(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 July 2024 (18.07.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/148432 A1

(51) International Patent Classification:
G01S 5/00 (2006.01) *H04W 64/00* (2009.01)
G06F 16/29 (2019.01)

(21) International Application Number:
PCT/CA2024/050025

(22) International Filing Date:
10 January 2024 (10.01.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
63/479,349 10 January 2023 (10.01.2023) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

(54) Title: EFFICIENT GEOLOCATION

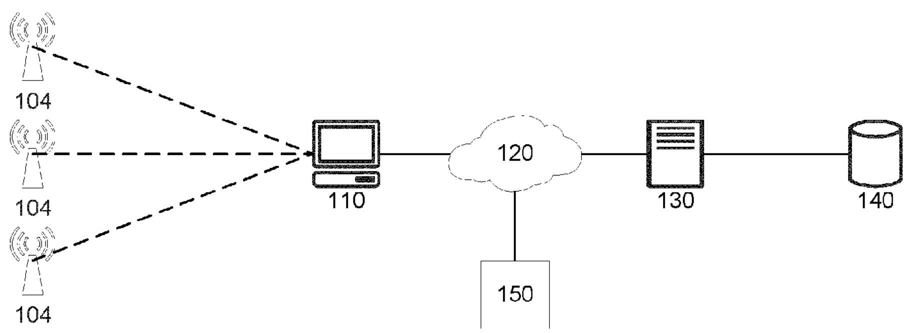

FIG. 1

(57) Abstract: Access point identifiers that are associated with a common location are grouped into sets of three and stored in a document in a database. When the location of a device is required, the access points that it detects are searched for in the database. If a matching set of three access points are found in the database, then the corresponding location is retrieved from the document in which the three access points are found.

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EFFICIENT GEOLOCATION

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority to U.S. Provisional Application Serial Number 63/479,349 filed January 10, 2024, the content of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to geolocation of an electronic device. In particular, it relates to the use of BSSID (Basic Service Set Identifier) data.

BACKGROUND

[0003] Geolocation services may use third-party application programming interfaces (APIs) to resolve a mobile device's location using detected Basic Service Set Identifiers (BSSIDs) or Media Access Control (MAC) addresses. Fleets of remote devices may need to make hundreds of millions or even billions of API requests annually. The number of API requests increases as the fleets grow and as more location-sensitive features are added to services that manage the devices.

[0004] Typically, a device's locations are stored infrequently in a database, if at all. The locations are only used for single device itself.

[0005] There is a need for improved methods to geolocate devices.

SUMMARY

[0006] Embodiments of the present invention can use geolocation data more efficiently using device location histories extracted from a large number of documents. A query can be formed based on the database location history of a device to see if there is a location that satisfies some pre-determined, including but not limited to are there a certain number of access points that overlap with a current list of access points detected by a device, having the same public IP, and so on. In this fashion, using the techniques described herein, a potential benefit of embodiments of the invention is that they may reduce the costs of resolving locations.

[0007] In an aspect, there is provided a method including receiving a geolocation payload from a first device having a receiver, the geolocation payload including a first plurality of basic service set identifications (BSSID) detected by the first device; and determining a location of the first device by searching, using the first plurality of BSSIDs, a database including a second plurality of BSSIDs and location data associated with the second plurality of BSSIDs.

[0008] In an embodiment, the method further includes determining the location using an alternative location lookup if the search does not find location data in the database based on the first plurality of BSSIDs.

[0009] In an embodiment, the alternative location lookup is a geolocation API, a location determined using global navigation satellite system (GNSS), or a loca-tion of the OS.

[0010] In an embodiment, the method further includes assembling the first plurality of BSSIDs into received BSSID combinations, each received BSSID combination including a first number of BSSIDs from the first plurality of BSSIDs; where the second plurality of BSSIDs are stored as stored BSSID combinations, each stored BSSID combination including the first number of BSSIDs from the second plurality of BSSIDs, and where the determining of the location searches using the received BSSID combinations for matches in the stored BSSID combinations.

[0011] In an embodiment, the first number is at least 3.

[0012] In an embodiment, the determining of the location of the device searches the database using the received BSSID combinations until at least one received BSSID combination is found.

[0013] In an embodiment, the geolocation payload includes a signal strength for each of the first plurality of BSSIDs, and the searching using the received BSSID combinations are based on the signal strengths.

[0014] In an embodiment, the determining the location of the device searches the second plurality of BSSIDs from a first time period.

[0015] In an embodiment, the geolocation payload further comprises a received internet protocol (IP) address of the device, wherein the database includes stored device IP addresses associated with the location data, and where-in the determining of the location of the device uses the received IP address.

[0016] In an embodiment, the determining of the location of the devices compares the received IP address to determine if it is within range of the stored device IP addresses.

[0017] In an embodiment, the location data stored in the database comprises previously stored location data of the first device, second device, or a combination thereof

[0018] In an embodiment, the location data stored in the database comprises previously stored location data of the first device.

[0019] In an embodiment, the location data stored in the database comprises previously stored location data of a second device.

[0020] In an embodiment, the method further includes enforcing device rules based on the determined location of the device.

[0021] In an embodiment, the method further includes updating the database with the deter-mined location, the first plurality of BSSIDs and a timestamp of the geolocation payload.

[0022] In an embodiment, the method further includes verifying the determined location against a previous location of the first device.

[0023] In an aspect, there is provided a system for determining a location of a first device including a first device including a receiver for detecting a first plurality of BSSIDs, a processor for assembling a geolocation payload including the detected BSSIDs, and a transmitter for transmitting the geolocation payload; a database including a second plurality of BSSIDs and locations associated therewith; and a second device including a receiver and computer readable medium having instructions stored thereon that when executed, causes the second device to receive a geolocation payload from a first device having a receiver, the geolocation payload including a first plurality of basic service set identifications (BSSID) detected by the first device; and determine a location of the first device by searching, using the first plurality of BSSIDs, a database including a second plurality of BSSIDs and location data associated the second plurality of BSSIDs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The present disclosure provides the following drawings, in which:

[0025] FIG. 1 is a representation of an environment in which the present disclosure may be deployed in accordance with some embodiments of the invention.

[0026] FIG. 2 is a representation of an alternative environment in which the present disclosure may be deployed in accordance with some embodiments of the invention.

[0027] FIG. 3 is a representation of another alternative environment in which the present disclosure may be deployed in accordance with some embodiments of the invention.

[0028] FIG. 4 is a flowchart of a method according to an embodiment of the present invention.

