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(54) **Title:** DRIVING LANE CHANGE SUGGESTIONS

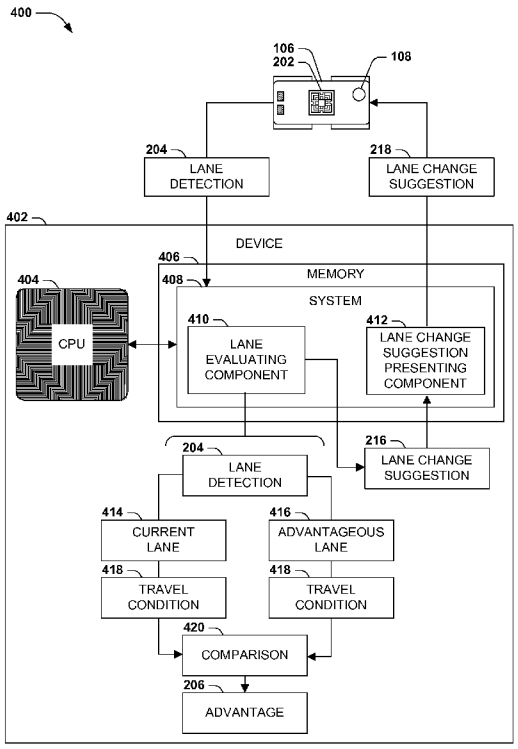


FIG. 4

(57) **Abstract:** Various types of vehicle navigation may facilitate a driver of a vehicle, including lane suggestions (e.g., a message indicating that the current route of the vehicle involves an exit from the rightmost lane of a causeway). A device may be configured to formulate lane change suggestions by detecting a current lane of the driver; comparing the travel conditions of the current lane with the travel conditions of other lanes of the causeway; and presenting a lane change suggestion of another lane presenting advantageous travel conditions as compared with the current lane. The inclusion of the current lane in the selection and formulation of lane change suggestions may improve the relevance of the suggestions (e.g., presenting lane change suggestions only if the travel condition of another lane is advantageous over the current lane, and presenting lane change suggestions relative to the current lane, e.g., "move two lanes to the left").

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# DRIVING LANE CHANGE SUGGESTIONS

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority to U.S. Provisional Patent Application No. 61/946,962 titled "DETERMINING HOV/HOT LANE TRAVEL TIMES", filed on March 3, 2014, which is hereby incorporated by reference.

## BACKGROUND

**[0002]** Within the field of computing, many scenarios involve a vehicle traveling on a causeway featuring at least two lanes of travel, such as an automobile traveling on a road with at least two lanes, or a watercraft traveling in a waterway with at least two lanes. In these scenarios, a device may provide a variety of location-based information to assist with navigation, such as a map, a depiction of an automatically or manually designated navigation route, and areas of obstacles such as traffic congestion. In particular, a navigation device may advise a driver of the vehicle as to lane suggestions; *e.g.* , a navigation device may indicate to the driver that a route involves an exit from a rightmost lane of the causeway, and may suggest that the driver occupy the right rightmost lane in order to follow the route.

## SUMMARY

**[0003]** This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key factors or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

**[0004]** While the presentation of regional (including navigation) information including suggestions for lane selection may be advantageous, such advantages are often limited in both the evaluation and the presentation of lane suggestions. As a first example, while pre-programmed lane suggestions may be helpful *(e.g.* , a routing database may indicate that a route between two points involves an exit from the rightmost lane), but additional suggestions may be identified based on the evaluation of travel conditions in each lane *(e.g.* , current traffic congestion in each lane, or the

presence of an obstacle such as a collision in a particular lane), and the comparison of the travel conditions of the respective lanes of the causeway. As a second example, the device that is configured to detect the lane currently occupied by the vehicle may also indicate to the driver whether another lane is more advantageous than the current lane *(e.g. ,* that the lane to the left of the vehicle is less congested than the current lane). Such detection and comparison may enable a selective presentation of lane change suggestions *(e.g. ,* not suggesting a lane to the driver if the current lane is optimal), and/or the presentation more contextually relevant lane change suggestions *(e.g. ,* rather than depicting or speaking "the second lane," which may be confusing in a multi-lane causeway, a device may advise the driver to "move two lanes to the left"), as well as refraining from presenting unhelpful lane suggestions *(e.g. ,* advising the driver that a particular lane is optimal when the driver is already occupying the lane, thus disadvantageously distracting the attention of the driver and possibly confusing the navigation).

[0005] In view of these and other advantages, the present disclosure provides a variety of techniques for selecting and presenting lane change suggestions. In an embodiment, a device may facilitate a driver of a vehicle operating on a causeway having at least two lanes by detecting, among the lanes of the causeway, a current lane that is occupied by the vehicle; for respective lanes, identifying a travel condition; identifying an advantageous lane of the causeway having a travel condition presenting an advantage over the travel condition of the current lane; and presenting to the driver a suggestion to transfer the vehicle to the advantageous lane. These and other variations of the techniques herein may enable the presentation of lane change suggestions, in a manner that is contextually related to the current lane of the user, in accordance with the techniques presented herein.

[0006] To the accomplishment of the foregoing and related ends, the following description and annexed drawings set forth certain illustrative aspects and implementations. These are indicative of but a few of the various ways in which one or more aspects may be employed. Other aspects, advantages, and novel features of the disclosure will become apparent from the following detailed description when considered in conjunction with the annexed drawings.

## DESCRIPTION OF THE DRAWINGS

**[0007]** Fig. 1 is an illustration of an example scenario featuring driving suggestions.

**[0008]** Fig. 2 is an illustration of an example scenario featuring a device facilitating a driver of a vehicle through the presentation of lane change suggestions that are contextually related to the current lane of the vehicle, in accordance with the techniques presented herein.

**[0009]** Fig. 3 is an illustration of an example method of facilitating a driver of a vehicle through the presentation of lane change suggestions in accordance with the techniques presented herein.

**[0010]** Fig. 4 is a component block diagram of an example system for facilitating a driver of a vehicle through the presentation of lane change suggestions in accordance with the techniques presented herein.

**[0011]** Fig. 5 is an illustration of an example scenario featuring the facilitation of drivers of vehicles through the presentation of lane change suggestions in accordance with the techniques presented herein.

**[0012]** Fig. 6 is an illustration of an example computer-readable medium comprising processor-executable instructions configured to embody one or more of the provisions set forth herein.

**[0013]** Fig. 7 is an illustration of an example scenario featuring a server configured to evaluate the travel conditions of respective lanes of a causeway, and to advise a set of drivers on a causeway of lane change suggestions, in accordance with the techniques presented herein.

**[0014]** Fig. 8 is an illustration of an example scenario featuring various techniques for configuring a device of a vehicle to detect a current lane, and/or the travel conditions of various lanes of a causeway, in accordance with the techniques presented herein.

**[0015]** Fig. 9 is an illustration of an example scenario featuring additional techniques for configuring a device of a vehicle to detect a current lane, and/or the travel conditions of various lanes of a causeway, in accordance with the techniques presented herein.

**[0016]** Fig. 10 is an illustration of an example scenario featuring additional techniques for configuring a device of a vehicle to detect a current lane, and/or the travel conditions of various lanes of a causeway, in accordance with the techniques presented herein.

**[0017]** Fig. 11 is an illustration of an example scenario featuring a collection of lane information by a travel service, in accordance with the techniques presented herein.

**[0018]** Fig. 12 is an illustration of an example scenario featuring the presentation of a lane change suggestion within a lane change suggestion window, in accordance with the techniques presented herein.

**[0019]** Fig. 13 is an illustration of an example scenario featuring a presentation of lane change suggestions on a window through which the driver observes the operation of the vehicle, in accordance with the techniques presented herein.

**[0020]** Fig. 14 illustrates an example computing environment wherein one or more of the provisions set forth herein may be implemented.

## DETAILED DESCRIPTION

**[0021]** The claimed subject matter is now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the claimed subject matter. It may be evident, however, that the claimed subject matter may be practiced without these specific details. In other instances, structures and devices are shown in block diagram form in order to facilitate describing the claimed subject matter.

### [0022] A. Introduction

**[0023]** In the field of vehicle computing, many types of devices and services may be provided that facilitate the driver of a vehicle, such as mapping, navigation, routing, and travel condition advisories. The computations of the devices may result in various types of suggestions that may facilitate the driver of the vehicle, and the

presentation of such suggestions to the driver *(e.g.* , as visual text, graphical icons, maps, photographic images, three-dimensional renderings, audio cues, spoken text, and/or haptic feedback) to signal the suggestions to the driver.

**[0024]** Fig. 1 presents an illustration of various scenarios in which suggestions may be presented to facilitate a driver 108 operating a vehicle 106 operating on a causeway 102 having at least two lanes 104. In a first example scenario 100, a detection of traffic congestion 110 ahead on the causeway 102 due to a collision 114 between vehicles 106 may result in a notification 112 to the driver of the upcoming traffic congestion 110, which may prompt the driver 108 to slow down or to select an alternate route. In a second example scenario 116, the driver 108 may request routing from an origin location to a destination location, and a navigation device or service may determine that a next direction along the route involves taking an exit ramp 118 that is accessible from the right lane 104 of the causeway 102. A notification 112 may therefore be presented to the driver 108 of the vehicle 106 to exit the causeway 102 from the right lane 104. In a third example scenario 120, an emergency vehicle 122 may be approaching a set of vehicles 106 on a causeway 102, and a device may present to a driver 108 of a vehicle 106 within the vehicle set a notification 112 alerting the driver 108 of the approaching emergency vehicle 102, which may enable the driver 108 to make room for the passage of the emergency vehicle 122.

**[0025]** **B. Presented Techniques**

**[0026]** While the notifications 112 presented in the example scenarios presented in Fig. 1 may facilitate the driver 106 of the vehicle 108, it may be appreciated that some disadvantages may arise within these scenarios. In the first example scenario 100, the notification 112 advises the driver 108 of approaching traffic congestion 110, but does not inform the driver 108 that the traffic congestion 110 is caused by a collision in a particular lane 104, and that moving the vehicle 106 to the other lane 104 may facilitate the driver 108 in quickly and safely avoiding the source of the traffic congestion 110. In the second example scenario 116, the notification 112 advises the driver 108 that the exit ramp 118 is accessible from the right lane 104, but such an instruction may be misinterpreted as an instruction to change lanes 104, possibly misdirecting the driver 108. Such confusion may particularly arise, *e.g.* ,

where the causeway 102 presents a large number of lanes 104 and the notification 112 attempts to describe a particular lane 104 *(e.g.* , instructing the driver 108 to occupy the third of six lanes 104). Alternatively or additionally, the instruction may be moot because the vehicle 106 already occupies the designated lane 104, and presenting the notification 112 may unhelpfully confuse or distract the driver 108. In the third example scenario 120, the notification 112 informs the driver 180 of the approaching emergency vehicle 122, but the driver 108 may not be able to see the lane occupied by the emergency vehicle 122, and may inadvertently block the passage of the emergency vehicle 122 *(e.g.* , by inducing the driver 108 to change lanes 104 into the path of the emergency vehicle 122). These and other scenarios illustrate the limitations of some notifications 112 presented to the driver 108 that do not utilize the context of the driver 108 and/or the vehicle 106.

**[0027]** Instead, in each of the example scenarios of Fig. 1, a device that is configured to determine, among the lanes 104 of a causeway 102, the current lane 104 of the vehicle 106 may further choose the notifications 112 in the context of the current lane 104 of the vehicle 106. Using the context of the current lane 104 of the vehicle 106 may enable the presentation not just of notifications 112, but of lane change suggestions - *i.e.* , suggestions that the driver 108 change the lane 104 of the vehicle 102 in order to achieve a particular type of advantage.

**[0028]** Fig. 2 presents illustrations of example scenarios where the detection of a current lane 104 of a vehicle 106 may enable a device 202 to facilitate a driver 108 in the operation of the vehicle 106 in the context of the current lane 104. In particular, rather than presenting notifications 112 outside of the context of the vehicle 108, these techniques involve presenting lane change suggestions 208 that encourage the user 108 to change the lane 104 of the vehicle 106 based on a perceived advantage 206 identified through a comparison of travel conditions of respective lanes 104. In a first example scenario 200, in addition to detecting imminent traffic congestion 110 caused by a collision 114, the device 202 may perform a lane determination 204 that the vehicle 106 is in a right lane 114, compare the travel condition of the current lane 104 with the travel condition of another lane, and may identify an advantage 206 from switching from the current lane 104 to an advantageous lane 104 *(e.g.* , determining that switching to the left lane may enable the vehicle 106 to avoid the traffic obstacle caused by the collision 114). The device 202 may therefore present a lane change

suggestion 208 indicating that the driver 108 should move to the left lane 104. In a second example scenario 210, two vehicles 106 may respectively occupy a left lane 104 and a right lane 104 of a causeway 102, and both may be approaching an exit ramp 118 included in the directions for a route of each vehicle 106. If a device 202 is configured in the manner of the second example scenario 116 of Fig. 1, a notification 112 might be presented to each vehicle 106, but may be confusing if not specified relative to the current lane 104 of the vehicle 106. Rather, each device 202 may perform a lane determination 204 of the current lane 104 of the vehicle 106. The first vehicle 106 occupying the left lane may determine that an advantage 206 exists for changing to the right lane 104 *(e.g.*, complying with the routing directions), and may therefore present a lane change suggestion 208 to change the lane 104 of the vehicle 106 to the right lane. However, the device 202 of the second vehicle 106 may determine that no advantage 206 exists for changing to the left lane 104, and may therefore refrain from presenting a lane change suggestion 208, *e.g.*, thus reducing the distraction and possible confusion of the driver 108 resulting form the presentation of a moot notification 112. In a third example scenario 212, a device 202 detecting an approaching emergency vehicle 122, and may perform a lane determination 204 of the current lane 104 for comparison with the lane 104 of the emergency vehicle 122. Determining that the vehicle 106 occupies the same lane 104 as the emergency vehicle 122, and that changing lanes 104 may lead to an advantage 206 by avoiding the path of the emergency vehicle 122, the device 106 may present a lane change suggestion 208 indicating that the driver 108 should change to the right lane 104 to enable passage of the emergency vehicle 122. These and other scenarios may demonstrate the value of presenting lane change suggestions 208 in order to facilitate a user 108 in the operation of a vehicle 106 in accordance with the techniques presented herein.

