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(54) **TEMPORAL TRANSFORMATION OF LOCATION-BASED QUERIES**

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(51) **Int. Cl.**

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G06F 16/9038	(2019.01)
G06F 16/9535	(2019.01)

(52) **U.S. Cl.**
CPC ***G06F 16/9535*** (2019.01); ***G06F 16/29*** (2019.01); ***G06F 16/9038*** (2019.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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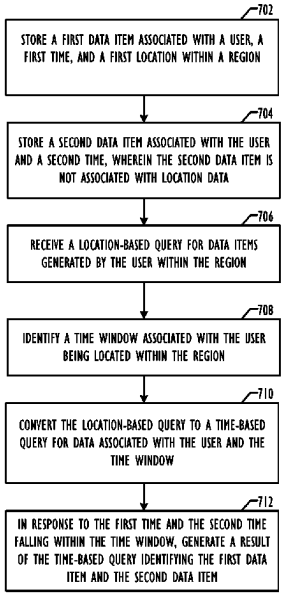
(57) **ABSTRACT**

A system and method for transforming location-based data queries into temporal domain by leveraging a location-to-time knowledge conversion graph. In some systems which contain diverse sets of data objects, only certain objects may contain explicit location data, while others may not. Therefore, queriability of this diverse data by location properties would likely yield incomplete results. In some embodiments, this method allows for the transformation and augmentation of a given data query containing location-based filtering properties into a time-region-based lookup, wherein a given location has been assigned to a time region in the given data graph and all data events within that time region may be augmented with location metadata automatically in the knowledge graph. Over time, a system utilizing these embodiments can offer comprehensive location-based data services and insights with a diverse set of data objects that exists and not all objects contain explicit location information.

17 Claims, 8 Drawing Sheets



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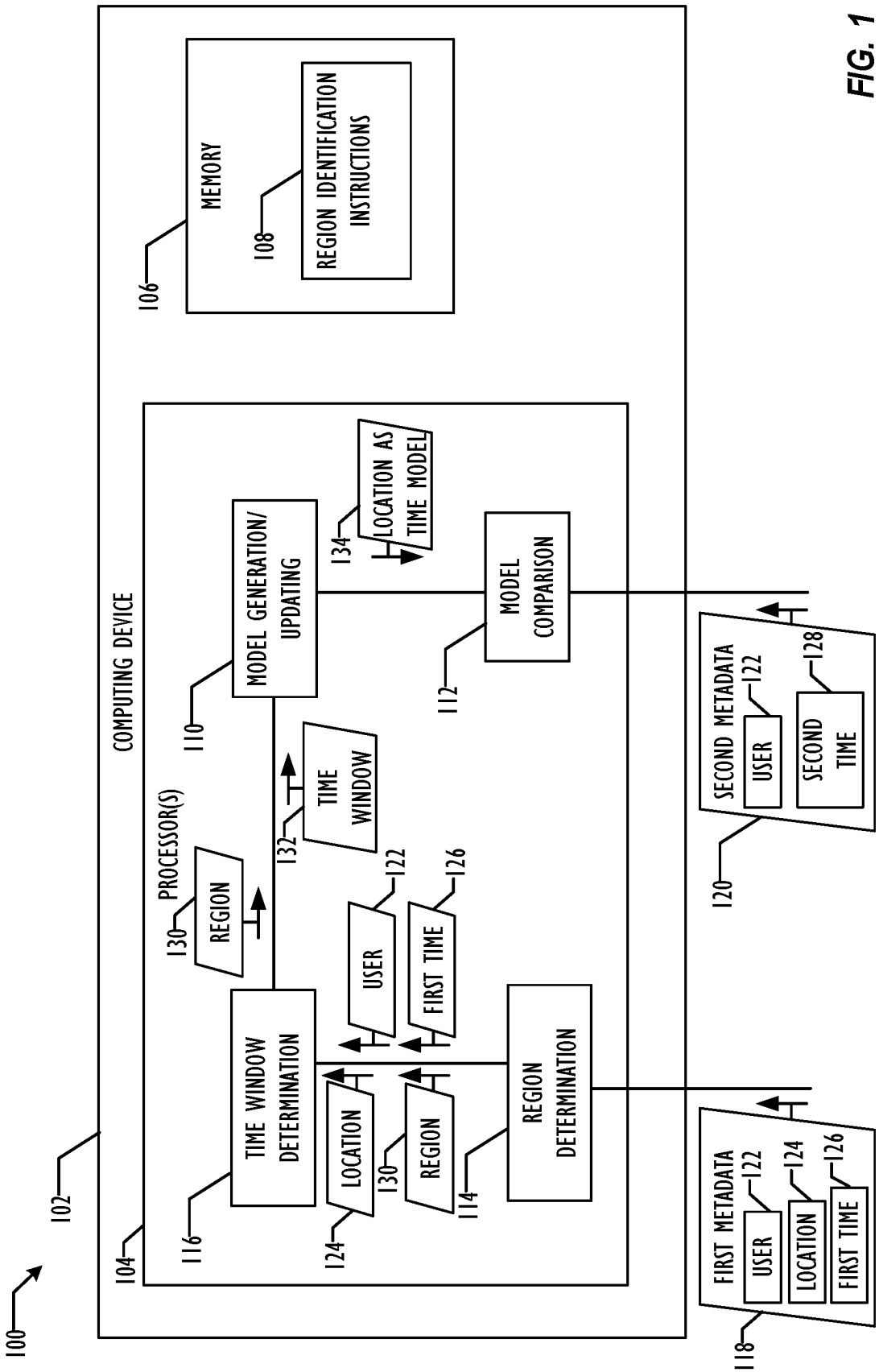
100
102
COMPUTING DEVICE
104
PROCESSOR(S)
106
MEMORY
108
REGION IDENTIFICATION INSTRUCTIONS
110
MODEL GENERATION/ UPDATING
112
MODEL COMPARISON
114
REGION DETERMINATION
116
TIME WINDOW DETERMINATION
118
FIRST METADATA
120
SECOND METADATA
122
USER
124
LOCATION
126
FIRST TIME
128
SECOND TIME
130
REGION
132
TIME WINDOW
134
LOCATION AS TIME MODEL

