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### Systems and methods for identifying and merging duplicate charge station locations using geohashing

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#### Abstract

The disclosure is generally directed to a method and system for charge station management including collecting data related to a plurality of charge stations, the data identifying location data, an operator, and a data provider for each of the plurality of charge stations, collating the data to match the location data with the operators of each of the plurality of charge stations, and merging the location data based on a set of criteria including the data from each of the data providers within an identified geohash location. Merging includes setting a geohash about a data provider, and merging location data within the predetermined perimeter to remove redundant locations based on a set of criteria, including criteria identifying a same operator within the geohash.

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## **Background/Summary**

### **FIELD OF THE DISCLOSURE**

(1) This disclosure generally relates to vehicles, and more particularly relates to systems and methods for locating and merging charging station location data using that meet defined criteria.

### **BACKGROUND**

(2) Electric vehicles require frequent charging. Many drivers who prefer to fast charge or are on a trip some distance from home need to locate a charging station within a defined distance from their vehicle. For example, if a vehicle only has a limited amount of charge, it is frequently necessary to locate a charging station that is within a predefined area close to the electric vehicle. When locating a charge station, there are applications available to drivers to help locate charging stations. Some applications use crowd-sourced data collected from other drivers, some applications are supported by charge station operators. Some charge station location applications may conflict with other applications or do not take into account redundancies in the data provided.

(3) It is desirable to provide solutions that address redundancies in typical charge station location applications.

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## **Description**

### **BRIEF DESCRIPTION OF THE DRAWINGS**

(1) A detailed description is set forth below with reference to the accompanying drawings. The use of the same reference numerals may indicate similar or identical items. Various embodiments may utilize elements and/or components other than those illustrated in the drawings, and some elements and/or components may not be present in various embodiments. Elements and/or components in the figures are not necessarily drawn to scale. Throughout this disclosure, depending on the context, singular and plural terminology may be used interchangeably.

(2) FIG. 1 illustrates an example system that includes an electric vehicle in accordance with one or more embodiments of the disclosure.

(3) FIG. 2 illustrates some example functional blocks that may be included in a cloud server system

appropriate for providing charge station location data without redundancies in accordance with embodiments of the disclosure.

(4) FIG. 3 illustrates a decision flow diagram illustrating a method in accordance with an embodiment of the disclosure.

(5) FIG. 4 illustrates an exemplary flow diagram of a method in accordance with an embodiment of the disclosure.

(6) FIG. 5 illustrates an exemplary flow diagram of another method in accordance with an embodiment of the disclosure.

(7) FIG. 6A illustrated an example map for sequential merging in accordance with an embodiment of the disclosure.

(8) FIG. 6B illustrates an example map for an alternate geohash solution in accordance with an embodiment of the disclosure.

(9) FIG. 7 illustrates an example schematic diagram of operator locations being assigned to data providers in accordance with an embodiment of the disclosure.

## DETAILED DESCRIPTION

### Overview

(10) In terms of a general overview, this disclosure is generally directed to systems and methods for identifying and merging duplicate charge station locations.

(11) In one or more embodiments, a method for electric vehicle charge station management includes collecting data related to a plurality of charge stations, the data including location data for the plurality of charge stations, operators of the plurality of charge stations, and charge station data providers for the plurality of charge stations, collating the data to match the location data with the operators of each of the plurality of charge stations, merging the location data for the plurality of charge stations within the predetermined geohash by merging the location data identified as having a same operator, and sending the reduced set of charging locations to a user device or vehicle.

(12) In one or more embodiments, collecting data related to the plurality of charge stations includes receiving the data from crowd-sourced data providers, and receiving the data from the operators of the plurality of charge stations, and receiving the data as periodic batch data from charge station data providers on a daily basis.

(13) Other embodiments are directed to a system and an electric vehicle with a vehicle computer configured a memory that stores computer-executable instructions; a transceiver coupled to memory, the transceiver configured to receive raw data related to a plurality of charge stations, the raw data identifying location data of the plurality of charge stations, operators of each of the plurality of charge stations, and data providers for each of the plurality of charge stations; a processor configured to access the memory and execute the computer-executable instructions to collate the data to match the location data with the operators of each of the plurality of charge stations, merge the location data for the plurality of charge stations within the predetermined geohash by merging the location data for the plurality of charge stations within the predetermined geohash by merging the location data identified as having a same operator, and send the reduced set of charging locations to a user device or vehicle.

### Illustrative Embodiments

(14) The disclosure will be described more fully hereinafter with reference to the accompanying drawings, in which example embodiments of the disclosure are shown. This disclosure may, however, be embodied in many different forms and should not be construed as limited to the example embodiments set forth herein. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made to various embodiments without departing from the spirit and scope of the present disclosure. Thus, the breadth and scope of the present disclosure should not be limited by any of the above-described example embodiments but should be defined only in accordance with the following claims and their equivalents. The description below has been presented for the purposes of illustration and is not intended to be exhaustive or to be limited to the

precise form disclosed. It should be understood that alternative implementations may be used in any combination desired to form additional hybrid implementations of the present disclosure. For example, any of the functionality described with respect to a particular device or component may be performed by another device or component. Furthermore, while specific device characteristics have been described, embodiments of the disclosure may relate to numerous other device characteristics. Further, although embodiments have been described in language specific to structural features and/or methodological acts, it is to be understood that the disclosure is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as illustrative forms of implementing the embodiments.