**[0029] C. Technical Effects**

**[0030]** The techniques presented herein may provide a variety of technical effects in the scenarios provided herein.

**[0031]** As a first such example, the techniques provided herein may enable a determination of the status of a causeway 102, such as traffic conditions of various

lanes of a road, based upon a collection of information about the lanes 104 of the causeway 102 from respective vehicles 108 traveling on the causeway 102. That is, while general traffic information about the causeway 102 may be derived from more generalized metrics such as the reported speeds of vehicles 108, such metrics may not provide a fully detailed account of the conditions of the respective lanes 104 of the causeway 102. For example, a discrepancy arising in a particular lane 104 of the causeway 102 as compared with the other lanes 104 of the causeway 102 may indicate the presence of an obstruction, such as traffic, a vehicular accident, or a pothole, which may otherwise be difficult to differentiate from a generalized traffic condition such as volume-induced congestion. Such indications may enable a determination of whether to advise the driver to transfer to a different lane 104, to maintain the present lane 104, or to detour to a different causeway 102 altogether.

**[0032]** As a second such example, the techniques provided herein may enable a more detailed evaluation of the conditions of the causeway, and therefore may provide more accurate determination of routing factors, such as an estimated travel duration and an estimated time of arrival. For example, if traffic congestion is detected along the route of the user, an estimated travel duration reported to the user may be updated to reflect a projected delay. The duration of the projected delay may be estimated based in part on whether the traffic congestion is confined to one of the lanes 104 of the causeway 102 and may therefore be avoidable, or whether the traffic congestion applies to all lanes 104 of the causeway 102. Additionally, the determination of the conditions of the lanes 104 of the causeway 102 may assist a navigation device with a determination of whether or not to re-route the user 102 through a different causeway 102 that may enable an avoidance of a travel delay affecting the current causeway 102 of the user. Moreover, such indications may enable a determination of the urgency of presenting the suggestion. For example, construction arising six miles ahead in the driver' s lane of a road may prompt no suggestion, or a more generalized suggestion, such as a change of route; construction arising in the driver' s lane on the road three miles ahead may prompt a suggestion to change lanes sometime in the next several minutes; and construction arising within the next mile may prompt an urgent recommendation to change lanes 104.

**[0033]** As a third such example, the techniques provided herein may enable more detailed notification of the lane change suggestion to the user 102. Such information

may be presented to the user 102 in a timely manner *(e.g.*, choosing an ideal moment to advise the user 102 to select a different lane 112), and/or may be based upon current or typical conditions for the respective lanes 104 of the causeway 102. For example, a user may be operating a vehicle 108 in a left lane 104 of the causeway 102, and may be embarking upon a route that involves a right turn from the right lane 104 two miles ahead. Based on the evaluation of the conditions of the lanes 104 of the causeway 102, a navigation device may decide whether to advise the user to switch to the right lane 104 as soon as possible *(e.g.*, because traffic is developing in the left lane 104), or to remain in the left lane 104 until the turn is imminent (e.g., because traffic is developing in the right lane 104). In this manner, the navigation device may advise the user in the navigation of the vehicle 108 in a manner that is informed by the current conditions of the lanes 104 of the causeway 102 in accordance with the techniques presented herein.

**[0034] D. Example Embodiments**

**[0035]** Fig. 3 presents a first example embodiment of the techniques presented herein, illustrated as an example method 300 of facilitating a driver 108 in the operation of a vehicle 106 on a causeway 102 having at least two lanes 104. The example method 300 may involve a device 202 having a processor, and may be implemented, *e.g.*, as a set of instructions stored in a memory component of a device *(e.g.*, a memory circuit, a platter of a hard disk drive, a solid-state memory component, or a magnetic or optical disc) that, when executed by the processor of the device, cause the device 202 to perform the techniques presented herein. The example method 300 begins at 302 and involves executing 304 the instructions on the processor. Specifically, the instructions cause the device 202 to detect 306, among the at least two lanes 104 of the causeway 102, a current lane 104 that is occupied by the vehicle 106. The instructions also cause the device 202 to, for respective lanes 104, identify 308 a travel condition. The instructions also cause the device 202 to identify 310 an advantageous lane 104 of the causeway 102 having a travel condition that presents an advantage 206 over the travel condition of the current lane 104. The instructions also cause the device 202 to present 312 to the driver 108 of the vehicle 106 a lane change suggestion 208 to transfer the vehicle 106 to the advantageous lane 104. In this manner, the example method 300 of Fig. 3 achieves the facilitation of the

operation of the vehicle 106 by the driver 108 by presenting lane change suggestions 208 relative to the current lane 104 of the vehicle 106, and so ends at 314.

**[0036]** Fig. 4 presents an illustration of an example scenario 400 featuring a second example embodiment of the techniques presented herein, illustrated as an example system 408 for facilitating a driver 108 in the operation of a vehicle 106. The example system 408 may be implemented, *e.g.,* on a device 402 having a processor 404 and a memory 406. Respective components of the example system 408 may be implemented, *e.g.,* as a set of instructions stored in the memory 406 of the device 402 and executable on the processor 404 of the device 402, such that the interoperation of the components causes the device 402 to operate according to the techniques presented herein. The example system 408 comprises a lane evaluating component 410, comprising instructions that, when executed on the processor 404, cause the device 402 to, while the vehicle 106 operates on a causeway 102 having at least two lanes 104, perform a lane detection 204 identifying, among the lanes 104 of the causeway 102, a current lane 414 that is occupied by the vehicle 106. The instructions of the lane detecting component 410 further cause the device 402 to, for respective lanes 104, identify a travel condition 416; and by performing a comparison 418 of the travel conditions 416 of the respective lanes 104, identify an advantageous lane 416 of the causeway 102 having a travel condition 418 presenting an advantage 206 over the travel condition 418 of the current lane 414. The example system 408 also comprises a lane change suggestion presenting component 412, comprising instructions that, when executed on a processor 404 of the device 402, cause the device 402 to present to the driver 108 a lane change suggestion 208 to transfer the vehicle 106 to the advantageous lane 416. The interoperation of the components of the example system 408 of Fig. 4 thereby achieves the selection and presentation of the lane change suggestion 208 and therefore facilitate the driver 108 in the operation of the vehicle 106.

**[0037]** Fig. 5 presents a third example embodiment of the techniques presented herein, illustrated as an example method 500 of facilitating drivers 108 of vehicles 106 operating on a causeway 102 having at least two lanes 104. The example method 500 may involve a device 202 having a processor, and may be implemented, *e.g.,* as a set of instructions stored in a memory component of a device *(e.g.,* a memory circuit, a platter of a hard disk drive, a solid-state memory component, or a magnetic or

optical disc) that, when executed by the processor of the device, cause the device 202 to perform the techniques presented herein. The example method 500 begins at 502 and involves executing 504 the instructions on the processor. Specifically, the instructions cause the device 202 to, for respective lanes 104 of the causeway 102, identify 506 a travel condition 418. The instructions also cause the device 202 to, among the lanes 104 of the causeway 102, identify 508 at least one advantageous lane 416 of the causeway 102 presenting an advantage 206 over the other lanes 104 of the causeway 102. The instructions also cause the device 202 to notify 510 the vehicles 104 of the at least one advantageous lane 416 of the causeway 102. In this manner, the example method 500 of Fig. 5 achieves the facilitation of the operation of the vehicles 106 operating on the causeway 102 by the drivers 108, and so ends at 512.

**[0038]** A fourth embodiment of the techniques presented herein involves a computer-readable medium comprising processor-executable instructions configured to apply the techniques presented herein. Such computer-readable media may include, *e.g.* , computer-readable storage media involving a tangible device, such as a memory semiconductor *(e.g.* , a semiconductor utilizing static random access memory (SRAM), dynamic random access memory (DRAM), and/or synchronous dynamic random access memory (SDRAM) technologies), a platter of a hard disk drive, a flash memory device, or a magnetic or optical disc (such as a CD-R, DVD-R, or floppy disc), encoding a set of computer-readable instructions that, when executed by a processor of a device, cause the device to implement the techniques presented herein. Such computer-readable media may also include (as a class of technologies that are distinct from computer-readable storage media) various types of communications media, such as a signal that may be propagated through various physical phenomena *(e.g.* , an electromagnetic signal, a sound wave signal, or an optical signal) and in various wired scenarios *(e.g.* , via an Ethernet or fiber optic cable) and/or wireless scenarios *(e.g.* , a wireless local area network (WLAN) such as WiFi, a personal area network (PAN) such as Bluetooth, or a cellular or radio network), and which encodes a set of computer-readable instructions that, when executed by a processor of a device, cause the device to implement the techniques presented herein.

**[0039]** An example computer-readable medium that may be devised in these ways is illustrated in Fig. 6, wherein the implementation 600 comprises a computer-readable medium 602 (e.g., a CD-R, DVD-R, or a platter of a hard disk drive), on

which is encoded computer-readable data 604. This computer-readable data 604 in turn comprises a set of computer instructions 606 configured to operate according to the principles set forth herein. In a first such embodiment, the processor-executable instructions 606 may be configured to, when executed by a processor 612 of a device 610, cause the device 610 to facilitate a driver 108 in the operation of a vehicle 106 through the presentation of lane change suggestions 208, such as the example method 300 of Fig. 3. In a second such embodiment, the processor-executable instructions 606 may be configured to implement a system for advising a driver 108 in the operation of a vehicle 106 through the presentation of lane change suggestions 208, such as the example system 408 of Fig. 4. In a third such embodiment, the processor-executable instructions 606 may be configured to, when executed by a processor 612 of a device 610, cause the device 610 to facilitate drivers 108 in the operation of vehicles 106 operating on a causeway 102 by advising devices 202 on board the vehicles 106 of advantageous lanes 418 of the causeway 102, such as the example method 500 of Fig. 5. Some embodiments of this computer-readable medium may comprise a nontransitory computer-readable storage medium *(e.g.* , a hard disk drive, an optical disc, or a flash memory device) that is configured to store processor-executable instructions configured in this manner. Many such computer-readable media may be devised by those of ordinary skill in the art that are configured to operate in accordance with the techniques presented herein.

**[0040] E. Variable Aspects**

**[0041]** The techniques discussed herein may be devised with variations in many aspects, and some variations may present additional advantages and/or reduce disadvantages with respect to other variations of these and other techniques. Moreover, some variations may be implemented in combination, and some combinations may feature additional advantages and/or reduced disadvantages through synergistic cooperation. The variations may be incorporated in various embodiments *(e.g.* , the example method 300 of Fig. 3; the example system 408 of Fig. 4; the example method 500 of Fig. 5; and the example computer-readable storage device 602 of Fig. 6) to confer individual and/or synergistic advantages upon such embodiments.

**[0042] El. Scenarios**

**[0043]** A first aspect that may vary among embodiments of these techniques relates to the scenarios wherein such techniques may be utilized.

**[0044]** As a first variation of this first aspect, the techniques presented herein may be used with many types of vehicles 106, including automobiles, motorcycles, trucks, buses, watercraft, aircraft, and spacecraft. Additionally, the techniques presented herein may be used to evaluate many types of multi-lane causeways 102, including walking and biking paths, roads, highways, railways, waterways, and airspaces. Such vehicles may be controlled by one or more humans, may be autonomous, or may involve a combination thereof, such as an autonomous automobile that can also be controlled by a human.

**[0045]** As a second variation of this first aspect, the techniques presented herein may be used to evaluate many types of advantages 206 in choosing an advantageous lane 416 over a current lane 414, such as a lane compliance with a route of the vehicle 106 *(e.g.* , a lane 104 that the vehicle 106 is to occupy to fulfill a route); a fuel economy promoting advantage; a cost economy promoting advantage *(e.g.* , toll avoidance); a travel time consistency promoting advantage *(e.g.* , a lane 104 providing a more consistent and/or predictable travel time); an emissions reducing advantage; a travel time reducing advantage; a driving safety promoting advantage; a vehicle proximity reducing advantage *(e.g.* , a less crowded lane 104); a traffic congestion avoiding advantage; a construction zone avoiding advantage; a causeway hazard avoiding advantage; and a smooth driving experience promoting advantage *(e.g.* , a lane 104 that provides a more consistent and/or comfortable driving route).

**[0046]** As a third variation of this first aspect, the techniques presented herein may be implemented in a variety of architectures. As a first example, the techniques presented herein may be implemented in a device 202 aboard a vehicle 106; by a first device 202 aboard a first vehicle 106 in communication with a second device 202 aboard a second vehicle 106 *(e.g.* , interoperating devices 202 that enable a collective determination of the advantageous lane 208 of the causeway 102); by a first device 202 aboard a vehicle 106 in communication with a second device 202 that is transiently or permanently stationary on or near the causeway 102; and/or by a first

device 202 aboard a vehicle 106 in communication with a remote device 202 that is accessible over a wireless communication protocol, such as a radio, cellular, or WiFi communications network. As one such example, the comparison 420 and determination of an advantageous lane 416 of the causeway 102 may be determined by a device 202 on behalf of a vehicle 106 storing the device 202; by a device 202 aboard a first vehicle 106 on behalf of a second vehicle 106; and/or by a remote device 202, such as a server providing a lane change suggestions service.

**[0047]** Fig. 7 presents an illustration of an example scenario 700 featuring an example architecture for implementing the techniques presented herein among a set of devices. In this example scenario 700, respective vehicles 106 comprise a device 202 that presents lane change suggestions 208 to the driver 108 of the vehicle 106 in accordance with the techniques presented herein. The information from one or more devices 202, optionally including the current lane 414 of each vehicle 106, is provided to a server 702 that is configured to perform an advantageous lane evaluation 702 *(e.g.* , the example method 500 of Fig. 5) to evaluate the travel conditions 418 of the lanes 104 and to identify an advantageous lane 208 *(e.g.* , determining that the right lane 104 of the causeway 102 advantageously avoids vehicles 106 involved in a collision 114 in the left lane 104). The server 702 transmits 708 *(e.g.* , through multicast or broadcast) the advantageous lane 208 over a communications network 706 *(e.g.* , a radio network, a cellular network, and/or a computer network such as the Internet) to the devices 202 on board the vehicles 106, which in turn present a lane change suggestion of the advantageous lane 208 to the drivers 108 of the vehicles 106. These and other variations may be included in various embodiments of the techniques presented herein.

**[0048] E2. Current Lane Detection**

**[0049]** A second aspect that may vary among embodiments of these techniques relates to the manner of detecting the current lane 414 of the vehicle 106. Many such techniques may be utilized for current lane detection, and some devices 202 may combine multiple techniques for added accuracy and/or verification.