[0029] FIG. 5 is a flowchart depicting the searching and updating of a database according to an embodiment of the present invention.

[0030] FIG. 6 is a flowchart of a method according to another embodiment of the present invention.

DESCRIPTION

[0031] The methods, processes, and systems described herein enable geolocation of a device based on wireless access points detected by the device. Geolocation of a device may be based on historical data of the device or multiple devices. Multiple wireless access points detected by the device may be grouped to reduce the size of the database, query times, and increase accuracy.

Glossary

[0032] Access point (AP) or wireless access point (WAP): a device that creates a wireless local area network (WLAN), usually in an office or large building.

[0033] Application programming interface (API): a way for computer programs to communicate with each other. For example, an API can be used by a first program access geolocation services available through a second program.

[0034] Basic Service Set Identifier (BSSID): the MAC address of an AP. BSSID is often used to refer to devices that provides a connection to a network. Since a MAC address can be used to refer to identifiers of any device network device and not just those of APs, this disclosure uses BSSIDs to refer to MAC addresses of APs unless context dictates otherwise.

[0035] Geolocation: the identification of the geographical location of a device.

[0036] Media Access Control (MAC) address: a unique identifier assigned to a network interface controller of a device, such as an AP. MAC addresses are provided as six groups of two hexadecimal digits separated by hyphens, colons, or without a separator (e.g. 00:0C:E6:02:37:F8)

[0037] WLAN: wireless local area network.

Exemplary Embodiment

[0038] One embodiment involves looking up and finding one document in the location history database that has an AP list that overlaps with at least 3 items (that is, 3 APs that are currently detected by the device). If found, then the location recorded in that document is reused without calling a geolocation API. However, as the size of the geolocation history collection is usually huge, we have a way to return the result in a minimum response time.

[0039] Another embodiment involves storing the geolocation history records in a new collection with an identification (_id) that is the combination of 3 BSSIDs. In order to make sure that the identification is unique among 3 BSSIDs, we have to sort the BSSIDs into a list first.

[0040] **FIG. 1** illustrates an example of an environment **100** in which the geolocation of a client device can be determined, according to some embodiments. The example environment **100** can include one or more devices such as client device **110**. The client device **110** includes receiver (not pictured) for use in collecting information for use in detecting the BSSIDs of access points (APs) **104** in its vicinity signals. The receiver may be a wireless receiver, a WIFI antenna, or the like. As depicted in FIG. 1, the client device **110** is. A client device can include a desktop computer, a laptop computer, a tablet computer, a smartphone, a set-top box, a smart watch, an internet of things device, and the like. Although illustrated using 3 APs, the client device **110** may detect fewer or more APs based on the number of APs in its vicinity and the strengths of their signals.

[0041] The client device **110** includes network hardware (not pictured), such as a transmitter, for communicating with a server **130** via a wide area network (WAN) **120**, such as the Internet. Although shown as connecting directly to the WAN **120**, the client device **110** may connect to the WAN through other methods, such as through one of the APs **104** detected by client device **110**.

[0042] The server **130** can communicate with location database **140**. Location database **140** includes historical location data of client devices **110** and BSSIDs detected by client device **110** at corresponding historical locations. Location database **140** may be stored on server **130** or remote therefrom.

[0043] The client device **110** can communicate with a geolocation server **150** using an API to obtain the location of the client device **110** where a location of client device **110** is not found on database **140**.

[0044] **FIG. 2** illustrates another example of an environment **200** in which the geolocation of a client device can be determined, according to some embodiments. The example environment **200** includes client device **210**. The client device **210** includes a receiver for use in collecting information for use in BSSIDs of APs **204** in its vicinity. As noted above, the client device **210** may detect fewer or more APs based on the number of APs in its vicinity and the strengths of their signals.

[0045] The client device **210** can communicate with a server **230** via a wide area network (WAN) **220**, such as the Internet. Although shown as connecting directly to the WAN **220**, the client device **210** may connect to the WAN through other methods, such as through one of the APs **204** detectable by client device **210**.

[0046] The server **230** can communicate with location database **240**. Location database **240** includes historical location data of client device **210** and BSSIDs detected by client device **210** at corresponding historical locations. Location database **240** may be stored on server **230** or remote therefrom.

[0047] The client device **210** can communicate with a geolocation server **250** using an API to obtain the location of the client device **210** where a location of client device **210** is not found on database **240**.

[0048] The client device **210** includes or pairs to a satellite navigation receiver capable of communicating with a global navigation satellite system (GNSS) **260** for determining its location. Typically such client devices include smart phones, but other client devices paired with satellite navigation receivers may also be suitable. Exemplary GNSS implementations include the Global Positioning System (GPS), Global Navigation Satellite System (GLONASS), BeiDou, and Galileo.

[0049] **FIG. 3** illustrates yet another alternative example of an environment **300** in which the geolocation of a client device can be determined, according to some embodiments. The example environment **300** includes multiple client devices **310**. Each client device **310** includes a receiver for use in collecting information for use in detecting the BSSIDs of APs **304** in its vicinity.

[0050] The client devices **310** can communicate with a server **330** via a wide area network (WAN) **320**, such as the Internet. Although shown as connecting directly to the WAN **320**, the client devices **310** may connect to the WAN through other methods, such as through one of the APs **304** detectable by client device **310**. As noted above, the client device **310** may detect fewer or more APs based on the number of APs in its vicinity and the strengths of their signals.

[0051] The server **330** can communicate with location database **340**. Location database **340** includes historical location data of all client devices **310** and BSSIDs detected by client devices **310** at corresponding historical locations. Location database **340** may be stored on server **330** or remote therefrom.

[0052] Each client device **310** can communicate with a geolocation server **350** using an API to obtain the location of the client device **310** where a location of client device **310** is not found on database **340**.

[0053] Each client device **310** may connect asynchronously in the environment **300**, such that different client devices **310** may be connected at once to each of the server **330**, geolocation server **340**, etc.

[0054] Turning now to FIG 4, example operational procedures for implementing the examples are illustrated, according to some embodiments. At operation **402**, a geolocation payload is received from a first device (e.g. a client device **110**) having a receiver. The geolocation payload comprises a first plurality of BSSIDs detected by the first device. In some embodiments, the receiving of the payload is at the first device. Performing the lookup locally at the first device may speed up determination since it would eliminate transit times of the geolocation payload. However, this may require significant storage space on the first device (see, for example, the size of an exemplary database in Table 1, may not be able to access historical locations of other devices, reduce performance if the first client does not have sufficient computing power, and increase payload size if received BSSID combinations are transmitted to a server to duplicate the database or augment a secondary database. In some embodiments, the receiving is by a second device remote from the first device (e.g. a server **130**, **230**, **330**).