(15) It should also be understood that the word “example” as used herein is intended to be non-exclusionary and non-limiting in nature. Furthermore, certain words and phrases that are used herein should be interpreted as referring to various objects and actions that are generally understood in various forms and equivalencies by persons of ordinary skill in the art. For example, the word “application” or the phrase “software application” as used herein with respect to a mobile device such as a smartphone, refers to code (software code, typically) that is installed in the mobile device. The code may be launched and operated via a human machine interface (HMI) such as a touchscreen. The word “action” may be used interchangeably with words such as “operation” and “maneuver” in the disclosure. The word “maneuvering” may be used interchangeably with the word “controlling” in some instances. The word “vehicle” as used in this disclosure can pertain to any one of various types of vehicles such as cars, vans, sports utility vehicles, trucks, electric vehicles, gasoline vehicles, hybrid vehicles, and autonomous vehicles. Phrases such as “automated vehicle,” “autonomous vehicle,” and “partially-autonomous vehicle” as used in this disclosure generally refer to a vehicle that can perform at least some operations without a driver being seated in the vehicle.

(16) FIG. 1 illustrates an example electric vehicle system **100**. Vehicle **130** represents an electric vehicle requiring periodic charging. The system **100** may be implemented in a variety of ways and can include various types of devices. For example, the example system **100** can include some components that are a part of the vehicle **130**, and, in some embodiments, other components that are accessible via a communications network **140**. The components that can be a part of the vehicle **130** can include a vehicle computer **110**, shown in exploded form.

(17) FIG. 1 illustrates vehicle computer **110** in exploded form and may perform various functions such as controlling engine operations (fuel injection, speed control, emissions control, braking, etc.), managing climate controls (air conditioning, heating etc.), activating airbags, and issuing warnings (check engine light, bulb failure, low tire pressure, vehicle in a blind spot, etc.). Vehicle computer **110** includes example components that may be included in vehicle **130** including memory **102**, which is one example of a non-transitory computer-readable medium, transceiver **104** to enable communications, processor **106**, operating system **108**, shown coupled to a bus **163**. Further components include a sensor system **112**, including both internal and external cameras **150**, communication system **114**, which may be a wireless communication system such as a Ford intranet system, vehicle control components **126**, location services module **130** including GPS location services, infotainment system **160** with display system **164** which may have a GUI used for carrying out various operations including, for example, by a driver to input a level of responsiveness for Driver Assistance System (ADAS) **161** to perform an operation. A further example component may include a battery management system **162** which may provide information to a driver to indicate when electric vehicle **130** requires a charge. The various components are communicatively coupled to each other via one or more buses such as an example bus **163**, which may be implemented using various wired and/or wireless technologies. For example, bus **163** can be a vehicle bus that uses a controller area network (CAN) bus protocol, a Media Oriented Systems Transport (MOST) bus protocol, and/or a CAN flexible data (CAN-FD) bus protocol, or an automotive ethernet system in accordance with IEEE 802.3 and 802.1

specifications using a wired network to connect components with vehicle **130**.

(18) Some or all portions of the bus **163** may also be implemented using wireless technologies such as Bluetooth®, Bluetooth® Ultra-Wideband, Wi-Fi, Zigbee®, or near-field-communications (NFC).

(19) Sensor system **112** can include various types of sensors such as, for example, a weight sensor, and an external and internal camera such as sensors **150** capable of facial detection, a radar detector, a front-facing camera, and others on vehicle **130**. Vehicle control components **126** can include various components and systems associated with driving functions of electric vehicle **130** and its various other functions (such as, for example, stocks and struts whose characteristics can be controlled for varying a performance of vehicle **130**). The various components may be controlled, activated, and/or operated by the vehicle computer **110** and ADAS **161**.

(20) In one implementation, vehicle **110** includes a charging station location and merge module **170** relying on cloud-based application data or implemented as a part of vehicle computer **110**. In another implementation, charge station location and merge module **170** receives data from charge station locator **120** accessible through network **140**.

(21) Memory **102** which is one example of a non-transitory computer-readable medium, may be used to store the OS **108**, and various software modules utilized by or to implement features such as charging station and location merge module **170** which is one or more modules in the form of computer-executable instructions executed by processor **106** for performing various operations in accordance with the disclosure. More particularly, charging station and location merge module **170** may be executed by processor **106** to provide charging stations within an area when electric vehicle **130** requires a charge.

(22) Vehicle computer **110**, in one or more embodiments, may execute certain operations associated with facial recognition to allow entry and operation of vehicle systems such as the ADAS system **161** in accordance with the disclosure.

(23) The wireless communication system **114** may include a set of wireless communication nodes and/or sensors **150** mounted upon vehicle **130** and within vehicle **130** in a manner that allows the vehicle computer **110** to communicate with a cloud network **120** accessible through a network connection **140**. Examples of wireless communication nodes **150** may include sensors and/or emitters capable of detecting objects and distances and may include ultrasonic radar, LiDAR, cameras, and the like. In one or more embodiments, wireless communication node data may be enhanced or substituted with cloud-based network data communicated to vehicle **130**.

(24) The vehicle computer **110** may connect to charge station locator server **120** via communications network **140**. The communications network **140** may include any one network, or a combination of networks, such as a local area network (LAN), a wide area network (WAN), a telephone network, a cellular network, a cable network, a wireless network, and/or private/public networks such as the Internet. For example, the communications network **140** may support communication technologies such as TCP/IP, Bluetooth®, Bluetooth Low Energy (BLE), cellular, near-field communication (NFC), Wi-Fi, Wi-Fi direct, Li-Fi, acoustic or ultrasonic audio communication, Ultra-Wideband (UWB), machine-to-machine communication, and/or human-to-machine communication. Battery management system module **162** may be executed by processor **106** for performing various operations in accordance with the disclosure. For example, battery management system **162** may operate to inform a user that battery **111** requires a charge. Memory **102** may be used to store information that can be accessed and used by processor **106** when executing the charging station location and merge module **170**. As another example, the battery management system **162** may manage the charge, discharge, and general operation of the battery to maximize its efficiency. This may include predicting charge times based on current charge as well as other considerations such as ambient temperature, historical charging data, charger capability (rating, such as amps per minute), etc. The battery management system may also be connected to a CAN bus system **163** or as part of an automotive ethernet.

