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(54) **MINIMIZING A VEHICLE CHARGE TIME**

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

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(57)

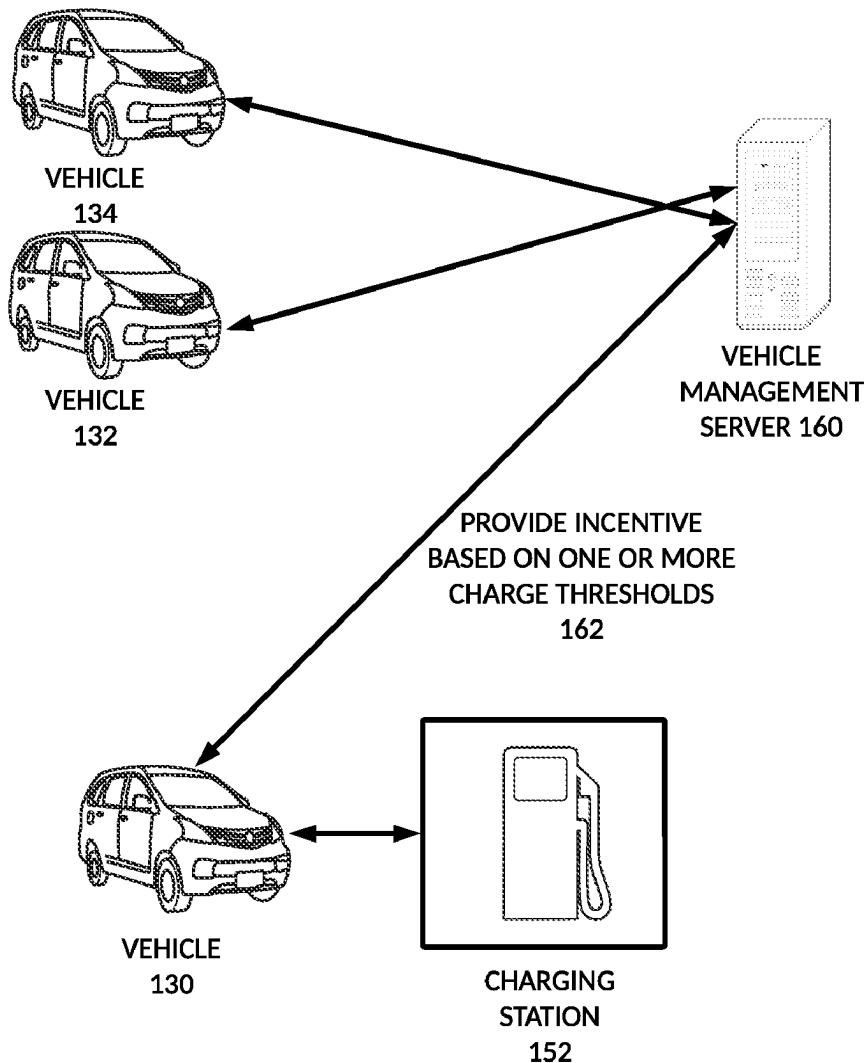
**ABSTRACT**

An example operation includes one or more of determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point, and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

