowski et al.
2011/0175754 A1 7/2011 Karpinsky
2011/0183658 A1 7/2011 Zellner
2011/0187520 A1 8/2011 Filev et al.
2011/0190972 A1 8/2011 Timmons et al.
2011/0193707 A1 8/2011 Ngo
2011/0193726 A1 8/2011 Szwabowski et al.
2011/0195699 A1 8/2011 Tadayon et al.
2011/0197187 A1 8/2011 Roh
2011/0205047 A1 8/2011 Patel et al.
2011/0209079 A1 8/2011 Tarte et al.
2011/0210867 A1 9/2011 Benedikt
2011/0212717 A1 9/2011 Rhoads et al.
2011/0213656 A1 9/2011 Turner
2011/0221656 A1 9/2011 Haddick et al.
2011/0224865 A1 9/2011 Gordon et al.
2011/0224898 A1 9/2011 Scofield et al.
2011/0225527 A1 9/2011 Law et al.
2011/0227757 A1 9/2011 Chen et al.
2011/0231091 A1 9/2011 Gourlay et al.
2011/0234369 A1 9/2011 Cai et al.
2011/0245999 A1 10/2011 Kordonowy
2011/0246210 A1 10/2011 Matsur
2011/0247013 A1 10/2011 Feller et al.
2011/0251734 A1 10/2011 Schepp et al.
2011/0257973 A1 10/2011 Chutorash et al.
2011/0267204 A1 11/2011 Chuang et al.
2011/0267205 A1 11/2011 McClellan et al.
2011/0286676 A1 11/2011 El Dokor
2011/0288765 A1 11/2011 Conway
2011/0291886 A1 12/2011 Krieter
2011/0291926 A1 12/2011 Gokturk et al.
2011/0298808 A1 12/2011 Rovik
2011/0301844 A1 12/2011 Aono
2011/0307354 A1 12/2011 Erman et al.
2011/0307570 A1 12/2011 Speks
2011/0309926 A1 12/2011 Eikelenberg et al.
2011/0309953 A1 12/2011 Petite et al.
2011/0313653 A1 12/2011 Lindner
2011/0320089 A1 12/2011 Lewis
2012/0006610 A1 1/2012 Wallace et al.
2012/0010807 A1 1/2012 Zhou
2012/0016581 A1 1/2012 Mochizuki et al.
2012/0029852 A1 2/2012 Goff et al.
2012/0030002 A1 2/2012 Bous et al.
2012/0030512 A1 2/2012 Wadhwa et al.
2012/0038489 A1 2/2012 Goldshmidt
2012/0046822 A1 2/2012 Anderson
2012/0047530 A1 2/2012 Shkedi
2012/0053793 A1 3/2012 Sala et al.
2012/0053888 A1 3/2012 Stahlin et al.
2012/0059789 A1 3/2012 Sakai et al.
2012/0065815 A1 3/2012 Hess
2012/0065834 A1 3/2012 Senart
2012/0068956 A1 3/2012 Jira et al.
2012/0071097 A1 3/2012 Matsushita et al.
2012/0072244 A1 3/2012 Collins et al.
2012/0074770 A1 3/2012 Lee
2012/0083947 A1 4/2012 Anderson et al.
2012/0083960 A1 4/2012 Zhu et al.
2012/0083971 A1 4/2012 Preston
2012/0084773 A1 4/2012 Lee et al.
2012/0089299 A1 4/2012 Breed
2012/0092251 A1 4/2012 Hashimoto et al.
2012/0101876 A1 4/2012 Truvey et al.
2012/0101914 A1 4/2012 Kumar et al.
2012/0105613 A1 5/2012 Weng et al.
2012/0106114 A1 5/2012 Caron et al.
2012/0109446 A1 5/2012 Yousefi et al.
2012/0109451 A1 5/2012 Tan
2012/0110356 A1 5/2012 Yousefi et al.
2012/0113822 A1 5/2012 Letner
2012/0115446 A1 5/2012 Guatama et al.
2012/0116609 A1 5/2012 Jung et al.
2012/0116678 A1 5/2012 Witmer
2012/0116696 A1 5/2012 Wank
2012/0146766 A1 6/2012 Geisler et al.
2012/0146809 A1 6/2012 Oh et al.
2012/0149341 A1 6/2012 Tadayon et al.
2012/0150651 A1 6/2012 Hoffberg et al.
2012/0155636 A1 6/2012 Muthaiah
2012/0158436 A1 6/2012 Bauer et al.
2012/0173135 A1 7/2012 Gutman
2012/0173900 A1 7/2012 Diab et al.
2012/0173905 A1 7/2012 Diab et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0179325 A1 7/2012 Faenger
2012/0179547 A1 7/2012 Besore et al.
2012/0188876 A1 7/2012 Chow et al.
2012/0197523 A1 8/2012 Kirsch
2012/0197669 A1 8/2012 Kote et al.
2012/0204166 A1 8/2012 Ichihara
2012/0210160 A1 8/2012 Fuhrman
2012/0215375 A1 8/2012 Chang
2012/0217928 A1 8/2012 Kulidjian
2012/0218125 A1 8/2012 Demirdjian et al.
2012/0226413 A1 9/2012 Chen et al.
2012/0238286 A1 9/2012 Mallavarapu et al.
2012/0239242 A1 9/2012 Uehara
2012/0242510 A1 9/2012 Choi et al.
2012/0254763 A1 10/2012 Protopapas et al.
2012/0254804 A1 10/2012 Shema et al.
2012/0259951 A1 10/2012 Schalk et al.
2012/0265359 A1 10/2012 Das
2012/0274459 A1 11/2012 Jaisimha et al.
2012/0274481 A1 11/2012 Ginsberg et al.
2012/0284292 A1 11/2012 Rechsteiner et al.
2012/0289217 A1 11/2012 Reimer et al.
2012/0289253 A1 11/2012 Haag et al.
2012/0296567 A1 11/2012 Breed
2012/0313771 A1 12/2012 Wottlifff, III
2012/0316720 A1 12/2012 Hyde et al.
2012/0317561 A1 12/2012 Aslam et al.
2012/0323413 A1 12/2012 Kedar-Dongarkar et al.
2012/0327231 A1 12/2012 Cochran et al.
2013/0005263 A1 1/2013 Sakata
2013/0005414 A1 1/2013 Bindra et al.
2013/0013157 A1 1/2013 Kim et al.
2013/0015814 A1 1/2013 Kelty et al.
2013/0019252 A1 1/2013 Haase et al.
2013/0024060 A1 1/2013 Sukkarie et al.
2013/0030645 A1 1/2013 Divine et al.
2013/0030811 A1 1/2013 Olleon et al.
2013/0031540 A1 1/2013 Throop et al.
2013/0031541 A1 1/2013 Wilks et al.
2013/0035063 A1 2/2013 Fisk et al.
2013/0046624 A1 2/2013 Calman
2013/0050069 A1 2/2013 Ota
2013/0055096 A1 2/2013 Kim et al.
2013/0059607 A1 3/2013 Herz et al.
2013/0063336 A1 3/2013 Sugimoto et al.
2013/0066512 A1 3/2013 Willard et al.
2013/0067599 A1 3/2013 Raje et al.
2013/0075530 A1 3/2013 Shander et al.
2013/0079964 A1 3/2013 Sukkarie et al.
2013/0083805 A1 4/2013 Lu et al.
2013/0085787 A1 4/2013 Gore et al.
2013/0086164 A1 4/2013 Wheeler et al.
2013/0099915 A1 4/2013 Prasad et al.
2013/0103196 A1 4/2013 Monceaux et al.
2013/0105264 A1 5/2013 Ruth et al.
2013/0116882 A1 5/2013 Link et al.
2013/0116915 A1 5/2013 Ferreira et al.
2013/0134730 A1 5/2013 Ricci
2013/0135118 A1 5/2013 Ricci
2013/0138591 A1 5/2013 Ricci
2013/0138714 A1 5/2013 Ricci
2013/0139140 A1 5/2013 Rao et al.
2013/0141247 A1 6/2013 Ricci
2013/0141252 A1 6/2013 Ricci
2013/0143495 A1 6/2013 Ricci
2013/0143546 A1 6/2013 Ricci
2013/0143601 A1 6/2013 Ricci
2013/0144459 A1 6/2013 Ricci
2013/0144460 A1 6/2013 Ricci
2013/0144461 A1 6/2013 Ricci
2013/0144462 A1 6/2013 Ricci
2013/0144463 A1 6/2013 Ricci et al.
2013/0144469 A1 6/2013 Ricci
2013/0144470 A1 6/2013 Ricci
2013/0144474 A1 6/2013 Ricci
2013/0144486 A1 6/2013 Ricci
2013/0144520 A1 6/2013 Ricci
2013/0144657 A1 6/2013 Ricci
2013/0145065 A1 6/2013 Ricci
2013/0145279 A1 6/2013 Ricci
2013/0145297 A1 6/2013 Ricci et al.
2013/0145360 A1 6/2013 Ricci
2013/0145401 A1 6/2013 Ricci
2013/0145482 A1 6/2013 Ricci et al.
2013/0147638 A1 6/2013 Ricci
2013/0151031 A1 6/2013 Ricci
2013/0151065 A1 6/2013 Ricci
2013/0151088 A1 6/2013 Ricci
2013/0151288 A1 6/2013 Bowne et al.
2013/0152003 A1 6/2013 Ricci et al.
2013/0154298 A1 6/2013 Ricci
2013/0157640 A1 6/2013 Aycock
2013/0157647 A1 6/2013 Kolodziej
2013/0158778 A1 6/2013 Tengler et al.
2013/0158821 A1 6/2013 Ricci
2013/0166096 A1 6/2013 Jotanovic
2013/0166097 A1 6/2013 Ricci
2013/0166098 A1 6/2013 Lavie et al.
2013/0166109 A1 6/2013 Ginsberg
2013/0166152 A1 6/2013 Butterworth
2013/0166208 A1 6/2013 Forstall et al.
2013/0167159 A1 6/2013 Ricci et al.
2013/0173531 A1 7/2013 Rinearson et al.
2013/0179689 A1 7/2013 Matsumoto et al.
2013/0190978 A1 7/2013 Kato et al.
2013/0194108 A1 8/2013 Lapiotis et al.
2013/0197796 A1 8/2013 Obradovich et al.
2013/0198031 A1 8/2013 Mitchell et al.
2013/0198737 A1 8/2013 Ricci
2013/0198802 A1 8/2013 Ricci
2013/0200991 A1 8/2013 Ricci et al.
2013/0203400 A1 8/2013 Ricci
2013/0204455 A1 8/2013 Chia et al.
2013/0204457 A1 8/2013 King
2013/0204466 A1 8/2013 Ricci
2013/0204484 A1 8/2013 Ricci
2013/0204493 A1 8/2013 Ricci et al.
2013/0204943 A1 8/2013 Ricci
2013/0205026 A1 8/2013 Ricci
2013/0205412 A1 8/2013 Ricci
2013/0207794 A1 8/2013 Patel et al.
2013/0212065 A1 8/2013 Rahnama
2013/0212659 A1 8/2013 Maher et al.
2013/0215116 A1 8/2013 Siddique et al.
2013/0218412 A1 8/2013 Ricci
2013/0218445 A1 8/2013 Basir
2013/0219039 A1 8/2013 Ricci
2013/0226365 A1 8/2013 Brozovich
2013/0226371 A1 8/2013 Rovik et al.
2013/0226392 A1 8/2013 Schneider et al.
2013/0226449 A1 8/2013 Rovik et al.
2013/0226622 A1 8/2013 Adamson et al.
2013/0227648 A1 8/2013 Ricci
2013/0231784 A1 9/2013 Rovik et al.
2013/0231800 A1 9/2013 Ricci
2013/0232142 A1 9/2013 Nielsen et al.
2013/0238165 A1 9/2013 Garrett et al.
2013/0241720 A1 9/2013 Ricci et al.
2013/0245882 A1 9/2013 Ricci
2013/0250933 A1 9/2013 Yousefi et al.
2013/0261871 A1 10/2013 Hobbs et al.
2013/0261966 A1 10/2013 Wang et al.
2013/0265178 A1 10/2013 Tengler et al.
2013/0274997 A1 10/2013 Chien
2013/0279111 A1 10/2013 Lee
2013/0279491 A1 10/2013 Rubin et al.
2013/0282238 A1 10/2013 Ricci et al.
2013/0282357 A1 10/2013 Rubin et al.
2013/0282946 A1 10/2013 Ricci
2013/0288606 A1 10/2013 Kirsch
2013/0293364 A1 11/2013 Ricci et al.
2013/0293452 A1 11/2013 Ricci et al.
2013/0293480 A1 11/2013 Kritt et al.
2013/0295901 A1 11/2013 Abramson et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0295908 A1 11/2013 Zeinstra et al.
2013/0295913 A1 11/2013 Matthews et al.
2013/0297195 A1 11/2013 Das et al.
2013/0300554 A1 11/2013 Braden
2013/0301584 A1 11/2013 Addepalli et al.
2013/0304371 A1 11/2013 Kitatani et al.
2013/0308265 A1 11/2013 Arnouse
2013/0309977 A1 11/2013 Heines et al.
2013/0311038 A1 11/2013 Kim et al.
2013/0325453 A1 12/2013 Levien et al.
2013/0325568 A1 12/2013 Mangalvedkar et al.
2013/0329372 A1 12/2013 Wilkins
2013/0332023 A1 12/2013 Bertosa et al.
2013/0338914 A1 12/2013 Weiss
2013/0339027 A1 12/2013 Dokor et al.
2013/0345929 A1 12/2013 Bowden et al.
2014/0028542 A1 1/2014 Lovitt et al.
2014/0032014 A1 1/2014 DeBiasio et al.
2014/0054957 A1 2/2014 Bellis
2014/0058672 A1 2/2014 Wansley et al.
2014/0066014 A1 3/2014 Nicholson et al.
2014/0067201 A1 3/2014 Visintainer et al.
2014/0067564 A1 3/2014 Yuan
2014/0070917 A1 3/2014 Protopapas
2014/0081544 A1 3/2014 Fry
2014/0088798 A1 3/2014 Himmelstein
2014/0096068 A1 4/2014 Dewan et al.
2014/0097955 A1 4/2014 Lovitt et al.
2014/0109075 A1 4/2014 Hoffman et al.
2014/0109080 A1 4/2014 Ricci
2014/0120829 A1 5/2014 Bhamidipati et al.
2014/0121862 A1 5/2014 Zarrella et al.
2014/0125802 A1 5/2014 Beckert et al.
2014/0143839 A1 5/2014 Ricci
2014/0156133 A1 6/2014 Cullinane et al.
2014/0164611 A1 6/2014 Molettiere et al.
2014/0168062 A1 6/2014 Katz et al.
2014/0168436 A1 6/2014 Pedicino
2014/0169621 A1 6/2014 Burr
2014/0171752 A1 6/2014 Park et al.
2014/0172727 A1 6/2014 Abhyanker et al.
2014/0188533 A1 7/2014 Davidson
2014/0195272 A1 7/2014 Sadiq et al.
2014/0198216 A1 7/2014 Zhai et al.
2014/0200737 A1 7/2014 Lortz et al.
2014/0207328 A1 7/2014 Wolf et al.
2014/0220966 A1 8/2014 Muetzel et al.
2014/0222298 A1 8/2014 Gurin
2014/0223384 A1 8/2014 Graumann
2014/0240089 A1 8/2014 Chang
2014/0244078 A1 8/2014 Downey et al.
2014/0244096 A1 8/2014 AN et al.
2014/0244111 A1 8/2014 Gross et al.
2014/0244156 A1 8/2014 Magnusson et al.
2014/0245277 A1 8/2014 Petro et al.
2014/0245278 A1 8/2014 Zellen
2014/0245284 A1 8/2014 Alrabady et al.
2014/0252091 A1 9/2014 Morse et al.
2014/0257627 A1 9/2014 Hagan, Jr.
2014/0267035 A1 9/2014 Schalk et al.
2014/0277936 A1 9/2014 El Dokor et al.
2014/0278070 A1 9/2014 McGavran et al.
2014/0278071 A1 9/2014 San Filippo et al.
2014/0278086 A1 9/2014 San Filippo et al.
2014/0281971 A1 9/2014 Isbell, III et al.
2014/0282161 A1 9/2014 Cash
2014/0282278 A1 9/2014 Anderson et al.
2014/0282470 A1 9/2014 Buga et al.
2014/0282931 A1 9/2014 Protopapas
2014/0292545 A1 10/2014 Nemoto
2014/0292665 A1 10/2014 Lathrop et al.
2014/0303899 A1 10/2014 Fung
2014/0306799 A1 10/2014 Ricci
2014/0306814 A1 10/2014 Ricci
2014/0306817 A1 10/2014 Ricci
2014/0306826 A1 10/2014 Ricci
2014/0306833 A1 10/2014 Ricci
2014/0306834 A1 10/2014 Ricci
2014/0306835 A1 10/2014 Ricci
2014/0307655 A1 10/2014 Ricci
2014/0307724 A1 10/2014 Ricci
2014/0308902 A1 10/2014 Ricci
2014/0309789 A1 10/2014 Ricci
2014/0309790 A1 10/2014 Ricci
2014/0309804 A1 10/2014 Ricci
2014/0309805 A1 10/2014 Ricci
2014/0309806 A1 10/2014 Ricci
2014/0309813 A1 10/2014 Ricci
2014/0309814 A1 10/2014 Ricci et al.
2014/0309815 A1 10/2014 Ricci et al.
2014/0309838 A1 10/2014 Ricci
2014/0309839 A1 10/2014 Ricci et al.
2014/0309847 A1 10/2014 Ricci
2014/0309849 A1 10/2014 Ricci
2014/0309852 A1 10/2014 Ricci
2014/0309853 A1 10/2014 Ricci
2014/0309862 A1 10/2014 Ricci
2014/0309863 A1 10/2014 Ricci
2014/0309864 A1 10/2014 Ricci
2014/0309865 A1 10/2014 Ricci
2014/0309866 A1 10/2014 Ricci
2014/0309867 A1 10/2014 Ricci
2014/0309868 A1 10/2014 Ricci
2014/0309869 A1 10/2014 Ricci
2014/0309870 A1 10/2014 Ricci et al.
2014/0309871 A1 10/2014 Ricci
2014/0309872 A1 10/2014 Ricci
2014/0309873 A1 10/2014 Ricci
2014/0309874 A1 10/2014 Ricci
2014/0309875 A1 10/2014 Ricci
2014/0309876 A1 10/2014 Ricci
2014/0309877 A1 10/2014 Ricci
2014/0309878 A1 10/2014 Ricci
2014/0309879 A1 10/2014 Ricci
2014/0309880 A1 10/2014 Ricci
2014/0309885 A1 10/2014 Ricci
2014/0309886 A1 10/2014 Ricci
2014/0309891 A1 10/2014 Ricci
2014/0309892 A1 10/2014 Ricci
2014/0309893 A1 10/2014 Ricci
2014/0309913 A1 10/2014 Ricci et al.
2014/0309919 A1 10/2014 Ricci
2014/0309920 A1 10/2014 Ricci
2014/0309921 A1 10/2014 Ricci et al.
2014/0309922 A1 10/2014 Ricci
2014/0309923 A1 10/2014 Ricci
2014/0309927 A1 10/2014 Ricci
2014/0309929 A1 10/2014 Ricci
2014/0309930 A1 10/2014 Ricci
2014/0309934 A1 10/2014 Ricci
2014/0309935 A1 10/2014 Ricci
2014/0309982 A1 10/2014 Ricci
2014/0310031 A1 10/2014 Ricci
2014/0310075 A1 10/2014 Ricci
2014/0310103 A1 10/2014 Ricci
2014/0310186 A1 10/2014 Ricci
2014/0310277 A1 10/2014 Ricci
2014/0310379 A1 10/2014 Ricci et al.
2014/0310594 A1 10/2014 Ricci et al.
2014/0310610 A1 10/2014 Ricci
2014/0310702 A1 10/2014 Ricci et al.
2014/0310739 A1 10/2014 Ricci et al.
2014/0310788 A1 10/2014 Ricci
2014/0322676 A1 10/2014 Raman
2014/0347207 A1 11/2014 Zeng et al.
2014/0347265 A1 11/2014 Allen et al.
2015/0007155 A1 1/2015 Hoffman et al.
2015/0012186 A1 1/2015 Horseman
2015/0032366 A1 1/2015 Man et al.
2015/0032670 A1 1/2015 Brazell
2015/0057839 A1 2/2015 Chang et al.
2015/0061895 A1 3/2015 Ricci
2015/0081133 A1 3/2015 Schulz
2015/0081167 A1 3/2015 Pisz et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0088423	A1	3/2015	Tuukkanen	
2015/0088515	A1	3/2015	Beaumont et al.	
2015/0116200	A1	4/2015	Kurosawa et al.	
2015/0158499	A1	6/2015	Koravadi	
2015/0178034	A1	6/2015	Penilla et al.	
2015/0235480	A1	8/2015	Cudak et al.	
2016/0003637	A1	1/2016	Andersen	
2016/0008985	A1	1/2016	Kim et al.	
2016/0009291	A1	1/2016	Pallett et al.	
2016/0009295	A1	1/2016	Chun et al.	
2016/0009391	A1	1/2016	Friesel	
2016/0026182	A1	1/2016	Boroditsky et al.	
2016/0046288	A1	2/2016	Pawlicki et al.	
2016/0059856	A1	3/2016	Van Dan Elzen et al.	
2016/0070527	A1	3/2016	Ricci	
2016/0086391	A1	3/2016	Ricci	
2016/0129908	A1	5/2016	Harda	
2016/0202074	A1	7/2016	Woodard et al.	
2016/0221573	A1	8/2016	Prokhorov	
2016/0269456	A1	9/2016	Ricci	
2016/0269469	A1	9/2016	Ricci	
2016/0276854	A1	9/2016	Lian	
2016/0355192	A1	12/2016	James et al.	
2016/0368396	A1	12/2016	Konet et al.	
2016/0375788	A1	12/2016	Liu	
2017/0008523	A1	1/2017	Christensen et al.	
2017/0015288	A1	1/2017	Coelingh et al.	
2017/0036673	A1	2/2017	Lee	
2017/0053538	A1	2/2017	Samarasekera et al.	
2017/0057507	A1	3/2017	Gordon et al.	
2017/0057542	A1	3/2017	Kim et al.	
2017/0076455	A1	3/2017	Newman et al.	
2017/0212515	A1	7/2017	Bertollini et al.	
2017/0242442	A1	8/2017	Minster	
2017/0267256	A1	9/2017	Minster et al.	
2017/0291615	A1	10/2017	Kusano et al.	
2017/0349045	A1	12/2017	McNew	
2017/0349185	A1	12/2017	McNew	
2017/0355377	A1	12/2017	Vijaya Kumar et al.	
2018/0052463	A1	2/2018	Mays	
2018/0113450	A1	4/2018	Sherony	
2018/0118219	A1	5/2018	Hiei et al.	
2018/0143639	A1*	5/2018	Singhal	G01S 13/862
2018/0151064	A1	5/2018	Xu et al.	
2018/0208209	A1	7/2018	Al-Dahle et al.	

FOREIGN PATENT DOCUMENTS

CN	101303878	11/2008
CN	102467827	5/2012
EP	1223567	7/2002
EP	1484729	12/2004
EP	2192015	6/2010
JP	2004-284450	10/2004
KR	2006-0128484	12/2006
WO	WO 2007/126204	11/2007
WO	WO 2012/102879	8/2012
WO	WO 2013/074866	5/2013
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WO	WO 2014/172323	10/2014
WO	WO 2014/172327	10/2014
WO	WO 2016/145073	9/2016
WO	WO 2016/145100	9/2016
WO	WO 2017/167790	10/2017

OTHER PUBLICATIONS

Engel et al., "LSD-SLAM: Large-Scale Direct Monocular SLAM," Springer, Cham., European Conference, 2014, Computer Vision, pp. 834-849, 16 pages.

Final Action for U.S. Appl. No. 15/395,924, dated Jul. 30, 2018, 14 pages.

Official Action for U.S. Appl. No. 15/395,952, dated Aug. 3, 2018, 11 pages.

U.S. Appl. No. 15/395,924, filed Dec. 30, 2016, Singhal et al.

U.S. Appl. No. 15/395,952, filed Dec. 30, 2016, Singhal et al.

U.S. Appl. No. 15/407,066, filed Jan. 16, 2017, Yellambalase et al.

U.S. Appl. No. 15/408,143, filed Jan. 17, 2017, Xiao et al.

U.S. Appl. No. 15/665,644, filed Aug. 1, 2017, Singhal.

U.S. Appl. No. 15/848,851, filed Dec. 20, 2017, Cox et al.

U.S. Appl. No. 15/727,838, filed Oct. 9, 2017, Cox et al.

U.S. Appl. No. 15/786,373, filed Oct. 17, 2017, Guo et al.

U.S. Appl. No. 15/798,016, filed Oct. 30, 2017, Valla et al.

U.S. Appl. No. 61/567,962, filed Dec. 7, 2011, Baarman et al.

"Carpool, HOV, Transit lanes," WazeWiki, 2016, retrieved from https://wiki.waze.com/wiki/Carpool,_HOV,_Transit_lanes, retrieved on Feb. 27, 2018, 3 pages.

"Managing Demand Through Travel Information Services," U.S. Department of Transportation brochure, FHWA, retrieved from http://www.ops.fhwa.dot.gov/publications/manag_demand_tis/travelinfo.htm, retrieved on Feb. 28, 2018, 30 pages.