**[0050]** Fig. 8 presents an illustration of an example scenario 800 featuring a causeway 102 with three lanes 104, wherein a vehicle 106 traveling in each lane 104

detects the current lane 414 using a different technique. As a first variation of this second aspect, a device 202 aboard a first vehicle 802 may comprise a lane identifier map 806 specifying, for respective locations 808, a lane 104 of the causeway 102 that is associated with the location 808. The device 202 may therefore detect the current lane 414 occupied by the first vehicle 802 by receiving from a geolocator device 804 *(e.g.* , a global positioning system (GPS) receiver) a current location 808 of the first vehicle 802, and determining the current lane 414 occupied by the first vehicle 802 according to the current location 808 and the lane identifier map 806.

**[0051]** As further illustrated in the example scenario 800 of Fig. 8, and as a second variation of this second aspect, a second vehicle 810 may comprise a camera 812 configured to capture an image 814 of the causeway 102, and may detect the current lane 414 occupied by the second vehicle 810 by evaluating the image 814 of the causeway 102. For example, visual indicators, such as lane lines and reflectors, may be automatically detected to determine the course of the causeway 102, the number of lanes 104 in the causeway 102, and the position of the vehicle 106 related thereto.

**[0052]** As further illustrated in the example scenario 800 of Fig. 8, and as a third variation of this second aspect, a third vehicle 816 may comprise a detector 818 that receives lane indications from a lane indicator service, where the lane indication 820 identifies the current lane 414 occupied by the third vehicle 816. As a first such example, respective lanes 104 may comprise a near-field transmitter device *(e.g.* , a radiofrequency identifier (RFID) tag) broadcasting an identification of the current lane 414 that is receivable by a near-field detector. As a second such example, a device in visual contact with the causeway 102 may determine the locations of respective vehicles 106 traveling thereupon, and may transmit to each vehicle 106 an identification of the current lane 414 of the vehicle 106.

**[0053]** Fig. 9 presents an illustration of an example scenario 700 featuring a fourth variation of this second aspect, wherein the lane 104 of the causeway 102 occupied by a vehicle 106 of the driver 108 is detected according to a proximity sensor 902 of the vehicle 106 that includes a variety of techniques, such as visual evaluation of camera data; ranging data gathered by sonar, radar, and/or lidar detection; and/or electronic communication with other vehicles 106 operating on the causeway 104. In this example scenario 900, the vehicle 106 is equipped with a

proximity sensor 902 that detects a proximity of the vehicle 106 with respect to other vehicles 106 operating on the causeway 102, such as a distance 904 between the vehicle 106 and another vehicle 106 that is ahead of and/or behind the vehicle 106 of the driver 108; the relative speeds of the vehicles 106 ahead of and/or behind the driver 108; and/or the rates of acceleration, braking, turning, and/or swerving by the driver 108 and the drivers 108 of the other vehicles 106. The proximity sensor 902 may also detect information about vehicles 106 in other lanes 104 of the causeway 102, such as the relative or absolute speeds of vehicles 106 in adjacent lanes 104, and/or whether or not such vehicles 106 are passing 906 and/or are being passed by the vehicle 106 of the driver 108. The device 202 may transmit 908 the information detected by the proximity sensor 902 to a travel service 912, *e.g.* , as a lane condition report 910 indicating the conditions of the respective lanes 104 of the causeway 102, optionally including information about other *(e.g.* , adjacent) lanes 104 of the causeway 102 and/or vehicles 106 utilizing such lanes 104, and/or information about the driver 108 and/or the other vehicles 106 traveling along the causeway 102, such as the travel duration between a first location and a second location of the causeway.

**[0054]** Fig. 10 presents an illustration of example scenarios 1000 featuring a fifth set of variations of this second aspect, wherein the lanes 104 and/or lane conditions of the respective lanes 104 of the causeway 102 are determined by a machine vision technique 1008. As a first example scenario 1002, a device 202 on board the vehicle 106 may include and/or be in communication with a forward-mounted camera 1002 that captures a forward-facing image 1004 *(e.g.* , through a windshield 1006 of the vehicle 106). A machine vision technique 1008 may be applied to the image 1004, such as a line detection algorithm that is configured to detect visible lines indicating the respective lanes 104 of the causeway 102. The position of the vehicle 106 on the causeway 102 may also be extrapolated by the machine vision technique 1008, and may therefore be utilized to determine the selected lane that is currently occupied by the vehicle 106. Alternatively or additionally, other machine vision techniques may be applied to the image 1004 to detect the lane conditions of the lanes 104 of the causeway 102, such as object recognition to detect and optionally count a number of visible vehicles 106 ahead of the vehicle 106 of the drive 108 in the respective lanes 104, and/or visual sizing machine vision techniques that estimate a distance of vehicles 106 ahead of the vehicle 106 of the driver 108. As a second example scenario

1010, a downward-facing camera 1002 may capture a downward-facing image 1004 of the causeway 102, and a line detection machine vision technique 1008 may be utilized to detect the visible lines indicating the lanes 104 of the causeway 102, and/or the selected lane that is currently occupied by the vehicle 106 of the driver 108. These and other techniques may be used to determine the current lane 104 of the vehicle 106 in accordance with the techniques presented herein.

**[0055] E3. Travel Condition Communication**

**[0056]** A third aspect that may vary among embodiments of these techniques involves the manner of transmitting travel conditions 418 of the lanes 104 of the causeway 102 to a travel service for evaluation, which may enable the travel service to notify the devices 202 on board various vehicles 104 of developments in the travel conditions 418 of the causeway 102.

**[0057]** Fig. 11 presents an illustration of an example scenario 1100 featuring a collection of travel reports about the lanes 104 of a causeway 102. In this example scenario 1100, a set of vehicles 106 is operated by a set of drivers 108 on a causeway 102, and information about the lanes 104 of the causeway 102 may be collected by a travel service 912 as a set of travel reports, including such information as the vehicles 106 in each lane 104; the travel duration of each vehicle 106 in each lane 104; and other information, such as lane costs during the observed period. Such travel reports may be collected from devices 202 on board the vehicles 106; from the drivers 108 of such vehicles 106; from toll booths 1102, traffic cameras 1104, or other forms of path monitoring; and/or from aerial surveillance, such as from a drone 1106. The travel reports may be transmitted to the travel service 912 in a variety of ways, including the internet 1108 and radio transmissions 1110, and may be stored by the travel service 912 to facilitate the evaluation of information about the respective lanes 104 of the causeway, including incidents that may enable a suggestion to a driver 108 operating a vehicle 106 on the causeway 102 to transition to a more advantageous lane. Many techniques may be utilized to detect and collect information about the lanes 104 of the causeway 102 in accordance with the techniques presented herein.

**[0058] E4. Travel Condition Evaluation and Advantageous Lane Selection**

**[0059]** A fourth aspect that may vary among embodiments of these techniques involves the evaluation of travel conditions 418 of the lanes 104 of the causeway 102, and the selection of an advantageous lane 208 among the lanes 104 of the causeway 102.

**[0060]** As a first variation of this fourth aspect, many types of travel conditions 418 may be evaluated to arrive at the determination of the advantageous lane 416, including past, current, and/or predicted traffic congestion 110; causeway surface evaluation; past, current, and/or predicted weather conditions; the preferences of the driver 108; and/or details of the vehicle 106 *(e.g.,* cargo weight).

**[0061]** As a second variation of this fourth aspect, many techniques may be utilized to detect the travel conditions 418 of respective lanes 104 of the causeway 102. As a first such example, the travel conditions of the lanes 104 of the causeway 102 may be evaluated within a distance threshold of a location of the vehicle 106 *(e.g.* , for one mile of the causeway 102 ahead of the vehicle 106, and/or for one mile of a current route of the vehicle 106).

**[0062]** As a third variation of this fourth aspect, a device 202 aboard a vehicle 106 may receive, from a causeway descriptor service, a current lane condition of the current lane 414, and a second lane condition of the advantageous lane 416 *(e.g.* , an accumulation of water and/or ice in each lane 104 of a road), and may determine the advantageous lane 416 by comparing the current lane condition and the second lane condition.

**[0063]** As a fourth variation of this fourth aspect, a device 202 aboard a vehicle 106 may evaluate a first image of the current lane 414 to detect a current lane available vehicle capacity of the current lane 414 *(e.g.* , counting the number of vehicles 106 occupying the current lane 414 ahead of the vehicle 106); evaluate a second image of a second lane 104 to detect a second lane available vehicle capacity of the second lane 104; and, upon determining that the second lane available vehicle capacity is higher than the current lane available vehicle capacity *(e.g.* , that the second lane 104 has fewer vehicles 106 than the current lane 414), identify the second lane as the advantageous lane 416.

**[0064]** As a fifth variation of this fourth aspect, a device 202 aboard a vehicle 106 may detect a first vehicle speed of at least one vehicle 106 in the current lane 414;

detect a second vehicle speed of at least one vehicle 106 in a second lane 104; and, upon determining that the second vehicle speed is higher than the current lane vehicle speed, identifying the second lane 104 as the advantageous lane 416.

**[0065]** As a sixth variation of this fourth aspect, a device 202 having a camera 812 may evaluate an image 814 of the current lane 414 to detect an obstruction affecting the current lane 414, and evaluate an image of the advantageous lane 416 to detect an avoidance of the obstruction by the advantageous lane *416 (e.g. ,* using machine vision techniques to detect an obstruction of the causeway 102, as well as a lane 104 providing a path around the obstruction).

**[0066]** As a seventh variation of this fourth aspect, a server 702 may determine the travel conditions 418 through the evaluation of information aggregated from a variety of vehicles 106. For example, the server 702 may receive, from at least one vehicle 106 operating on the causeway 102, at least one driving input involving at least one lane 104 of the causeway 102 *(e.g. ,* detecting that drivers 108 in a particular lane 104 are frequently braking or swerving), and may identify the travel condition 418 of the respective lanes 104 based on the driving inputs for the vehicles 106 operating in the lane 104.

**[0067]** As an eighth variation of this fourth aspect, the comparison 420 may be performed in view of many aspects of the travel conditions 418. As a first such example, respective travel conditions 418 may be associated with a weight indicating its significance in the comparison 420 *(e.g. ,* an improvement in driving safety may be considered more advantageous than a reduction in travel time duration). As a second such example, the preferences of respective drivers 108 may be considered in the comparison 420, such as the comparative significance and value of fuel economy and travel time to the driver 108, in identifying an advantageous lane 416 among the lanes 104 of the causeway 102.

**[0068]** As a ninth variation of this fourth aspect, a device 202 aboard a vehicle 106 may also notify the driver 108 of the advantage 206 conferred by the advantageous lane 416 as part of the lane change suggestion 208, and/or may provide alternative lane change suggestions 208 respectively presenting an advantage 206 *(e.g. ,* a first advantageous lane 416 providing a fuel economy advantage 206, and a second advantageous lane 416 providing a travel time reducing advantage 206).

**[0069]** As a tenth variation of this fourth aspect, some lanes 104 of a causeway 102 may only be utilized under certain conditions. As a first such example, respective lanes 104 may have an occupancy minimum *(e.g.* , a high occupancy vehicle ("HOV") lane that may only be utilized legally by vehicles 104 having at least a minimum number of passengers). A device 202 may determine a current occupancy of the vehicle 106 *(e.g.* , by detecting and evaluating symbols painted on the lanes 104 of the causeway 102, and/or signs positioned near the causeway 102), and may select a lane 104 as an advantageous lane 416 only if the current occupancy of the vehicle satisfies the occupancy minimum of the lane 104. As a second such example, a toll lane may be usable only in exchange for paying a toll *(e.g.* , signing up to an automated toll-paying service), and a device 202 may select the lane 104 as an advantageous lane 416 only if the toll may be paid by the vehicle 106 and/or the driver 108. These and other techniques may be utilized to evaluate the travel conditions 418 of the lanes 104 of the causeway 102 and to select the advantageous lane 416 in accordance with the techniques presented herein.

**[0070] E4. Presenting Lane Change Suggestions**

**[0071]** A fifth aspect that may vary among embodiments of the techniques presented herein relates to the manner of presenting lane change suggestions 208 to a driver 108 of a vehicle 106.

**[0072]** As a first variation of this fifth aspect, the lane change suggestion 208 may be presented to the driver 108 through various communications modalities, such as a visual text message; a visual symbol presented on a display; a map or photographic image; an audio cue, such as a spoken message; or through haptic feedback.

**[0073]** Fig. 12 presents an illustration of an example scenario 1200 featuring a second variation of this fifth aspect, wherein a device 202 aboard a vehicle 106 may determine a suggestion window within which the vehicle 106 is safely transferable to the advantageous lane 416, and present the lane change suggestion 208 of the advantageous lane 416 to the driver 108 only within the suggestion window. For example, the advantageous lane 416 may comprise a right lane 104 of a causeway 102 having the advantage 206 of easier access to an exit ramp 118. It may be desirable to present the lane change suggestion 208 in advance of an exit location 1202 where the

driver 108 follows the exit lane 118. However, at a current location 1204, between the current lane 414 and the advantageous lane 416, a set of pylons 1206 may exist that impose a barrier between the lanes 104, and presenting the lane change suggestion 208 to the driver 108 at the current location 1204 may jeopardize the safety of the vehicle 106 and the driver 108. Instead, the device 202 aboard the vehicle 108 may select a lane change suggestion location 1208 that is past the set of pylons 1206, and may present the lane change suggestion 208 upon detecting the vehicle 106 arriving at the lane change suggestion location 1208. As a related variation, where the causeway 102 has at least one intervening lane 104 that is between the current lane 414 and the advantageous lane 416, the lane change suggestion 208 may be presented to the driver 108 only while the vehicle 106 is safely transferable across the at least one intervening lane *(e.g.* , while no other vehicles 106 are present in the intervening lane).

**[0074]** As a third variation of this fifth aspect, in some scenarios, the advantageous lane 416 may comprise the current lane 414 that is currently occupied by the vehicle 106, and the lane change suggestion 208. As a first such example, in such circumstances, the device 202 may refrain from presenting the lane change suggestion 208 *(e.g.* , not presenting any notification to the driver 108 when the current lane 414 is the advantageous lane 416). As a second such example, in such circumstances, upon detecting an intent of the driver 108 to transfer to a second lane 104 of the causeway 102, a device 202 may present to the driver 108 a lane change suggestion 208 comprising a suggestion to maintain the current lane 414 instead of transitioning to the second lane.