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**150**



100

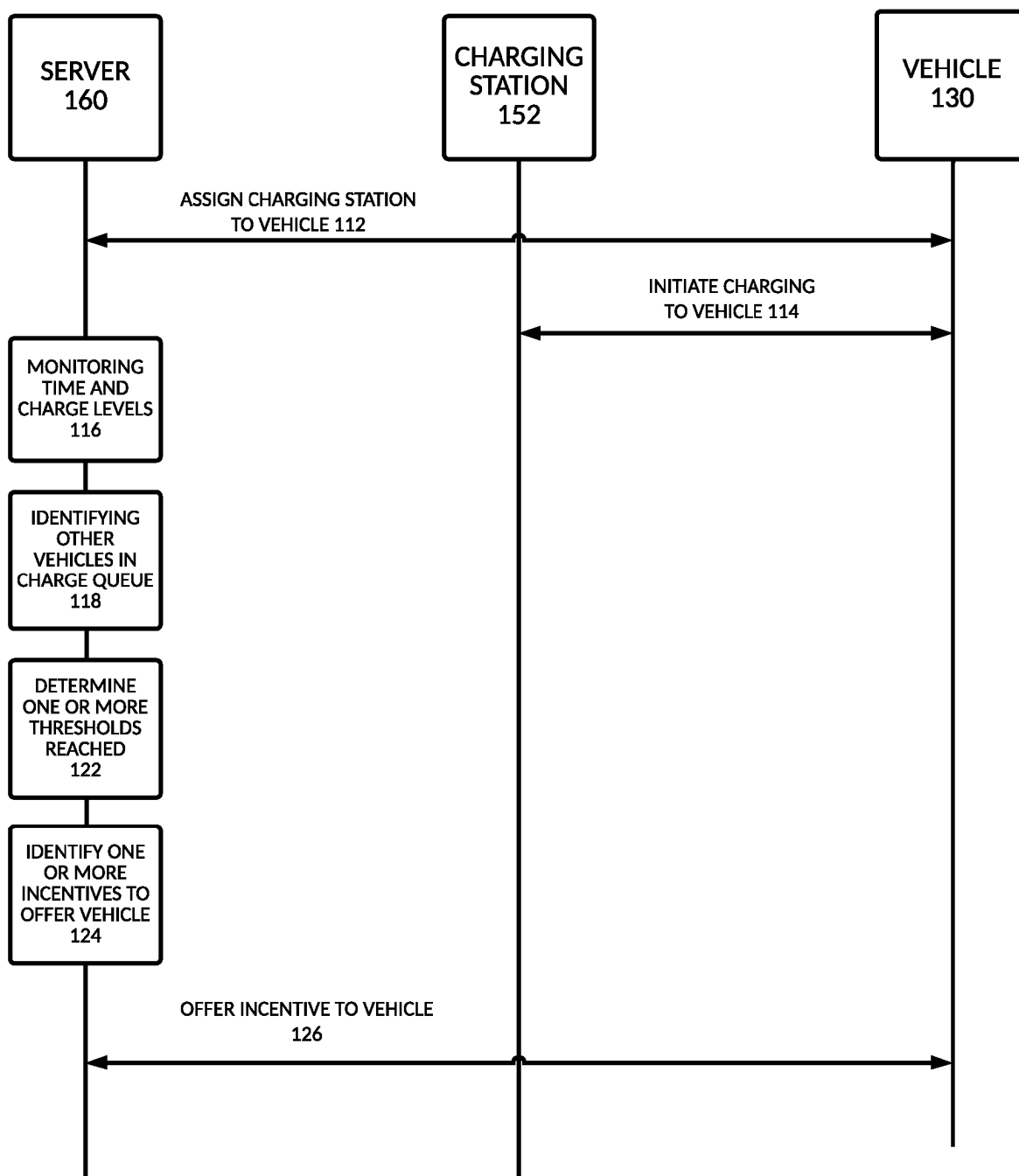


FIG. 1A

150

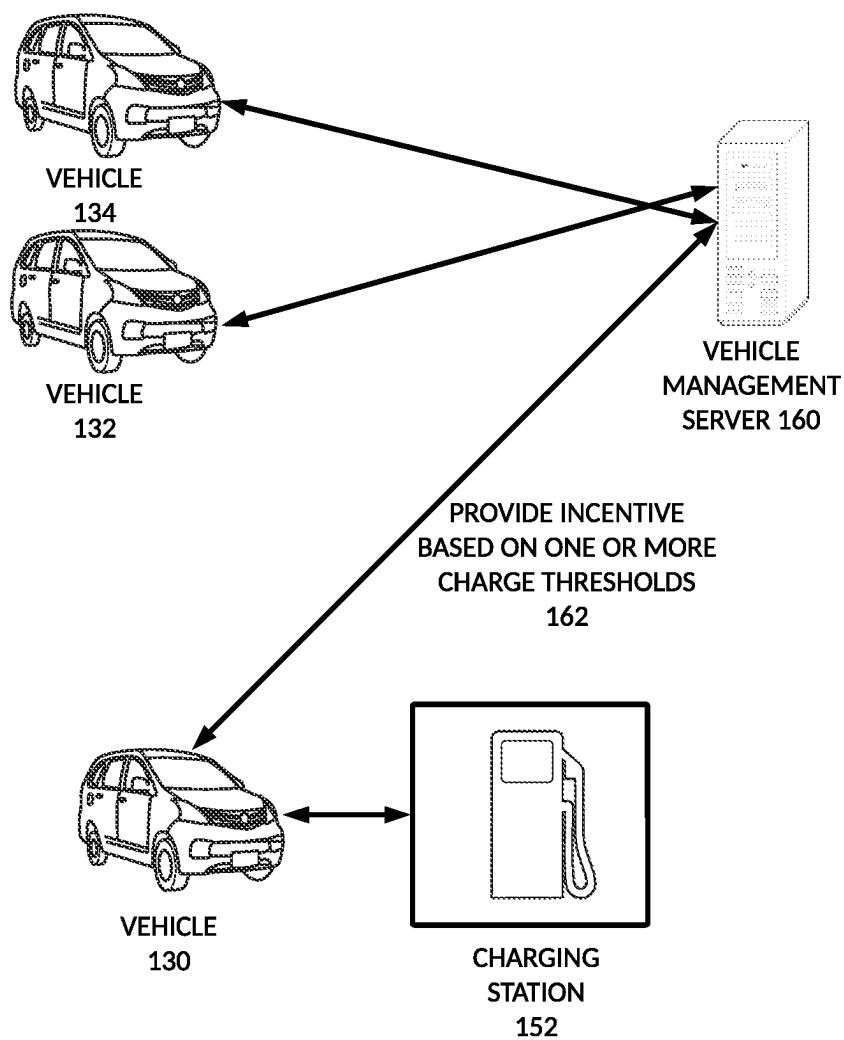


FIG. 1B

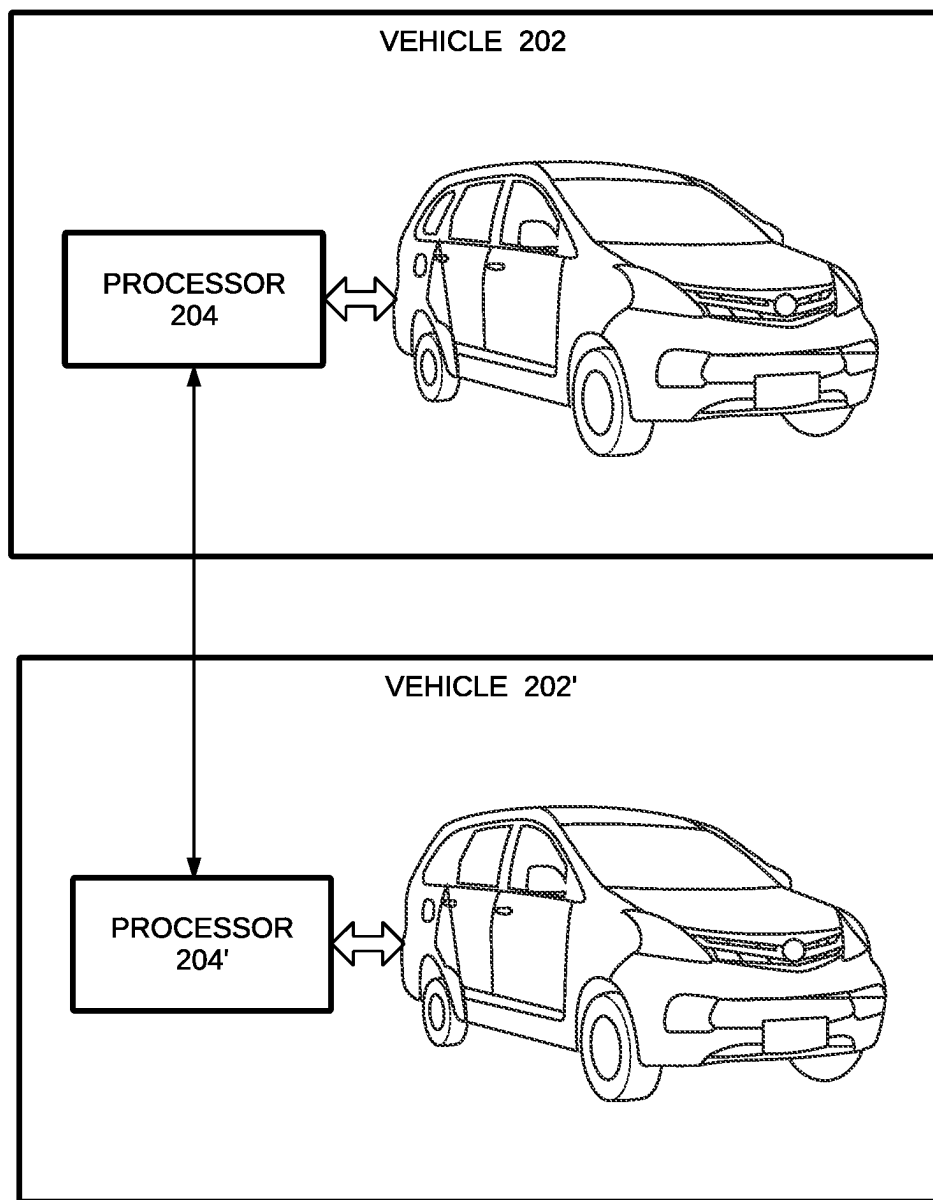


FIG. 2A

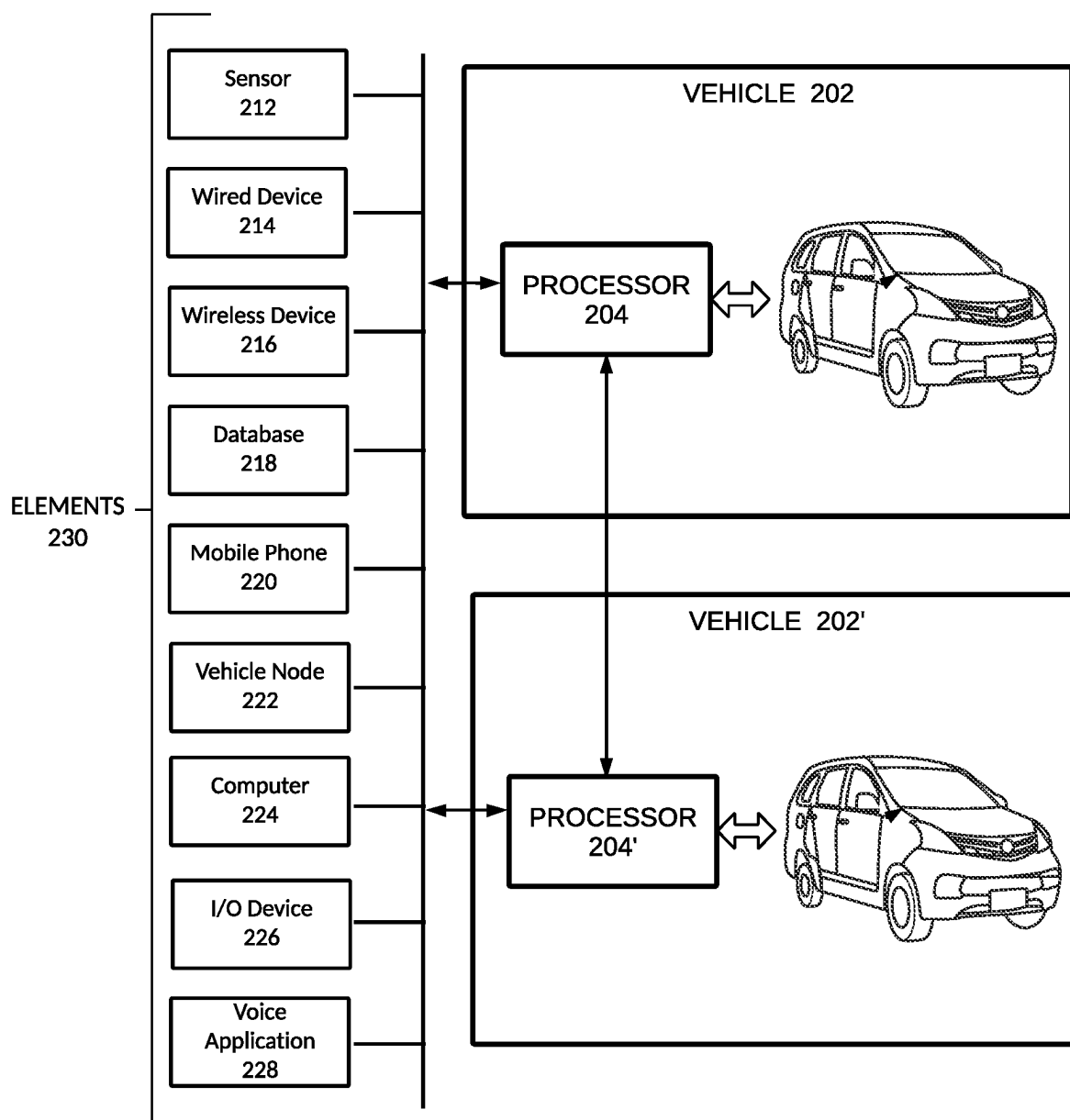


FIG. 2B

240

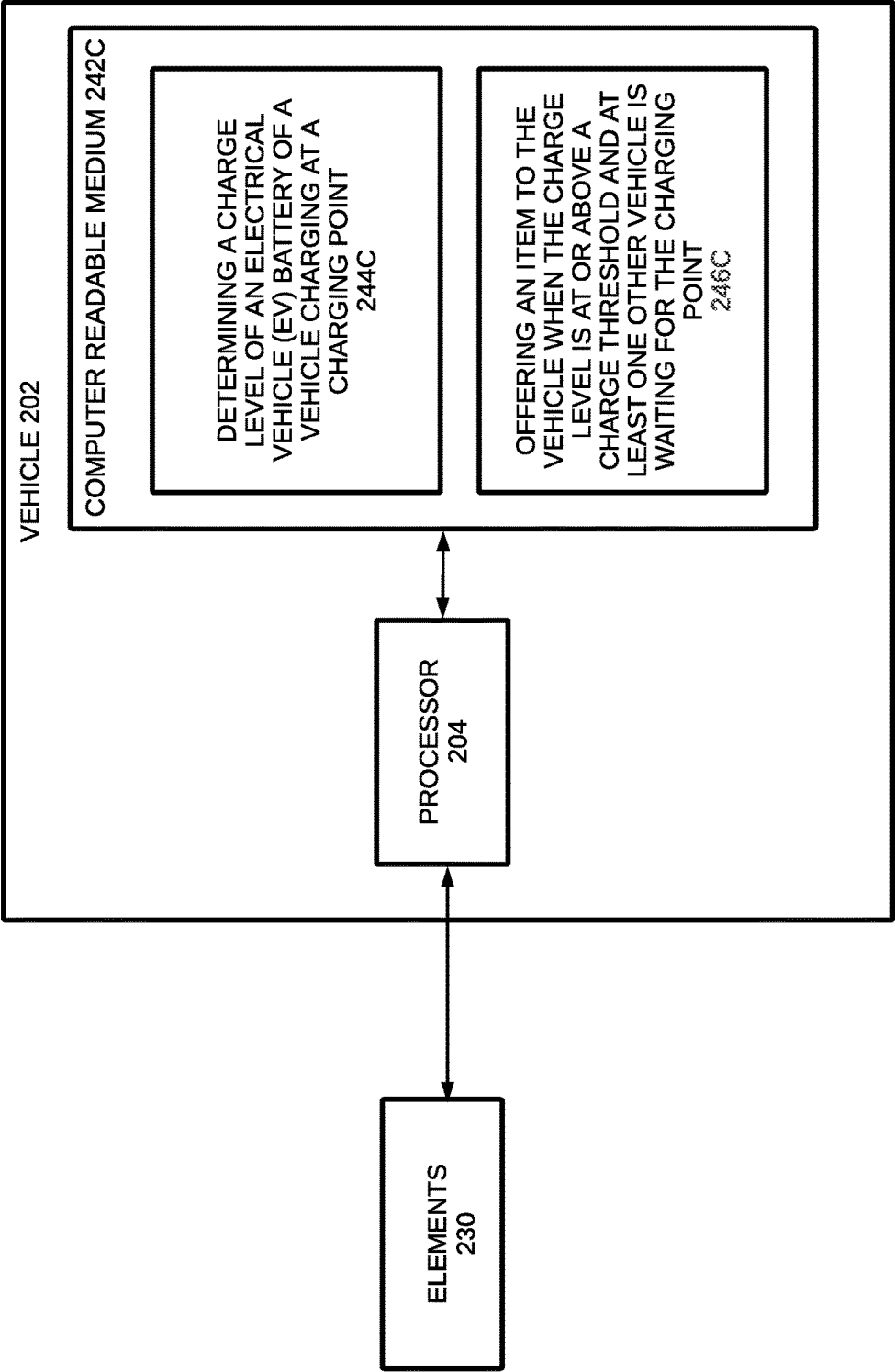


FIG. 2C

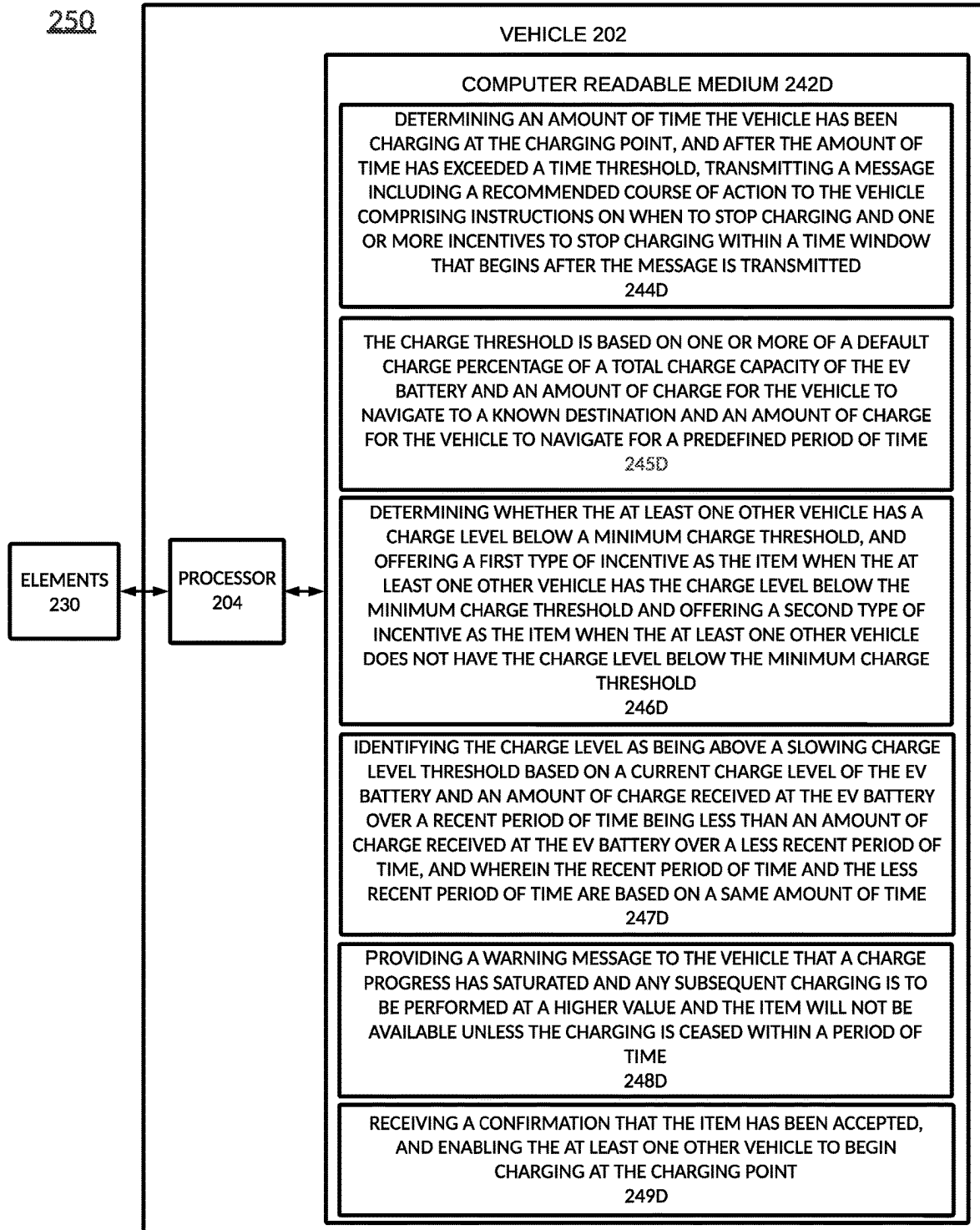


FIG. 2D

260

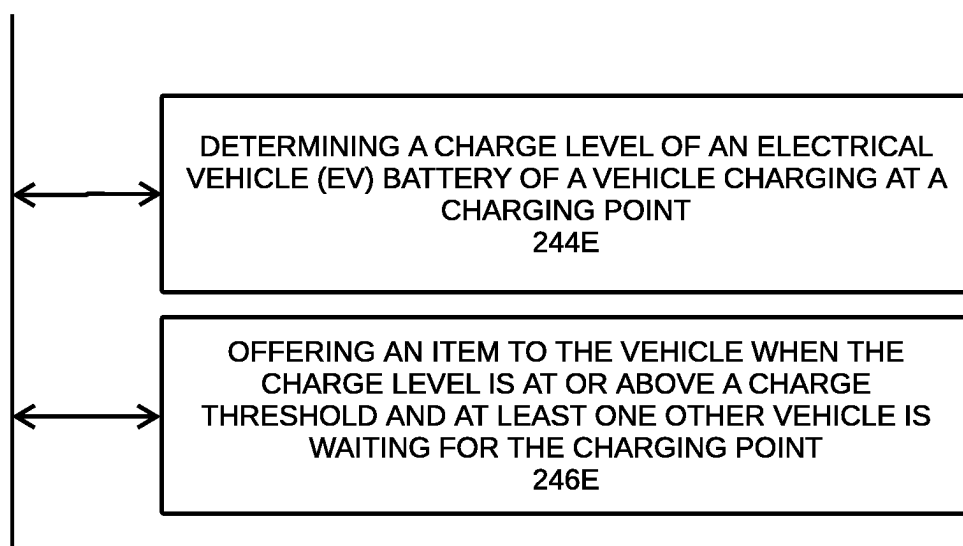


FIG. 2E



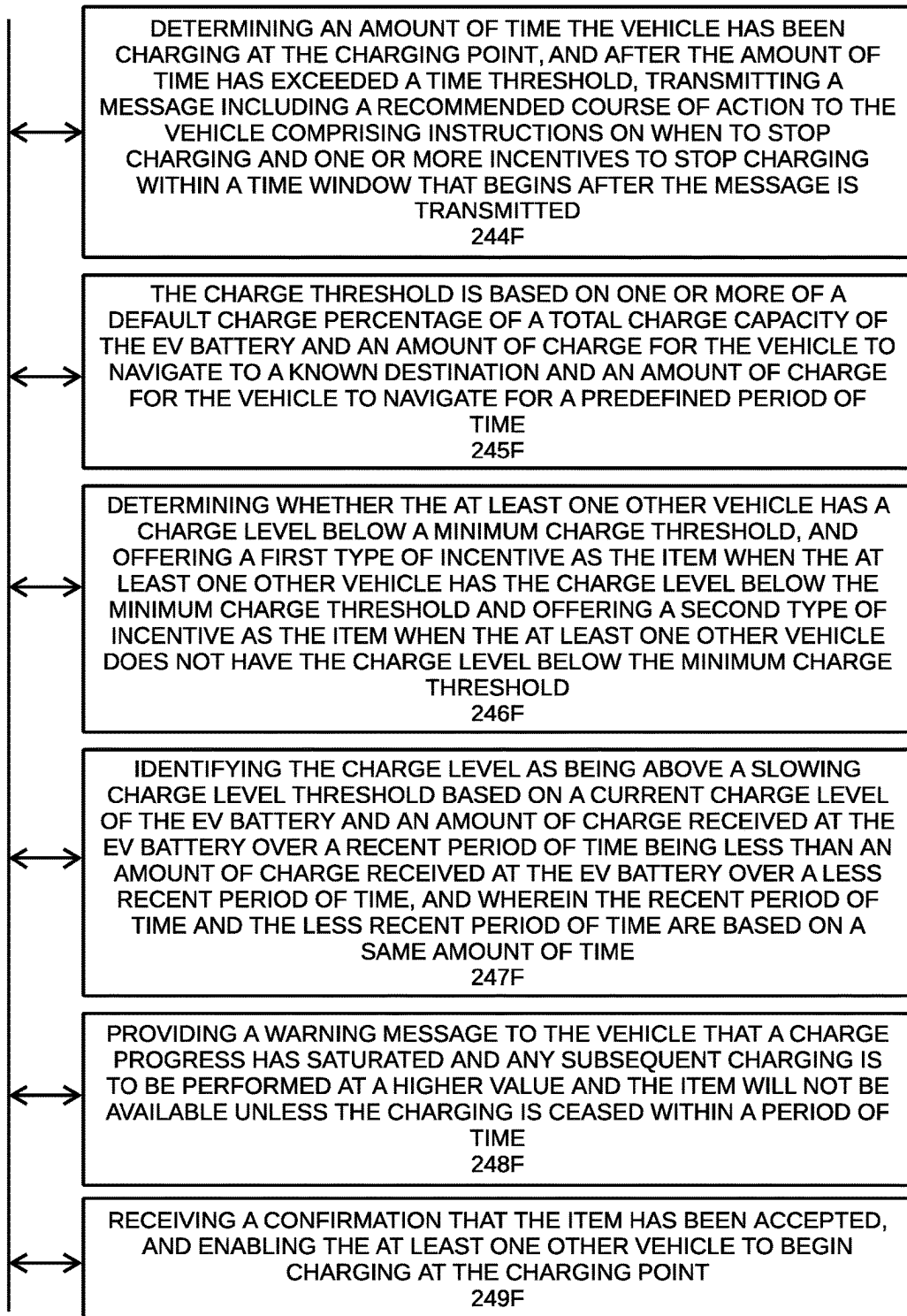
270

FIG. 2F

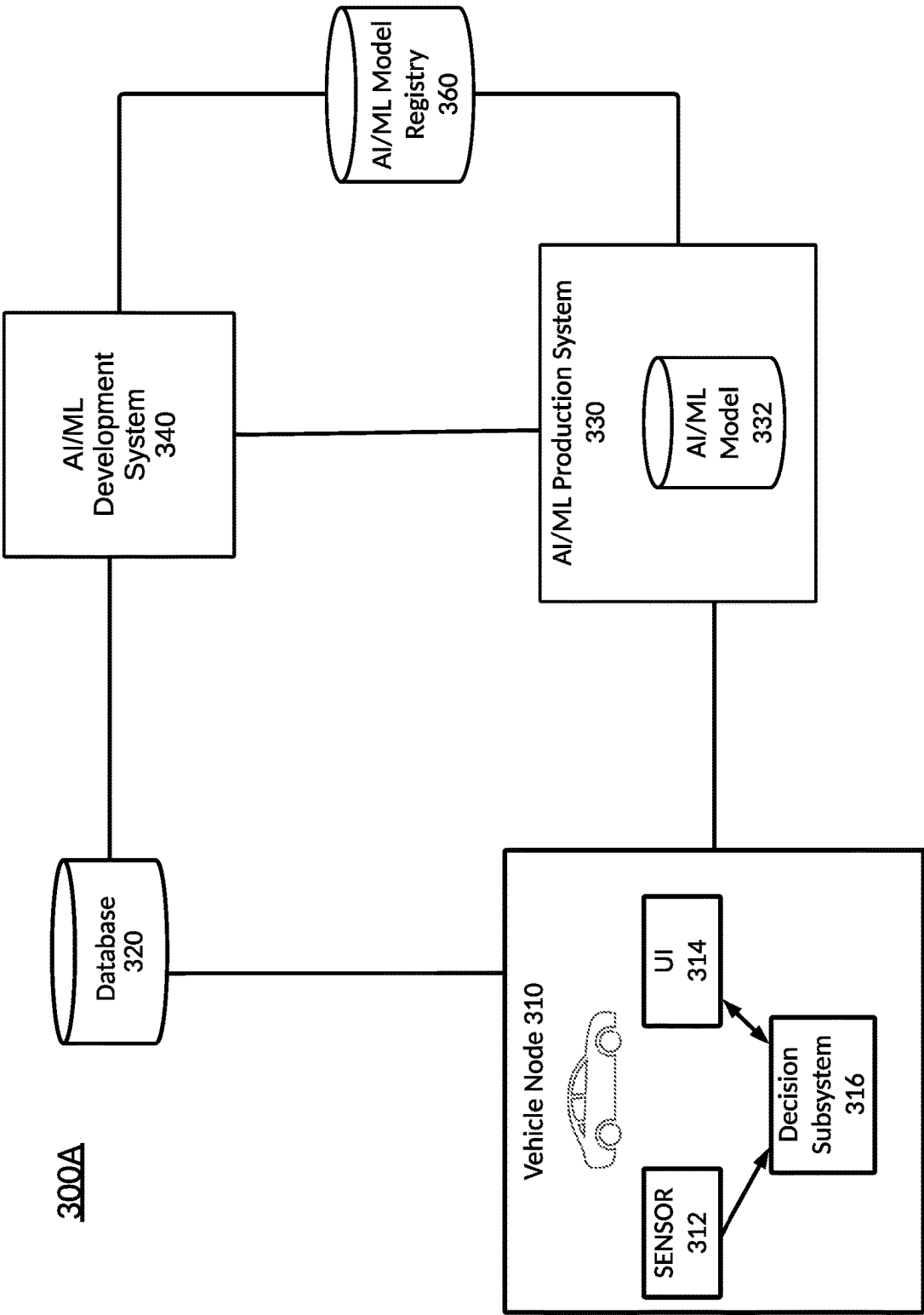


FIG. 3A

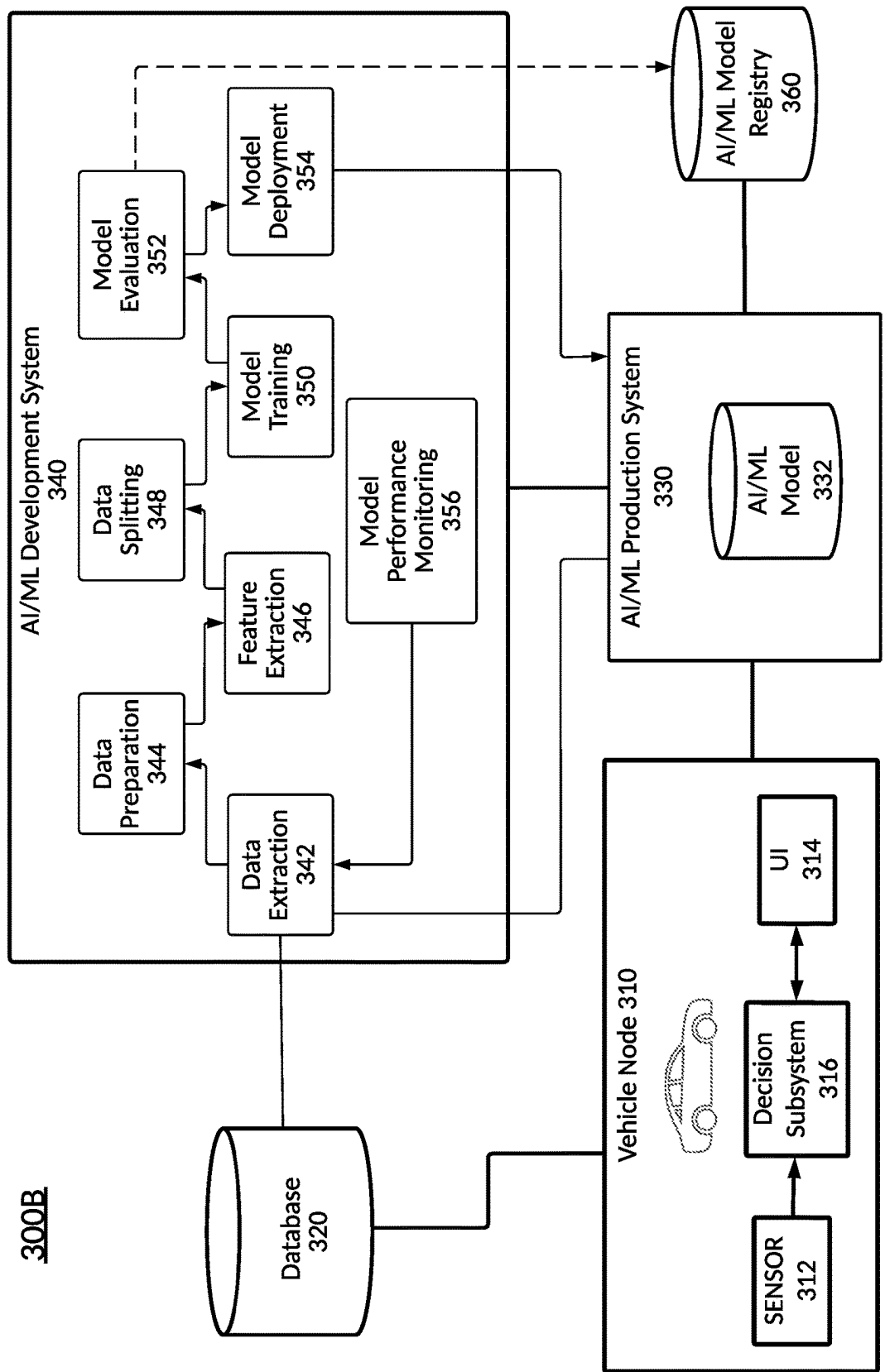


FIG. 3B

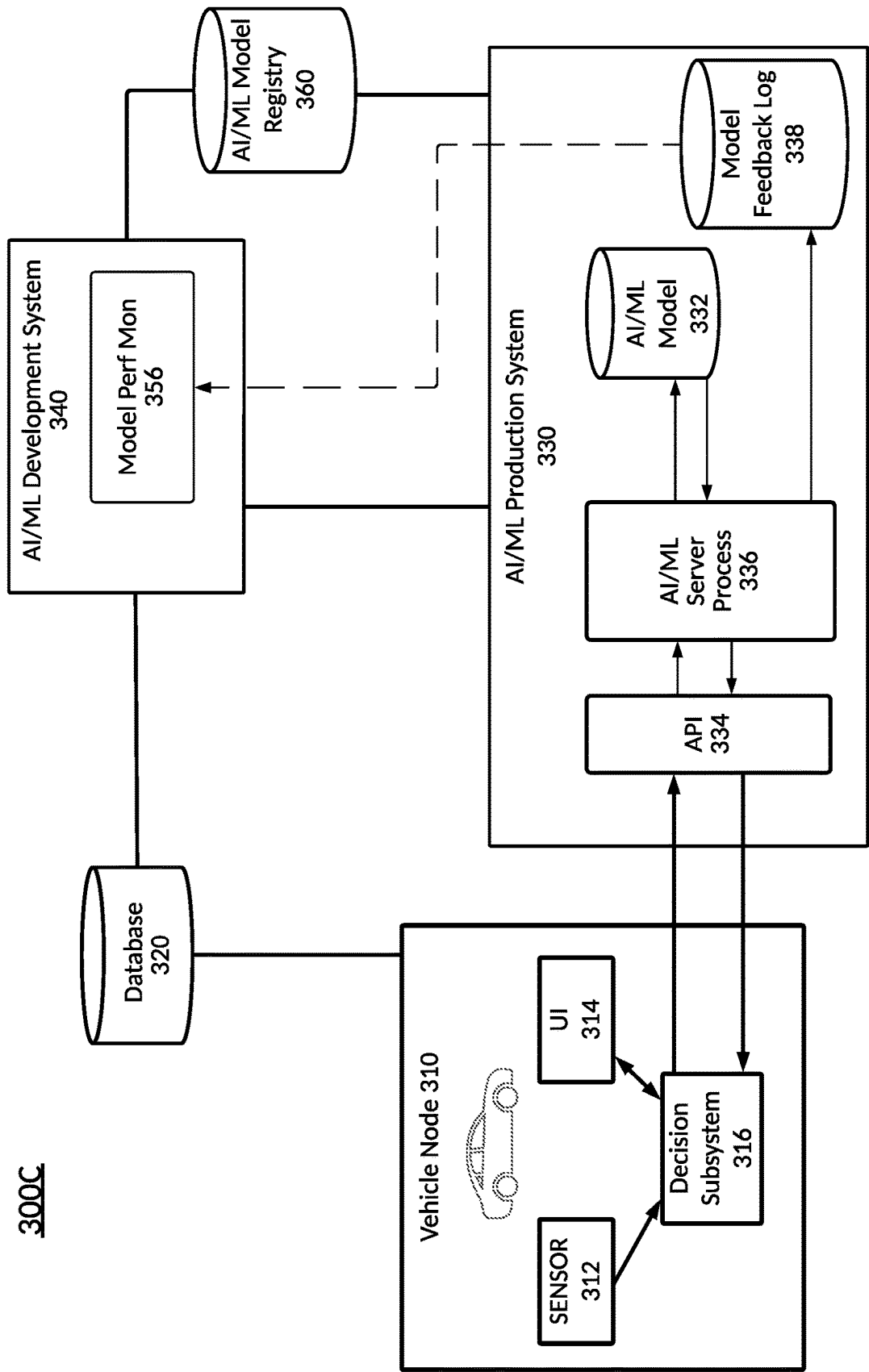


FIG. 3C

300C

300D

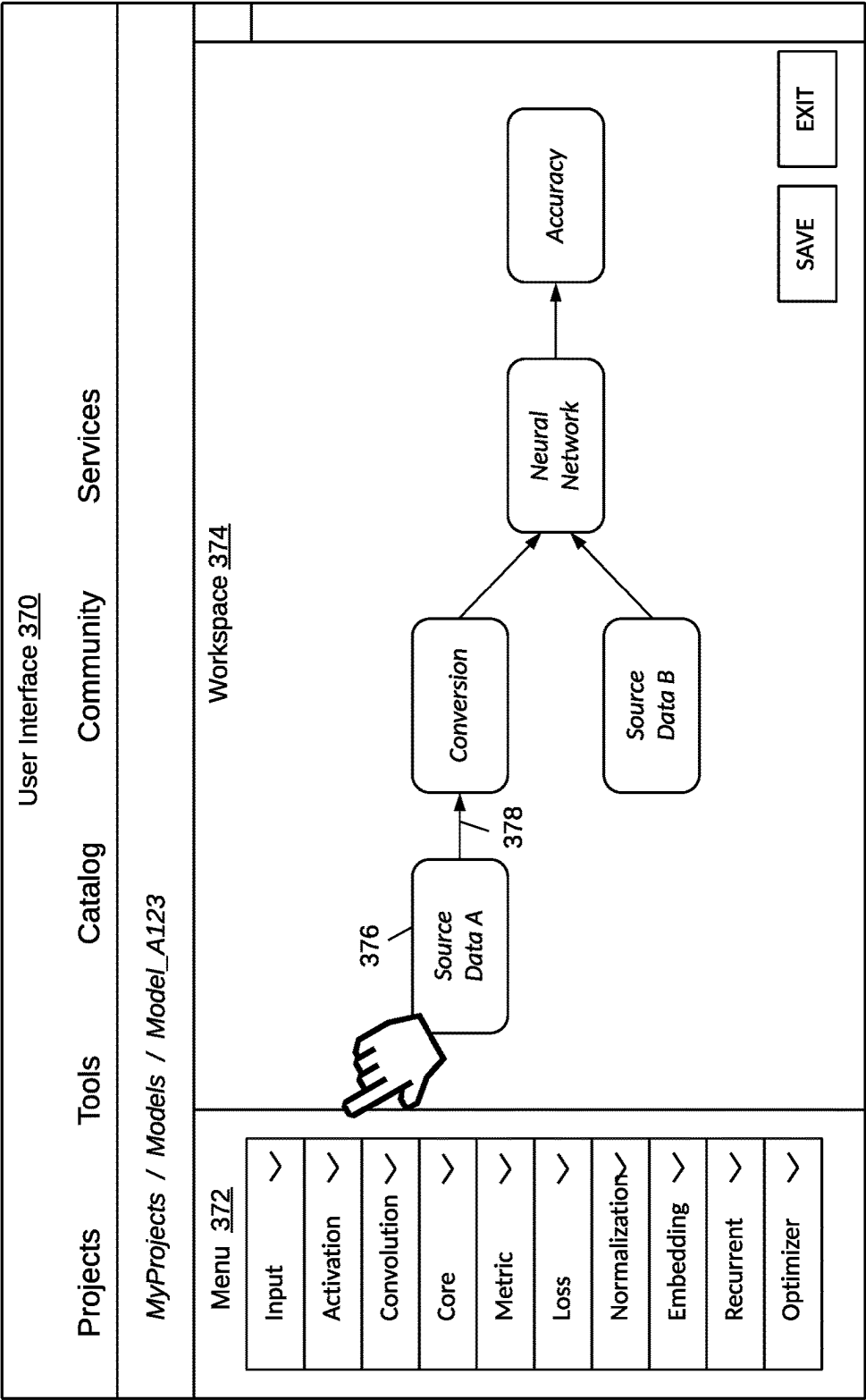


FIG. 3D

300E

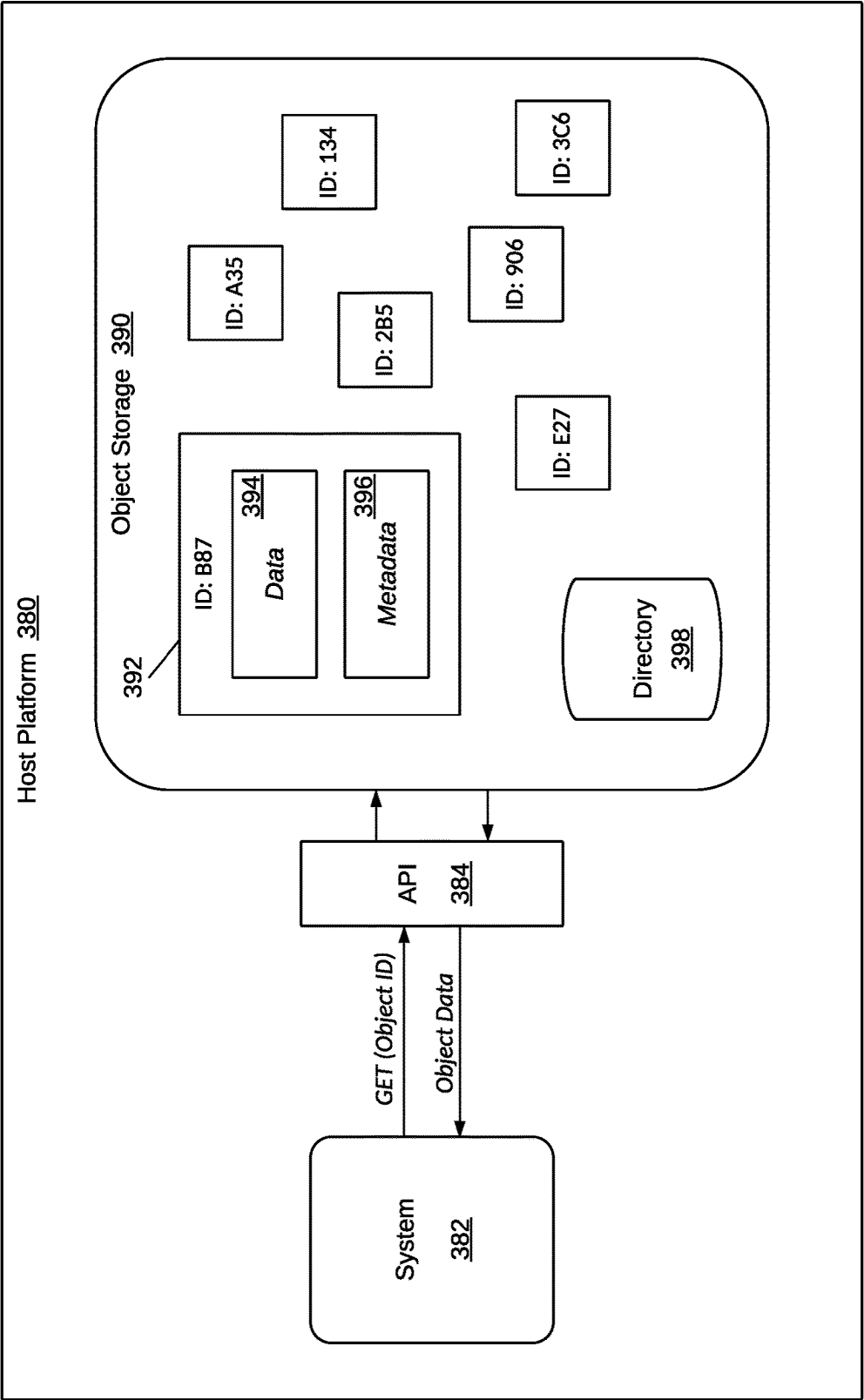


FIG. 3E

400A

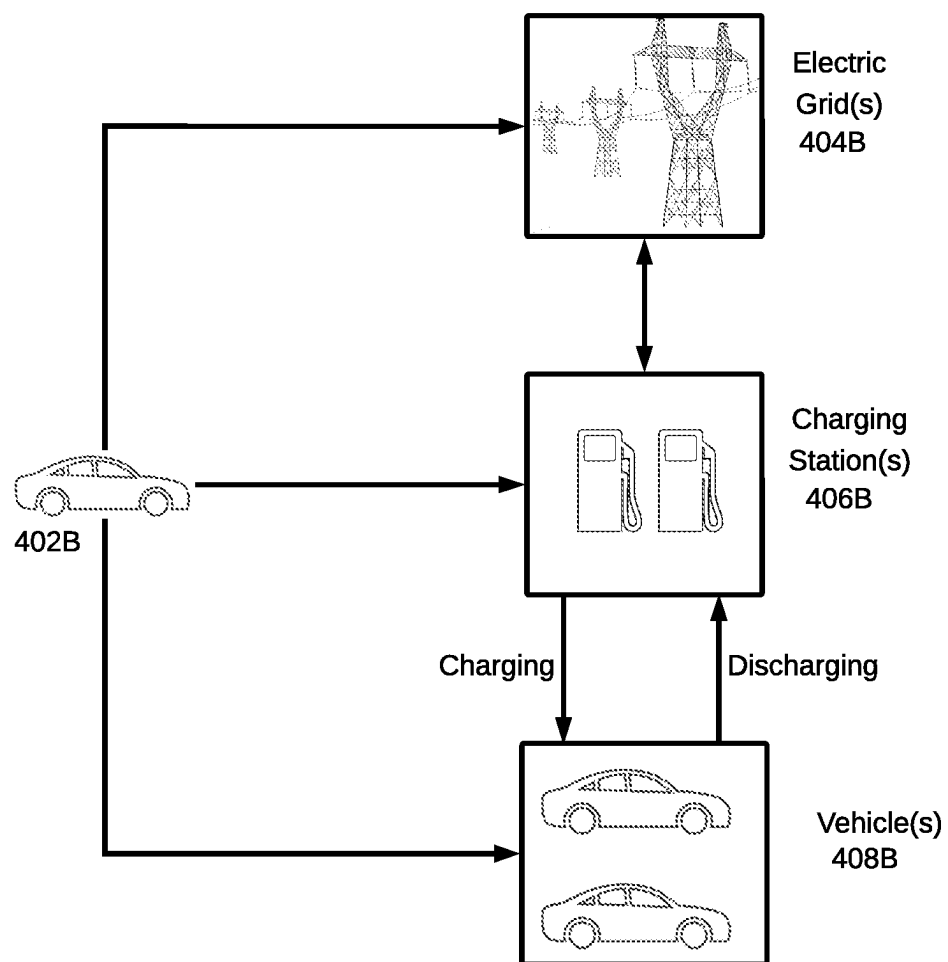
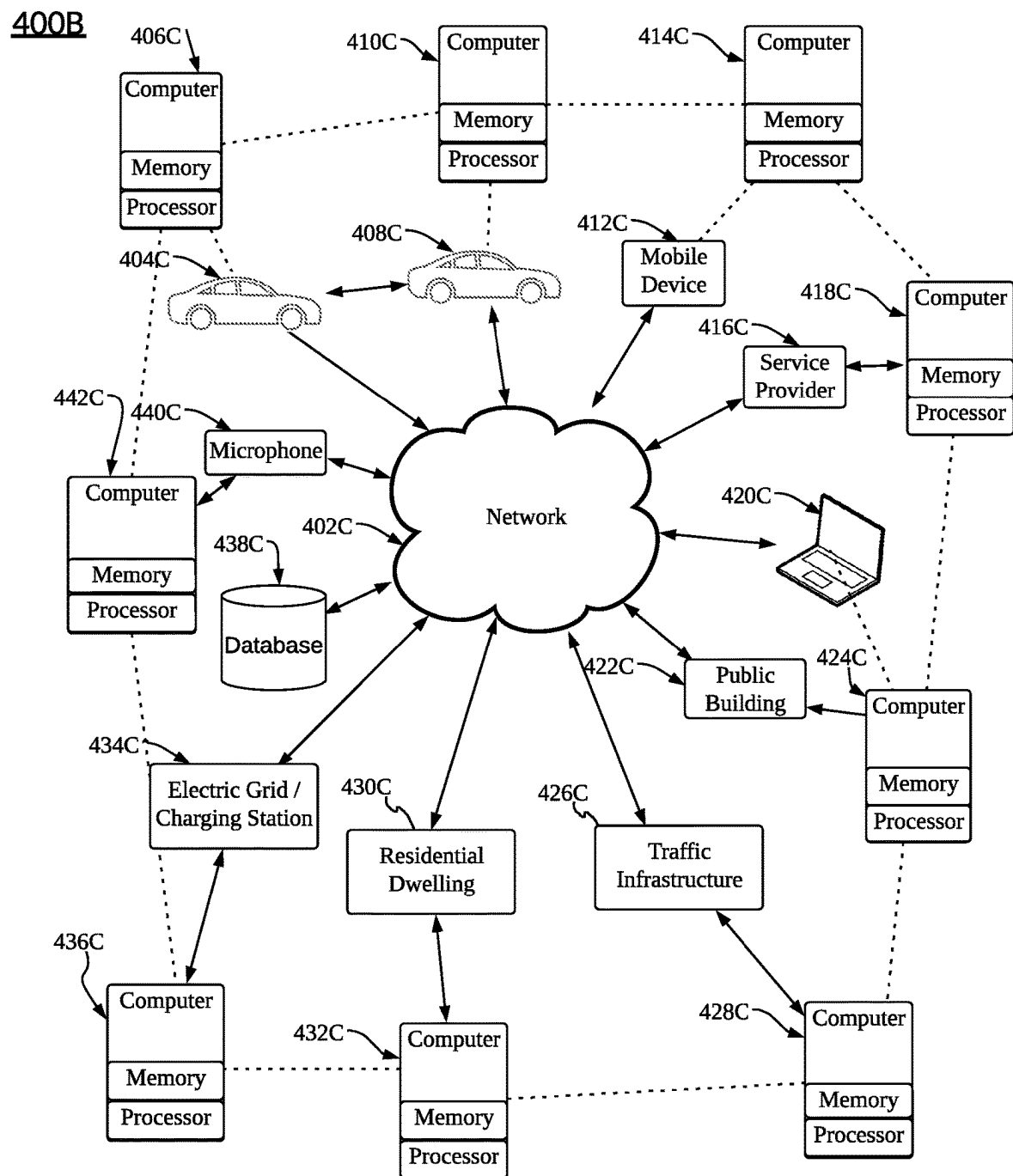


