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(54) **GATEWAY SELECTION FOR A VIRTUAL PARKED VEHICLE NETWORK**

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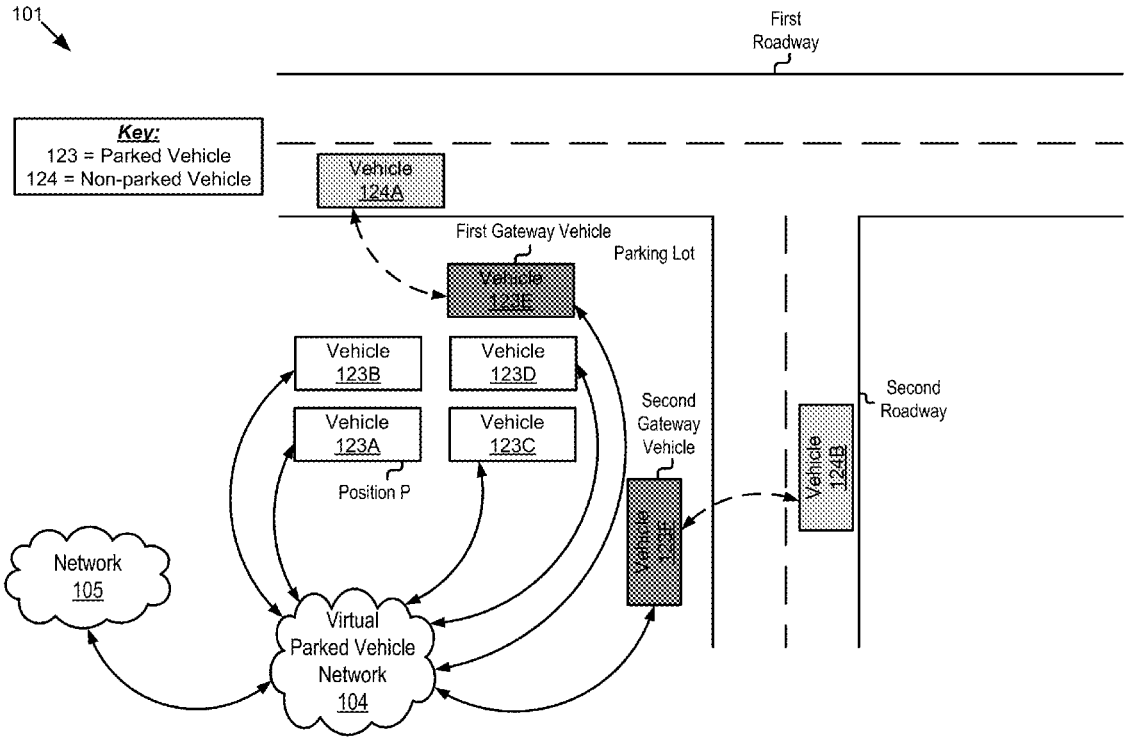
(57) **ABSTRACT**

The disclosure includes embodiments for selecting one or more gateway vehicles for a virtual parked vehicle network including a plurality of parked vehicles that are members of the virtual parked vehicle network. A method according to some embodiments includes assigning position data to the plurality of parked vehicles which describes a plurality of unique position values for the plurality of parked vehicles in the virtual parked vehicle network. The method includes designating a parked vehicle having a lowest position value in the plurality of unique position values as a gateway vehicle for the virtual parked vehicle network. In some embodiments, the gateway vehicle is an only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network.



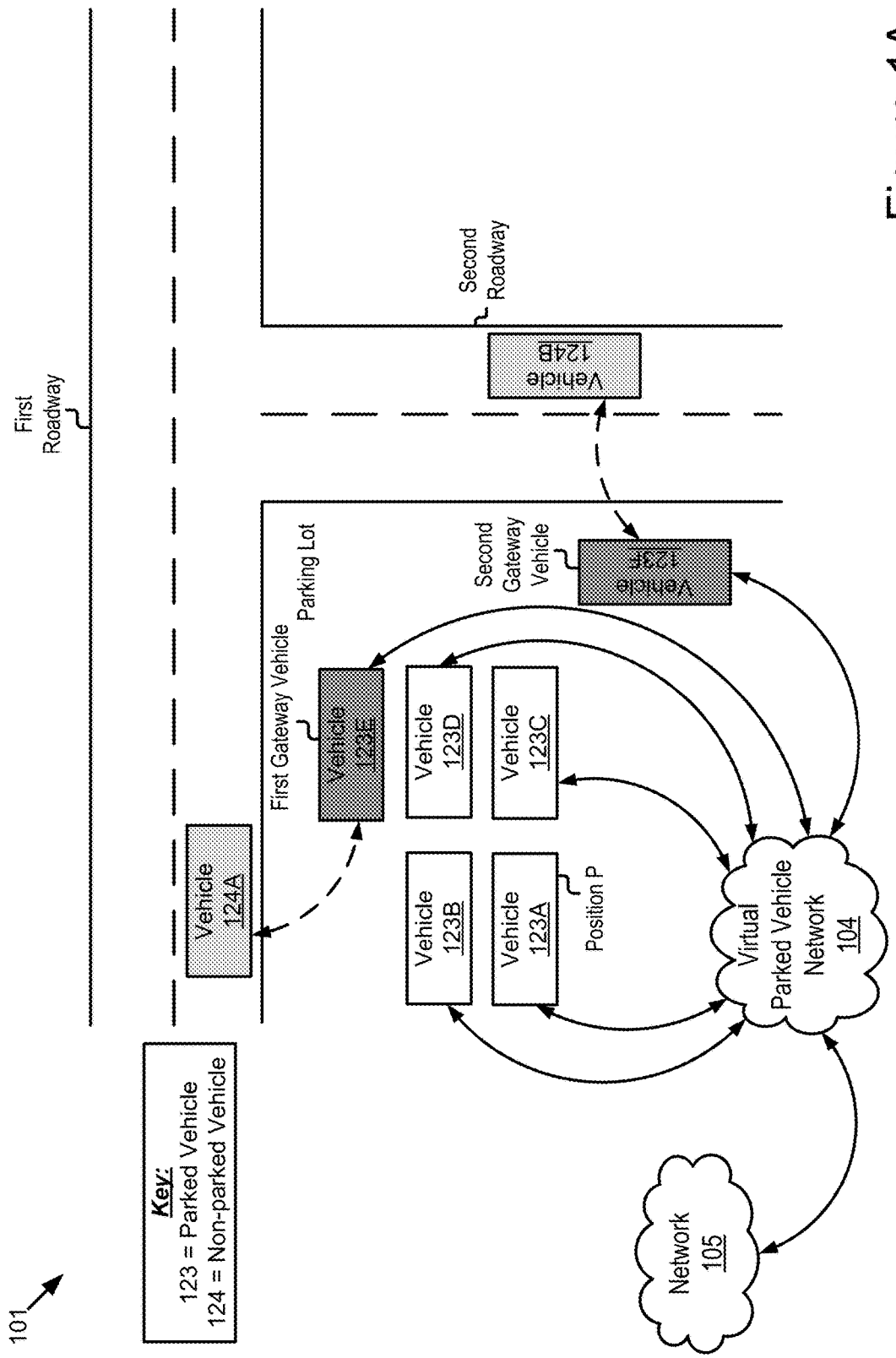

101
Key:
123 = Parked Vehicle
124 = Non-parked Vehicle
First Roadway
Second Roadway
Vehicle 124A
Vehicle 124B
First Gateway Vehicle
Parking Lot
Vehicle 123E
Vehicle 123D
Vehicle 123C
Vehicle 123B
Vehicle 123A
Position P
Second Gateway Vehicle
Vehicle 123F
Virtual Parked Vehicle Network 104
Network 105

Figure 1A

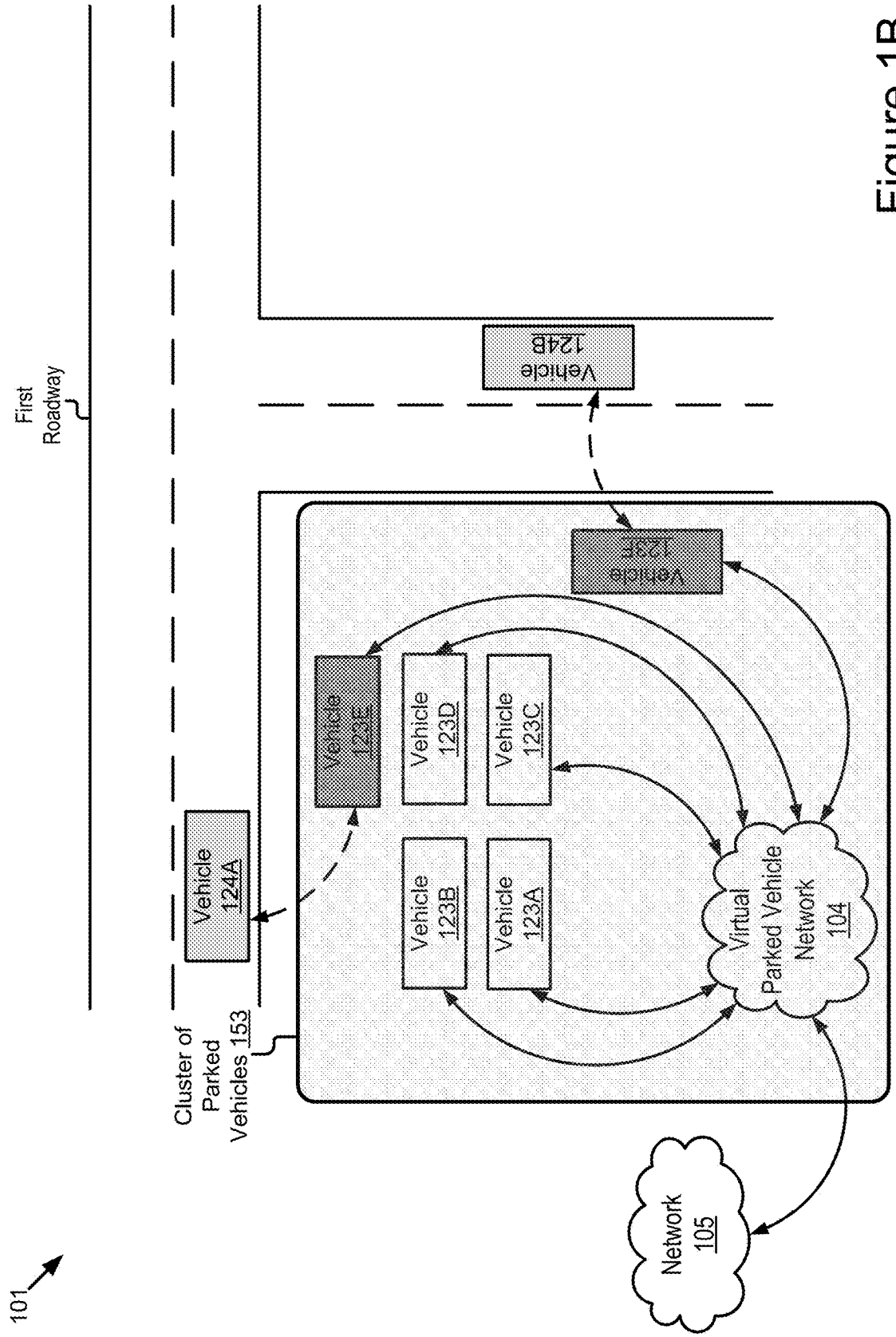

101
First Roadway
Vehicle 124A
Vehicle 124B
Vehicle 123E
Vehicle 123D
Vehicle 123C
Vehicle 123B
Vehicle 123A
Vehicle 123F
Cluster of Parked Vehicles 153
Virtual Parked Vehicle Network 104
Network 105