"Nexus 10 Guidebook for Android," Google Inc., © 2012, Edition 1.2, 166 pages.

"ORB (Oriented FAST and Rotated BRIEF)", Open CV 3.0.0-dev documentation, retrieved from https://docs.opencv.org/3.0-beta/doc/py_tutorials/py_feature2d/py_orb/py_orb.html, 2014, 3 pages.

"Self-Driving: Self-Driving Autonomous Cars," available at http://www.automotivetechnologies.com/autonomous-self-driving-cars, accessed Dec. 2016, 9 pages.

"Softmax function," Wikipedia, retrieved from https://en.wikipedia.org/wiki/Softmax_function, retrieved on Feb. 28, 2018, 4 pages.

Amor-Segan et al., "Towards the Self Healing Vehicle," Automotive Electronics, Jun. 2007, 2007 3rd Institution of Engineering and Technology Conference, 7 pages.

Badino et al., "Real-Time Topometric Localization," IEEE International Conference, Robotics and Automation, 2012, 8 pages.

Bennett, "Meet Samsung's Version of Apple AirPlay," CNET.com, Oct. 10, 2012, 11 pages.

Brubaker et al., "Lost! Leveraging the Crowd for Probabilistic Visual Self-Localization," Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2013, 8 pages.

Cairnie et al., "Using Finger-Pointing to Operate Secondary Controls in Automobiles," Proceedings of the IEEE Intelligent Vehicles Symposium 2000, Oct. 3-5, 2000, 6 pages.

Cathy et al., "A prescription for transit arrival/departure prediction using automatic vehicle location data," Transportation Research Part C, 2003, vol. 11, pp. 241-264.

Clark, "How Self-Driving Cars Work: The Nuts and Bolts Behind Google's Autonomous Car Program," Feb. 21, 2015, available at http://www.makeuseof.com/tag/how-self-driving-cars-work-the-nuts-and-bolts-behind-googles-autonomous-car-program/, 9 pages.

Davies, "This NIO EP9 performance EV wants to be the Tesla of Supercars," SlashGear, 2016, retrieved from https//www.slashgear.com/nextev-nio-ep9-car-tesla-of-performance-evs-21464829, 9 pages.

Deaton et al., "How Driverless Cars Will Work," Jul. 1, 2008, HowStuffWorks.com. <http://auto.howstuffworks.com/under-the-hood/trends-innovations/driverless-car.htm> Sep. 18, 2017, 10 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Dellaert et al., "Monte Carlo Localization for Mobile Robots," IEEE, Robotics and Automation, 1999 Proceedings, vol. 2, pp. 1322-1328.
Dumbaugh, "Safe Streets, Livable Streets: A Positive Approach to urban Roadside Design," Ph.D. dissertation for School of Civil & Environ. Engr., Georgia Inst. of Technology, Dec. 2005, 235 pages.
Engel et al., "LSD-SLAM: Large-Scale Direct Monocular SLAM," Springer, Cham., European Conference, Computer Vision, pp. 834-849, 16 pages.
Fei et al., "A QoS-aware Dynamic Bandwidth Allocation Algorithm for Relay Stations in IEEE 802.16j-based Vehicular Networks," Proceedings of the 2010 IEEE Global Telecommunications Conference, Dec. 10, 2010, 6 pages.
Floros et al., "OpenStreetSLAM: Global Vehicle Localization Using OpenStreetMaps," RWTH Aachen University, Computer Vision Group, 2013, 20 pages.
Galvez-Lopez et al., "Bags of Binary Words for Fast Place Recognition in Image Sequences," IEEE Transactions on Robotics, 2012, vol. 28(5), pp. 1188-1197.
Ge et al., "Optimal Relay Selection in IEEE 802.16 Multihop Relay Vehicular Networks," IEEE Transactions on Vehicular Technology, 2010, vol. 59(5), pp. 2198-2206.
Grauman et al., "Excerpt chapter from Synthesis lecture draft: Visual Recognition," 2012, retrieved from http://www.cs.utexas.edu/~grauman/courses/fall2009/papers/bag_of_visual_words.pdf, 8 pages.
Guizzo, "How Google's Self-Driving Car Works," Oct. 18, 2011, available at https://spectrum.ieee.org/automaton/robotics/artificial-intelligence/how-google-self-driving-car-works, 5 pages.
Haklay et al., "OpenStreetMap: User-Generated Street Maps," IEEE Pervasive Computing, 2008, pp. 12-18.
Hays et al., "IM2GPS: estimating geographic information from a single image," IEEE Conference, Computer Vision and Pattern Recognition, 2008, pp. 1-8.
Heer et al., "ALPHA: An Adaptive and Lightweight Protocol for Hop-by-hop Authentication," Proceedings of CoNEXT 2008, Dec. 2008, pp. 1-12.
Jahnich et al., "Towards a Middleware Approach for a Self-Configurable Automotive Embedded System," International Federation for Information Processing, 2008, pp. 55-65.
Kautonen, "NextEV unveils the NIO EP9 electric supercar in London," Autoblog, 2016, retrieved from http://www.autoblog.com/2016/11/21/nextev-unveiles-the-nio-ep9-electric-supercar-in-london/, 3 pages.
Kneip et al., "Robust Real-Time Visual Odometry with a Single Camera and an IMU," Proceedings of the British Machine Vision Conference, 2011, 11 pages.
Konolige et al., "Large-Scale Visual Odometry for Rough Terrain," Robotics Research, 2010, pp. 201-212, 12 pages.
Levinson et al., "Map-Based Precision Vehicle Localization in Urban Environments," Robotics: Science and Systems, 2007, vol. 4, 8 pages.
Ma et al., "Find your Way by Observing the Sun and Other Semantic Cues," Computer Vision and Pattern Recognition, 2016, 12 pages.
Muja et al., "Fast Approximate Nearest Neighbors with Automatic Algorithm Configuration," VISAPP International Conference on Computer Vision Theory and Applications, 2009, vol. 1, pp. 331-340, 10 pages.
Mur-Artal et al., "ORB-SLAM: a Versatile and Accurate Monocular SLAM System," IEEE Translations, Robotics, 2015, vol. 31(5), pp. 1147-1163.
Nister et al., "Visual odometry," IEEE Computer Vision and Pattern Recognition, 2004, vol. 1, 35 pages.
Persson "Adaptive Middleware for Self-Configurable Embedded Real-Time Systems," KTH Industrial Engineering and Management, 2009, 92 pages.
Raychaudhuri et al., "Emerging Wireless Technologies and the Future Mobile Internet," p. 48, Cambridge Press, 2011, 3 pages.
Rublee et al., ORB: an efficient alternative to SIFT or SURF, In Computer Vision (ICCV), 2011 IEEE international conference on (pp. 2564-2571) retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.370.4395&rep=rep1&type=pdfs, 8 pages.
Ruchti et al., "Localization on openstreetmap data using a 3D Laser Scanner," IEEE International Conference, Robotics and Automation, 2015, 6 pages.
Scaramuzza et al., "Visual Odometry[tutorial]," IEEE Robotics & Automation Magazine, 2011, vol. 18(4), pp. 80-92.
Stachniss, "Robot Mapping: Short Introduction to Particle Filters and Monte Carlo Localization," Albert-Ludwigs-Universitat Freiburg, 2012, retrieved from http://ais.informatik.uni-freiburg.de/teaching/ws12/mapping/pdf/slam09-particle-filter-4.pdf, 9 pages.
Stephens, Leah, "How Driverless Cars Work," Interesting Engineering, Apr. 28, 2016, available at https://interestingengineering.com/driverless-cars-work/, 7 pages.
Stoller, "Leader Election in Distributed Systems with Crash Failures," Indiana University, 1997, pp. 1-15.
Strunk et al., "The Elements of Style," 3d ed., Macmillan Publishing Co., 1979, 3 pages.
Suwatthikul, "Fault detection and diagnosis for in-vehicle networks," Intech, 2010, pp. 283-286 [retrieved from: www.intechopen.com/books/fault-detection-and-diagnosis-for-in-vehicle-networks].
Thurn/Burgard/Fox, "Probabilistic Robotics," The MIT Press, 2010, retrieved from http://robotics.usc.edu/~gaurav/CS547/lecture6-2010-particle-filters.pdf, 51 pages.
Urmson et al., "Autonomous Driving in Urban Environments: Boss and the Urban Challenge," Journal of Field Robotics, 2008, vol. 25(8), pp. 425-466.
Walter et al., "The smart car seat: personalized monitoring of vital signs in automotive applications." Personal and Ubiquitous Computing, Oct. 2011, vol. 15, No. 7, pp. 707-715.
White, "NextEV's NIO IP9 is an incredible four-wheel-drive electric hypercar," WIRED, 2016, retrieved from http://www.wired.co.uk/article/nextev-hypercar-nio-ep9, 6 pages.
Wolf et al., "Design, Implementation, and Evaluation of a Vehicular Hardware Security Module," ICISC'11 Proceedings of the 14th Int'l Conf. Information Security & Cryptology, Springer-Verlag Berlin, Heidelberg, 2011, pp. 302-318.
Wu et al., "Where am I: Place instance and category recognition using spatial PACT," IEEE Conference, Computer Vision and Pattern Recognition, 2008, 8 pages.
Zhang et al., "LOAM: Lidar Odometry and Mapping in Real-time," Robotics Science and Systems, 2014, vol. 2, 9 pages.
Zhang et al., "Real-time Depth Enhanced Monocular Odometry," IEEE/RSJ International Conference, Intelligent Robots and Systems, 2014, pp. 4973-4980.
Zhang et al., "Visual-lidar Odometry and Mapping: Low-drift, Robust, and Fast," IEEE International Conference, Robotics and Automation, 2015, pp. 2174-2181.
Official Action for U.S. Appl. No. 15/395,924, dated Jan. 25, 2018, 10 pages.
Official Action for U.S. Appl. No. 15/395,924, dated Nov. 19, 2018, 13 pages.
Official Action for U.S. Appl. No. 15/407,066, dated Nov. 8, 2018, 9 pages.
Notice of Allowance for U.S. Appl. No. 15/408,143, dated Nov. 20, 2018, 8 pages.
Official Action for U.S. Appl. No. 15/665,644, dated Nov. 19, 2018, 32 pages.

* cited by examiner

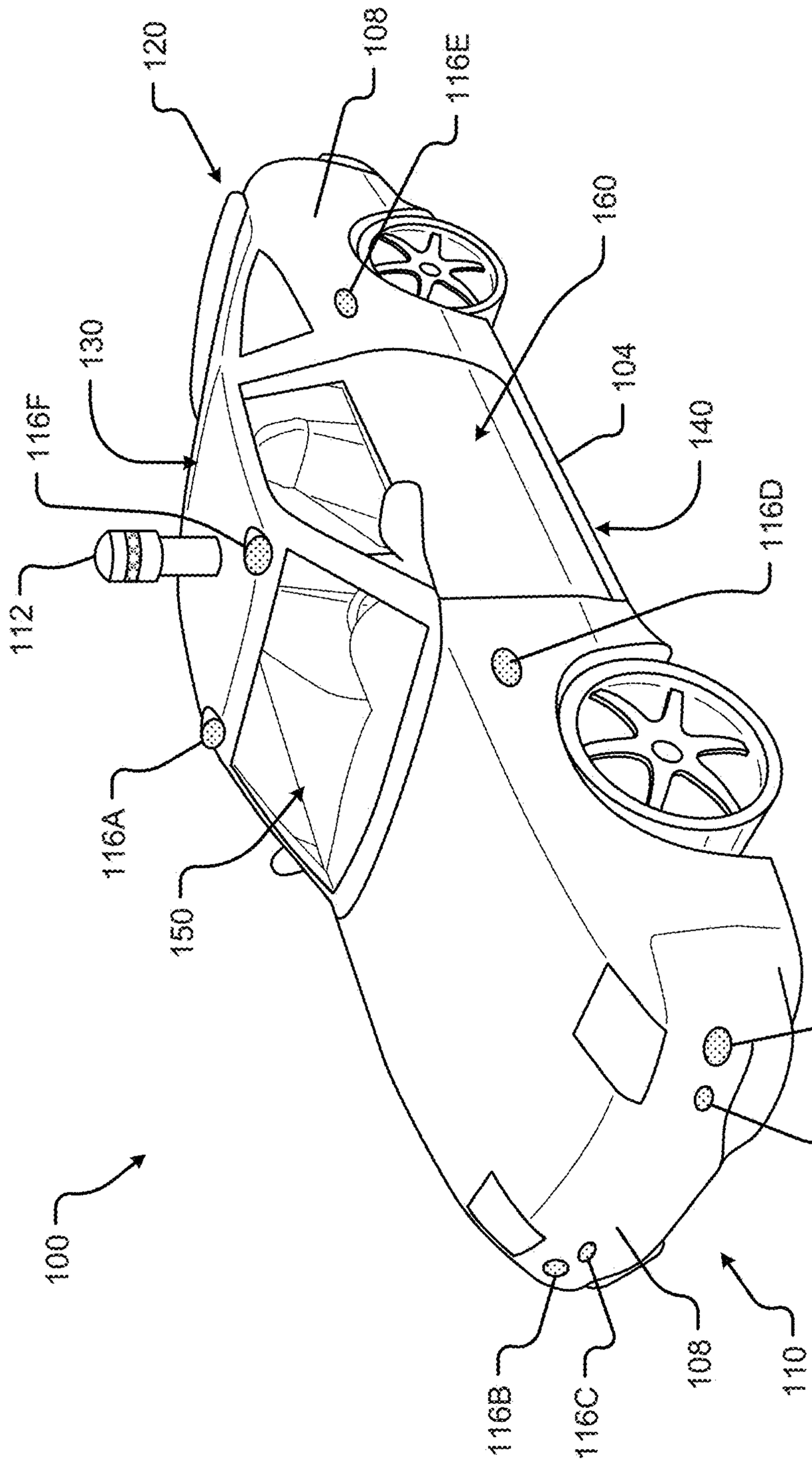

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116E
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116D
116A
150
116B
116C
108
110
116C
100

Fig. 1

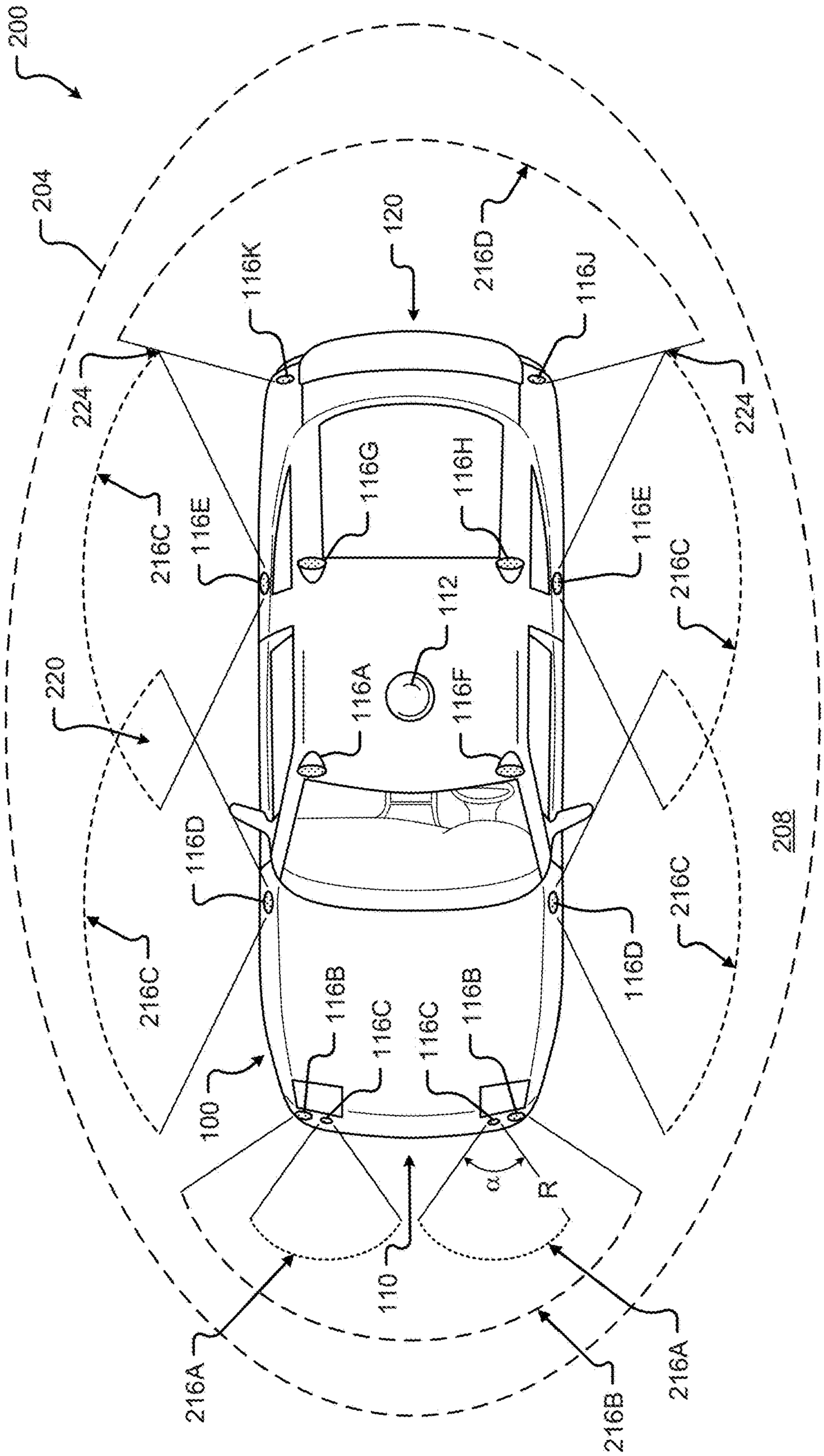

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204
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216C
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216C
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116F
216C
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α
R
216A
216B
216A

Fig. 2

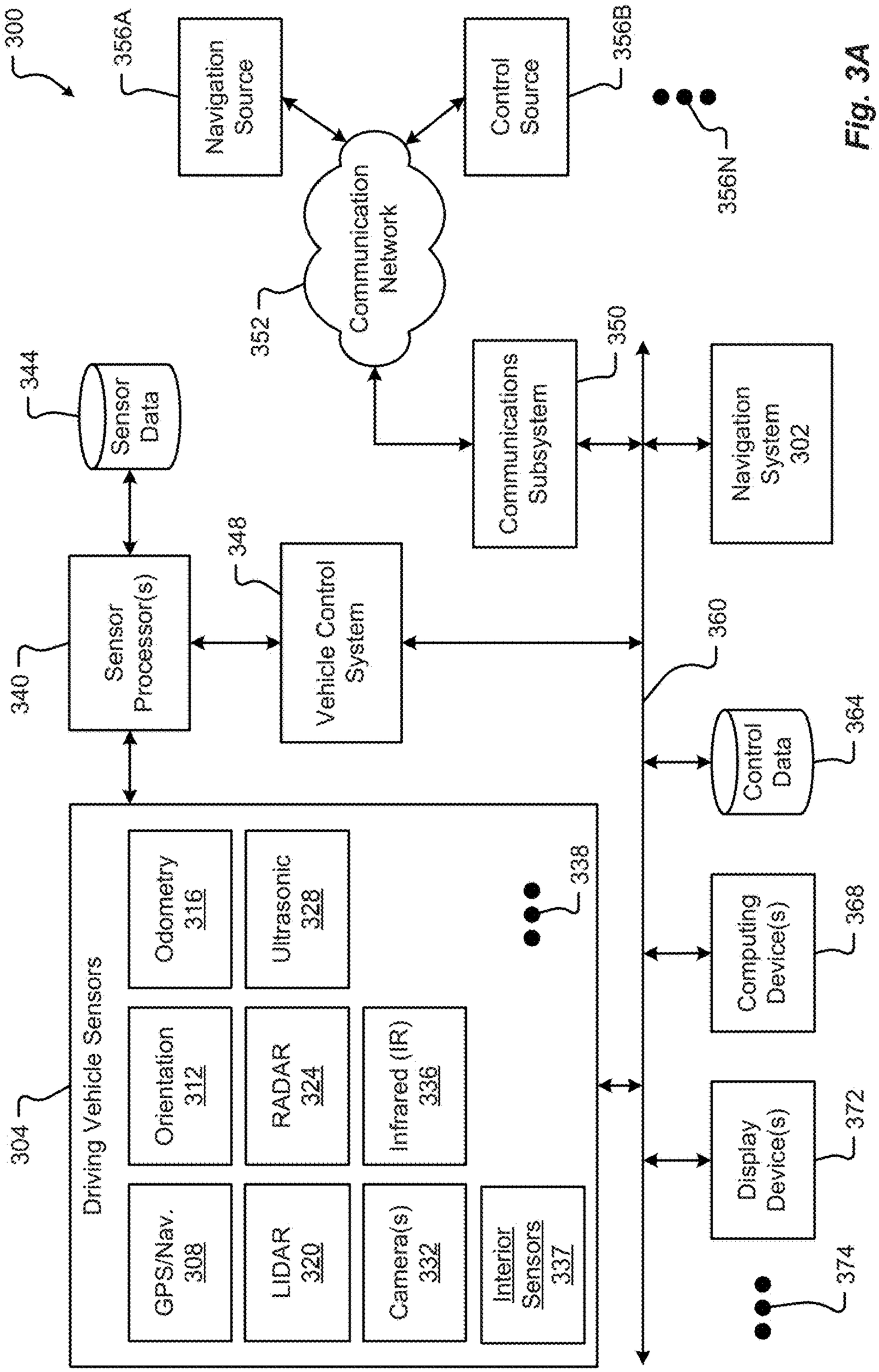

300
304
Driving Vehicle Sensors
GPS/Nav. 308
Odometry 316
Orientation 312
LIDAR 320
Ultrasonic 328
RADAR 324
Camera(s) 332
Infrared (IR) 336
Interior Sensors 337
338
340
Sensor Processor(s)
344
Sensor Data
348
Vehicle Control System
352
Communication Network
356A
Navigation Source
356B
Control Source
356N
350
Communications Subsystem
Navigation System 302
360
Control Data
364
Computing Device(s)
368
Display Device(s)
372
374

Fig. 3A

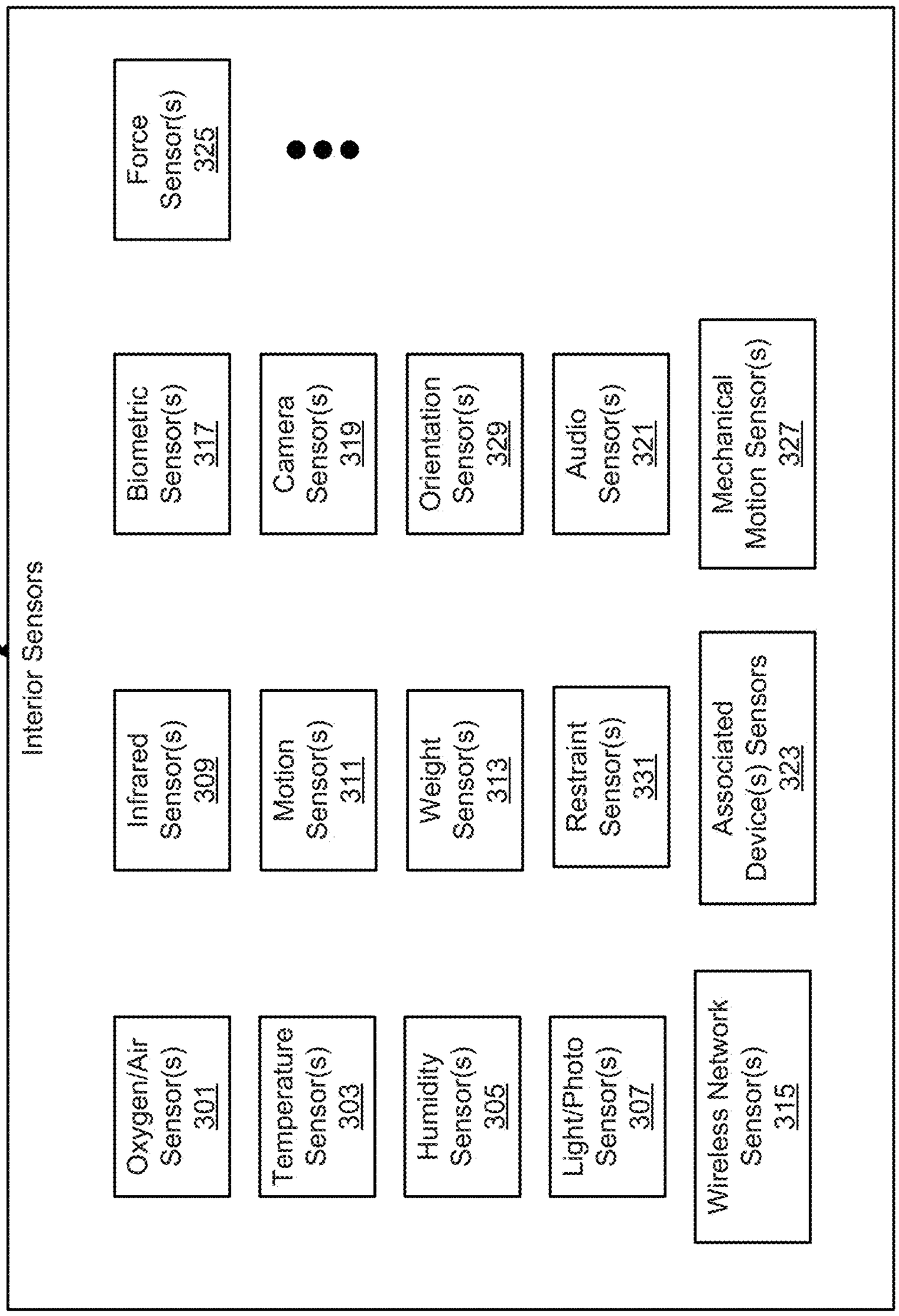

337
Interior Sensors
Oxygen/Air Sensor(s) 301
Temperature Sensor(s) 303
Humidity Sensor(s) 305
Light/Photo Sensor(s) 307
Wireless Network Sensor(s) 315
Infrared Sensor(s) 309
Motion Sensor(s) 311
Weight Sensor(s) 313
Restraint Sensor(s) 331
Associated Device(s) Sensors 323
Biometric Sensor(s) 317
Camera Sensor(s) 319
Orientation Sensor(s) 329
Audio Sensor(s) 321
Mechanical Motion Sensor(s) 327
Force Sensor(s) 325