FIG. 4A





400C

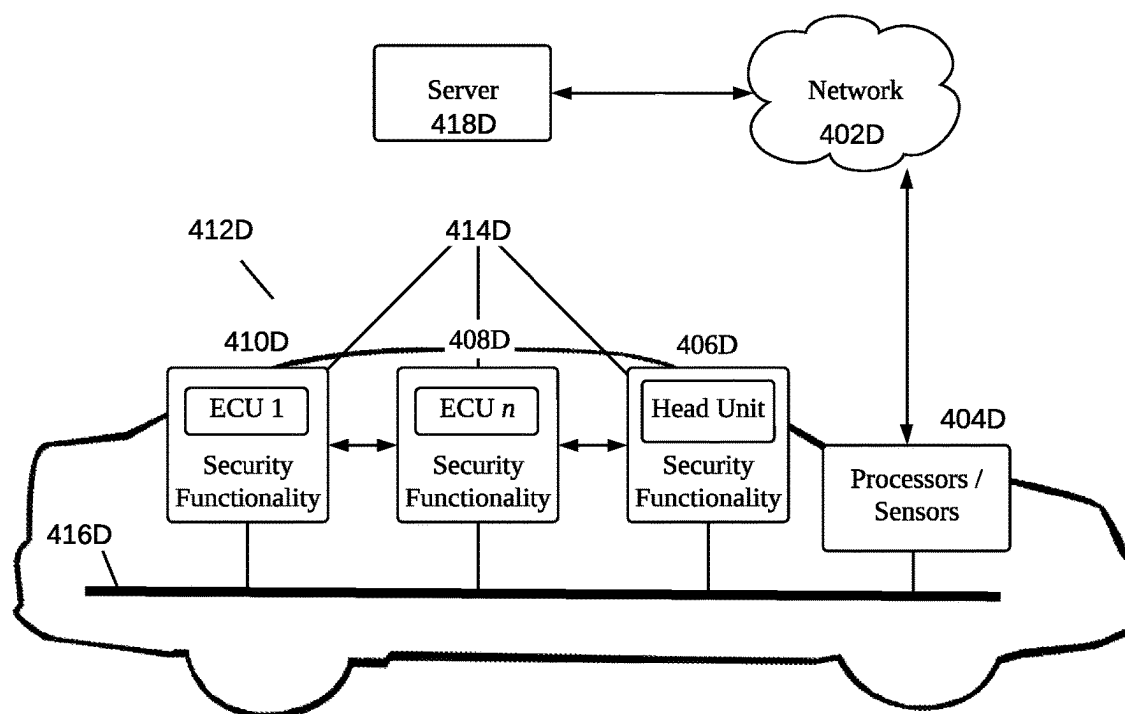


FIG. 4C

400D

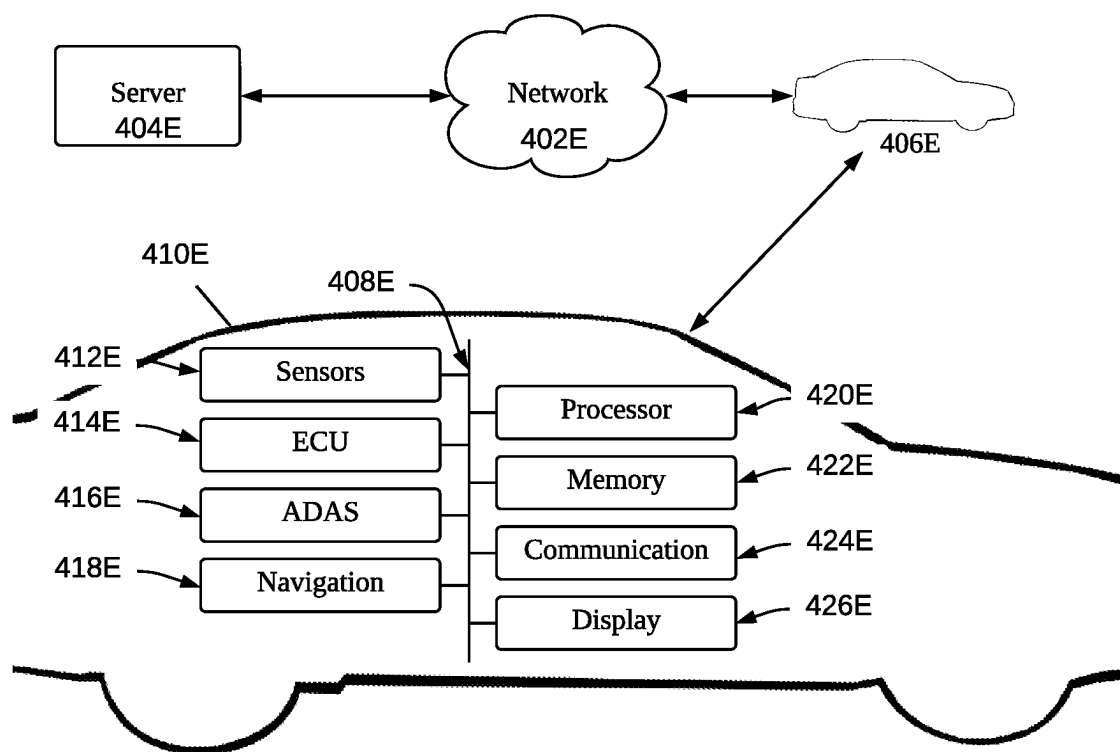


FIG. 4D

400E

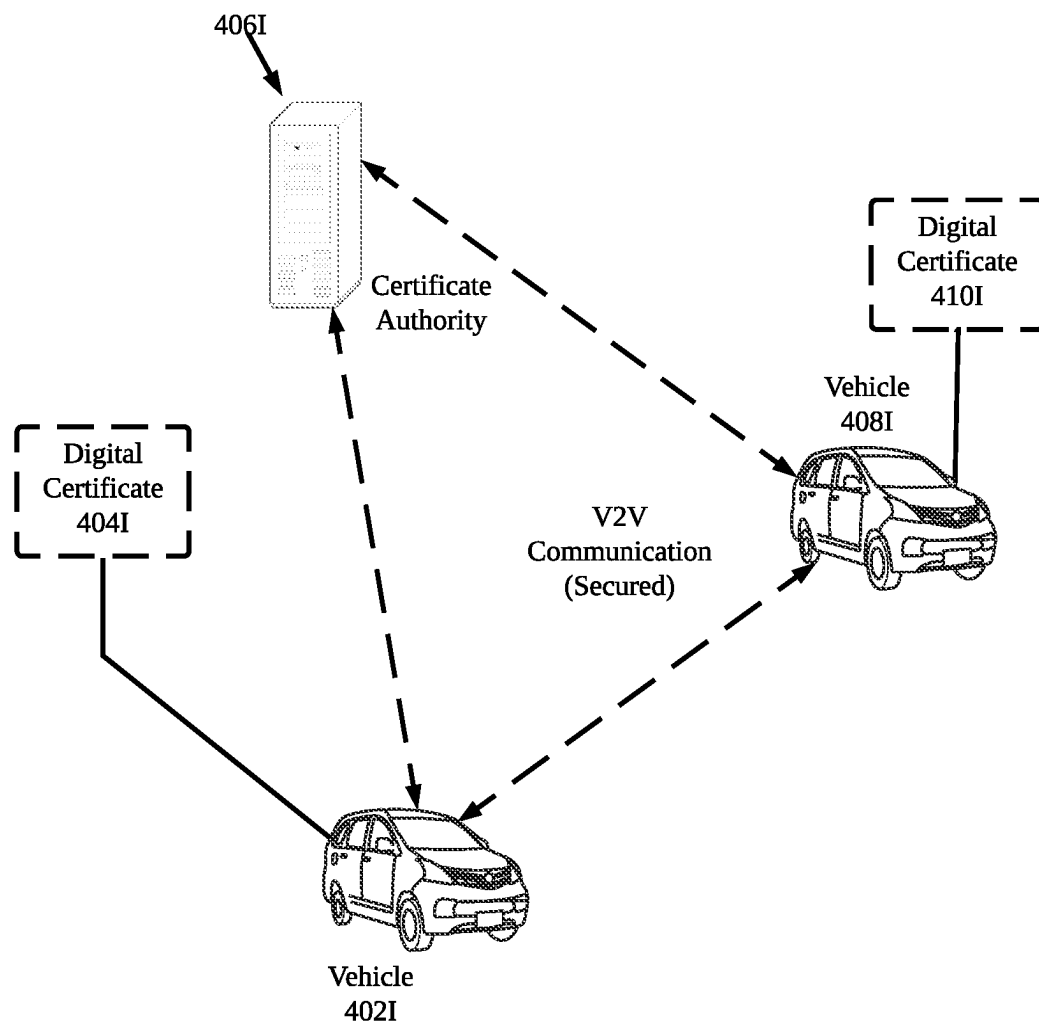


FIG. 4E

500A

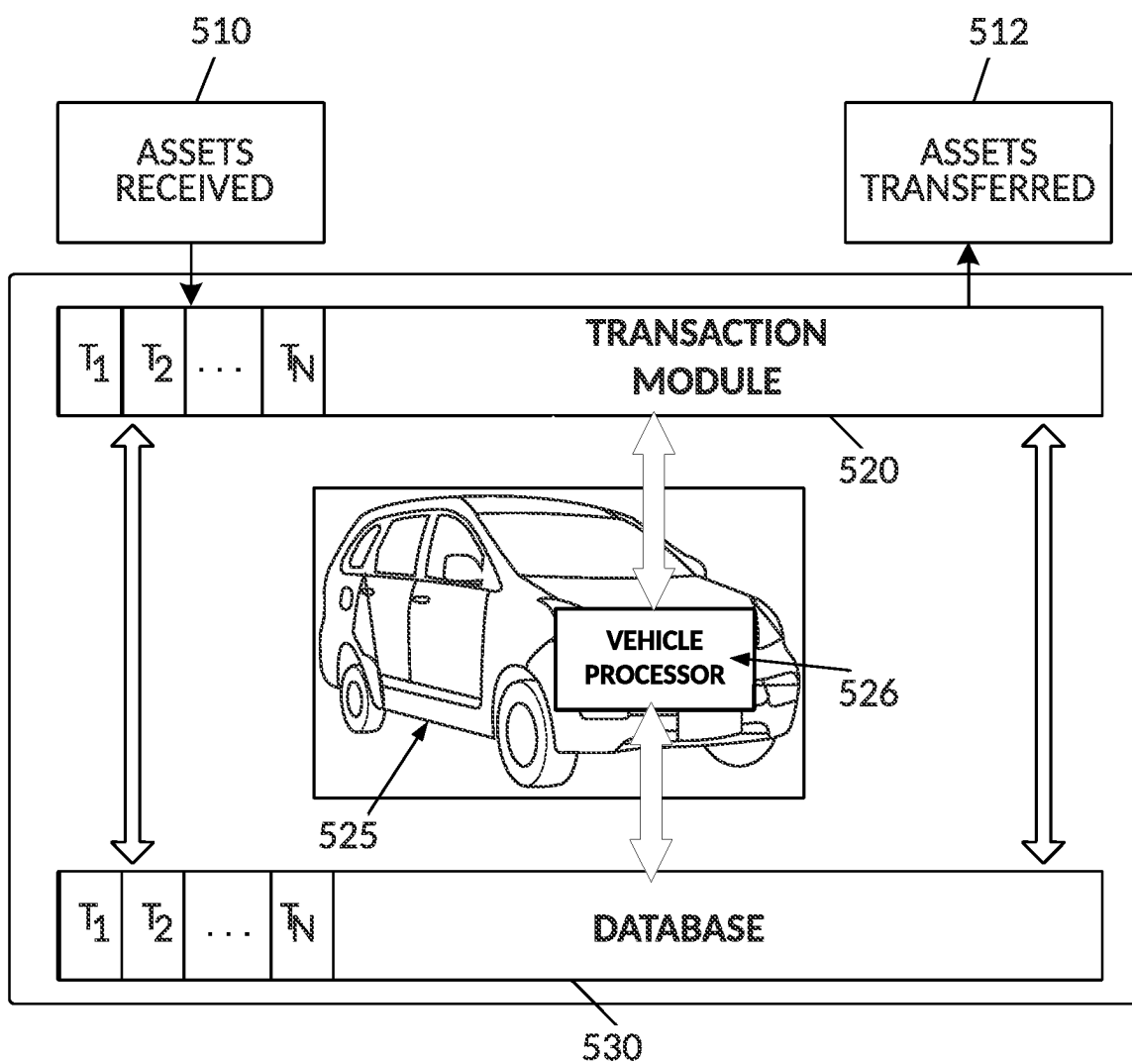


FIG. 5A

500B

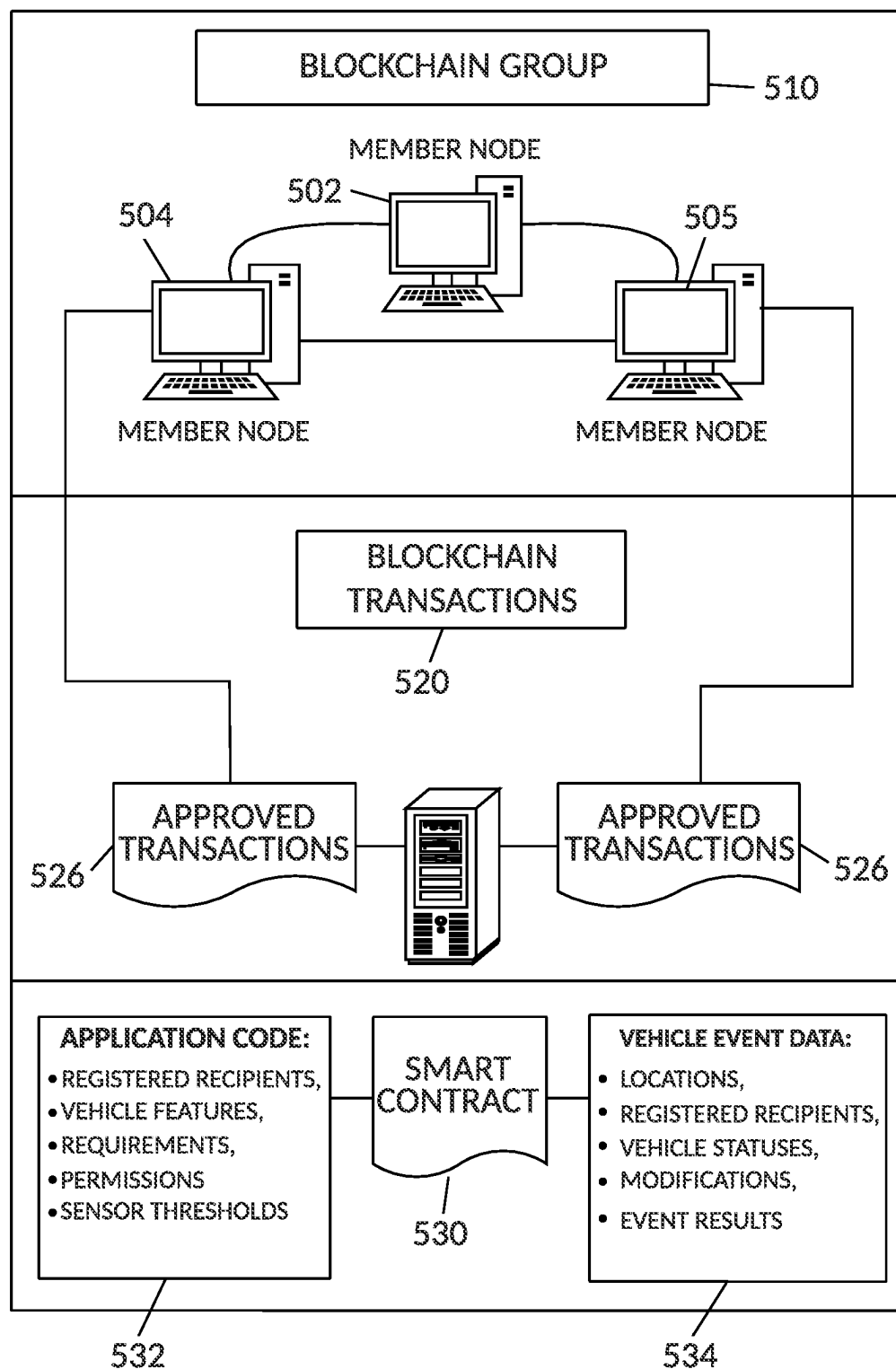


FIG. 5B

500C

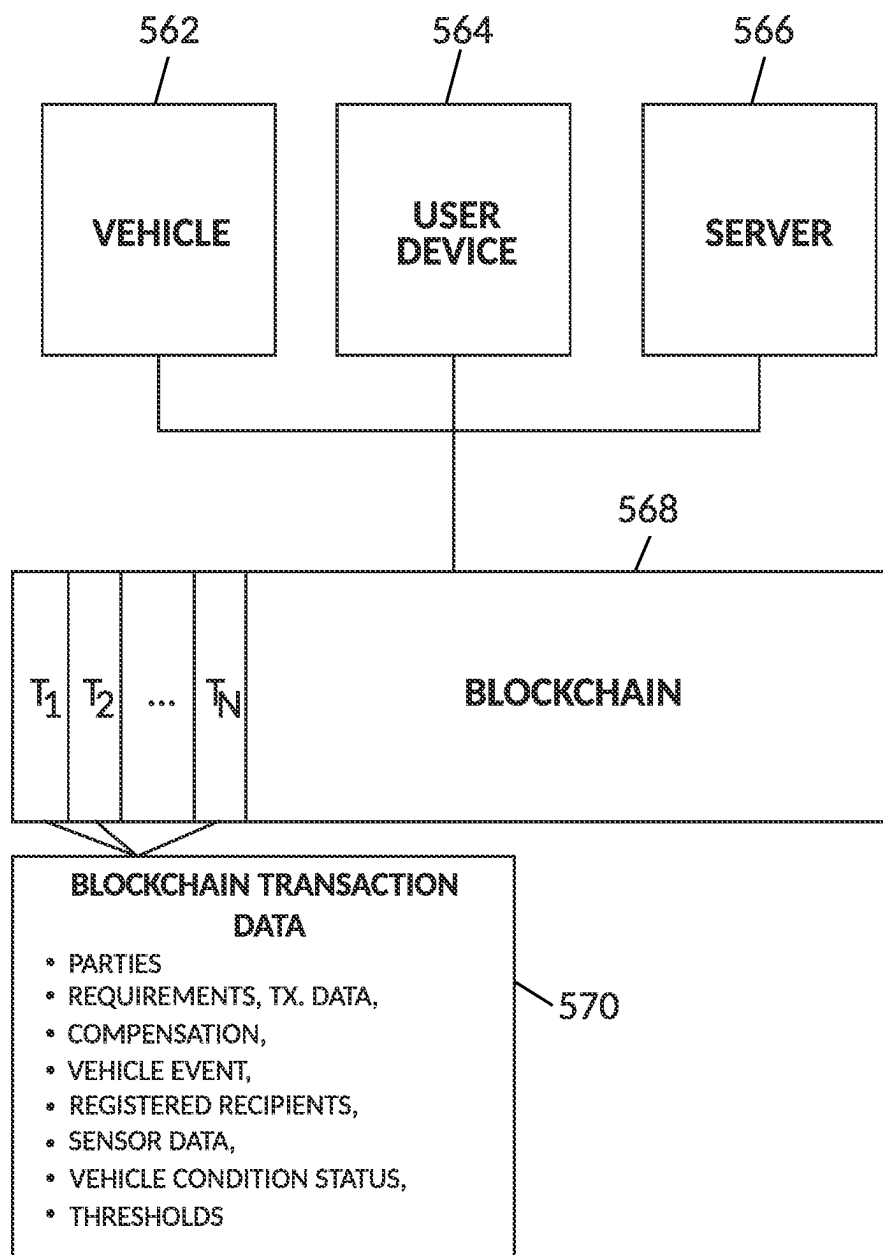
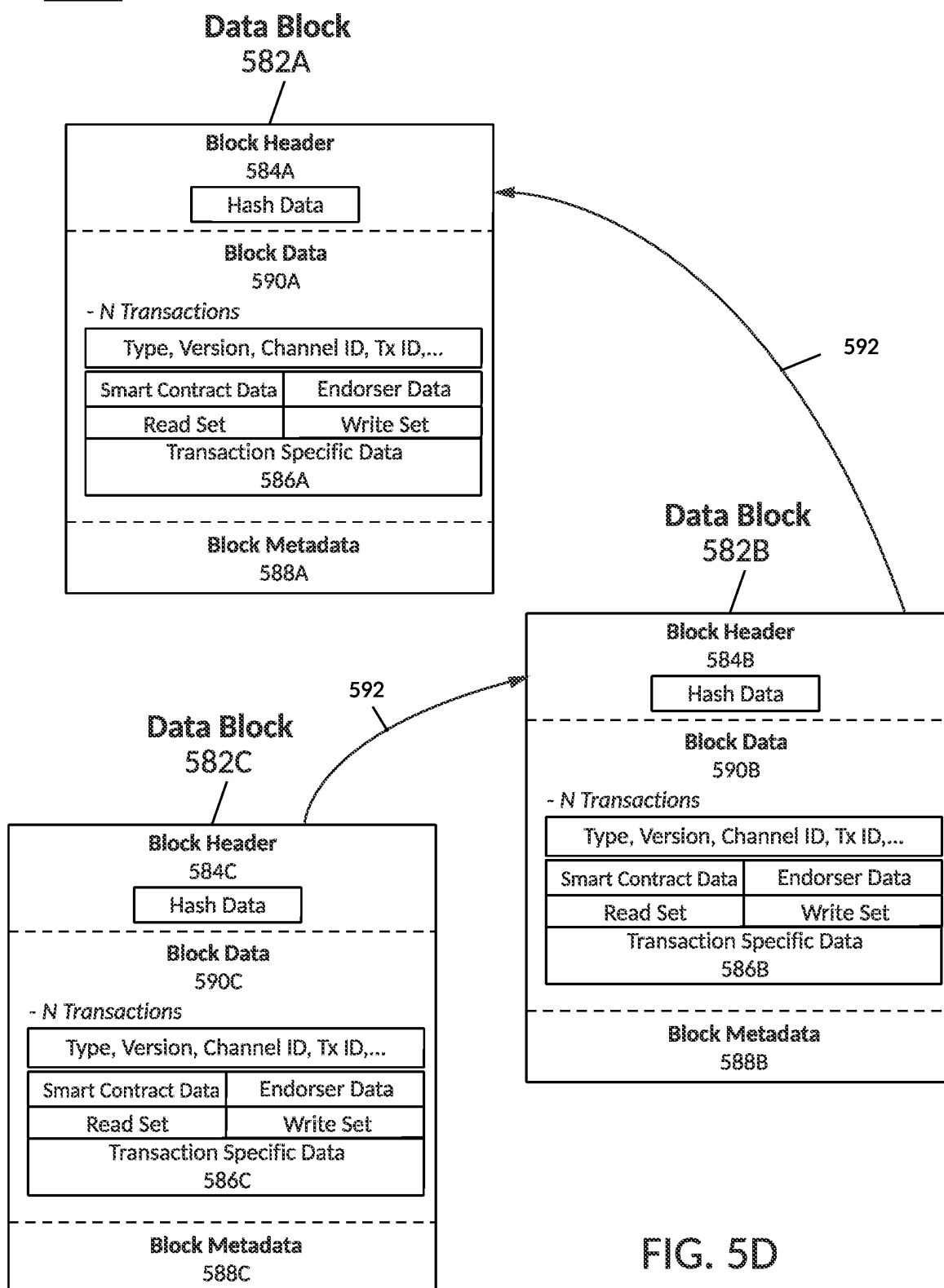