Figure 1B

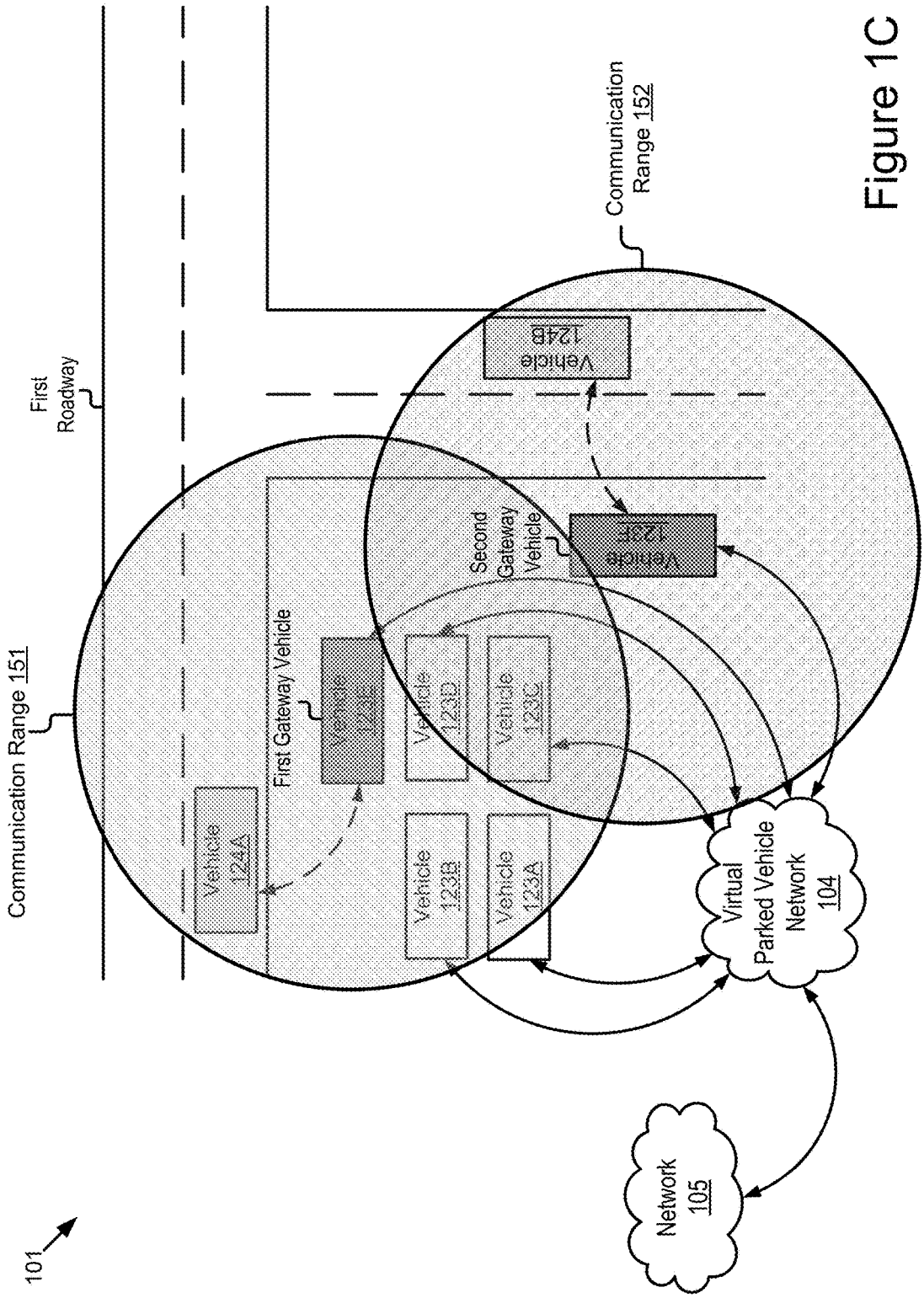

101
Communication Range 151
First Roadway
Vehicle 124A
First Gateway Vehicle
Vehicle 123B
Vehicle 123D
Vehicle 123C
Vehicle 123A
Communication Range 152
Vehicle 124B
Second Gateway Vehicle
Vehicle 127
Virtual Parked Vehicle Network 104
Network 105

Figure 1C

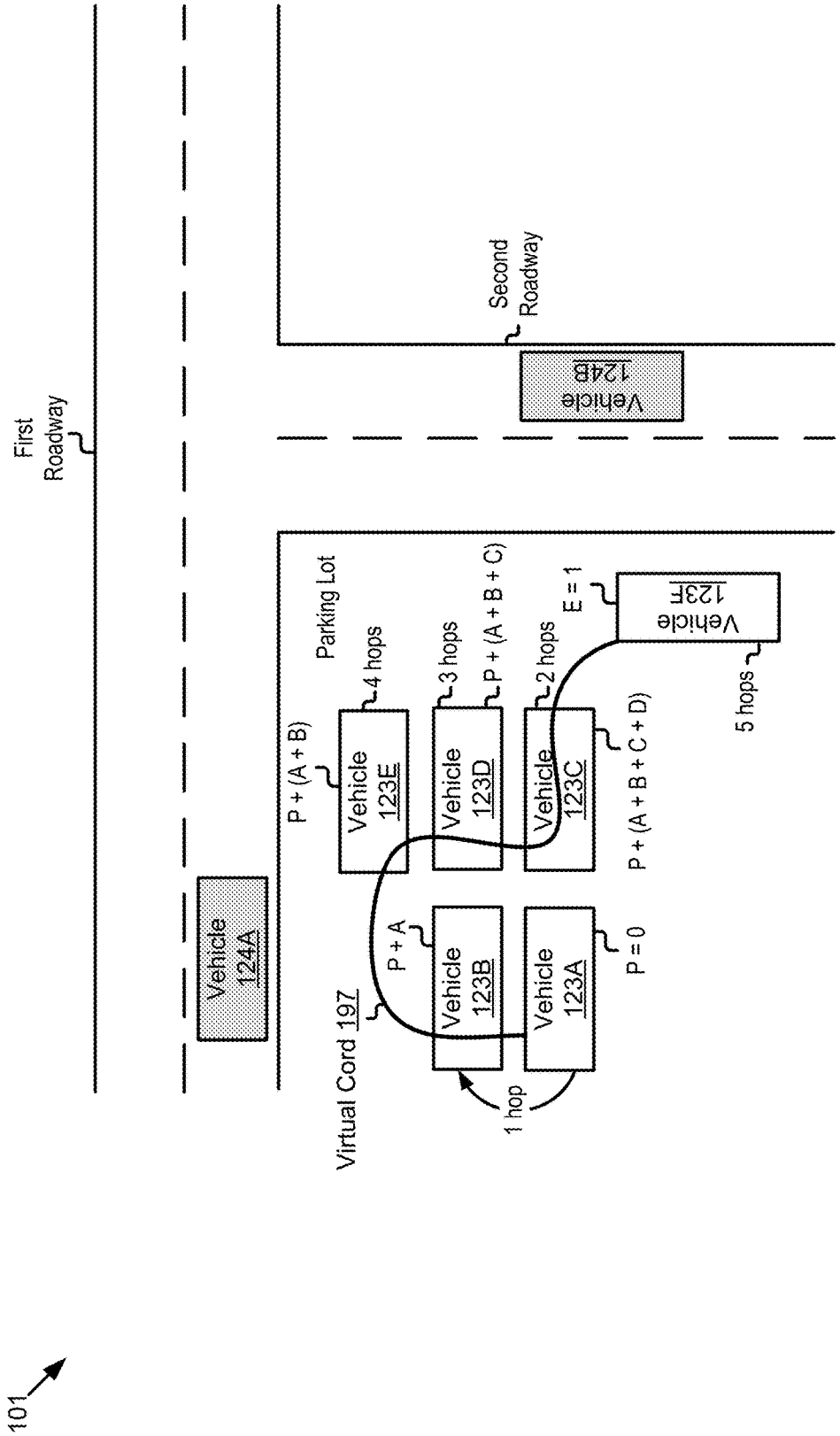

101
First Roadway
Second Roadway
Vehicle 124A
Vehicle 124B
Parking Lot
Virtual Cord 197
Vehicle 123A
Vehicle 123B
Vehicle 123C
Vehicle 123D
Vehicle 123E
Vehicle 123F
P = 0
P + A
P + (A + B)
P + (A + B + C)
P + (A + B + C + D)
E = 1
1 hop
2 hops
3 hops
4 hops
5 hops

Figure 1D

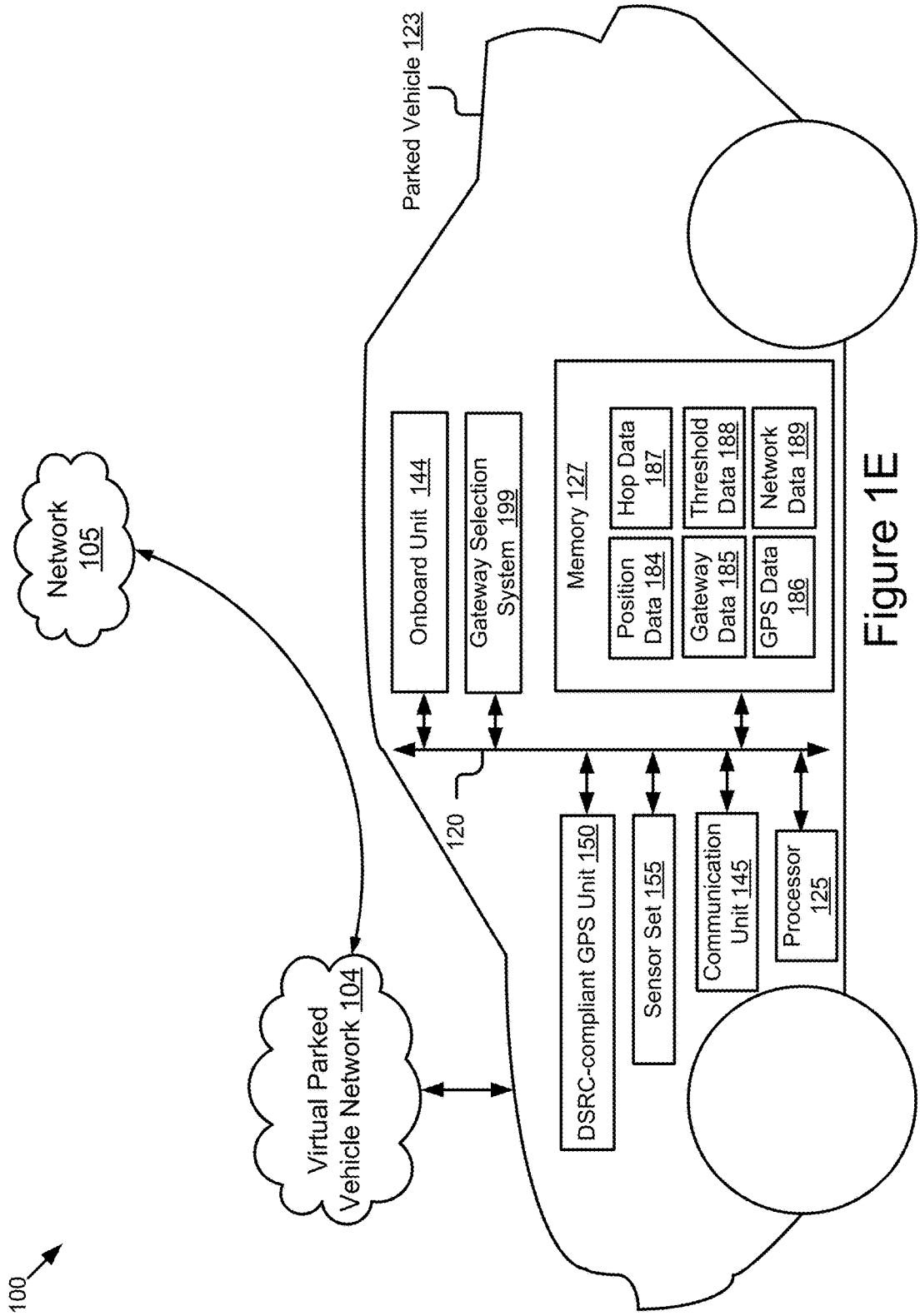

100
Network 105
Virtual Parked Vehicle Network 104
Parked Vehicle 123
Onboard Unit 144
Gateway Selection System 199
Memory 127
Position Data 184
Hop Data 187
Gateway Data 185
Threshold Data 188
GPS Data 186
Network Data 189
120
DSRC-compliant GPS Unit 150
Sensor Set 155
Communication Unit 145
Processor 125