(25) Vehicle on board computer **110** may include a display, such as a touchscreen having softkeys (graphical icons), and a biometric component (to enable facial recognition, a fingerprint scanner, or a microphone for voice command input). Operating system **108** can be any of various kinds of software used, for example, as an iOS® operating system, an Android® operating system, or a Windows® operating system.

(26) In one or more embodiments, communications network **140** may be coupled to a charge station locator server **120**, shown in more detail in FIG. 2, or a user device **155**, which may include a mobile device, desktop, or other interactive user device in accordance with this disclosure. Communications network **140** is further shown coupled to charge management system providers and aggregators **180** which may provide raw data via communications network **140** to charge station locator **120** and/or to vehicle **130**.

(27) Charge station location and merging module **170** may receive data over transceiver **104** to allow a user to request performing operations such as, for example, locating a charging station appropriate for charging vehicle **130** and accessible given a remaining charge on vehicle **130**. In accordance with embodiments, a user may request a charge location and receive a plurality of charge station locations that have been merged to reduce redundancies. In accordance with one or more embodiments, the charging station location and merge module **170** may perform some or all of the location and merge processing either within the vehicle or receive the already processed and merged charge location data over network **140**. For example, charge station locator server **120** shown in further detail FIG. 2 includes a charging station location and merge module **270** which may process data and provide such data to a user requesting such data. Depending on system requirements and processing power of vehicle **130**, those of skill in the art will appreciate that data processing may be performed in a charge station locator server **120**, a remote data processing server, within vehicle **130** or partially within vehicle **130**. In one or more embodiments, charge station location and merging module **170** may receive data from a charge station locator server **120** that receives location data from vehicle **130** and returns charge station locations within a predetermined perimeter. In some embodiments, the perimeter is a radius is 150 meters near a location identified by a provider, or within a geohash with an identified location within a perimeter. In other embodiments, the radius may be a function of congestion of electric charging stations, such as in a downtown city area. In such areas, a perimeter identifying smaller area may be more appropriate.

(28) FIG. 2 illustrates some example functional blocks that may be included in charge station locator server **120** in accordance with an embodiment of the disclosure. The functional blocks of charge station locator **120** may include a memory **204**, processor **210**, location/GPS module **220**, transceiver **213**, charge station location and merge module **270**, database **230**, and an operating system (OS) **240**. The operating system **240** can be any of various kinds of software used for operating cloud network server **120** such as, for example, a Windows® operating system.

(29) In one or more embodiments, the charge station location and merge module **270** locates a charge station for an electric vehicle driver after collecting data, collating the data and merging redundancies. After merging, a software application such as FordPass™ may be used to display results from merging different charging locations in accordance with embodiments disclosed herein.

(30) In one or more embodiments, charge station location and merge module **270** operates to carry out various actions for displaying available charge stations after merging locations that are combined through merging redundant locations. Charge station location and merge module **270** further removes locations under certain criteria. The processing of data within charge station location and merge module **270**, while described with reference to FIG. 2 may be partially performed by charging station location and merge module **170** within vehicle **130** in cooperation with vehicle **130**.

(31) The memory **204**, which is one example of a non-transitory computer-readable medium, may

be used to store the operating system (OS) **240**, database **230**, and various modules such as the charge station location and merge module **270**. One or more modules in the form of computer-executable instructions may be executed by the processor **210** for performing various operations in accordance with the disclosure. More particularly, charge station location and merge module **270** may be executed by the processor **210** to carrying out actions of the charge station location and merge module **270**, in one or more embodiments, may be executed for performing methods for merging and reducing redundancies in received raw data, such as batch data received from different providers of charge station locations.

(32) As shown in FIG. **3** in one or more embodiments, charge station location and merging module **170**, at block **310**, may retrieve charge station information such as raw batch data from different data providers, such as Charge Management System (CMS) providers. Different CMS providers may provide the same charge station information for the same geographical location resulting in redundant charge station location data.

(33) In some embodiments, the location data relates to GPS data or geohash locations, such as a grid of geohash locations such as provided over GPS or the like. In other embodiments location data is referenced within a circumference defined by a radius such as 150 meters or the like.

(34) As will be appreciated by one of skill in the art, a geohash is a unique identifier of a specific region on the Earth. Earth is divided into regions, or grids, of a defined size and each region is assigned a unique identifier, which is called its geohash. For a given location on earth, the geohash algorithm converts its latitude and longitude into a string. As one of skill in the art will appreciate, the granularity of a geohash location is determined by the number of digits/letters in the hash.

(35) Geohashes have a choice of precision between 1 and 12. The highest-precision geohash of length **12** produces cells that cover less than a square meter of land. The location of where cells are located are predetermined. For example, a 7-digit geohash identifies a location grid that is larger than an 8 digit geohash grid. Charge station location and merge module **170/270** normalizes charge station location data from different CMS providers based on a set of criteria to reduce redundancies. In some embodiments, such data is received daily in a batch data collection retrieval. For example, batch data may be received from providers such as crowd-sourced providers, paid providers, operators and the like.