FIG. 5C

**500D**



**FIG. 5D**

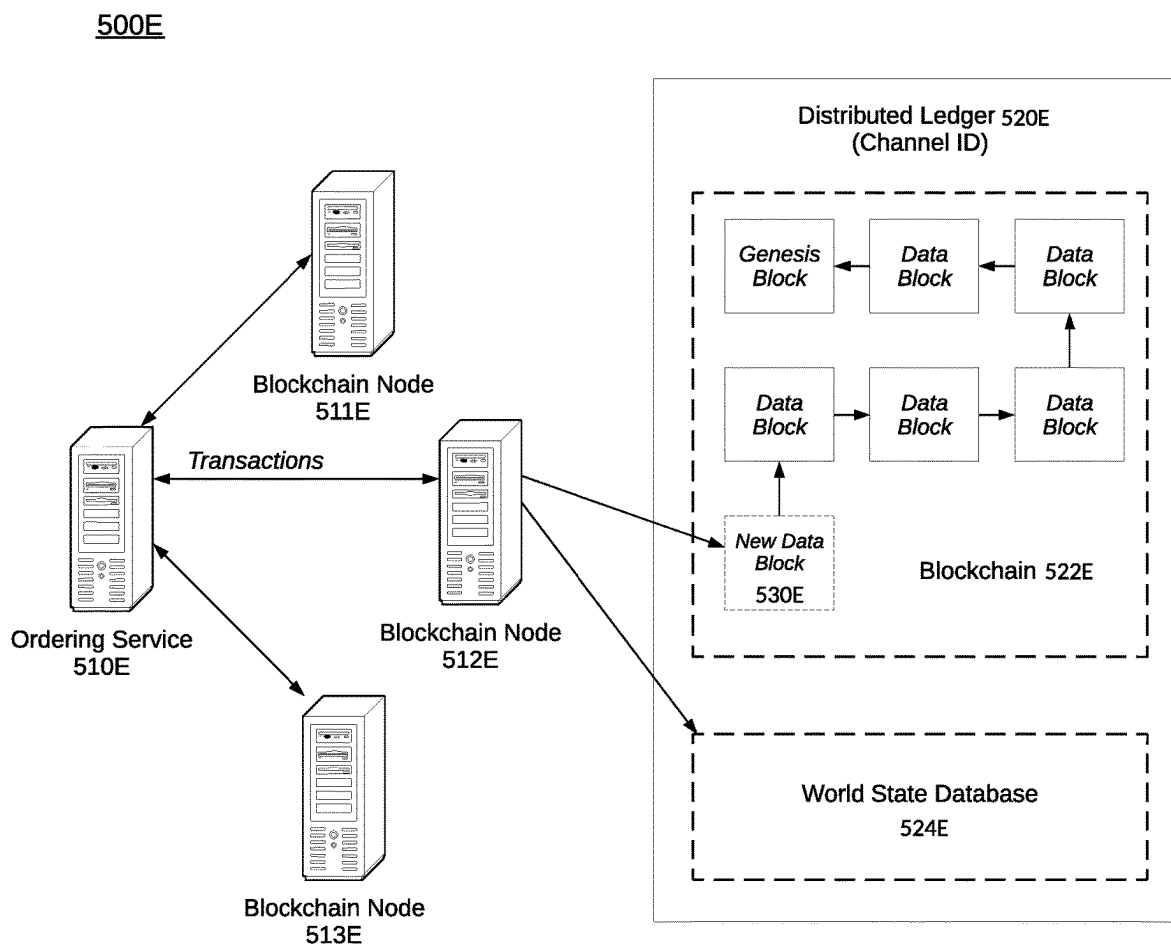


FIG. 5E



500F

New Data Block 530

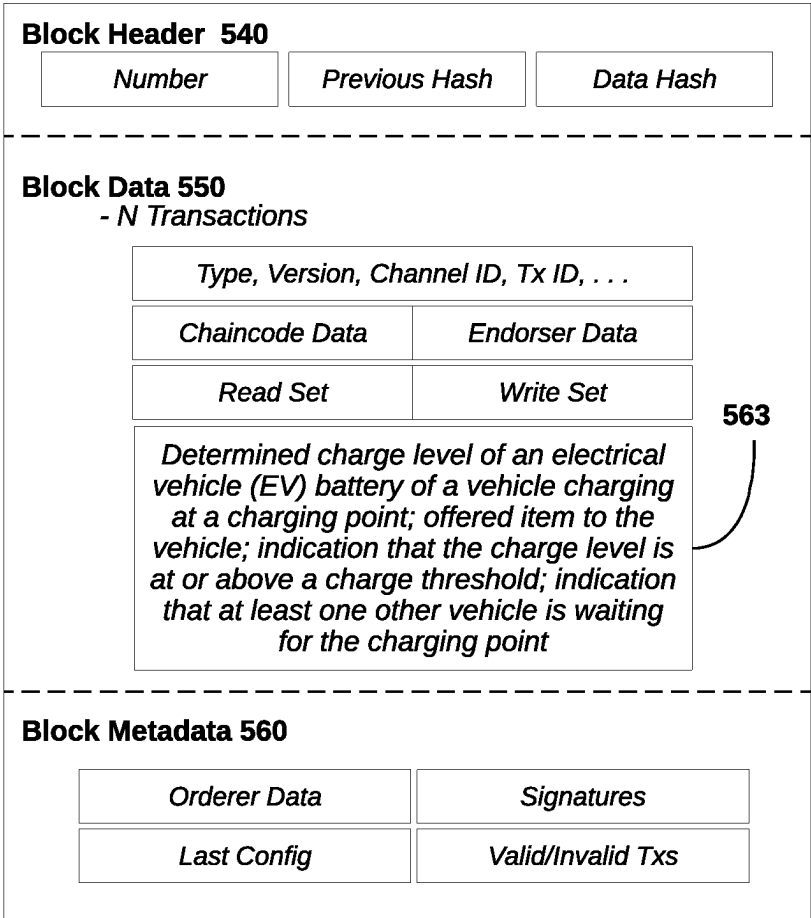


FIG. 5F

600

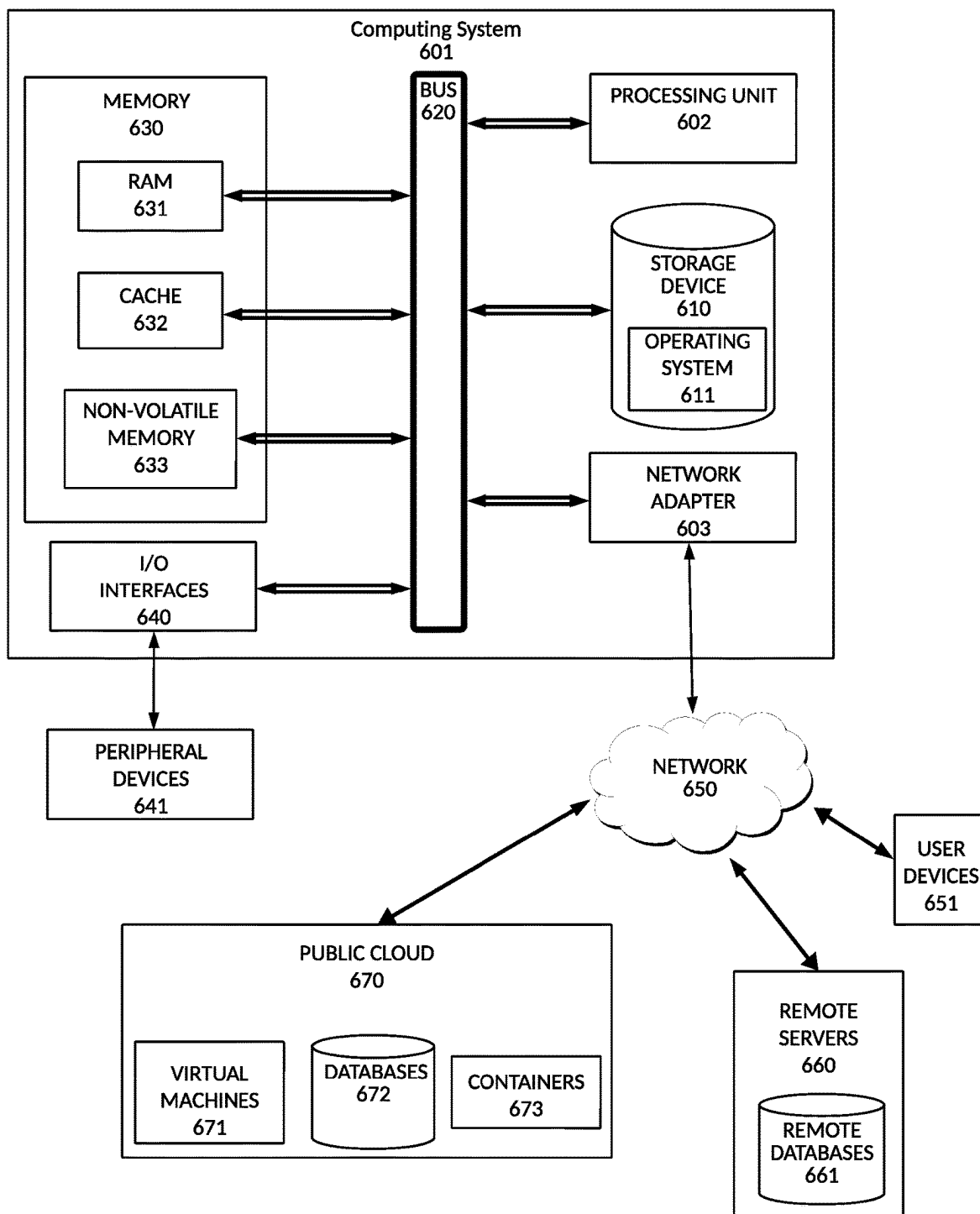


FIG. 6

## MINIMIZING A VEHICLE CHARGE TIME

### BACKGROUND

**[0001]** Vehicles or transports, such as cars, motorcycles, trucks, planes, trains, etc., generally provide transportation needs to occupants and/or goods in a variety of ways. Functions related to vehicles may be identified and utilized by various computing devices, such as a smartphone or a computer located on and/or off the vehicle.

### SUMMARY

**[0002]** One example embodiment provides a method that includes one or more of determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point, and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

**[0003]** Another example embodiment provides a system that includes a memory communicably coupled to a processor, wherein the processor performs one or more of determine a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point, and offer an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

**[0004]** Another example embodiment may include a non-transitory computer readable storage medium configured to store instructions that when executed cause a processor to perform determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point, and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0005]** FIG. 1A illustrates an example system diagram of a vehicle charging at a charging station and the process being managed by a server, according to example embodiments.

**[0006]** FIG. 1B illustrates a network diagram of vehicles registered to use a charging station, according to example embodiments.

**[0007]** FIG. 2A illustrates a vehicle network diagram, according to example embodiments.

**[0008]** FIG. 2B illustrates another vehicle network diagram, according to example embodiments.

**[0009]** FIG. 2C illustrates yet another vehicle network diagram, according to example embodiments.

**[0010]** FIG. 2D illustrates a further vehicle network diagram, according to example embodiments.

**[0011]** FIG. 2E illustrates a flow diagram, according to example embodiments.

**[0012]** FIG. 2F illustrates another flow diagram, according to example embodiments.

**[0013]** FIG. 3A illustrates an Artificial Intelligence (AI)/Machine Learning (ML) network diagram for integrating an artificial intelligence (AI) model into any decision point in the example embodiments.

**[0014]** FIG. 3B illustrates a process for developing an Artificial Intelligence (AI)/Machine Learning (ML) model that supports AI-assisted vehicle or occupant decision points.

**[0015]** FIG. 3C illustrates a process for utilizing an Artificial Intelligence (AI)/Machine Learning (ML) model that supports AI-assisted vehicle or occupant decision points.

**[0016]** FIG. 3D illustrates a machine learning network diagram, according to example embodiments.

**[0017]** FIG. 3E illustrates a machine learning network diagram, according to example embodiments.

**[0018]** FIG. 4A illustrates a diagram depicting electrification of one or more elements, according to example embodiments.

**[0019]** FIG. 4B illustrates a diagram depicting interconnections between different elements, according to example embodiments.

**[0020]** FIG. 4C illustrates a further diagram depicting interconnections between different elements, according to example embodiments.

**[0021]** FIG. 4D illustrates yet a further diagram depicting interconnections between elements, according to example embodiments.

**[0022]** FIG. 4E illustrates yet a further diagram depicting an example of vehicles performing secured Vehicle-to-Vehicle (V2V) communications using security certificates, according to example embodiments.

**[0023]** FIG. 5A illustrates an example vehicle configuration for managing database transactions associated with a vehicle, according to example embodiments.

**[0024]** FIG. 5B illustrates an example blockchain group, according to example embodiments.

**[0025]** FIG. 5C illustrates an example interaction between elements and a blockchain, according to example embodiments.

**[0026]** FIG. 5D illustrates an example data block interaction, according to example embodiments.

**[0027]** FIG. 5E illustrates a blockchain network diagram, according to example embodiments.

**[0028]** FIG. 5F illustrates an example new data block, according to example embodiments.

**[0029]** FIG. 6 illustrates an example system that supports one or more of the example embodiments.

### DETAILED DESCRIPTION

**[0030]** It will be readily understood that the instant components, as generally described and illustrated in the figures herein, may be arranged and designed in a wide variety of different configurations. Thus, the following detailed description of the embodiments of at least one of a method, apparatus, computer readable storage medium and system, as represented in the attached figures, is not intended to limit the scope of the application as claimed but is merely representative of selected embodiments. Multiple embodiments depicted herein are not intended to limit the scope of the solution. The computer-readable storage medium may be a non-transitory computer readable medium or a non-transitory computer readable storage medium.

**[0031]** Communications between the vehicle(s) and certain entities, such as remote servers, other vehicles and local computing devices (e.g., smartphones, personal computers, vehicle-embedded computers, etc.) may be sent and/or received and processed by one or more 'components' which may be hardware, firmware, software, or a combination thereof. The components may be part of any of these entities or computing devices or certain other computing devices. In one example, consensus decisions related to blockchain transactions may be performed by one or more computing

devices or components (which may be any element described and/or depicted herein) associated with the vehicle (s) and one or more of the components outside or at a remote location from the vehicle(s).

**[0032]** The instant features, structures, or characteristics described in this specification may be combined in any suitable manner in one or more embodiments. For example, the usage of the phrases “example embodiments,” “some embodiments,” “a first embodiment,” or other similar language throughout this specification refers to the fact that a particular feature, structure, or characteristic described in connection with the one or more embodiments may be included in one or more other embodiments described or depicted herein. Thus, the one or more embodiments, described or depicted throughout this specification can all refer to the same embodiment. Thus, these embodiments may work in conjunction with any of the other embodiments, may not be functionally separate, and the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. Although described in a particular manner, by example only, or more feature(s), element(s), and step(s) described herein may be utilized together and in various combinations, without exclusivity, unless expressly indicated otherwise herein. In the figures, any connection between elements can permit one-way and/or two-way communication, even if the depicted connection is a one-way or two-way connection, such as an arrow.

**[0033]** In the instant solution, a vehicle may include one or more of cars, trucks, Internal Combustion Engine (ICE) vehicles, battery electric vehicle (BEV), fuel cell vehicles, any vehicle utilizing renewable sources, hybrid vehicles, e-Pallettes, buses, motorcycles, scooters, bicycles, boats, recreational vehicles, planes, drones, Unmanned Aerial Vehicle (UAV) and any object that may be used to transport people and/or goods from one location to another.

**[0034]** In addition, while the term “message” may have been used in the description of embodiments, other types of network data, such as, a packet, frame, datagram, etc. may also be used. Furthermore, while certain types of messages and signaling may be depicted in exemplary embodiments they are not limited to a certain type of message and signaling.

**[0035]** Example embodiments provide methods, systems, components, non-transitory computer readable medium, devices, and/or networks, which provide at least one of a transport (also referred to as a vehicle or car herein), a data collection system, a data monitoring system, a verification system, an authorization system, and a vehicle data distribution system. The vehicle status condition data received in the form of communication messages, such as wireless data network communications and/or wired communication messages, may be processed to identify vehicle status conditions and provide feedback on the condition and/or changes of a vehicle. In one example, a user profile may be applied to a particular vehicle to authorize a current vehicle event, service stops at service stations, to authorize subsequent vehicle rental services, and enable vehicle-to-vehicle communications.

**[0036]** Within the communication infrastructure, a decentralized database is a distributed storage system which includes multiple nodes that communicate with each other. A blockchain is an example of a decentralized database, which includes an append-only immutable data structure

(i.e., a distributed ledger) capable of maintaining records between untrusted parties. The untrusted parties are referred to herein as peers, nodes, or peer nodes. Each peer maintains a copy of the database records, and no single peer can modify the database records without a consensus being reached among the distributed peers. For example, the peers may execute a consensus protocol to validate blockchain storage entries, group the storage entries into blocks, and build a hash chain via the blocks. This process forms the ledger by ordering the storage entries, as is necessary, for consistency. In public or permissionless blockchains, anyone can participate without a specific identity. Public blockchains can involve crypto-currencies and use consensus-based on various protocols such as proof of work (PoW). Conversely, a permissioned blockchain database can secure interactions among a group of entities, which share a common goal, but which do not or cannot fully trust one another, such as businesses that exchange funds, goods, information, and the like. The instant solution can function in a permissioned and/or a permissionless blockchain setting.

**[0037]** Smart contracts are trusted distributed applications which leverage tamper-proof properties of the shared or distributed ledger (which may be in the form of a blockchain) and an underlying agreement between member nodes, which is referred to as an endorsement or endorsement policy. In general, blockchain entries are “endorsed” before being committed to the blockchain while entries which are not endorsed are disregarded. A typical endorsement policy allows smart contract executable code to specify endorsers for an entry in the form of a set of peer nodes that are necessary for endorsement. When a client sends the entry to the peers specified in the endorsement policy, the entry is executed to validate the entry. After validation, the entries enter an ordering phase in which a consensus protocol produces an ordered sequence of endorsed entries grouped into blocks.

**[0038]** Nodes are the communication entities of the blockchain system. A “node” may perform a logical function in the sense that multiple nodes of different types can run on the same physical server. Nodes are grouped in trust domains and are associated with logical entities that control them in various ways. Nodes may include different types, such as a client or submitting-client node, which submits an entry-invocation to an endorser (e.g., peer), and broadcasts entry proposals to an ordering service (e.g., ordering node). Another type of node is a peer node, which can receive client submitted entries, commit the entries, and maintain a state and a copy of the ledger of blockchain entries. Peers can also have the role of an endorser. An ordering-service-node or orderer is a node running the communication service for all nodes and which implements a delivery guarantee, such as a broadcast to each of the peer nodes in the system when committing entries and modifying a world state of the blockchain. The world state can constitute the initial blockchain entry, which normally includes control and setup information.

**[0039]** A ledger is a sequenced, tamper-resistant record of all state transitions of a blockchain. State transitions may result from smart contract executable code invocations (i.e., entries) submitted by participating parties (e.g., client nodes, ordering nodes, endorser nodes, peer nodes, etc.). An entry may result in a set of asset key-value pairs being committed to the ledger as one or more operands, such as creates, updates, deletes, and the like. The ledger includes a block-

chain (also referred to as a chain), which stores an immutable, sequenced record in blocks. The ledger also includes a state database, which maintains a current state of the blockchain. There is typically one ledger per channel. Each peer node maintains a copy of the ledger for each channel of which they are a member.

**[0040]** A chain is an entry log structured as hash-linked blocks, and each block contains a sequence of N entries where N is equal to or greater than one. The block header includes a hash of the blocks' entries, as well as a hash of the prior block's header. In this way, all entries on the ledger may be sequenced and cryptographically linked together. Accordingly, it is not possible to tamper with the ledger data without breaking the hash links. A hash of a most recently added blockchain block represents every entry on the chain that has come before it, making it possible to ensure that all peer nodes are in a consistent and trusted state. The chain may be stored on a peer node file system (i.e., local, attached storage, cloud, etc.), efficiently supporting the append-only nature of the blockchain workload.

**[0041]** The current state of the immutable ledger represents the latest values for all keys that are included in the chain entry log. Since the current state represents the latest key values known to a channel, it is sometimes referred to as a world state. Smart contract executable code invocations execute entries against the current state data of the ledger. To make these smart contract executable code interactions efficient, the latest values of the keys may be stored in a state database. The state database may be simply an indexed view into the chain's entry log and can therefore be regenerated from the chain at any time. The state database may automatically be recovered (or generated if needed) upon peer node startup and before entries are accepted.

**[0042]** A blockchain is different from a traditional database in that the blockchain is not a central storage but rather a decentralized, immutable, and secure storage, where nodes must share in changes to records in the storage. Some properties that are inherent in blockchain and which help implement the blockchain include, but are not limited to, an immutable ledger, smart contracts, security, privacy, decentralization, consensus, endorsement, accessibility, and the like.

**[0043]** Example embodiments provide a service to a particular vehicle and/or a user profile that is applied to the vehicle. For example, a user may be the owner of a vehicle or the operator of a vehicle owned by another party. The vehicle may require service at certain intervals, and the service needs may require authorization before permitting the services to be received. Also, service centers may offer services to vehicles in a nearby area based on the vehicle's current route plan and a relative level of service requirements (e.g., immediate, severe, intermediate, minor, etc.). The vehicle needs may be monitored via one or more vehicle and/or road sensors or cameras, which report sensed data to a central controller computer device in and/or apart from the vehicle. This data is forwarded to a management server for review and action. A sensor may be located on one or more of the interior of the vehicle, the exterior of the vehicle, on a fixed object apart from the vehicle, and on another vehicle proximate the vehicle. The sensor may also be associated with the vehicle's speed, the vehicle's braking, the vehicle's acceleration, fuel levels, service needs, the gear-shifting of the vehicle, the vehicle's steering, and the like. A sensor, as described herein, may also be a device, such as a wireless

device in and/or proximate to the vehicle. Also, sensor information may be used to identify whether the vehicle is operating safely and whether an occupant has engaged in any unexpected vehicle conditions, such as during a vehicle access and/or utilization period. Vehicle information collected before, during and/or after a vehicle's operation may be identified and stored in a transaction on a shared/distributed ledger, which may be generated and committed to the immutable ledger as determined by a permission granting consortium, and thus in a "decentralized" manner, such as via a blockchain membership group.

**[0044]** Each interested party (i.e., owner, user, company, agency, etc.) may want to limit the exposure of private information, and therefore the blockchain and its immutability can be used to manage permissions for each particular user vehicle profile. A smart contract may be used to provide compensation, quantify a user profile score/rating/review, apply vehicle event permissions, determine when service is needed, identify a collision and/or degradation event, identify a safety concern event, identify parties to the event and provide distribution to registered entities seeking access to such vehicle event data. Also, the results may be identified, and the necessary information can be shared among the registered companies and/or individuals based on a consensus approach associated with the blockchain. Such an approach may not be implemented on a traditional centralized database.

**[0045]** Various driving systems of the instant solution can utilize software, an array of sensors as well as machine learning functionality, light detection and ranging (Lidar) projectors, radar, ultrasonic sensors, etc. to create a map of terrain and road that a vehicle can use for navigation and other purposes. In some embodiments, GPS, maps, cameras, sensors, and the like can also be used in autonomous vehicles in place of Lidar.

**[0046]** The instant solution includes, in certain embodiments, authorizing a vehicle for service via an automated and quick authentication scheme. For example, driving up to a charging station or fuel pump may be performed by a vehicle operator or an autonomous vehicle and the authorization to receive charge or fuel may be performed without any delays provided the authorization is received by the service and/or charging station. A vehicle may provide a communication signal that provides an identification of a vehicle that has a currently active profile linked to an account that is authorized to accept a service, which can be later rectified by compensation. Additional measures may be used to provide further authentication, such as another identifier may be sent from the user's device wirelessly to the service center to replace or supplement the first authorization effort between the vehicle and the service center with an additional authorization effort.

**[0047]** Data shared and received may be stored in a database, which maintains data in one single database (e.g., database server) and generally at one particular location. This location is often a central computer, for example, a desktop central processing unit (CPU), a server CPU, or a mainframe computer. Information stored on a centralized database is typically accessible from multiple different points. A centralized database is easy to manage, maintain, and control, especially for purposes of security because of its single location. Within a centralized database, data redundancy is minimized as a single storing place of all data also

implies that a given set of data only has one primary record. A blockchain may be used for storing vehicle-related data and transactions.

**[0048]** Any of the actions described herein may be performed by one or more processors (such as a microprocessor, a sensor, an Electronic Control Unit (ECU), a head unit, and the like), with or without memory, which may be located on-board the vehicle and/or off-board the vehicle (such as a server, computer, mobile/wireless device, etc.). The one or more processors may communicate with other memory and/or other processors on-board or off-board other vehicles to utilize data being sent by and/or to the vehicle. The one or more processors and the other processors can send data, receive data, and utilize this data to perform one or more of the actions described or depicted herein.

**[0049]** FIG. 1A illustrates an example system diagram of a vehicle charging at a charging station and the process being managed by a server, according to example embodiments. Referring to FIG. 1A, the system configuration 100 includes a vehicle 130 being identified as a candidate to initiate charging at a charging station 152 or charging point, hereinafter used interchangeably. A server 160 may be a remote computer in a cloud network or a local computer operating near the vehicle 130, such as a mobile device or other computing device associated with the vehicle 130. Once a vehicle is identified as a candidate for power charging (e.g., electrical charging), the server may assign 112 the vehicle to a particular charging station 152 and the vehicle 130 may begin receiving charge 114. An initial vehicle charge level may quickly change to an elevated/higher/greater amount of charge which is monitored by the server 160. The amount of time, the updated charge level at any particular time, and other charge attributes may be monitored 116 by the server 160 on an ongoing basis. A prediction may be made as to how long the vehicle should charge or will need to charge to reach an optimal charge level (e.g., 50 percent, 60 percent, or higher). The type of vehicle, the type of charging station, previous charge durations on a per vehicle basis, etc., may all be used as the basis for predicting by the server 160 how much time the vehicle 130 should remain charging at the charge station 152.