Figure 1E

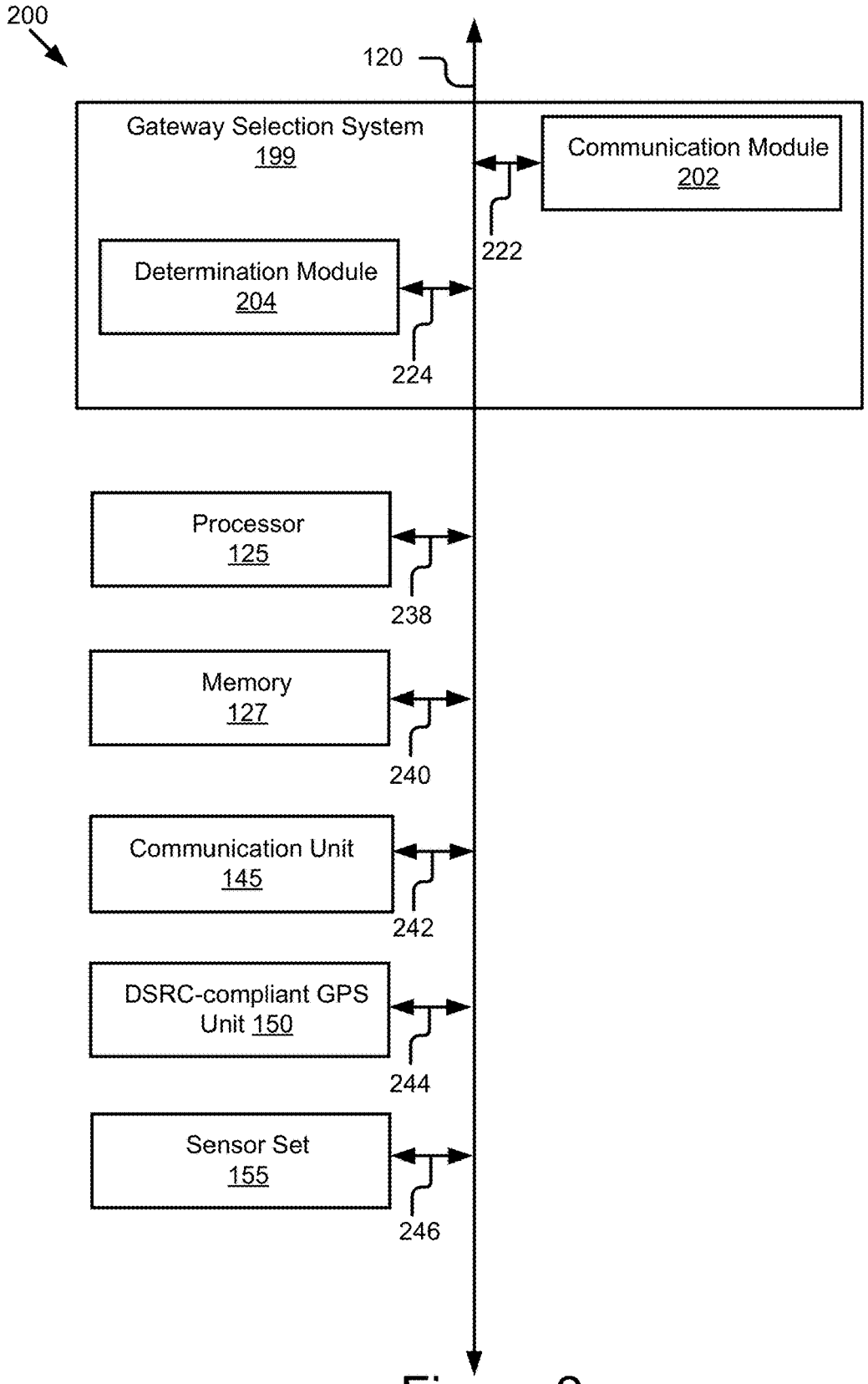

200
120
Gateway Selection System
199
Communication Module
202
222
Determination Module
204
224
Processor
125
238
Memory
127
240
Communication Unit
145
242
DSRC-compliant GPS
Unit 150
244
Sensor Set
155
246

Figure 2

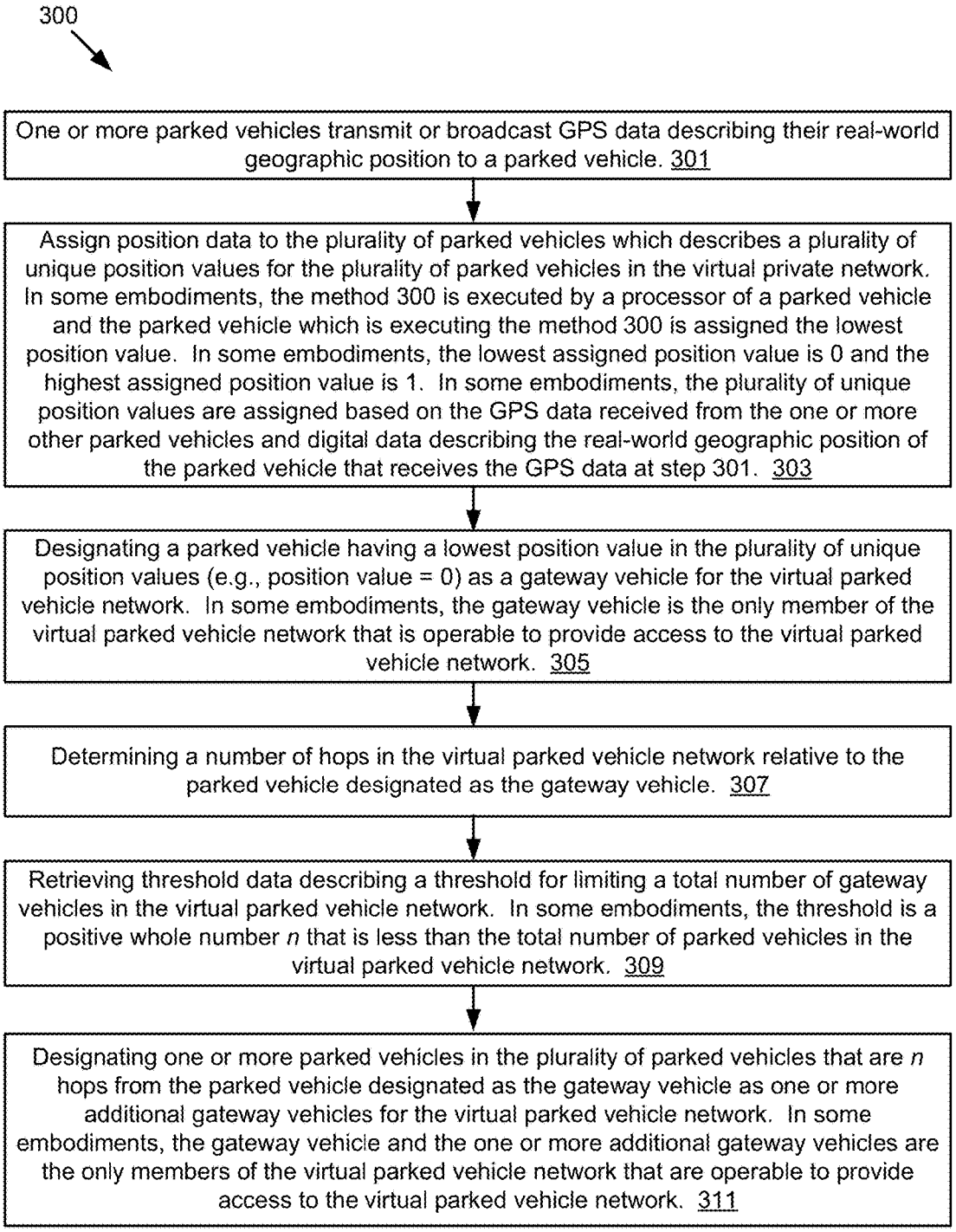

300
One or more parked vehicles transmit or broadcast GPS data describing their real-world geographic position to a parked vehicle. 301
Assign position data to the plurality of parked vehicles which describes a plurality of unique position values for the plurality of parked vehicles in the virtual private network. In some embodiments, the method 300 is executed by a processor of a parked vehicle and the parked vehicle which is executing the method 300 is assigned the lowest position value. In some embodiments, the lowest assigned position value is 0 and the highest assigned position value is 1. In some embodiments, the plurality of unique position values are assigned based on the GPS data received from the one or more other parked vehicles and digital data describing the real-world geographic position of the parked vehicle that receives the GPS data at step 301. 303
Designating a parked vehicle having a lowest position value in the plurality of unique position values (e.g., position value = 0) as a gateway vehicle for the virtual parked vehicle network. In some embodiments, the gateway vehicle is the only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network. 305
Determining a number of hops in the virtual parked vehicle network relative to the parked vehicle designated as the gateway vehicle. 307
Retrieving threshold data describing a threshold for limiting a total number of gateway vehicles in the virtual parked vehicle network. In some embodiments, the threshold is a positive whole number n that is less than the total number of parked vehicles in the virtual parked vehicle network. 309
Designating one or more parked vehicles in the plurality of parked vehicles that are n hops from the parked vehicle designated as the gateway vehicle as one or more additional gateway vehicles for the virtual parked vehicle network. In some embodiments, the gateway vehicle and the one or more additional gateway vehicles are the only members of the virtual parked vehicle network that are operable to provide access to the virtual parked vehicle network. 311

Figure 3

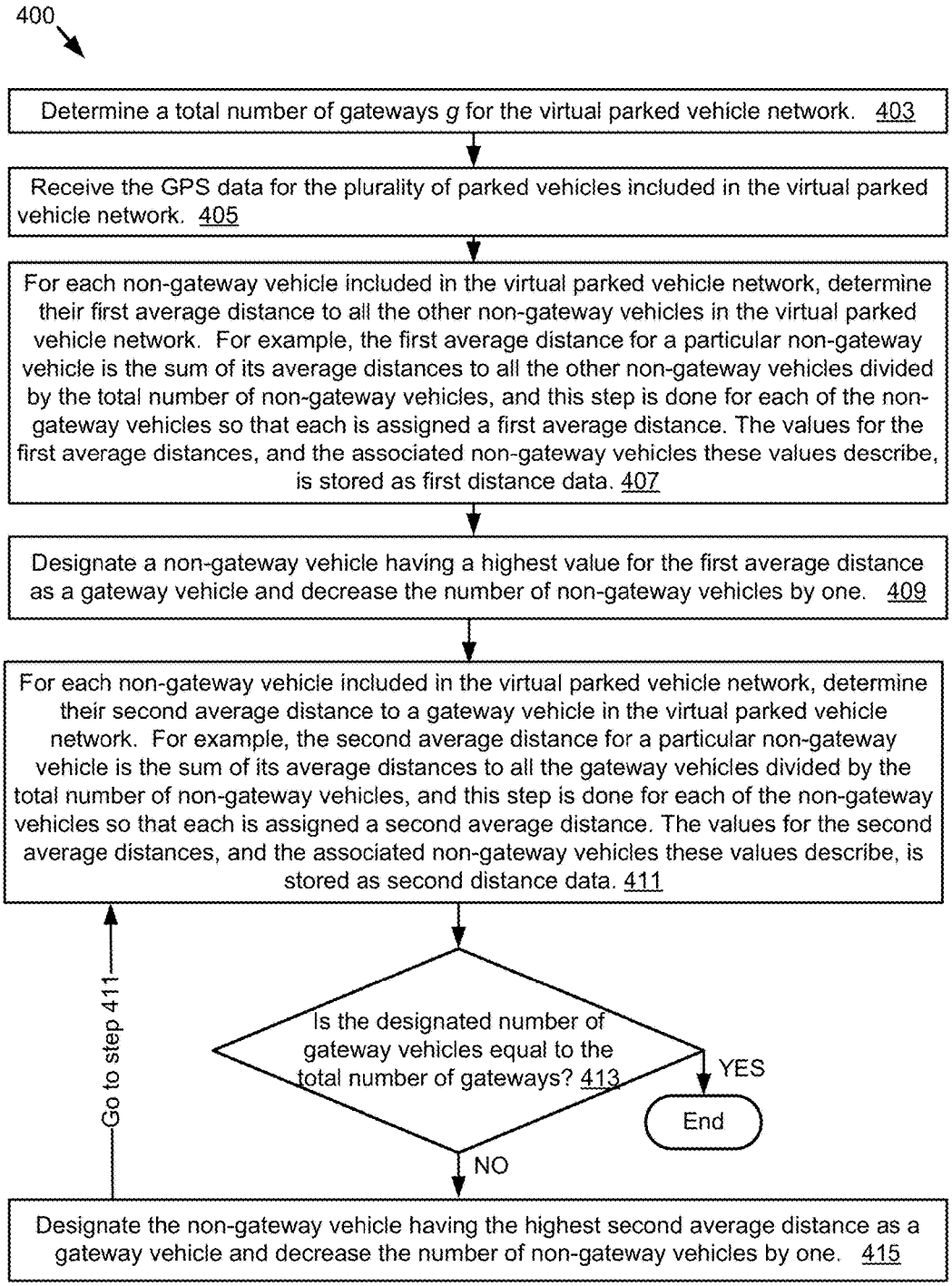

400
Determine a total number of gateways g for the virtual parked vehicle network. 403
Receive the GPS data for the plurality of parked vehicles included in the virtual parked vehicle network. 405
For each non-gateway vehicle included in the virtual parked vehicle network, determine their first average distance to all the other non-gateway vehicles in the virtual parked vehicle network. For example, the first average distance for a particular non-gateway vehicle is the sum of its average distances to all the other non-gateway vehicles divided by the total number of non-gateway vehicles, and this step is done for each of the non-gateway vehicles so that each is assigned a first average distance. The values for the first average distances, and the associated non-gateway vehicles these values describe, is stored as first distance data. 407
Designate a non-gateway vehicle having a highest value for the first average distance as a gateway vehicle and decrease the number of non-gateway vehicles by one. 409
For each non-gateway vehicle included in the virtual parked vehicle network, determine their second average distance to a gateway vehicle in the virtual parked vehicle network. For example, the second average distance for a particular non-gateway vehicle is the sum of its average distances to all the gateway vehicles divided by the total number of non-gateway vehicles, and this step is done for each of the non-gateway vehicles so that each is assigned a second average distance. The values for the second average distances, and the associated non-gateway vehicles these values describe, is stored as second distance data. 411
Is the designated number of gateway vehicles equal to the total number of gateways? 413
YES
End
NO
Go to step 411
Designate the non-gateway vehicle having the highest second average distance as a gateway vehicle and decrease the number of non-gateway vehicles by one. 415

Figure 4

GATEWAY SELECTION FOR A VIRTUAL PARKED VEHICLE NETWORK

BACKGROUND

[0001] The specification relates to gateway selection for a virtual parked vehicle network. The virtual parked vehicle network includes a cluster of parked vehicles.