**[0075]** As a fourth variation of this fifth aspect, a device 202 may identify the advantageous lane 416 in various ways. As a first such example, the device 202 may describe the advantageous lane 416 relative to the current lane *414 (e.g.* , "move one lane to the right"), or relative to the causeway 102 *(e.g.* , "move to the rightmost lane"). As a second such example, a device 202 may present to the driver 108 an explanation of the advantage 206 of the advantageous lane 416 compared with the current lane 414 *(e.g.* , "move one lane to the right to avoid an accident in this lane").

**[0076]** Fig. 13 presents an illustration of an example scenario 1300 featuring a third such example of this fourth variation of this fifth aspect, wherein the driver 108 operates the 106 while viewing the causeway 102 through a window 1302, such as a front windshield of the vehicle 106, or eyewear, such as goggles or glasses, upon

which visual cues may be depicted for the driver 108. In such scenarios, a device 202 (such as a controller operating a pair of eyewear, or a display component embedded in a windshield of the vehicle 106) may display the lane change 208 on the window 1302. Moreover, in some embodiments, a device 202 may position the lane change suggestion 208 on the window 1302 to visually indicate the advantageous lane 416 *(e.g.* , overlaying a visual marker 1304 or shading indicating the advantageous lane 416, and/or a pointer 1306 indicating the advantageous lane 416). These and other variations in the presentation of the lane change suggestions 208 may be included in variations of the techniques presented herein.

**[0077] F. Computing Environment**

**[0078]** Fig. 14 and the following discussion provide a brief, general description of a suitable computing environment to implement embodiments of one or more of the provisions set forth herein. The operating environment of Fig. 14 is only one example of a suitable operating environment and is not intended to suggest any limitation as to the scope of use or functionality of the operating environment. Example computing devices include, but are not limited to, personal computers, server computers, hand-held or laptop devices, mobile devices (such as mobile phones, Personal Digital Assistants (PDAs), media players, and the like), multiprocessor systems, consumer electronics, mini computers, mainframe computers, distributed computing environments that include any of the above systems or devices, and the like.

**[0079]** Although not required, embodiments are described in the general context of "computer readable instructions" being executed by one or more computing devices. Computer readable instructions may be distributed via computer readable media (discussed below). Computer readable instructions may be implemented as program modules, such as functions, objects, Application Programming Interfaces (APIs), data structures, and the like, that perform particular tasks or implement particular abstract data types. Typically, the functionality of the computer readable instructions may be combined or distributed as desired in various environments.

**[0080]** Fig. 14 illustrates an example of a system 1400 comprising a computing device 1402 configured to implement one or more embodiments provided herein. In one configuration, computing device 1402 includes at least one processing unit 1406

and memory 1408. Depending on the exact configuration and type of computing device, memory 1408 may be volatile (such as RAM, for example), non-volatile (such as ROM, flash memory, etc., for example) or some combination of the two. This configuration is illustrated in Fig. 14 by dashed line 1404.

**[0081]** In other embodiments, device 1402 may include additional features and/or functionality. For example, device 1402 may also include additional storage (e.g., removable and/or non-removable) including, but not limited to, magnetic storage, optical storage, and the like. Such additional storage is illustrated in Fig. 14 by storage 1410. In one embodiment, computer readable instructions to implement one or more embodiments provided herein may be in storage 1410. Storage 1410 may also store other computer readable instructions to implement an operating system, an application program, and the like. Computer readable instructions may be loaded in memory 1408 for execution by processing unit 1406, for example.

**[0082]** The term "computer readable media" as used herein includes computer storage media. Computer storage media includes volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions or other data. Memory 1408 and storage 1410 are examples of computer storage media. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, Digital Versatile Disks (DVDs) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by device 1402. Any such computer storage media may be part of device 1402.

**[0083]** Device 1402 may also include communication connection(s) 1416 that allows device 1402 to communicate with other devices. Communication connection(s) 1416 may include, but is not limited to, a modem, a Network Interface Card (NIC), an integrated network interface, a radio frequency transmitter/receiver, an infrared port, a USB connection, or other interfaces for connecting computing device 1402 to other computing devices. Communication connection(s) 1416 may include a wired connection or a wireless connection. Communication connection(s) 1416 may transmit and/or receive communication media.

**[0084]** The term "computer readable media" may include communication media. Communication media typically embodies computer readable instructions or other data in a "modulated data signal" such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" may include a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal.

**[0085]** Device 1402 may include input device(s) 1414 such as keyboard, mouse, pen, voice input device, touch input device, infrared cameras, video input devices, and/or any other input device. Output device(s) 1412 such as one or more displays, speakers, printers, and/or any other output device may also be included in device 1402. Input device(s) 1414 and output device(s) 1412 may be connected to device 1402 via a wired connection, wireless connection, or any combination thereof. In one embodiment, an input device or an output device from another computing device may be used as input device(s) 1414 or output device(s) 1412 for computing device 1402.

**[0086]** Components of computing device 1402 may be connected by various interconnects, such as a bus. Such interconnects may include a Peripheral Component Interconnect (PCI), such as PCI Express, a Universal Serial Bus (USB), firewire (IEEE 1394), an optical bus structure, and the like. In another embodiment, components of computing device 1402 may be interconnected by a network. For example, memory 1408 may be comprised of multiple physical memory units located in different physical locations interconnected by a network.

**[0087]** Those skilled in the art will realize that storage devices utilized to store computer readable instructions may be distributed across a network. For example, a computing device 1420 accessible via network 1418 may store computer readable instructions to implement one or more embodiments provided herein. Computing device 1402 may access computing device 1420 and download a part or all of the computer readable instructions for execution. Alternatively, computing device 1402 may download pieces of the computer readable instructions, as needed, or some instructions may be executed at computing device 1402 and some at computing device 1420.

**[0088] G. Usage of Terms**

**[0089]** Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

**[0090]** As used in this application, the terms "component," "module," "system", "interface", and the like are generally intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a controller and the controller can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers.

**[0091]** Furthermore, the claimed subject matter may be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computer to implement the disclosed subject matter. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device, carrier, or media. Of course, those skilled in the art will recognize many modifications may be made to this configuration without departing from the scope or spirit of the claimed subject matter.

**[0092]** Various operations of embodiments are provided herein. In one embodiment, one or more of the operations described may constitute computer readable instructions stored on one or more computer readable media, which if executed by a computing device, will cause the computing device to perform the operations described. The order in which some or all of the operations are described should not be construed as to imply that these operations are necessarily order dependent. Alternative ordering will be appreciated by one skilled in the art having the benefit of this description. Further, it will be understood that not all operations are necessarily present in each embodiment provided herein.

[0093] Moreover, the word "example" is used herein to mean serving as an example, instance, or illustration. Any aspect or design described herein as "example" is not necessarily to be construed as advantageous over other aspects or designs. Rather, use of the word example is intended to present concepts in a concrete fashion. As used in this application, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or". That is, unless specified otherwise, or clear from context, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then "X employs A or B" is satisfied under any of the foregoing instances. In addition, the articles "a" and "an" as used in this application and the appended claims may generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form.

[0094] Also, although the disclosure has been shown and described with respect to one or more implementations, equivalent alterations and modifications will occur to others skilled in the art based upon a reading and understanding of this specification and the annexed drawings. The disclosure includes all such modifications and alterations and is limited only by the scope of the following claims. In particular regard to the various functions performed by the above described components (e.g., elements, resources, etc.), the terms used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component *(e.g.* , that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated example implementations of the disclosure. In addition, while a particular feature of the disclosure may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application. Furthermore, to the extent that the terms "includes", "having", "has", "with", or variants thereof are used in either the detailed description or the claims, such terms are intended to be inclusive in a manner similar to the term "comprising."

What is claimed is:

1. A method of facilitating a driver of a vehicle, the method involving a device having a processor and comprising:

executing on the processor instructions configured to, while the vehicle operates on a causeway having at least two lanes:

detect, among the lanes of the causeway, a current lane that is occupied by the vehicle;

for respective lanes, identify a travel condition;

identify an advantageous lane of the causeway having a travel condition presenting an advantage over the travel condition of the current lane; and

present to the driver a lane change suggestion to transfer the vehicle to the advantageous lane.

2. The method of claim 1, the advantage selected from an advantage set comprising:

a lane compliance with a route of the vehicle;

a fuel economy promoting advantage;

a cost economy promoting advantage;

a travel time consistency promoting advantage;

an emissions reducing advantage;

a travel time reducing advantage;

a driving safety promoting advantage;

a vehicle proximity reducing advantage;

a traffic congestion avoiding advantage;

a construction zone avoiding advantage;

a causeway hazard avoiding advantage; and

a smooth driving experience promoting advantage.

3. The method of claim 1:

the device comprising a lane identifier map specifying, for respective locations, a lane associated with the location; and

detecting the current lane occupied by the vehicle further comprising:

receiving from a geolocator device a current location of the vehicle; and

determining the current lane occupied by the vehicle according to the current location and the lane identifier map.

4. The method of claim 1, detecting the current lane occupied by the vehicle further comprising: evaluating an image of the causeway to determine the current lane occupied by the vehicle.

5. The method of claim 1, detecting the current lane occupied by the vehicle further comprising: receiving from a lane identifier service a lane indication identifying, among the lanes of the causeway, the current lane occupied by the vehicle.

6. The method of claim 1, identifying the travel conditions comprising: identifying the travel conditions of the lanes of the causeway within a distance threshold of a location of the vehicle.

7. The method of claim 1:

identifying the travel conditions of respective lanes further comprising: receiving from a causeway descriptor service:

a current lane condition of the current lane, and

a second lane condition of the advantageous lane; and

determining the advantageous lane further comprising: determining the advantageous lane by comparing the current lane condition and the second lane condition.

8. The method of claim 1:

identifying the travel conditions of respective lanes further comprising:

evaluating a first image of the current lane to detect a current lane available vehicle capacity;

evaluating a second image of a second lane to detect a second lane available vehicle capacity; and

identifying the advantageous lane further comprising: upon determining that the second lane available vehicle capacity is higher than the current lane available vehicle capacity, identifying the second lane as the advantageous lane.

9. The method of claim 1:

identifying the travel conditions of respective lanes further comprising:

detecting a first vehicle speed of at least one vehicle in the current lane;

detecting a second vehicle speed of at least one vehicle in a second lane; and

identifying the advantageous lane further comprising: upon determining that the second vehicle speed is higher than the first vehicle speed, identifying the second lane as the advantageous lane.

10. The method of claim 1, identifying the travel conditions of respective lanes further comprising:

evaluating an image of the current lane to detect an obstruction affecting the current lane; and

evaluating an image of the advantageous lane to detect an avoidance of the obstruction by the advantageous lane.

11. The method of claim 1:

the advantageous lane having an occupancy minimum; and

identifying the advantageous lane further comprising: determining a current occupancy of the vehicle; and

presenting the lane change suggestion to the driver further comprising: presenting the lane change suggestion of the advantageous lane to the driver only if the current occupancy of the vehicle satisfies the occupancy minimum.

12. The method of claim 1:

the instructions further configured to determine a lane change suggestion window within which the vehicle is safely transferable to the advantageous lane; and

presenting the lane change suggestion to the driver further comprising: presenting the lane change suggestion of the advantageous lane to the driver only within the suggestion window.

13. The method of claim 1:

the causeway having at least one intervening lane between the current lane and the advantageous lane; and

presenting the lane change suggestion to the driver only while the vehicle is safely transferable across the at least one intervening lane.

14. The method of claim 1:

the advantageous lane comprising a current lane that is currently occupied by the vehicle; and

presenting the lane change suggestion further comprising: upon detecting an intent of the driver to transfer to a second lane of the causeway, presenting to the driver a lane change suggestion to maintain the current lane instead of transitioning to the second lane.

15. The method of claim 1, presenting the suggestion further comprising: presenting to the driver an explanation of the advantage of the advantageous lane compared with the current lane.

16. The method of claim 1:

the driver operating the vehicle while viewing the causeway through a window; and

presenting the lane change suggestion to the driver further comprising: displaying the lane change suggestion on the window.

17. The method of claim 16, displaying the lane change suggestion on the window further comprising: positioning the lane change suggestion on the window to visually indicate the advantageous lane.

18. A system for facilitating a driver of a vehicle, the system involving a device having a processor and comprising:

a lane evaluating component comprising instructions that, when executed on the processor, cause the device to, while the vehicle operates on a causeway having at least two lanes:

detect, among the lanes of the causeway, a current lane that is occupied by the vehicle;

for respective lanes, identify a travel condition;

identify an advantageous lane of the causeway having a travel condition having an advantage over the travel condition of the current lane; and

a lane change suggestion presenting component comprising instructions that, when executed on the processor, cause the device to present to the driver a lane change suggestion to transfer the vehicle to the advantageous lane.

19. A method of facilitating drivers of vehicles operating on a causeway having at least two lanes, the method involving a device having a processor and comprising:

executing on the processor instructions configured to:

for respective lanes, identify a travel condition;

among the lanes, identify at least one advantageous lane of the causeway; and

notify the vehicles of the at least one advantageous lane of the causeway.

20. The method of claim 19, identifying the travel conditions of respective lanes comprising:

receiving from at least one vehicle operating on the causeway at least one driving input involving at least one lane of the causeway; and

for respective lanes, identify a travel condition based on the driving inputs for the lane.