Fig. 3B

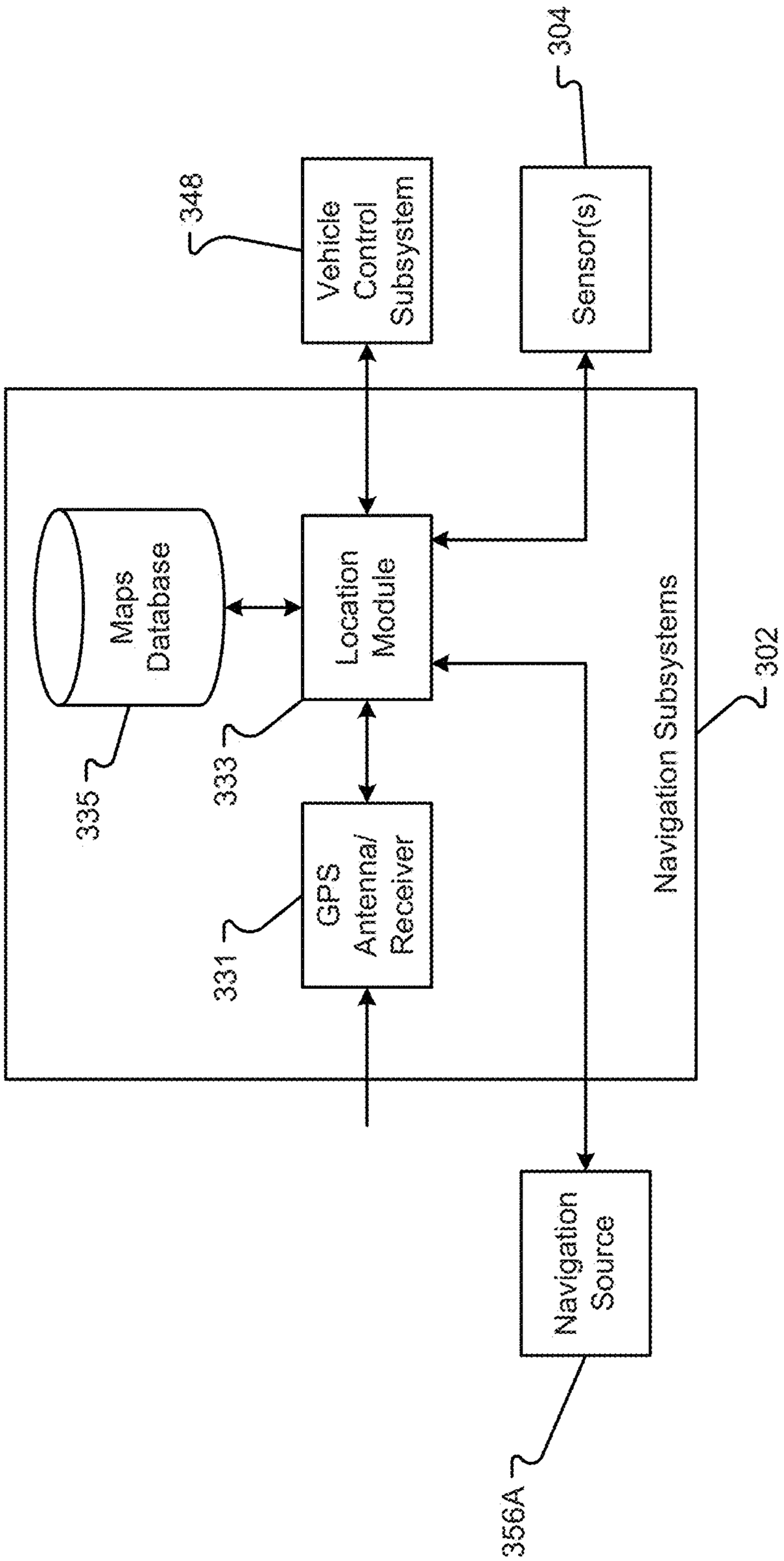

348
Vehicle Control Subsystem
304
Sensor(s)
Maps Database
335
Location Module
333
GPS Antenna/ Receiver
331
Navigation Subsystems
302
Navigation Source
356A

Fig. 3C

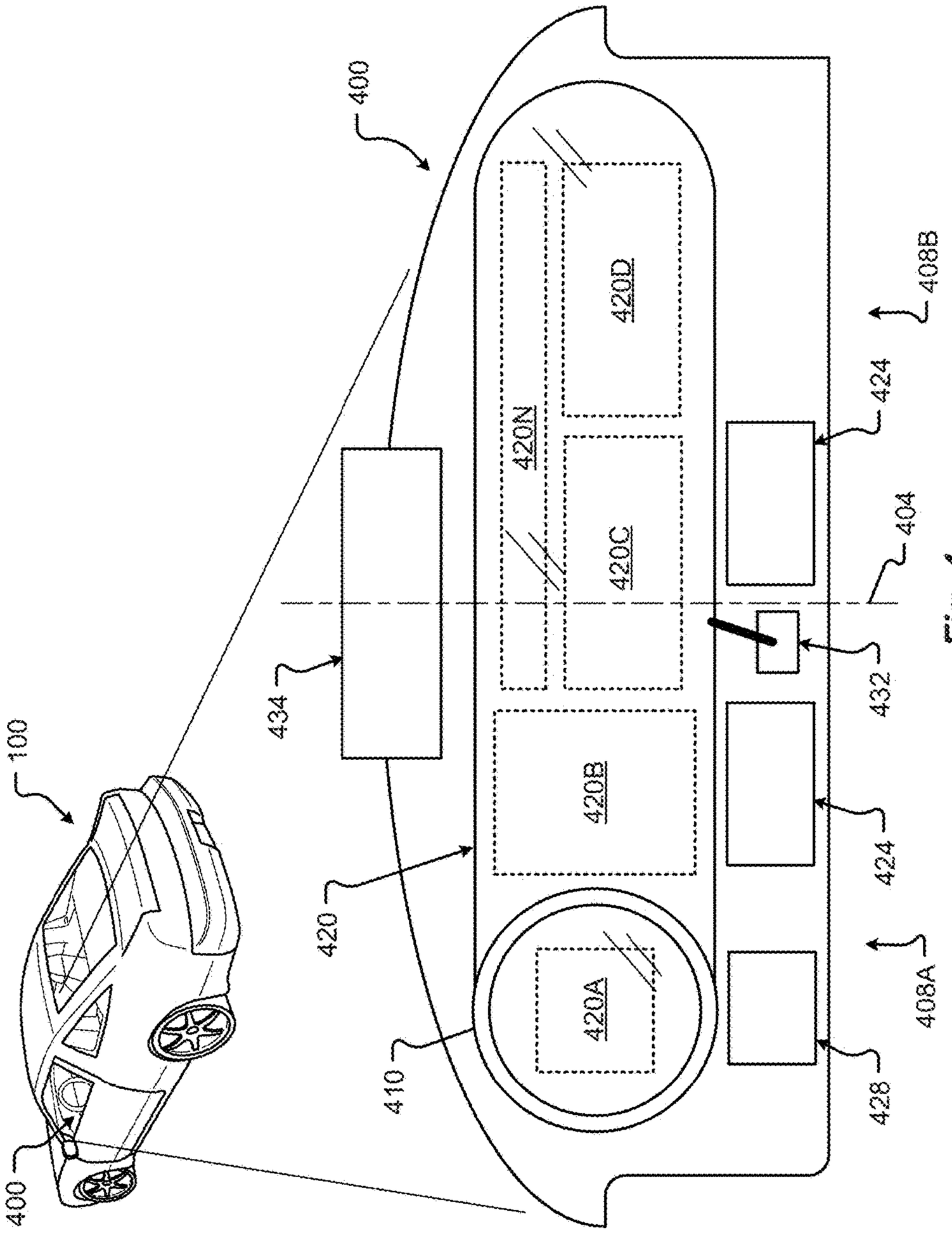

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420B
420C
420N
420D
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424
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432
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408A
408B

Fig. 4

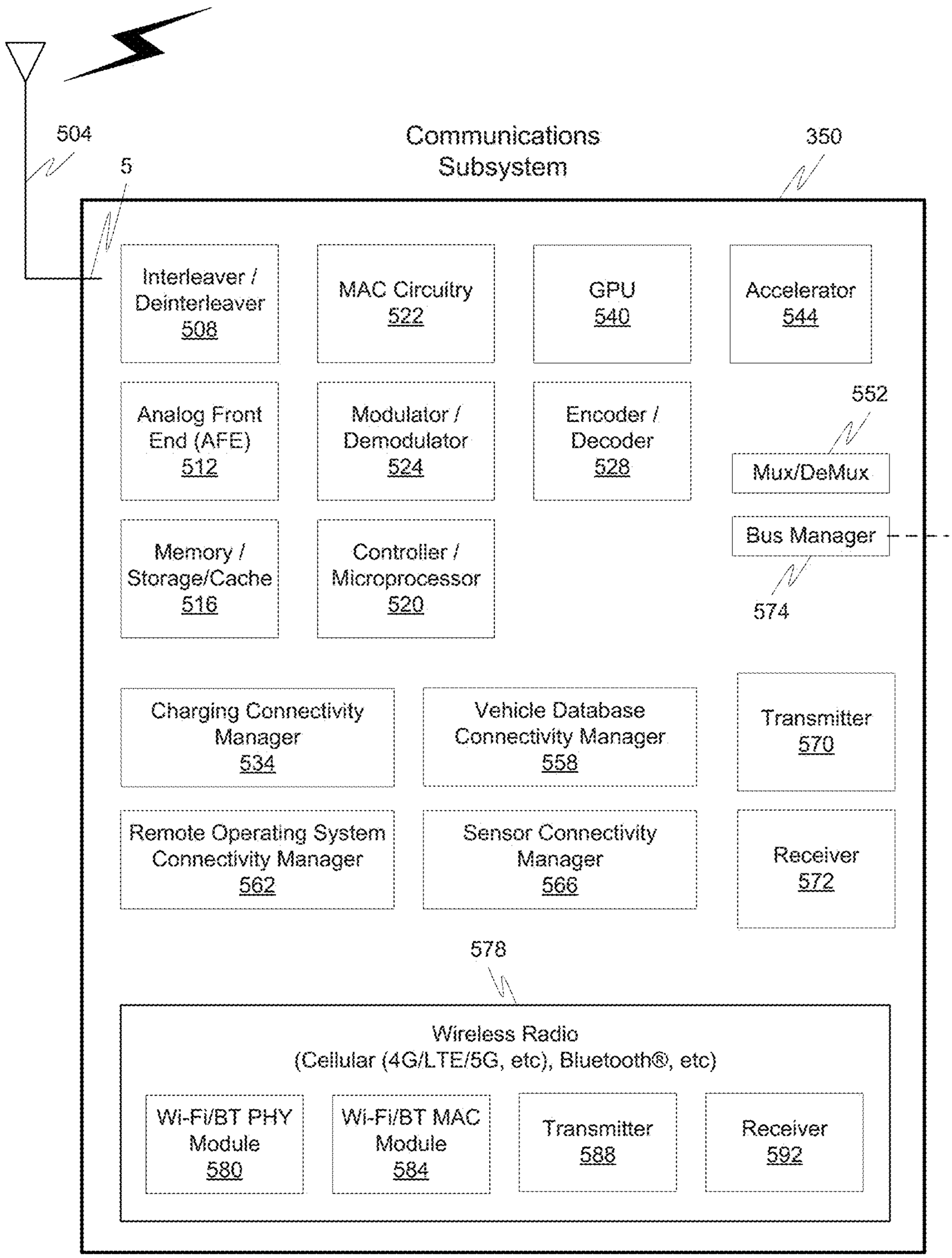

504
5
Communications Subsystem
350
Interleaver / Deinterleaver 508
MAC Circuitry 522
GPU 540
Accelerator 544
Analog Front End (AFE) 512
Modulator / Demodulator 524
Encoder / Decoder 528
552
Mux/DeMux
Bus Manager
574
Memory / Storage/Cache 516
Controller / Microprocessor 520
Charging Connectivity Manager 534
Vehicle Database Connectivity Manager 558
Transmitter 570
Remote Operating System Connectivity Manager 562
Sensor Connectivity Manager 566
Receiver 572
578
Wireless Radio
(Cellular (4G/LTE/5G, etc), Bluetooth®, etc)
Wi-Fi/BT PHY Module 580
Wi-Fi/BT MAC Module 584
Transmitter 588
Receiver 592

Fig. 5

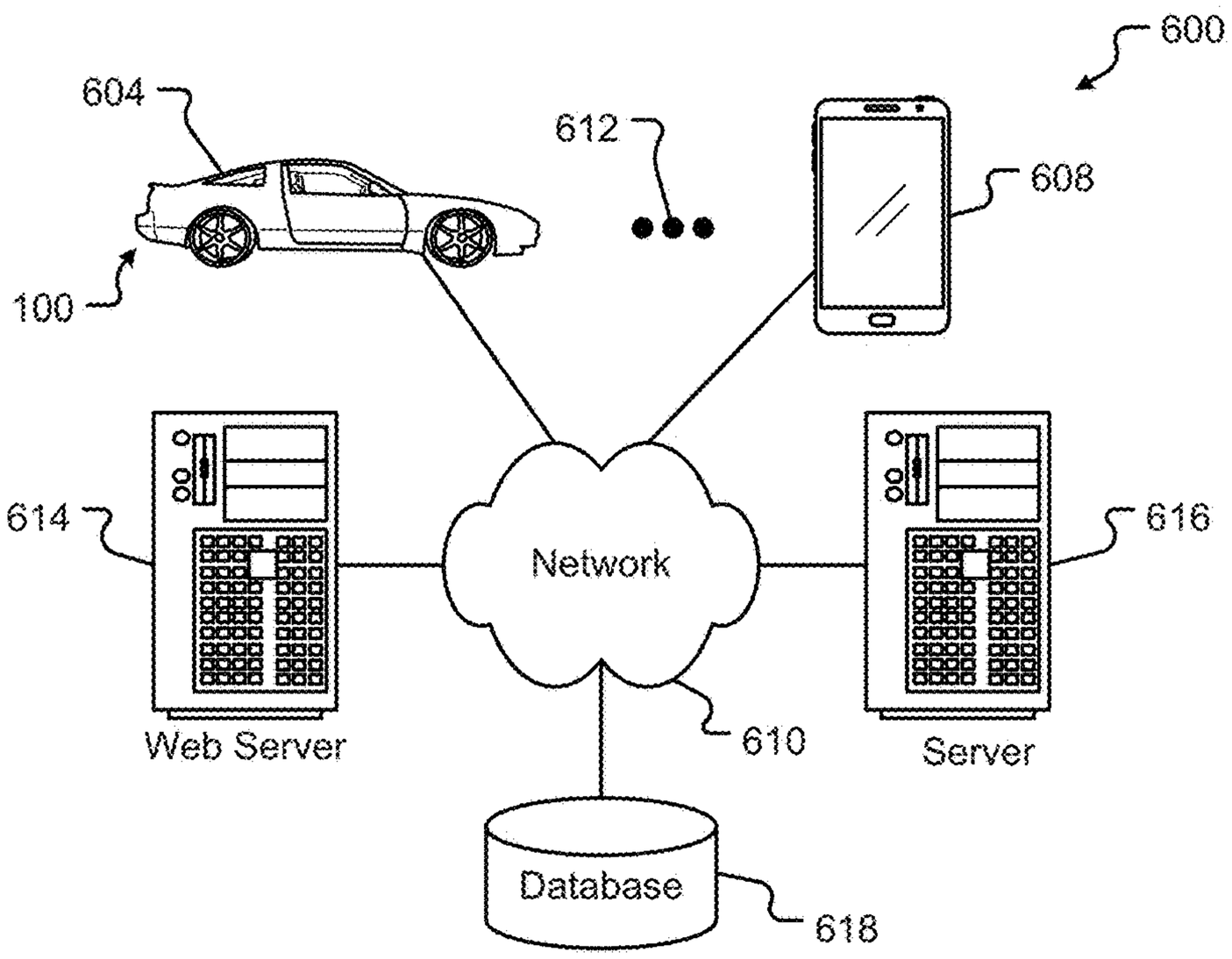

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Network
616
Web Server
610
Server
Database
618

Fig. 6

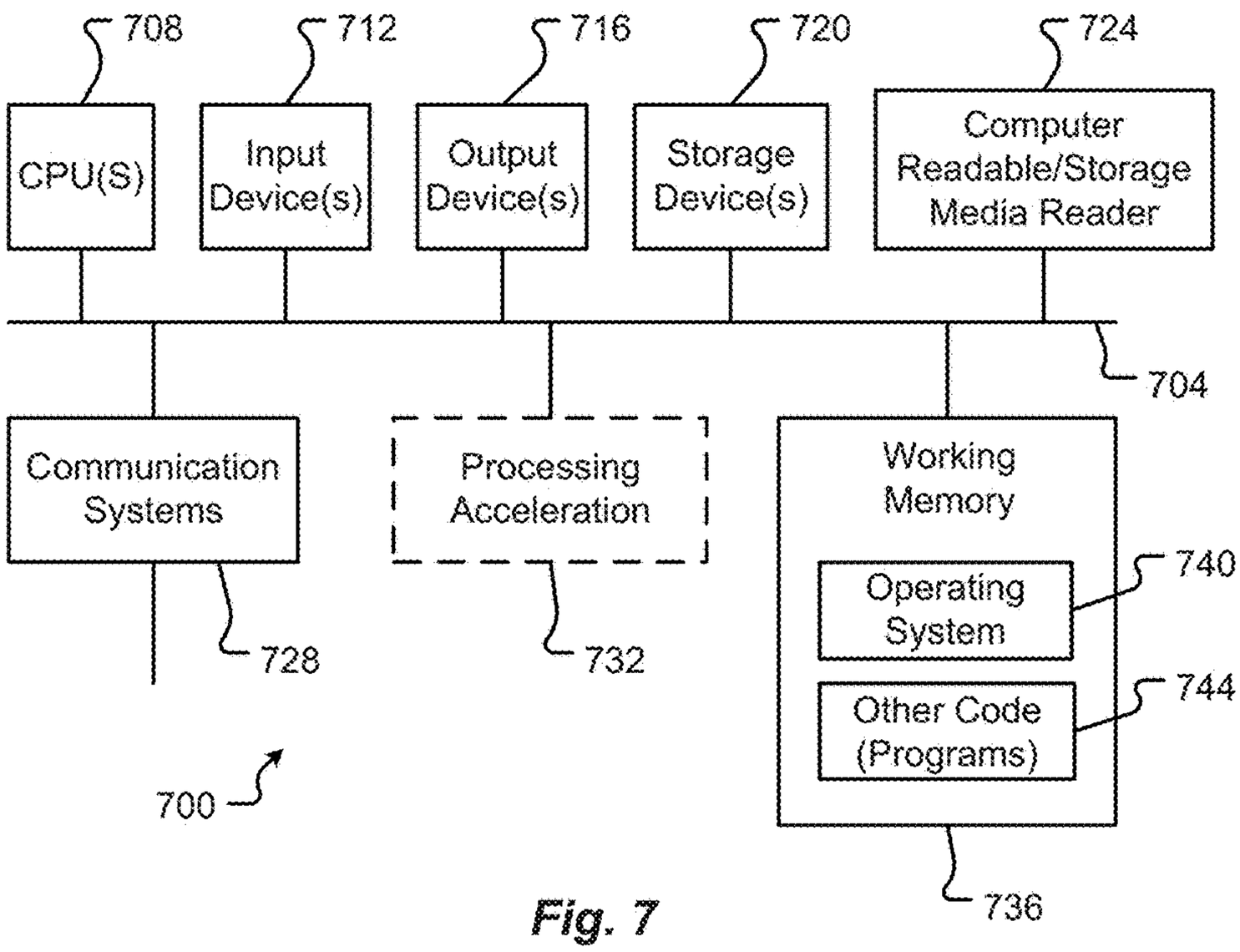

708
712
716
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CPU(S)
Input Device(s)
Output Device(s)
Storage Device(s)
Computer Readable/Storage Media Reader
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Communication Systems
Processing Acceleration
Working Memory
Operating System
740
Other Code (Programs)
744
728
732
736
700

Fig. 7

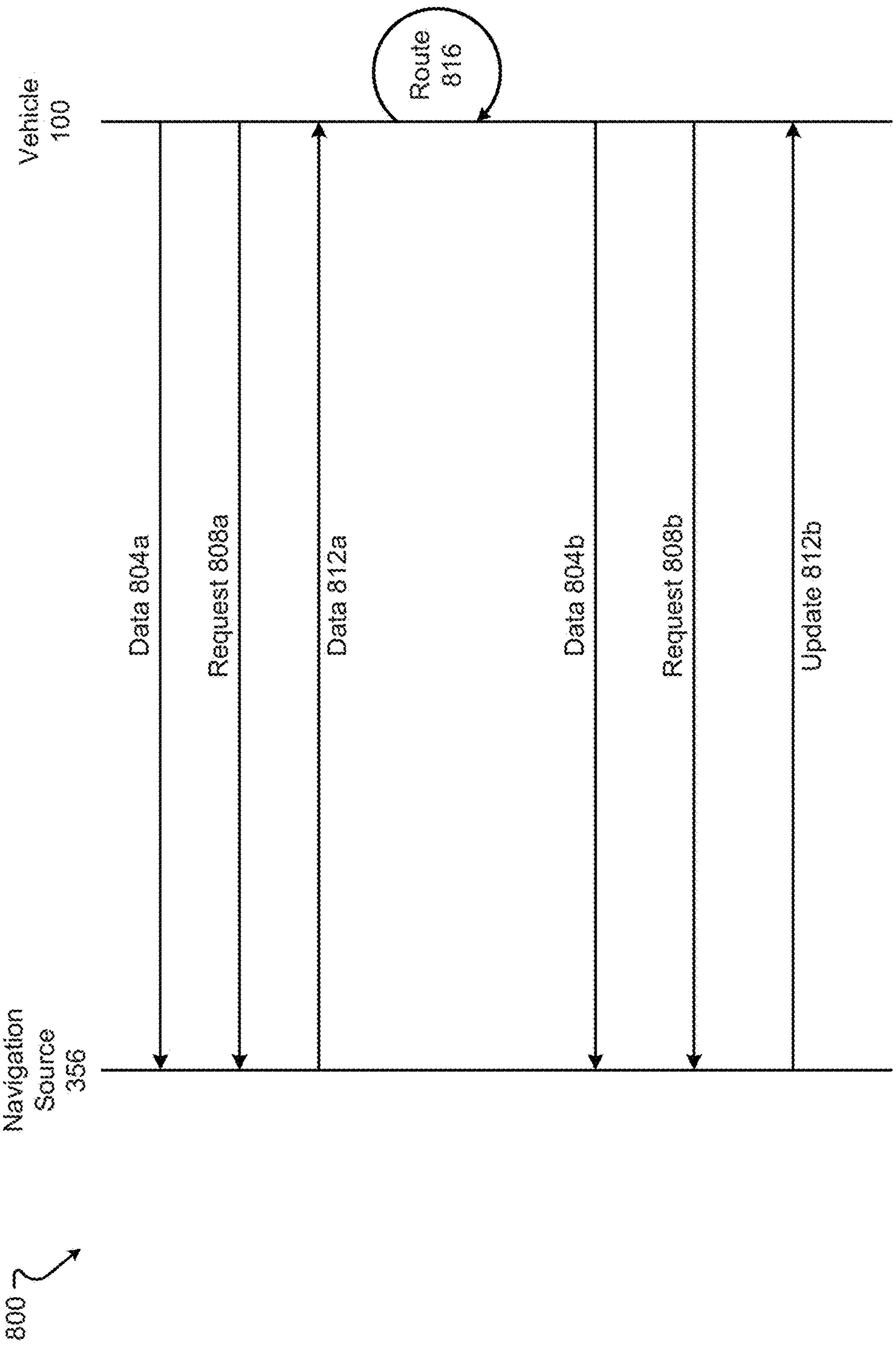

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Data 812a
Data 804b
Request 808b
Update 812b