[0002] Modern vehicles require regular access to wireless networks and updated sensor data describing their current environment. Accordingly, modern vehicles seek to access sensor data and other data provided by other vehicles or endpoints, or provide other vehicles and endpoints with updated sensor data and other data, on a regular basis. However, wireless networks and updated sensor data describing their current environment are not always available. Sometimes a wireless network is available, but the signal strength for the wireless network is too weak or variable, or the speed of the wireless network is too slow or unstable. These deficiencies are because the wireless networks are not optimized for mobility applications, or because they are transmitted from an access point which is too far from the roadway.

SUMMARY

[0003] A virtual parked vehicle network includes a plurality of parked vehicles that are wirelessly communicated to one another to form the virtual parked vehicle network. In this way, each of the plurality of parked vehicles is a member of the virtual parked vehicle network and can send and receive wireless communications with other members of the virtual parked vehicle network. Each of the plurality of parked vehicles includes an onboard unit that remains active while they are parked and members of the virtual parked vehicle network. The onboard unit includes, for example, a processor and a non-transitory memory.

[0004] In some embodiments, the non-transitory memories of the plurality of parked vehicles stores data for other endpoints that are not members of the virtual parked vehicle network (e.g., non-parked vehicles that are located within wireless communication range of the virtual parked vehicle network, which can be referred to herein as a "non-member endpoint" if referenced in the singular or "non-member endpoints" if referenced in the plural). This is an example of a service provided by the virtual parked vehicle network to non-member endpoints.

[0005] In some embodiments, the virtual parked vehicle network stores data for one or more non-parked vehicles that are not part of the virtual parked vehicle network using one or more non-transitory memories of the plurality of parked vehicles and the data is electronically transmissible via the gateway vehicle. In some embodiments, data is electronically transmissible if it is capable of being sent, received, accessed or retrieved via the gateway vehicle.

[0006] In some embodiments, the processors of the plurality of parked vehicles execute operations and process data for the non-member endpoints. This is another example of a service provided by the virtual parked vehicle network to non-member endpoints.

[0007] In some embodiments, a gateway vehicle is a parked vehicle that is a member of the virtual parked vehicle network which is operable to invite non-member endpoints to access the virtual parked vehicle network (e.g., to receive one or more services from the virtual parked vehicle network); parked vehicles which are members of the virtual parked vehicle network but not designated as a gateway vehicle are not operable to invite non-member endpoints to access the virtual parked vehicle network. In other words, being designated as a gateway vehicle includes modifying the operation of the vehicle which is designated as the gateway vehicle so that it can invite non-member endpoints to access the virtual parked vehicle network, and members which have not been designated as a gateway vehicle have not been similarly modified, and as a result of their lacking this necessary modification, they cannot invite non-member endpoints to access the virtual parked vehicle network.

[0008] A problem with the virtual parked vehicle network is that it includes a wireless communication channel for inviting non-member endpoints to access the virtual parked vehicle network and this channel becomes overloaded if each of the parked vehicles is allowed to act as a gateway vehicle for the virtual parked vehicle network. The gateway selection system described herein solves this problem by: (1) selecting which of the parked vehicles of the virtual parked vehicle network are designated as gateway vehicles; and (2) limiting the number of parked vehicles which are designated as gateway vehicles so that the overall number of invitations transmitted to non-member endpoints to access the virtual parked vehicle network is limited to a level which prevents the wireless communication channel for inviting non-member endpoints from becoming overloaded.

[0009] A system of one or more computers can be configured to perform particular operations or actions by virtue of having software, firmware, hardware, or a combination of them installed on the system that in operation causes or cause the system to perform the actions. One or more computer programs can be configured to perform particular operations or actions by virtue of including instructions that, when executed by data processing apparatus, cause the apparatus to perform the actions.

[0010] One general aspect includes a method for selecting one or more gateway vehicles for a virtual parked vehicle network including a plurality of parked vehicles that are members of the virtual parked vehicle network, the method including: assigning position data to the plurality of parked vehicles which describes a plurality of unique position values for the plurality of parked vehicles in the virtual parked vehicle network; and designating a parked vehicle having a lowest position value in the plurality of unique position values as a gateway vehicle for the virtual parked vehicle network, where the gateway vehicle is an only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network, the method is executed by a processor of the parked vehicle and the parked vehicle is assigned the lowest position value because it is executing the method. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0011] Implementations may include one or more of the following features. The method where the virtual parked vehicle network stores data for one or more non-parked vehicles that are not part of the virtual parked vehicle network using one or more non-transitory memories of the plurality of parked vehicles and the data is electronically transmissible via the gateway vehicle. In some embodiments, data is electronically transmissible if it is capable of

being sent, received, accessed or retrieved via the gateway vehicle. The method where the virtual parked vehicle network processes data for one or more non-parked vehicles that are not part of the virtual parked vehicle network and the data is electronically transmissible via the gateway vehicle. The method where one or more other parked vehicles in the plurality that are not designated as the gateway vehicle are assigned their unique position values based on their real-world geographic position relative to a real-world geographic position of the parked vehicle that is designated as the gateway vehicle. The method further including one or more other parked vehicles transmitting global positioning system ("GPS") data describing their real-world geographic position to the parked vehicle that is designated as the gateway vehicle, where the one or more other parked vehicles include members of the virtual parked vehicle network that are not designated as the gateway vehicle. The method further including determining the plurality of unique position values based on the GPS data received from the one or more other parked vehicles and digital data describing the real-world geographic position of the parked vehicle that is designated as the gateway vehicle. The method further including: determining a number of hops in the virtual parked vehicle network relative to the parked vehicle designated as the gateway vehicle; retrieving threshold data describing a threshold for limiting a total number of gateway vehicles in the virtual parked vehicle network, where the threshold is a positive whole number n; and designating one or more parked vehicles in the plurality of parked vehicles that are n hops from the parked vehicle designated as the gateway vehicle as one or more additional gateway vehicles for the virtual parked vehicle network, where the gateway vehicle and the one or more additional gateway vehicles are the only members of the virtual parked vehicle network that are operable to provide access to the virtual parked vehicle network. Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

[0012] One general aspect includes a system for selecting one or more gateway vehicles for a virtual parked vehicle network including a plurality of parked vehicles that are members of the virtual parked vehicle network, the system including: an onboard unit of a parked vehicle including a non-transitory memory storing computer code which, when executed by the onboard unit causes the onboard unit to execute steps including: assigning position data to the plurality of parked vehicles which describes a plurality of unique position values for the plurality of parked vehicles, where the parked vehicle is assigned a lowest position value in the plurality of unique position values because the onboard unit of the parked vehicle is executing the steps; and designating the parked vehicle having the lowest position value in the plurality of unique position values as a gateway vehicle for the virtual parked vehicle network, where the gateway vehicle is an only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0013] Implementations may include one or more of the following features. The system where the virtual parked vehicle network stores data for one or more non-parked vehicles that are not part of the virtual parked vehicle network using one or more non-transitory memories of the plurality of parked vehicles and the data is electronically transmissible via the gateway vehicle. The system where the virtual parked vehicle network processes data for one or more non-parked vehicles that are not part of the virtual parked vehicle network and the data is electronically transmissible via the gateway vehicle. The system where one or more other parked vehicles in the plurality that are not designated as the gateway vehicle are assigned their unique position values based on their real-world geographic position relative to a real-world geographic position of the parked vehicle that is designated as the gateway vehicle. The system further including one or more other parked vehicles transmitting GPS data describing their real-world geographic position to the parked vehicle that is designated as the gateway vehicle, where the one or more other parked vehicles include members of the virtual parked vehicle network that are not designated as the gateway vehicle. The system where the steps further include determining the plurality of unique position values based on the GPS data received from the one or more other parked vehicles and digital data describing the real-world geographic position of the parked vehicle that is designated as the gateway vehicle. The system where the steps further include: determining a number of hops in the virtual parked vehicle network relative to the parked vehicle designated as the gateway vehicle; retrieving threshold data describing a threshold for limiting a total number of gateway vehicles in the virtual parked vehicle network, where the threshold is a positive whole number n; and designating one or more parked vehicles in the plurality of parked vehicles that are n hops from the parked vehicle designated as the gateway vehicle as one or more additional gateway vehicles for the virtual parked vehicle network, where the gateway vehicle and the one or more additional gateway vehicles are the only members of the virtual parked vehicle network that are operable to provide access to the virtual parked vehicle network. Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

[0014] One general aspect includes a method for selecting one or more gateway vehicles for a virtual parked vehicle network including a plurality of parked vehicles, the method including: receiving GPS data for the plurality of parked vehicles included in the virtual parked vehicle network; for each non-gateway vehicle included in the virtual parked vehicle network, determining their first average distance to all the other non-gateway vehicles in the virtual parked vehicle network based on the GPS data; and designating a non-gateway vehicle having a highest value for first average distance as a gateway vehicle for the virtual parked vehicle network, where the gateway vehicle is an only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network for one or more other vehicles which are not members of the virtual parked vehicle network. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0015] Implementations may include one or more of the following features. The method where the first average distance for a particular non-gateway vehicle is a sum of its

average distances to all the other non-gateway vehicles, as determined based on the GPS data, divided by a total number of non-gateway vehicles included in the virtual parked vehicle network. The method where the total number of non-gateway vehicles is determined based on unique instances of GPS data and the total number of non-gateway vehicles is decreased by one after the gateway vehicle is designated. The method further including: determining whether a threshold number of gateway vehicles is exceeded; responsive to the threshold number not being exceeded, determining, for each non-gateway vehicle included in the virtual parked vehicle network, a second average distance to the gateway vehicle; and designating the non-gateway vehicle having a highest value for the second average distance as an additional gateway vehicle for the virtual parked vehicle network, where the gateway vehicle and the additional gateway vehicle are the only members of the virtual parked vehicle network that are operable to provide access to the virtual parked vehicle network for the one or more other vehicles which are not members of the virtual parked vehicle network. The method where the threshold number is operable to limit a load for a designated channel used for inviting the one or more other vehicles which are not members of the virtual parked vehicle network to access the virtual parked vehicle network. Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The disclosure is illustrated by way of example, and not by way of limitation in the figures of the accompanying drawings in which like reference numerals are used to refer to similar elements.

[0017] FIG. **1**A is a block diagram illustrating an operating environment for a virtual parked vehicle network according to some embodiments.

[0018] FIG. **1**B is a block diagram illustrating a cluster of parked vehicles included in the operating environment according to some embodiments.

[0019] FIG. **1**C is a block diagram illustrating communication ranges for a first gateway vehicle and second gateway vehicle of the virtual parked vehicle network included in the operating environment according to some embodiments.

[0020] FIG. **1**D is a block diagram illustrating a virtual cord included in the operating environment according to some embodiments.

[0021] FIG. **1**E is a block diagram illustrating an operating environment for a gateway selection system of a parked vehicle included in a virtual parked vehicle network according to some embodiments.

[0022] FIG. **2** is a block diagram illustrating an example computer system including the gateway selection system of a vehicle according to some embodiments.

[0023] FIG. **3** is an example flow diagram of a method for selecting one or more gateway vehicles for the virtual parked vehicle network based on position data for the members of the virtual parked vehicle network, according to some embodiments.

[0024] FIG. **4** is an example flow diagram of a method for selecting one or more gateway vehicles for the virtual parked vehicle network based on GPS data for the members of the virtual parked vehicle network, according to some embodiments.

DETAILED DESCRIPTION

[0025] Referring to FIG. **1**A, depicted is an operating environment **100** for a gateway selection system of a virtual parked vehicle network **104** according to some embodiments.