**[0050]** If another vehicle or vehicles are registered and identified 118 as being in a queue maintained by the server 160, certain considerations are initiated regarding the status of the vehicle 130 that is actively charging, such as what charge level did the vehicle have before charging, what charge level does it currently have, how long has it been charging, what is the destination of the vehicle, etc. The vehicle charging station 152 and/or the vehicle 130 may determine one or more charging thresholds have been reached 122 and incentives should be offered 124 at the current time to persuade vehicle operators to leave their charging stations so queued vehicles can begin charging. The incentivized items 126 may be sent to the vehicle 130 to offer the vehicle an opportunity to accept the incentivized items and leave the charging station. The incentives may be sent to the display of the vehicle, a user's mobile device or other notification platforms.

**[0051]** Examples of charging thresholds may be a minimum basis threshold, such as 50 percent, which may represent a baseline as a minimum amount of charge necessary for the vehicle 130 to operate on the roadway without the concern of losing charge prior to a next destination. Another threshold may be an ideal basis threshold, such as 70 percent

as a goal for the vehicle to achieve based on one or more user settings. Another threshold may be a saturation threshold which may vary by vehicle, such as a point in charging where the amount of charge per unit of time is less than the amount of charge per unit of time prior to the vehicle battery reaching the saturation threshold, such as, for example, when the vehicle 130 begins to charge slower and should probably leave the station for optimal time use purposes for the vehicle driver and other vehicles waiting for the charging station. At any one or more of the charging thresholds, the incentives may be offered and they may be different at each threshold identified. A number of vehicles in the queue may affect whether an incentive is offered at any one or more of the thresholds. No vehicles in the queue may indicate no incentives at any particular time. The greater the number of vehicles in the queue waiting for a charging station 152 may elevate the quality of the incentives.

**[0052]** FIG. 1B illustrates a network diagram of vehicles registered to use a charging station, according to example embodiments. Referring to FIG. 1B, the network 150 includes a vehicle management server 160 which may maintain a queue of vehicles 130, 132, 134 . . . N, which are planning to have a charge cycle at a charging point or charging station 152. The currently charging vehicle 130 may have an initial charge level, such as 10 percent or a low amount of charge respective to a full charge level of 100 percent. Any vehicle that is attempting to charge below an initial minimum charge level, such as 30 percent, may be charged more per unit of charge received since that vehicle may not be considered charge deficient at that particular time. The vehicle 130 may receive a consistent charge rate to reach a saturation point, such as 80 percent, where the charge rate over time begins to slow and the other vehicles should be offered charge at a sooner time to avoid overuse of the charging station 152.

**[0053]** If the charge is occurring during a peak use period, such as 7 am to 10 am or 3 pm to 6 pm, the saturation point of 80 percent may be adjusted to include a preferred exit point, such as 60 percent battery capacity to encourage those on the charging station to leave in favor of other vehicles. After the peak use time is over, the preferred exit point of 60 percent capacity may be removed from consideration. At any of the example thresholds of time and charge junctions noted, an incentive 162 may be offered to leave the charging station.

**[0054]** The magnitude of the incentives or number of incentives may increase based on whether it is a peak use period or whether there are a large quantity of other vehicles waiting to charge (e.g., 3 or more). A weighted function may be used to determine which incentive(s) to offer a currently charging vehicle 130, such as if the vehicle has charged past a predefined period of time (e.g., 20 minutes), the time portion (T) of the function may be weighted heavier than it was prior to the predefined period of time having matured, a number of vehicles (V) may also begin with one and move to three over the predefined period of time, thus increasing the value of (V) by 200 percent, and the saturation point and/or maximum charge value (M) permitted may be 60, 70, 80 percent, or whatever basis the charging station system is using at that time as a threshold for increasing the charging rate or offering incentives to the vehicle that is charging. All of those variables are used in determining an incentive value (IV). For example,  $T+V+M=(IV)$ , which may change in value. As the values increase, the incentive values and/or

number of incentives may increase in value based on the weighted function total sum value. The cost per charge will also increase as a way to admonish the vehicle user for remaining at the charging station after the warning message is sent to the vehicle's display and/or user's device located inside the vehicle.

**[0055]** One example process of operation may include determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point. This may be performed prior to the charging begins, after the charging begins and periodically every minute or so while charging, and/or after a predefined period of time, such as 10 minutes or a different period of time. The process may also include offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

**[0056]** The process may include determining an amount of time the vehicle has been charging at the charging point, and after the amount of time has exceeded a time threshold, transmitting a message including a recommended course of action to the vehicle comprising instructions on when to stop charging and one or more incentives to stop charging within a time window that begins after the message is transmitted. The charge threshold is based on one or more of a default charge percentage of a total charge capacity of the EV battery and an amount of charge required for the vehicle to navigate to a known destination and an amount of charge required for the vehicle to navigate for a predefined period of time. When a vehicle has a subsequent list of locations to visit, such as a list of data stored as a navigation route(s), the amount of charge may be larger than a standard threshold value assigned by the charging station **152**. In this case, the charging station **152** may identify the list and elevate the threshold to a higher level to accommodate the vehicle's needs for more charge and more time spent at the charging station **152**.

**[0057]** The process may include determining whether the at least one other vehicle has a charge level below a minimum charge threshold, and offering a first type of incentive as the item when the at least one other vehicle has a charge level below the minimum charge threshold, and offering a second type of incentive as the item when the at least one other vehicle does not have a charge level below the minimum charge threshold. The more charge needed by a vehicle that is waiting for the charging station may increase the value of the incentive(s) offered to the vehicle that is currently charging. The process may also include identifying the charge level as being above a slowing charge level threshold (i.e., saturation rate, such as 80 percent) based on a current charge level of the EV battery and an amount of charge received at the EV battery over a recent period of time being less than an amount of charge received at the EV battery over a previous period of time, and the recent period of time and the less recent or previous period of time are based on a same amount of time, such as 10 minutes.

**[0058]** The process may also include providing a warning message to the vehicle that the charge progress has saturated and any subsequent charging is to be performed at a higher value and the item will not be available unless the charging is ceased within a period of time. The process may further include receiving a confirmation that the item has been accepted, and enabling the at least one other vehicle to begin charging at the charging point. A user may be prompted to

accept the charge credit for use at a future date, such as the free movie tickets, the free movie online, the coupon for a local restaurant, etc., and then leave the charge station within a short time period, such as 60 seconds, in order for the incentive to stay active.

**[0059]** In one example, the system application, such as the monitoring application of the vehicle management server **160** and/or a computing device associated with the vehicle **130** may be actively monitoring the charge level of the vehicle's battery while it is currently using the charging station/point **152**. The application may trigger a response when the charge level reaches or exceeds a predefined threshold (e.g., 80%), and at that point the vehicle **130** may be offered an item or incentive **162** to stop charging and vacate the charging point. When other vehicles **132-134** are waiting to use the charging point, a queue may be created with profiles of other vehicles which are waiting for the charging point. The queue information may be maintained, updated, and monitored by the server **160**. When the server **160** can identify a vehicle **132/134** in the queue is needing charge more urgently than a currently charging vehicle **130**, the server **160** may dispatch an incentive and/or request to the vehicle **130** to vacate the charging point.

**[0060]** Charging stations may manage growing queues of vehicles waiting for charge through increased costs for idle vehicle fees and increased costs for charges over 80% of a vehicle's battery capacity. The server **160** may have knowledge of the vehicle's current charge and when it reaches saturation point (e.g., 80%) the cost thereafter may increase and/or the vehicle may be invited to leave or may instead be offered an incentive to leave the charging station. Charging providers currently use idle fees to discourage vehicles from idling in a spot after charging is complete or after a threshold charge level is reached. In the basic sense, an idle fee is what the provider charges a driver for the additional time they remain plugged into the charger after reaching a saturation charge level, such as 80 percent, where the vehicle will begin charging slower. Idle fees may only be enabled when the entire station location is at 50 percent capacity or more and/or other vehicles are waiting. Another approach is to increase the charging cost once a vehicle reaches the ideal level or saturation point (e.g., 80 percent charged). In some cases, once a battery reaches the saturation point percentage of charge, the charging rate over time significantly reduces, which can further increase queuing issues and may cause charging costs to rise. One example enables the ability for vehicles at a charging station to be incentivized with an item for allowing waiting vehicles to charge once their charge level is above a threshold (e.g., 50, 60, 80%). Items used for the incentives may include content (free movies) being sent to the vehicle directly, vehicle-related services such as an oil changes, charging credits, local product coupons, and the like, etc.

**[0061]** The system application may offer an item to the EV driver to encourage drivers to stop charging at a threshold level, such as the saturation point where the charge rate of the battery begins to slow down, especially when other vehicles are waiting. The threshold of when the system triggers a response can be adjusted based on factors such as the estimated distance the vehicle needs to travel to reach its destination, and the threshold may be related to the efficiency of the received charge, such as when the efficiency is lowered when the vehicle battery or batteries are charged above a particular level (e.g., 80%). The item presented to

the vehicle may be anything from entertainment options (movies, television shows, etc.), discount vouchers, additional charging credits for future use, or other incentives. Drivers that agree to stop charging at the threshold level might be offered enhanced items or benefits for their next charging session, such as a pass to move to the front of the line or extra time with no added cost. The incentive is used to promote cooperative behavior among the vehicle users. Providing incentives to drivers to stop charging once their battery reaches a sufficient level, especially when others are waiting, can reduce waiting times at charging stations and improve overall user experiences.

**[0062]** One example item offered to a vehicle may be based on a dynamic pricing model. For example, as the vehicle battery charge approaches a threshold level, the cost per unit of electricity increases significantly at the threshold, and any attempt for charging past the threshold, the cost increases. The incentivizing of the drivers to disconnect their vehicle once it has sufficient charge and/or it has passed the threshold value of charge may lower a wait time especially when there is a queue of drivers. Conversely, drivers arriving at a less busy time may benefit from lower rates and may not be subject to higher charge rates on or after reaching a threshold amount of charge.

**[0063]** In one example, a network of information is created so that all nearby drivers and vehicles can share information about their charging needs and schedules. The system may use artificial intelligence and/or machine learning to optimize the distribution of charging points and vehicles across different charging areas based on anticipated demand. Drivers who adjust their charging schedule to less busy times or locations receive benefits, such as reduced charging fees and/or additional items.

**[0064]** Identifying vehicles and their charging needs may begin with a vehicle identification system that can recognize a vehicle by an image detection process and/or a license plate reading process. This may automatically register a vehicle near a charging queue when the vehicle approaches the charging station. Once a vehicle is identified, a vehicle type and charging station type may be identified so a scheduling process may be enabled to determine when and where the vehicle should be to receive a charge. The type of content offered may be based on a type of charging station, such as more premium content for slower charging stations and better incentives for slower charging stations. Peak hours for charging may also dictate the types of items presented to the vehicles. During peak hours, the threshold for charge saturation may be lower, such as 60 percent. Charging beyond that level may cause costs to increase, and any invitations to leave the charging station may be provided beyond that percent threshold. During off-peak hours the threshold may be increased to 80 percent at which time items of incentive are offered to stop charging at that threshold rate. The content provided may be based on peak hours and off-peak hours.

**[0065]** In one embodiment, the instant solution integrates with a charging station network that utilizes geolocation data to provide incentives. The system manages charging station turnover and supports local commerce, creating a symbiotic relationship between EV drivers, charging stations, and nearby businesses. The system tracks the geolocation of EVs currently using charging stations and those in proximity waiting for a charge. When an EV at a charging point reaches a predetermined charge level, and there are other

vehicles waiting, the system activates its incentive mechanism. The geolocation data of the charging EV is used to identify nearby amenities and businesses such as restaurants, cafes, shopping centers, or entertainment venues. Based on the proximity and partnerships with local businesses, the system generates tailored incentives for the EV driver. The incentives range from discounts at nearby restaurants, free or discounted tickets to a nearby cinema, shopping vouchers, and special offers at local stores. The nature of the incentive is dynamically determined based on factors such as the time of day, the driver's historical preferences (if available), and the current deals offered by participating businesses. Once an incentive is generated, the EV driver is notified through an in-car system or a mobile application associated with the charging network. The notification includes details about the incentive, its validity, and directions to the business offering the incentive. To redeem the offer, the driver must vacate the charging spot within a specified time frame, encouraging timely turnover at the charging station. Upon vacating, a digital coupon or digital code for the incentive is activated, which the driver can present at the respective business. The system is integrated with a smart city's infrastructure, allowing for real-time updates on traffic conditions, parking availability, and other relevant urban data. The integration provides additional contextually relevant information, such as suggesting the best time to visit a particular business based on current traffic patterns or event schedules. The system also includes a feedback mechanism where drivers can rate their experience with both the charging service and the incentives. The feedback is used to continuously refine the algorithm that selects and offers incentives, ensuring that the offers remain attractive and relevant to EV drivers.

**[0066]** In one embodiment, the instant solution integrates a gamification system into the EV charging process. The system is a points-based system, where EV drivers earn points for charging behaviors that contribute to the efficient utilization of charging stations. This includes actions like vacating a charging spot promptly after reaching a predetermined charge level, especially during high-demand periods, or opting to charge during off-peak hours. Drivers' accumulated points are reflected on a leaderboard, which is accessible through a dedicated mobile application or a website. The leaderboard creates a sense of competition and community among EV drivers. Users can see their ranking in comparison to others in their local area, city, or even on a national level. The leaderboard is updated in real time, providing continuous feedback and motivation to drivers. The points earned can be redeemed for various rewards, including free or discounted charging sessions, priority access to charging stations (such as reserved spots or queue jumps), and non-charging-related rewards like vouchers for local businesses or EV accessories. Top performers on the leaderboard receive special recognition and exclusive rewards, such as EV-related merchandise or a significant number of free charging credits. The system can personalize challenges based on individual charging patterns and behaviors. For instance, a driver who typically charges to 100% might receive a challenge to stop at 80% when the station is busy, earning extra points for doing so. Achievements can also be unlocked for various milestones, like a certain number of efficient charges, contributing to the user's overall score and position on the leaderboard. The system includes social features allowing users to connect with friends, share achievements, and compare rankings. Com-



munity forums and chat functions foster discussions about efficient charging habits, EV maintenance tips, and more, building a sense of community among users. The system uses data analytics to continuously refine its point algorithms and challenges based on user behavior, station usage patterns, and overall system efficiency to ensure the gamification elements remain effective and engaging over time. The system also provides users with reports on their personal contribution to reducing carbon emissions through efficient charging, further reinforcing the positive impact of their behavior.

**[0067]** In one embodiment, the system incentivizes EV charging using renewable energy sources. When EVs charge using renewable energy sources (like solar or wind power) and vacate the spot upon reaching a certain threshold during high-demand periods, they receive eco-credits. These credits can be used for various green initiatives or discounts on eco-friendly products, aligning with broader environmental goals and encouraging sustainable energy usage among EV drivers. The system targets times when renewable energy availability is high, promoting its use over non-renewable sources. When an EV charges using renewable energy, and especially during periods of high renewable energy generation, the driver earns eco-credits. The credits are accumulated based on factors such as the amount of energy consumed, the time of charging (coinciding with peak renewable energy production times), and the consistency of using renewable sources for charging. The system automatically detects the energy source type being used for charging and allocates credits accordingly. Accumulated eco-credits can be redeemed for various rewards, including discounts on future charging sessions, especially those powered by renewable energy, rebates on eco-friendly products or services, and contributions to environmental causes in the driver's name. The system incorporates intelligent scheduling advising drivers on the best times to charge based on renewable energy availability. For instance, it might suggest charging during daylight hours in areas with abundant solar power or at night in regions where wind power is more readily available. The system integrates with smart grid technologies, allowing it to respond in real time to changes in renewable energy production and grid demand, adjusting incentives and charging recommendations accordingly. A user-friendly application or dashboard provides drivers with real-time information about their eco-credit balance, the environmental impact of their charging habits, and personalized suggestions for optimizing renewable energy use. The interface includes educational content about renewable energy and its benefits, reinforcing the program's environmental focus. The program incorporates community challenges and goals, such as achieving a certain number of green charges in a month or collectively saving a set amount of CO<sub>2</sub> emissions. Success in these challenges leads to additional rewards and public recognition, fostering a sense of community and collective environmental responsibility. The system can scale up and integrate with larger entities such as corporate fleets, public transport systems, and municipal vehicles, further amplifying its environmental impact.

**[0068]** In one embodiment, the system uses artificial intelligence to predict the optimal charging levels for EVs based on their travel patterns, battery health, and upcoming route requirements. When an EV is charging, and another vehicle is waiting, the artificial intelligence (AI) system can calcu-

late the minimum necessary charge for the first vehicle to complete its immediate journey efficiently. It then offers tailored incentives to the driver to stop charging at this optimally calculated level. The incentives include future charging priority or specialized service offers. The system leverages AI algorithms, to analyze a multitude of factors and determine the most efficient charging strategy for each EV. The factors include the vehicle's current battery level, historical charging patterns, battery health, anticipated energy consumption based on upcoming travel routes, and real-time data on charging station availability. The AI predicts not just the ideal charge level for each vehicle but also the optimal time and duration for charging. When an EV is charging, and the AI system determines that vacating the charging spot at a certain threshold may significantly benefit overall station efficiency (especially when other vehicles are waiting), it offers tailored incentives to the driver. The incentives vary based on the urgency of the need for the charging spot and the driver's charging behavior. For example, a driver might be offered additional charging credits, priority access in future charging sessions, or discounts at affiliated services for complying with the AI's recommendations. The AI system continuously updates its charging recommendations based on changing conditions, such as the arrival of new vehicles needing urgent charging, fluctuations in energy demand, or updates in a driver's travel plans. Drivers interact with the system through a user-friendly application or in-car interface. The interface displays the AI's charging recommendations, real-time incentives being offered, and an explanation of how following these suggestions helps improve overall charging network efficiency. The interface also provides insights into the environmental impact of the driver's charging habits and tips for further optimization. This system also integrates with broader smart city infrastructure and IoT devices. This integration allows for a more comprehensive approach to energy management, considering factors like local energy grid demands, renewable energy availability, and even real-time traffic conditions. The AI system employs machine learning algorithms to refine its predictive models based on real-world data. As it receives feedback on its recommendations—both from the charging infrastructure and driver responses—it continuously improves its accuracy and effectiveness.

**[0069]** In one embodiment, the instant solution revolves around a community-based approach where EV owners can share personal charging stations. The system involves individual EV owners offering their private charging stations for community use. These may be home chargers or chargers installed at privately owned locations, such as businesses or apartment complexes. Both the owners of the charging stations and the users who charge their EVs at these stations receive incentives. For instance, station owners earn credits every time another community member uses their charger. These credits can be redeemed for free charging at other community stations, monetary compensation, or discounts on electricity bills or EV maintenance services. To manage demand and supply effectively, the system employs a dynamic pricing model. During peak hours or high-demand periods, charging at these community stations may cost more, encouraging users to charge during off-peak hours. Regular contributors to the network (either by frequently offering their chargers or by maintaining efficient charging habits) may be rewarded with priority access or reduced

rates. A mobile application or web platform serves as the central hub for this system. Users can locate available charging stations, reserve charging slots, and manage transactions. Station owners can control the availability of their chargers, set pricing, and track their earnings and usage statistics. The platform also facilitates payment processing and credit redemption. The system can promote community goals, such as achieving a certain number of shared charges in a month or reducing overall carbon emissions by a specific target, leading to community-wide rewards, such as collective discounts or donations to local environmental initiatives. A feedback and rating system allows users to rate their charging experience and the charging station. This feedback is crucial for maintaining trust within the community and ensuring the quality of the service. High-rated stations and users who consistently receive positive feedback may be rewarded with additional incentives. The system integrates with renewable energy sources. Station owners who power their chargers with solar or wind energy can receive additional incentives, promoting green energy use within the community. The model can scale up to create a widespread network of community charging stations. Partnerships with local businesses, government entities, and EV manufacturers may further expand the network's reach and impact.

[0070] Flow diagrams depicted herein, such as FIG. 1A, FIG. 2C, FIG. 2D, FIG. 2E, and FIG. 2F, are separate examples but may be the same or different embodiments. Any of the operations in one flow diagram may be adopted and shared with another flow diagram. No example operation is intended to limit the subject matter of any embodiment or corresponding claim.

[0071] It is important to note that all the flow diagrams and corresponding processes derived from FIG. 1A, FIG. 2C, FIG. 2D, FIG. 2E, and FIG. 2F may be part of a same process or may share sub-processes with one another thus making the diagrams combinable into a single preferred embodiment that does not require any one specific operation but which performs certain operations from one example process and from one or more additional processes. All the example processes are related to the same physical system and can be used separately or interchangeably.

[0072] The instant solution can be used in conjunction with one or more types of vehicles: battery electric vehicles, hybrid vehicles, fuel cell vehicles, internal combustion engine vehicles and/or vehicles utilizing renewable sources.

[0073] FIG. 2A illustrates a vehicle network diagram 200, according to example embodiments. The network comprises elements including a vehicle 202 including a processor 204, as well as a vehicle 202' including a processor 204'. The vehicles 202, 202' communicate with one another via the processors 204, 204', as well as other elements (not shown) including transceivers, transmitters, receivers, storage, sensors, and other elements capable of providing communication. The communication between the vehicles 202, and 202' can occur directly, via a private and/or a public network (not shown), or via other vehicles and elements comprising one or more of a processor, memory, and software. Although depicted as single vehicles and processors, a plurality of vehicles and processors may be present. One or more of the applications, features, steps, solutions, etc., described and/or depicted herein may be utilized and/or provided by the instant elements.

[0074] FIG. 2B illustrates another vehicle network diagram 210, according to example embodiments. The network comprises elements including a vehicle 202 including a processor 204, as well as a vehicle 202' including a processor 204'. The vehicles 202, 202' communicate with one another via the processors 204, 204', as well as other elements (not shown), including transceivers, transmitters, receivers, storage, sensors, and other elements capable of providing communication. The communication between the vehicles 202, and 202' can occur directly, via a private and/or a public network (not shown), or via other vehicles and elements comprising one or more of a processor, memory, and software. The processors 204, 204' can further communicate with one or more elements 230 including sensor 212, wired device 214, wireless device 216, database 218, mobile phone 220, vehicle 222, computer 224, input/output (I/O) device 226, and voice application 228. The processors 204, 204' can further communicate with elements comprising one or more of a processor, memory, and software.

[0075] Although depicted as single vehicles, processors and elements, a plurality of vehicles, processors and elements may be present. Information or communication can occur to and/or from any of the processors 204, 204' and elements 230. For example, the mobile phone 220 may provide information to the processor 204, which may initiate the vehicle 202 to take an action, may further provide the information or additional information to the processor 204', which may initiate the vehicle 202' to take an action, may further provide the information or additional information to the mobile phone 220, the vehicle 222, and/or the computer 224. One or more of the applications, features, steps, solutions, etc., described and/or depicted herein may be utilized and/or provided by the instant elements.

[0076] FIG. 2C illustrates yet another vehicle network diagram 240, according to example embodiments. The network comprises elements including a vehicle 202, a processor 204, and a non-transitory computer readable medium 242C. The processor 204 is communicably coupled to the non-transitory computer readable medium 242C and elements 230 (which were depicted in FIG. 2B). The vehicle 202 may be a vehicle, server, or any device with a processor and memory.

[0077] The processor 204 performs one or more of determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point 244C and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point 246C.

[0078] FIG. 2D illustrates a further vehicle network diagram 250, according to example embodiments. The network comprises elements including a vehicle 202 a processor 204, and a non-transitory computer readable medium 242D. The processor 204 is communicably coupled to the non-transitory computer readable medium 242D and elements 230 (which were depicted in FIG. 2B). The vehicle 202 may be a vehicle, server or any device with a processor and memory.

[0079] The processor 204 performs one or more of determining an amount of time the vehicle has been charging at the charging point, and after the amount of time has exceeded a time threshold, transmitting a message including a recommended course of action to the vehicle comprising instructions on when to stop charging and one or more incentives to stop charging within a time window that begins after the message is transmitted 244D, the charge threshold

is based on one or more of a default charge percentage of a total charge capacity of the EV battery and an amount of charge for the vehicle to navigate to a known destination and an amount of charge for the vehicle to navigate for a predefined period of time **245D**, determining whether the at least one other vehicle has a charge level below a minimum charge threshold, and offering a first type of incentive as the item when the at least one other vehicle has the charge level below the minimum charge threshold and offering a second type of incentive as the item when the at least one other vehicle does not have the charge level below the minimum charge threshold **246D**, identifying the charge level as being above a slowing charge level threshold based on a current charge level of the EV battery and an amount of charge received at the EV battery over a recent period of time being less than an amount of charge received at the EV battery over a less recent period of time, and wherein the recent period of time and the less recent period of time are based on a same amount of time **247D**, providing a warning message to the vehicle that a charge progress has saturated and any subsequent charging is to be performed at a higher value and the item will not be available unless the charging is ceased within a period of time **248D**, receiving a confirmation that the item has been accepted, and enabling the at least one other vehicle to begin charging at the charging point **249D**.

**[0080]** While this example describes in detail only one vehicle **202**, multiple such nodes may be connected to the blockchain. It should be understood that the vehicle **202** may include additional components and that some of the components described herein may be removed and/or modified without departing from a scope of the instant application. The vehicle **202** may have a computing device or a server computer, or the like, and may include a processor **204**, which may be a semiconductor-based microprocessor, a central processing unit (CPU), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), and/or another hardware device. Although a single processor **204** is depicted, it should be understood that the vehicle **202** may include multiple processors, multiple cores, or the like without departing from the scope of the instant application. The vehicle **202** may be a vehicle, server or any device with a processor and memory.

**[0081]** The processor **204** performs one or more of receiving a confirmation of an event from one or more elements described or depicted herein, wherein the confirmation comprises a blockchain consensus between peers represented by any of the elements and executing a smart contract to record the confirmation on the blockchain consensus. Consensus is formed between one or more of any element **230** and/or any element described or depicted herein, including a vehicle, a server, a wireless device, etc. In another example, the vehicle **202** can be one or more of any element **230** and/or any element described or depicted herein, including a server, a wireless device, etc.

**[0082]** The processors and/or computer readable medium may fully or partially reside in the interior or exterior of the vehicles. The steps or features stored in the computer readable medium may be fully or partially performed by any of the processors and/or elements in any order. Additionally, one or more steps or features may be added, omitted, combined, performed at a later time, etc.

**[0083]** FIG. 2E illustrates a flow diagram **260**, according to example embodiments. Referring to FIG. 2E, the instant

solution includes one or more of determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point **244E**, and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point **246E**.