Fig. 8

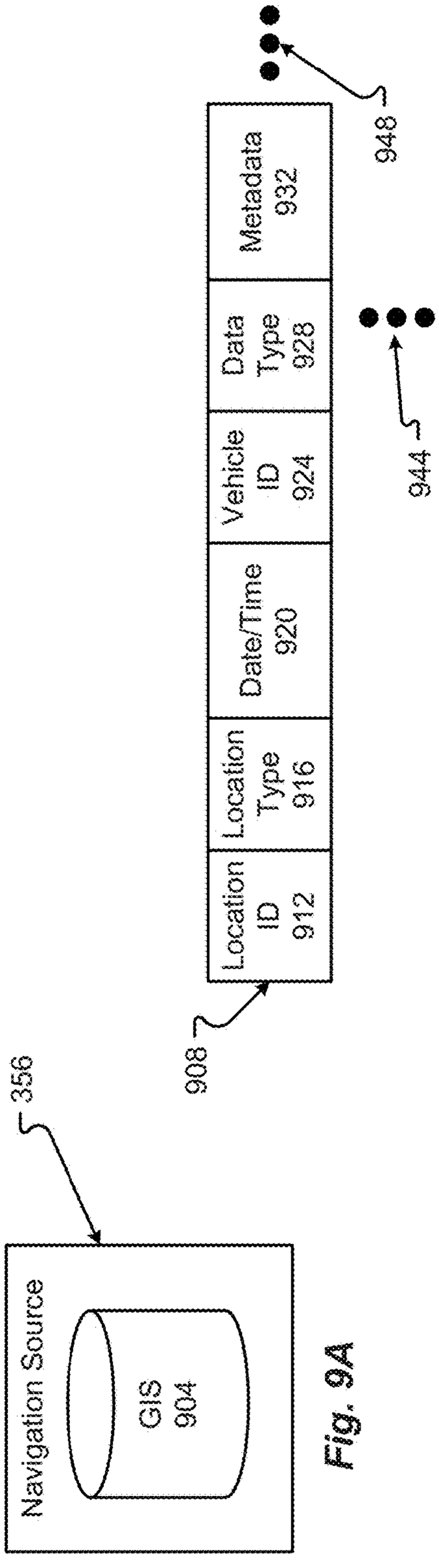


Fig. 9A

Fig. 9B

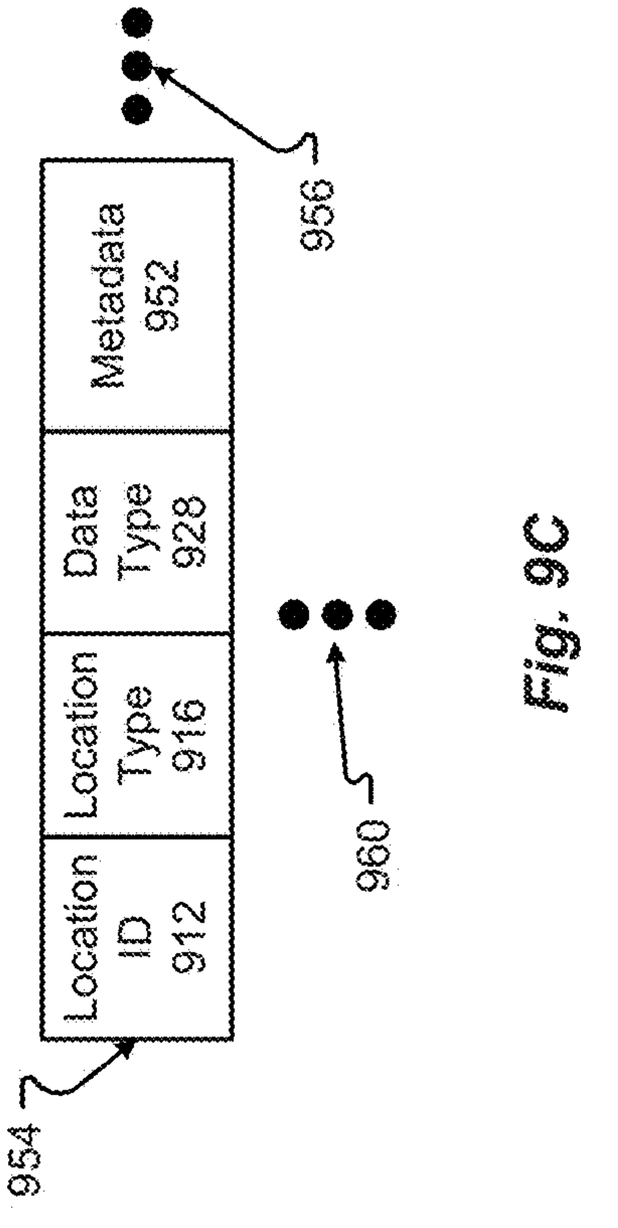


Fig. 9C

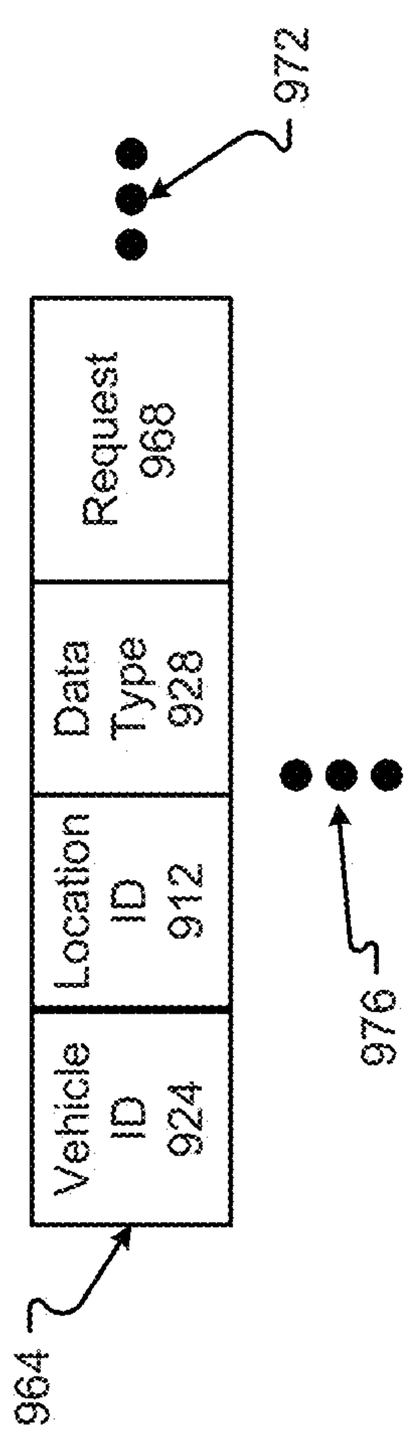

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Request 968
976
972

Fig. 9D

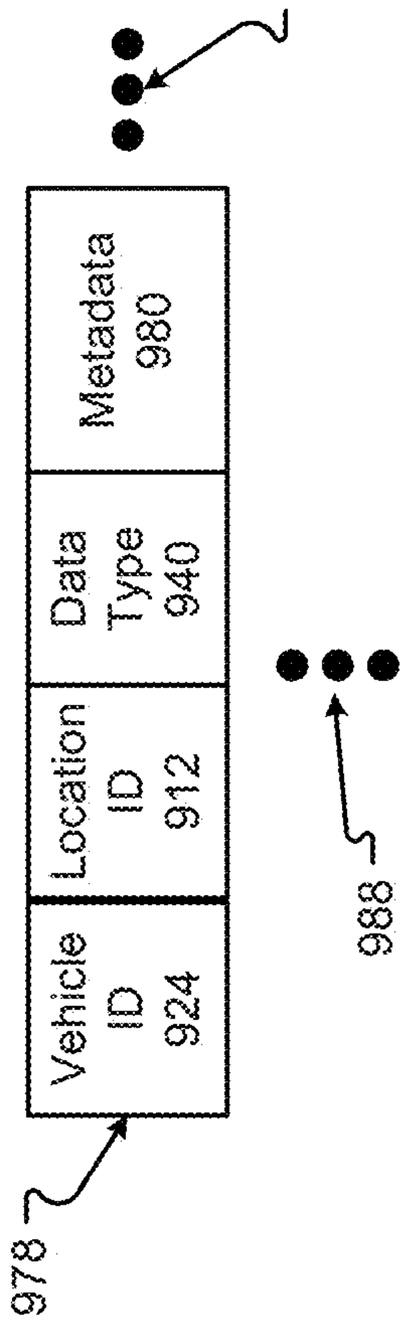

964
Vehicle ID 924
Location ID 912
Data Type 940
Metadata 980
988
978
984

Fig. 9E

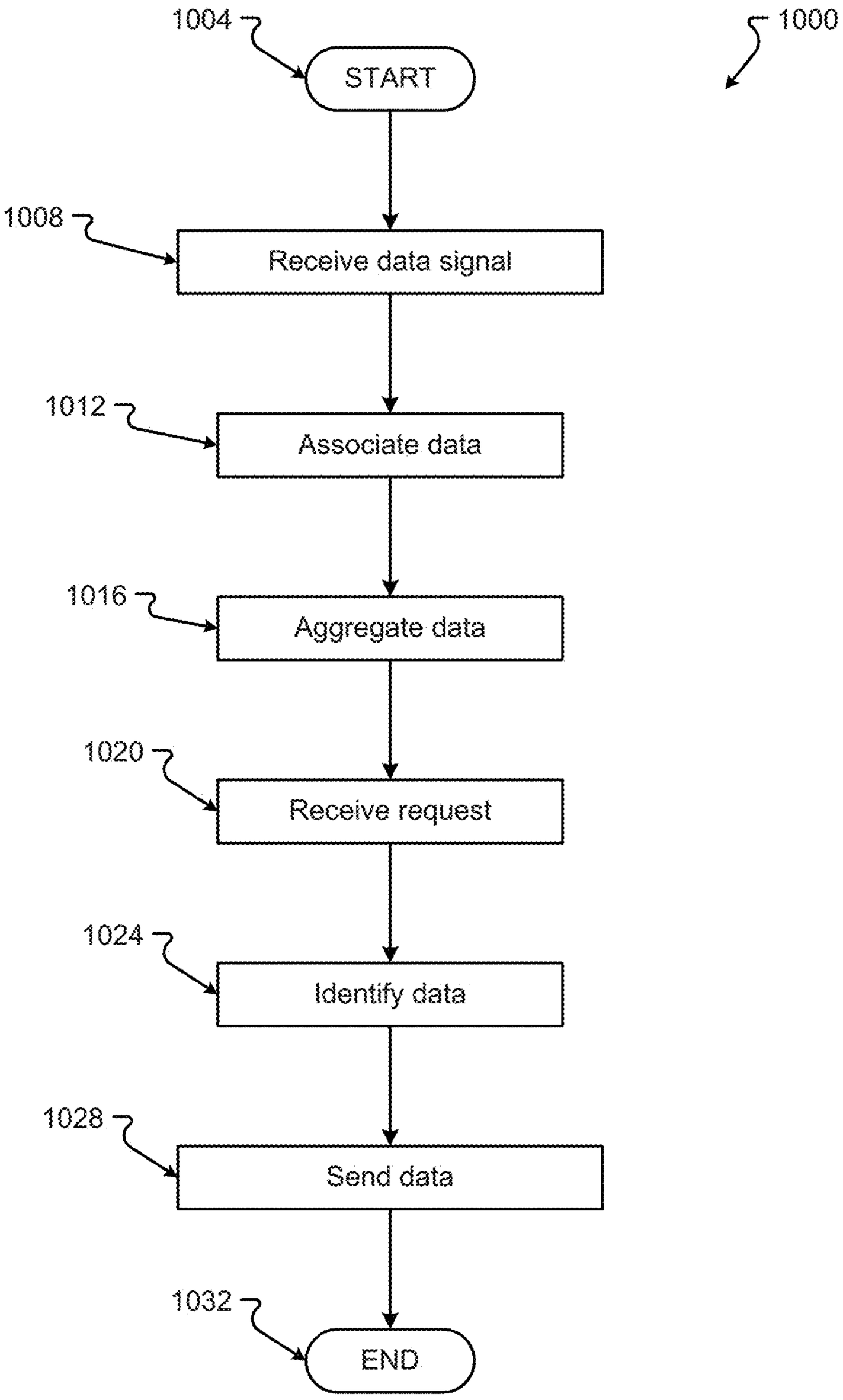

1004
START
1000
1008
Receive data signal
1012
Associate data
1016
Aggregate data
1020
Receive request
1024
Identify data
1028
Send data
1032
END

Fig. 10

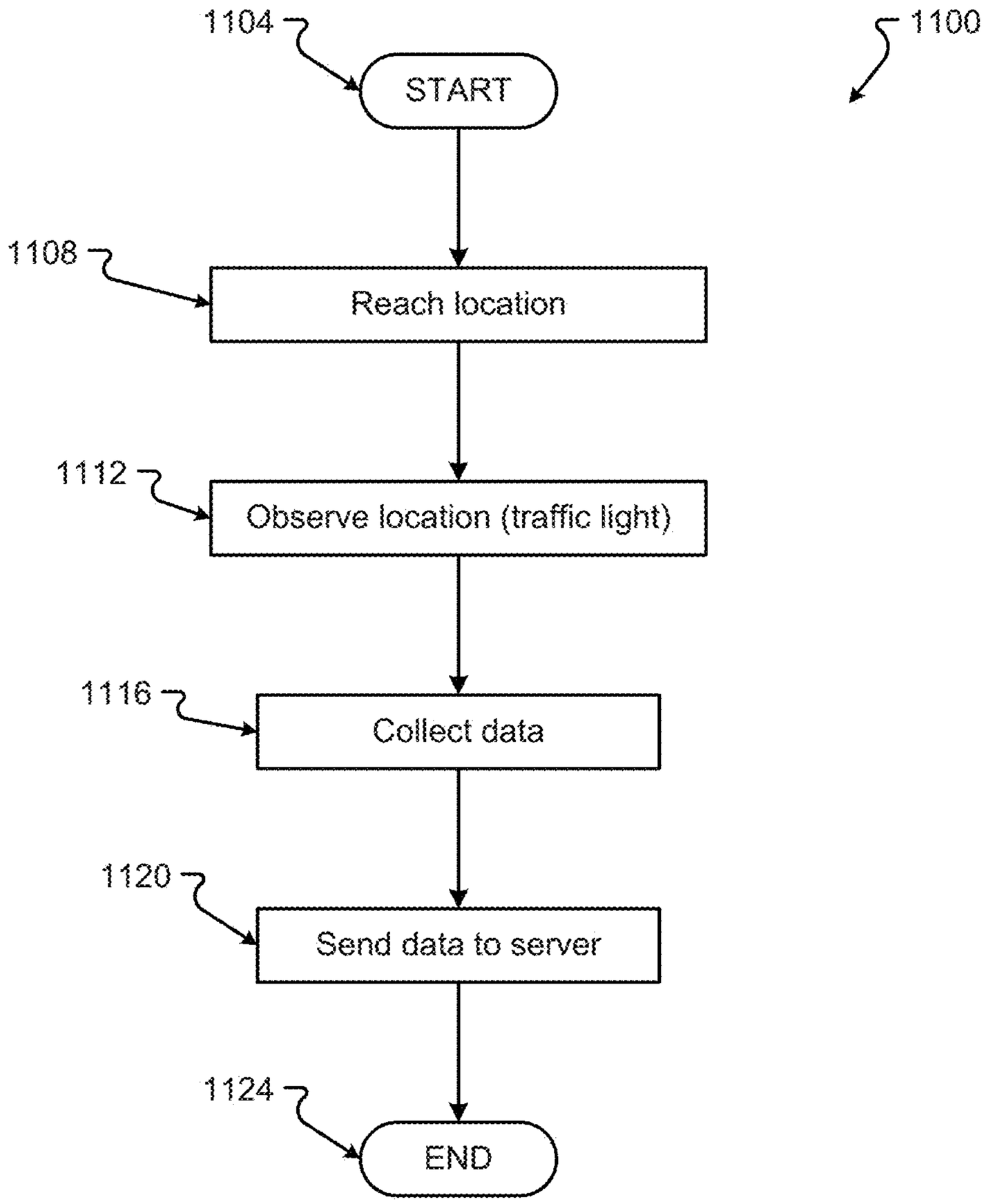

1104
START
1100
1108
Reach location
1112
Observe location (traffic light)
1116
Collect data
1120
Send data to server
1124
END

Fig. 11

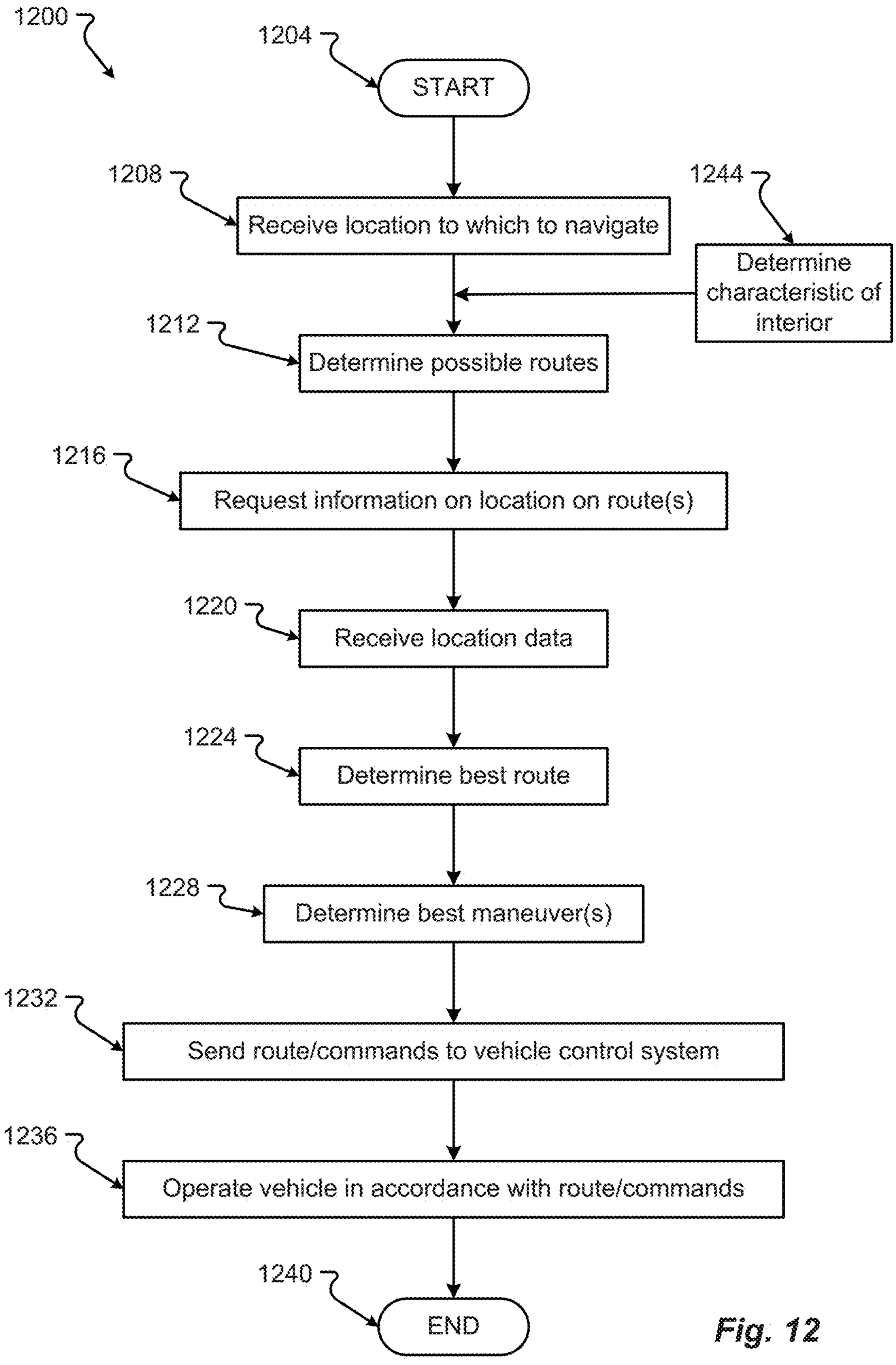

1200
1204
START
1208
Receive location to which to navigate
1244
Determine characteristic of interior
1212
Determine possible routes
1216
Request information on location on route(s)
1220
Receive location data
1224
Determine best route
1228
Determine best maneuver(s)
1232
Send route/commands to vehicle control system
1236
Operate vehicle in accordance with route/commands
1240
END

Fig. 12

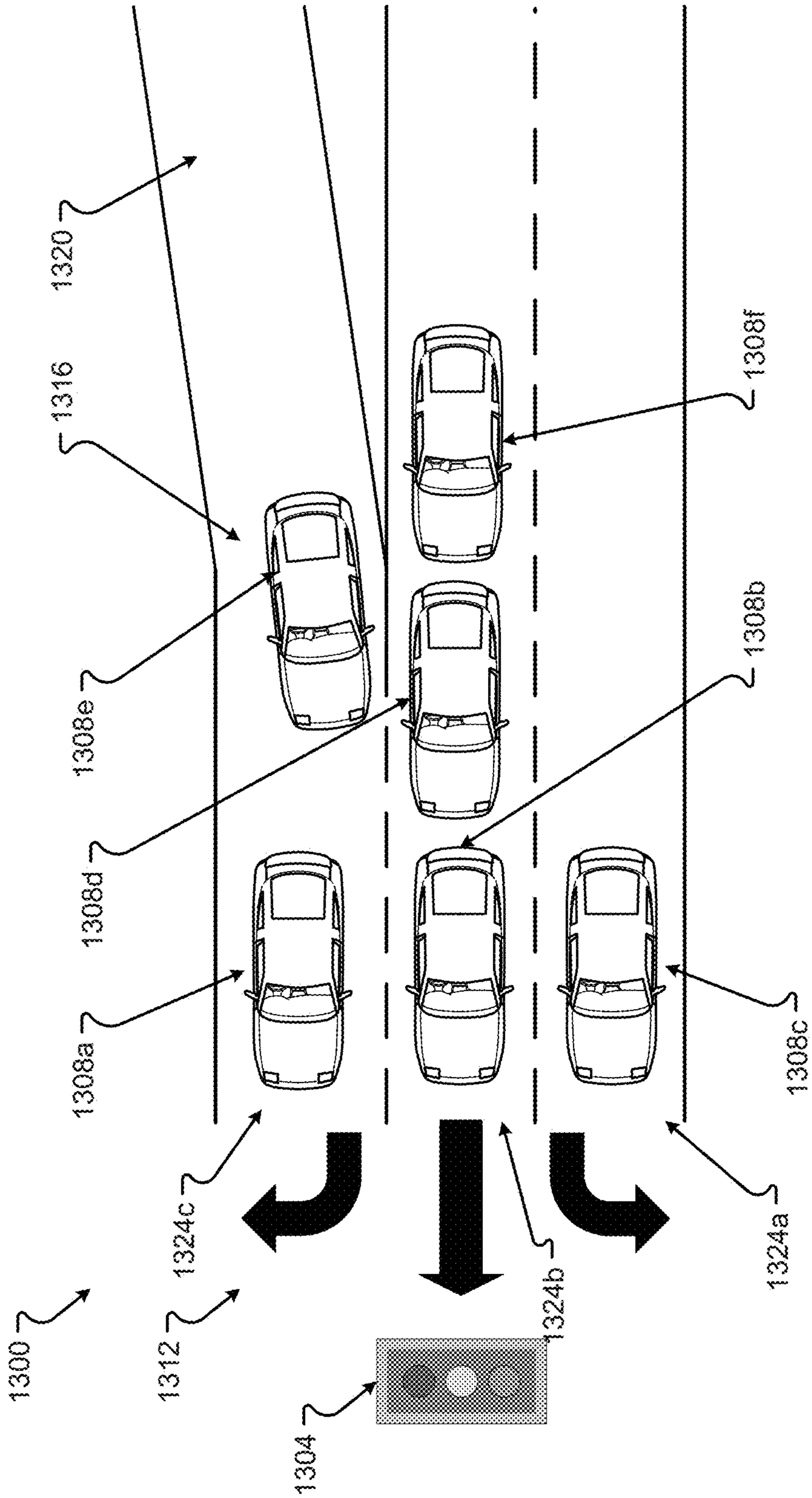

1320
1316
1308f
1308e
1308b
1308d
1308a
1308c
1324c
1324b
1324a
1300
1312
1304

Fig. 13

ADAPTIVE ROUTE AND MOTION PLANNING BASED ON LEARNED EXTERNAL AND INTERNAL VEHICLE ENVIRONMENT

FIELD

The present disclosure is generally directed to vehicle systems, in particular, toward vehicle navigation systems.