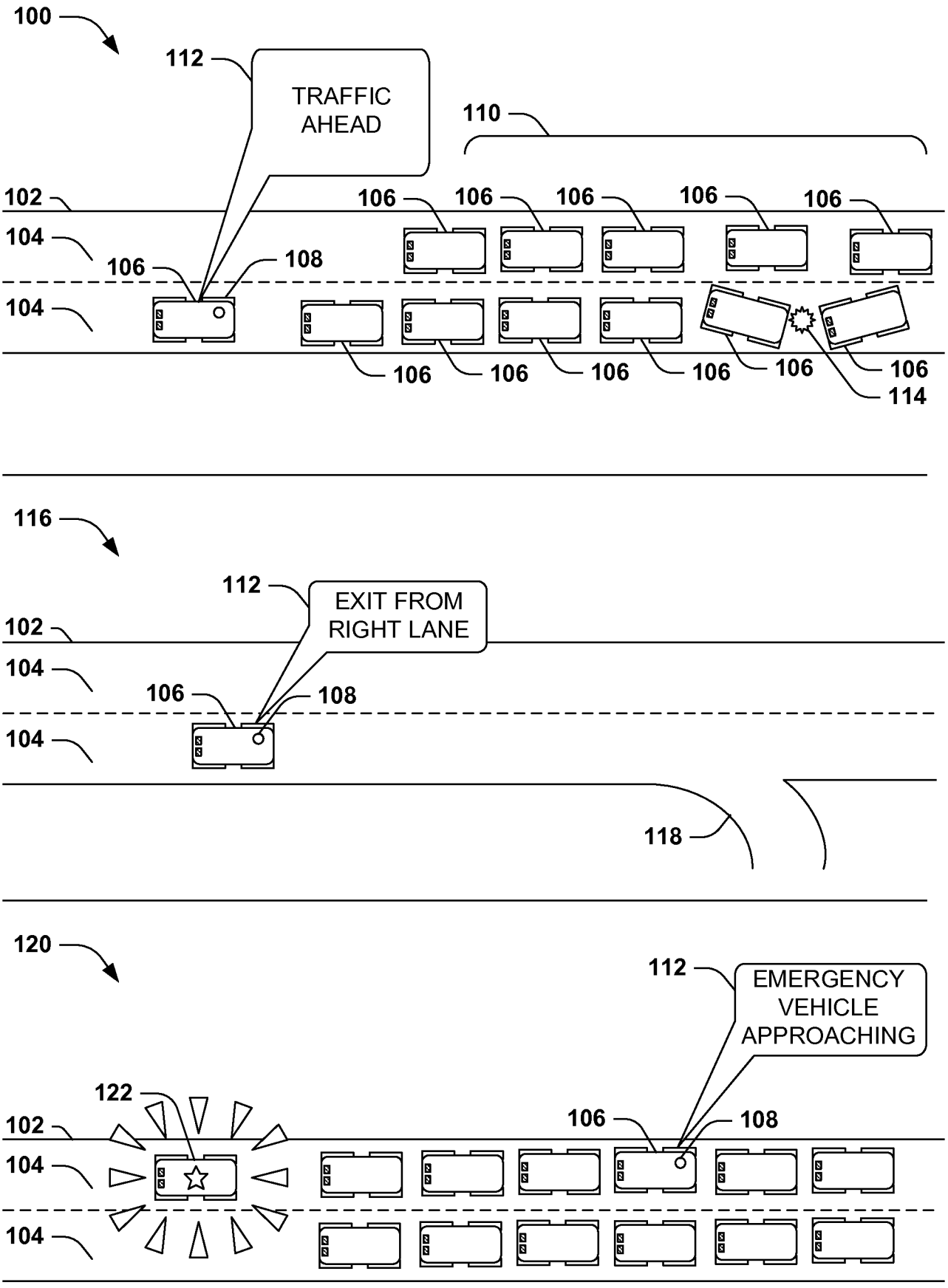

100
112
TRAFFIC AHEAD
110
102
104
106
108
114
116
EXIT FROM RIGHT LANE
118
120
EMERGENCY VEHICLE APPROACHING
122

FIG. 1

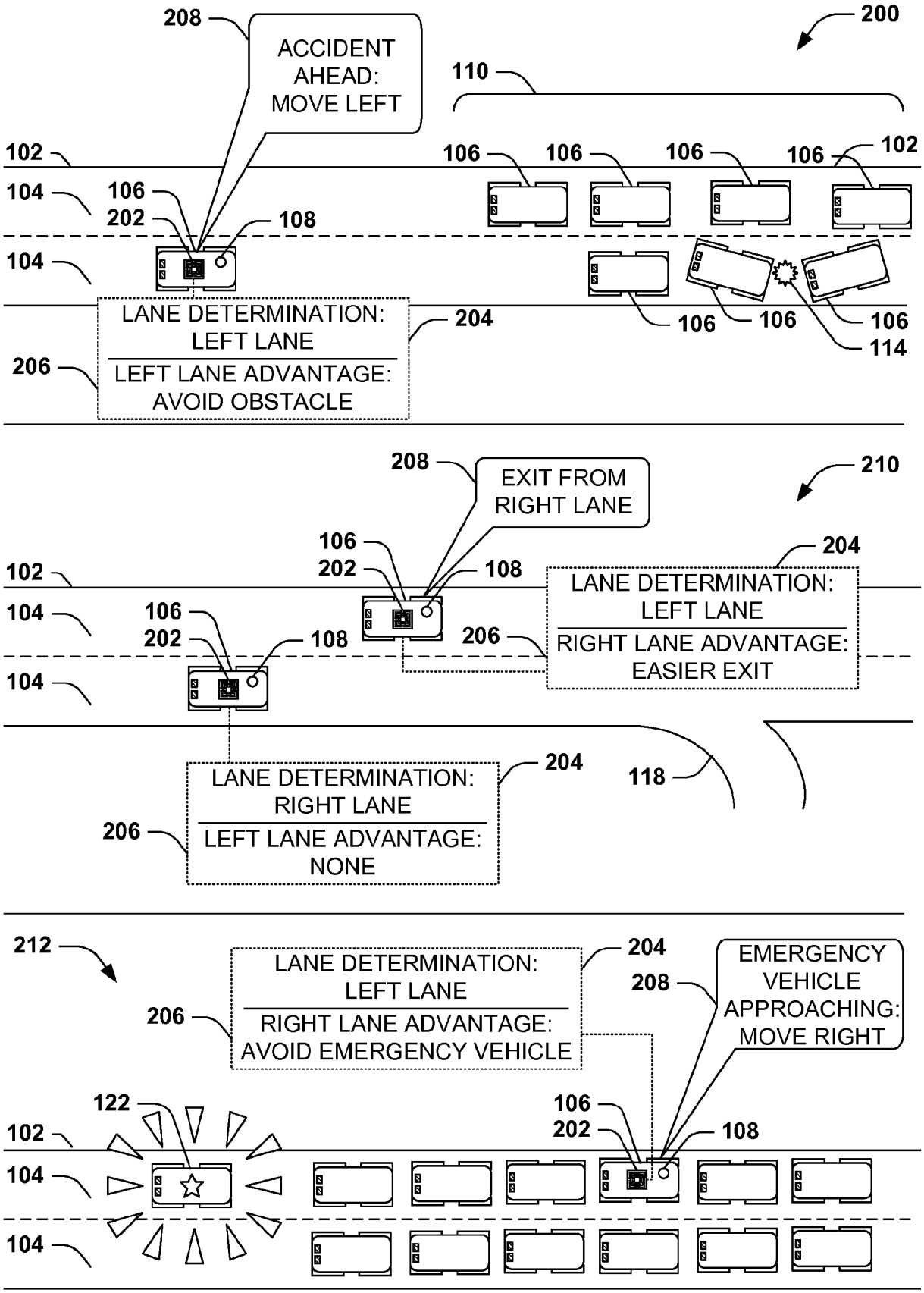

208
ACCIDENT AHEAD: MOVE LEFT
200
110
102
106
106
106
106
102
104
106
202
108
104
LANE DETERMINATION: LEFT LANE
LEFT LANE ADVANTAGE: AVOID OBSTACLE
204
206
106
106
106
114
208
EXIT FROM RIGHT LANE
210
106
202
108
204
102
104
106
202
108
206
LANE DETERMINATION: LEFT LANE
RIGHT LANE ADVANTAGE: EASIER EXIT
104
LANE DETERMINATION: RIGHT LANE
LEFT LANE ADVANTAGE: NONE
204
206
118
212
LANE DETERMINATION: LEFT LANE
RIGHT LANE ADVANTAGE: AVOID EMERGENCY VEHICLE
204
206
208
EMERGENCY VEHICLE APPROACHING: MOVE RIGHT
122
106
202
108
102
104
104

FIG. 2

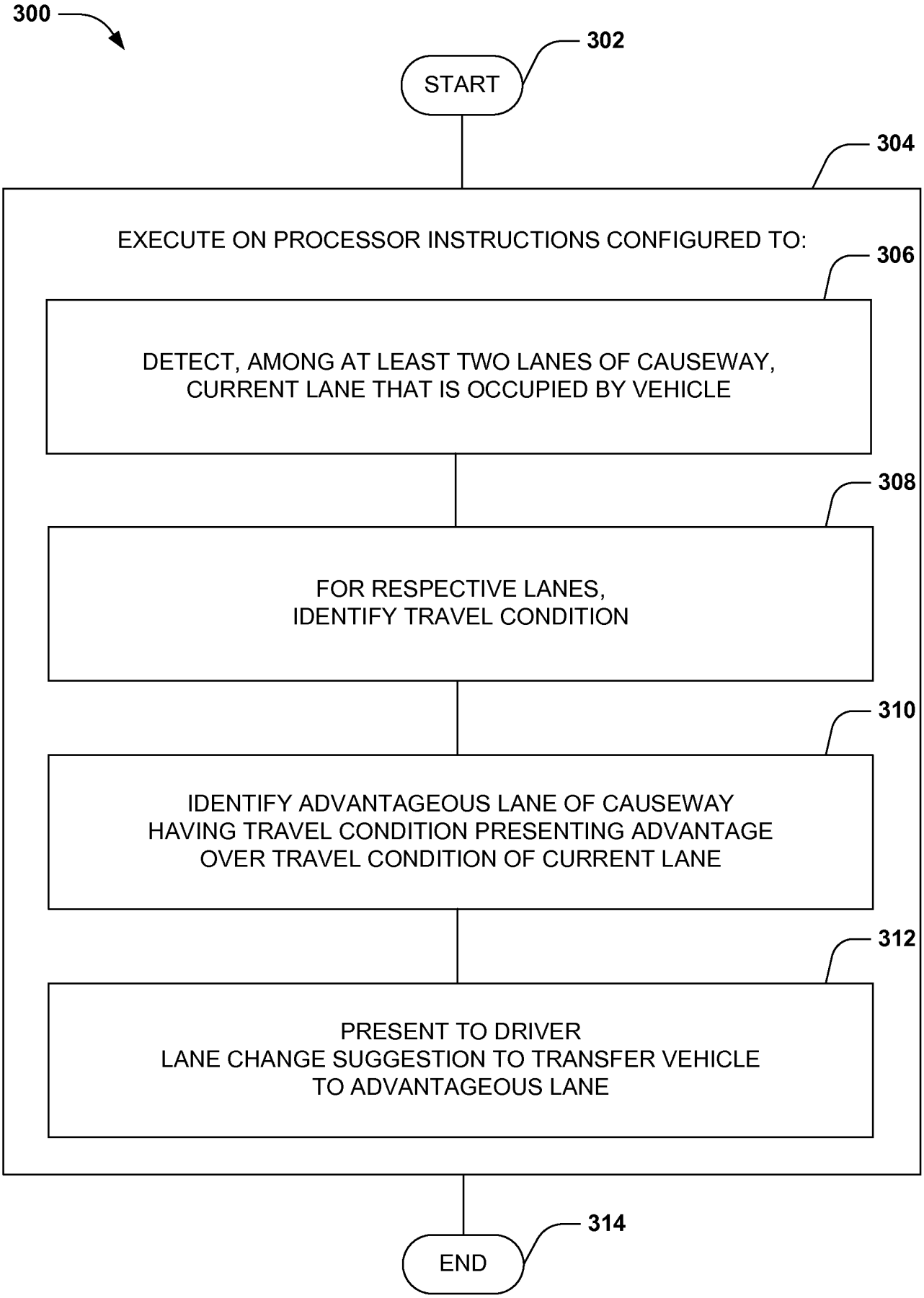

300
302
START
304
EXECUTE ON PROCESSOR INSTRUCTIONS CONFIGURED TO:
306
DETECT, AMONG AT LEAST TWO LANES OF CAUSEWAY, CURRENT LANE THAT IS OCCUPIED BY VEHICLE
308
FOR RESPECTIVE LANES, IDENTIFY TRAVEL CONDITION
310
IDENTIFY ADVANTAGEOUS LANE OF CAUSEWAY HAVING TRAVEL CONDITION PRESENTING ADVANTAGE OVER TRAVEL CONDITION OF CURRENT LANE
312
PRESENT TO DRIVER LANE CHANGE SUGGESTION TO TRANSFER VEHICLE TO ADVANTAGEOUS LANE
314
END

FIG. 3

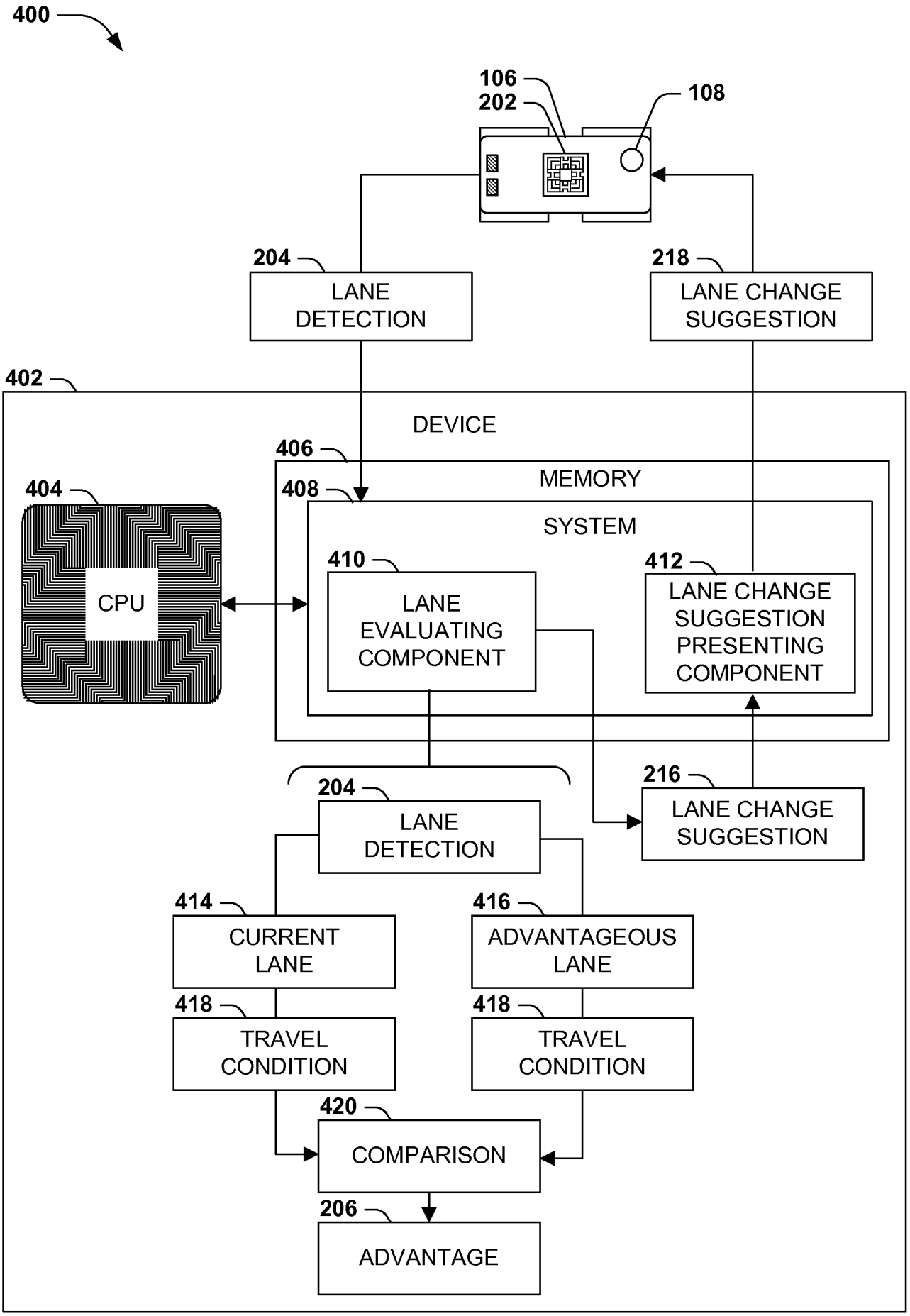

400
106
202
108
204
LANE DETECTION
218
LANE CHANGE SUGGESTION
402
DEVICE
406
MEMORY
404
408
SYSTEM
CPU
410
LANE EVALUATING COMPONENT
412
LANE CHANGE SUGGESTION PRESENTING COMPONENT
216
LANE CHANGE SUGGESTION
204
LANE DETECTION
414
CURRENT LANE
416
ADVANTAGEOUS LANE
418
TRAVEL CONDITION
418
TRAVEL CONDITION
420
COMPARISON
206
ADVANTAGE