**[0084]** FIG. 2F illustrates another flow diagram **270**, according to example embodiments. Referring to FIG. 2F, the instant solution includes one or more of determining an amount of time the vehicle has been charging at the charging point, and after the amount of time has exceeded a time threshold, transmitting a message including a recommended course of action to the vehicle comprising instructions on when to stop charging and one or more incentives to stop charging within a time window that begins after the message is transmitted **244F**, the charge threshold is based on one or more of a default charge percentage of a total charge capacity of the EV battery and an amount of charge for the vehicle to navigate to a known destination and an amount of charge for the vehicle to navigate for a predefined period of time **245F**, determining whether the at least one other vehicle has a charge level below a minimum charge threshold, and offering a first type of incentive as the item when the at least one other vehicle has the charge level below the minimum charge threshold and offering a second type of incentive as the item when the at least one other vehicle does not have the charge level below the minimum charge threshold **246F**, identifying the charge level as being above a slowing charge level threshold based on a current charge level of the EV battery and an amount of charge received at the EV battery over a recent period of time being less than an amount of charge received at the EV battery over a less recent period of time, and the recent period of time and the less recent period of time are based on a same amount of time **247F**. The process may also include providing a warning message to the vehicle that a charge progress has saturated and any subsequent charging is to be performed at a higher value and the item will not be available unless the charging is ceased within a period of time **248F**, receiving a confirmation that the item has been accepted, and enabling the at least one other vehicle to begin charging at the charging point **249F**.

**[0085]** Technological advancements typically build upon the fundamentals of predecessor technologies; such is the case with Artificial Intelligence (AI) models. An AI classification system describes the stages of AI progression. The first classification is known as “Reactive Machines,” followed by present-day AI classification “Limited Memory Machines” (also known as “Artificial Narrow Intelligence”), then progressing to “Theory of Mind” (also known as “Artificial General Intelligence”), and reaching the AI classification “Self-Aware” (also known as “Artificial Superintelligence”). Present-day Limited Memory Machines are a growing group of AI models built upon the foundation of its predecessor, Reactive Machines. Reactive Machines emulate human responses to stimuli; however, they are limited in their capabilities as they cannot typically learn from prior experience. Once the AI model’s learning abilities emerged, its classification was promoted to Limited Memory Machines. In this present-day classification, AI models learn from large volumes of data, detect patterns, solve problems, generate and predict data, and the like, while inheriting all of the capabilities of Reactive Machines. Examples of AI models classified as Limited Memory Machines include, but

are not limited to, Chatbots, Virtual Assistants, Machine Learning (ML), Deep Learning (DL), Natural Language Processing (NLP), Generative AI (GenAI) models, and any future AI models that are yet to be developed possessing characteristics of Limited Memory Machines. Generative AI models combine Limited Memory Machine technologies, incorporating ML and DL, forming the foundational building blocks of future AI models. For example, Theory of Mind is the next progression of AI that may be able to perceive, connect, and react by generating appropriate reactions in response to an entity with which the AI model is interacting; all of these capabilities rely on the fundamentals of Generative AI. Furthermore, in an evolution into the Self-Aware classification, AI models will be able to understand and evoke emotions in the entities they interact with, as well as possessing their own emotions, beliefs, and needs, all of which rely on Generative AI fundamentals of learning from experiences to generate and draw conclusions about itself and its surroundings. Generative AI models are integral and core to future artificial intelligence models. As described herein, Generative AI refers to present-day Generative AI models and future AI models.

**[0086]** FIG. 3A illustrates an AI/ML network diagram 300A that supports AI-assisted vehicle or occupant decision points. Other branches of AI, such as, but not limited to, computer vision, fuzzy logic, expert systems, neural networks/deep learning, generative AI, and natural language processing, may all be employed in developing the AI model shown in these embodiments. Further, the AI model included in these embodiments is not limited to particular AI algorithms. Any algorithm or combination of algorithms related to supervised, unsupervised, and reinforcement learning algorithms may be employed.

**[0087]** In one embodiment, Generative AI (GenAI) may be used by the instant solution in the transformation of data. Vehicles are equipped with diverse sensors, cameras, radars, and LIDARs, which collect a vast array of data, such as images, speed readings, GPS data, and acceleration metrics. However, raw data, once acquired, undergoes preprocessing that may involve normalization, anonymization, missing value imputation, or noise reduction to allow the data to be further used effectively.

**[0088]** The GenAI executes data augmentation following the preprocessing of the data. Due to the limitation of datasets in capturing the vast complexity of real-world vehicle scenarios, augmentation tools are employed to expand the dataset. This might involve image-specific transformations like rotations, translations, or brightness adjustments. For non-image data, techniques like jittering can be used to introduce synthetic noise, simulating a broader set of conditions.

**[0089]** In the instant solution, data generation is then performed on the data. Tools like Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) are trained on existing datasets to generate new, plausible data samples. For example, GANs might be tasked with crafting images showcasing vehicles in uncharted conditions or from unique perspectives. As another example, the synthesis of sensor data may be performed to model and create synthetic readings for such scenarios, enabling thorough system testing without actual physical encounters. A critical step in the use of GenAI, given the safety-critical nature of vehicles, is validation. This validation might include the output data

being compared with real-world datasets or using specialized tools like a GAN discriminator to gauge the realism of the crafted samples.

**[0090]** Vehicle node 310 may include a plurality of sensors 312 that may include but are not limited to, light sensors, weight sensors, cameras, lidar, and radar. In some embodiments, these sensors 312 send data to a database 320 that stores data about the vehicle and occupants of the vehicle. In some embodiments, these sensors 312 send data to one or more decision subsystems 316 in vehicle node 310 to assist in decision-making.

**[0091]** Vehicle node 310 may include one or more user interfaces (UIs) 314, such as a steering wheel, navigation controls, audio/video controls, temperature controls, etc. In some embodiments, these UIs 314 send data to a database 320 that stores event data about the UIs 314 that includes but is not limited to selection, state, and display data. In some embodiments, these UIs 314 send data to one or more decision subsystems 316 in vehicle node 310 to assist decision-making.

**[0092]** Vehicle node 310 may include one or more decision subsystems 316 that drive a decision-making process around, but are not limited to, vehicle control, temperature control, charging control, etc. In some embodiments, the decision subsystems 316 gather data from one or more sensors 312 to aid in the decision-making process. In some embodiments, a decision subsystem 316 may gather data from one or more UIs 314 to aid in the decision-making process. In some embodiments, a decision subsystem 316 may provide feedback to a UI 314.

**[0093]** An AI/ML production system 330 may be used by a decision subsystem 316 in a vehicle node 310 to assist in its decision-making process. The AI/ML production system 330 includes one or more AI/ML models 332 that are executed to retrieve the needed data, such as, but not limited to, a prediction, a categorization, a UI prompt, etc. In some embodiments, an AI/ML production system 330 is hosted on a server. In some embodiments, the AI/ML production system 330 is cloud-hosted. In some embodiments, the AI/ML production system 330 is deployed in a distributed multi-node architecture. In some embodiments, the AI production system resides in vehicle node 310.

**[0094]** An AI/ML development system 340 creates one or more AI/ML models 332. In some embodiments, the AI/ML development system 340 utilizes data in the database 320 to develop and train one or more AI models 332. In some embodiments, the AI/ML development system 340 utilizes feedback data from one or more AI/ML production systems 330 for new model development and/or existing model re-training. In an embodiment, the AI/ML development system 340 resides and executes on a server. In another embodiment the AI/ML development system 340 is cloud hosted. In a further embodiment, the AI/ML development system 340 utilizes a distributed data pipeline/analytics engine.

**[0095]** Once an AI/ML model 332 has been trained and validated in the AI/ML development system 340, it may be stored in an AI/ML model registry 360 for retrieval by either the AI/ML development system 340 or by one or more AI/ML production systems 330. The AI/ML model registry 360 resides in a dedicated server in one embodiment. In some embodiments, the AI/ML model registry 360 is cloud-hosted. The AI/ML model registry 360 is a distributed

database in other embodiments. In further embodiments, the AI/ML model registry 360 resides in the AI/ML production system 330.

[0096] FIG. 3B illustrates a process 300B for developing one or more AI/ML models that support AI-assisted vehicle or occupant decision points. An AI/ML development system 340 executes steps to develop an AI/ML model 332 that begins with data extraction 342, in which data is loaded and ingested from one or more data sources. In some embodiments, vehicle and user data is extracted from a database 320. In some embodiments, model feedback data is extracted from one or more AI/ML production systems 330.

[0097] Once the required data has been extracted 342, it must be prepared 344 for model training. In some embodiments, this step involves statistical testing of the data to see how well it reflects real-world events, its distribution, the variety of data in the dataset, etc. In some embodiments, the results of this statistical testing may lead to one or more data transformations being employed to normalize one or more values in the dataset. In some embodiments, this step includes cleaning data deemed to be noisy. A noisy dataset includes values that do not contribute to the training, such as but are not limited to, null and long string values. Data preparation 344 may be a manual process or an automated process using one or more of the elements, functions described or depicted herein.

[0098] Features of the data are identified and extracted 346. In some embodiments, a feature of the data is internal to the prepared data from step 344. In other embodiments, a feature of the data requires a piece of prepared data from step 344 to be enriched by data from another data source to be useful in developing an AI/ML model 332. In some embodiments, identifying features is a manual process or an automated process using one or more of the elements, functions described or depicted herein. Once the features have been identified, the values of the features are collected into a dataset that will be used to develop the AI/ML model 332.

[0099] The dataset output from feature extraction step 346 is split 348 into a training and validation data set. The training data set is used to train the AI/ML model 332, and the validation data set is used to evaluate the performance of the AI/ML model 332 on unseen data.

[0100] The AI/ML model 332 is trained and tuned 350 using the training data set from the data splitting step 348. In this step, the training data set is fed into an AI/ML algorithm and an initial set of algorithm parameters. The performance of the AI/ML model 332 is then tested within the AI/ML development system 340 utilizing the validation data set from step 348. These steps may be repeated with adjustments to one or more algorithm parameters until the model's performance is acceptable based on various goals and/or results.

[0101] The AI/ML model 332 is evaluated 352 in a staging environment (not shown) that resembles the ultimate AI/ML production system 330. This evaluation uses a validation dataset to ensure the performance in an AI/ML production system 330 matches or exceeds expectations. In some embodiments, the validation dataset from step 348 is used. In other embodiments, one or more unseen validation datasets are used. In some embodiments, the staging environment is part of the AI/ML development system 340. In other embodiments, the staging environment is managed separately from the AI/ML development system 340. Once the

AI/ML model 332 has been validated, it is stored in an AI/ML model registry 360, which can be retrieved for deployment and future updates. As before, in some embodiments, the model evaluation step 352 is a manual process or an automated process using one or more of the elements, functions described or depicted herein.

[0102] Once an AI/ML model 332 has been validated and published to an AI/ML model registry 360, it may be deployed 354 to one or more AI/ML production systems 330. In some embodiments, the performance of deployed AI/ML models 332 is monitored 356 by the AI/ML development system 340. In some embodiments, AI/ML model 332 feedback data is provided by the AI/ML production system 330 to enable model performance monitoring 356. In some embodiments, the AI/ML development system 340 periodically requests feedback data for model performance monitoring 356. In some embodiments, model performance monitoring includes one or more triggers that result in the AI/ML model 332 being updated by repeating steps 342-354 with updated data from one or more data sources.

[0103] FIG. 3C illustrates a process 300C for utilizing an AI/ML model that supports AI-assisted vehicle or occupant decision points. As stated previously, the AI model utilization process depicted herein reflects ML, which is a particular branch of AI, but the instant solution is not limited to ML and is not limited to any AI algorithm or combination of algorithms.

[0104] Referring to FIG. 3C, an AI/ML production system 330 may be used by a decision subsystem 316 in vehicle node 310 to assist in its decision-making process. The AI/ML production system 330 provides an application programming interface (API) 334, executed by an AI/ML server process 336 through which requests can be made. In some embodiments, a request may include an AI/ML model 332 identifier to be executed. In some embodiments, the AI/ML model 332 to be executed is implicit based on the type of request. In some embodiments, a data payload (e.g., to be input to the model during execution) is included in the request. In some embodiments, the data payload includes sensor 312 data from vehicle node 310. In some embodiments, the data payload includes UI 314 data from vehicle node 310. In some embodiments, the data payload includes data from other vehicle node 310 subsystems (not shown), including but not limited to, occupant data subsystems. In an embodiment, one or more elements or nodes 320, 330, 340, or 360 may be located in the vehicle node 310.

[0105] Upon receiving the API 334 request, the AI/ML server process 336 may need to transform the data payload or portions of the data payload to be valid feature values into an AI/ML model 332. Data transformation may include but is not limited to combining data values, normalizing data values, and enriching the incoming data with data from other data sources. Once any required data transformation occurs, the AI/ML server process 336 executes the appropriate AI/ML model 332 using the transformed input data. Upon receiving the execution result, the AI/ML server process 336 responds to the API caller, which is a decision subsystem 316 of vehicle node 310. In some embodiments, the response may result in an update to a UI 314 in vehicle node 310. In some embodiments, the response includes a request identifier that can be used later by the decision subsystem 316 to provide feedback on the AI/ML model 332 performance. Further, in some embodiments, immediate performance feedback may be recorded into a model feedback log

**338** by the AI/ML server process **336**. In some embodiments, execution model failure is a reason for immediate feedback.

**[0106]** In some embodiments, the API **334** includes an interface to provide AI/ML model **332** feedback after an AI/ML model **332** execution response has been processed. This mechanism may be used to evaluate the performance of the AI/ML model **332** by enabling the API caller to provide feedback on the accuracy of the model results. For example, if the AI/ML model **332** provided an estimated time of arrival of 20 minutes, but the actual travel time was 24 minutes, that may be indicated. In some embodiments, the feedback interface includes the identifier of the initial request so that it can be used to associate the feedback with the request. Upon receiving a call into the feedback interface of API **334**, the AI/ML server process **336** records the feedback in the model feedback log **338**. In some embodiments, the data in this model feedback log **338** is provided to model performance monitoring **356** in the AI/ML development system **340**. This log data is streamed to the AI/ML development system **340** in one embodiment. In some embodiments, the log data is provided upon request.

**[0107]** A number of the steps/features that may utilize the AI/ML process described herein include one or more of: determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point, determining an amount of time the vehicle has been charging at the charging point, and after the amount of time has exceeded a time threshold, transmitting a message including a recommended course of action to the vehicle comprising instructions on when to stop charging and one or more incentives to stop charging within a time window that begins after the message is transmitted, the charge threshold is based on one or more of a default charge percentage of a total charge capacity of the EV battery and an amount of charge for the vehicle to navigate to a known destination and an amount of charge for the vehicle to navigate for a predefined period of time, determining whether the at least one other vehicle has a charge level below a minimum charge threshold, and offering a first type of incentive as the item when the at least one other vehicle has a charge level below the minimum charge threshold and offering a second type of incentive as the item when the at least one other vehicle does not have a charge level below the minimum charge threshold, identifying the charge level as being above a slowing charge level threshold based on a current charge level of the EV battery and an amount of charge received at the EV battery over a recent period of time being less than an amount of charge received at the EV battery over a less recent period of time, and wherein the recent period of time and the less recent period of time are based on a same amount of time, providing a warning message to the vehicle that a charge progress has saturated and any subsequent charging is to be performed at a higher value and the item will not be available unless the charging is ceased within a period of time, receiving a confirmation that the item has been accepted, and enabling the at least one other vehicle to begin charging at the charging point.

**[0108]** Data associated with any of these steps/features, as well as any other features or functionality described or depicted herein, the AI/ML production system **330**, as well as one or more of the other elements depicted in FIG. 3C

may be used to process this data in a pre-transformation and/or post-transformation process. Data related to this process can be used by the vehicle node **310**. In one embodiment, data related to this process may be used with a charging station/charging point, a server, a wireless device, and/or any of the processors described or depicted herein.

**[0109]** FIG. 3D illustrates a process **300D** of designing a new machine learning model via a user interface **370** of the system according to example embodiments. As an example, a model may be output as part of the AI/ML Development System **340**. Referring to FIG. 3D, a user can use an input mechanism from a menu **372** of a user interface **370** to add pieces/components to a model being developed within a workspace **374** of the user interface **370**.

**[0110]** The menu **372** includes a plurality of graphical user interface (GUI) menu options which can be selected to reveal additional components that can be added to the model design shown in the workspace **374**. The GUI menu includes options for adding elements to the workspace, such as features which may include neural networks, machine learning models, AI models, data sources, conversion processes (e.g., vectorization, encoding, etc.), analytics, etc. The user can continue to add features to the model and connect them using edges or other elements to create a flow within the workspace **374**. For example, the user may add a node **376** to a flow of a new model within the workspace **374**. For example, the user may connect the node **376** to another node in the diagram via an edge **378**, creating a dependency within the diagram. When the user is done, the user can save the model for subsequent training/testing.

**[0111]** In another example, the name of the object can be identified from a web page or a user interface **370** where the object is visible within a browser or the workspace **374** on the user device. A pop-up within the browser or the workspace **374** can be overlaid where the object is visible, which includes an option to navigate to the identified web page corresponding to the alternative object via a rule set.

**[0112]** FIG. 3E illustrates a process **300E** of accessing an object **392** from an object storage **390** of the host platform **380** according to example embodiments. For example, the object storage **390** may store data that is used by the AI models and machine learning (ML) models, training data, expected outputs for testing, training results, and the like. The object storage **390** may also store any other kind of data. Each object may include a unique identifier, a data section **394**, and a metadata section **396**, which provide a descriptive context associated with the data, including data that can later be extracted for purposes of machine learning. The unique identifier may uniquely identify an object with respect to all other objects in the object storage **390**. The data section **394** may include unstructured data such as web pages, digital content, images, audio, text, and the like.

**[0113]** Instead of breaking files into blocks stored on disks in a file system, the object storage **390** handles objects as discrete units of data stored in a structurally flat data environment. Here, the object storage may not use folders, directories, or complex hierarchies. Instead, each object may be a simple, self-contained repository that includes the data, the metadata, and the unique identifier that a client application can use to locate and access it. In this case, the metadata is more descriptive than a file-based approach. The metadata can be customized with additional context that can later be extracted and leveraged for other purposes, such as data analytics.

[0114] The objects that are stored in the object storage 390 may be accessed via an API 384. The API 384 may be a Hypertext Transfer Protocol (HTTP)-based RESTful API (also known as a RESTful Web service). The API 384 can be used by the client application to query an object's metadata to locate the desired object (data) via the Internet from anywhere on any device. The API 384 may use HTTP commands such as "PUT" or "POST" to upload an object, "GET" to retrieve an object, "DELETE" to remove an object, and the like.

[0115] The object storage 390 may provide a directory 398 that uses the metadata of the objects to locate appropriate data files. The directory 398 may contain descriptive information about each object stored in the object storage 390, such as a name, a unique identifier, a creation timestamp, a collection name, etc. To query the object within the object storage 390, the client application may submit a command, such as an HTTP command, with an identifier of the object 392, a payload, etc. The object storage 390 can store the actions and results described herein, including associating two or more lists of ranked assets with one another based on variables used by the two or more lists of ranked assets that have a correlation above a predetermined threshold.

[0116] FIG. 4A illustrates a diagram 400A depicting the electrification of one or more elements. In one example, a vehicle 402B may provide power stored in its batteries to one or more elements, including other vehicle(s) 408B, charging station(s) 406B, and electric grid(s) 404B. The electric grid(s) 404B is/are coupled to one or more of the charging stations 406B, which may be coupled to one or more of the vehicles 408B. This configuration allows the distribution of electricity/power received from the vehicle 402B. The vehicle 402B may also interact with the other vehicle(s) 408B, such as via V2V technology, communication over cellular, Wi-Fi, and the like. The vehicle 402B may also interact wirelessly and/or wired with other vehicles 408B, the charging station(s) 406B and/or with the electric grid(s) 404B. In one example, the vehicle 402B is routed (or routes itself) in a safe and efficient manner to the electric grid(s) 404B, the charging station(s) 406B, or the other vehicle(s) 408B. Using one or more embodiments of the instant solution, the vehicle 402B can provide energy to one or more of the elements depicted herein in various advantageous ways as described and/or depicted herein. Further, the safety and efficiency of the vehicle may be increased, and the environment may be positively affected as described and/or depicted herein.

[0117] The term 'energy', 'electricity', 'power', and the like may be used to denote any form of energy received, stored, used, shared, and/or lost by the vehicle(s). The energy may be referred to in conjunction with a voltage source and/or a current supply of charge provided from an entity to the vehicle(s) during a charge/use operation. Energy may also be in the form of fossil fuels (for example, for use with a hybrid vehicle) or via alternative power sources, including but not limited to lithium-based, nickel-based, hydrogen fuel cells, atomic/nuclear energy, fusion-based energy sources, and energy generated during an energy sharing and/or usage operation for increasing or decreasing one or more vehicles energy levels at a given time.

[0118] In one example, the charging station 406B manages the amount of energy transferred from the vehicle 402B such that there is sufficient charge remaining in the vehicle 402B

to arrive at a destination. In one example, a wireless connection is used to wirelessly direct an amount of energy transfer between vehicles 408B, wherein the vehicles may both be in motion. In one embodiment, wireless charging may occur via a fixed charger and batteries of the vehicle in alignment with one another (such as a charging mat in a garage or parking space). In one example, an idle vehicle, such as a vehicle 402B (which may be autonomous) is directed to provide an amount of energy to a charging station 406B and return to the original location (for example, its original location or a different destination). In one example, a mobile energy storage unit (not shown) is used to collect surplus energy from at least one other vehicle 408B and transfer the stored surplus energy at a charging station 406B. In one example, factors determine an amount of energy to transfer to a charging station 406B, such as distance, time, as well as traffic conditions, road conditions, environmental/weather conditions, the vehicle's condition (weight, etc.), an occupant(s) schedule while utilizing the vehicle, a prospective occupant(s) schedule waiting for the vehicle, etc. In one example, the vehicle(s) 408B, the charging station(s) 406B and/or the electric grid(s) 404B can provide energy to the vehicle 402B.

[0119] In one embodiment, a location such as a building, a residence, or the like (not depicted), communicably coupled to one or more of the electric grid 404B, the vehicle 402B, and/or the charging station(s) 406B. The rate of electric flow to one or more of the location, the vehicle 402B, the other vehicle(s) 408B is modified, depending on external conditions, such as weather. For example, when the external temperature is extremely hot or extremely cold, raising the chance for an outage of electricity, the flow of electricity to a connected vehicle 402B/408B is slowed to help minimize the chance for an outage.

[0120] In one embodiment, vehicles 402B and 408B may be utilized as bidirectional vehicles. Bidirectional vehicles are those that may serve as mobile microgrids that can assist in the supplying of electrical power to the grid 404B and/or reduce the power consumption when the grid is stressed. Bidirectional vehicles incorporate bidirectional charging, which in addition to receiving a charge to the vehicle, the vehicle can transfer energy from the vehicle to the grid 404B, otherwise referred to as "V2G". In bidirectional charging, the electricity flows both ways; to the vehicle and from the vehicle. When a vehicle is charged, alternating current (AC) electricity from the grid 404B is converted to direct current (DC). This may be performed by one or more of the vehicle's own converter or a converter on the charging station 406B. The energy stored in the vehicle's batteries may be sent in an opposite direction back to the grid. The energy is converted from DC to AC through a converter usually located in the charging station 406B, otherwise referred to as a bidirectional charger. Further, the instant solution as described and depicted with respect to FIG. 4B can be utilized in this and other networks and/or systems.

[0121] FIG. 4B is a diagram showing interconnections between different elements 400B. The instant solution may be stored and/or executed entirely or partially on and/or by one or more computing devices 414C, 418C, 424C, 428C, 432C, 436C, 406C, 442C and 410C associated with various entities, all communicably coupled and in communication with a network 402C. A database 438C is communicably coupled to the network and allows for the storage and retrieval of data. In one example, the database is an immu-



table ledger. One or more of the various entities may be a vehicle **404C**, one or more service provider **416C**, one or more public buildings **422C**, one or more traffic infrastructure **426C**, one or more residential dwellings **430C**, an electric grid/charging station **434C**, a microphone **440C**, and/or another vehicle **408C**. Other entities and/or devices, such as one or more private users using a smartphone **412C**, a laptop **420C**, an augmented reality (AR) device, a virtual reality (VR) device, and/or any wearable device may also interwork with the instant solution. The smartphone **412C**, laptop **420C**, the microphone **440C**, and other devices may be connected to one or more of the connected computing devices **414C**, **418C**, **424C**, **428C**, **432C**, **436C**, **406C**, **442C**, and **410C**. The one or more public buildings **422C** may include various agencies. The one or more public buildings **422C** may utilize a computing device **424C**. The one or more service provider **416C** may include a dealership, a tow truck service, a collision center, or other repair shop. The one or more service provider **416C** may utilize a computing apparatus **418C**. These various computer devices may be directly and/or communicably coupled to one another, such as via wired networks, wireless networks, blockchain networks, and the like. The microphone **440C** may be utilized as a virtual assistant, in one example. In one example, the one or more traffic infrastructure **426C** may include one or more traffic signals, one or more sensors including one or more cameras, vehicle speed sensors or traffic sensors, and/or other traffic infrastructure. The one or more traffic infrastructure **426C** may utilize a computing device **428C**.

**[0122]** In one embodiment, anytime an electrical charge is given or received to/from a charging station and/or an electrical grid, the entities that allow that to occur are one or more of a vehicle, a charging station, a server, and a network communicably coupled to the vehicle, the charging station, and the electrical grid.

**[0123]** In one example, a vehicle **408C/404C** can transport a person, an object, a permanently or temporarily affixed apparatus, and the like. In one example, the vehicle **408C** may communicate with vehicle **404C** via V2V communication through the computers associated with each vehicle **406C** and **410C** and may be referred to as a car, vehicle, automobile, and the like. The vehicle **404C/408C** may be a self-propelled wheeled conveyance, such as a car, a sports utility vehicle, a truck, a bus, a van, or other motor or battery-driven or fuel cell-driven vehicle. For example, vehicle **404C/408C** may be an electric vehicle, a hybrid vehicle, a hydrogen fuel cell vehicle, a plug-in hybrid vehicle, or any other type of vehicle with a fuel cell stack, a motor, and/or a generator. Other examples of vehicles include bicycles, scooters, trains, planes, boats, and any other form of conveyance that is capable of transportation. The vehicle **404C/408C** may be semi-autonomous or autonomous. For example, vehicle **404C/408C** may be self-maneuvering and navigate without human input. An autonomous vehicle may have and use one or more sensors and/or a navigation unit to drive autonomously. All of the data described or depicted herein can be stored, analyzed, processed and/or forwarded by one or more of the elements in FIG. 4B.