FIG. 1

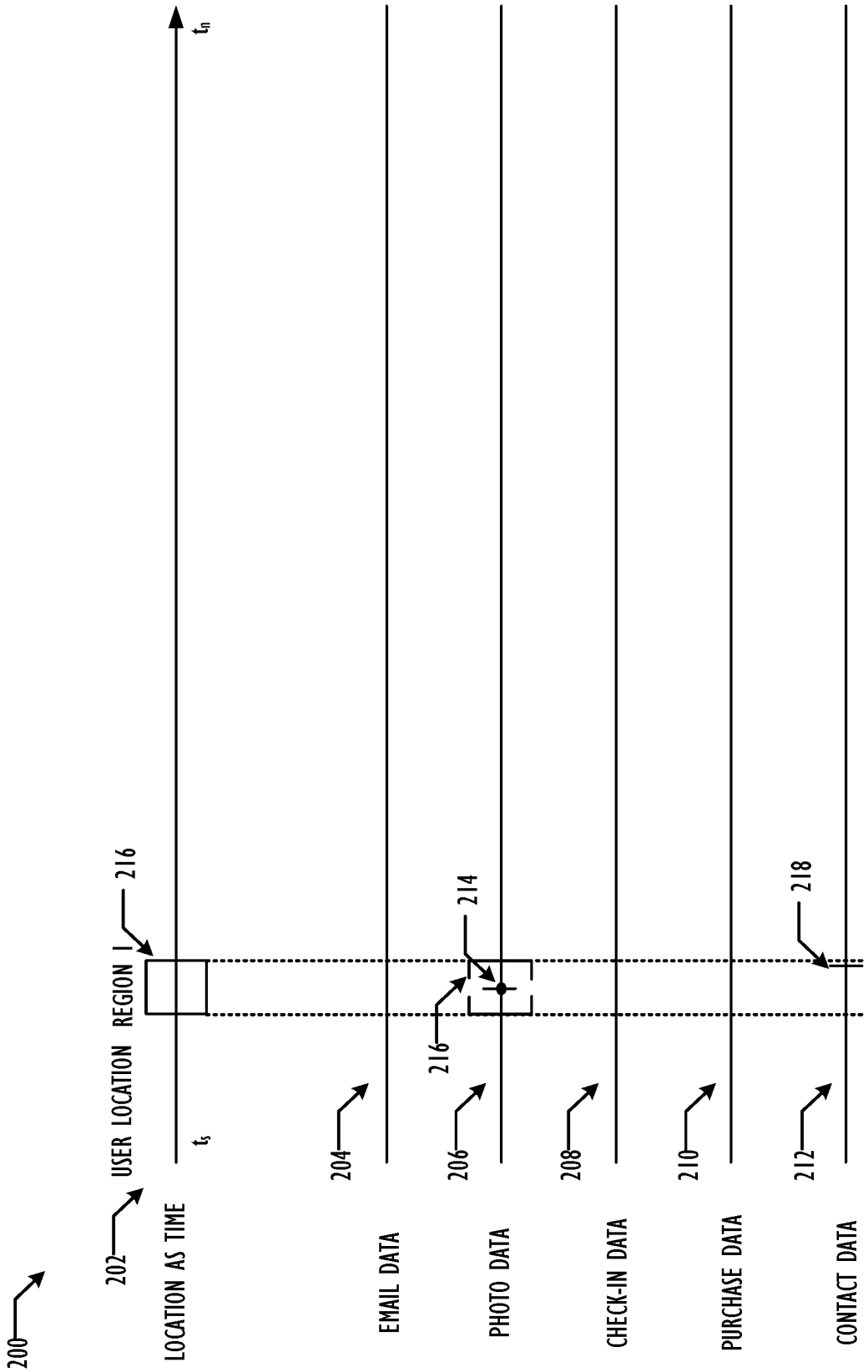
200
202
LOCATION AS TIME
USER LOCATION REGION
216
t_s
t_n
204
EMAIL DATA
206
PHOTO DATA
214
216
208
CHECK-IN DATA
210
PURCHASE DATA
212
CONTACT DATA
218