FIG. 4

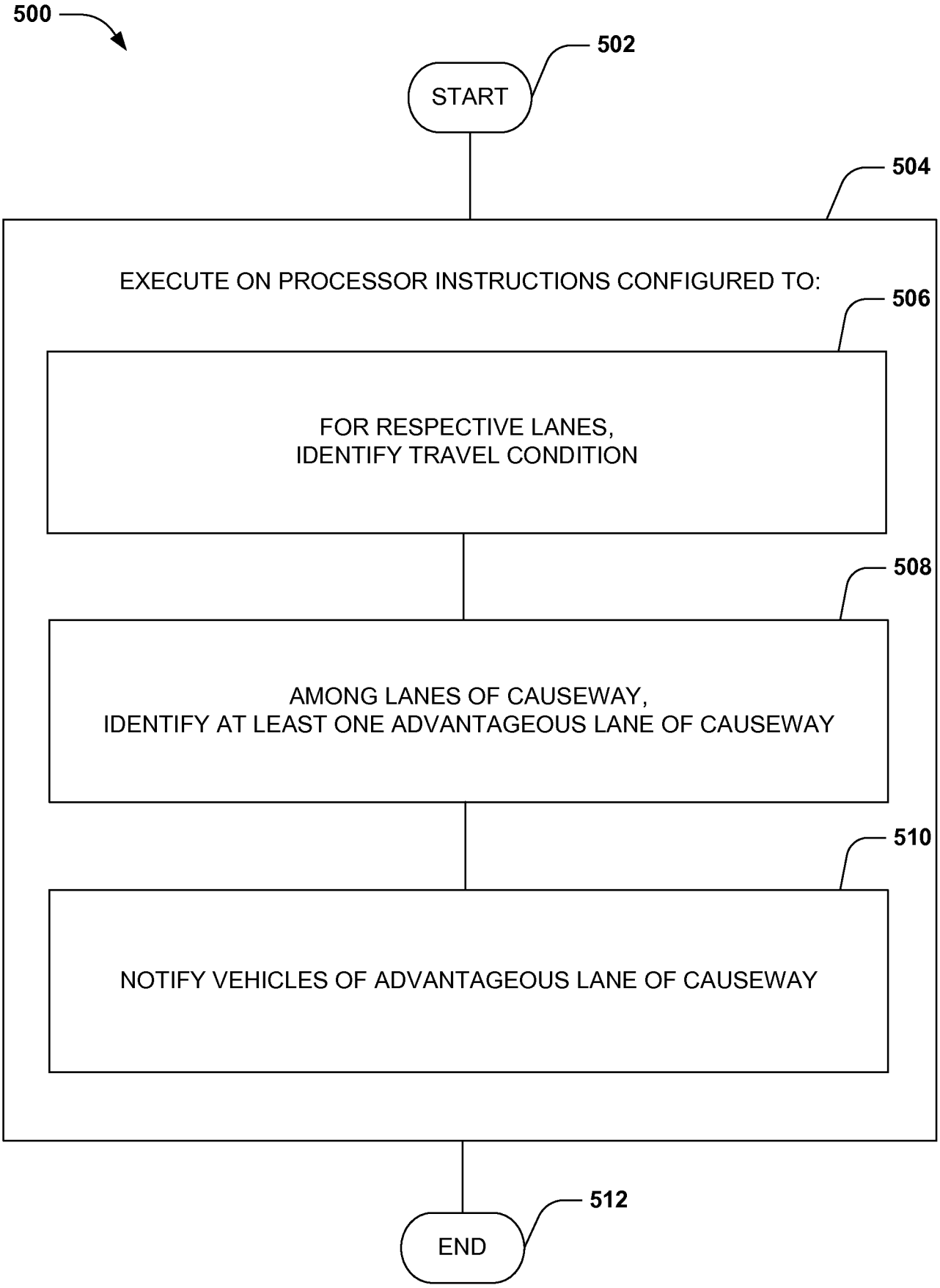

500
502
START
504
EXECUTE ON PROCESSOR INSTRUCTIONS CONFIGURED TO:
506
FOR RESPECTIVE LANES,
IDENTIFY TRAVEL CONDITION
508
AMONG LANES OF CAUSEWAY,
IDENTIFY AT LEAST ONE ADVANTAGEOUS LANE OF CAUSEWAY
510
NOTIFY VEHICLES OF ADVANTAGEOUS LANE OF CAUSEWAY
512
END

FIG. 5

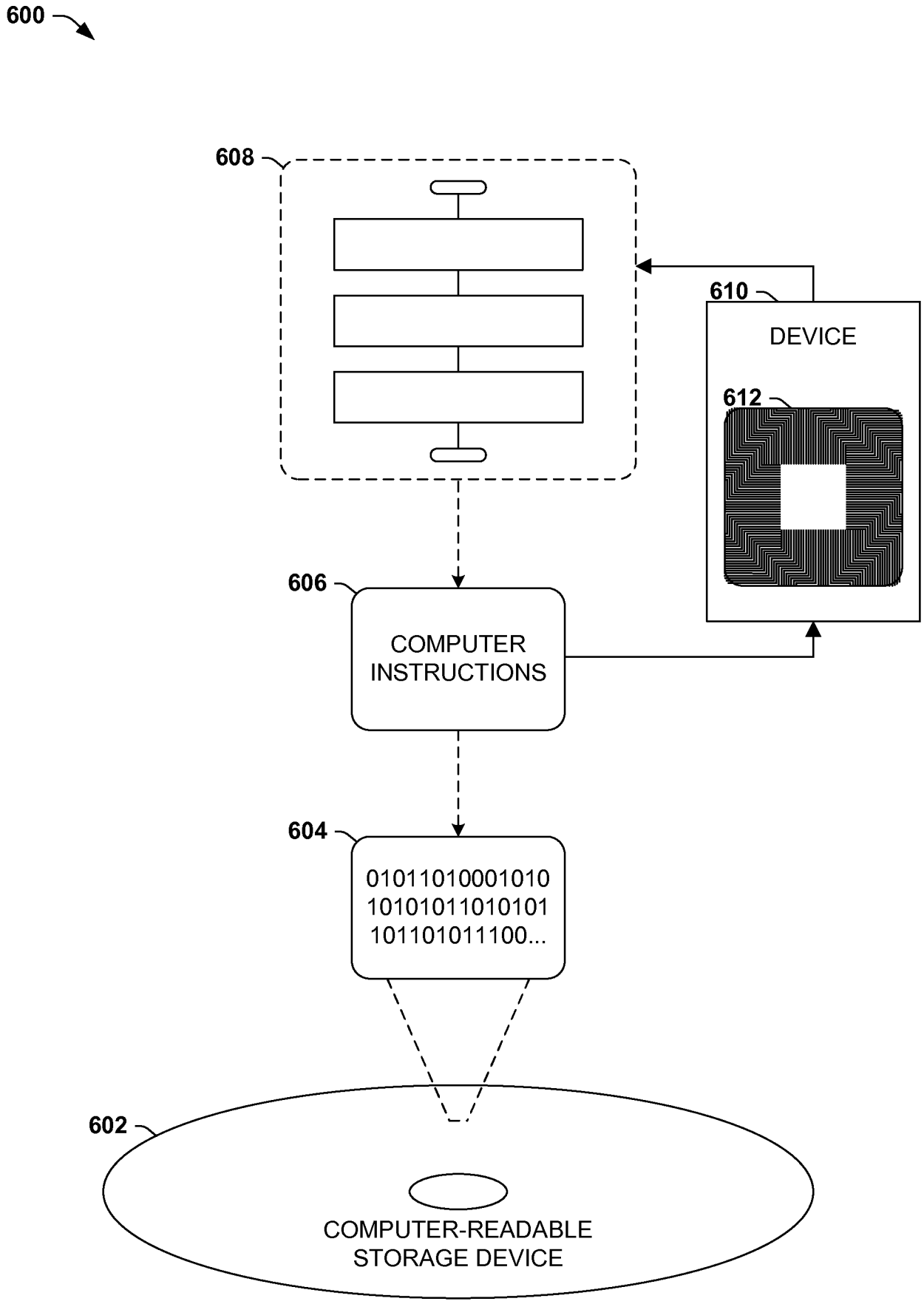

600
608
610
DEVICE
612
606
COMPUTER INSTRUCTIONS
604
01011010001010
10101011010101
101101011100...
602
COMPUTER-READABLE STORAGE DEVICE