[0055] At operation **406**, the geolocation payload is used to determine a location of the first device by searching a database that includes a second plurality of BSSIDs and location data associated with the second plurality of BSSIDs. If one or more of the BSSIDs in the first plurality of BSSIDs matches the one or more of the BSSIDs in the second plurality of BSSIDs, the first device is determined as being located at the location associated with the one or more of the matching BSSIDs of the second plurality of BSSIDs. The confidence in the location may be increased with an increasing number of matches. This may be useful, for example, where a single physical AP broadcasts multiple SSIDs (e.g. virtual APs each with separate BSSIDs), or where BSSIDs. Matches to such BSSIDs may not increase the accuracy of the location, so increasing the number of matches may increase the likelihood that a BSSID from a different physical AP is matched. The speed of the operation may be increased by decreasing the number searches performed (e.g. by searching based on only a subset of the first plurality of BSSIDs). In some embodiments, at least 3, 4, 5, 6, 7, 8, 9 or 10 of the first plurality of BSSIDs have corresponding entries in the second plurality of BSSIDs. In some embodiments, 3, 4, 5, 6, 7, 8, 9 or 10 of the first plurality of BSSIDs have corresponding entries in the second plurality of BSSIDs. In some embodiments, 3 of the first plurality of BSSIDs have corresponding entries in the second plurality of BSSIDs.

[0056] In some embodiments, at operation **404**, the BSSIDs are optionally assembled into received BSSID combinations, each received BSSID combination including a first number of BSSIDs from the first plurality of BSSIDs (see, e.g. FIG. **1**). The first number of BSSIDs may be 2, 3, 4, 5, 6, 7, 8, 9, 10, or more. Increasing the first number of BSSIDs may improve the accuracy, confidence, or both, of the determination of the location. However, where the first number of BSSIDs is too high, the time required to perform the searches, the size of the dataset or both, may be increased. In embodiments where BSSIDs are assembled into received BSSID combinations, the second plurality of BSSIDs are stored as stored BSSID combination, each having the same number of BSSIDs as the received BSSIDs. The determination of the location at **406** searches using the received BSSID combinations for matches in the stored BSSID combination.

[0057] In some embodiments, the first number is at least 3, and each received BSSID combination includes at least 3 BSSIDs. In a preferred embodiment, the first number is 3. The use of 3 APs (such as 3 different physical APs) helps to reduce uncertainty in location. If locations of three known APs are provided, a location can be determined using signal strength as a proxy for distance from the particular location.

[0058] The number of received BSSID combinations depends on the number of BSSIDs in the first plurality of BSSIDs in the geolocation payload and the first number. For example, where the first plurality of BSSIDs has 20 BSSIDs and the first number is 3, there are 1140 (20 choose 3) received BSSID combinations.

[0059] In some embodiments, the first plurality of BSSIDs includes all BSSIDs detected by the first device. In some embodiments, the first plurality of BSSIDs is limited based on a predetermined number, signal strength, or both. Depending on the number of APs in the vicinity of the first device, the first device may detect a very large number of BSSIDs. Thus, it may be desirable to limit the number of BSSIDs included in the geolocation payload. For example, where the first number is 3, and the predetermined number of BSSIDs is 20, there are 1140 received BSSID combinations; where the predetermined number of BSSIDs is 30, there are 4060 received BSSID combinations; where the predetermined number of BSSIDs is 40, there are 9880 received BSSID combinations.

[0060] In some embodiments, predetermined number is selected to reduce the number of potential searches performed during the determination. In some embodiments, the predetermined number is between 10 and 30. In some embodiments, the predetermined number is 20.

[0061] In some embodiments, the BSSIDs selected for inclusion in the geolocation payload is based on the signal strength of the corresponding AP as detected by the first device. For example, only the BSSIDs of the APs with the strongest signals are included in the geolocation payload. This may be limited to the predetermined number described above. In some embodiments, only those BSSIDs of APs with a threshold signal strength are included.

[0062] In some embodiments, the database includes historical locations of the first device, and, optionally, a timestamp of the historical location. In some embodiments, the determination of the location first searches the database based on a first time period, for example, recent locations of the first device. If a location cannot be found in the first time period, then the search is expanded to locations in a second time period longer than the first time period.

[0063] In some embodiments, the database includes historical locations of additional devices (e.g. additional client devices 310).

[0064] Turning now to **FIG. 5,** an embodiment of the updating of the database at operation **404** is provided for a group of BSSIDs **512** detected for a given longitude and latitude. The BSSIDs are then sorted into numerical order to provide a sorted array **514**. The sorted array **514** is arranged into arrays for each combination of BSSIDs **516** that may be assembled from the array **516** (depicted with 3 BSSIDs in each combination). Each combination in each array **516** is joined into a separate string **518**. Each joined combination **518** is related to the specific longitude and latitude and stored in the database **540** (such as database **140**, **240**, or **340**) in a separate document **542**. Later, when a server (such as server **130**, **230**, **330**) receives, from the same device or another device, a geolocation payload (also referred to as a WIFI payload) **502** that includes BSSIDs detected by the device (such as at operation **402**), it can create received BSSID combinations **504** from the geolocation payload **502** (such as at operation **404**), similar to how the arrays of combinations of BSSIDs **516** are created (e.g. combinations of three

BSSIDs from the detected BSSIDs). If one of the received BSSID combinations **504** matches a combined document entry **542** in the database **540** (such as at operation **407**), the corresponding longitude and latitude can be retrieved from the document **542** without having to call a geolocation API.

[0065] TABLE 1 shows results of an exemplary database, e.g. in Collection: LocationByWifiMacAddress

Number of documents	490,510,900
Size	45.1GB
Number of combinations	1140 (for 20 BSSIDs)
Query time	0.879s

TABLE 1

This shows that for 20 BSSIDs that are detected, there are 1140 combinations of three BSSIDs that can be selected from those 20. It also shows that a typical query time is below a second.

[0066] In other embodiments, groups of four or more BSSIDs (or APs) may be used instead of three. By increasing the number of APs, the accuracy, confidence, or both, maybe increased, but the database size, the query time, or both may be reduced.

[0067] The BSSIDs (e.g. 3 BSSIDs) may be combined in another way for storage in the database. For example, in some embodiments, the BSSIDs are stored as individual arrays of BSSID combinations **506** and not joined into strings. In such embodiments, the document **512** includes the array of BSSIDs, and, optionally, relative signal strengths of the BSSIDs at the particular location.