[0026] The virtual parked vehicle network **104** is a wireless communication network formed by a plurality of parked vehicles which are each within wireless communication range of one another using a wireless communication protocol which is common to each of the plurality of parked vehicles and used to form the virtual parked vehicle network **104**. The wireless communication protocol used to form the virtual parked vehicle network **104** is any form of wireless communication described below with reference to the network **105**. For example, the wireless communication protocol used to form the virtual parked vehicle network **104** is Dedicated Short Range Communication ("DSRC") and each of the plurality of parked vehicles that are members of the virtual parked vehicle network **104** are DSRC-enabled vehicles which include any hardware or software necessary to comply with one or more of the following DSRC standards, including any derivative or fork thereof: EN 12253:2004 Dedicated Short-Range Communication—Physical layer using microwave at 5.8 GHz (review); EN 12795:2002 Dedicated Short-Range Communication (DSRC)—DSRC Data link layer: Medium Access and Logical Link Control (review); EN 12834:2002 Dedicated Short-Range Communication—Application layer (review); and EN 13372:2004 Dedicated Short-Range Communication (DSRC)—DSRC profiles for RTTT applications (review); EN ISO 14906:2004 Electronic Fee Collection—Application interface.

[0027] As depicted in FIG. **1**A, the following vehicles are members of the virtual parked vehicle network **104**: a first parked vehicle **123**A; a second parked vehicle **123**B; a third parked vehicle **123**C; a fourth parked vehicle **123**D; a fifth parked vehicle **123**E; and a sixth parked vehicle **123**F. This plurality of parked vehicles **123**A, **123**B, **123**C, **123**D, **123**E, **123**F can be referred to individually as the "vehicle **123**" or the "parked vehicle **123**," or collectively as the "vehicles **123**" or the "plurality of parked vehicles **123**." The plurality of parked vehicles **123** are each parked so long as they are members of the virtual parked vehicle network **104**. The plurality of parked vehicles **123** individually include their own onboard unit which is powered on while they are members of the virtual parked vehicle network **104**. See, for example, FIG. **1**E.

[0028] In some embodiments, only connected vehicles can become members of the virtual parked vehicle network **104**. In some embodiments, a connected vehicle is a vehicle that includes a communication unit **145** as described below with reference to FIG. **1**E (or some component providing functionality which is similar to the communication unit **145**).

[0029] In some embodiments, each of the plurality of parked vehicles **123** includes a gateway selection system **199** (see, e.g., FIGS. **1**E and **2**). In some embodiments, less than all of the plurality of parked vehicles **123** include the gateway selection system **199**.

[0030] Although six parked vehicles **123** are depicted as members of the virtual parked vehicle network **104** in FIG. **1**A, in practice the virtual parked vehicle network **104** can include any positive whole number of parked vehicles **123**, including just one parked vehicle **123**.

[0031] As depicted in FIG. **1**A, the fifth parked vehicle **123**E and the sixth parked vehicle **123**F are designated by

the gateway selection system **199** (which is, at a minimum, an element of one of the plurality of parked vehicles **123**) as a first gateway vehicle and a second gateway vehicle, respectively. In some embodiments, a gateway vehicle is a parked vehicle that is a member of the virtual parked vehicle network **104** and is operable to invite non-member endpoints (e.g., the non-parked first vehicle **124**A and the non-parked second vehicle **124**B) to access the virtual parked vehicle network **104** (e.g., to receive one or more services from the virtual parked vehicle network **104**). Parked vehicles **123** which are members of the virtual parked vehicle network **104** but not designated as a gateway vehicle (such as, in the depicted embodiment, the first parked vehicle **123**A, the second parked vehicle **123**B, the third parked vehicle **123**C and the fourth parked vehicle **123**D), are not operable to invite non-member endpoints to access the virtual parked vehicle network **104**.

[0032] In some embodiments, being designated as a gateway vehicle includes the gateway selection system **199** modifying the operation of the parked vehicle **123** which is designated as the gateway vehicle so that it can invite non-member endpoints to access the virtual parked vehicle network **104**, and members of the virtual parked vehicle network **104** which have not been designated as a gateway vehicle have not been similarly modified, and as a result, these unmodified members cannot invite non-member endpoints to access the virtual parked vehicle network **104**.

[0033] In some embodiments, the first non-parked vehicle **124**A and the second non-parked vehicle **124**B are vehicles which are not parked and also not members of the virtual parked vehicle network **104**. For example, the first non-parked vehicle **124**A and the second non-parked vehicle **124**B are traveling on roadways near a parking lot where the plurality of parked vehicles **123** are located. In some embodiments, the first non-parked vehicle **124**A and the second non-parked vehicle **124**B include a gateway selection system **199** and a communication unit (e.g., the communication unit **145** depicted in FIGS. **1**E and **2**) which enables them to wirelessly communicate with the virtual parked vehicle network **104**.

[0034] A first example service provided by the virtual parked vehicle network **104** is now described. In some embodiments, the non-transitory memories of the plurality of parked vehicles **123** which are members of the virtual parked vehicle network **104** store data for other endpoints that are not members of the virtual parked vehicle network **104** (e.g., non-parked vehicles **124**A, **124**B) that are located within wireless communication range of the virtual parked vehicle network **104**. An endpoint that is not a member of the virtual parked vehicle network **104** may be referred to herein as a "non-member endpoint" if referenced in the singular, or "non-member endpoints" if referenced in the plural.

[0035] A second example service provided by the virtual parked vehicle network **104** is now described. In some embodiments, the processors or onboard units of the plurality of parked vehicles **123**, which are members of the virtual parked vehicle network **104**, execute operations and process data for the non-member endpoints.

[0036] The plurality of parked vehicles **123** are each communicatively coupled to the virtual parked vehicle network **104**. The virtual parked vehicle network **104** itself is optionally communicatively coupled to a network **105**. For example, one or more of the parked vehicles **123** included in the plurality of parked vehicles **123** includes a communication unit **145** (as described below with reference to FIGS. **1**E and **2**) which enables the one or more parked vehicles **123** to provide the virtual parked vehicle network **104** with access to the network **105**.

[0037] The network **105** may be a conventional type, wired or wireless, and may have numerous different configurations including a star configuration, token ring configuration, or other configurations. Furthermore, the network **105** may include a local area network (LAN), a wide area network (WAN) (e.g., the Internet), or other interconnected data paths across which multiple devices and/or entities may communicate. In some embodiments, the network **105** may include a peer-to-peer network. The network **105** may also be coupled to or may include portions of a telecommunications network for sending data in a variety of different communication protocols. In some embodiments, the network **105** includes Bluetooth® communication networks or a cellular communications network for sending and receiving data including via short messaging service (SMS), multimedia messaging service (MMS), hypertext transfer protocol (HTTP), direct data connection, wireless application protocol (WAP), e-mail, DSRC, full-duplex wireless communication, mmWave, WiFi (infrastructure mode), WiFi (ad-hoc mode), visible light communication, TV white space communication and satellite communication. The network **105** may also include a mobile data network that may include 3G, 4G, 5G, LTE, LTE-V2X, LTE-D2D, VoLTE or any other mobile data network or combination of mobile data networks. Further, the network **105** may include one or more IEEE 802.11 wireless networks.

[0038] In some embodiments, one or more of the plurality of parked vehicles **123** and the non-member endpoints is a DSRC-equipped vehicle. The network **105** may include one or more communication channels shared among one or more of the plurality of parked vehicles **123** and the virtual parked vehicle network **104**. The communication channel may include DSRC, LTE, LTE-D2D, mmWave, WiFi (infrastructure mode), WiFi (ad-hoc mode), visible light communication, TV white space communication, satellite communication, full-duplex wireless communication or any other wireless communication protocol such as those mentioned above.

[0039] The parked vehicles **123**, the first non-parked vehicles **124**A and the second non-parked vehicle **124**B are any type of vehicle. For example, the parked vehicle **123** is one of the following types of vehicles: a car; a truck; a sports utility vehicle; a bus; a semi-truck; a drone or any other roadway-based conveyance.

[0040] In some embodiments, one or more of the parked vehicles **123**, the first non-parked vehicles **124**A and the second non-parked vehicle **124**B are an autonomous vehicle or a semi-autonomous vehicle. For example, the first non-parked vehicle **124**A includes a set of Advanced Driver Assistance Systems (a set of "ADAS systems") which provide autonomous features to the first non-parked vehicle **124**A which are sufficient to render the first non-parked vehicle **124**A an autonomous vehicle.

[0041] The National Highway Traffic Safety Administration ("NHTSA") has defined different "levels" of autonomous vehicles, e.g., Level 0, Level 1, Level 2, Level 3, Level 4 and Level 5. If an autonomous vehicle has a higher level number than another autonomous vehicle (e.g., Level 3 is a higher level number than Levels 2 or 1), then the autonomous vehicle with a higher level number offers a greater

combination and quantity of autonomous features relative to the vehicle with the lower level number. The different levels of autonomous vehicles are described briefly below.

[0042] Level 0: The set of ADAS systems installed in a vehicle have no vehicle control, but may issue warnings to the driver of the vehicle. A vehicle which is Level 0 is not an autonomous or semi-autonomous vehicle.

[0043] Level 1: The driver must be ready to take driving control of the autonomous vehicle at any time. The set of ADAS systems installed in the autonomous vehicle may provide autonomous features such as one or more of the following: Adaptive Cruise Control ("ACC"); and Parking Assistance with automated steering and Lane Keeping Assistance ("LKA") Type II, in any combination.

[0044] Level 2: The driver is obliged to detect objects and events in the roadway environment and respond if the set of ADAS systems installed in the autonomous vehicle fail to respond properly (based on the driver's subjective judgement). The set of ADAS systems installed in the autonomous vehicle executes accelerating, braking, and steering. The set of ADAS systems installed in the autonomous vehicle can deactivate immediately upon takeover by the driver.

[0045] Level 3: Within known, limited environments (such as freeways), the driver can safely turn their attention away from driving tasks, but must still be prepared to take control of the autonomous vehicle when needed.

[0046] Level 4: The set of ADAS systems installed in the autonomous vehicle can control the autonomous vehicle in all but a few environments such as severe weather. The driver must enable the automated system (which is comprised of the set of ADAS systems installed in the vehicle) only when it is safe to do so. When the automated system is enabled, driver attention is not required for the autonomous vehicle to operate safely and consistent with accepted norms.

[0047] Level 5: Other than setting the destination and starting the system, no human intervention is required. The automated system can drive to any location where it is legal to drive and make its own decision (which may vary based on the jurisdiction where the vehicle is located).

[0048] A highly autonomous vehicle ("HAV") is an autonomous vehicle that is Level 3 or higher.

[0049] Accordingly, in some embodiments the parked vehicle **123** is one of the following: a Level 1 autonomous vehicle; a Level 2 autonomous vehicle; a Level 3 autonomous vehicle; a Level 4 autonomous vehicle; a Level 5 autonomous vehicle; and an HAV.

[0050] Referring now to FIG. **1**B, depicted is a block diagram illustrating a cluster **153** of parked vehicles **123** included in the operating environment **101** according to some embodiments. The cluster **153** includes the plurality of parked vehicles **123** that are members of the virtual parked vehicle network **104**. In some embodiments, the area of the cluster **153** is a function of the range of the wireless communication protocol used among the plurality of parked vehicles **123** to form the virtual parked vehicle network **104** and the nearest parked vehicle in the parking lot that is eligible to be a member of the virtual parked vehicle network **104** but outside of the range of the wireless communication protocol used to form the virtual parked vehicle network **104**. For example, if DSRC is used to form the virtual parked vehicle network **104**, and the range of DSRC is about 500 meters, then a parked vehicle in the parking lot which his otherwise eligible but greater than 500 meters from the nearest parked vehicle **123** that is a member of the virtual parked vehicle network **104** would contribute to limiting the total area of the cluster **153**.

[0051] Referring now to FIG. **1**C, depicted is a block diagram illustrating communication ranges for a first gateway vehicle (which, in the depicted embodiment, is the fifth parked vehicle **123**E, and as such, will be referred to as the first gateway vehicle **123**E when described with reference to FIG. **1**C) and a second gateway vehicle (which, in the depicted embodiment, is the sixth parked vehicle **123**F, and as such, will be referred to as the second gateway vehicle **123**F when described with reference to FIG. **1**C) of the virtual parked vehicle network **104** included in the operating environment **101** according to some embodiments.

[0052] In the depicted embodiment, the first non-parked vehicle **124**A is within a first communication range **151** of the first gateway vehicle **123**E. Accordingly, the first gateway vehicle **123**E can transmit an invitation to the first non-parked vehicle **124**A to access one or more services provided by the virtual parked vehicle network **104**. The dotted line joining the first non-parked vehicle **124**A and the first gateway vehicle **123**E in FIG. **1**C represents a wireless communication including the invitation and a wireless communication including a response to the invitation. Note, however, that the second parked vehicle **123**B cannot transmit an invitation to the first non-parked vehicle **124**A because the second parked vehicle **123**B is not designated as a gateway vehicle of the virtual parked vehicle network **104** in the depicted embodiment. For example, only vehicles designated as a gateway vehicle have been modified by the gateway selection system **199**, depicted in FIGS. **1**E and **2**, to include the computer code which is necessary to generate or transmit such an invitation.