BACKGROUND

In recent years, transportation methods have changed substantially. With the continuous development of navigation systems and autonomous driving, the ability for current systems to determine real time information about areas along a route is very limited. Generally, navigation systems may be able to determine traffic and delays due to traffic. Navigations systems have little ability to consider any other information that modifies the present driving context.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a vehicle in accordance with embodiments of the present disclosure;

FIG. **2** shows a plan view of the vehicle in accordance with embodiments of the present disclosure;

FIG. **3**A is a block diagram of an embodiment of a communication environment of the vehicle in accordance with embodiments of the present disclosure;

FIG. **3**B is a block diagram of an embodiment of interior sensors within the vehicle in accordance with embodiments of the present disclosure;

FIG. **3**C is a block diagram of an embodiment of a navigation system of the vehicle in accordance with embodiments of the present disclosure;

FIG. **4** shows an instrument panel of the vehicle in accordance with embodiments of the present disclosure;

FIG. **5** is a block diagram of a communications subsystem of the vehicle in accordance with embodiments of the present disclosure;

FIG. **6** is a block diagram of a computing environment in accordance with embodiments of the present disclosure;

FIG. **7** is a block diagram of a computing device in accordance with embodiments of the present disclosure;

FIG. **8** is a signaling diagram for data exchanges between a vehicle and a navigation source in accordance with embodiments of the present disclosure;

FIG. **9**A is a block diagram of a data store in accordance with embodiments of the present disclosure;

FIG. **9**B is a data diagram showing data that that may be stored, retrieved, exchanged, etc. in the systems and/or environments described herein in accordance with embodiments of the present disclosure;

FIG. **9**C is a data diagram showing data that that may be stored, retrieved, exchanged, etc. in the systems and/or environments described herein in accordance with embodiments of the present disclosure;

FIG. **9**D is a data diagram showing data that that may be stored, retrieved, exchanged, etc. in the systems and/or environments described herein in accordance with embodiments of the present disclosure;

FIG. **9**E is a data diagram showing data that that may be stored, retrieved, exchanged, etc. in the systems and/or environments described herein in accordance with embodiments of the present disclosure;

FIG. **10** is a flow diagram of an embodiment of a method for receiving data about a location in accordance with embodiments of the present disclosure;

FIG. **11** is a flow diagram of an embodiment of a method for sending data about a location in accordance with embodiments of the present disclosure;

FIG. **12** is a flow diagram of an embodiment of a method for receiving data about a location in accordance with embodiments of the present disclosure; and

FIG. **13** is an illustration of a driving environment in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

Embodiments of the present disclosure will be described in connection with a vehicle, and in some embodiments, an electric vehicle, rechargeable electric vehicle, and/or hybrid-electric vehicle and associated systems. Some embodiments relate to an autonomous vehicle or self-driving vehicle. The systems and methods described herein can be applied to a vehicle equipped with a sensor suite that can observe information about a location, for example, a traffic light duration. The system can record information, e.g., the traffic light colors, duration of color changes, and location of the traffic lights and can upload this information to the cloud. Then, the system can augment or learn about the location, e.g., learning of traffic patterns, and store the augmented data as database-based information, where available.

Then, the system can learn about the location, for example, the pattern of traffic light durations on common commuter paths to apply that knowledge. The learned information can help to better estimate an estimated time of arrival (ETA) for common routes taken, provide more accurate ETAs based on historical knowledge, and/or calculate or provide alternative route information.

The system can conduct real-time collection, by a sensor suite of a selected autonomous vehicle, of traffic light duration, light color, duration of color changes, traffic light location, analysis of a number of vehicles in each lane of approach to the signal and their respective speeds, and selected vehicle destination to control steer speed and direction for optimal lane selection to approach the signal and/or signal arrival time to avoid stopping at the signal. All this information helps improve the navigation system.

Further, a vehicle equipped with a sensor suite can observe a number of occupants inside (alternatively, a number of occupants can also be entered manually by a user or by other means, for example, by estimating the occupancy from a calendar entry, manifest, etc.). Further, the vehicle can observe the regulations related to lane-occupancy (e.g., times, number of occupants required, etc.) and/or may access a geographical information system or other geographic/road repository that includes lane-occupancy (for example, information about high occupancy vehicle (HOV) information or lane topography), toll related rules, and/or geolocation technology information. Further, the vehicle may recognize traffic patterns on a per lane basis and/or access traffic patterns available from the cloud on a per lane basis. Alternatively or additionally, the vehicle may estimate or approximate, at some level with statistical information, traffic patterns common to the conditions of the present drive (based on time of day, date, similar roads, etc.).

As such, the vehicle can identify a number of occupants inside the vehicle, identify the optimal route and path strategy for the occupants (based on, at least, time to destination or time reduction in net traffic encountered if destination is unknown), while accounting for potential time

savings by using an HOV lane and potential challenges of merging into and exiting out of an HOV lane while in traffic. Then, the system can recommend the driver to migrate into or out of HOV lane based on optimal strategy, if vehicle is not on autonomous mode. If in autonomous, vehicle operates automatically into or out of HOV lane. When calculating for ETA, the vehicle can account for traffic and account for the avoidance of traffic by using the HOV lane. This ability of onboard systems to detect the number of passengers in a vehicle and make routing decisions based on that information, e.g., whether there are enough people in the vehicle to qualify for using an HOV lane, can create a better route decision for the vehicle.

Embodiments of the present disclosure will be described in connection with a vehicle, and in some embodiments, an electric vehicle, rechargeable electric vehicle, and/or hybrid-electric vehicle and associated systems.

FIG. **1** shows a perspective view of a vehicle **100** in accordance with embodiments of the present disclosure. The electric vehicle **100** comprises a vehicle front **110**, vehicle aft or rear **120**, vehicle roof **130**, at least one vehicle side **160**, a vehicle undercarriage **140**, and a vehicle interior **150**. In any event, the vehicle **100** may include a frame **104** and one or more body panels **108** mounted or affixed thereto. The vehicle **100** may include one or more interior components (e.g., components inside an interior space **150**, or user space, of a vehicle **100**, etc.), exterior components (e.g., components outside of the interior space **150**, or user space, of a vehicle **100**, etc.), drive systems, controls systems, structural components, etc.

Although shown in the form of a car, it should be appreciated that the vehicle **100** described herein may include any conveyance or model of a conveyance, where the conveyance was designed for the purpose of moving one or more tangible objects, such as people, animals, cargo, and the like. The term "vehicle" does not require that a conveyance moves or is capable of movement. Typical vehicles may include but are in no way limited to cars, trucks, motorcycles, busses, automobiles, trains, railed conveyances, boats, ships, marine conveyances, submarine conveyances, airplanes, space craft, flying machines, human-powered conveyances, and the like.

In some embodiments, the vehicle **100** may include a number of sensors, devices, and/or systems that are capable of assisting in driving operations. Examples of the various sensors and systems may include, but are in no way limited to, one or more of cameras (e.g., independent, stereo, combined image, etc.), infrared (IR) sensors, radio frequency (RF) sensors, ultrasonic sensors (e.g., transducers, transceivers, etc.), RADAR sensors (e.g., object-detection sensors and/or systems), LIDAR systems, odometry sensors and/or devices (e.g., encoders, etc.), orientation sensors (e.g., accelerometers, gyroscopes, magnetometer, etc.), navigation sensors and systems (e.g., GPS, etc.), and other ranging, imaging, and/or object-detecting sensors. The sensors may be disposed in an interior space **150** of the vehicle **100** and/or on an outside of the vehicle **100**. In some embodiments, the sensors and systems may be disposed in one or more portions of a vehicle **100** (e.g., the frame **104**, a body panel, a compartment, etc.).

The vehicle sensors and systems may be selected and/or configured to suit a level of operation associated with the vehicle **100**. Among other things, the number of sensors used in a system may be altered to increase or decrease information available to a vehicle control system (e.g., affecting control capabilities of the vehicle **100**). Additionally or alternatively, the sensors and systems may be part of one or more advanced driver assistance systems (ADAS) associated with a vehicle **100**. In any event, the sensors and systems may be used to provide driving assistance at any level of operation (e.g., from fully-manual to fully-autonomous operations, etc.) as described herein.

The various levels of vehicle control and/or operation can be described as corresponding to a level of autonomy associated with a vehicle **100** for vehicle driving operations. For instance, at Level 0, or fully-manual driving operations, a driver (e.g., a human driver) may be responsible for all the driving control operations (e.g., steering, accelerating, braking, etc.) associated with the vehicle. Level 0 may be referred to as a "No Automation" level. At Level 1, the vehicle may be responsible for a limited number of the driving operations associated with the vehicle, while the driver is still responsible for most driving control operations. An example of a Level 1 vehicle may include a vehicle in which the throttle control and/or braking operations may be controlled by the vehicle (e.g., cruise control operations, etc.). Level 1 may be referred to as a "Driver Assistance" level. At Level 2, the vehicle may collect information (e.g., via one or more driving assistance systems, sensors, etc.) about an environment of the vehicle (e.g., surrounding area, roadway, traffic, ambient conditions, etc.) and use the collected information to control driving operations (e.g., steering, accelerating, braking, etc.) associated with the vehicle. In a Level 2 autonomous vehicle, the driver may be required to perform other aspects of driving operations not controlled by the vehicle. Level 2 may be referred to as a "Partial Automation" level. It should be appreciated that Levels 0-2 all involve the driver monitoring the driving operations of the vehicle.

At Level 3, the driver may be separated from controlling all the driving operations of the vehicle except when the vehicle makes a request for the operator to act or intervene in controlling one or more driving operations. In other words, the driver may be separated from controlling the vehicle unless the driver is required to take over for the vehicle. Level 3 may be referred to as a "Conditional Automation" level. At Level 4, the driver may be separated from controlling all the driving operations of the vehicle and the vehicle may control driving operations even when a user fails to respond to a request to intervene. Level 4 may be referred to as a "High Automation" level. At Level 5, the vehicle can control all the driving operations associated with the vehicle in all driving modes. The vehicle in Level 5 may continually monitor traffic, vehicular, roadway, and/or environmental conditions while driving the vehicle. In Level 5, there is no human driver interaction required in any driving mode. Accordingly, Level 5 may be referred to as a "Full Automation" level. It should be appreciated that in Levels 3-5 the vehicle, and/or one or more automated driving systems associated with the vehicle, monitors the driving operations of the vehicle and the driving environment.

As shown in FIG. **1**, the vehicle **100** may, for example, include at least one of a ranging and imaging system **112** (e.g., LIDAR, etc.), an imaging sensor **116**A, **116**F (e.g., camera, IR, etc.), a radio object-detection and ranging system sensors **116**B (e.g., RADAR, RF, etc.), ultrasonic sensors **116**C, and/or other object-detection sensors **116**D, **116**E. In some embodiments, the LIDAR system **112** and/or sensors may be mounted on a roof **130** of the vehicle **100**. In one embodiment, the RADAR sensors **116**B may be disposed at least at a front **110**, aft **120**, or side **160** of the vehicle **100**. Among other things, the RADAR sensors may be used to monitor and/or detect a position of other vehicles, pedestrians, and/or other objects near, or proximal to, the

vehicle **100**. While shown associated with one or more areas of a vehicle **100**, it should be appreciated that any of the sensors and systems **116**A-K, **112** illustrated in FIGS. **1** and **2** may be disposed in, on, and/or about the vehicle **100** in any position, area, and/or zone of the vehicle **100**.

Referring now to FIG. **2**, a plan view of a vehicle **100** will be described in accordance with embodiments of the present disclosure. In particular, FIG. **2** shows a vehicle sensing environment **200** at least partially defined by the sensors and systems **116**A-K, **112** disposed in, on, and/or about the vehicle **100**. Each sensor **116**A-K may include an operational detection range R and operational detection angle. The operational detection range R may define the effective detection limit, or distance, of the sensor **116**A-K. In some cases, this effective detection limit may be defined as a distance from a portion of the sensor **116**A-K (e.g., a lens, sensing surface, etc.) to a point in space offset from the sensor **116**A-K. The effective detection limit may define a distance, beyond which, the sensing capabilities of the sensor **116**A-K deteriorate, fail to work, or are unreliable. In some embodiments, the effective detection limit may define a distance, within which, the sensing capabilities of the sensors **116**A-K are able to provide accurate and/or reliable detection information. The operational detection angle may define at least one angle of a span, or between horizontal and/or vertical limits, of a sensor **116**A-K. As can be appreciated, the operational detection limit and the operational detection angle of a sensor **116**A-K together may define the effective detection zone **216**A-D (e.g., the effective detection area, and/or volume, etc.) of a sensor **116**A-K.

In some embodiments, the vehicle **100** may include a ranging and imaging system **112** such as LIDAR, or the like. The ranging and imaging system **112** may be configured to detect visual information in an environment surrounding the vehicle **100**. The visual information detected in the environment surrounding the ranging and imaging system **112** may be processed (e.g., via one or more sensor and/or system processors, etc.) to generate a complete 360-degree view of an environment **200** around the vehicle. The ranging and imaging system **112** may be configured to generate changing 360-degree views of the environment **200** in real-time, for instance, as the vehicle **100** drives. In some cases, the ranging and imaging system **112** may have an effective detection limit **204** that is some distance from the center of the vehicle **100** outward over 360 degrees. The effective detection limit **204** of the ranging and imaging system **112** defines a view zone **208** (e.g., an area and/or volume, etc.) surrounding the vehicle **100**. Any object falling outside of the view zone **208** is in the undetected zone **212** and would not be detected by the ranging and imaging system **112** of the vehicle **100**.

Sensor data and information may be collected by one or more sensors or systems **116**A-K, **112** of the vehicle **100** monitoring the vehicle sensing environment **200**. This information may be processed (e.g., via a processor, computer-vision system, etc.) to determine targets (e.g., objects, signs, people, markings, roadways, conditions, etc.) inside one or more detection zones **208**, **216**A-D associated with the vehicle sensing environment **200**. In some cases, information from multiple sensors **116**A-K may be processed to form composite sensor detection information. For example, a first sensor **116**A and a second sensor **116**F may correspond to a first camera **116**A and a second camera **116**F aimed in a forward traveling direction of the vehicle **100**. In this example, images collected by the cameras **116**A, **116**F may be combined to form stereo image information. This composite information may increase the capabilities of a single sensor in the one or more sensors **116**A-K by, for example, adding the ability to determine depth associated with targets in the one or more detection zones **208**, **216**A-D. Similar image data may be collected by rear view cameras (e.g., sensors **116**G, **116**H) aimed in a rearward traveling direction vehicle **100**.

In some embodiments, multiple sensors **116**A-K may be effectively joined to increase a sensing zone and provide increased sensing coverage. For instance, multiple RADAR sensors **116**B disposed on the front **110** of the vehicle may be joined to provide a zone **216**B of coverage that spans across an entirety of the front **110** of the vehicle. In some cases, the multiple RADAR sensors **116**B may cover a detection zone **216**B that includes one or more other sensor detection zones **216**A. These overlapping detection zones may provide redundant sensing, enhanced sensing, and/or provide greater detail in sensing within a particular portion (e.g., zone **216**A) of a larger zone (e.g., zone **216**B). Additionally or alternatively, the sensors **116**A-K of the vehicle **100** may be arranged to create a complete coverage, via one or more sensing zones **208**, **216**A-D around the vehicle **100**. In some areas, the sensing zones **216**C of two or more sensors **116**D, **116**E may intersect at an overlap zone **220**. In some areas, the angle and/or detection limit of two or more sensing zones **216**C, **216**D (e.g., of two or more sensors **116**E, **116**J, **116**K) may meet at a virtual intersection point **224**.

The vehicle **100** may include a number of sensors **116**E, **116**G, **116**H, **116**J, **116**K disposed proximal to the rear **120** of the vehicle **100**. These sensors can include, but are in no way limited to, an imaging sensor, camera, IR, a radio object-detection and ranging sensors, RADAR, RF, ultrasonic sensors, and/or other object-detection sensors. Among other things, these sensors **116**E, **116**G, **116**H, **116**J, **116**K may detect targets near or approaching the rear of the vehicle **100**. For example, another vehicle approaching the rear **120** of the vehicle **100** may be detected by one or more of the ranging and imaging system (e.g., LIDAR) **112**, rear-view cameras **116**G, **116**H, and/or rear facing RADAR sensors **116**J, **116**K. As described above, the images from the rear-view cameras **116**G, **116**H may be processed to generate a stereo view (e.g., providing depth associated with an object or environment, etc.) for targets visible to both cameras **116**G, **116**H. As another example, the vehicle **100** may be driving and one or more of the ranging and imaging system **112**, front-facing cameras **116**A, **116**F, front-facing RADAR sensors **116**B, and/or ultrasonic sensors **116**C may detect targets in front of the vehicle **100**. This approach may provide critical sensor information to a vehicle control system in at least one of the autonomous driving levels described above. For instance, when the vehicle **100** is driving autonomously (e.g., Level 3, Level 4, or Level 5) and detects other vehicles stopped in a travel path, the sensor detection information may be sent to the vehicle control system of the vehicle **100** to control a driving operation (e.g., braking, decelerating, etc.) associated with the vehicle **100** (in this example, slowing the vehicle **100** as to avoid colliding with the stopped other vehicles). As yet another example, the vehicle **100** may be operating and one or more of the ranging and imaging system **112**, and/or the side-facing sensors **116**D, **116**E (e.g., RADAR, ultrasonic, camera, combinations thereof, and/or other type of sensor), may detect targets at a side of the vehicle **100**. It should be appreciated that the sensors **116**A-K may detect a target that is both at a side **160** and a front **110** of the vehicle **100** (e.g., disposed at a diagonal angle to a centerline of the vehicle **100** running from the front **110** of the vehicle **100** to the rear

120 of the vehicle). Additionally or alternatively, the sensors 116A-K may detect a target that is both, or simultaneously, at a side 160 and a rear 120 of the vehicle 100 (e.g., disposed at a diagonal angle to the centerline of the vehicle 100).

FIG. 3A is a is a block diagram of an embodiment of a communication environment 300 of the vehicle 100 in accordance with embodiments of the present disclosure. The communication system 300 may include one or more vehicle driving vehicle sensors and systems 304, sensor processors 340, sensor data memory 344, vehicle control system 348, communications subsystem 350, control data 364, computing devices 368, display devices 372, and other components 374 that may be associated with a vehicle 100. These associated components may be electrically and/or communicatively coupled to one another via at least one bus 360. In some embodiments, the one or more associated components may send and/or receive signals across a communication network 352 to at least one of a navigation source 356A, a control source 356B, or some other entity 356N.

In accordance with at least some embodiments of the present disclosure, the communication network 352 may comprise any type of known communication medium or collection of communication media and may use any type of protocols, such as SIP, TCP/IP, SNA, IPX, AppleTalk, and the like, to transport messages between endpoints. The communication network 352 may include wired and/or wireless communication technologies. The Internet is an example of the communication network 352 that constitutes an Internet Protocol (IP) network consisting of many computers, computing networks, and other communication devices located all over the world, which are connected through many telephone systems and other means. Other examples of the communication network 104 include, without limitation, a standard Plain Old Telephone System (POTS), an Integrated Services Digital Network (ISDN), the Public Switched Telephone Network (PSTN), a Local Area Network (LAN), such as an Ethernet network, a Token-Ring network and/or the like, a Wide Area Network (WAN), a virtual network, including without limitation a virtual private network ("VPN"); the Internet, an intranet, an extranet, a cellular network, an infra-red network; a wireless network (e.g., a network operating under any of the IEEE 802.9 suite of protocols, the Bluetooth® protocol known in the art, and/or any other wireless protocol), and any other type of packet-switched or circuit-switched network known in the art and/or any combination of these and/or other networks. In addition, it can be appreciated that the communication network 352 need not be limited to any one network type, and instead may be comprised of a number of different networks and/or network types. The communication network 352 may comprise a number of different communication media such as coaxial cable, copper cable/wire, fiber-optic cable, antennas for transmitting/receiving wireless messages, and combinations thereof.

The driving vehicle sensors and systems 304 may include at least one navigation 308 (e.g., global positioning system (GPS), etc.), orientation 312, odometry 316, LIDAR 320, RADAR 324, ultrasonic 328, camera 332, infrared (IR) 336, and/or other sensor or system 338. These driving vehicle sensors and systems 304 may be similar, if not identical, to the sensors and systems 116A-K, 112 described in conjunction with FIGS. 1 and 2.

The navigation sensor 308 may include one or more sensors having receivers and antennas that are configured to utilize a satellite-based navigation system including a network of navigation satellites capable of providing geolocation and time information to at least one component of the vehicle 100. Examples of the navigation sensor 308 as described herein may include, but are not limited to, at least one of Garmin® GLO™ family of GPS and GLONASS combination sensors, Garmin® GPS 15x™ family of sensors, Garmin® GPS 16x™ family of sensors with high-sensitivity receiver and antenna, Garmin® GPS 18x OEM family of high-sensitivity GPS sensors, Dewetron DEWE-VGPS series of GPS sensors, GlobalSat 1-Hz series of GPS sensors, other industry-equivalent navigation sensors and/or systems, and may perform navigational and/or geolocation functions using any known or future-developed standard and/or architecture.

The orientation sensor 312 may include one or more sensors configured to determine an orientation of the vehicle 100 relative to at least one reference point. In some embodiments, the orientation sensor 312 may include at least one pressure transducer, stress/strain gauge, accelerometer, gyroscope, and/or geomagnetic sensor. Examples of the navigation sensor 308 as described herein may include, but are not limited to, at least one of Bosch Sensortec BMX 160 series low-power absolute orientation sensors, Bosch Sensortec BMX055 9-axis sensors, Bosch Sensortec BMI055 6-axis inertial sensors, Bosch Sensortec BMI160 6-axis inertial sensors, Bosch Sensortec BMF055 9-axis inertial sensors (accelerometer, gyroscope, and magnetometer) with integrated Cortex M0+ microcontroller, Bosch Sensortec BMP280 absolute barometric pressure sensors, Infineon TLV493D-A1B6 3D magnetic sensors, Infineon TLI493D-W1B6 3D magnetic sensors, Infineon TL family of 3D magnetic sensors, Murata Electronics SCC2000 series combined gyro sensor and accelerometer, Murata Electronics SCC1300 series combined gyro sensor and accelerometer, other industry-equivalent orientation sensors and/or systems, and may perform orientation detection and/or determination functions using any known or future-developed standard and/or architecture.

The odometry sensor and/or system 316 may include one or more components that is configured to determine a change in position of the vehicle 100 over time. In some embodiments, the odometry system 316 may utilize data from one or more other sensors and/or systems 304 in determining a position (e.g., distance, location, etc.) of the vehicle 100 relative to a previously measured position for the vehicle 100. Additionally or alternatively, the odometry sensors 316 may include one or more encoders, Hall speed sensors, and/or other measurement sensors/devices configured to measure a wheel speed, rotation, and/or number of revolutions made over time. Examples of the odometry sensor/system 316 as described herein may include, but are not limited to, at least one of Infineon TLE4924/26/27/28C high-performance speed sensors, Infineon TL4941plusC(B) single chip differential Hall wheel-speed sensors, Infineon TL5041plusC Giant Mangnetoresistance (GMR) effect sensors, Infineon TL family of magnetic sensors, EPC Model 25SP Accu-CoderPro™ incremental shaft encoders, EPC Model 30M compact incremental encoders with advanced magnetic sensing and signal processing technology, EPC Model 925 absolute shaft encoders, EPC Model 958 absolute shaft encoders, EPC Model MA36S/MA63S/SA36S absolute shaft encoders, Dynapar™ F18 commutating optical encoder, Dynapar™ HS35R family of phased array encoder sensors, other industry-equivalent odometry sensors and/or systems, and may perform change in position detection and/or determination functions using any known or future-developed standard and/or architecture.

The LIDAR sensor/system 320 may include one or more components configured to measure distances to targets using

laser illumination. In some embodiments, the LIDAR sensor/system **320** may provide 3D imaging data of an environment around the vehicle **100**. The imaging data may be processed to generate a full 360-degree view of the environment around the vehicle **100**. The LIDAR sensor/system **320** may include a laser light generator configured to generate a plurality of target illumination laser beams (e.g., laser light channels). In some embodiments, this plurality of laser beams may be aimed at, or directed to, a rotating reflective surface (e.g., a mirror) and guided outwardly from the LIDAR sensor/system **320** into a measurement environment. The rotating reflective surface may be configured to continually rotate 360 degrees about an axis, such that the plurality of laser beams is directed in a full 360-degree range around the vehicle **100**. A photodiode receiver of the LIDAR sensor/system **320** may detect when light from the plurality of laser beams emitted into the measurement environment returns (e.g., reflected echo) to the LIDAR sensor/system **320**. The LIDAR sensor/system **320** may calculate, based on a time associated with the emission of light to the detected return of light, a distance from the vehicle **100** to the illuminated target. In some embodiments, the LIDAR sensor/system **320** may generate over 2.0 million points per second and have an effective operational range of at least 100 meters. Examples of the LIDAR sensor/system **320** as described herein may include, but are not limited to, at least one of Velodyne® LiDAR™ HDL-64E 64-channel LIDAR sensors, Velodyne® LiDAR™ HDL-32E 32-channel LIDAR sensors, Velodyne® LiDAR™ PUCK™ VLP-16 16-channel LIDAR sensors, Leica Geosystems Pegasus: Two mobile sensor platform, Garmin® LIDAR-Lite v3 measurement sensor, Quanergy M8 LiDAR sensors, Quanergy S3 solid state LiDAR sensor, LeddarTech® LeddarVU compact solid state fixed-beam LIDAR sensors, other industry-equivalent LIDAR sensors and/or systems, and may perform illuminated target and/or obstacle detection in an environment around the vehicle **100** using any known or future-developed standard and/or architecture.

The RADAR sensors **324** may include one or more radio components that are configured to detect objects/targets in an environment of the vehicle **100**. In some embodiments, the RADAR sensors **324** may determine a distance, position, and/or movement vector (e.g., angle, speed, etc.) associated with a target over time. The RADAR sensors **324** may include a transmitter configured to generate and emit electromagnetic waves (e.g., radio, microwaves, etc.) and a receiver configured to detect returned electromagnetic waves. In some embodiments, the RADAR sensors **324** may include at least one processor configured to interpret the returned electromagnetic waves and determine locational properties of targets. Examples of the RADAR sensors **324** as described herein may include, but are not limited to, at least one of Infineon RASIC™ RTN7735PL transmitter and RRN7745PL/46PL receiver sensors, Autoliv ASP Vehicle RADAR sensors, Delphi L2C0051TR 77 GHz ESR Electronically Scanning Radar sensors, Fujitsu Ten Ltd. Automotive Compact 77 GHz 3D Electronic Scan Millimeter Wave Radar sensors, other industry-equivalent RADAR sensors and/or systems, and may perform radio target and/or obstacle detection in an environment around the vehicle **100** using any known or future-developed standard and/or architecture.