[0068] Turning back to **FIG. 4**, in some embodiments, at operation **410**, the database is updated with documents including the determined location, the first plurality of BSSIDs and a timestamp of the geolocation payload. In some embodiments, the first plurality is saved in the form of the received BSSID combination in a document that includes the determined location, and the timestamp of the geolocation payload. In some embodiments, documents with unique BSSID combinations are saved to the database rather than duplicating BSSID combinations and locations, to reduce storage requirements. In some embodiments, the document that includes a matched BSSID combination is updated with the timestamp of the document. In other embodiments, the particular received BSSID combination with a matching stored BSSID combination in a pre-existing document is saved in a new document. In some embodiments, each received BSSID combination is combined into a single string. In some embodiments, each received combination BSSID is stored as an array.

[0069] In some embodiments, at operation **407**, if a location is found at operation **406**, then the determined location can be used as further set out in the method. However, if a location cannot be determined based on the database, an alternative location lookup is optionally performed at operation **408**. Alternative location lookups include using an API to determine the location of the first device, such as using a geolocation API (such as one offered by Googe, Baidu, etc.), using a satellite navigation receiver to receive a position using a GNSS, using a location of the OS, or a combination thereof. For example, a second device that received the geolocation payload may send a request to the first device for the position using the GNSS or location of the OS, if the first device is equipped with such information. Typically, requests for the use of satellite navigation receiver is limited due to higher power consumption, time taken to synchronize with GNSS, and availability of satellite navigation receivers (e.g. not typically equipped with laptop or desktop devices). Further, with OS location, reliability may be limited because they may be manually input by a user. Further still, geolocation API calls may incur costs, which are magnified when managing a fleet of devices. As such, use of BSSIDs is preferred.

[0070] In some embodiments, the determined location is optionally verified at operation **409** against a previous location of the first device, such as the last known location. In some embodiments, the previous location is stored in the database. If there is a seemingly unreasonable distance between the location of the first device based on the timestamp of the geolocation payload and the previous location based on its timestamp, then an inaccurate location may have been determined. In such cases, the location may optionally be determined or verified at operation **408**. In some embodiments, the determined location at operation **408** is compared against the determined location at **406**. If determined locations are proximate to one another, then the location may be presumed to be accurate. If however, the locations determined at **406** and **408** are not proximate to one another, then the location may be erroneous. In such cases, in some embodiments, an alternative location lookup may be performed, the database may be updated to remove the association of that location with the particular BSSIDs, the case is logged for further investigation, or a combination thereof.

[0071] In some embodiments, the geolocation payload includes internet protocol (IP) addresses. In some embodiments, historical IP addresses are associated with each location and the second plurality of BSSIDs stored on the database. IP addresses may, in some embodiments, be used to filter requests from previously unknown locations. For example, the IP address may be used as error verification by determining whether the IP address been previously associated with any location. If the IP address of the geographic payload does not match any IP address stored on the database, this may indicate that the first device has not been at such location and obviate any need to search the BSSIDs. In some embodiments, the matching of the IP address of the geolocation payload need not be an exact match to an IP address of the database, but one within a certain IP range. For example, certain internet service providers will not assign a static IP to a particular device, but will dynamically assign one. In such cases, a range of IPs may be assigned at the same location based on subnetting practices. In other embodiments, the IP address of the geolocation payload must be identical to an IP of the previous location. In some embodiments, the IP address from the geolocation payload can be used to determine or improve the confidence of the location of the first device based on the database.

[0072] In some embodiments, the determined location is optionally used to enforce geofencing rules at operation **412**. In some embodiments, the determined location is used to provide geotags for additional data received from the first device. In some embodiments, the determined location is used to deliver location-based services, such as targeted advertisements, navigation services, tracking, search results, to provide data for analysis and research, or a combination thereof.

[0073] Turning now to **FIG. 6**, an alternate embodiment of the method is presented. At **602**, a geolocation payload is received. The geolocation payload includes a timestamp, and, optionally, BSSIDs, GNSS data, OS location data, and IP addresses.

[0074] At **604**, the timestamp is used to perform error checking. For example, if the timestamp is unavailable, has a time that is before a previous entry, or ahead of the receiving device.

[0075] At **606**, the geolocation is payload is inspected to verify whether it includes BSSIDs. If the geolocation payload is determined to include BSSIDs, then the database is searched to determine whether historical locations with those BSSIDs are available in a first time period at 608 (e.g. a recent locations, such as the past 24 hours). At **610**, if historical locations are found in the 1st time period, then the location is verified at **612** to determine whether determined location is within a predetermined radius of the last known location of the device. If the device is within the predetermined radius, then database is updated with the new BSSIDs detected by the device. If the device is not within the predetermined radius, then an alternative location lookup is initiated to verify that the location in the databases is still accurate.

[0076] If, at **610**, no historical locations are found in the 1st time period, then the search is broadened to include historical locations found in a 2nd time period. At **614**, if a usable location is found in the 2nd time period, then the location is verified at **612**. If no usable location is found in the second time period, then the location proceeds to an alternate location lookup at **616**.

[0077] If no BSSIDs are included in the geolocation payload at **606**, an alternate location lookup is performed at **616**.

[0078] After the location is verified at **612**, the database is updated at **618** with the location and times of the new geolocation payload, and optionally the BSSIDs, and IP address.

[0079] A description of an embodiment with several components or features does not imply that any particular component and/or feature is required. On the contrary, a variety of optional components have been described to illustrate the wide variety of possible embodiments of the present invention(s).

[0080] It will be readily apparent that the various methods and algorithms described in this disclosure may be implemented by appropriately programmed computers and/or computing devices. Typically a processor will receive instructions from a memory or like device, and execute those instructions, thereby performing one or more processes defined by those instructions. Further, programs that implement such methods and algorithms may be stored and transmitted using a variety of media (e.g., computer-readable media) in a number of manners. Thus, embodiments are not limited to any specific combination of hardware and software.

[0081] Accordingly, a description of a process likewise describes at least one apparatus for performing the process, and likewise describes at least one computer-readable medium and/or computer-readable memory for performing the process. The apparatus that performs a described process may include components and/or devices (e.g., a processor, input and output devices) appropriate to perform the process. A computer-readable medium may store program elements and/or instructions appropriate to perform a described method.

CLAIMS

1. A method comprising:

   receiving a geolocation payload from a first device having a receiver, the geolocation payload comprising a first plurality of basic service set identifications (BSSID) detected by the first device;

   determining a location of the first device by searching, using the first plurality of BSSIDs, a database including a second plurality of BSSIDs and location data associated with the second plurality of BSSIDs.