(36) The batch data may contain duplicate charge station data from different data providers. Block **320** provides for collating and identifying locations eligible for merging. The collating and identifying locations includes applying a set of criteria to the raw data that may be received daily as batch data. The set of criteria includes rules for collating by organizing the locations according to data provider, according to locations, and according to operators that operate charge stations. As will be appreciated by those of skill in the art, some operators have multiple charge stations and some locations may have multiple operators. Thus, collating and organizing raw data prior to merging is a necessary step.

(37) Block **330** provides for identifying a charge station data provider as a pivot point or geohash center, setting a radius or geohash granularity to determine a perimeter. For example, locating a radius of a close distance from the pivot point/geohash center location, such as 150 meters. As one of skill in the art with the benefit of the disclosure with appreciate, a pivot point is a point about which a radius may be determined, such as on a map, by pivoting about a point at a given distance (radius) to set a circumference of a circle. A pivot point as used herein relates to a circumference about a center point (pivot point) to locate charge stations within a perimeter of the identified circle. In other embodiments, a geohash grid with a charge station data provider located within the geohash area identifies the area of concern. More specifically, in some embodiments, a GPS location identifying a location to two decimal places, generally enables locating an area of  $\frac{1}{4}$  mile perimeter. As one of skill in the art will appreciate, a GPS location can be converted into a geohash grid area, and to longitude and latitude coordinates, in accordance with system requirements. The geohash perimeter may be determined first by either receiving an address or a GPS location, and



identifying the location to two decimal places, which generally enables locating an area of the size of a ¼ mile perimeter. As one of skill in the art will appreciate, a GPS location can be converted into a geohash grid area, and to longitude and latitude coordinates, in accordance with system requirements.

(38) A GPS area may include a circumference area which may serve to identify a pivot point center, which may be more appropriate for some embodiments.

(39) In some embodiments, the perimeter size of the geohash grid may be a function of the congestion of an area or congestion of charge stations or the like. Thus, in a congested area, a radius of 30 meters is more appropriate. Block **340** provides for identifying locations that fall within a perimeter. It may be a perimeter defined by a geohash grid, or it may be the circumference of the circle defined by the radius. If geohashing is being used to define a perimeter, the size of the geohash in numbers of digits may be increased to accommodate the congestion of the area.

(40) Block **350** provides for matching locations based on an operator's name. More specifically, if a same operator has a location at or near a second location with a same operator, criteria may indicate combining locations. As will be appreciated, many operators have multiple locations and at times, near a same location. Matching locations based on an operator's name combines locations that list a same operator within a given perimeter. The locations will not be the same, but will be within the given perimeter. If, however, a location is within a meter of another location, criteria will indicate that the locations should be combined as more than likely redundant.

(41) Decision block **360** asks if redundancies have been identified. If not, block **370** provides for setting a new radius based on a next provider within the circumference or new geohash grid and returning to block **320**. For example, if all redundancies are accounted for, block **370** loops back to block **320** to collate and identify locations eligible for merging until all providers are accounted for.

(42) If the decision is yes, block **380** provides for merging locations and removing any redundancies. For example, if criteria, set to merge all locations within a given distance with a same operator, they can be merged. The distance is determined according to the size of the area under consideration and whether the locations are associated with a same operator. Block **390** provides for removing locations according to distance. In one embodiment, all locations with a same operator within the perimeter of an area under consideration may be merged. In another embodiment, all locations with a same operator within a perimeter are merged except for edge cases. For example, if there are edge cases that can be part of a different circumference/perimeter or geohash grid area, criteria may dictate removing the location as not helpful for users trying to locate charge stations closer to the center of the perimeter.

(43) In one embodiment, a perimeter is set that is determined according to the location of a data provider. More particularly, as shown in FIG. 1, charge management system (CMS) providers and aggregators **180** may provide inconsistent information including redundant information or locations that are inaccurate. For example, if a crowd-sourced location is provided based on where the crowd-sourced provider is located, such as a driver of a vehicle simply designating a current location close to an operator, such data is not as accurate as data from the actual operator. Other CMS providers may be more accurate, such as fleet-based CMS providers that include actual location data, cost data and efficiency data concerning a charging station. Tables A, B, C and D below illustrate a merge logic that takes into account the different CMS data, both crowd sourced and other data provider-based information and combines the data, which may be batch data, and reduces redundancies based on perimeters or circumferences about different data provider locations, depending on whether a radius about a provider is considered or a geohash grid.

(44) As shown in Table A, below, charge station data providers such as charge station data provider locations are identified within a perimeter, and raw data provides matching locations and operator names. Thus, for example, if a same location has different operators, the locations would not be combined. As will be appreciated by one of skill in the art, a perimeter applies to both geohash grid areas which may be square and to circumferences defined by a radius.

(45) After a data provider is identified, and a perimeter is determined around it, within the perimeter the method identifies all the matching locations from other data providers (Ex: Data provider B locations B1, B2, B3 . . . Bn) that fall within the perimeter—either a geohash grid or a circumference defined by a radius or GPS identifier. Locations within the perimeter get further compared and matched based on the operator's name.

(46) All matching locations per operator may be identified for all the locations from data provider A. (Locations ranging from—A1, A2, A3, . . . An). As shown in Table A, matching location data is shown:

(47) TABLE-US-00001 TABLE A Provider A - Locations Matching Location Operator Name  
A.sub.1 {B.sub.1, B.sub.2} X A.sub.2 {B.sub.3, B.sub.4, B.sub.5} Y A.sub.3 {B.sub.1, B.sub.2, B.sub.4} Z

(48) After matching locations for data provider A and identifying operator names is completed for provider A, as shown in FIG. 3, the same procedure is repeated for data provider B within the same original perimeter. Then, each location from provider B becomes a center of a geohash grid or, if a radius is used, a pivot point. For example, block 370 in FIG. 3 sets a new radius or center of a geohash based on a next data provider (provider B). Below is a sample representation, Table B of matching location data.