[0053] In the depicted embodiment, the second non-parked vehicle **124**B is within a second communication range **152** of the second gateway vehicle **123**F. Accordingly, the second gateway vehicle **123**F can transmit an invitation to the second non-parked vehicle **124**B to access one or more services provided by the virtual parked vehicle network **104**. Note, however, that the third parked vehicle **123**C cannot transmit an invitation to the second non-parked vehicle **124**B because the third parked vehicle **123**C is not designated as a gateway vehicle of the virtual parked vehicle network **104** in the depicted embodiment. The dotted line joining the second non-parked vehicle **124**B and the second gateway vehicle **123**F in FIG. **1**C represents a wireless communication including the invitation and a wireless communication including a response to the invitation.

[0054] Referring now to FIG. **1**D, depicted is a block diagram illustrating a virtual cord **197** included in the operating environment **101** according to some embodiments. Note in FIG. **1**D that the fifth parked vehicle **123**E and the sixth parked vehicle **123**F are not depicted with a shaded block because in some embodiments described with reference to FIG. **1**D these parked vehicles are not designated as gateway vehicles.

[0055] In some embodiments the virtual cord **197** organizes how one or more of the parked vehicles **123** included in the virtual parked vehicle network **104** are selected to be gateway vehicles for the virtual parked vehicle network **104**. For example, the virtual cord **197** includes each of the plurality of parked vehicles **123** included in the virtual parked vehicle network **104**, and defines their position within the virtual parked vehicle network **104**. The position

for each of the plurality of parked vehicles **123** is described by position data **184**, which is depicted in FIG. **1**E.

[0056] In the depicted embodiment, a first end of the virtual cord **197** is the first parked vehicle **123**A, which is assigned a position value, P, equal to 0 within the virtual cord **197**; this is a lowest position value within the virtual cord **197**. In some embodiments, the first parked vehicle **123**A is designated as a gateway vehicle because it is assigned the lowest position value.

[0057] The second end of the virtual cord is the sixth parked vehicle **123**F, which his assigned a position value, E, equal to 1 within the virtual cord **197**; this is a highest position value within the virtual cord **197**. All other assigned position values for the plurality of vehicles **123** are between 0 and 1. The second parked vehicle **123**B is assigned position value equal to P+A where P=0 and A is a positive real number which is greater than 0 and less than 1. The second parked vehicle **123**B is one hop from the first parked vehicle **123**A, which may be the gateway vehicle as described in the preceding paragraph. The third parked vehicle **123**C is assigned position value equal to P+(A+B) where P=0 and B is a positive real number which is greater than 0 and less than 1, and the sum of P+A+B is less than 1. The third parked vehicle **123**C is two hops from the first parked vehicle **123**A. The fourth parked vehicle **123**D is assigned position value equal to P+(A+B+C) where P=0 and C is a positive real number which is greater than 0 and less than 1, and the sum of P+A+B+C is less than 1. The fourth parked vehicle **123**D is three hops from the first parked vehicle **123**A. The fifth parked vehicle **123**E is assigned position value equal to P+(A+B+C+D) where P=0 and D is a positive real number which is greater than 0 and less than 1, and the sum of P+A+B+C+D is less than 1. The fifth parked vehicle **123**E is four hops from the first parked vehicle **123**A. The sixth parked vehicle **123**F is assigned position value equal to 1 because it is the second end of the virtual cord **197**. The sixth parked vehicle **123**F is five hops from the first parked vehicle **123**A.

[0058] In some embodiments, a threshold limits a total number of gateway vehicles in the virtual parked vehicle network **104**, where the threshold is a positive whole number n and is described by threshold data **188** which is depicted in FIG. **1**E. The gateway selection system **199** of the gateway vehicle, which is the first parked vehicle **123**A in the depicted embodiment, designates one or more parked vehicles **123** in the virtual cord **197** that are n hops from the parked vehicle designated as the gateway vehicle as one or more additional gateway vehicles for the virtual parked vehicle network **104**, where the gateway vehicle and the one or more additional gateway vehicles are the only members of the virtual parked vehicle network **104** that are operable to provide access to the virtual parked vehicle network **104** (e.g., via an invitation).

[0059] Referring now to FIG. **1**E, depicted is a block diagram illustrating an operating environment **100** for a gateway selection system **199** of a parked vehicle **123** included in a virtual parked vehicle network **104** according to some embodiments.

[0060] In some embodiments, the parked vehicle **123** includes one or more of the following elements: a processor **125**; a memory **127**; a communication unit **145**; a DSRC-compliant GPS unit **150**; a sensor set **155**; an onboard unit **144**; and a gateway selection system **199**. These elements of the parked vehicle **123** are communicatively coupled to one another via a bus **120**.

[0061] In some embodiments, the processor **125** and the memory **127** may be elements of an onboard vehicle computer system (such as computer system **200** described below with reference to FIG. **2**). The onboard vehicle computer system may be operable to cause or control the operation of the gateway selection system **199**. The onboard vehicle computer system may be operable to access and execute the data stored on the memory **127** to provide the functionality described herein for the gateway selection system **199** or its elements (see, e.g., FIG. **2**). The onboard vehicle computer system may be operable to execute the gateway selection system **199** which causes the onboard vehicle computer system to execute one or more of the steps of the method **300** described below with reference to FIGS. **3**A and **3**B.

[0062] In some embodiments, the processor **125** and the memory **127** may be elements of onboard unit **144**. The onboard unit **144** includes an electronic control unit (herein "ECU") or an onboard vehicle computer system that may be operable to cause or control the operation of the gateway selection system **199**. The onboard unit **144** may be operable to access and execute the data stored on the memory **127** to provide the functionality described herein for the gateway selection system **199** or its elements. The onboard unit **144** may be operable to execute the gateway selection system **199** which causes the onboard unit **144** to execute one or more of the steps of the method **300** described below with reference to FIGS. **3**A and **3**B. In some embodiments, the computer system **200** depicted in FIG. **2** is an example of an onboard unit **144**.

[0063] In some embodiments, the DSRC-compliant GPS unit **150** includes any hardware and software necessary to make the parked vehicle **123** or the DSRC-compliant GPS unit **150** compliant with one or more of the following DSRC standards, including any derivative or fork thereof: EN 12253:2004 Dedicated Short-Range Communication—Physical layer using microwave at 5.8 GHz (review); EN 12795:2002 Dedicated Short-Range Communication (DSRC)—DSRC Data link layer: Medium Access and Logical Link Control (review); EN 12834:2002 Dedicated Short-Range Communication—Application layer (review); and EN 13372:2004 Dedicated Short-Range Communication (DSRC)—DSRC profiles for RTTT applications (review); EN ISO 14906:2004 Electronic Fee Collection—Application interface.

[0064] In some embodiments, the DSRC-compliant GPS unit **150** is operable to provide GPS data **186** describing the location of vehicle **123** with space-level accuracy. For example, the parked vehicle **123** is parked in a parking space of a parking lot. Space-level accuracy means that the location of the parked vehicle **123** is described by the GPS data **186** so accurately that the parked vehicle's **123** parking space within the parking lot may be accurately determined based on the GPS data **186** for this parked vehicle **123**. In the context of the gateway selection system **199**, space-level accuracy enables the gateway selection system **199** to more accurately determine whether a particular parked vehicle **123** is a gateway vehicle (see, e.g., FIG. **4**) as determined based on the GPS data for each of the parked vehicles within the virtual parked vehicle network **104**. Space-level accuracy means that the geographic position of the parked vehicle **123** is described by the GPS data **186** with an

accuracy of plus or minus 1.5 meters relative to an actual geographic position of the parked vehicle **123** in the real-world.

[0065] In some embodiments, the DSRC-compliant GPS unit **150** includes hardware that wirelessly communicates with a GPS satellite to retrieve GPS data **186** that describes the geographic location of the parked vehicle **123** with a precision that is compliant with the DSRC standard. The DSRC standard requires that GPS data **186** be precise enough to infer if two vehicles (one of which is, for example, the parked vehicle **123**) are located in adjacent parking spaces. In some embodiments, the DSRC-compliant GPS unit **150** is operable to identify, monitor and track its two-dimensional position within 1.5 meters of its actual position 68% of the time under an open sky. Since parking spaces are typically no less than 3 meters wide, whenever the two-dimensional error of the GPS data **186** is less than 1.5 meters the gateway selection system **199** described herein may analyze the GPS data **186** provided by the DSRC-compliant GPS unit **150** and determine what parking space the parked vehicle **123** is parked in based on the relative positions of two or more different parked vehicles (one of which is, for example, the parked vehicle **123**) in a parking lot at the same time.

[0066] By comparison to the DSRC-compliant GPS unit **150**, a conventional GPS unit which is not compliant with the DSRC standard is unable to determine the location of a vehicle **123** with space-level accuracy. For example, a typical parking space is approximately 3 meters wide. However, a conventional GPS unit only has an accuracy of plus or minus 10 meters relative to the actual location of the parked vehicle **123**. As a result, such conventional GPS units are not sufficiently accurate for use by the gateway selection system **199** in some embodiments since they would not enable the gateway selection system **199** to accurately identify average distances as described below with reference to FIG. **4**.

[0067] The sensor set **155** may include one or more sensors that are operable to measure the physical environment outside of the parked vehicle **123**. For example, the sensor set **155** may include one or more sensors that record one or more physical characteristics of the physical environment that is proximate to the parked vehicle **123**. The memory **127** may store sensor data that describes the one or more physical characteristics recorded by the sensor set **155**. The sensor data may be used by the gateway selection system **199** to confirm or deny the GPS data **186** or other data stored in the memory **127**. For example, the GPS data **186** may indicate that the parked vehicle **123** is located near a particular landmark, and the sensor data may include an image that includes the particular landmark, thereby confirming the accuracy of the GPS data **186**.

[0068] In some embodiments, the sensor set **155** may include one or more of the following vehicle sensors: a camera; a LIDAR sensor; a radar sensor; a laser altimeter; an infrared detector; a motion detector; a thermostat; a sound detector, a carbon monoxide sensor; a carbon dioxide sensor; an oxygen sensor; a mass air flow sensor; an engine coolant temperature sensor; a throttle position sensor; a crank shaft position sensor; an automobile engine sensor; a valve timer; an air-fuel ratio meter; a blind spot meter; a curb feeler; a defect detector; a Hall effect sensor, a manifold absolute pressure sensor; a parking sensor; a radar gun; a speedometer; a speed sensor; a tire-pressure monitoring sensor; a torque sensor; a transmission fluid temperature sensor; a turbine speed sensor (TSS); a variable reluctance sensor; a vehicle speed sensor (VSS); a water sensor; a wheel speed sensor; and any other type of automotive sensor.

[0069] The processor **125** includes an arithmetic logic unit, a microprocessor, a general-purpose controller, or some other processor array to perform computations and provide electronic display signals to a display device. The processor **125** processes data signals and may include various computing architectures including a complex instruction set computer (CISC) architecture, a reduced instruction set computer (RISC) architecture, or an architecture implementing a combination of instruction sets. The parked vehicle **123** may include one or more processors **125**. Other processors, operating systems, sensors, displays, and physical configurations may be possible.

[0070] The memory **127** is a non-transitory memory that stores instructions or data that may accessed and executed by the processor **125**. The instructions or data may include code for performing the techniques described herein. The memory **127** may be a dynamic random access memory (DRAM) device, a static random access memory (SRAM) device, flash memory, or some other memory device. In some embodiments, the memory **127** also includes a non-volatile memory or similar permanent storage device and media including a hard disk drive, a floppy disk drive, a CD-ROM device, a DVD-ROM device, a DVD-RAM device, a DVD-RW device, a flash memory device, or some other mass storage device for storing information on a more permanent basis. A portion of the memory **127** may be reserved for use as a buffer or virtual random access memory (virtual RAM). The parked vehicle **123** may include one or more memories **127**.

[0071] The memory **127** of the parked vehicle **123** stores one or more of the following types of digital data: position data **184**; gateway data **185**; GPS data **186**; hop data **187**; threshold data **188**; and network data **189**.

[0072] The position data **184** is digital data that describes a plurality of unique position values for each of the plurality of parked vehicles **123** included in the virtual parked vehicle network **104**. In some embodiments, the parked vehicle **123** including the gateway selection system **199** which assigns the position data **184** to the plurality of parked vehicles **123** is assigned a lowed assigned position value (e.g., 0). In some embodiments, the lowed assigned position value for any given virtual parked vehicle network **104** is always 0 and a highest assigned position value for any given virtual parked vehicle network **104** is always 1, with any other parked vehicles **123** being assigned a position value between 0 and 1. In some embodiments, the position data **184** is assigned based on the GPS data **186** for the plurality of parked vehicles **123**.