2. The method of claim 1 further comprising:

   determining the location using an alternative location lookup if the search does not find location data in the database based on the first plurality of BSSIDs.

3. The method of claim 2, wherein the alternative location lookup is a geolocation API, a location determined using global navigation satellite system (GNSS), or a location of the OS.

4. The method of claim 1, further comprising:

   assembling the first plurality of BSSIDs into received BSSID combinations, each received BSSID combination including a first number of BSSIDs from the first plurality of BSSIDs,

   wherein the second plurality of BSSIDs are stored as stored BSSID combinations, each stored BSSID combination including the first number of BSSIDs from the second plurality of BSSIDs, and

   wherein the determining of the location searches using the received BSSID combinations for matches in the stored BSSID combinations.

5. The method of claim 4, wherein the first number is at least 3.

6. The method of claim 4, wherein the determining of the location of the device searches the database using the received BSSID combinations until at least one received BSSID combination is found.

7. The method of claim 4, wherein the geolocation payload includes a signal strength for each of the first plurality of BSSIDs, and the searching using the received BSSID combinations are based on the signal strengths.

8. The method of claim 1, wherein the determining the location of the device searches the second plurality of BSSIDs from a first time period.

9. The method of claim 1, wherein the geolocation payload further comprises a received internet protocol (IP) address of the device, wherein the database includes stored device IP addresses associated with the location data, and wherein the determining of the location of the device uses the received IP address.

10. The method of claim 9, wherein the determining of the location of the devices compares the received IP address to determine if it is within range of the stored device IP addresses.

11. The method of claim 1, wherein the location data stored in the database comprises previously stored location data of the first device, a second device, or a combination thereof.

12. The method of claim 1, wherein the location data stored in the database comprises previously stored location data of a second device.

13. The method of claim 1, wherein the location data stored in the database comprises previously stored location data of a second device.

14. The method of claim 1, further comprising enforcing device rules based on the determined location of the device.

15. The method of claim 1, further comprising updating the database with the determined location, the first plurality of BSSIDs and a timestamp of the geolocation payload.

16. The method of claim 1, further comprising verifying the determined location against a previous location of the first device.

17. A system for determining a location of a first device comprising:

a first device comprising a receiver for detecting a first plurality of BSSIDs, a processor for assembling a geolocation payload comprising the detected BSSIDs, and a transmitter for transmitting the geolocation payload;
a database comprising a second plurality of BSSIDs and locations associated therewith; and
a second device comprising a receiver and computer readable medium having instructions stored thereon that when executed, causes the second device to:

receive a geolocation payload from a first device having a receiver, the geolocation payload comprising a first plurality of basic service set identifications (BSSID) detected by the first device; and

determine a location of the first device by searching, using the first plurality of BSSIDs, a database including a second plurality of BSSIDs and location data associated the second plurality of BSSIDs.