The ultrasonic sensors **328** may include one or more components that are configured to detect objects/targets in an environment of the vehicle **100**. In some embodiments, the ultrasonic sensors **328** may determine a distance, position, and/or movement vector (e.g., angle, speed, etc.) associated with a target over time. The ultrasonic sensors **328** may include an ultrasonic transmitter and receiver, or transceiver, configured to generate and emit ultrasound waves and interpret returned echoes of those waves. In some embodiments, the ultrasonic sensors **328** may include at least one processor configured to interpret the returned ultrasonic waves and determine locational properties of targets. Examples of the ultrasonic sensors **328** as described herein may include, but are not limited to, at least one of Texas Instruments TIDA-00151 automotive ultrasonic sensor interface IC sensors, MaxBotix® MB8450 ultrasonic proximity sensor, MaxBotix® ParkSonar™-EZ ultrasonic proximity sensors, Murata Electronics MA40H1S-R open-structure ultrasonic sensors, Murata Electronics MA40S4R/S open-structure ultrasonic sensors, Murata Electronics MA58MF14-7N waterproof ultrasonic sensors, other industry-equivalent ultrasonic sensors and/or systems, and may perform ultrasonic target and/or obstacle detection in an environment around the vehicle **100** using any known or future-developed standard and/or architecture.

The camera sensors **332** may include one or more components configured to detect image information associated with an environment of the vehicle **100**. In some embodiments, the camera sensors **332** may include a lens, filter, image sensor, and/or a digital image processor. It is an aspect of the present disclosure that multiple camera sensors **332** may be used together to generate stereo images providing depth measurements. Examples of the camera sensors **332** as described herein may include, but are not limited to, at least one of ON Semiconductor® MT9V024 Global Shutter VGA GS CMOS image sensors, Teledyne DALSA Falcon2 camera sensors, CMOSIS CMV50000 high-speed CMOS image sensors, other industry-equivalent camera sensors and/or systems, and may perform visual target and/or obstacle detection in an environment around the vehicle **100** using any known or future-developed standard and/or architecture.

The infrared (IR) sensors **336** may include one or more components configured to detect image information associated with an environment of the vehicle **100**. The IR sensors **336** may be configured to detect targets in low-light, dark, or poorly-lit environments. The IR sensors **336** may include an IR light emitting element (e.g., IR light emitting diode (LED), etc.) and an IR photodiode. In some embodiments, the IR photodiode may be configured to detect returned IR light at or about the same wavelength to that emitted by the IR light emitting element. In some embodiments, the IR sensors **336** may include at least one processor configured to interpret the returned IR light and determine locational properties of targets. The IR sensors **336** may be configured to detect and/or measure a temperature associated with a target (e.g., an object, pedestrian, other vehicle, etc.). Examples of IR sensors **336** as described herein may include, but are not limited to, at least one of Opto Diode lead-salt IR array sensors, Opto Diode OD-850 Near-IR LED sensors, Opto Diode SA/SHA727 steady state IR emitters and IR detectors, FLIR® LS microbolometer sensors, FLIR® TacFLIR 380-HD InSb MWIR FPA and HD MWIR thermal sensors, FLIR® VOx 640×480 pixel detector sensors, Delphi IR sensors, other industry-equivalent IR sensors and/or systems, and may perform IR visual target and/or obstacle detection in an environment around the vehicle **100** using any known or future-developed standard and/or architecture.

The vehicle **100** can also include one or more interior sensors **337**. Interior sensors **337** can measure characteristics

of the inside environment of the vehicle **100**. The interior sensors **337** may be as described in conjunction with FIG. **3**B.

A navigation system **302** can include any hardware and/or software used to navigate the vehicle either manually or autonomously. The navigation system **302** may be as described in conjunction with FIG. **3**C.

In some embodiments, the driving vehicle sensors and systems **304** may include other sensors **338** and/or combinations of the sensors **306-337** described above. Additionally or alternatively, one or more of the sensors **306-337** described above may include one or more processors configured to process and/or interpret signals detected by the one or more sensors **306-337**. In some embodiments, the processing of at least some sensor information provided by the vehicle sensors and systems **304** may be processed by at least one sensor processor **340**. Raw and/or processed sensor data may be stored in a sensor data memory **344** storage medium. In some embodiments, the sensor data memory **344** may store instructions used by the sensor processor **340** for processing sensor information provided by the sensors and systems **304**. In any event, the sensor data memory **344** may be a disk drive, optical storage device, solid-state storage device such as a random access memory ("RAM") and/or a read-only memory ("ROM"), which can be programmable, flash-updateable, and/or the like.

The vehicle control system **348** may receive processed sensor information from the sensor processor **340** and determine to control an aspect of the vehicle **100**. Controlling an aspect of the vehicle **100** may include presenting information via one or more display devices **372** associated with the vehicle, sending commands to one or more computing devices **368** associated with the vehicle, and/or controlling a driving operation of the vehicle. In some embodiments, the vehicle control system **348** may correspond to one or more computing systems that control driving operations of the vehicle **100** in accordance with the Levels of driving autonomy described above. In one embodiment, the vehicle control system **348** may operate a speed of the vehicle **100** by controlling an output signal to the accelerator and/or braking system of the vehicle. In this example, the vehicle control system **348** may receive sensor data describing an environment surrounding the vehicle **100** and, based on the sensor data received, determine to adjust the acceleration, power output, and/or braking of the vehicle **100**. The vehicle control system **348** may additionally control steering and/or other driving functions of the vehicle **100**.

The vehicle control system **348** may communicate, in real-time, with the driving sensors and systems **304** forming a feedback loop. In particular, upon receiving sensor information describing a condition of targets in the environment surrounding the vehicle **100**, the vehicle control system **348** may autonomously make changes to a driving operation of the vehicle **100**. The vehicle control system **348** may then receive subsequent sensor information describing any change to the condition of the targets detected in the environment as a result of the changes made to the driving operation. This continual cycle of observation (e.g., via the sensors, etc.) and action (e.g., selected control or non-control of vehicle operations, etc.) allows the vehicle **100** to operate autonomously in the environment.

In some embodiments, the one or more components of the vehicle **100** (e.g., the driving vehicle sensors **304**, vehicle control system **348**, display devices **372**, etc.) may communicate across the communication network **352** to one or more entities **356**A-N via a communications subsystem **350** of the vehicle **100**. Embodiments of the communications subsystem **350** are described in greater detail in conjunction with FIG. **5**. For instance, the navigation sensors **308** may receive global positioning, location, and/or navigational information from a navigation source **356**A. In some embodiments, the navigation source **356**A may be a global navigation satellite system (GNSS) similar, if not identical, to NAVSTAR GPS, GLONASS, EU Galileo, and/or the BeiDou Navigation Satellite System (BDS) to name a few.

In some embodiments, the vehicle control system **348** may receive control information from one or more control sources **356**B. The control source **356** may provide vehicle control information including autonomous driving control commands, vehicle operation override control commands, and the like. The control source **356** may correspond to an autonomous vehicle control system, a traffic control system, an administrative control entity, and/or some other controlling server. It is an aspect of the present disclosure that the vehicle control system **348** and/or other components of the vehicle **100** may exchange communications with the control source **356** across the communication network **352** and via the communications subsystem **350**.

Information associated with controlling driving operations of the vehicle **100** may be stored in a control data memory **364** storage medium. The control data memory **364** may store instructions used by the vehicle control system **348** for controlling driving operations of the vehicle **100**, historical control information, autonomous driving control rules, and the like. In some embodiments, the control data memory **364** may be a disk drive, optical storage device, solid-state storage device such as a random access memory ("RAM") and/or a read-only memory ("ROM"), which can be programmable, flash-updateable, and/or the like.

In addition to the mechanical components described herein, the vehicle **100** may include a number of user interface devices. The user interface devices receive and translate human input into a mechanical movement or electrical signal or stimulus. The human input may be one or more of motion (e.g., body movement, body part movement, in two-dimensional or three-dimensional space, etc.), voice, touch, and/or physical interaction with the components of the vehicle **100**. In some embodiments, the human input may be configured to control one or more functions of the vehicle **100** and/or systems of the vehicle **100** described herein. User interfaces may include, but are in no way limited to, at least one graphical user interface of a display device, steering wheel or mechanism, transmission lever or button (e.g., including park, neutral, reverse, and/or drive positions, etc.), throttle control pedal or mechanism, brake control pedal or mechanism, power control switch, communications equipment, etc.

FIG. **3**B shows a block diagram of an embodiment of interior sensors **337** for a vehicle **100** in accordance with embodiments of the present disclosure. The interior sensors **337** may be arranged into one or more groups, based at least partially on the function of the interior sensors **337**. For example, the interior space of a vehicle **100** may include environmental sensors, a user interface sensors, and/or safety sensors. Additionally or alternatively, there may be sensors associated with various devices inside the vehicle (e.g., smart phones, tablets, mobile computers, wearables, etc.)

Environmental sensors may comprise sensors configured to collect data relating to the internal environment of a vehicle **100**. Examples of environmental sensors may include one or more of, but are not limited to: oxygen/air sensors **301**, temperature sensors **303**, humidity sensors **305**, light/photo sensors **307**, and more. The oxygen/air sensors

301 may be configured to detect a quality or characteristic of the air in the interior space 108 of the vehicle 100 (e.g., ratios and/or types of gasses comprising the air inside the vehicle 100, dangerous gas levels, safe gas levels, etc.). Temperature sensors 303 may be configured to detect temperature readings of one or more objects, users 216, and/or areas of a vehicle 100. Humidity sensors 305 may detect an amount of water vapor present in the air inside the vehicle 100. The light/photo sensors 307 can detect an amount of light present in the vehicle 100. Further, the light/photo sensors 307 may be configured to detect various levels of light intensity associated with light in the vehicle 100.

User interface sensors may comprise sensors configured to collect data relating to one or more users (e.g., a driver and/or passenger(s)) in a vehicle 100. As can be appreciated, the user interface sensors may include sensors that are configured to collect data from users 216 in one or more areas of the vehicle 100. Examples of user interface sensors may include one or more of, but are not limited to: infrared sensors 309, motion sensors 311, weight sensors 313, wireless network sensors 315, biometric sensors 317, camera (or image) sensors 319, audio sensors 321, and more.

Infrared sensors 309 may be used to measure IR light irradiating from at least one surface, user, or another object in the vehicle 100. Among other things, the Infrared sensors 309 may be used to measure temperatures, form images (especially in low light conditions), identify users 216, and even detect motion in the vehicle 100.

The motion sensors 311 may detect motion and/or movement of objects inside the vehicle 104. Optionally, the motion sensors 311 may be used alone or in combination to detect movement. For example, a user may be operating a vehicle 100 (e.g., while driving, etc.) when a passenger in the rear of the vehicle 100 unbuckles a safety belt and proceeds to move about the vehicle 10. In this example, the movement of the passenger could be detected by the motion sensors 311. In response to detecting the movement and/or the direction associated with the movement, the passenger may be prevented from interfacing with and/or accessing at least some of the vehicle control features. As can be appreciated, the user may be alerted of the movement/motion such that the user can act to prevent the passenger from interfering with the vehicle controls. Optionally, the number of motion sensors in a vehicle may be increased to increase an accuracy associated with motion detected in the vehicle 100.

Weight sensors 313 may be employed to collect data relating to objects and/or users in various areas of the vehicle 100. In some cases, the weight sensors 313 may be included in the seats and/or floor of a vehicle 100. Optionally, the vehicle 100 may include a wireless network sensor 315. This sensor 315 may be configured to detect one or more wireless network(s) inside the vehicle 100. Examples of wireless networks may include, but are not limited to, wireless communications utilizing Bluetooth®, Wi-Fi™, ZigBee, IEEE 802.11, and other wireless technology standards. For example, a mobile hotspot may be detected inside the vehicle 100 via the wireless network sensor 315. In this case, the vehicle 100 may determine to utilize and/or share the mobile hotspot detected via/with one or more other devices associated with the vehicle 100.

Biometric sensors 317 may be employed to identify and/or record characteristics associated with a user. It is anticipated that biometric sensors 317 can include at least one of image sensors, IR sensors, fingerprint readers, weight sensors, load cells, force transducers, heart rate monitors, blood pressure monitors, and the like as provided herein.

The camera sensors 319 may record still images, video, and/or combinations thereof. Camera sensors 319 may be used alone or in combination to identify objects, users, and/or other features, inside the vehicle 100. Two or more camera sensors 319 may be used in combination to form, among other things, stereo and/or three-dimensional (3D) images. The stereo images can be recorded and/or used to determine depth associated with objects and/or users in a vehicle 100. Further, the camera sensors 319 used in combination may determine the complex geometry associated with identifying characteristics of a user. For example, the camera sensors 319 may be used to determine dimensions between various features of a user's face (e.g., the depth/distance from a user's nose to a user's cheeks, a linear distance between the center of a user's eyes, and more). These dimensions may be used to verify, record, and even modify characteristics that serve to identify a user. The camera sensors 319 may also be used to determine movement associated with objects and/or users within the vehicle 100. It should be appreciated that the number of image sensors used in a vehicle 100 may be increased to provide greater dimensional accuracy and/or views of a detected image in the vehicle 100.

The audio sensors 321 may be configured to receive audio input from a user of the vehicle 100. The audio input from a user may correspond to voice commands, conversations detected in the vehicle 100, phone calls made in the vehicle 100, and/or other audible expressions made in the vehicle 100. Audio sensors 321 may include, but are not limited to, microphones and other types of acoustic-to-electric transducers or sensors. Optionally, the interior audio sensors 321 may be configured to receive and convert sound waves into an equivalent analog or digital signal. The interior audio sensors 321 may serve to determine one or more locations associated with various sounds in the vehicle 100. The location of the sounds may be determined based on a comparison of volume levels, intensity, and the like, between sounds detected by two or more interior audio sensors 321. For instance, a first audio sensor 321 may be located in a first area of the vehicle 100 and a second audio sensor 321 may be located in a second area of the vehicle 100. If a sound is detected at a first volume level by the first audio sensors 321 A and a second, higher, volume level by the second audio sensors 321 in the second area of the vehicle 100, the sound may be determined to be closer to the second area of the vehicle 100. As can be appreciated, the number of sound receivers used in a vehicle 100 may be increased (e.g., more than two, etc.) to increase measurement accuracy surrounding sound detection and location, or source, of the sound (e.g., via triangulation, etc.).

The safety sensors may comprise sensors configured to collect data relating to the safety of a user and/or one or more components of a vehicle 100. Examples of safety sensors may include one or more of, but are not limited to: force sensors 325, mechanical motion sensors 327, orientation sensors 329, restraint sensors 331, and more.

The force sensors 325 may include one or more sensors inside the vehicle 100 configured to detect a force observed in the vehicle 100. One example of a force sensor 325 may include a force transducer that converts measured forces (e.g., force, weight, pressure, etc.) into output signals. Mechanical motion sensors 327 may correspond to encoders, accelerometers, damped masses, and the like. Optionally, the mechanical motion sensors 327 may be adapted to measure the force of gravity (i.e., G-force) as observed inside the vehicle 100. Measuring the G-force observed inside a vehicle 100 can provide valuable information

related to a vehicle's acceleration, deceleration, collisions, and/or forces that may have been suffered by one or more users in the vehicle **100**. Orientation sensors **329** can include accelerometers, gyroscopes, magnetic sensors, and the like that are configured to detect an orientation associated with the vehicle **100**.

The restraint sensors **331** may correspond to sensors associated with one or more restraint devices and/or systems in a vehicle **100**. Seatbelts and airbags are examples of restraint devices and/or systems. As can be appreciated, the restraint devices and/or systems may be associated with one or more sensors that are configured to detect a state of the device/system. The state may include extension, engagement, retraction, disengagement, deployment, and/or other electrical or mechanical conditions associated with the device/system.

The associated device sensors **323** can include any sensors that are associated with a device in the vehicle **100**. As previously stated, typical devices may include smart phones, tablets, laptops, mobile computers, and the like. It is anticipated that the various sensors associated with these devices can be employed by the vehicle control system **348**. For example, a typical smart phone can include, an image sensor, an IR sensor, audio sensor, gyroscope, accelerometer, wireless network sensor, fingerprint reader, and more. It is an aspect of the present disclosure that one or more of these associated device sensors **323** may be used by one or more subsystems of the vehicle **100**.

FIG. **3**C illustrates a GPS/Navigation subsystem(s) **302** in accordance with embodiments of the present disclosure. The navigation subsystem(s) **302** can be any present or future-built navigation system that may use location data, for example, from the Global Positioning System (GPS), to provide navigation information or control the vehicle **100**. The navigation subsystem(s) **302** can include several components, such as, one or more of, but not limited to: a GPS Antenna/receiver **331**, a location module **333**, a maps database **335**, etc. Generally, the several components or modules **331-335** may be hardware, software, firmware, computer readable media, or combinations thereof.

A GPS Antenna/receiver **331** can be any antenna, GPS puck, and/or receiver capable of receiving signals from a GPS satellite or other navigation system. The signals may be demodulated, converted, interpreted, etc. by the GPS Antenna/receiver **331** and provided to the location module **333**. Thus, the GPS Antenna/receiver **331** may convert the time signals from the GPS system and provide a location (e.g., coordinates on a map) to the location module **333**. Alternatively, the location module **333** can interpret the time signals into coordinates or other location information.

The location module **333** can be the controller of the satellite navigation system designed for use in the vehicle **100**. The location module **333** can acquire position data, as from the GPS Antenna/receiver **331**, to locate the user or vehicle **100** on a road in the unit's map database **335**. Using the road database **335**, the location module **333** can give directions to other locations along roads also in the database **335**. When a GPS signal is not available, the location module **333** may apply dead reckoning to estimate distance data from sensors **304** including one or more of, but not limited to, a speed sensor attached to the drive train of the vehicle **100**, a gyroscope, an accelerometer, etc. Additionally or alternatively, the location module **333** may use known locations of Wi-Fi hotspots, cell tower data, etc. to determine the position of the vehicle **100**, such as by using time difference of arrival (TDOA) and/or frequency difference of arrival (FDOA) techniques.

The maps database **335** can include any hardware and/or software to store information about maps, geographical information system (GIS) information, location information, etc. The maps database **335** can include any data definition or other structure to store the information. Generally, the maps database **335** can include a road database that may include one or more vector maps of areas of interest. Street names, street numbers, house numbers, and other information can be encoded as geographic coordinates so that the user can find some desired destination by street address. Points of interest (waypoints) can also be stored with their geographic coordinates. For example, a point of interest may include speed cameras, fuel stations, public parking, and "parked here" (or "you parked here") information. The maps database **335** may also include road or street characteristics, for example, speed limits, location of stop lights/stop signs, lane divisions, school locations, etc. The map database contents can be produced or updated by a server connected through a wireless system in communication with the Internet, even as the vehicle **100** is driven along existing streets, yielding an up-to-date map.

FIG. **4** shows an instrument panel **400** of the vehicle **100** in accordance with embodiments of the present disclosure. The instrument panel **400** of vehicle **100** comprises a steering wheel **410**, a vehicle operational display **420** (e.g., configured to present and/or display driving data such as speed, measured air resistance, vehicle information, entertainment information, etc.), one or more auxiliary displays **424** (e.g., configured to present and/or display information segregated from the operational display **420**, entertainment applications, movies, music, etc.), a heads-up display **434** (e.g., configured to display any information previously described including, but in no way limited to, guidance information such as route to destination, or obstacle warning information to warn of a potential collision, or some or all primary vehicle operational data such as speed, resistance, etc.), a power management display **428** (e.g., configured to display data corresponding to electric power levels of vehicle **100**, reserve power, charging status, etc.), and an input device **432** (e.g., a controller, touchscreen, or other interface device configured to interface with one or more displays in the instrument panel or components of the vehicle **100**. The input device **432** may be configured as a joystick, mouse, touchpad, tablet, 3D gesture capture device, etc.). In some embodiments, the input device **432** may be used to manually maneuver a portion of the vehicle **100** into a charging position (e.g., moving a charging plate to a desired separation distance, etc.).

While one or more of displays of instrument panel **400** may be touch-screen displays, it should be appreciated that the vehicle operational display may be a display incapable of receiving touch input. For instance, the operational display **420** that spans across an interior space centerline **404** and across both a first zone **408**A and a second zone **408**B may be isolated from receiving input from touch, especially from a passenger. In some cases, a display that provides vehicle operation or critical systems information and interface may be restricted from receiving touch input and/or be configured as a non-touch display. This type of configuration can prevent dangerous mistakes in providing touch input where such input may cause an accident or unwanted control.

In some embodiments, one or more displays of the instrument panel **400** may be mobile devices and/or applications residing on a mobile device such as a smart phone. Additionally or alternatively, any of the information described herein may be presented to one or more portions **420**A-N of the operational display **420** or other display **424**,

428, **434**. In one embodiment, one or more displays of the instrument panel **400** may be physically separated or detached from the instrument panel **400**. In some cases, a detachable display may remain tethered to the instrument panel.

The portions **420**A-N of the operational display **420** may be dynamically reconfigured and/or resized to suit any display of information as described. Additionally or alternatively, the number of portions **420**A-N used to visually present information via the operational display **420** may be dynamically increased or decreased as required, and are not limited to the configurations shown.

FIG. **5** illustrates a hardware diagram of communications componentry that can be optionally associated with the vehicle **100** in accordance with embodiments of the present disclosure.

The communications componentry can include one or more wired or wireless devices such as a transceiver(s) and/or modem that allows communications not only between the various systems disclosed herein but also with other devices, such as devices on a network, and/or on a distributed network such as the Internet and/or in the cloud and/or with another vehicle(s).

The communications subsystem **350** can also include inter- and intra-vehicle communications capabilities such as hotspot and/or access point connectivity for any one or more of the vehicle occupants and/or vehicle-to-vehicle communications.

Additionally, and while not specifically illustrated, the communications subsystem **350** can include one or more communications links (that can be wired or wireless) and/or communications busses (managed by the bus manager **574**), including one or more of CANbus, OBD-II, ARCINC 429, Byteflight, CAN (Controller Area Network), D2B (Domestic Digital Bus), FlexRay, DC-BUS, IDB-1394, IEBus, I2C, ISO 9141-1/-2, J1708, J1587, J1850, J1939, ISO 11783, Keyword Protocol 2000, LIN (Local Interconnect Network), MOST (Media Oriented Systems Transport), Multifunction Vehicle Bus, SMARTwireX, SPI, VAN (Vehicle Area Network), and the like or in general any communications protocol and/or standard(s).

The various protocols and communications can be communicated one or more of wirelessly and/or over transmission media such as single wire, twisted pair, fiber optic, IEEE 1394, MIL-STD-1553, MIL-STD-1773, power-line communication, or the like. (All of the above standards and protocols are incorporated herein by reference in their entirety).

As discussed, the communications subsystem **350** enables communications between any if the inter-vehicle systems and subsystems as well as communications with non-collocated resources, such as those reachable over a network such as the Internet.

The communications subsystem **350**, in addition to well-known componentry (which has been omitted for clarity), includes interconnected elements including one or more of: one or more antennas **504**, an interleaver/deinterleaver **508**, an analog front end (AFE) **512**, memory/storage/cache **516**, controller/microprocessor **520**, MAC circuitry **522**, modulator/demodulator **524**, encoder/decoder **528**, a plurality of connectivity managers **534**, **558**, **562**, **566**, GPU **540**, accelerator **544**, a multiplexer/demultiplexer **552**, transmitter **570**, receiver **572** and wireless radio **578** components such as a Wi-Fi PHY/Bluetooth® module **580**, a Wi-Fi/BT MAC module **584**, transmitter **588** and receiver **592**. The various elements in the device **350** are connected by one or more links/busses **5** (not shown, again for sake of clarity).

The device **350** can have one more antennas **504**, for use in wireless communications such as multi-input multi-output (MIMO) communications, multi-user multi-input multi-output (MU-MIMO) communications Bluetooth®, LTE, 4G, 5G, Near-Field Communication (NFC), etc., and in general for any type of wireless communications. The antenna(s) **504** can include, but are not limited to one or more of directional antennas, omnidirectional antennas, monopoles, patch antennas, loop antennas, microstrip antennas, dipoles, and any other antenna(s) suitable for communication transmission/reception. In an exemplary embodiment, transmission/reception using MIMO may require particular antenna spacing. In another exemplary embodiment, MIMO transmission/reception can enable spatial diversity allowing for different channel characteristics at each of the antennas. In yet another embodiment, MIMO transmission/reception can be used to distribute resources to multiple users for example within the vehicle **100** and/or in another vehicle.

Antenna(s) **504** generally interact with the Analog Front End (AFE) **512**, which is needed to enable the correct processing of the received modulated signal and signal conditioning for a transmitted signal. The AFE **512** can be functionally located between the antenna and a digital baseband system to convert the analog signal into a digital signal for processing and vice-versa.

The subsystem **350** can also include a controller/microprocessor **520** and a memory/storage/cache **516**. The subsystem **350** can interact with the memory/storage/cache **516** which may store information and operations necessary for configuring and transmitting or receiving the information described herein. The memory/storage/cache **516** may also be used in connection with the execution of application programming or instructions by the controller/microprocessor **520**, and for temporary or long term storage of program instructions and/or data. As examples, the memory/storage/cache **520** may comprise a computer-readable device, RAM, ROM, DRAM, SDRAM, and/or other storage device(s) and media.