**[0124]** FIG. 4C is another block diagram showing interconnections between different elements in one example **400C**. A vehicle **412D** is presented and includes ECUs **410D**, **408D**, and a Head Unit (otherwise known as an Infotainment System) **406D**. An ECU is an embedded sys-

tem in automotive electronics controlling one or more of the electrical systems or subsystems in a vehicle. ECUs may include but are not limited to the management of a vehicle's engine, brake system, gearbox system, door locks, dashboard, airbag system, infotainment system, electronic differential, and active suspension. ECUs are connected to the vehicle's Controller Area Network (CAN) bus **416D**. The ECUs may also communicate with a vehicle computer **404D** via the CAN bus **416D**. The vehicle's processors/sensors (such as the vehicle computer) **404D** can communicate with external elements, such as a server **418D** via a network **402D** (such as the Internet). Each ECU **410D**, **408D**, and Head Unit **406D** may contain its own security policy. The security policy defines permissible processes that can be executed in the proper context. In one example, the security policy may be partially or entirely provided in the vehicle computer **404D**.

**[0125]** ECUs **410D**, **408D**, and Head Unit **406D** may each include a custom security functionality element **414D** defining authorized processes and contexts within which those processes are permitted to run. Context-based authorization to determine validity if a process can be executed allows ECUs to maintain secure operation and prevent unauthorized access from elements such as the vehicle's CAN Bus. When an ECU encounters a process that is unauthorized, that ECU can block the process from operating. Automotive ECUs can use different contexts to determine whether a process is operating within its permitted bounds, such as proximity contexts, nearby objects, distance to approaching objects, speed, and trajectory relative to other moving objects, and operational contexts such as an indication of whether the vehicle is moving or parked, the vehicle's current speed, the transmission state, user-related contexts such as devices connected to the transport via wireless protocols, use of the infotainment, cruise control, parking assist, driving assist, location-based contexts, and/or other contexts.

**[0126]** Referring to FIG. 4D, an operating environment **400D** for a connected vehicle, is illustrated according to some embodiments. As depicted, the vehicle **410E** includes a CAN bus **408E** connecting elements **412E-426E** of the vehicle. Other elements may be connected to the CAN bus and are not depicted herein. The depicted elements connected to the CAN bus include a sensor set **412E**, Electronic Control Units **414E**, autonomous features or Advanced Driver Assistance Systems (ADAS) **416E**, and the navigation system **418E**. In some embodiments, the vehicle **410E** includes a processor **420E**, a memory **422E**, a communication unit **424E**, and an electronic display **426E**.

**[0127]** The processor **420E** includes an arithmetic logic unit, a microprocessor, a general-purpose controller, and/or a similar processor array to perform computations and provide electronic display signals to a display unit **426E**. The processor **420E** 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 vehicle **410E** may include one or more processors **420E**. Other processors, operating systems, sensors, displays, and physical configurations that are communicably coupled to one another (not depicted) may be used with the instant solution.



[0128] Memory 422E is a non-transitory memory storing instructions or data that may be accessed and executed by the processor 420E. The instructions and/or data may include code to perform the techniques described herein. The memory 422E may be a dynamic random-access memory (DRAM) device, a static random-access memory (SRAM) device, flash memory, or another memory device. In some embodiments, the memory 422E also may include non-volatile memory or a similar permanent storage device and media, which may include a hard disk drive, a floppy disk drive, a compact disc read only memory (CD-ROM) device, a digital versatile disk read only memory (DVD-ROM) device, a digital versatile disk random access memory (DVD-RAM) device, a digital versatile disk rewritable (DVD-RW) device, a flash memory device, or some other mass storage device for storing information on a permanent basis. A portion of the memory 422E may be reserved for use as a buffer or virtual random-access memory (virtual RAM). The vehicle 410E may include one or more memories 422E without deviating from the current solution.

[0129] The memory 422E of the vehicle 410E may store one or more of the following types of data: navigation route data 418E, and autonomous features data 416E. In some embodiments, the memory 422E stores data that may be necessary for the navigation application 418E to provide the functions.

[0130] The navigation system 418E may describe at least one navigation route including a start point and an endpoint. In some embodiments, the navigation system 418E of the vehicle 410E receives a request from a user for navigation routes wherein the request includes a starting point and an ending point. The navigation system 418E may query a real-time data server 404E (via a network 402E), such as a server that provides driving directions, for navigation route data corresponding to navigation routes, including the start point and the endpoint. The real-time data server 404E transmits the navigation route data to the vehicle 410E via a wireless network 402E, and the communication system 424E stores the navigation data 418E in the memory 422E of the vehicle 410E.

[0131] The ECU 414E controls the operation of many of the systems of the vehicle 410E, including the ADAS systems 416E. The ECU 414E may, responsive to instructions received from the navigation system 418E, deactivate any unsafe and/or unselected autonomous features for the duration of a journey controlled by the ADAS systems 416E. In this way, the navigation system 418E may control whether ADAS systems 416E are activated or enabled so that they may be activated for a given navigation route.

[0132] The sensor set 412E may include any sensors in the vehicle 410E generating sensor data. For example, the sensor set 412E may include short-range sensors and long-range sensors. In some embodiments, the sensor set 412E of the vehicle 410E may include one or more of the following vehicle sensors: a camera, a Light Detection and Ranging (Lidar) sensor, an ultrasonic sensor, an automobile engine sensor, a radar sensor, a laser altimeter, a manifold absolute pressure sensor, an infrared detector, a motion detector, a thermostat, a sound detector, a carbon monoxide sensor, a carbon dioxide sensor, an oxygen sensor, a mass airflow sensor, an engine coolant temperature sensor, a throttle position sensor, a crankshaft position sensor, a valve timer, an air-fuel ratio meter, a blind spot meter, a curb feeler, a

defect detector, a Hall effect 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, a global positioning system (GPS) sensor, a mapping functionality, and any other type of automotive sensor. The navigation system 418E may store the sensor data in the memory 422E.

[0133] The communication unit 424E transmits and receives data to and from the network 402E or to another communication channel. In some embodiments, the communication unit 424E may include a dedicated short-range communication (DSRC) transceiver, a DSRC receiver, and other hardware or software necessary to make the vehicle 410E a DSRC-equipped device.

[0134] The vehicle 410E may interact with other vehicles 406E via V2V technology. V2V communication includes sensing radar information corresponding to relative distances to external objects, receiving GPS information of the vehicles, setting areas where the other vehicles 406E are located based on the sensed radar information, calculating probabilities that the GPS information of the object vehicles will be located at the set areas, and identifying vehicles and/or objects corresponding to the radar information and the GPS information of the object vehicles based on the calculated probabilities, in one example.

[0135] For a vehicle to be adequately secured, the vehicle must be protected from unauthorized physical access as well as unauthorized remote access (e.g., cyber-threats). To prevent unauthorized physical access, a vehicle is equipped with a secure access system such as a keyless entry in one example. Meanwhile, security protocols are added to a vehicle's computers and computer networks to facilitate secure remote communications to and from the vehicle in one example.

[0136] ECUs are nodes within a vehicle that control tasks such as activating the windshield wipers to tasks such as an anti-lock brake system. ECUs are often connected to one another through the vehicle's central network, which may be referred to as a controller area network (CAN). State-of-the-art features such as autonomous driving are strongly reliant on implementing new, complex ECUs such as ADAS, sensors, and the like. While these new technologies have helped improve the safety and driving experience of a vehicle, they have also increased the number of externally communicating units inside of the vehicle, making them more vulnerable to attack. Below are some examples of protecting the vehicle from physical intrusion and remote intrusion.

[0137] In one embodiment, a CAN includes a CAN bus with a high and low terminal and a plurality of ECUs, which are connected to the CAN bus via wired connections. The CAN bus is designed to allow microcontrollers and devices to communicate with each other in an application without a host computer. The CAN bus implements a message-based protocol (i.e., ISO 11898 standards) that allows ECUs to send commands to one another at a root level. Meanwhile, the ECUs represent controllers for controlling electrical systems or subsystems within the vehicle. Examples of the electrical systems include power steering, anti-lock brakes, air-conditioning, tire pressure monitoring, cruise control, and many other features.

[0138] In this example, the ECU includes a transceiver and a microcontroller. The transceiver may be used to transmit and receive messages to and from the CAN bus. For example, the transceiver may convert the data from the microcontroller into a format of the CAN bus and also convert data from the CAN bus into a format for the microcontroller. Meanwhile, the microcontroller interprets the messages and also decides what messages to send using ECU software installed therein in one example.

[0139] To protect the CAN from cyber threats, various security protocols may be implemented. For example, sub-networks (e.g., sub-networks A and B, etc.) may be used to divide the CAN into smaller sub-CANs and limit an attacker's capabilities to access the vehicle remotely. In one embodiment, a firewall (or gateway, etc.) may be added to block messages from crossing the CAN bus across sub-networks. If an attacker gains access to one sub-network, the attacker will not have access to the entire network. To make sub-networks even more secure, the most critical ECUs are not placed on the same sub-network, in one example.

[0140] In addition to protecting a vehicle's internal network, vehicles may also be protected when communicating with external networks such as the Internet. One of the benefits of having a vehicle connection to a data source such as the Internet is that information from the vehicle can be sent through a network to remote locations for analysis. Examples of vehicle information include GPS, onboard diagnostics, tire pressure, and the like. These communication systems are often referred to as telematics because they involve the combination of telecommunications and informatics. Further, the instant solution as described and depicted can be utilized in this and other networks and/or systems, including those that are described and depicted herein.

[0141] FIG. 4E illustrates an example 400E of vehicles 402I and 408I performing secured V2V communications using security certificates, according to example embodiments. Referring to FIG. 4E, the vehicles 402I and 408I may communicate via V2V communications over a short-range network, a cellular network, or the like. Before sending messages, the vehicles 402I and 408I may sign the messages using a respective public key certificate. For example, the vehicle 402I may sign a V2V message using a public key certificate 404I. Likewise, the vehicle 408I may sign a V2V message using a public key certificate 410I. The public key certificates 404I and 410I are associated with the vehicles 402I and 408I, respectively, in one example.

[0142] Upon receiving the communications from each other, the vehicles may verify the signatures with a certificate authority 406I or the like. For example, the vehicle 408I may verify with the certificate authority 406I that the public key certificate 404I used by vehicle 402I to sign a V2V communication is authentic. If the vehicle 408I successfully verifies the public key certificate 404I, the vehicle knows that the data is from a legitimate source. Likewise, the vehicle 402I may verify with the certificate authority 406I that the public key certificate 410I used by the vehicle 408I to sign a V2V communication is authentic. Further, the instant solution as described and depicted with respect to FIG. 4E can be utilized in this and other networks and/or systems including those that are described and depicted herein.

[0143] In some embodiments, a computer may include a security processor. In particular, the security processor may

perform authorization, authentication, cryptography (e.g., encryption), and the like, for data transmissions that are sent between ECUs and other devices on a CAN bus of a vehicle, and also data messages that are transmitted between different vehicles. The security processor may include an authorization module, an authentication module, and a cryptography module. The security processor may be implemented within the vehicle's computer and may communicate with other vehicle elements, for example, the ECUs/CAN network, wired and wireless devices such as wireless network interfaces, input ports, and the like. The security processor may ensure that data frames (e.g., CAN frames, etc.) that are transmitted internally within a vehicle (e.g., via the ECUs/CAN network) are secure. Likewise, the security processor can ensure that messages transmitted between different vehicles and devices attached or connected via a wire to the vehicle's computer are also secured.

[0144] For example, the authorization module may store passwords, usernames, PIN codes, biometric scans, and the like for different vehicle users. The authorization module may determine whether a user (or technician) has permission to access certain settings such as a vehicle's computer. In some embodiments, the authorization module may communicate with a network interface to download any necessary authorization information from an external server. When a user desires to make changes to the vehicle settings or modify technical details of the vehicle via a console or GUI within the vehicle or via an attached/connected device, the authorization module may require the user to verify themselves in some way before such settings are changed. For example, the authorization module may require a username, a password, a PIN code, a biometric scan, a predefined line drawing or gesture, and the like. In response, the authorization module may determine whether the user has the necessary permissions (access, etc.) being requested.

[0145] The authentication module may be used to authenticate internal communications between ECUs on the CAN network of the vehicle. As an example, the authentication module may provide information for authenticating communications between the ECUs. As an example, the authentication module may transmit a bit signature algorithm to the ECUs of the CAN network. The ECUs may use the bit signature algorithm to insert authentication bits into the CAN fields of the CAN frame. All ECUs on the CAN network typically receive each CAN frame. The bit signature algorithm may dynamically change the position, amount, etc., of authentication bits each time a new CAN frame is generated by one of the ECUs. The authentication module may also provide a list of ECUs that are exempt (safe list) and that do not need to use the authentication bits. The authentication module may communicate with a remote server to retrieve updates to the bit signature algorithm and the like.

[0146] The encryption module may store asymmetric key pairs to be used by the vehicle to communicate with other external user devices and vehicles. For example, the encryption module may provide a private key to be used by the vehicle to encrypt/decrypt communications, while the corresponding public key may be provided to other user devices and vehicles to enable the other devices to decrypt/encrypt the communications. The encryption module may communicate with a remote server to receive new keys, updates to keys, keys of new vehicles, users, etc., and the like. The

encryption module may also transmit any updates to a local private/public key pair to the remote server.

**[0147]** FIG. 5A illustrates an example vehicle configuration **500A** for managing database transactions associated with a vehicle, according to example embodiments. Referring to FIG. 5A, as a particular vehicle **525** is engaged in transactions (e.g., vehicle service, dealer transactions, delivery/pickup, transportation services, etc.), the vehicle may receive assets **510** and/or expel/transfer assets **512** according to a transaction(s). A vehicle processor **526** resides in the vehicle **525** and communication exists between the vehicle processor **526**, a database **530**, and the transaction module **520**. The transaction module **520** may record information, such as assets, parties, credits, service descriptions, date, time, location, results, notifications, unexpected events, etc. Those transactions in the transaction module **520** may be replicated into a database **530**. The database **530** can be one of a SQL database, a relational database management system (RDBMS), a relational database, a non-relational database, a blockchain, a distributed ledger, and may be on board the vehicle, may be off-board the vehicle, may be accessed directly and/or through a network, or be accessible to the vehicle.

**[0148]** In one embodiment, a vehicle may engage with another vehicle to perform various actions such as to share, transfer, acquire service calls, etc. when the vehicle has reached a status where the services need to be shared with another vehicle. For example, the vehicle may be due for a battery charge and/or may have an issue with a tire and may be in route to pick up a package for delivery. A vehicle processor resides in the vehicle and communication exists between the vehicle processor, a first database, and a transaction module. The vehicle may notify another vehicle, which is in its network and which operates on its blockchain member service. A vehicle processor resides in another vehicle and communication exists between the vehicle processor, a second database, the vehicle processor, and a transaction module. The another vehicle may then receive the information via a wireless communication request to perform the package pickup from the vehicle and/or from a server (not shown). The transactions are logged in the transaction modules and of both vehicles. The credits are transferred from the vehicle to the other vehicle and the record of the transferred service is logged in the first database, assuming that the blockchains are different from one another, or are logged in the same blockchain used by all members. The first database can be one of a SQL database, an RDBMS, a relational database, a non-relational database, a blockchain, a distributed ledger, and may be on board the vehicle, may be off-board the vehicle, may be accessible directly and/or through a network.

**[0149]** FIG. 5B illustrates a blockchain architecture configuration **500B**, according to example embodiments. Referring to FIG. 5B, the blockchain architecture **500B** may include certain blockchain elements, for example, a group of blockchain member nodes **502-505** as part of a blockchain group **510**. In one example embodiment, a permissioned blockchain is not accessible to all parties but only to those members with permissioned access to the blockchain data. The blockchain nodes participate in a number of activities, such as blockchain entry addition and validation process (consensus). One or more of the blockchain nodes may endorse entries based on an endorsement policy and may provide an ordering service for all blockchain nodes. A

blockchain node may initiate a blockchain action (such as an authentication) and seek to write to a blockchain immutable ledger stored in the blockchain, a copy of which may also be stored on the underpinning physical infrastructure.

**[0150]** The blockchain transactions **520** are stored in memory of computers as the transactions are received and approved by the consensus model dictated by the members' nodes. Approved transactions **526** are stored in current blocks of the blockchain and committed to the blockchain via a committal procedure, which includes performing a hash of the data contents of the transactions in a current block and referencing a previous hash of a previous block. Within the blockchain, one or more smart contracts **530** may exist that define the terms of transaction agreements and actions included in smart contract executable application code **532**, such as registered recipients, vehicle features, requirements, permissions, sensor thresholds, etc. The code may be configured to identify whether requesting entities are registered to receive vehicle services, what service features they are entitled/required to receive given their profile statuses and whether to monitor their actions in subsequent events. For example, when a service event occurs and a user is riding in the vehicle, the sensor data monitoring may be triggered, and a certain parameter, such as a vehicle charge level, may be identified as being above/below a particular threshold for a particular period of time, then the result may be a change to a current status, which requires an alert to be sent to the managing party (i.e., vehicle owner, vehicle operator, server, etc.) so the service can be identified and stored for reference. The vehicle sensor data collected may be based on types of sensor data used to collect information about vehicle's status. The sensor data may also be the basis for the vehicle event data **534**, such as a location(s) to be traveled, an average speed, a top speed, acceleration rates, whether there were any collisions, was the expected route taken, what is the next destination, whether safety measures are in place, whether the vehicle has enough charge/fuel, etc. All such information may be the basis of smart contract terms **530**, which are then stored in a blockchain. For example, sensor thresholds stored in the smart contract can be used as the basis for whether a detected service is necessary and when and where the service should be performed.

**[0151]** In one embodiment, a blockchain logic example includes a blockchain application interface as an API or plug-in application that links to the computing device and execution platform for a particular transaction. The blockchain configuration may include one or more applications, which are linked to application programming interfaces (APIs) to access and execute stored program/application code (e.g., smart contract executable code, smart contracts, etc.), which can be created according to a customized configuration sought by participants and can maintain their own state, control their own assets, and receive external information. This can be deployed as an entry and installed, via appending to the distributed ledger, on all blockchain nodes.

**[0152]** The smart contract application code provides a basis for the blockchain transactions by establishing application code, which when executed causes the transaction terms and conditions to become active. The smart contract, when executed, causes certain approved transactions to be generated, which are then forwarded to the blockchain platform. The platform includes a security/authorization,

computing devices, which execute the transaction management and a storage portion as a memory that stores transactions and smart contracts in the blockchain.

**[0153]** The blockchain platform may include various layers of blockchain data, services (e.g., cryptographic trust services, virtual execution environment, etc.), and underpinning physical computer infrastructure that may be used to receive and store new entries and provide access to auditors, which are seeking to access data entries. The blockchain may expose an interface that provides access to the virtual execution environment necessary to process the program code and engage the physical infrastructure. Cryptographic trust services may be used to verify entries such as asset exchange entries and keep information private.

**[0154]** The blockchain architecture configuration of FIGS. 5A and 5B may process and execute program/application code via one or more interfaces exposed, and services provided, by the blockchain platform. As a non-limiting example, smart contracts may be created to execute reminders, updates, and/or other notifications subject to the changes, updates, etc. The smart contracts can themselves be used to identify rules associated with authorization and access requirements and usage of the ledger. For example, the information may include a new entry, which may be processed by one or more processing entities (e.g., processors, virtual machines, etc.) included in the blockchain layer. The result may include a decision to reject or approve the new entry based on the criteria defined in the smart contract and/or a consensus of the peers. The physical infrastructure may be utilized to retrieve any of the data or information described herein.

**[0155]** Within smart contract executable code, a smart contract may be created via a high-level application and programming language, and then written to a block in the blockchain. The smart contract may include executable code that is registered, stored, and/or replicated with a blockchain (e.g., distributed network of blockchain peers). An entry is an execution of the smart contract code, which can be performed in response to conditions associated with the smart contract being satisfied. The executing of the smart contract may trigger a trusted modification(s) to a state of a digital blockchain ledger. The modification(s) to the blockchain ledger caused by the smart contract execution may be automatically replicated throughout the distributed network of blockchain peers through one or more consensus protocols.

**[0156]** The smart contract may write data to the blockchain in the format of key-value pairs. Furthermore, the smart contract code can read the values stored in a blockchain and use them in application operations. The smart contract code can write the output of various logic operations into the blockchain. The code may be used to create a temporary data structure in a virtual machine or other computing platform. Data written to the blockchain can be public and/or can be encrypted and maintained as private. The temporary data that is used/generated by the smart contract is held in memory by the supplied execution environment, then deleted once the data needed for the blockchain is identified.

**[0157]** A smart contract executable code may include the code interpretation of a smart contract, with additional features. As described herein, the smart contract executable code may be program code deployed on a computing network, where it is executed and validated by chain vali-

dators together during a consensus process. The smart contract executable code receives a hash and retrieves from the blockchain a hash associated with the data template created by use of a previously stored feature extractor. If the hashes of the hash identifier and the hash created from the stored identifier template data match, then the smart contract executable code sends an authorization key to the requested service. The smart contract executable code may write to the blockchain data associated with the cryptographic details.

**[0158]** FIG. 5C illustrates a blockchain configuration for storing blockchain transaction data, according to example embodiments. Referring to FIG. 5C, the example configuration 500C provides for the vehicle 562, the user device 564 and a server 566 sharing information with a distributed ledger (i.e., blockchain) 568. The server may represent a service provider entity inquiring with a vehicle service provider to share user profile rating information in the event that a known and established user profile is attempting to rent a vehicle with an established rated profile. The server 566 may be receiving and processing data related to a vehicle's service requirements. As the service events occur, such as the vehicle sensor data indicates a need for fuel/charge, a maintenance service, etc., a smart contract may be used to invoke rules, thresholds, sensor information gathering, etc., which may be used to invoke the vehicle service event. The blockchain transaction data 570 is saved for each transaction, such as the access event, the subsequent updates to a vehicle's service status, event updates, etc. The transactions may include the parties, the requirements (e.g., 18 years of age, service eligible candidate, valid driver's license, etc.), compensation levels, the distance traveled during the event, the registered recipients permitted to access the event and host a vehicle service, rights/permissions, sensor data retrieved during the vehicle event operation to log details of the next service event and identify a vehicle's condition status, and thresholds used to make determinations about whether the service event was completed and whether the vehicle's condition status has changed.

**[0159]** FIG. 5D illustrates blockchain blocks that can be added to a distributed ledger, according to example embodiments, and contents of block structures 582A to 582N. Referring to FIG. 5D, clients (not shown) may submit entries to blockchain nodes to enact activity on the blockchain. As an example, clients may be applications that act on behalf of a requester, such as a device, person, or entity to propose entries for the blockchain. The plurality of blockchain peers (e.g., blockchain nodes) may maintain a state of the blockchain network and a copy of the distributed ledger. Different types of blockchain nodes/peers may be present in the blockchain network including endorsing peers, which simulate and endorse entries proposed by clients and committing peers which verify endorsements, validate entries, and commit entries to the distributed ledger. In this example, the blockchain nodes may perform the role of endorser node, committer node, or both.

**[0160]** The instant system includes a blockchain that stores immutable, sequenced records in blocks, and a state database (current world state) maintaining a current state of the blockchain. One distributed ledger may exist per channel and each peer maintains its own copy of the distributed ledger for each channel of which they are a member. The instant blockchain is an entry log, structured as hash-linked blocks where each block contains a sequence of N entries.

Blocks may include various components such as those shown in FIG. 5D. The linking of the blocks may be generated by adding a hash of a prior block's header within a block header of a current block. In this way, all entries on the blockchain are sequenced and cryptographically linked together preventing tampering with blockchain data without breaking the hash links. Furthermore, because of the links, the latest block in the blockchain represents every entry that has come before it. The instant blockchain may be stored on a peer file system (local or attached storage), which supports an append-only blockchain workload.

[0161] The current state of the blockchain and the distributed ledger may be stored in the state database. Here, the current state data represents the latest values for all keys ever included in the chain entry log of the blockchain. Smart contract executable code invocations execute entries against the current state in the state database. To make these smart contract executable code interactions extremely efficient, the latest values of all keys are stored in the state database. The state database may include an indexed view into the entry log of the blockchain, it can therefore be regenerated from the chain at any time. The state database may automatically get recovered (or generated if needed) upon peer startup, before entries are accepted.

[0162] Endorsing nodes receive entries from clients and endorse the entry based on simulated results. Endorsing nodes hold smart contracts, which simulate the entry proposals. When an endorsing node endorses an entry, the endorsing nodes creates an entry endorsement, which is a signed response from the endorsing node to the client application indicating the endorsement of the simulated entry. The method of endorsing an entry depends on an endorsement policy that may be specified within smart contract executable code. An example of an endorsement policy is "the majority of endorsing peers must endorse the entry." Different channels may have different endorsement policies. Endorsed entries are forwarded by the client application to an ordering service.

[0163] The ordering service accepts endorsed entries, orders them into a block, and delivers the blocks to the committing peers. For example, the ordering service may initiate a new block when a threshold of entries has been reached, a timer times out, or another condition. In this example, blockchain node is a committing peer that has received a data block 582A for storage on the blockchain. The ordering service may be made up of a cluster of orderers. The ordering service does not process entries, smart contracts, or maintain the shared ledger. Rather, the ordering service may accept the endorsed entries and specifies the order in which those entries are committed to the distributed ledger. The architecture of the blockchain network may be designed such that the specific implementation of 'ordering' becomes a pluggable component.

[0164] Entries are written to the distributed ledger in a consistent order. The order of entries is established to ensure that the updates to the state database are valid when they are committed to the network. Unlike a cryptocurrency blockchain system where ordering occurs through the solving of a cryptographic puzzle, or mining, in this example the parties of the distributed ledger may choose the ordering mechanism that best suits that network.

[0165] Referring to FIG. 5D, a block 582A (also referred to as a data block) that is stored on the blockchain and/or the distributed ledger may include multiple data segments such

as a block header 584A to 584n, transaction-specific data 586A to 586n, and block metadata 588A to 588n. It should be appreciated that the various depicted blocks and their contents, such as block 582A and its contents are merely for purposes of an example and are not meant to limit the scope of the example embodiments. In some cases, both the block header 584A and the block metadata 588A may be smaller than the transaction-specific data 586A, which stores entry data; however, this is not a requirement. The block 582A may store transactional information of N entries (e.g., 100, 500, 1000, 2000, 3000, etc.) within the block data 590A to 590n. The block 582A may also include a link to a previous block (e.g., on the blockchain) within the block header 584A. In particular, the block header 584A may include a hash of a previous block's header. The block header 584A may also include a unique block number, a hash of the block data 590A of the current block 582A, and the like. The block number of the block 582A may be unique and assigned in an incremental/sequential order starting from zero. The first block in the blockchain may be referred to as a genesis block, which includes information about the blockchain, its members, the data stored therein, etc.