FIG. 2

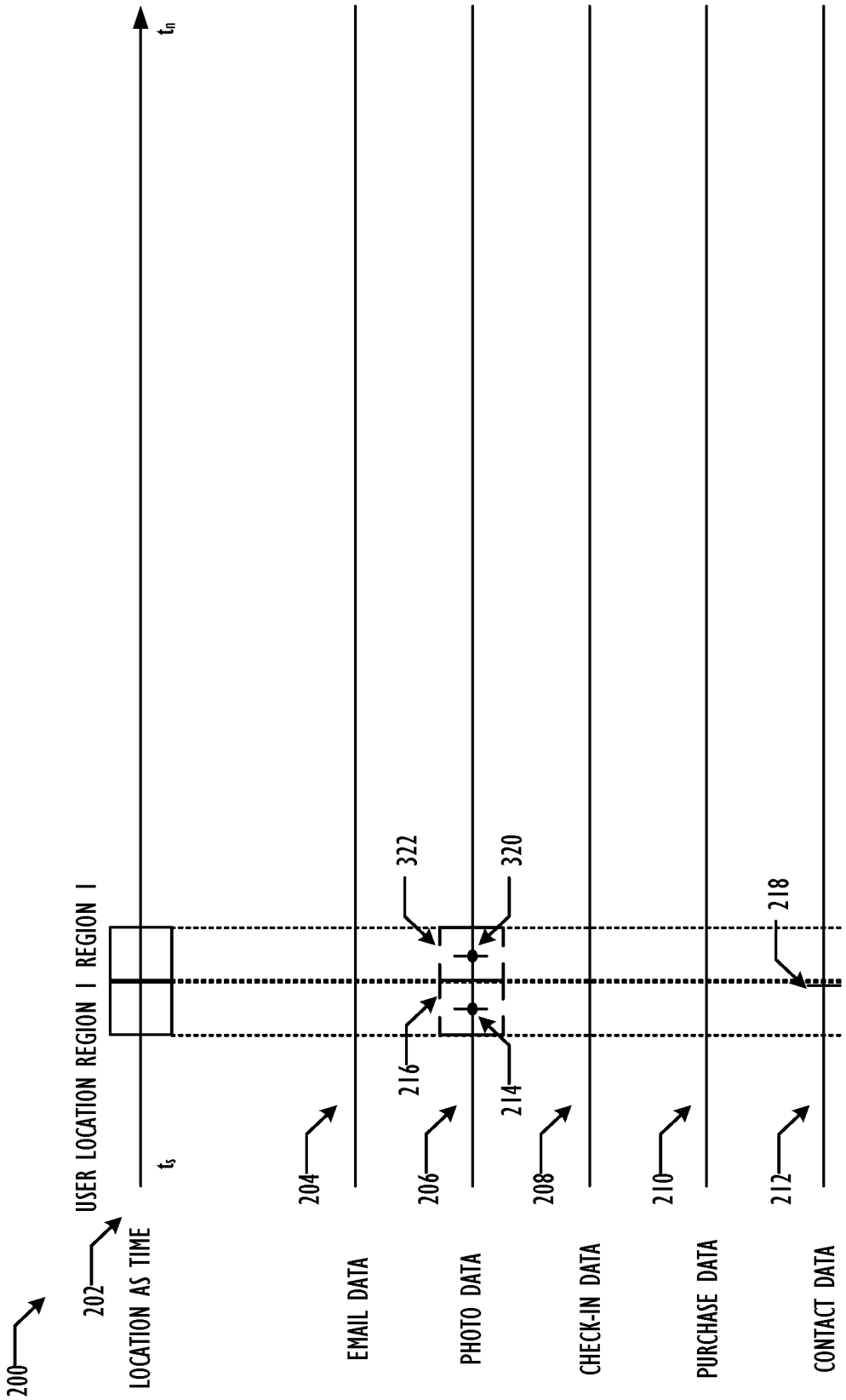
200
202
LOCATION AS TIME
USER LOCATION REGION 1 REGION 1
t_s
t_n
204
EMAIL DATA
206
PHOTO DATA
208
CHECK-IN DATA
210
PURCHASE DATA
212
CONTACT DATA
214
216
320
322
218