The controller/microprocessor **520** may comprise a general purpose programmable processor or controller for executing application programming or instructions related to the subsystem **350**. Furthermore, the controller/microprocessor **520** can perform operations for configuring and transmitting/receiving information as described herein. The controller/microprocessor **520** may include multiple processor cores, and/or implement multiple virtual processors. Optionally, the controller/microprocessor **520** may include multiple physical processors. By way of example, the controller/microprocessor **520** may comprise a specially configured Application Specific Integrated Circuit (ASIC) or other integrated circuit, a digital signal processor(s), a controller, a hardwired electronic or logic circuit, a programmable logic device or gate array, a special purpose computer, or the like.

The subsystem **350** can further include a transmitter **570** and receiver **572** which can transmit and receive signals, respectively, to and from other devices, subsystems and/or other destinations using the one or more antennas **504** and/or links/busses. Included in the subsystem **350** circuitry is the medium access control or MAC Circuitry **522**. MAC circuitry **522** provides for controlling access to the wireless medium. In an exemplary embodiment, the MAC circuitry **522** may be arranged to contend for the wireless medium and configure frames or packets for communicating over the wired/wireless medium.

The subsystem **350** can also optionally contain a security module (not shown). This security module can contain

information regarding but not limited to, security parameters required to connect the device to one or more other devices or other available network(s), and can include WEP or WPA/WPA-2 (optionally+AES and/or TKIP) security access keys, network keys, etc. The WEP security access key is a security password used by Wi-Fi networks. Knowledge of this code can enable a wireless device to exchange information with an access point and/or another device. The information exchange can occur through encoded messages with the WEP access code often being chosen by the network administrator. WPA is an added security standard that is also used in conjunction with network connectivity with stronger encryption than WEP.

In some embodiments, the communications subsystem **350** also includes a GPU **540**, an accelerator **544**, a Wi-Fi/BT/BLE PHY module **580** and a Wi-Fi/BT/BLE MAC module **584** and wireless transmitter **588** and receiver **592**. In some embodiments, the GPU **540** may be a graphics processing unit, or visual processing unit, comprising at least one circuit and/or chip that manipulates and changes memory to accelerate the creation of images in a frame buffer for output to at least one display device. The GPU **540** may include one or more of a display device connection port, printed circuit board (PCB), a GPU chip, a metal-oxide-semiconductor field-effect transistor (MOSFET), memory (e.g., single data rate random-access memory (SDRAM), double data rate random-access memory (DDR) RAM, etc., and/or combinations thereof), a secondary processing chip (e.g., handling video out capabilities, processing, and/or other functions in addition to the GPU chip, etc.), a capacitor, heatsink, temperature control or cooling fan, motherboard connection, shielding, and the like.

The various connectivity managers **534**, **558**, **562**, **566** manage and/or coordinate communications between the subsystem **350** and one or more of the systems disclosed herein and one or more other devices/systems. The connectivity managers **534**, **558**, **562**, **566** include a charging connectivity manager **534**, a vehicle database connectivity manager **558**, a remote operating system connectivity manager **562**, and a sensor connectivity manager **566**.

The charging connectivity manager **534** can coordinate not only the physical connectivity between the vehicle **100** and a charging device/vehicle, but can also communicate with one or more of a power management controller, one or more third parties and optionally a billing system(s). As an example, the vehicle **100** can establish communications with the charging device/vehicle to one or more of coordinate interconnectivity between the two (e.g., by spatially aligning the charging receptacle on the vehicle with the charger on the charging vehicle) and optionally share navigation information. Once charging is complete, the amount of charge provided can be tracked and optionally forwarded to, for example, a third party for billing. In addition to being able to manage connectivity for the exchange of power, the charging connectivity manager **534** can also communicate information, such as billing information to the charging vehicle and/or a third party. This billing information could be, for example, the owner of the vehicle, the driver/occupant(s) of the vehicle, company information, or in general any information usable to charge the appropriate entity for the power received.

The vehicle database connectivity manager **558** allows the subsystem to receive and/or share information stored in the vehicle database. This information can be shared with other vehicle components/subsystems and/or other entities, such as third parties and/or charging systems. The information can also be shared with one or more vehicle occupant devices, such as an app (application) on a mobile device the driver uses to track information about the vehicle **100** and/or a dealer or service/maintenance provider. In general, any information stored in the vehicle database can optionally be shared with any one or more other devices optionally subject to any privacy or confidentially restrictions.

The remote operating system connectivity manager **562** facilitates communications between the vehicle **100** and any one or more autonomous vehicle systems. These communications can include one or more of navigation information, vehicle information, other vehicle information, weather information, occupant information, or in general any information related to the remote operation of the vehicle **100**.

The sensor connectivity manager **566** facilitates communications between any one or more of the vehicle sensors (e.g., the driving vehicle sensors and systems **304**, etc.) and any one or more of the other vehicle systems. The sensor connectivity manager **566** can also facilitate communications between any one or more of the sensors and/or vehicle systems and any other destination, such as a service company, app, or in general to any destination where sensor data is needed.

In accordance with one exemplary embodiment, any of the communications discussed herein can be communicated via the conductor(s) used for charging. One exemplary protocol usable for these communications is Power-line communication (PLC). PLC is a communication protocol that uses electrical wiring to simultaneously carry both data, and Alternating Current (AC) electric power transmission or electric power distribution. It is also known as power-line carrier, power-line digital subscriber line (PDSL), mains communication, power-line telecommunications, or power-line networking (PLN). For DC environments in vehicles PLC can be used in conjunction with CAN-bus, LIN-bus over power line (DC-LIN) and DC-BUS.

The communications subsystem can also optionally manage one or more identifiers, such as an IP (internet protocol) address(es), associated with the vehicle and one or other system or subsystems or components therein. These identifiers can be used in conjunction with any one or more of the connectivity managers as discussed herein.

FIG. **6** illustrates a block diagram of a computing environment **600** that may function as the servers, user computers, or other systems provided and described herein in accordance with embodiments of the present disclosure. The computing environment **600** includes one or more user computers, or computing devices, such as a vehicle computing device **604**, a communication device **608**, and/or more **612**. The computing devices **604**, **608**, **612** may include general purpose personal computers (including, merely by way of example, personal computers, and/or laptop computers running various versions of Microsoft Corp.'s Windows® and/or Apple Corp.'s Macintosh® operating systems) and/or workstation computers running any of a variety of commercially-available UNIX® or UNIX-like operating systems. These computing devices **604**, **608**, **612** may also have any of a variety of applications, including for example, database client and/or server applications, and web browser applications. Alternatively, the computing devices **604**, **608**, **612** may be any other electronic device, such as a thin-client computer, Internet-enabled mobile telephone, and/or personal digital assistant, capable of communicating via a network **352** and/or displaying and navigating web pages or other types of electronic documents. Although the exemplary computing environment **600** is shown with two computing devices, any number of user computers or computing devices may be supported.

The computing environment **600** may also include one or more servers **614**, **616**. In this example, server **614** is shown as a web server and server **616** is shown as an application server. The web server **614**, which may be used to process requests for web pages or other electronic documents from computing devices **604**, **608**, **612**. The web server **614** can be running an operating system including any of those discussed above, as well as any commercially-available server operating systems. The web server **614** can also run a variety of server applications, including SIP (Session Initiation Protocol) servers, HTTP(s) servers, FTP servers, CGI servers, database servers, Java servers, and the like. In some instances, the web server **614** may publish operations available operations as one or more web services.

The computing environment **600** may also include one or more file and or/application servers **616**, which can, in addition to an operating system, include one or more applications accessible by a client running on one or more of the computing devices **604**, **608**, **612**. The server(s) **616** and/or **614** may be one or more general purpose computers capable of executing programs or scripts in response to the computing devices **604**, **608**, **612**. As one example, the server **616**, **614** may execute one or more web applications. The web application may be implemented as one or more scripts or programs written in any programming language, such as Java™, C, C#®, or C++, and/or any scripting language, such as Perl, Python, or TCL, as well as combinations of any programming/scripting languages. The application server(s) **616** may also include database servers, including without limitation those commercially available from Oracle®, Microsoft®, Sybase®, IBM® and the like, which can process requests from database clients running on a computing device **604**, **608**, **612**.

The web pages created by the server **614** and/or **616** may be forwarded to a computing device **604**, **608**, **612** via a web (file) server **614**, **616**. Similarly, the web server **614** may be able to receive web page requests, web services invocations, and/or input data from a computing device **604**, **608**, **612** (e.g., a user computer, etc.) and can forward the web page requests and/or input data to the web (application) server **616**. In further embodiments, the server **616** may function as a file server. Although for ease of description, FIG. **6** illustrates a separate web server **614** and file/application server **616**, those skilled in the art will recognize that the functions described with respect to servers **614**, **616** may be performed by a single server and/or a plurality of specialized servers, depending on implementation-specific needs and parameters. The computer systems **604**, **608**, **612**, web (file) server **614** and/or web (application) server **616** may function as the system, devices, or components described in FIGS. **1-6**.

The computing environment **600** may also include a database **618**. The database **618** may reside in a variety of locations. By way of example, database **618** may reside on a storage medium local to (and/or resident in) one or more of the computers **604**, **608**, **612**, **614**, **616**. Alternatively, it may be remote from any or all of the computers **604**, **608**, **612**, **614**, **616**, and in communication (e.g., via the network **610**) with one or more of these. The database **618** may reside in a storage-area network ("SAN") familiar to those skilled in the art. Similarly, any necessary files for performing the functions attributed to the computers **604**, **608**, **612**, **614**, **616** may be stored locally on the respective computer and/or remotely, as appropriate. The database **618** may be a relational database, such as Oracle 20i®, that is adapted to store, update, and retrieve data in response to SQL-formatted commands.

FIG. **7** illustrates a computer system **700** upon which the servers, user computers, computing devices, or other systems or components described above may be deployed or executed in accordance with embodiments of the present disclosure. The computer system **700** is shown comprising hardware elements that may be electrically coupled via a bus **704**. The hardware elements may include one or more central processing units (CPUs) **708**; one or more input devices **712** (e.g., a mouse, a keyboard, etc.); and one or more output devices **716** (e.g., a display device, a printer, etc.). The computer system **700** may also include one or more storage devices **720**. By way of example, storage device(s) **720** may be disk drives, optical storage devices, solid-state storage devices such as a random access memory ("RAM") and/or a read-only memory ("ROM"), which can be programmable, flash-updateable and/or the like.

The computer system **700** may additionally include a computer-readable storage media reader **724**; a communications system **728** (e.g., a modem, a network card (wireless or wired), an infra-red communication device, etc.); and working memory **736**, which may include RAM and ROM devices as described above. The computer system **700** may also include a processing acceleration unit **732**, which can include a DSP, a special-purpose processor, and/or the like.

The computer-readable storage media reader **724** can further be connected to a computer-readable storage medium, together (and, optionally, in combination with storage device(s) **720**) comprehensively representing remote, local, fixed, and/or removable storage devices plus storage media for temporarily and/or more permanently containing computer-readable information. The communications system **728** may permit data to be exchanged with a network and/or any other computer described above with respect to the computer environments described herein. Moreover, as disclosed herein, the term "storage medium" may represent one or more devices for storing data, including read only memory (ROM), random access memory (RAM), magnetic RAM, core memory, magnetic disk storage mediums, optical storage mediums, flash memory devices and/or other machine readable mediums for storing information.

The computer system **700** may also comprise software elements, shown as being currently located within a working memory **736**, including an operating system **740** and/or other code **744**. It should be appreciated that alternate embodiments of a computer system **700** may have numerous variations from that described above. For example, customized hardware might also be used and/or particular elements might be implemented in hardware, software (including portable software, such as applets), or both. Further, connection to other computing devices such as network input/output devices may be employed.

Examples of the processors **340**, **708** as described herein may include, but are not limited to, at least one of Qualcomm® Snapdragon® 800 and 801, Qualcomm® Snapdragon® 620 and 615 with 4G LTE Integration and 64-bit computing, Apple® A7 processor with 64-bit architecture, Apple® M7 motion coprocessors, Samsung® Exynos® series, the Intel® Core™ family of processors, the Intel® Xeon® family of processors, the Intel® Atom™ family of processors, the Intel Itanium® family of processors, Intel® Core® i5-4670K and i7-4770K 22 nm Haswell, Intel® Core® i5-3570K 22 nm Ivy Bridge, the AMD® FX™ family of processors, AMD® FX-4300, FX-6300, and FX-8350 32 nm Vishera, AMD® Kaveri processors, Texas Instruments® Jacinto C6000™ automotive infotainment processors, Texas Instruments® OMAP™ automotive-grade

mobile processors, ARM® Cortex™-M processors, ARM® Cortex-A and ARM926EJ-S™ processors, other industry-equivalent processors, and may perform computational functions using any known or future-developed standard, instruction set, libraries, and/or architecture.

An embodiment of a communications process **800** between a navigation source **356**, which may be a server **616** that communicates with a communications subsystem **350**, and a vehicle **100**, having communications system **350** and executing a processor **708**, may be as shown in FIG. **8** in accordance with embodiments of the present disclosure. The vehicle **100** may communicate one or more items of data received from sensors **304**, in communication **804***a*. The data communicated may be as described in conjunction with FIG. **9**A. The data can be gathered from the sensors **304**, provided through the processor **708**, and sent to the navigation source **356**, through a communications subsystem **350**. For example, the sensor data may be processed by a processor **708** of the location module/route engine **333** and sent to the navigation source **356** as shown in FIG. **3**C. This sensor data can include any one or more items of metadata about a location observed by the vehicle **100**.

Sometime thereinafter, the processor **708** of the location module/route engine **333** may request information from a navigation source **356**, in signal **808***a*. The request can be as described in conjunction with FIG. **9**B. This request **808***a* can request, from the navigation source **356**, some information about a location where the vehicle **100** is or a location where the vehicle **100** will be at some time in the future. For example, with reference to the driving environment **1300** of FIG. **13**, the request **808***a* can be for information or metadata about a traffic light **1304** at an intersection **1312** along the route of travel for the vehicle **100**.

In response to the request, the communications system **350**, of the navigation source **356**, can send data **812***a* back to the vehicle **100**. This data **812***a* may be as described in conjunction with FIG. **9**E. Dissimilar to data **804***a*, data **812***a* includes data from two or more vehicles that is aggregated and associated with the requested information. For example, data **812***a* can include aggregated data from two or more vehicles about the traffic light **1304**. As such, the aggregated data can be more accurate, be time-based, and be more relevant to the current situation of the vehicle **100** compared to what data was sent in signal **804***a*.

The location module/route engine **333** may then determine a route **816**, based on this information in data **812**A. The route may then be sent to the user interface to direct the driver or may be sent to the vehicle control subsystem **348** to automatically control the vehicle **100** on the route. Sometime thereinafter, the location module/route engine **333** can obtain more sensor data from sensors **304** and send that data to the navigation source **356**, as data signal **804***b*. This data signal **804***b* may be the same or similar to data signal **804***a*, but be associated with a different location or sent at a different time. Further, the location module/route engine **333** can also make a second request **808***b* for more information and receive an update about information in signal **812***b*. As such, the location module/route engine **333** can be in persistent communication with the navigation source **356** to receive information about the route or about locations along the route that will be or may be encountered by the vehicle **100**.

An embodiment of the navigation source **356**, having a geographical information systems (GIS) database **904** may be as shown in FIG. **9**A in accordance with embodiments of the present disclosure. The data storage **904** can include one or more different types of data or send and/or retrieve such data in one or more different types of packets or signals. The GIS data **904**, shown in FIG. **9**A, may include one or more different data structures provided in FIGS. **9**B-**9**E in accordance with embodiments of the present disclosure. In FIG. **9**B, an embodiment of data **908**, which may be sent in signals **804**, may be shown. Here, the data structure **908** can include one or more of, but is not limited to, a location identifier (ID) **912**, location type **916**, a date and/or timestamp **920**, a vehicle ID **924**, a data type **928**, and/or metadata **932**. There may be more or fewer fields than those shown in FIG. **9**B, as represented by ellipses **948**. Further, there may be one or more items of data sent by the vehicle **100** or received by the navigation source **356**, as represented by ellipses **944**.

A location identifier **912** can be any type of identifier, such as a globally unique identifier (GUID), an alphanumeric identifier, a numeric identifier, a pseudorandom code, a randomly generated identifier, etc. This identifier **912** identifies a location within a geographical area, and thus, can include a latitude and longitude for the location. For example, a certain intersection **1312** may have an identifier identifying that intersection **1312** uniquely to all other intersections within a geographical area. The identifier **912** allows for the association of metadata with the location and allows the GIS database **904** to provide a context or information about those locations. Locations can include such things as intersections **1312**, parking lots, places for merging into traffic or merging out of traffic **1316**, interchanges, tunnels, bridges, etc.

The type of location may be as provided in field **916**. As such, whatever type of location is identified by ID **912** can also include a location type **916**. Therefore, if the location ID **912** identifies an intersection, the location type **916** will list the location as an intersection. There may be various types of locations as has already been mentioned.

A date and timestamp **920** can include a data and/or time of when the data was either observed or sent from the vehicle **100** to the navigation source **356**. The date **920** can include a year, month, day, etc. The time **920** may include an hour, minute, second, or time measures that are less than a second. The date and time **920** can also be universal clock time provided by a broadcast signal from some universal time clock. Further, the date and timestamp **920** can include a duration of the observation or event. The date and time **920** allow for the GIS database **904** to gather information over a time period to allow for better information about the locations based on the day and the time of day.

A vehicle ID **924** can identify the vehicle **100** sending the data **908**. The vehicle ID **924** can be any GUID, alphanumeric identifier, numeric identifier, etc. that uniquely identifies this vehicle **100**. For example, the vehicle identifier **924** can be a VIN number or some other type of vehicle-centric identifier.

The data type **928** can be the type of data being associated with the location. This data type can include such information as traffic light information, clearing time (which is the amount of time allotted to clear traffic from an intersection if a light goes green), clearing time for a turn lane, lane congestion information, etc. that deals with an intersection. Other types of data may also be provided. For example, the amount of time to merge or unmerge from a high-occupancy vehicle (HOV) lane, the amount of time or the speed driven along an HOV lane, etc.

Depending on the location, the data types **928** can be several and different. There also may be several data types for each location. The data type **928** allows for the determination of what type of metadata **932** is being provided.

The metadata **932** can be some type of measure or observation from the vehicle sensor **304**. For example, if the data type **928** is cycle time for an intersection traffic light, the metadata **932** may include the number of seconds in cycle time for a green light. The metadata **932** can include any information about any transitory environmental structures. For example, the transitory environmental structures can include, (a) traffic lights and duration of the lights, a fixed element, a presence of temporary human obstacles, traffic restrictions (e.g., traffic controls near a school zone that may be semi-fixed elements and only present during a particular time of the year, day of the week, and/or time of the day), pedestrian amounts (e.g., a busy crossing in San Francisco), etc. Any observation about any of the environmental structures may be stored with a latitude and longitude, a time of the observation, and/or a duration of the event or observation. There may be other information provided in the metadata **932** that allows for the determination of a function or operation at or for that location.

As an example, one data type, light timing **936**, may be provided in an example data packet. This data type **936** can include metadata **932** for a 30-second time period where the light remains green at that traffic signal **1304**. This 30-second cycle time metadata **940** may be provided to allow for determination of how to route a vehicle **100**.

Any of the above information may be learned information that can be used to augment a "static" map. A map can be static as the underlying roads, crossings, buildings, and other structures are generally unchanging. However, the "static map can be augmented with the above transitory information generated by the observations described above. Thus, the observation information relates to the unchanging structures but may not include traffic information and the like unless associated with one of the transitory environmental structures in some manner.

An embodiment of how data **954** may be stored in the graphical information system **904** may be as shown in FIG. **9**C in accordance with embodiments of the present disclosure. Here, data is aggregated into an aggregated data store **954** that can include similar information, such as a location ID **912**, a location type **916**, and data type **920**. However, the metadata **952** may be different than metadata **932** because the metadata **952** is a conglomeration of data from two or more vehicles. Thus, the navigation source **356** can use stochastic modeling or other types of algorithms to determine aggregations of data provided by several different vehicles. There may be more or fewer fields in the data structure **954**, as represented by ellipses **956**. There also may be more than one data structure **954** in the GIS database **904** based on number of locations and other information, as represented by ellipses **960**. The data **954** in FIG. **9**C can be retrieved by the location ID **912**, location type **916**, and data type **928** for sending in a data packet **812**, as described in conjunction with FIG. **8**. Thus, if no data is available for a specific location, the navigation source **356** may provide data from other similar locations from other environments that include similar data types (e.g., data from the same type of traffic light), or in other formats.

A request **964**, which may be included in request signal **808**, may be as shown in FIG. **9**D. The request may include one of more of, but is not limited to, a vehicle identifier **924**, a location ID **912**, a data type **920**, and/or a request **968**. There may be more or fewer fields in the request **964**, as represented by ellipses **972**. Further, there may be several requests sent and, as such, there may be more requests than that shown in FIG. **9**D, as represented by ellipses **976**. The request **968** can include what information is desired about the location provided in location ID **912**. For example, the request **964** can be timing information, such as that stored in field **940**. Thus, the request **964** can provide some information to the navigation source **356** about what data needs to be returned to the vehicle **100**.

An example of data that may be returned to the vehicle **100** may be as shown in FIG. **9**E. Here, the return data **978** may be provided in data signal **812**. The data **978** can include one of more of, but is not limited to, a vehicle ID **924**, a location ID **912**, data type **940**, and metadata **980**. There may be more or fewer fields in data structure **978** than that shown in FIG. **9**E, as represented by ellipses **984**. Further, there may be two or more different data packets **978**, sent in response to a request signal **808**, in a data signal **812**, as represented by ellipses **988**. The sent data packet **978** includes metadata **980**, which can include any information aggregated or drawn from metadata **952** that is in response to the request **968**.

A method **1000** for consolidating data about one or more locations at a navigation source **356** may be as shown in FIG. **10** in accordance with embodiments of the present disclosure. A general order for the steps of the method **1000** is shown in FIG. **10**. Generally, the method **1000** starts with a start operation **1004** and ends with operation **1032**. The method **1000** can include more or fewer steps or can arrange the order of the steps differently than those shown in FIG. **10**. The method **1000** can be executed as a set of computer-executable instructions executed by a computer system or processor and encoded or stored on a computer readable medium. In other configurations, the method **1000** may be executed by a series of components, circuits, gates, etc. created in a hardware device, such as a System of Chip (SOC), Application Specific Integrated Circuit (ASIC), and/r a Field Programmable Gate Array (FPGA). Hereinafter, the method **1000** shall be explained with reference to the systems, components, circuits, modules, software, data structures, signaling processes, models, environments, vehicles, etc. described in conjunction with FIGS. **1-9** and **11-13**.

The navigation source **356** receives a data signal **804**, in step **1008**. Here, the data signal **804** may be as provided in data structure **908** in FIG. **9**B. The data signal **804** may be sent from the location module/route engine **333** to the navigation source **356** through a communications system **350**. The server **616**, representing the navigation source **356**, can receive the data **908** for storage in the GIS **904**.

The navigation source **356** can then associate the data **908**, in step **1012**. Associating the data includes the navigation source **356** extracting the location ID **912** to associate the received data **908** with the associated location. As such, the navigation source **356** can associate the received data **908** with data **954** already stored in the GIS **904** about the same location. Thus, this received data **908** can become another entry or data portion for the data **954**.

The navigation source **356** may then aggregate the data, in step **1016**. Here, the received data **908** becomes part of the data **954** of the location, represented by location ID **912**. Aggregation includes any modeling, such as stochastic modeling, or other types of algorithms that may be performed on the received data **908** to become part of the stored data **954**.

Sometime thereinafter, the navigation source **356** may receive a request **808** from the vehicle or vehicles **100**, in step **1020**. The request **808** may be the same or similar to request **964** shown in FIG. **9**D. This request **964** may be received by the navigation source **356** through a communications subsystem **350** and transmitted by the location

module/route engine **333** of the vehicle **100**. The request **964** may include the various fields as shown in FIG. **9**D, which may identify what type of data is requested by data type **940**, the request **968**, and for which location is identified by location ID **912**. From this data, the navigation source **356** can identify what data is requested, in step **1024**.

The requested data may then be extracted from the GIS **904**, as stored in data structure **954**. From this information **954**, the navigation source **356** can create the data structure **978** shown in FIG. **9**E. This data structure **978** may include the data requested in field **980** and be composed into signal **812** to be sent from the navigation source **356** to the vehicle **100**, in step **1028**.

A method **1110** for a vehicle **110** to collect data about a geographic location may be as shown in FIG. **11** in accordance with embodiments of the present disclosure. A general order for the steps of the method **1100** is shown in FIG. **11**. Generally, the method **1100** starts with a start operation **1104** and ends with operation **1124**. The method **1100** can include more or fewer steps or can arrange the order of the steps differently than those shown in FIG. **11**. The method **1100** can be executed as a set of computer-executable instructions executed by a computer system or processor and encoded or stored on a computer readable medium. In other configurations, the method **1100** may be executed by a series of components, circuits, gates, etc. created in a hardware device, such as a System of Chip (SOC), Application Specific Integrated Circuit (ASIC), and/r a Field Programmable Gate Array (FPGA). Hereinafter, the method **1100** shall be explained with reference to the systems, components, circuits, modules, software, data structures, signaling processes, models, environments, vehicles, etc. described in conjunction with FIGS. **1-10** and **12-13**.