[0073] The gateway data **185** is digital data that describe which of the parked vehicles **123** included in the plurality of parked vehicles **123** included in the virtual parked vehicle network **104** is designated as a gateway vehicle. The gateway data **185** may also include the first distance data and the second distance data described below with reference to FIG. **4**.

[0074] The GPS data **186** is digital data that describes one or more of the following: (1) a location of the parked vehicle **123**; and (2) a current time for the parked vehicle **123**. In some embodiments, the GPS data **186** describes the location

of the vehicle with space-level precision. For example, the GPS data **186** is received from the DSRC-compliant GPS unit **150** and describes the current location of the parked vehicle **123** with such precision that the location of the parked vehicle **123** within a particular parking space of a parking lot is identifiable based on the GPS data **186**.

[0075] In some embodiments, each of the plurality of parked vehicles **123** transmits or broadcasts a DSRC message to the other parked vehicles **123** included in the plurality, and this DSRC message includes the GPS data **186** for the parked vehicle **123** which transmits or broadcasts this DSRC message. This transmission or broadcast may occur at regular intervals. For example, the DSRC message is a Basic Safety Message ("BSM message") which includes the GPS data **186** and is transmitted at regular intervals as specified by the DSRC standard.

[0076] The hop data **187** is digital data that describes one or more of the following: (1) a number of hops in the virtual parked vehicle network **104**; (2) for each parked vehicle **123** included in the virtual parked vehicle network **104**, the number of hops separating it from parked vehicle **123** having the lowest position value as described by the position data **184**; and (3) for each parked vehicle **123** included in the virtual parked vehicle network **104**, the number of hops separating it from one or more gateway vehicles for the virtual parked vehicle network **104**.

[0077] The threshold data **188** is digital data that describes a threshold for limiting the total number of gateway vehicles in the virtual parked vehicle network **104**. In some embodiments, the threshold is a value n and the value is a positive whole number which is less than the total number of parked vehicles **123** included in the virtual parked vehicle network **104**. In some embodiments, the threshold described by the threshold data **188** is operable to prevent a channel which is used to send invitations to access the virtual parked vehicle network **104** from becoming overloaded due to wireless messages including invitations. In some embodiments, the threshold may be updated based on measured load for this channel, such that some gateway vehicles may have their designation as a gateway vehicle revoked.

[0078] The network data **189** is digital data that identifies each of the parked vehicles **123** included in the virtual parked vehicle network **104** at any given time and any information about these parked vehicles that is included in the DSRC messages or BSM messages that they transmit or broadcast.

[0079] The communication unit **145** transmits and receives data to and from a virtual parked vehicle network **104**, a network **105** or to another communication channel. For example, the communication unit **145** includes any hardware or software necessary to enable the communication unit **145** to send and receive wireless messages via one or more of the following interface types (herein referred to as the "plurality of different interface types"); DSRC; LTE; LTE-D2D; mmWave; WiFi (infrastructure mode); WiFi (ad-hoc mode); visible light communication; TV white space communication; and satellite communication.

[0080] In some embodiments, if the communication unit **145** is an element of a parked vehicle **123** that is not designated as a gateway vehicle, then the communication unit **145** is configured or made operable so that the communication unit **145** is unable to transmit invitations using a channel that is reserved for sending invitations.

[0081] In some embodiments, the communication unit **145** includes a DSRC transceiver, a DSRC receiver and other hardware or software necessary to make the parked vehicle **123** (and, optionally, one or more of the first non-parked vehicle **124**A and the second non-parked vehicle **124**B) a DSRC-enabled device such as a DSRC-enabled vehicle.

[0082] In some embodiments, the communication unit **145** includes a port for direct physical connection to the network **105** or to another communication channel. For example, the communication unit **145** includes a universal serial bus (USB), secure digital (SD), CAT-5, or similar port for wired communication with the network **105**. In some embodiments, the communication unit **145** includes a wireless transceiver for exchanging data with the network **105** or other communication channels using one or more wireless communication methods, including: IEEE 802.11; IEEE 802.16, BLUETOOTH®; EN ISO 14906:2004 Electronic Fee Collection—Application interface EN 11253:2004 Dedicated Short-Range Communication—Physical layer using microwave at 5.8 GHz (review); EN 12795:2002 Dedicated Short-Range Communication (DSRC)—DSRC Data link layer: Medium Access and Logical Link Control (review); EN 12834:2002 Dedicated Short-Range Communication—Application layer (review); EN 13372:2004 Dedicated Short-Range Communication (DSRC)—DSRC profiles for RTTT applications (review); the communication method described in U.S. patent application Ser. No. 14/471,387 filed on Aug. 28, 2014 and entitled "Full-Duplex Coordination System"; or another suitable wireless communication method.

[0083] In some embodiments, the communication unit **145** includes a full-duplex coordination system as described in U.S. patent application Ser. No. 14/471,387 filed on Aug. 28, 2014 and entitled "Full-Duplex Coordination System."

[0084] In some embodiments, the communication unit **145** includes a cellular communications transceiver for sending and receiving data over a cellular communications network including via short messaging service (SMS), multimedia messaging service (MMS), hypertext transfer protocol (HTTP), direct data connection, WAP, e-mail, or another suitable type of electronic communication. In some embodiments, the communication unit **145** includes a wired port and a wireless transceiver. The communication unit **145** also provides other conventional connections to the network **105** for distribution of files or media objects using standard network protocols including TCP/IP, HTTP, HTTPS, and SMTP, millimeter wave, DSRC, etc.

[0085] The onboard unit **144** is a vehicular processor-based computing device. For example, the onboard unit **144** is an onboard vehicle computer system or an ECU of the parked vehicle **123**. In some embodiments, the onboard unit **144** is a special-purpose computing device which is operable to execute the gateway selection system **199**. In some embodiments, the gateway selection system is an element of the onboard unit **144**.

[0086] In some embodiments, the gateway selection system **199** includes code and routines that are operable, when executed by the processor **125**, to cause the processor **125** to execute one or more of the steps of the method **300** described below with reference to FIG. **3** or the method **400** described below with reference to FIG. **4**.

[0087] In some embodiments, the gateway selection system **199** of the parked vehicle **123** may be implemented using hardware including a field-programmable gate array

("FPGA") or an application-specific integrated circuit ("ASIC"). In some other embodiments, the gateway selection system **199** may be implemented using a combination of hardware and software. The gateway selection system **199** may be stored in a combination of the devices (e.g., servers or other devices) or parked vehicles **123**.

[0088] The gateway selection system **199** is described in more detail FIGS. **2**, **3** and **4**.

Example Computer System

[0089] Referring now to FIG. **2**, depicted is a block diagram illustrating an example computer system **200** including a gateway selection system **199** according to some embodiments.

[0090] In some embodiments, the computer system **200** may include a special-purpose computer system that is programmed to perform one or more steps of a method **300** described below with reference to FIG. **3**.

[0091] In some embodiments, the computer system **200** may include a special-purpose computer system that is programmed to perform one or more steps of a method **400** described below with reference to FIG. **4**.

[0092] In some embodiments, the computer system **200** is an onboard vehicle computer of the parked vehicle **123**. In some embodiments, the computer system **200** is an onboard unit **144** of the parked vehicle **123**. In some embodiments, the computer system **200** is an ECU, head unit or some other processor-based computing device of the parked vehicle **123**.

[0093] The computer system **200** may include one or more of the following elements according to some examples: the gateway selection system **199**; the processor **125**; the memory **127**; the communication unit **145**; the DSRC-compliant GPS unit **150**; and the sensor set **155**. The components of the computer system **200** are communicatively coupled by a bus **120**.

[0094] In the illustrated embodiment, the processor **125** is communicatively coupled to the bus **120** via a signal line **238**. The memory **127** is communicatively coupled to the bus **120** via a signal line **240**. The communication unit **145** is communicatively coupled to the bus **120** via a signal line **242**. The DSRC-compliant GPS unit **150** is communicatively coupled to the bus **120** via a signal line **244**. The sensor set **155** are communicatively coupled to the bus **120** via a signal line **246**.

[0095] The following elements of the computer system **200** were described above with reference to FIGS. **1**A-**1**E, and so, those descriptions will not be repeated here: the processor **125**; the memory **127**; the communication unit **145**; the DSRC-compliant GPS unit **150**; and the sensor set **155**.

[0096] The memory **127** may store any of the data described above with reference to FIGS. **1**A-**1**E. The memory **127** may store any data needed for the computer system **200** to provide its functionality.

[0097] In the illustrated embodiment shown in FIG. **2**, the gateway selection system **199** includes a communication module **202** and a determination module **204**.

[0098] The communication module **202** can be software including routines for handling communications between the gateway selection system **199** and other components of the computer system **200** or one or more of the operating environments **100**, **101**. In some embodiments, the communication module **202** can be a set of instructions executable by the processor **125** to provide the functionality described below for handling communications between the gateway selection system **199** and other components of the computer system **200**. In some embodiments, the communication module **202** can be stored in the memory **127** of the computer system **200** and can be accessible and executable by the processor **125**. The communication module **202** may be adapted for cooperation and communication with the processor **125** and other components of the computer system **200** via signal line **222**.

[0099] The communication module **202** sends and receives data, via the communication unit **145**, to and from one or more elements of the operating environment **100**. For example, the communication module **202** receives or transmits, via the communication unit **145**, one or more types of digital data stored on the memory **127**. The communication module **202** may send or receive any of the data or messages described above with reference to FIGS. **1**A-**1**E, or below with reference to FIGS. **3** and **4**, via the communication unit **145**.

[0100] In some embodiments, the communication module **202** receives data from components of the gateway selection system **199** and stores the data in the memory **127** (or a buffer or cache of the memory **127**). For example, the communication module **202** receives any of the data described above with reference to the memory **127** from the communication unit **145** (via the virtual parked vehicle network **104** or the network **105**) and stores this data in the memory **127** (or a buffer or cache of the memory **127**).

[0101] In some embodiments, the communication module **202** may handle communications between components of the gateway selection system **199**. For example, the communication module **202** may transmit GPS data **186** to the determination module **204**.

[0102] The determination module **204** can be software including routines for selecting one or more of the parked vehicles included in a virtual parked vehicle network **104** to designate as gateway vehicles and then causing the communication unit **145** to transmit digital data to the one or more designated gateway vehicles which configures these one or more parked vehicles **123** to operate as gateway vehicles. In some embodiments, the determination module **204** can be a set of instructions executable by the processor **125** which, when executed by the processor **125**, cause the processor **125** to execute one or more of the steps described below with reference to FIGS. **3** and **4**.

[0103] In some embodiments, the determination module **204** can be stored in the memory **127** of the computer system **200** and can be accessible and executable by the processor **125**. The determination module **204** may be adapted for cooperation and communication with the processor **125** and other components of the computer system **200** via signal line **224**.

Example Methods

[0104] Referring now to FIG. **3**, depicted is an method **300** for selecting one or more gateway vehicles for the virtual parked vehicle network based on position data for the members of the virtual parked vehicle network, according to some embodiments.

[0105] One or more of the steps described herein for the method **300** may be executed by one or more computer systems **200**.

[0106] At step **301**, one or more parked vehicles transmit or broadcast GPS data describing their real-world geographic position to a parked vehicle. The GPS data may be transmitted or broadcast via a DSRC message (e.g., a BSM message). A particular parked vehicle receives the wireless message that includes the GPS data. In some embodiments, this particular parked vehicle includes a gateway selection system **199** that executes the steps of the method **300**.

[0107] At step **303**, position data is assigned to the plurality of parked vehicles which describes a plurality of unique position values for the plurality of parked vehicles in the virtual parked vehicle network. In some embodiments, the method **300** is executed by a processor of a parked vehicle and the parked vehicle which is executing the method **300** is assigned the lowest position value. In some embodiments, the lowest assigned position value is 0 and the highest assigned position value is 1. In some embodiments, the plurality of unique position values are assigned based on the GPS data received from the one or more other parked vehicles and digital data describing the real-world geographic position of the parked vehicle that receives the GPS data at step **301**.

[0108] At step **305**, a parked vehicle having a lowest position value in the plurality of unique position values (e.g., position value=0) is designated as a gateway vehicle for the virtual parked vehicle network. In some embodiments, the gateway vehicle is the only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network.

[0109] At step **307**, a number of hops in the virtual parked vehicle network relative to the parked vehicle designated as the gateway vehicle is determined. This number is stored as hop data.

[0110] At step **309**, threshold data describing a threshold for limiting a total number of gateway vehicles in the virtual parked vehicle network is retrieved. In some embodiments, the threshold is a positive whole number n that is less than the total number of parked vehicles in the virtual parked vehicle network.