(49) TABLE-US-00002 TABLE B Provider B - Locations Matching Location Operator Name  
B.sub.1 {A.sub.1, A.sub.3} X B.sub.2 {A.sub.1, A.sub.3} Y B.sub.3 {A.sub.2} Z

(50) After populating all the matching locations for data providers A and B, the closest matching locations for data provider B locations are merged and farther locations may be removed as shown in Table C.

(51) TABLE-US-00003 TABLE C Provider B - Locations Matching Location Operator Name  
B.sub.1 {A.sub.1} X B.sub.2 {A.sub.3} Y B.sub.3 {A.sub.2} Z

(52) Next, the matching locations for data provider A are merged and the closest locations retained as shown in Table D:

(53) TABLE-US-00004 TABLE D Provider A Locations Matching Location Operator Name  
A.sub.1 {B.sub.1} X A.sub.2 {B.sub.3, B.sub.4, B.sub.5} Y A.sub.3 {B.sub.2, B.sub.4} Z

(54) Based on Table C, location data for data provider A and Table D, merging logic merges location data for Provider B.

(55) Referring now to FIG. 4, a flow diagram 400 illustrates a method in accordance with an embodiment. Block 410 provides for collecting raw data related to electric charging stations, the raw data identifying location data of a plurality of charge stations, an operator of each of the plurality of charge stations, and a data provider for each of the plurality of charge stations. For example, collecting raw data may be from a data provider that identifies a plurality of charge stations from different operators. In one or more embodiments, the collecting raw data may include receiving raw data from crowd-sourced data providers. For example, as shown in optional block 4102, crowd-sourced data providers may collect data from different users in real time and provide raw data as batch data to different sources. Raw data may also be made available from operators of charge stations as periodic batch data, as shown in optional block 4104. Some raw data may be collected and sent periodically as batch data on a daily basis, as shown in optional block 4106.

(56) Block 420 provides for collating the raw data to match first location data with a first operator of the plurality of charge stations, and to match the second location data with a second operator of the plurality of charge stations. Within block 420 is optional block 4202 which provides for identifying redundancies in the data, and optional block 4204 which provides for organizing data according to operator location. For example, the data may have redundancies because raw data and crowd sourced data may include the same data. Further organizing data according to operator location enables a sorting of data within different geographical locations.

(57) In one or more embodiments, the collating the raw data includes collecting the raw data as batch data. The raw data may be derived from crowd sourcing, commercial sources and from

operators and the like. Given the different sources, conflicting and duplicative data may be identified during collation of the data. Thus, in some embodiments, the collating may include identifying and removing redundancies in the raw data and organizing the raw data according to operator location. Thus, as used herein, data provider refers to any provider of data and locations identified by any particular data provider may or may not be accurate. Operators, on the other hand, are confirmed charge station operators and their locations may be known and may be used as a center for determining a perimeter thereabout. In some embodiments, a perimeter about a known location of a confirmed charge station operator is beneficial to weed out redundancies presented by inaccurate crowd sourced data, or subscription based data and the like. In other embodiments, the confirmed charge station operator location is unknown, each data provider, whether confirmed as accurate or not, may be considered as a center location, with alternate perimeters considered to enable a statistical likelihood that redundancies may be reduced by repeating the process in a statistical analysis converging onto a more likely than not identification of true locations of charging stations within an area under consideration.

(58) Block **430** provides for defining an area according to a predetermined geohash identifier. For example, in one embodiment, the geohash identifier for an area may cover several operators in the area or just a single operator. Defining an area according to a geohash identifier limits the data to be considered to the geographical area defined by the geohash identifier. As described above, a geohash identifier has a precision determined by the length of the identifier. Thus defining the area includes determining the precision and size of the area under consideration. In one embodiment, an area may include defining operator **610** as a center of a geohash grid that is located by converting a GPS location to a geohash identifier at a predetermined precision.

(59) In some embodiments, setting the predetermined geohash identifier is a function of charge station congestion such that dispersed charge station location areas have a larger geohash than congested metropolis location areas. For example, a larger radius or geohash (smaller identifier) would result in a larger perimeter for both embodiments. A typical urban area in the United States may require a radius of 150 meters to provide a reasonable circumference for charge stations. In contrast, a typical urban area in Germany however, being a congested area with many charging stations may benefit from a configurable radius of 30 meters or a geohash area with more precision.

(60) Thus, in one embodiment, a geohash in Germany may require eight digits of granularity due to congestion and a United States urban area may only require seven digits of granularity due to the lack of congestion and the need for a larger area to compare.

(61) Block **440** provides for merging the location data for the plurality of charge stations within the identified predetermined geohash identifier. For example, as shown in FIGS. **6A** and **6B**, different geohash areas are illustrated. In FIG. **6A**, if charging location data **640** and **610** are in the same geohash area they may be merged if there is one known operator in the area. Referring to FIG. **6B**, if two different geohash areas split the location data, then according to one embodiment, the location data would not be merged. Rather, the location data would be associated with different charging stations. Thus, depending on the different system requirements, embodiments may benefit from either a geohash solution or a radius solution. For example, if energy efficiency and processing time is of concern, a geohash perimeter may be preferred due to the increased processing requirements of radius determinations identifying a circumference.