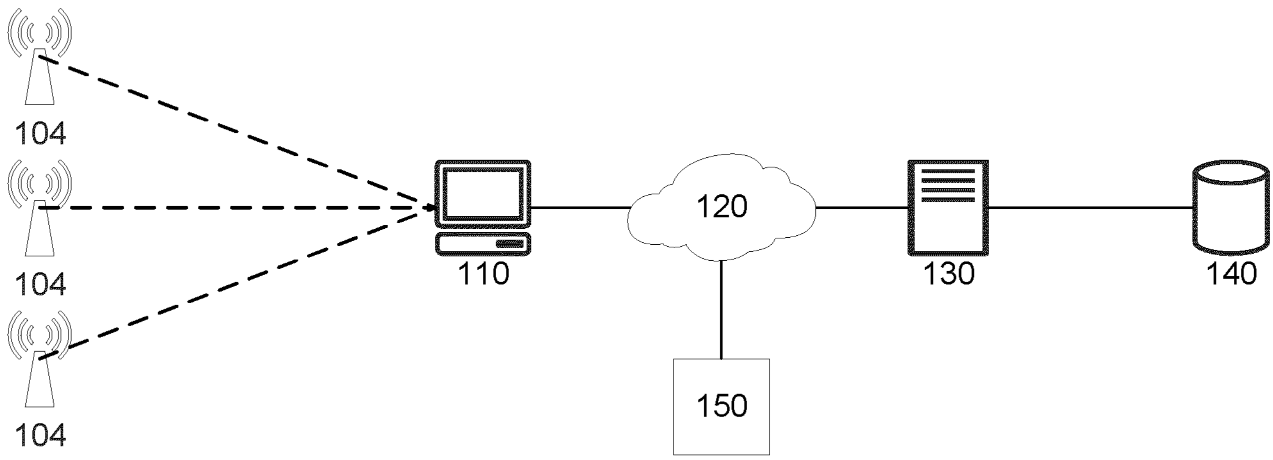

104
104
104
110
120
130
140
150

FIG. 1

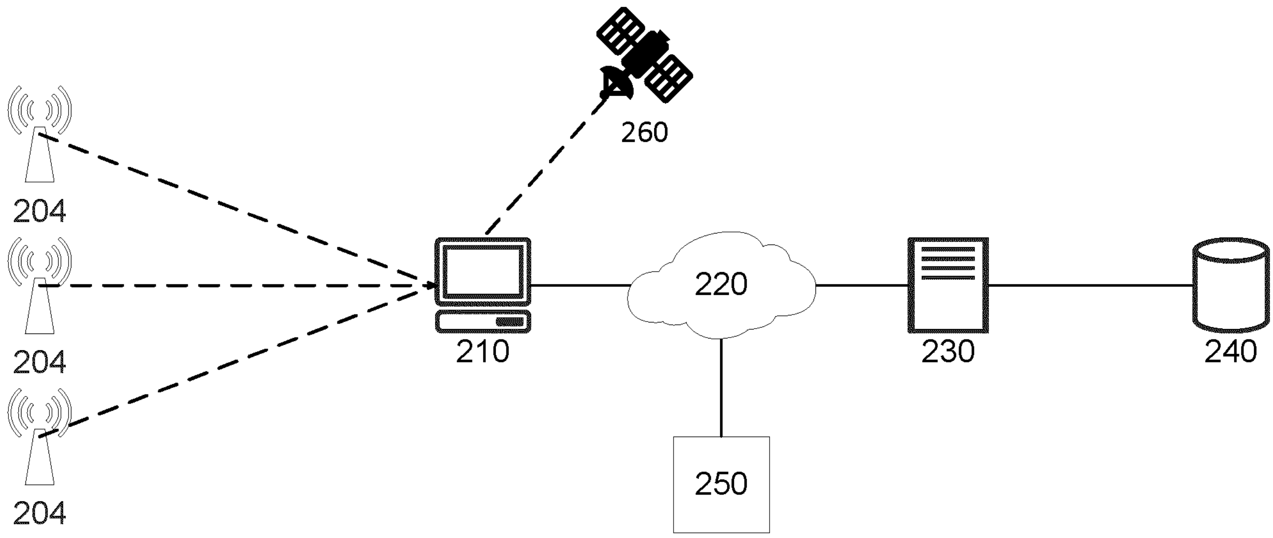

260
204
204
204
210
220
230
240
250

FIG. 2

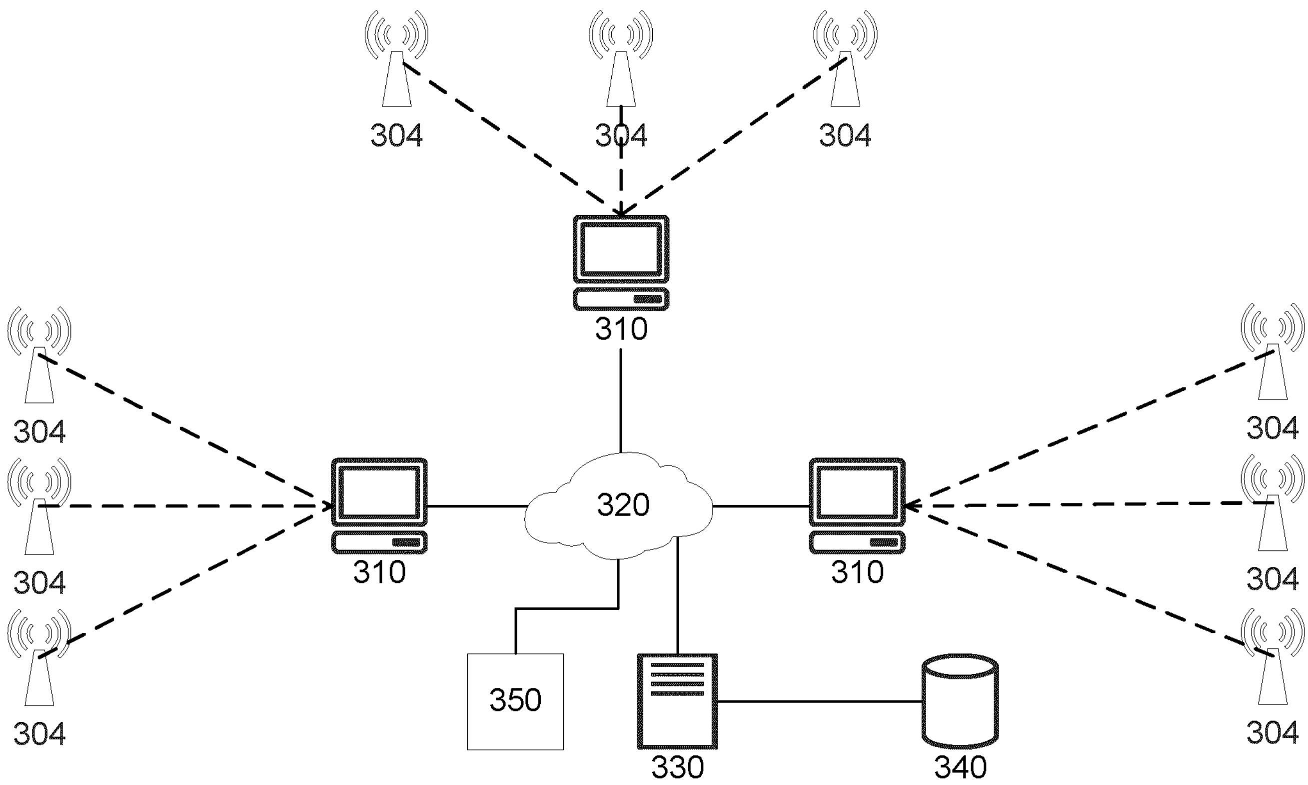


FIG. 3

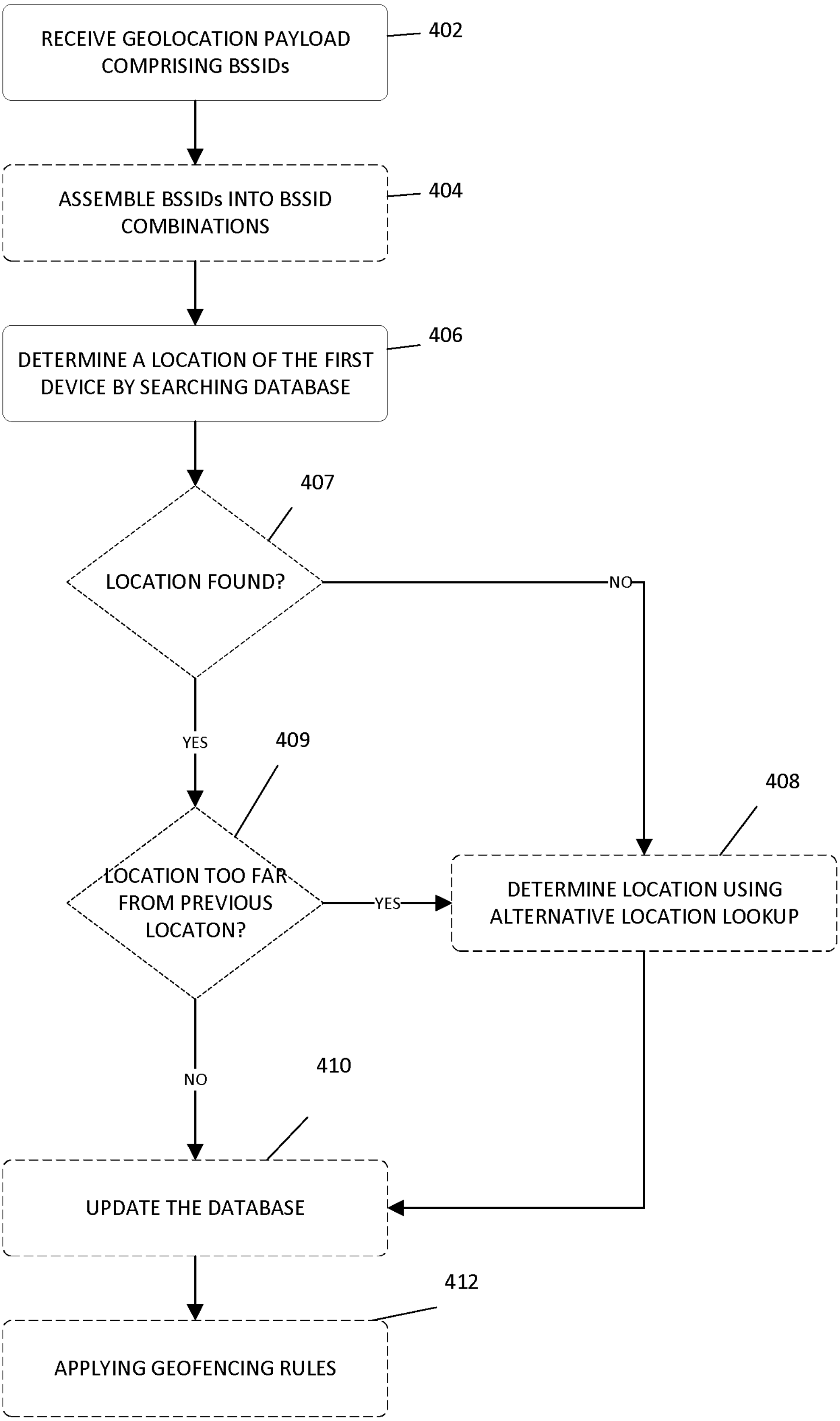
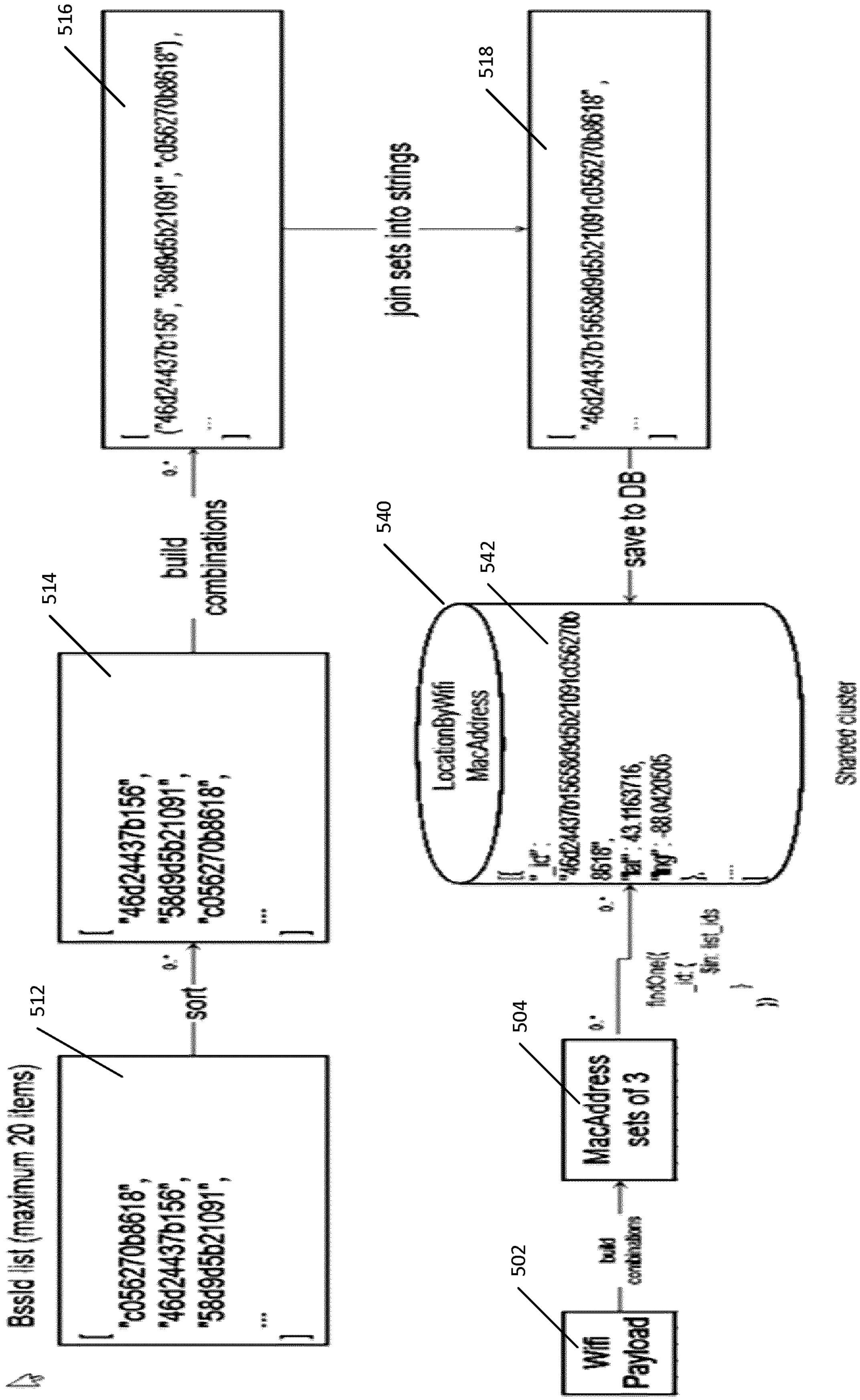

RECEIVE GEOLOCATION PAYLOAD COMPRISING BSSIDs
402
ASSEMBLE BSSIDs INTO BSSID COMBINATIONS
404
DETERMINE A LOCATION OF THE FIRST DEVICE BY SEARCHING DATABASE
406
407
LOCATION FOUND?
NO
YES
409
408
LOCATION TOO FAR FROM PREVIOUS LOCATON?
YES
DETERMINE LOCATION USING ALTERNATIVE LOCATION LOOKUP
NO
410
UPDATE THE DATABASE
412
APPLYING GEOFENCING RULES

FIG. 4



Bssid list (maximum 20 items)
512
"c056270b8618",
"46d24437b156",
"58d9d5b21091",
...
sort
514
"46d24437b156",
"58d9d5b21091",
"c056270b8618",
build combinations
516
("46d24437b156", "58d9d5b21091", "c056270b8618"),
join sets into strings
518
"46d24437b15658d9d5b21091c056270b8618",
save to DB
540
542
LocationByWifi MacAddress
Sharded cluster
502
Wifi Payload
build combinations
504
MacAddress sets of 3