[0111] At step **311**, one or more parked vehicles in the plurality of parked vehicles that are n hops from the parked vehicle designated as the gateway vehicle are designated as one or more additional gateway vehicles for the virtual parked vehicle network. In some embodiments, the gateway vehicle and the one or more additional gateway vehicles are the only members of the virtual parked vehicle network that are operable to provide access to the virtual parked vehicle network.

[0112] Referring now to FIG. **4**, depicted is an example flow diagram of a method **400** for selecting one or more gateway vehicles for the virtual parked vehicle network based on GPS data for the members of the virtual parked vehicle network, according to some embodiments.

[0113] One or more of the steps described herein for the method **400** may be executed by one or more computer systems **200**.

[0114] At step **403**, a total number of gateways g for the virtual parked vehicle network is determined.

[0115] At step **405**, GPS data for the plurality of parked vehicles included in the virtual parked vehicle network is received.

[0116] At step **407**, for each non-gateway vehicle included in the virtual parked vehicle network, their first average distance to all the other non-gateway vehicles in the virtual parked vehicle network is determined. For example, the first average distance for a particular non-gateway vehicle is the sum of its average distances to all the other non-gateway vehicles divided by the total number of non-gateway vehicles, and this step is done for each of the non-gateway vehicles so that each is assigned a value for their first average distance. The values for the first average distances, and the associated non-gateway vehicles these values describe, is stored as first distance data.

[0117] At step **409**, a non-gateway vehicle having a highest value for the first average distance is designated as a gateway vehicle and the number of non-gateway vehicles is decreased by one.

[0118] At step **411**, for each non-gateway vehicle included in the virtual parked vehicle network, their second average distance to a gateway vehicle in the virtual parked vehicle network is determined. For example, the second average distance for a particular non-gateway vehicle is the sum of its average distances to all the gateway vehicles divided by the total number of non-gateway vehicles, and this step **411** is done for each of the non-gateway vehicles so that each is assigned a value for their second average distance. The values for the second average distances, and the associated non-gateway vehicles these values describe, is stored as second distance data.

[0119] At step **413**, a determination is made regarding whether designated number of gateway vehicles for the virtual parked vehicle network is equal to the total number of gateway vehicles from step **403**. If the determination is positive, then the method **400** ends. If the determination is negative, then the method proceeds to step **415**.

[0120] At step **415**, the non-gateway vehicle included in the virtual parked vehicle network having a highest second average distance is designated as a gateway vehicle. Also at step **415**, the total number of non-gateway vehicles is decreased by one. The method **400** then returns to step **411**.

[0121] In some embodiments, the digital data describing placement is determined based on a virtual cord protocol, which is known to those having skill in the art.

[0122] In the above description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the specification. It will be apparent, however, to one skilled in the art that the disclosure can be practiced without these specific details. In some instances, structures and devices are shown in block diagram form in order to avoid obscuring the description. For example, the present embodiments can be described above primarily with reference to user interfaces and particular hardware. However, the present embodiments can apply to any type of computer system that can receive data and commands, and any peripheral devices providing services.

[0123] Reference in the specification to "some embodiments" or "some instances" means that a particular feature, structure, or characteristic described in connection with the embodiments or instances can be included in at least one embodiment of the description. The appearances of the phrase "in some embodiments" in various places in the specification are not necessarily all referring to the same embodiments.

[0124] Some portions of the detailed descriptions that follow are presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations

are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

[0125] It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussion, it is appreciated that throughout the description, discussions utilizing terms including "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission, or display devices.

[0126] The present embodiments of the specification can also relate to an apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes, or it may include a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer-readable storage medium, including, but is not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or optical cards, flash memories including USB keys with non-volatile memory, or any type of media suitable for storing electronic instructions, each coupled to a computer system bus.

[0127] The specification can take the form of some entirely hardware embodiments, some entirely software embodiments or some embodiments containing both hardware and software elements. In some preferred embodiments, the specification is implemented in software, which includes, but is not limited to, firmware, resident software, microcode, etc.

[0128] Furthermore, the description can take the form of a computer program product accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer-readable medium can be any apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

[0129] A data processing system suitable for storing or executing program code will include at least one processor coupled directly or indirectly to memory elements through a system bus. The memory elements can include local memory employed during actual execution of the program code, bulk storage, and cache memories which provide temporary storage of at least some program code in order to reduce the number of times code must be retrieved from bulk storage during execution.

[0130] Input/output or I/O devices (including, but not limited, to keyboards, displays, pointing devices, etc.) can be coupled to the system either directly or through intervening I/O controllers.

[0131] Network adapters may also be coupled to the system to enable the data processing system to become coupled to other data processing systems or remote printers or storage devices through intervening private or public networks. Modems, cable modem, and Ethernet cards are just a few of the currently available types of network adapters.

[0132] Finally, the algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the required method steps. The required structure for a variety of these systems will appear from the description below. In addition, the specification is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the specification as described herein.

[0133] The foregoing description of the embodiments of the specification has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the specification to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the disclosure be limited not by this detailed description, but rather by the claims of this application. As will be understood by those familiar with the art, the specification may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Likewise, the particular naming and division of the modules, routines, features, attributes, methodologies, and other aspects are not mandatory or significant, and the mechanisms that implement the specification or its features may have different names, divisions, or formats. Furthermore, as will be apparent to one of ordinary skill in the relevant art, the modules, routines, features, attributes, methodologies, and other aspects of the disclosure can be implemented as software, hardware, firmware, or any combination of the three. Also, wherever a component, an example of which is a module, of the specification is implemented as software, the component can be implemented as a standalone program, as part of a larger program, as a plurality of separate programs, as a statically or dynamically linked library, as a kernel-loadable module, as a device driver, or in every and any other way known now or in the future to those of ordinary skill in the art of computer programming. Additionally, the disclosure is in no way limited to embodiment in any specific programming language, or for any specific operating system or environment. Accordingly, the disclosure is intended to be illustrative, but not limiting, of the scope of the specification, which is set forth in the following claims.

What is claimed is:

1. A method for selecting one or more gateway vehicles for a virtual parked vehicle network including a plurality of

parked vehicles that are members of the virtual parked vehicle network, the method comprising:

assigning position data to the plurality of parked vehicles which describes a plurality of unique position values for the plurality of parked vehicles in the virtual parked vehicle network; and

designating a parked vehicle having a lowest position value in the plurality of unique position values as a gateway vehicle for the virtual parked vehicle network, wherein the gateway vehicle is an only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network, the method is executed by a processor of the parked vehicle and the parked vehicle is assigned the lowest position value because it is executing the method.

2. The method of claim **1**, wherein the virtual parked vehicle network stores data for one or more non-parked vehicles that are not part of the virtual parked vehicle network using one or more non-transitory memories of the plurality of parked vehicles and the data is electronically transmissible via the gateway vehicle.

3. The method of claim **1**, wherein the virtual parked vehicle network processes data for one or more non-parked vehicles that are not part of the virtual parked vehicle network and the data is electronically transmissible via the gateway vehicle.

4. The method of claim **1**, wherein one or more other parked vehicles in the plurality that are not designated as the gateway vehicle are assigned their unique position values based on their real-world geographic position relative to a real-world geographic position of the parked vehicle that is designated as the gateway vehicle.

5. The method of claim **1**, further comprising one or more other parked vehicles transmitting global positioning system data (GPS data) describing their real-world geographic position to the parked vehicle that is designated as the gateway vehicle, wherein the one or more other parked vehicles include members of the virtual parked vehicle network that are not designated as the gateway vehicle.

6. The method of claim **5**, further comprising determining the plurality of unique position values based on the GPS data received from the one or more other parked vehicles and digital data describing the real-world geographic position of the parked vehicle that is designated as the gateway vehicle.

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

determining a number of hops in the virtual parked vehicle network relative to the parked vehicle designated as the gateway vehicle;

retrieving threshold data describing a threshold for limiting a total number of gateway vehicles in the virtual parked vehicle network, wherein the threshold is a positive whole number n; and

designating one or more parked vehicles in the plurality of parked vehicles that are n hops from the parked vehicle designated as the gateway vehicle as one or more additional gateway vehicles for the virtual parked vehicle network, wherein the gateway vehicle and the one or more additional gateway vehicles are the only members of the virtual parked vehicle network that are operable to provide access to the virtual parked vehicle network.

8. A system for selecting one or more gateway vehicles for a virtual parked vehicle network including a plurality of parked vehicles that are members of the virtual parked vehicle network, the system comprising:

an onboard unit of a parked vehicle including a non-transitory memory storing computer code which, when executed by the onboard unit causes the onboard unit to execute steps comprising:

assigning position data to the plurality of parked vehicles which describes a plurality of unique position values for the plurality of parked vehicles, wherein the parked vehicle is assigned a lowest position value in the plurality of unique position values because the onboard unit of the parked vehicle is executing the steps; and

designating the parked vehicle having the lowest position value in the plurality of unique position values as a gateway vehicle for the virtual parked vehicle network, wherein the gateway vehicle is an only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network.

9. The system of claim **8**, wherein the virtual parked vehicle network stores data for one or more non-parked vehicles that are not part of the virtual parked vehicle network using one or more non-transitory memories of the plurality of parked vehicles and the data is electronically transmissible via the gateway vehicle.

10. The system of claim **8**, wherein the virtual parked vehicle network processes data for one or more non-parked vehicles that are not part of the virtual parked vehicle network and the data is electronically transmissible via the gateway vehicle.

11. The system of claim **8**, wherein one or more other parked vehicles in the plurality that are not designated as the gateway vehicle are assigned their unique position values based on their real-world geographic position relative to a real-world geographic position of the parked vehicle that is designated as the gateway vehicle.

12. The system of claim **8**, further comprising one or more other parked vehicles transmitting global positioning system data (GPS data) describing their real-world geographic position to the parked vehicle that is designated as the gateway vehicle, wherein the one or more other parked vehicles include members of the virtual parked vehicle network that are not designated as the gateway vehicle.

13. The system of claim **12**, wherein the steps further comprise determining the plurality of unique position values based on the GPS data received from the one or more other parked vehicles and digital data describing the real-world geographic position of the parked vehicle that is designated as the gateway vehicle.

14. The system of claim **8**, wherein the steps further comprise:

determining a number of hops in the virtual parked vehicle network relative to the parked vehicle designated as the gateway vehicle;

retrieving threshold data describing a threshold for limiting a total number of gateway vehicles in the virtual parked vehicle network, wherein the threshold is a positive whole number n; and

designating one or more parked vehicles in the plurality of parked vehicles that are n hops from the parked vehicle designated as the gateway vehicle as one or more additional gateway vehicles for the virtual parked vehicle network, wherein the gateway vehicle and the one or more additional gateway vehicles are the only

members of the virtual parked vehicle network that are operable to provide access to the virtual parked vehicle network.

15. The system of claim **14**, wherein the gateway vehicle transmits a wireless message including an invitation to access the virtual parked vehicle network.

16. A method for selecting one or more gateway vehicles for a virtual parked vehicle network including a plurality of parked vehicles, the method comprising:

receiving global positioning system data (GPS data) for the plurality of parked vehicles included in the virtual parked vehicle network;

for each non-gateway vehicle included in the virtual parked vehicle network, determining their first average distance to all the other non-gateway vehicles in the virtual parked vehicle network based on the GPS data; and

designating a non-gateway vehicle having a highest value for first average distance as a gateway vehicle for the virtual parked vehicle network, wherein the gateway vehicle is an only member of the virtual parked vehicle network that is operable to provide access to the virtual parked vehicle network for one or more other vehicles which are not members of the virtual parked vehicle network.

17. The method of claim **16**, wherein the first average distance for a particular non-gateway vehicle is a sum of its average distances to all the other non-gateway vehicles, as determined based on the GPS data, divided by a total number of non-gateway vehicles included in the virtual parked vehicle network.

18. The method of claim **17**, wherein the total number of non-gateway vehicles is determined based on unique instances of GPS data and the total number of non-gateway vehicles is decreased by one after the gateway vehicle is designated.

19. The method of claim **18**, further comprising:

determining whether a threshold number of gateway vehicles is exceeded;

responsive to the threshold number not being exceeded, determining, for each non-gateway vehicle included in the virtual parked vehicle network, a second average distance to the gateway vehicle; and

designating the non-gateway vehicle having a highest value for the second average distance as an additional gateway vehicle for the virtual parked vehicle network, wherein the gateway vehicle and the additional gateway vehicle are the only members of the virtual parked vehicle network that are operable to provide access to the virtual parked vehicle network for the one or more other vehicles which are not members of the virtual parked vehicle network.

20. The method of claim **19**, wherein the threshold number is operable to limit a load for a designated channel used for inviting the one or more other vehicles which are not members of the virtual parked vehicle network to access the virtual parked vehicle network.

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