(62) Within block **440** is block **4402** and block **4404**. Block **4402** provides for merging the location data for the first the operator with location data within an area closer to the first operator than the second operator. Block **4404** provides for merging the location data for the second operator with location data within an area closer to the second operator than the first operator. Thus, merging the location data for the plurality of charge stations within a given geohash area includes identifying the location data associated with a first operator as location data closer to the first operator than a second operator. Thus, if a geohash area has two operators known in the area, any location data within the area can be designated according to vicinity of an operator. If several operators are

identified within a geohash area, location data can be similarly merged with location data closest to the operators. Thus, a geohashing solution includes merging the location data for the plurality of charge stations within the predetermined geohash by merging the location data identified as having a same operator.

(63) Next, block **450** provides for sending the reduced set of charging locations to a user device or vehicle. For example, a user device may be a mobile device or a computer. The reduced set of charging locations enables a user or a driver to locate a charge station without requiring additional steps to sift through possible locations.

(64) Referring now to FIG. 5, a flow diagram illustrating a method according to another embodiment is directed to a solution including determining a radius about a pivot point rather than a geohash area. Block **510** provides for collecting raw data related to electric charging stations, the raw data identifying location data of a plurality of charge stations, an operator or each of the plurality of charge stations and a data source for each of the plurality of charge stations. Block **5102**, **5104** and **5106** provide for receiving raw data from crowd sourced providers, from operators, and as batch data. The data may include a large area as a function of the data providers and the availability of data and system requirements. Block **520** provides for collating the data to match the location data with the operators of each of the plurality of charge stations. For example, the collating can include reducing redundancies by matching the same data and deleting redundancies, as described above.

(65) Block **530** provides for sequentially merging the location data based using a configurable radius defining a circumference surrounding each data provider-identified location. The sequential merging, meaning merging sequentially by considering each potential charging location individually, may be based on a set of criteria, which is further described with reference to FIGS. **6A**, **6B**, and **7**. As shown, a map illustrates a confirmed operator **610** as a center of a circumference **620** using a configurable radius **630** of 150 meters. The data also provides a location of an operator at location **640** within the circumference. In a 150-meter radius embodiment, both operator locations **610** and **640** may be combined due to the proximity of the locations.

(66) Block **540** provides for setting the configurable radius around a first operator as a first pivot point for a first predetermined perimeter. As shown in FIG. **6A**, operator **610** is used as a pivot point or center. The radius shown in FIGS. **6A** and **6B** is 150 meters but may be altered in accordance with system requirements or in accordance with criteria associated with the number charging stations in an area under consideration.

(67) Block **550** provides for merging location data within the first predetermined perimeter to remove redundant locations based on a set of criteria, including criteria identifying a same operator within the first predetermined perimeter. For example, the data associated with operator **640** in FIG. **6A** is merged with the data related to operator **610** to more accurately reflect the location of a charge station. Because the operator's actual location may be known, the data provider location may be determined to be incorrect as to the area within the perimeter. The result is the same for a geohash solution if the geohash grid does not separate the two charge station data providers among different predetermined geohash grids, as shown in FIG. **6A** as compared to FIG. **6B**.

(68) Block **560** provides for setting a second location of a second data provider as a second pivot point for a second predetermined perimeter. For example, referring to FIG. **7**, two pivot points are illustrated, one centered at **702** and one centered at **704**. The additional pivot point may serve to address edge cases in which a charge station location may be near an edge of one circumference but be closer to second pivot point.

(69) Block **570** provides for merging location data within the second predetermined perimeter to remove redundant locations based on the set of criteria, the set of criteria including identifying locations within the first predetermined perimeter. For example, as shown in FIG. **7**, if only one pivot point **702**, were present, then location data for **760** and **770** would be associated with operator **702**. With second pivot point **704**, data for **760** is merged with operator **704**, and data associated

with **770** is merged with operator **702**, depending on the distance between **704** and **760** as compared to the distance between **760** and **702**. Thus merging location data within second predetermined perimeter, **720**, to remove redundant locations, such as location **760**, based on distance criteria, and identifying locations **760** and **770** that are within the first perimeter **710**.

(70) After merging the charging station location data and removing redundancies, in one or more embodiments, the data is sent to a user device, such as user device **155** or sent to vehicle **130**, such as to charging station location and merge module **170** for display within vehicle **130**.

(71) According an embodiment using pivot points, the operator locations **650** and **660** are assigned as merged to different operators according to distance criteria. Thus, NM1 **660** is assigned to the first operator **602** because the distance criteria is set to include NM1 **660** and NM2 **650** is assigned to the second operator **604**. The data is then merged accordingly. For example, the data for NM1 **660** is merged with operator **602** information, and the data for NM2 **650** is merged with second operator **604** information.

(72) Referring to FIG. 7, map **700** illustrates that first data provider **702**, a second data provider **704**, a first circumference **710** and a second circumference **720**. In one embodiment, the circumferences are both with 150-meter radii as to each data provider. Charge station operators are shown as NM1, NM2 and PS1, PS2 operators which may or may not be located in a same geographical area. As described above, in some embodiments, a geohash perimeter is used to merge data associated with different locations, and in other embodiments, a radius of 150 meters as shown around operator **704** and **702**. For a geohash of **730** area, all operators are combined into one operator identified as closest to a center of geohash **730**. In a circumference embodiment, data may be combined into operator **702** or operator **704**, depending on the distance from each operator when used as a pivot point.

(73) In the above disclosure, reference has been made to the accompanying drawings, which form a part hereof, which illustrate specific implementations in which the present disclosure may be practiced. It is understood that other implementations may be utilized, and structural changes may be made without departing from the scope of the present disclosure. References in the specification to “one embodiment,” “an embodiment,” “an example embodiment,” “an example embodiment,” “example implementation,” etc., indicate that the embodiment or implementation described may include a particular feature, structure, or characteristic, but every embodiment or implementation may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment or implementation. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment or implementation, one skilled in the art will recognize such feature, structure, or characteristic in connection with other embodiments or implementations whether or not explicitly described. For example, various features, aspects, and actions described above with respect to an autonomous parking maneuver are applicable to various other autonomous maneuvers and must be interpreted accordingly.