[0166] The block data 590A may store entry information of each entry that is recorded within the block. For example, the entry data may include one or more of a type of the entry, a version, a timestamp, a channel ID of the distributed ledger, an entry ID, an epoch, a payload visibility, a smart contract executable code path (deploy tx), a smart contract executable code name, a smart contract executable code version, input (smart contract executable code and functions), a client (creator) identify such as a public key and certificate, a signature of the client, identities of endorsers, endorser signatures, a proposal hash, smart contract executable code events, response status, namespace, a read set (list of key and version read by the entry, etc.), a write set (list of key and value, etc.), a start key, an end key, a list of keys, a Merkel tree query summary, and the like. The entry data may be stored for each of the N entries.

[0167] In some embodiments, the block data 590A may also store transaction-specific data 586A, which adds additional information to the hash-linked chain of blocks in the blockchain. Accordingly, the data 586A can be stored in an immutable log of blocks on the distributed ledger. Some of the benefits of storing such data 586A are reflected in the various embodiments disclosed and depicted herein. The block metadata 588A may store multiple fields of metadata (e.g., as a byte array, etc.). Metadata fields may include signature on block creation, a reference to a last configuration block, an entry filter identifying valid and invalid entries within the block, last offset persisted of an ordering service that ordered the block, and the like. The signature, the last configuration block, and the orderer metadata may be added by the ordering service. Meanwhile, a committer of the block (such as a blockchain node) may add validity/invalidity information based on an endorsement policy, verification of read/write sets, and the like. The entry filter may include a byte array of a size equal to the number of entries in the block data and a validation code identifying whether an entry was valid/invalid.

[0168] The other blocks 582B to 582n in the blockchain also have headers, files, and values. However, unlike the first block 582A, each of the headers 584A to 584n in the other blocks includes the hash value of an immediately preceding block. The hash value of the immediately preceding block

may be just the hash of the header of the previous block or may be the hash value of the entire previous block. By including the hash value of a preceding block in each of the remaining blocks, a trace can be performed from the Nth block back to the genesis block (and the associated original file) on a block-by-block basis, as indicated by arrows 592, to establish an auditable and immutable chain-of-custody.

[0169] FIG. 5E illustrates a process 500E of a new block being added to a distributed ledger 520E, according to example embodiments, and FIG. 5D illustrates the contents of FIG. 5E's new data block structure 530E for blockchain, according to example embodiments. Referring to FIG. 5E, clients (not shown) may submit transactions to blockchain nodes 511E, 512E, and/or 513E. Clients may be instructions received from any source to enact activity on the blockchain 522E. As an example, clients may be applications that act on behalf of a requester, such as a device, person, or entity to propose transactions for the blockchain. The plurality of blockchain peers (e.g., blockchain nodes 511E, 512E, and 513E) may maintain a state of the blockchain network and a copy of the distributed ledger 520E. Different types of blockchain nodes/peers may be present in the blockchain network including endorsing peers which simulate and endorse transactions proposed by clients and committing peers which verify endorsements, validate transactions, and commit transactions to the distributed ledger 520E. In this example, the blockchain nodes 511E, 512E, and 513E may perform the role of endorser node, committer node, or both.

[0170] The distributed ledger 520E includes a blockchain which stores immutable, sequenced records in blocks, and a state database 524E (current world state) maintaining a current state of the blockchain 522E. One distributed ledger 520E may exist per channel and each peer maintains its own copy of the distributed ledger 520E for each channel of which they are a member. The blockchain 522E is a transaction log, structured as hash-linked blocks where each block contains a sequence of N transactions. The linking of the blocks (shown by arrows in FIG. 5E) may be generated by adding a hash of a prior block's header within a block header of a current block. In this way, all transactions on the blockchain 522E are sequenced and cryptographically linked together preventing tampering with blockchain data without breaking the hash links. Furthermore, because of the links, the latest block in the blockchain 522E represents every transaction that has come before it. The blockchain 522E may be stored on a peer file system (local or attached storage), which supports an append-only blockchain workload.

[0171] The current state of the blockchain 522E and the distributed ledger 520E may be stored in the state database 524E. Here, the current state data represents the latest values for all keys ever included in the chain transaction log of the blockchain 522E. Chaincode invocations execute transactions against the current state in the state database 524E. To make these chaincode interactions extremely efficient, the latest values of all keys are stored in the state database 524E. The state database 524E may include an indexed view into the transaction log of the blockchain 522E, and it can therefore be regenerated from the chain at any time. The state database 524E may automatically get recovered (or generated if needed) upon peer startup, before transactions are accepted.

[0172] Endorsing nodes receive transactions from clients and endorse the transaction based on simulated results.

Endorsing nodes hold smart contracts which simulate the transaction proposals. When an endorsing node endorses a transaction, the endorsing node creates a transaction endorsement which is a signed response from the endorsing node to the client application indicating the endorsement of the simulated transaction. The method of endorsing a transaction depends on an endorsement policy which may be specified within chaincode. An example of an endorsement policy is "the majority of endorsing peers must endorse the transaction." Different channels may have different endorsement policies. Endorsed transactions are forwarded by the client application to the ordering service 510E.

[0173] The ordering service 510E accepts endorsed transactions, orders them into a block, and delivers the blocks to the committing peers. For example, the ordering service 510E may initiate a new block when a threshold of transactions has been reached, a timer times out, or another condition. In the example of FIG. 5E, blockchain node 512E is a committing peer that has received a new data block 530E for storage on blockchain 522E. The first block in the blockchain may be referred to as a genesis block which includes information about the blockchain, its members, the data stored therein, etc.

[0174] The ordering service 510E may be made up of a cluster of orderers. The ordering service 510E does not process transactions, smart contracts, or maintain the shared ledger. Rather, the ordering service 510E may accept the endorsed transactions and specifies the order in which those transactions are committed to the distributed ledger 522E. The architecture of the blockchain network may be designed such that the specific implementation of 'ordering' becomes a pluggable component.

[0175] Transactions are written to the distributed ledger 520E in a consistent order. The order of transactions is established to ensure that the updates to the state database 524E are valid when they are committed to the network. Unlike a cryptocurrency blockchain system where ordering occurs through the solving of a cryptographic puzzle, or mining, in this example the parties of the distributed ledger 520E may choose the ordering mechanism that best suits the network.

[0176] When the ordering service 510E initializes a new data block 530E, the new data block 530E may be broadcast to committing peers (e.g., blockchain nodes 511E, 512E, and 513E). In response, each committing peer validates the transaction within the new data block 530E by checking to make sure that the read set and the write set still match the current world state in the state database 524E. Specifically, the committing peer can determine whether the read data that existed when the endorsers simulated the transaction is identical to the current world state in the state database 524E. When the committing peer validates the transaction, the transaction is written to the blockchain 522E on the distributed ledger 520E, and the state database 524E is updated with the write data from the read-write set. If a transaction fails, that is, if the committing peer finds that the read-write set does not match the current world state in the state database 524E, the transaction ordered into a block will still be included in that block, but it will be marked as invalid, and the state database 524E will not be updated.

[0177] Referring to FIG. 5F 500F, a new data block 530 (also referred to as a data block) that is stored on the blockchain 522E of the distributed ledger 520E may include multiple data segments such as a block header 540, block

data **550**, and block metadata **560**. It should be appreciated that the various depicted blocks and their contents, such as new data block **530** and its contents shown in FIG. 5F, are merely examples and are not meant to limit the scope of the example embodiments. The new data block **530** may store transactional information of N transaction(s) (e.g., 1, 10, 100, 500, 1000, 2000, 3000, etc.) within the block data **550**. The new data block **530** may also include a link to a previous block (e.g., on the blockchain **522E** in FIG. 5E) within the block header **540**. In particular, the block header **540** may include a hash of a previous block's header. The block header **540** may also include a unique block number, a hash of the block data **550** of the new data block **530**, and the like. The block number of the new data block **530** may be unique and assigned in various orders, such as an incremental/sequential order starting from zero.

[0178] The block data **550** may store transactional information of each transaction that is recorded within the new data block **530**. For example, the transaction data may include one or more of a type of the transaction, a version, a timestamp, a channel ID of the distributed ledger **520E** (shown in FIG. 5E), a transaction ID, an epoch, a payload visibility, a chaincode path (deploy tx), a chaincode name, a chaincode version, input (chaincode and functions), a client (creator) identify such as a public key and certificate, a signature of the client, identities of endorsers, endorser signatures, a proposal hash, chaincode events, response status, namespace, a read set (list of key and version read by the transaction, etc.), a write set (list of key and value, etc.), a start key, an end key, a list of keys, a Merkel tree query summary, and the like. The transaction data may be stored for each of the N transactions.

[0179] In one embodiment of the instant solution, the block data may include data comprising one or more of determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

[0180] Although in FIG. 5F the blockchain data **563** is depicted in the block data **550** but may also be located in the block header **540** or the block metadata **560**. In some embodiments, the determined charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point, the offered item to the vehicle, an indication that the charge level is at or above a charge threshold, an indication that at least one other vehicle is waiting for the charging point, etc. may be written to the blockchain data **563** and committed to a blockchain ledger.

[0181] The block metadata **560** may store multiple fields of metadata (e.g., as a byte array, etc.). Metadata fields may include signature on block creation, a reference to a last configuration block, a transaction filter identifying valid and invalid transactions within the block, last offset persisted of an ordering service that ordered the block, and the like. The signature, the last configuration block, and the orderer metadata may be added by the ordering service **510E** in FIG. 5E. Meanwhile, a committer of the block (such as blockchain node **512E** in FIG. 5E) may add validity/invalidity information based on an endorsement policy, verification of read/write sets, and the like. The transaction filter may include a byte array of a size equal to the number of transactions in the block data and a validation code identifying whether a transaction was valid/invalid.

[0182] The above embodiments may be implemented in hardware, in a computer program executed by a processor, in firmware, or in a combination of the above. A computer program may be embodied on a computer readable medium, such as a storage medium. For example, a computer program may reside in random access memory ("RAM"), flash memory, read-only memory ("ROM"), erasable programmable read-only memory ("EPROM"), electrically erasable programmable read-only memory ("EEPROM"), registers, hard disk, a removable disk, a compact disk read-only memory ("CD-ROM"), or any other form of storage medium known in the art.

[0183] An exemplary storage medium may be coupled to the processor such that the processor may read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an application-specific integrated circuit ("ASIC"). In the alternative, the processor and the storage medium may reside as discrete components. For example, FIG. 6 illustrates an example computer system architecture **600**, which may represent or be integrated in any of the above-described components, etc.

[0184] FIG. 6 illustrates a computing environment according to example embodiments. FIG. 6 is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the application described herein. Regardless, the computing environment **600** can be implemented to perform any of the functionalities described herein. In computer environment **600**, computing system **601** is operational within numerous other general-purpose or special-purpose computing system environments or configurations.

[0185] Computing system **601** may take the form of a desktop computer, laptop computer, tablet computer, smartphone, smartwatch or other wearable computer, server computer system, thin client, thick client, network PC, mini-computer system, mainframe computer, quantum computer, and distributed cloud computing environment that include any of the described systems or devices, and the like or any other form of computer or mobile device now known or to be developed in the future that is capable of running a program, accessing a network **650** or querying a database. Depending upon the technology, the performance of a computer-implemented method may be distributed among multiple computers and between multiple locations. However, in this presentation of the computing environment **600**, a detailed discussion is focused on a single computer, specifically computing system **601**, to keep the presentation as simple as possible.

[0186] Computing system **601** may be located in a cloud, even though it is not shown in a cloud in FIG. 6. On the other hand, computing system **601** is not required to be in a cloud except to any extent as may be affirmatively indicated. Computing system **601** may be described in the general context of computer system-executable instructions, such as program modules, executed by a computing system **601**. Generally, program modules may include routines, programs, objects, components, logic, data structures, and so on that perform tasks or implement certain abstract data types. As shown in FIG. 6, computing system **601** in computing environment **600** is shown in the form of a general-purpose computing device. The components of computing system **601** may include but are not limited to, one or more processors or processing units **602**, a system memory **630**,

and a bus 620 that couples various system components, including system memory 630 to processing unit 602.

[0187] Processing unit 602 includes one or more computer processors of any type now known or to be developed. The processing unit 602 may contain circuitry distributed over multiple integrated circuit chips. The processing unit 602 may also implement multiple processor threads and multiple processor cores. Cache 632 is a memory that may be in the processor chip package(s) or located “off-chip,” as depicted in FIG. 6. Cache 632 is typically used for data or code that the threads or cores running on the processing unit 602 should be available for rapid access. In some computing environments, processing unit 602 may be designed to work with qubits and perform quantum computing.

[0188] Network adapter 603 enables the computing system 601 to connect and communicate with one or more networks 650, such as a local area network (LAN), a wide area network (WAN), and/or a public network (e.g., the Internet). It bridges the computer’s internal bus 620 and the external network, exchanging data efficiently and reliably. The network adapter 603 may include hardware, such as modems or Wi-Fi signal transceivers, and software for packetizing and/or de-packetizing data for communication network transmission. Network adapter 603 supports various communication protocols to ensure compatibility with network standards. For Ethernet connections, it adheres to protocols such as IEEE 802.3, while for wireless communications, it might support IEEE 802.11 standards, Bluetooth, near-field communication (NFC), or other network wireless radio standards.

[0189] Computing system 601 may include a removable/non-removable, volatile/non-volatile computer storage device 610. By way of example only, storage device 610 can be a non-removable, non-volatile magnetic media (not shown and typically called a “hard drive”). One or more data interfaces can connect it to the bus 620. In embodiments where computing system 601 is required to have a large amount of storage (for example, where computing system 601 locally stores and manages a large database), then this storage may be provided by storage devices 610 designed for storing very large amounts of data, such as a storage area network (SAN) that is shared by multiple, geographically distributed computers.

[0190] The operating system 611 is software that manages computing system 601 hardware resources and provides common services for computer programs. Operating system 611 may take several forms, such as various known proprietary operating systems or open-source Portable Operating System Interface type operating systems that employ a kernel.

[0191] The Bus 620 represents one or more of several types of bus structures, including a memory bus or memory controller, a peripheral bus, an accelerated graphics port, and a processor or local bus using various bus architectures. By way of example, and not limitation, such architectures include Industry Standard Architecture (ISA) buses, Micro Channel Architecture (MCA) buses, Enhanced ISA (EISA) buses, Video Electronics Standards Association (VESA) local buses, and Peripheral Component Interconnects (PCI) bus. The bus 620 is the signal conduction paths that allow the various components of computing system 601 to communicate with each other.

[0192] Memory 630 is any volatile memory now known or to be developed in the future. Examples include dynamic

random-access memory (RAM 631) or static type RAM 631. Typically, the volatile memory is characterized by random access, but this is not required unless affirmatively indicated. In computing system 601, memory 630 is in a single package and is internal to computing system 601, but alternatively or additionally, the volatile memory may be distributed over multiple packages and/or located externally with respect to computing system 601. By way of example only, memory 630 can be provided for reading from and writing to a non-removable, non-volatile magnetic media (shown as storage device 610, and typically called a “hard drive”). Memory 630 may include at least one program product having a set (e.g., at least one) of program modules configured to carry out various functions. A typical computing system 601 may include cache 632, a specialized volatile memory generally faster than RAM 631 and generally located closer to the processing unit 602. Cache 632 stores frequently accessed data and instructions accessed by the processing unit 602 to speed up processing time. The computing system 601 may include non-volatile memory 633 in ROM, PROM, EEPROM, and flash memory. Non-volatile memory 633 often contains programming instructions for starting the computer, including the BIOS and information required to start the operating system 611.

[0193] Computing system 601 may also communicate with one or more peripheral devices 641 via an I/O interface 640. Such devices may include a keyboard, a pointing device, a display, etc.; one or more devices that enable a user to interact with computing system 601; and/or any devices (e.g., network card, modem, etc.) that enable computing system 601 to communicate with one or more other computing devices. Such communication can occur via input/output (I/O) interfaces 640. As depicted, I/O interface 640 communicates with the other components of computing system 601 via bus 620.

[0194] Network 650 is any computer network that can receive and/or transmit data. Network 650 can include a WAN, LAN, private cloud, or public Internet, capable of communicating computer data over non-local distances by any technology that is now known or to be developed in the future. Any connection depicted can be wired and/or wireless and may traverse other components that are not shown. In some embodiments, a network 650 may be replaced and/or supplemented by LANs designed to communicate data between devices located in a local area, such as a Wi-Fi network. The network 650 typically includes computer hardware such as copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers, and edge servers. Computing system 601 connects to network 650 via network adapter 603 and bus 620.

[0195] User devices 651 are any computer systems used and controlled by an end user in connection with computing system 601. For example, in a hypothetical case where computing system 601 is designed to provide a recommendation to an end user, this recommendation may typically be communicated from network adapter 603 of computing system 601 through network 650 to a user device 651, allowing user device 651 to display, or otherwise present, the recommendation to an end user. User devices can be a wide array of devices, including PCs, laptops, tablet, hand-held, mobile phones, etc.

[0196] Remote servers 660 are any computers that serve at least some data and/or functionality over a network 650, for



example, WAN, a virtual private network (VPN), a private cloud, or via the Internet to computing system 601. These networks 650 may communicate with a LAN to reach users. The user interface may include a web browser or an application that facilitates communication between the user and remote data. Such applications have been called “thin” desktops or “thin clients.” Thin clients typically incorporate software programs to emulate desktop sessions. Mobile applications can also be used. Remote servers 660 can also host remote databases 661, with the database located on one remote server 660 or distributed across multiple remote servers 660. Remote databases 661 are accessible from database client applications installed locally on the remote server 660, other remote servers 660, user devices 651, or computing system 601 across a network 650.

[0197] A public cloud 670 is an on-demand availability of computer system resources, including data storage and computing power, without direct active management by the user. Public clouds 670 are often distributed, with data centers in multiple locations for availability and performance. Computing resources on public clouds (670) are shared across multiple tenants through virtual computing environments comprising virtual machines 671, databases 672, containers 673, and other resources. A container 673 is an isolated, lightweight software for running an application on the host operating system 611. Containers 673 are built on top of the host operating system’s kernel and contain only apps and some lightweight operating system APIs and services. In contrast, virtual machine 671 is a software layer that includes a complete operating system 611 and kernel. Virtual machines 671 are built on top of a hypervisor emulation layer designed to abstract a host computer’s hardware from the operating software environment. Public clouds 670 generally offer hosted databases 672 abstracting high-level database management activities. It should be further understood that one or more of the elements described or depicted in FIG. 6 can perform one or more of the actions, functionalities, or features described or depicted herein.

[0198] Although an exemplary embodiment of at least one of a system, method, and non-transitory computer readable medium has been illustrated in the accompanied drawings and described in the foregoing detailed description, it will be understood that the application is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions as set forth and defined by the following claims. For example, the capabilities of the system of the various figures can be performed by one or more of the modules or components described herein or in a distributed architecture and may include a transmitter, receiver, or pair of both. For example, all or part of the functionality performed by the individual modules, may be performed by one or more of these modules. Further, the functionality described herein may be performed at various times and in relation to various events, internal or external to the modules or components. Also, the information sent between various modules can be sent between the modules via at least one of: a data network, the Internet, a voice network, an Internet Protocol network, a wireless device, a wired device and/or via plurality of protocols. Also, the messages sent or received by any of the modules may be sent or received directly and/or via one or more of the other modules.

[0199] One skilled in the art will appreciate that a “system” may be embodied as a personal computer, a server, a

console, a personal digital assistant (PDA), a cell phone, a tablet computing device, a smartphone or any other suitable computing device, or combination of devices. Presenting the above-described functions as being performed by a “system” is not intended to limit the scope of the present application in any way but is intended to provide one example of many embodiments. Indeed, methods, systems and apparatuses disclosed herein may be implemented in localized and distributed forms consistent with computing technology.

[0200] It should be noted that some of the system features described in this specification have been presented as modules to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very-large-scale integration (VLSI) circuits or gate arrays, off-the-shelf semi-conductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field-programmable gate arrays, programmable array logic, programmable logic devices, graphics processing units, or the like.

[0201] A module may also be at least partially implemented in software for execution by various types of processors. An identified unit of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions that may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together but may comprise disparate instructions stored in different locations that, when joined logically together, comprise the module and achieve the stated purpose for the module. Further, modules may be stored on a computer-readable medium, which may be, for instance, a hard disk drive, flash device, random access memory (RAM), tape, or any other such medium used to store data.

[0202] Indeed, a module of executable code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set or may be distributed over different locations, including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network.

[0203] It will be readily understood that the components of the application, as generally described and illustrated in the figures herein, may be arranged and designed in a wide variety of different configurations. Thus, the detailed description of the embodiments is not intended to limit the scope of the application as claimed but is merely representative of selected embodiments of the application.

[0204] One having ordinary skill in the art will readily understand that the above may be practiced with steps in a different order and/or with hardware elements in configurations that are different from those which are disclosed. Therefore, although the application has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent.

[0205] While preferred embodiments of the present application have been described, it is to be understood that the embodiments described are illustrative only and the scope of the application is to be defined solely by the appended

claims when considered with a full range of equivalents and modifications (e.g., protocols, hardware devices, software platforms etc.) thereto.

What is claimed is:

1. A method comprising:

determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point; and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

2. The method of claim 1, comprising:

determining an amount of time the vehicle has been charging at the charging point; and after the amount of time has exceeded a time threshold, transmitting a message including a recommended course of action to the vehicle comprising instructions on when to stop charging and one or more incentives to stop charging within a time window that begins after the message is transmitted.

3. The method of claim 1, wherein the charge threshold is based on one or more of a default charge percentage of a total charge capacity of the EV battery and an amount of charge for the vehicle to navigate to a known destination and an amount of charge for the vehicle to navigate for a predefined period of time.

4. The method of claim 1, comprising:

determining whether the at least one other vehicle has a charge level below a minimum charge threshold; and offering a first type of incentive as the item when the at least one other vehicle has the charge level below the minimum charge threshold and offering a second type of incentive as the item when the at least one other vehicle does not have the charge level below the minimum charge threshold.

5. The method of claim 1, comprising:

identifying the charge level as being above a slowing charge level threshold based on a current charge level of the EV battery and an amount of charge received at the EV battery over a recent period of time being less than an amount of charge received at the EV battery over a less recent period of time, and wherein the recent period of time and the less recent period of time are based on a same amount of time.

6. The method of claim 5, comprising:

providing a warning message to the vehicle that a charge progress has saturated and any subsequent charging is to be performed at a higher value and the item will not be available unless the charging is ceased within a period of time.

7. The method of claim 1, comprising:

receiving a confirmation that the item has been accepted; and enabling the at least one other vehicle to begin charging at the charging point.

8. A system, comprising:

at least one processor; and

a memory, wherein the processor and the memory are communicably coupled,

wherein the processor:

determines a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point; and offers an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

9. The system of claim 8, wherein the processor is further configured to:

determine an amount of time the vehicle has been charging at the charging point; and

after the amount of time has exceeded a time threshold, transmit a message including a recommended course of action to the vehicle comprising instructions on when to stop charging and one or more incentives to stop charging within a time window that begins after the message is transmitted.

10. The system of claim 8, wherein the charge threshold is based on one or more of a default charge percentage of a total charge capacity of the EV battery and an amount of charge for the vehicle to navigate to a known destination and an amount of charge for the vehicle to navigate for a predefined period of time.

11. The system of claim 8, wherein the processor is further configured to:

determine whether the at least one other vehicle has a charge level below a minimum charge threshold; and offer a first type of incentive as the item when the at least one other vehicle has the charge level below the minimum charge threshold and offering a second type of incentive as the item when the at least one other vehicle does not have the charge level below the minimum charge threshold.

12. The system of claim 8, wherein the processor is further configured to:

identify the charge level as being above a slowing charge level threshold based on a current charge level of the EV battery and an amount of charge received at the EV battery over a recent period of time being less than an amount of charge received at the EV battery over a less recent period of time, and wherein the recent period of time and the less recent period of time are based on a same amount of time.

13. The system of claim 12, wherein the processor is further configured to:

provide a warning message to the vehicle that a charge progress has saturated and any subsequent charging is to be performed at a higher value and the item will not be available unless the charging is ceased within a period of time.

14. The system of claim 8, wherein the processor is further configured to:

receive a confirmation that the item has been accepted; and enable the at least one other vehicle to begin charging at the charging point.

15. A non-transitory computer readable storage medium configured to store instructions that when executed cause a processor to perform:

determining a charge level of an electrical vehicle (EV) battery of a vehicle charging at a charging point; and offering an item to the vehicle when the charge level is at or above a charge threshold and at least one other vehicle is waiting for the charging point.

16. The non-transitory computer readable storage medium of claim 15, wherein the processor is further configured to perform:

determining an amount of time the vehicle has been charging at the charging point; and after the amount of time has exceeded a time threshold, transmitting a message including a recommended

course of action to the vehicle comprising instructions on when to stop charging and one or more incentives to stop charging within a time window that begins after the message is transmitted.

**17.** The non-transitory computer readable storage medium of claim **15**, wherein the charge threshold is based on one or more of a default charge percentage of a total charge capacity of the EV battery and an amount of charge for the vehicle to navigate to a known destination and an amount of charge for the vehicle to navigate for a predefined period of time.

**18.** The non-transitory computer readable storage medium of claim **15**, wherein the processor is further configured to perform:

determining whether the at least one other vehicle has a charge level below a minimum charge threshold; and offering a first type of incentive as the item when the at least one other vehicle has the charge level below the minimum charge threshold and offering a second type of incentive as the item when the at least one other vehicle does not have the charge level below the minimum charge threshold.

**19.** The non-transitory computer readable storage medium of claim **15**, wherein the processor is further configured to perform:

identifying the charge level as being above a slowing charge level threshold based on a current charge level of the EV battery and an amount of charge received at the EV battery over a recent period of time being less than an amount of charge received at the EV battery over a less recent period of time, and wherein the recent period of time and the less recent period of time are based on a same amount of time.

**20.** The non-transitory computer readable storage medium of claim **19**, wherein the processor is further configured to perform:

providing a warning message to the vehicle that a charge progress has saturated and any subsequent charging is to be performed at a higher value and the item will not be available unless the charging is ceased within a period of time.

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