The vehicle **100** may be driving along a route and reach a location, in step **1108**. The location can be any type of location along a route, such as an intersection **1312**, an off-ramp, an on-ramp **1316**, a parking garage, etc. When approaching and/or upon reaching this location, the vehicle sensors **304** then can start to observe what is occurring at the location, in step **1112**. For example, the one or more exterior sensors **304**, described in conjunction with FIG. **3**A, may start to collect data or observe the location. For example, a camera may record information about a traffic light **1304**, such as the cycle time for the green lights, the amount of time it takes to clear the intersection **1312**, how many cars clear an intersection **1312**, which cars are in which lanes of the intersection **1312**, etc.

This observed information may be gathered, in step **1112**, and stored as collected data, in step **1116**. In other words, the sensors **304** may communicate the observations to the location module/route engine **333**. The location module/route engine **333** can take the observed information and place that information, as metadata **932**, in data packet **908**. The location module/route engine **333** can also add in the other fields in data structure **908** and then send that data **908** to the navigation source **356**, in step **1120**, as data signal **804**.

A method **1200** for using metadata about a location to determine a best route or to change a route may be as shown in FIG. **12** in accordance with embodiments of the present disclosure. A general order for the steps of the method **1200** is shown in FIG. **12**. Generally, the method **1200** starts with a start operation **1204** and ends with operation **1240**. The method **1200** can include more or fewer steps or can arrange the order of the steps differently than those shown in FIG. **12**. The method **1200** can be executed as a set of computer-executable instructions executed by a computer system or processor and encoded or stored on a computer readable medium. In other configurations, the method **1200** may be executed by a series of components, circuits, gates, etc. created in a hardware device, such as a System of Chip (SOC), Application Specific Integrated Circuit (ASIC), and/r a Field Programmable Gate Array (FPGA). Hereinafter, the method **1200** shall be explained with reference to the systems, components, circuits, modules, software, data structures, signaling processes, models, environments, vehicles, etc. described in conjunction with FIGS. **1-11** and **13**.

Generally, current GPS systems do not determine or evaluate information about different geographic locations to determine routes. While these GPS systems may include traffic determinations in determining a best route, information about intersections, on-ramps, off-ramps, and other types of geographic locations, where a vehicle may need to make a maneuver, is generally not considered. As such, the vehicle **100** of the present disclosure can determine best routes or change routes based on several factors or metadata associated with the geographic locations requiring maneuvers that may be along one or more routes being considered by the location module/route engine **333**.

The location module/route engine **333** can receive a request to navigate to a location, in step **1208**. Here, a user may use a user interface, such as those interfaces **400** described in conjunction with FIG. **4**, to enter a location to which the vehicle **100** is to navigate. This location may then be sent to the location module/route engine **333** to determine the best possible routes, in step **1212**. The best possible routes can be any route that can maneuver the vehicle **100** from the current location, determined by receiving a signal through the GPS antennae receiver **331**, to the requested location. Based on these routes, there may be intersections or other locations along the route where a vehicle may encounter traffic lights, require a maneuver, or conduct some other action along that route. These different locations may then be compiled by the location module/route engine **333**.

The location module/route engine **333** then can send one or more request(s) for information about the locations along the routes, to the navigation source **356**, in step **1216**. The required information may be stored in the cloud in the GIS **904**. However, in some configurations, the location information, or at least a portion of it, may be stored in the maps database **335**. In some situations, however, the location module/route engine **333** sends a request **808** for at least one type of or one item of information through to the navigation source **356**, as request **808**. The request can include the data structure **964**, as described in conjunction with FIG. **9**D. This request **964** can include a data type **940** and requested information **968**. There may be several requests sent by the location module/route engine **333**.

In response to the request, the navigation source **356** can send location data **812** back to the location module/route engine **333**. Thus, signal **812** can be received by the communication system **350** of the vehicle and sent to the location module/route engine **333**. This location data can include data structure **978**, which compiles metadata **980** in response to the request for information. This metadata **980** can describe different characteristics of the geographical locations requested by the vehicle **100**. For example, the location data can include the cycle times for the lights, the expected traffic congestion in one or more lanes at one or more lights at that time of day, or other information provided by a stochastic model of the different locations. The location module/route engine **333** can receive the information, in step **1220**.

From the received information, the location module/route engine **333** can determine a best route, in step **1224**. Here,

the location module/route engine **333** can avoid lights that have longer cycle times or more congestion, can make corners or make changes in the route to avoid areas where there may be a delay along the route, or make other decisions. As such, the location module/route engine **333** can create a route that is the most time-efficient regardless of traffic or other types of delays that may occur over the route.

To ensure the quickest travel along the route, the module route engine **333** can communicate with the vehicle control system **348** to determine the best maneuvers around the route, in step **1228**. A maneuver may include anything from a lane change, a turn, acceleration, deceleration, etc. These maneuvers are also planned and may be instructions to the user through a user interface **400**, as described in FIG. **4**. In other configurations, the vehicle control system **348** can automatically or autonomously control the vehicle and execute the maneuvers provided by the location module/route engine **333**. The determination of maneuvers ensures that not only is the best route taken, but the best driving pattern for that route is also conducted. The route and the maneuvers may be sent by the location module/route engine **333** to the vehicle control subsystem **348**, in step **1232**. The vehicle control system **348** may then operate the vehicle in accordance with the route commands, in step **1236**. As such, the vehicle control system **348** can autonomously control a vehicle without driver input to travel along the most efficient, quickest route based on information about different geographical locations along that route. For example, the cycle time or information about traffic lights.

Optionally, the location module/route engine **333** can also receive data from sensors **304** in the interior of the vehicle, in step **1244**. This information about the interior of the vehicle can determine characteristics of the interior that can also change routes. For example, if there is a driver and a passenger in the car, the location module/route engine **333** can determine that a HOV lane may be taken. Thus, the location module/route engine **333** can determine if there are enough passengers within the vehicle (e.g. two or more occupants in the vehicle **100**) to determine if HOV lanes are a viable option for the route.

Based on this information, the location module/route engine **333** can send a request to navigation source **356** about information about HOV lanes along the route. Further, the location module/route engine **333** may also access information from a maps database **333** or other source of information about how good the vehicle driver is at moving onto and off of the HOV lanes. These different times and route considerations may then also be in determining the best route maneuvers to provide a more efficient driving experience. As such, the location module/route engine **333** can automatically consider the driving context or context of the interior of the vehicle in determining a best route.

A driving environment **1300** having locations that can include associated metadata may be as shown in FIG. **13** in accordance with embodiments of the present disclosure. The driving environment **1300** may include one or more locations, for example, intersection **1312**, HOV lane **1320**, etc. A location may be any physical area in the driving environment **1300** where a vehicle **100** can or must make a maneuver. A location can have metadata associated with it (e.g., traffic patterns based on day and time of day, lane configuration, etc.). The intersection **1300** may be associated with a traffic light **1304**. The traffic light **1304** may be associated with the intersection **1312** in the GIS **904** and may also have metadata associated therewith. For example, the metadata about the light can include a cycle time between lights, a length of time for a red light, yellow light, green light, how light parameters change based on the time of day or the day of the week, etc.

In the driving environment, the intersection **1312** can include two or more lanes, **1324***a*, **1324***b*, and/or **1324***c*. Each lane **1324** may also have a set of metadata. For example, metadata for the lane can describe the type of lane (right turn lane, left turn lane, straight lane, etc.), how long a turn signal is active for the turn lane, how many cars clear a lane during a green light, how many cars are in a lane at a particular day and/or time, etc.

Some lanes or parts of a street may have other characteristics. An HOV lane **1320** can have other metadata particular to the HOV lane. For example, metadata about the HOV lane can include how many vehicle occupants are required to use the HOV lane, hours when HOV lane is operation, hours when HOV occupancy requirements change, traffic in the HOV lane at particular times of day or days of the week, etc. Further, a vehicle **100** can also store information about the HOV lane (or other locations) that may be specific to the vehicle **100**. For example, the vehicle **100** may store information about how long the vehicle takes to merge onto and out of the HOV lane, time to accelerate at a stop light, time to make turn, etc. This vehicle-specific information and metadata about the locations can allow for the routing based on this information, as described herein.

Any of the steps, functions, and operations discussed herein can be performed continuously and automatically.

The exemplary systems and methods of this disclosure have been described in relation to vehicle systems and electric vehicles. However, to avoid unnecessarily obscuring the present disclosure, the preceding description omits a number of known structures and devices. This omission is not to be construed as a limitation of the scope of the claimed disclosure. Specific details are set forth to provide an understanding of the present disclosure. It should, however, be appreciated that the present disclosure may be practiced in a variety of ways beyond the specific detail set forth herein.

Furthermore, while the exemplary embodiments illustrated herein show the various components of the system collocated, certain components of the system can be located remotely, at distant portions of a distributed network, such as a LAN and/or the Internet, or within a dedicated system. Thus, it should be appreciated, that the components of the system can be combined into one or more devices, such as a server, communication device, or collocated on a particular node of a distributed network, such as an analog and/or digital telecommunications network, a packet-switched network, or a circuit-switched network. It will be appreciated from the preceding description, and for reasons of computational efficiency, that the components of the system can be arranged at any location within a distributed network of components without affecting the operation of the system.

Furthermore, it should be appreciated that the various links connecting the elements can be wired or wireless links, or any combination thereof, or any other known or later developed element(s) that is capable of supplying and/or communicating data to and from the connected elements. These wired or wireless links can also be secure links and may be capable of communicating encrypted information. Transmission media used as links, for example, can be any suitable carrier for electrical signals, including coaxial cables, copper wire, and fiber optics, and may take the form of acoustic or light waves, such as those generated during radio-wave and infra-red data communications.

While the flowcharts have been discussed and illustrated in relation to a particular sequence of events, it should be appreciated that changes, additions, and omissions to this

sequence can occur without materially affecting the operation of the disclosed embodiments, configuration, and aspects.

A number of variations and modifications of the disclosure can be used. It would be possible to provide for some features of the disclosure without providing others.

In yet another embodiment, the systems and methods of this disclosure can be implemented in conjunction with a special purpose computer, a programmed microprocessor or microcontroller and peripheral integrated circuit element(s), an ASIC or other integrated circuit, a digital signal processor, a hard-wired electronic or logic circuit such as discrete element circuit, a programmable logic device or gate array such as PLD, PLA, FPGA, PAL, special purpose computer, any comparable means, or the like. In general, any device(s) or means capable of implementing the methodology illustrated herein can be used to implement the various aspects of this disclosure. Exemplary hardware that can be used for the present disclosure includes computers, handheld devices, telephones (e.g., cellular, Internet enabled, digital, analog, hybrids, and others), and other hardware known in the art. Some of these devices include processors (e.g., a single or multiple microprocessors), memory, nonvolatile storage, input devices, and output devices. Furthermore, alternative software implementations including, but not limited to, distributed processing or component/object distributed processing, parallel processing, or virtual machine processing can also be constructed to implement the methods described herein.

In yet another embodiment, the disclosed methods may be readily implemented in conjunction with software using object or object-oriented software development environments that provide portable source code that can be used on a variety of computer or workstation platforms. Alternatively, the disclosed system may be implemented partially or fully in hardware using standard logic circuits or VLSI design. Whether software or hardware is used to implement the systems in accordance with this disclosure is dependent on the speed and/or efficiency requirements of the system, the particular function, and the particular software or hardware systems or microprocessor or microcomputer systems being utilized.

In yet another embodiment, the disclosed methods may be partially implemented in software that can be stored on a storage medium, executed on programmed general-purpose computer with the cooperation of a controller and memory, a special purpose computer, a microprocessor, or the like. In these instances, the systems and methods of this disclosure can be implemented as a program embedded on a personal computer such as an applet, JAVA® or CGI script, as a resource residing on a server or computer workstation, as a routine embedded in a dedicated measurement system, system component, or the like. The system can also be implemented by physically incorporating the system and/or method into a software and/or hardware system.

Although the present disclosure describes components and functions implemented in the embodiments with reference to particular standards and protocols, the disclosure is not limited to such standards and protocols. Other similar standards and protocols not mentioned herein are in existence and are considered to be included in the present disclosure. Moreover, the standards and protocols mentioned herein and other similar standards and protocols not mentioned herein are periodically superseded by faster or more effective equivalents having essentially the same functions. Such replacement standards and protocols having the same functions are considered equivalents included in the present disclosure.

The present disclosure, in various embodiments, configurations, and aspects, includes components, methods, processes, systems and/or apparatus substantially as depicted and described herein, including various embodiments, subcombinations, and subsets thereof. Those of skill in the art will understand how to make and use the systems and methods disclosed herein after understanding the present disclosure. The present disclosure, in various embodiments, configurations, and aspects, includes providing devices and processes in the absence of items not depicted and/or described herein or in various embodiments, configurations, or aspects hereof, including in the absence of such items as may have been used in previous devices or processes, e.g., for improving performance, achieving ease, and/or reducing cost of implementation.

The foregoing discussion of the disclosure has been presented for purposes of illustration and description. The foregoing is not intended to limit the disclosure to the form or forms disclosed herein. In the foregoing Detailed Description for example, various features of the disclosure are grouped together in one or more embodiments, configurations, or aspects for the purpose of streamlining the disclosure. The features of the embodiments, configurations, or aspects of the disclosure may be combined in alternate embodiments, configurations, or aspects other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the claimed disclosure requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment, configuration, or aspect. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate preferred embodiment of the disclosure.

Moreover, though the description of the disclosure has included description of one or more embodiments, configurations, or aspects and certain variations and modifications, other variations, combinations, and modifications are within the scope of the disclosure, e.g., as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights, which include alternative embodiments, configurations, or aspects to the extent permitted, including alternate, interchangeable and/or equivalent structures, functions, ranges, or steps to those claimed, whether or not such alternate, interchangeable and/or equivalent structures, functions, ranges, or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

Any one or more of the aspects/embodiments as substantially disclosed herein.

Any one or more of the aspects/embodiments as substantially disclosed herein optionally in combination with any one or more other aspects/embodiments as substantially disclosed herein.

One or means adapted to perform any one or more of the above aspects/embodiments as substantially disclosed herein.

The phrases "at least one," "one or more," "or," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B and C," "at least one of A, B, or C," "one or more of A, B, and C," "one or more of A, B, or C," "A, B, and/or C," and "A, B, or C" means A alone,

B alone, C alone, A and B together, A and C together, B and C together, or A, B and C together.

The term "a" or "an" entity refers to one or more of that entity. As such, the terms "a" (or "an"), "one or more," and "at least one" can be used interchangeably herein. It is also to be noted that the terms "comprising," "including," and "having" can be used interchangeably.

The term "automatic" and variations thereof, as used herein, refers to any process or operation, which is typically continuous or semi-continuous, done without material human input when the process or operation is performed. However, a process or operation can be automatic, even though performance of the process or operation uses material or immaterial human input, if the input is received before performance of the process or operation. Human input is deemed to be material if such input influences how the process or operation will be performed. Human input that consents to the performance of the process or operation is not deemed to be "material."

Aspects of the present disclosure may take the form of an embodiment that is entirely hardware, an embodiment that is entirely software (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 "circuit," "module," or "system." Any combination of one or more computer-readable medium(s) may be utilized. The computer-readable medium may be a computer-readable signal medium or a computer-readable storage medium.

A computer-readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer-readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer-readable storage medium may be any tangible medium that can contain or store a program for use by or in connection with an instruction execution system, apparatus, or device.

A computer-readable signal medium may include a propagated data signal with computer-readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electromagnetic, optical, or any suitable combination thereof. A computer-readable signal medium may be any computer-readable medium that is not a computer-readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device. Program code embodied on a computer-readable medium may be transmitted using any appropriate medium, including, but not limited to, wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

The terms "determine," "calculate," "compute," and variations thereof, as used herein, are used interchangeably and include any type of methodology, process, mathematical operation or technique.

The term "electric vehicle" (EV), also referred to herein as an electric drive vehicle, may use one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery or generator to convert fuel to electricity. An electric vehicle generally includes a rechargeable electricity storage system (RESS) (also called Full Electric Vehicles (FEV)). Power storage methods may include: chemical energy stored on the vehicle in on-board batteries (e.g., battery electric vehicle or BEV), on board kinetic energy storage (e.g., flywheels), and/or static energy (e.g., by on-board double-layer capacitors). Batteries, electric double-layer capacitors, and flywheel energy storage may be forms of rechargeable on-board electrical storage.

The term "hybrid electric vehicle" refers to a vehicle that may combine a conventional (usually fossil fuel-powered) powertrain with some form of electric propulsion. Most hybrid electric vehicles combine a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system (hybrid vehicle drivetrain). In parallel hybrids, the ICE and the electric motor are both connected to the mechanical transmission and can simultaneously transmit power to drive the wheels, usually through a conventional transmission. In series hybrids, only the electric motor drives the drivetrain, and a smaller ICE works as a generator to power the electric motor or to recharge the batteries. Power-split hybrids combine series and parallel characteristics. A full hybrid, sometimes also called a strong hybrid, is a vehicle that can run on just the engine, just the batteries, or a combination of both. A mid hybrid is a vehicle that cannot be driven solely on its electric motor, because the electric motor does not have enough power to propel the vehicle on its own.

The term "rechargeable electric vehicle" or "REV" refers to a vehicle with on board rechargeable energy storage, including electric vehicles and hybrid electric vehicles.

What is claimed is:

1. A vehicle, comprising:

a first set of sensors to sense an environment surrounding the vehicle and to gather information about a location in which the vehicle is within physical proximity;

a second set of sensors to sense an inside of the vehicle, wherein the second set of sensors determines a number of occupants currently in the vehicle;

a vehicle control system to operate the vehicle in a high or a full automation level;

wherein the vehicle control system and/or a remote route engine, based on information gathered by first sets of sensors of multiple different vehicles, a number of occupants currently in the vehicle, and a destination selected by a current occupant of the vehicle, selects at least one of (a) from among multiple possible routes from the location and the selected destination, a route from the location to the selected destination, the selected route, relative to the other possible routes, being optimal for high or full automation level operation of the vehicle and (b) a set of maneuvers for the selected route to be executed by the vehicle control system while operating in the high or full automation level along the selected route, the set of maneuvers being optimal relative to a selected characteristic for the route.

2. The vehicle of claim **1**, wherein the vehicle control system and/or a remote route engine selects option (a), wherein, when the vehicle control system operates the vehicle in a high or full automation level, the vehicle control system executes driving operations autonomously, the driving operations comprising steering, accelerating the vehicle, decelerating the vehicle, and braking the vehicle, wherein

the optimal set of maneuvers comprises a lane change, a turn, an acceleration, and a deceleration, wherein the optimal set of maneuvers are selected are predetermined, and wherein the optimal set of maneuvers define an optimal driving pattern for the selected route.

3. The vehicle of claim **2**, wherein the selected characteristic for the selected route is travel time and/or estimated time of arrival and wherein the gathered information comprises traffic light locations along the selected route, for each traffic light along the selected route, one or more of traffic light cycle time to change from a first light color to a second light color, and a duration of illumination of a selected traffic light color, and a plurality of a number of vehicles in each lane along a length of the selected route, a vehicle occupancy requirement for each lane along a length of the selected route, and a toll related rule for a length of the selected route.

4. The vehicle of claim **1**, wherein the vehicle control system and/or a remote route engine selects option (b), wherein when the vehicle operates in the high automation level, a human driver is separated from controlling all vehicle operations and wherein a processor of the vehicle:

identifies the location within the environment;

collects metadata associated with the location; and

sends the collected metadata to a navigation source, wherein the metadata includes a characteristic about the location.

5. The vehicle of claim **4**, wherein the location is an intersection, wherein the metadata comprises a number of lanes and, for each lane, a plurality of a type of lane, vehicle occupancy requirements to use the lane, how long a turn signal is active for each lane, and how many cars are in the lane, and a navigation source, in communication with the route engine, aggregates metadata associated with the location received in temporal proximity from multiple vehicles and wherein the metadata is used by the vehicle control system and/or route engine to select the optimal route and/or set of maneuvers.

6. The vehicle of claim **4**, wherein the collected metadata is associated with a traffic light at the intersection and a navigation source, in communication with the route engine, aggregates metadata associated with the location received in temporal proximity from multiple vehicles and wherein the metadata is used by the vehicle control system and/or route engine to select the optimal route and/or set of maneuvers and wherein the collected metadata is a cycle time for the traffic light and/or a length of a green light.

7. The vehicle of claim **4**, wherein the navigation source receives, from each of the multiple vehicles, collected metadata in association with a unique identifier of the corresponding vehicle, an identifier of the location associated with the collected metadata, a type of location of the identified location, a type of the metadata collected, and a date and timestamp of metadata collection and aggregates the collected metadata from the multiple vehicles by identified location.

8. The vehicle of claim **5**, wherein a first portion of the collected metadata is a time to clear the intersection, a number of vehicles that clear the intersection during a green light, a number of vehicles that turn during a turn signal, and/or a number of vehicles in a lane during at particular time of day and/or day and a second portion of the collected metadata is associated with the high occupancy vehicle (HOV) lane.

9. The vehicle of claim **8**, wherein the collected metadata is a number of occupants required to use the HOV lane, a number of occupants required during a particular time of day and/or day, an amount of traffic expected in an HOV lane based on a time of day or day of a week, and/or a time to travel in the HOV lane.

10. The vehicle of claim **9**, wherein the processor:

receives a request to determine a route to a second location;

requests information, about a third location on the route, from the navigation source;

receives second metadata associated with the third location; and

determines the route based on the second metadata about the third location, wherein the third location is a second traffic light, and wherein the route avoids the second traffic light.

11. A method, comprising:

sensing, by a first set of sensors of a selected vehicle, an environment surrounding the vehicle and gathering information about a location in which the vehicle is within physical proximity;

sensing, by a second set of sensors of the selected vehicle, an inside of the vehicle, wherein the second set of sensors determines a number of occupants currently in the vehicle;

operating, by a vehicle control system, the selected vehicle in a high or a full automation level; and

selecting, by the vehicle control system and/or a remote route engine, based on information gathered by first sets of sensors of multiple different vehicles, a number of occupants currently in the vehicle, and a destination selected by a current occupant of the vehicle, one or more of (a) from among multiple possible routes from the location and the selected destination, a route from the location to the selected destination, the selected route, relative to the other possible routes, being optimal for high or full automation level operation of the vehicle and (b) a set of maneuvers for the selected route to be executed by the vehicle control system while operating in the high or full automation level along the selected route, the set of maneuvers being optimal relative to a selected characteristic for the route.

12. The method of claim **11**, wherein the vehicle control system and/or a remote route engine selects option (b), wherein, when the vehicle control system operates the vehicle in a high or full automation level, the vehicle control system executes driving operations autonomously, the driving operations comprising steering, accelerating the vehicle, decelerating the vehicle, and braking the vehicle, wherein the optimal set of maneuvers comprises a lane change, a turn, an acceleration, and a deceleration, wherein the optimal set of maneuvers are selected are predetermined, and wherein the optimal set of maneuvers define an optimal driving pattern for the selected route.

13. The method of claim **12**, wherein the selected characteristic for the selected route is travel time and/or estimated time of arrival and wherein the gathered information comprises traffic light locations along the selected route, for each traffic light along the selected route, one or more of traffic light cycle time to change from a first light color to a second light color, and a duration of illumination of a selected traffic light color, and a plurality of a number of vehicles in each lane along a length of the selected route, a vehicle occupancy requirement for each lane along a length of the selected route, and a toll related rule for a length of the selected route.

14. The method of claim **11**, wherein the vehicle control system and/or a remote route engine selects option (a), wherein when the vehicle operates in the high automation

level, a human driver is separated from controlling all vehicle operations and wherein a processor of the vehicle:

identifies the location within the environment;

collects metadata associated with the location; and

sends the collected metadata to a navigation source, wherein the metadata includes a characteristic about the location.

15. The method of claim **14**, wherein the location is an intersection, wherein the metadata comprises a number of lanes and, for each lane, a plurality of a type of lane, vehicle occupancy requirements to use the lane, how long a turn signal is active for each lane, and how many cars are in the lane, and a navigation source, in communication with the route engine, aggregates metadata associated with the location received in temporal proximity from multiple vehicles and wherein the metadata is used by the vehicle control system and/or route engine to select the optimal route and/or set of maneuvers.

16. The method of claim **14**, wherein the collected metadata is associated with a traffic light at the intersection and a navigation source, in communication with the route engine, aggregates metadata associated with the location received in temporal proximity from multiple vehicles and wherein the metadata is used by the vehicle control system and/or route engine to select the optimal route and/or set of maneuvers and wherein the collected metadata is a cycle time for the traffic light and/or a length of a green light.

17. The method of claim **14**, wherein the navigation source receives, from each of the multiple vehicles, collected metadata in association with a unique identifier of the corresponding vehicle, an identifier of the location associated with the collected metadata, a type of location of the identified location, a type of the metadata collected, and a date and timestamp of metadata collection and aggregates the collected metadata from the multiple vehicles by identified location.

18. The method of claim **15**, wherein a first portion of the collected metadata is a time to clear the intersection, a number of vehicles that clear the intersection during a green light, a number of vehicles that turn during a turn signal, and/or a number of vehicles in a lane during at particular time of day and/or day and a second portion of the collected metadata is associated with the high occupancy vehicle (HOV) lane.

19. The method of claim **18**, wherein the collected metadata is a number of occupants required to use the HOV lane, a number of occupants required during a particular time of day and/or day, an amount of traffic expected in an HOV lane based on a time of day or day of a week, and/or a time to travel in the HOV lane.

20. The method of claim **19**, further comprising:

receiving a request to determine a route to a second location;

requesting information, about a third location on the route, from the navigation source;

receiving second metadata associated with the third location; and

determining the route based on the second metadata about the third location, wherein the third location is a second traffic light, and wherein the route avoids the second traffic light.

* * * * *