FIG. 5

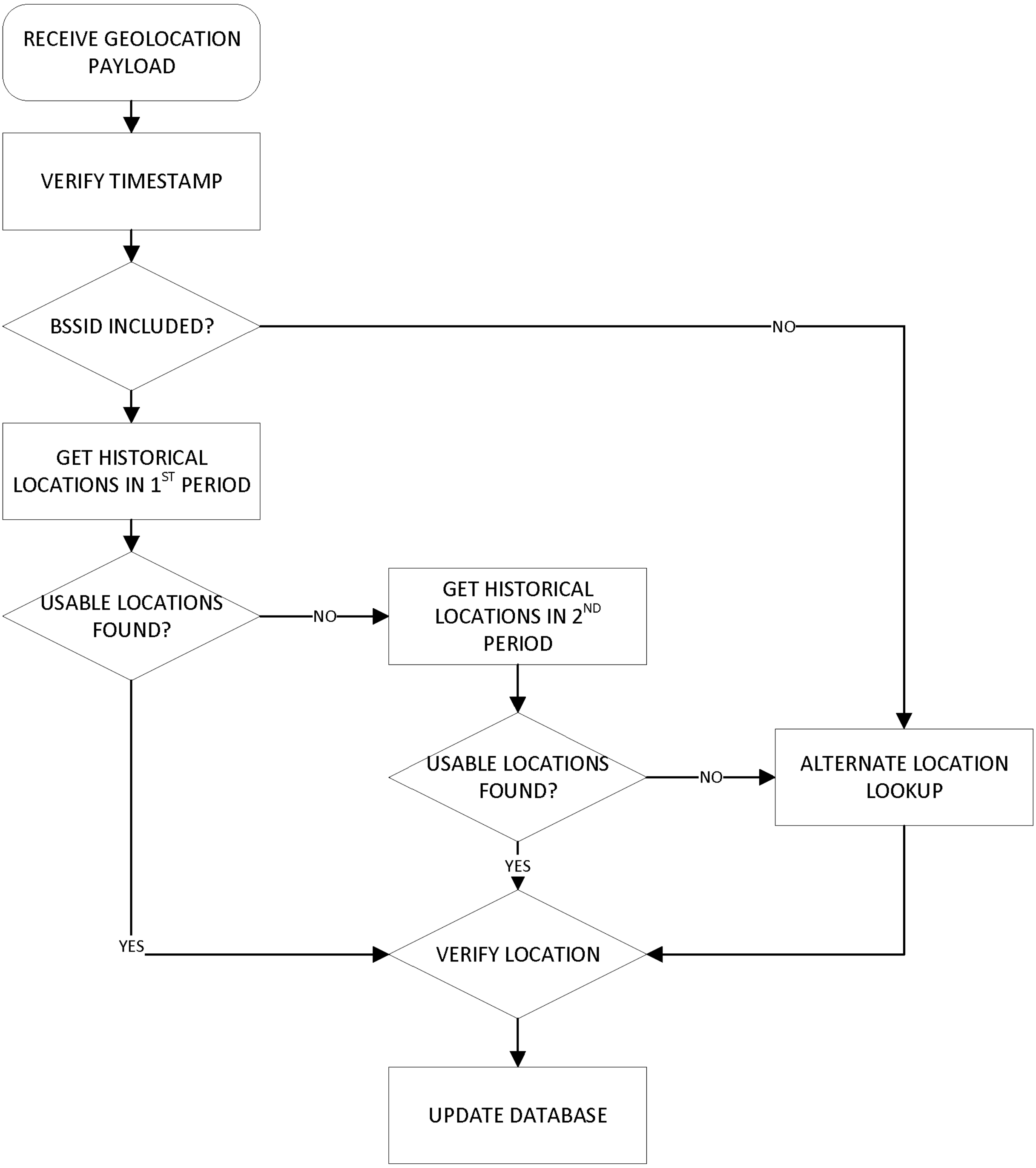

RECEIVE GEOLOCATION PAYLOAD
VERIFY TIMESTAMP
BSSID INCLUDED?
NO
GET HISTORICAL LOCATIONS IN 1ST PERIOD
USABLE LOCATIONS FOUND?
NO
GET HISTORICAL LOCATIONS IN 2ND PERIOD
USABLE LOCATIONS FOUND?
NO
ALTERNATE LOCATION LOOKUP
YES
YES
VERIFY LOCATION
UPDATE DATABASE

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2024/050025

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***G01S 5/00*** (2006.01) , ***G06F 16/29*** (2019.01) , ***H04W 64/00*** (2009.01)

CPC: **G01S 5/0036** (2020.01) , G06F 16/29 (2020.01) , H04W 64/003 (2020.01) , G01S 2205/00 (2020.05)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: G01S 5/00 (2006.01) , G06F 16/29 (2019.01) , H04W 64/00 (2009.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Databases: Canadian Patent Database, Questel Orbit

Keywords: BSSID, location, database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US7245900B1 (LAMB RC et al.) 17 July 2007 (17-07-2007) * claims 1, 17; column 1, line 46 - column 2, line 26; column 4, lines 33-63; column 7, lines 41-57; column 9, lines 22-41*	1-3, 8-17
Y	WO2017214979A1 (TAO Q et al.) 21 December 2017 (21-12-2017) *paragraphs 0010-0017, 0068-0071, 0079-0081*	1-3, 8-17
Y	US2020019580A1 (KIM J et al.) 16 January 2020 (16-01-2020) * claims 1, 12; paragraphs 0007-0010, 0060, 0064, 0092-0095, 0107-0112, 0142-0150*	1-3, 8-17

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

☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D"	document cited by the applicant in the international application	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2024 (21-02-2024)	17 April 2024 (17-04-2024)

Name and mailing address of the ISA/CA
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Gatineau, Quebec K1A 0C9
Facsimile No.: 819-953-2476

Authorized officer

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2024/050025

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US7245900B1	17 July 2007 (17-07-2007)	None	
WO2017214979A1	21 December 2017 (21-12-2017)	CN107771408A	06 March 2018 (06-03-2018)
		CN107771408B	21 February 2020 (21-02-2020)
US2020019580A1	16 January 2020 (16-01-2020)	US11086952B2	10 August 2021 (10-08-2021)
		CN112400346A	23 February 2021 (23-02-2021)
		EP3799699A1	07 April 2021 (07-04-2021)
		EP3799699A4	07 July 2021 (07-07-2021)
		KR20200007607A	22 January 2020 (22-01-2020)
		KR102537840B1	31 May 2023 (31-05-2023)
		WO2020013607A1	16 January 2020 (16-01-2020)