(74) Implementations of the systems, apparatuses, devices, and methods disclosed herein may comprise or utilize one or more devices that include hardware, such as, for example, one or more processors and system memory, as discussed herein. An implementation of the devices, systems, and methods disclosed herein may communicate over a computer network. A “network” is defined as one or more data links that enable the transport of electronic data between computer systems and/or modules and/or other electronic devices. When information is transferred or provided over a network or another communications connection (either hardwired, wireless, or any combination of hardwired or wireless) to a computer, the computer properly views the connection as a transmission medium. Transmission media can include a network and/or data links, which can be used to carry desired program code means in the form of computer-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer. Combinations of the above should also be included within the scope of non-transitory computer-readable media.

(75) Computer-executable instructions comprise, for example, instructions and data which, when executed at a processor, cause the processor to perform a certain function or group of functions. The computer-executable instructions may be, for example, binaries, intermediate format instructions such as assembly language, or even source code. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the described features or acts described above. Rather, the described features and acts are disclosed as example forms of implementing the claims.

(76) A memory device can include any one memory element or a combination of volatile memory elements (e.g., random access memory (RAM, such as DRAM, SRAM, SDRAM, etc.)) and non-volatile memory elements (e.g., ROM, hard drive, tape, CDROM, etc.). Moreover, the memory device may incorporate electronic, magnetic, optical, and/or other types of storage media. In the context of this document, a “non-transitory computer-readable medium” can be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device. More specific examples (a non-exhaustive list) of the computer-readable medium would include the following: a portable computer diskette (magnetic), a random-access memory (RAM) (electronic), a read-only memory (ROM) (electronic), an erasable programmable read-only memory (EPROM, EEPROM, or Flash memory) (electronic), and a portable compact disc read-only memory (CD ROM) (optical). Note that the computer-readable medium could even be paper or another suitable medium upon which the program is printed, since the program can be electronically captured, for instance, via optical scanning of the paper or other medium, then compiled, interpreted or otherwise processed in a suitable manner if necessary, and then stored in a computer memory.

(77) Those skilled in the art will appreciate that the present disclosure may be practiced in network computing environments with many types of computer system configurations, including in-dash vehicle computers, personal computers, desktop computers, laptop computers, message processors, mobile devices, multi-processor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, mobile telephones, PDAs, tablets, pagers, routers, switches, various storage devices, and the like. The disclosure may also be practiced in distributed system environments where local and remote computer systems, which are linked (either by hardwired data links, wireless data links, or by any combination of hardwired and wireless data links) through a network, both perform tasks. In a distributed system environment, program modules may be located in both the local and remote memory storage devices.

(78) Further, where appropriate, the functions described herein can be performed in one or more of hardware, software, firmware, digital components, or analog components. For example, one or more application specific integrated circuits (ASICs) can be programmed to carry out one or more of the systems and procedures described herein. Certain terms are used throughout the description, and claims refer to particular system components. As one skilled in the art will appreciate, components may be referred to by different names. This document does not intend to distinguish between components that differ in name, but not function.

(79) At least some embodiments of the present disclosure have been directed to computer program products comprising such logic (e.g., in the form of software) stored on any computer-usable medium. Such software, when executed in one or more data processing devices, causes a device to operate as described herein.

(80) While various embodiments of the present disclosure have been described above, it should be understood that they have been presented by way of example only, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the present disclosure. Thus, the breadth and scope of the present disclosure should not be limited by any of the above-described example embodiments but should be defined only in accordance with the following claims and their

equivalents. The foregoing description has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the present disclosure to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. Further, it should be noted that any or all of the aforementioned alternate implementations may be used in any combination desired to form additional hybrid implementations of the present disclosure. For example, any of the functionality described with respect to a particular device or component may be performed by another device or component. Further, while specific device characteristics have been described, embodiments of the disclosure may relate to numerous other device characteristics. Further, although embodiments have been described in language specific to structural features and/or methodological acts, it is to be understood that the disclosure is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as illustrative forms of implementing the embodiments. Conditional language, such as, among others, “can,” “could,” “might,” or “may,” unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments could include, while other embodiments may not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements, and/or steps are in any way required for one or more embodiments, as will be understood by those of ordinary skill in the art with the benefit of the present disclosure.

## Claims

1. A method for electric vehicle charge station management comprising: collecting first data related to a plurality of charge stations, the first data including (i) location data for the plurality of charge stations, (ii) information about operators of the plurality of charge stations, and (iii) information about charge station data providers for the plurality of charge stations; processing the first data to match first location data of a first charge station, from among the plurality of charge stations, with a first operator from among the operators, and to match second location data of a second charge station, from among the plurality of charging stations, with a second operator from among the operators; defining an area according to a predetermined geohash identifier, wherein the predetermined geohash identifier covers a first set of operators from among the operators and wherein defining the area further includes identifying the first operator as a center of a geohash grid associated with the geohash identifier, wherein the geohash grid is determined by converting global positioning system location data associated with the first operator to the geohash identifier at a predetermined precision; merging the location data for the plurality of charge stations within the predetermined geohash identifier by merging one or more location data identified as being associated with a same operator, from among the operators, wherein the merging further comprises merging location data associated with the first operator within a first portion of the area that is closer to the first operator than the second operator and merging location data associated with the second operator with a second portion of the area that is closer to the second operator than the first operator; generating, based on the merging, information about a reduced set of charge stations; and sending the information about the reduced set of charge stations to a user device or a vehicle enabling a user to locate a charge station for charging the vehicle.
2. The method of claim 1 wherein collecting the first data further comprises: receiving the first data from crowd-sourced data providers; or receiving the first data from the operators of the plurality of charge stations.
3. The method of claim 1 wherein collecting the first data further comprises: receiving the first data as periodic batch data from the charge station data providers on a daily basis.
4. The method of claim 1 wherein collating the first data further comprises: identifying redundancies in the first data; and organizing the first data according to location of the operators.
5. The method of claim 1 wherein defining the area further comprises: setting the predetermined

geohash identifier as a first geohash identifier about a first operator from among the operators.