FIG. 6

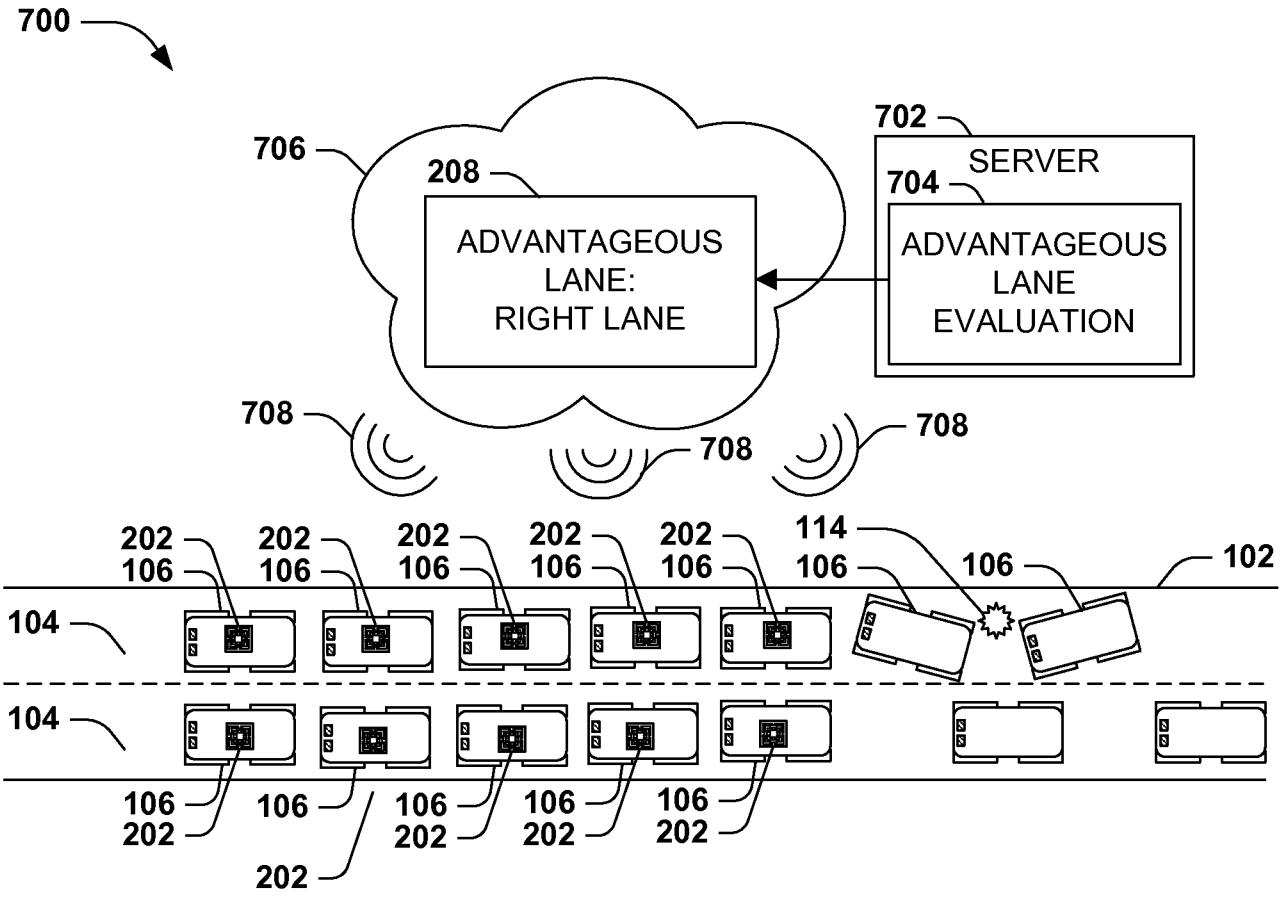

700
706
208
ADVANTAGEOUS LANE: RIGHT LANE
702
SERVER
704
ADVANTAGEOUS LANE EVALUATION
708
708
708
202
106
104
114
102

FIG. 7

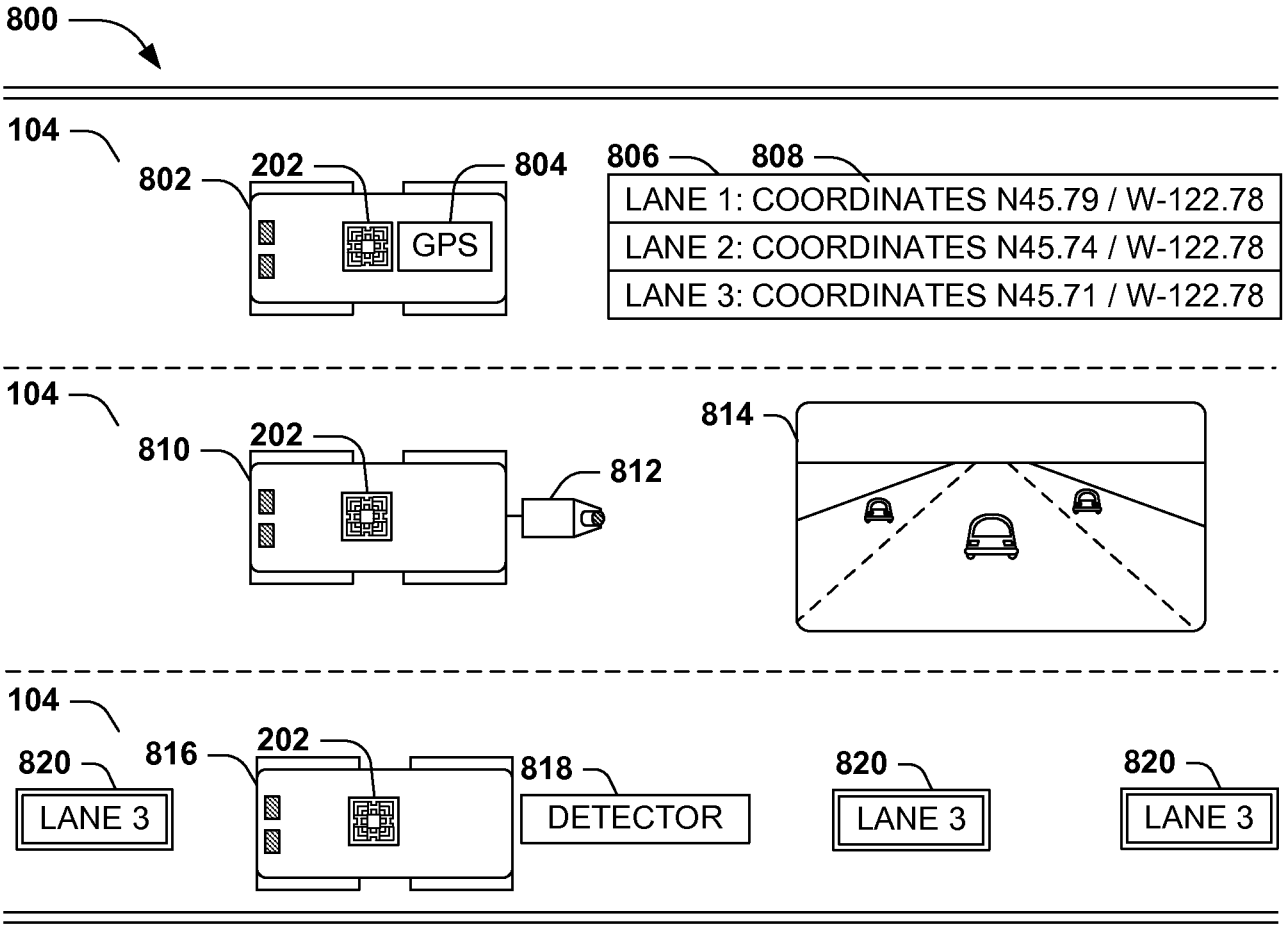

800
104
802
202
804
GPS
806
808
LANE 1: COORDINATES N45.79 / W-122.78
LANE 2: COORDINATES N45.74 / W-122.78
LANE 3: COORDINATES N45.71 / W-122.78
810
812
814
816
818
DETECTOR
820
LANE 3

FIG. 8

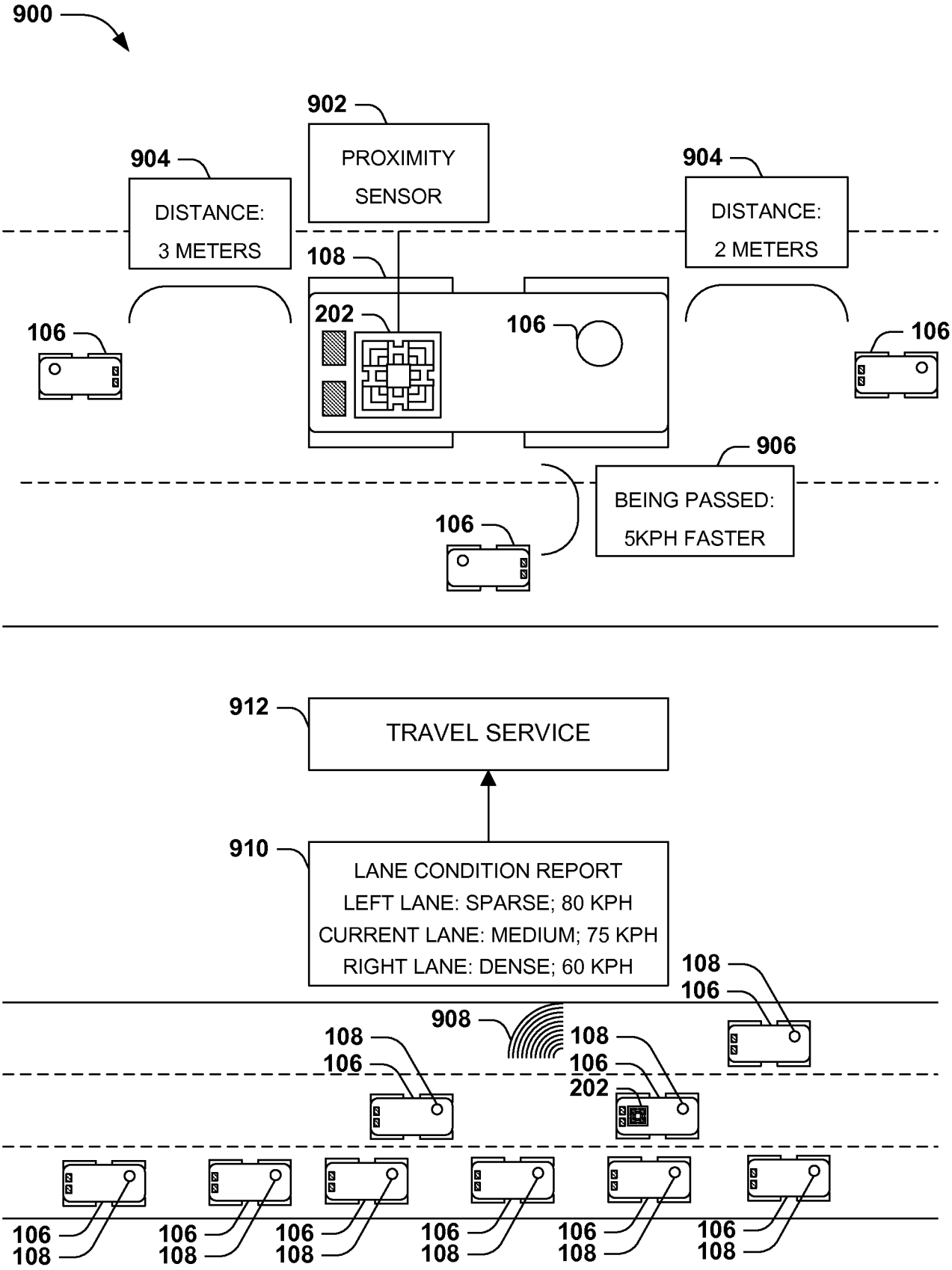

900
902
PROXIMITY SENSOR
904
DISTANCE: 3 METERS
904
DISTANCE: 2 METERS
108
202
106
106
106
906
BEING PASSED: 5KPH FASTER
106
912
TRAVEL SERVICE
910
LANE CONDITION REPORT
LEFT LANE: SPARSE; 80 KPH
CURRENT LANE: MEDIUM; 75 KPH
RIGHT LANE: DENSE; 60 KPH
908
108
106
202
106
108

FIG. 9

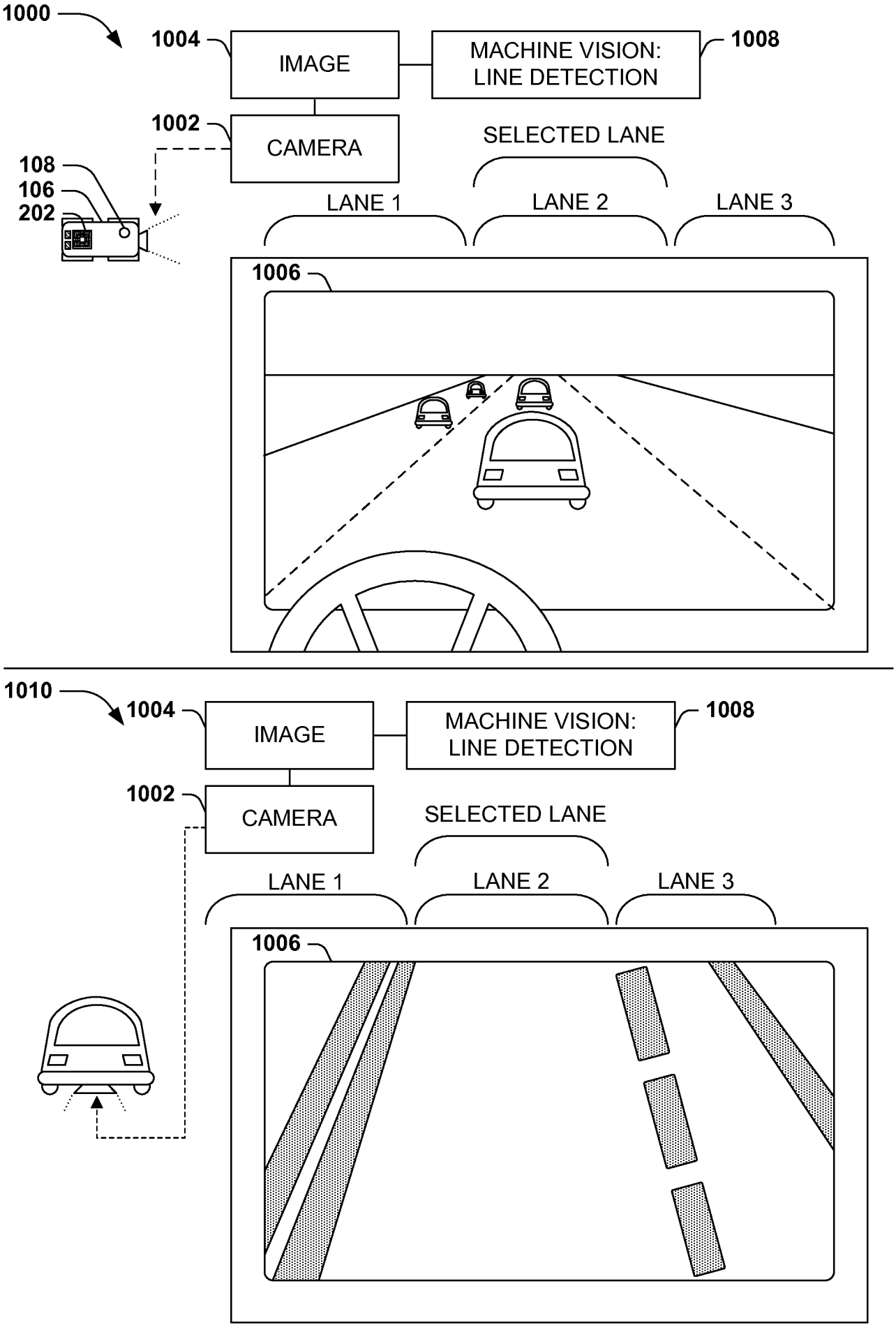
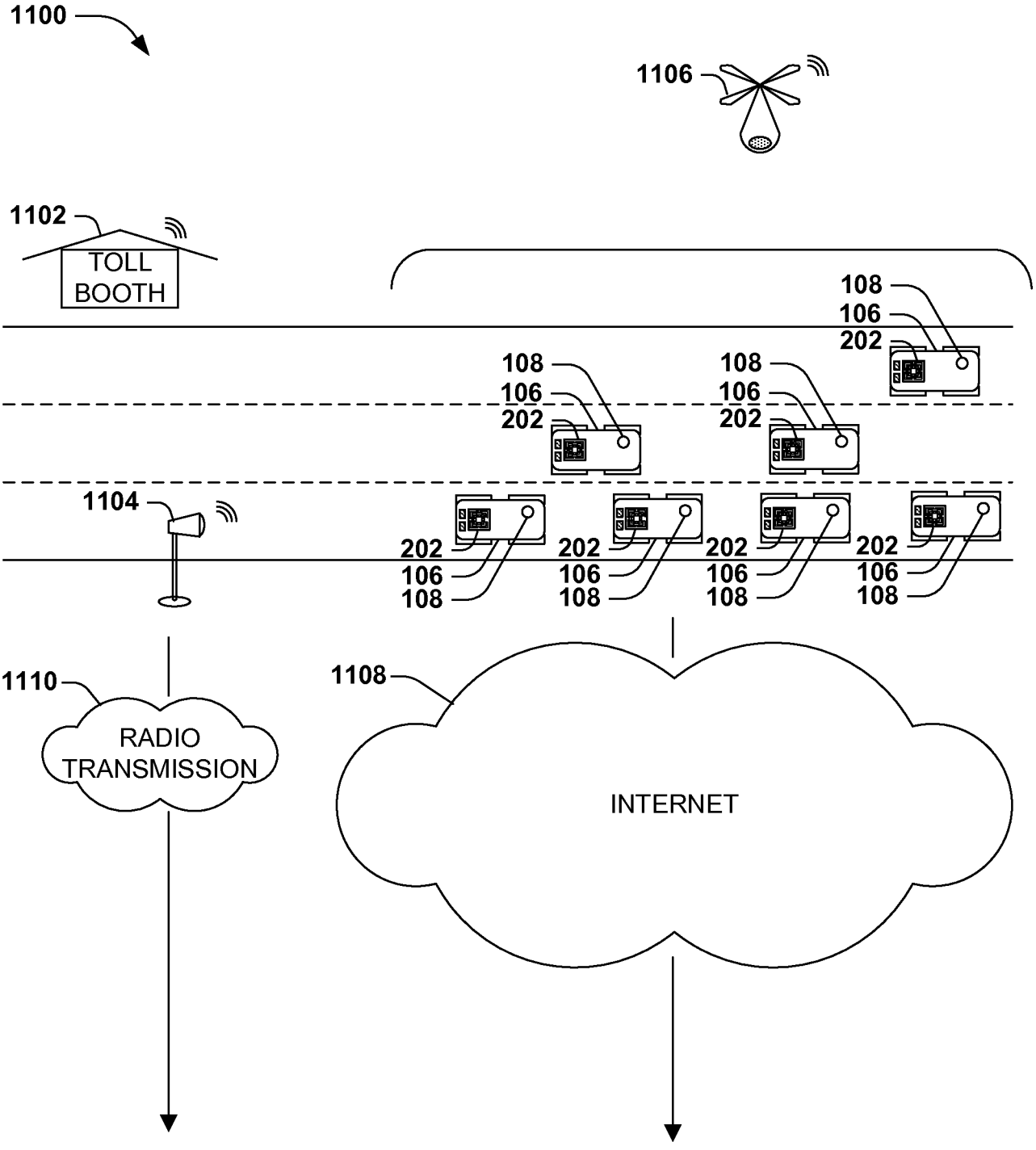