6. The method of claim 5 wherein merging the location data for the plurality of charge stations further comprises: setting a second geohash identifier about a second operator; and merging location data within the second geohash identifier to remove redundant locations including locations within the first geohash identifier.

7. The method of claim 6 further comprising: revising matching locations for the first operator based on the second geohash identifier; and removing locations identified by the first operator within the second geohash identifier based on distance.

8. A system comprising: a memory that stores computer-executable instructions; a transceiver coupled to memory, the transceiver configured to receive first data related to a plurality of charge stations, the first data including location data of the plurality of charge stations, location data of operators of each of the plurality of charge stations, and information about charge station data providers for each of the plurality of charge stations; a processor configured to access the memory and execute the computer-executable instructions to: receive the first data; process the first data to match first location data of a first charge station, from among the plurality of charge stations, with first location data of a first operator, from among the operators, and to match second location data of a second charge station, from among the plurality of charge stations, with a second location data of a second operator, from among the operators; define an area according to a predetermined geohash identifier, wherein the predetermined geohash identifier covers a first set of operators from among the operators and wherein defining the area further includes identifying the first operator as a center of a geohash grid associated with the geohash identifier, wherein the geohash grid is determined by converting global positioning system location data associated with the first operator to the geohash identifier at a predetermined precision; merge the location data for the plurality of charge stations within the predetermined geohash identifier by merging one or more location data identified as being associated with a same operator, from among the operators, wherein to merge the location data, the processor further merges location data associated with the first operator within a first portion of the area that is closer to the first operator than the second operator and merges location data associated with the second operator with a second portion of the area that is closer to the second operator than the first operator; generate, based on the merging, information about a reduced set of charge stations; and send the information about the reduced set of charging locations to a user device or a vehicle to enable a user to locate a charge station for charging the vehicle.

9. The system of claim 8 wherein the transceiver is further configured to: receive the first data from crowd-sourced data providers; and receive the first data from the operators of the plurality of charge stations.

10. The system of claim 8 wherein the processor is further configured to execute computer-executable instructions to: identify redundancies in the first data; and organize the first data according to location of the operators.

11. The system of claim 8 wherein the processor is further configured to execute computer-executable instructions to: set the predetermined geohash identifier as a first geohash identifier about the first operator for a first predetermined perimeter; and merge location data associated with the first geohash identifier to remove redundant locations by identifying a same operator within the first predetermined perimeter.

12. The system of claim 11 wherein the processor is further configured to execute computer-executable instructions to: set a second location of a second operator within a second predetermined perimeter identified by a second geohash identifier; and merge location data associated with the second geohash identifier to remove redundant locations including locations associated with the first geohash identifier.

13. The system of claim 12, wherein the processor is further configured to execute computer-executable instructions to: revise matching locations for first data provider based on the second



geohash identifier; and remove locations identified by the first data provider and associated with the second geohash identifier, based on distance.

14. An electric vehicle comprising: a plurality of batteries; a vehicle computer coupled to the battery, the vehicle computer configured with: a memory that stores computer-executable instructions; a transceiver coupled to memory, the transceiver configured to receive first data related to a plurality of charge stations, the first data including location data of the plurality of charge stations, location data associated with operators of each of the plurality of charge stations, and information about charge station data providers for each of the plurality of charge stations; a processor configured to access the memory and execute the computer-executable instructions to: receive the first data; process the first data to match first location data of a first charge station, from among the plurality of charge stations, with first location data of a first operator, from among the operators, and to match second location data of a second charge station, from among the plurality of charge stations, with a second location data of a second operator, from among the operators; define an area according to a predetermined geohash identifier, wherein the predetermined geohash identifier covers a first set of operators from among the operators and wherein defining the area further includes identifying the first operator as a center of a geohash grid associated with the geohash identifier, wherein the geohash grid is determined by converting global positioning system location data associated with the first operator to the geohash identifier at a predetermined precision; merge the location data for the plurality of charge stations within the predetermined geohash identifier by merging one or more location data identified as being associated with a same operator, from among the operators, wherein to merge the location data, the processor further merges location data associated with the first operator within a first portion of the area that is closer to the first operator than the second operator and merges location data associated with the second operator with a second portion of the area that is closer to the second operator than the first operator; generate, based on the merging, information about a reduced set of charge stations; and send the information about reduced set of charging locations to a user device or vehicle.

15. The electric vehicle of claim 14 wherein the processor is further configured to execute computer-executable instructions to: receive the first data from crowd-sourced data providers; receive the first data from the operators of the plurality of charge stations; receive the first data as periodic batch data from charge station data providers; identify redundancies in the first data; and organize the first data according to location of the operators.

16. The electric vehicle of claim 14 wherein the processor is further configured to execute computer-executable instructions to: set the predetermined geohash identifier around a first operator as a first geohash; merge location data within the first geohash to remove redundant locations based on a set of criteria, including identifying a same operator within the first geohash.

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