1000
1004
IMAGE
MACHINE VISION:
LINE DETECTION
1008
1002
CAMERA
SELECTED LANE
108
106
202
LANE 1
LANE 2
LANE 3
1006
1010
1004
IMAGE
MACHINE VISION:
LINE DETECTION
1008
1002
CAMERA
SELECTED LANE
LANE 1
LANE 2
LANE 3
1006

FIG. 10




912

| TRAVEL SERVICE | | |
|---|---|---|
| TRAVEL REPORTS | | |
| VEHICLE 1 | LANE 1 | 15 MINUTES |
| VEHICLE 2 | LANE 2 | 22 MINUTES |
| VEHICLE 3 | LANE 3 | 24 MINUTES |
| VEHICLE 4 | LANE 3 | 26 MINUTES |

FIG. 11

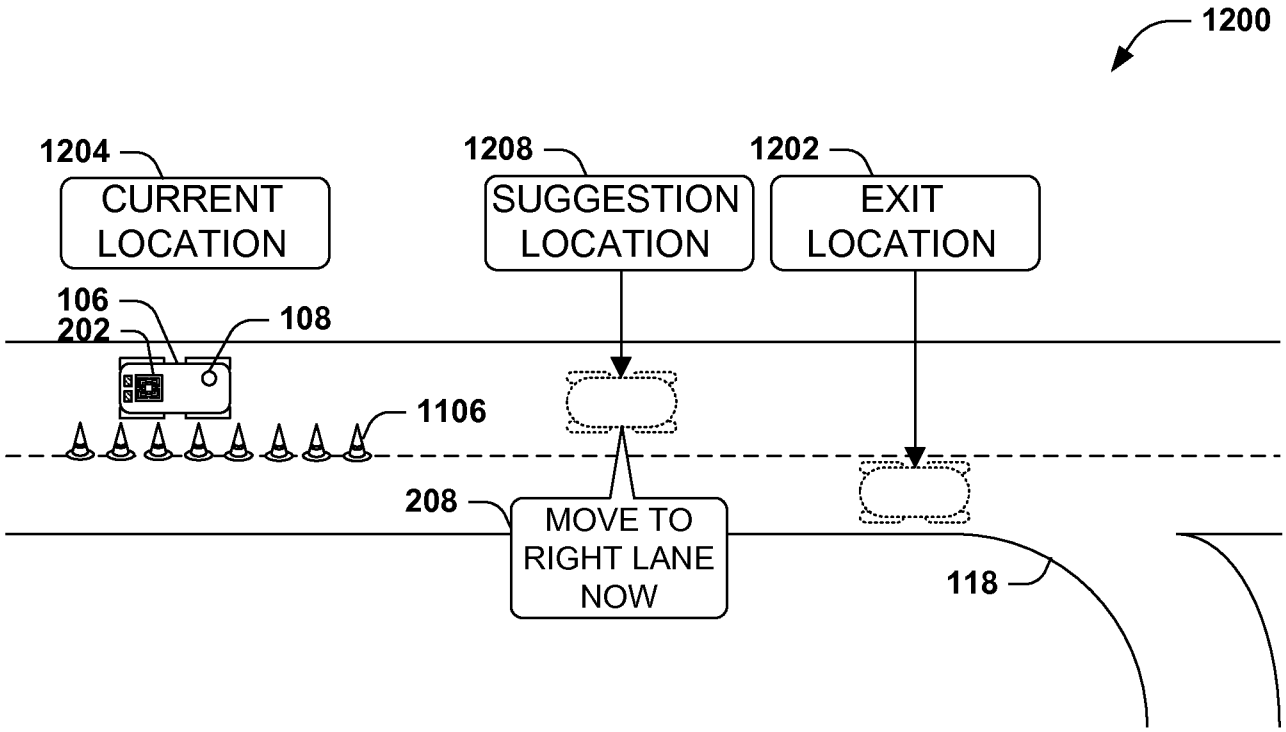

1200
1204
CURRENT LOCATION
1208
SUGGESTION LOCATION
1202
EXIT LOCATION
106
202
108
1106
208
MOVE TO RIGHT LANE NOW
118

FIG. 12

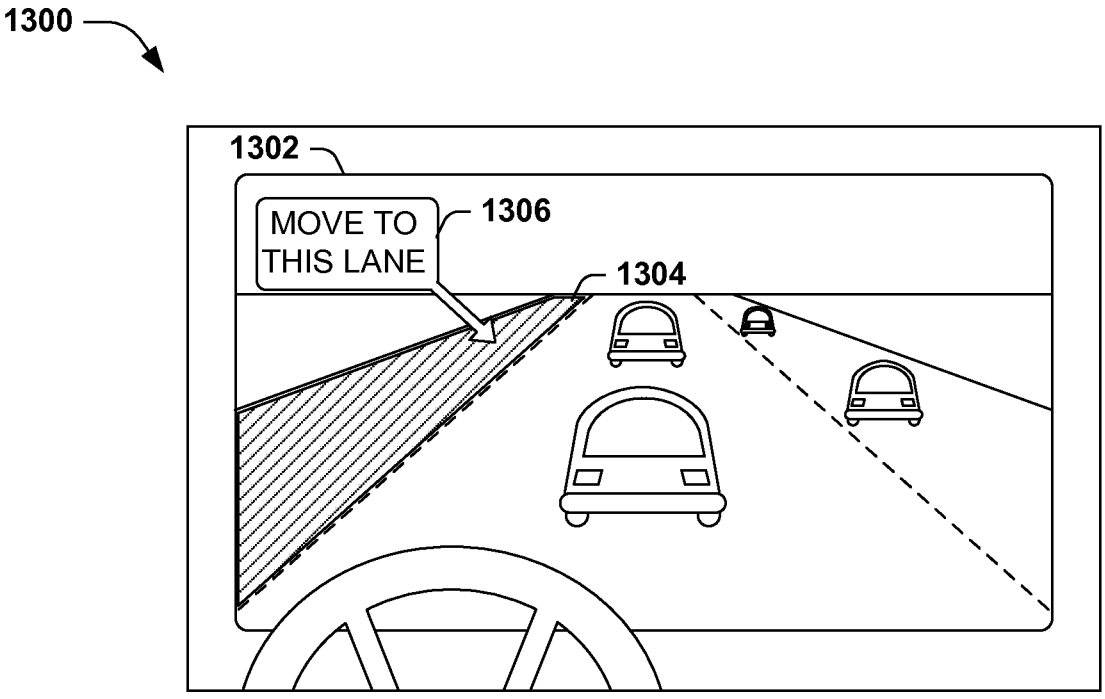

1300
1302
MOVE TO THIS LANE
1306
1304

FIG. 13

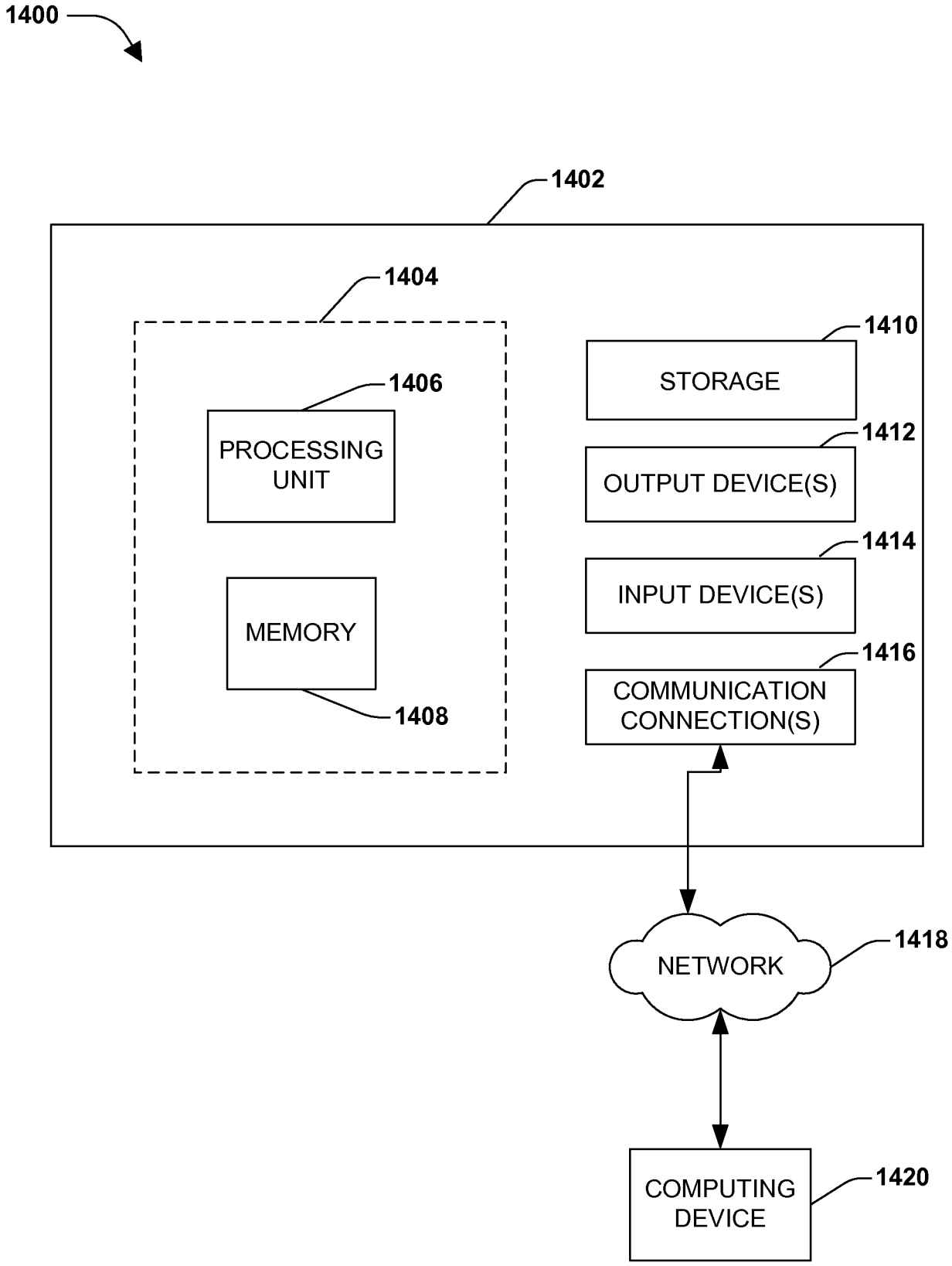

1400
1402
1404
1406
PROCESSING UNIT
MEMORY
1408
1410
STORAGE
1412
OUTPUT DEVICE(S)
1414
INPUT DEVICE(S)
1416
COMMUNICATION CONNECTION(S)
NETWORK
1418
COMPUTING DEVICE
1420

FIG. 14

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 15/18383

A. CLASSIFICATION OF SUBJECT MATTER
**IPC(8)** - G08G 1/123 (2015.01)
**CPC** - G08G 1/096827; G08G 1/096838; G08G 1/0969
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): G08G 1/123 (2015.01)
CPC: G08G 1/096827; G08G 1/096838; G08G 1/0969

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 340/995.19; 701/414; 701/442 (Keyword limited; terms below); IPC(8): G08G 1/123 (2015.01) (Keyword limited; terms below);
CPC: G08G 1/096827; G08G 1/096838; G08G 1/0969; G08G 1/096872; G08G 1/096894 (Keyword limited; terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase; Google (Scholar, Patents, Web)
Terms used: street highway current lane optimize detect identifier compare conditions recommend "lane change" speed fuel efficiency time occupancy camera gps distance threshold congestion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>---<br>Y | US 2013/0278441 A1 (RUBIN et al.), 24 October 2013 (24.10.2013), entire document, especially Abstract; para [0083], [01 16], [0157], [0356], [0395], [0447], [0477], [0534], [0558], [0594], [0621], [0674], [0706], [0738], [0743], [0762]-[0763], [0779] | 1-7, 9-1 1, 15-20<br>---<br>8, 12-14 |
| Y | US 2013/0275033 A1 (BASTIAENSEN et al.), 17 October 2013 (17.10.2013), entire document, especially Abstract; para [0032]-[0034], [0057], [0074]-[0075], [0077], [0086], [0190] | 8, 12-14 |
| A | US 2004/0107030 A1 (NISHIRA et al.), 03 June 2004 (03.06.2004), entire document | 1-20 |
| A | US 2010/0292886 A1 to (SZCZERBA et al.), 18 November 2010 (18.1 1.2010), entire document | 1-20 |

☐ Further documents are listed in the continuation of Box C. ☐

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"A" document defining the general stale of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 08 May 2015 (08.05.2015) | 18 JUN 2015 |

| Name and mailing address of the ISA/US | Authorized officer: |
|---|---|
| Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-8300 | Lee W. Young<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |

Form PCT/ISA/210 (second sheet) (January 2015)