FIG. 3

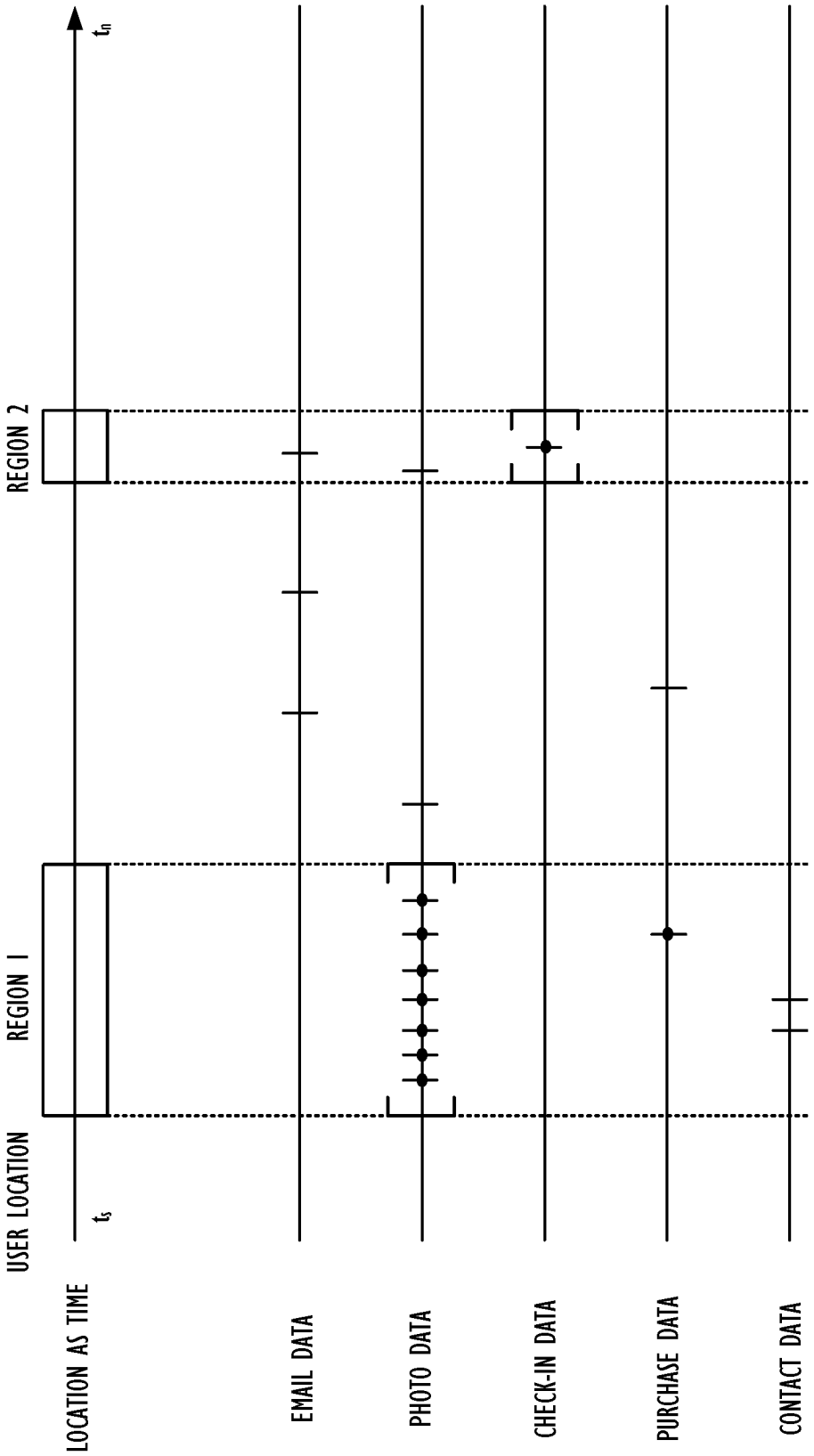
t_n
REGION 2
REGION 1
USER LOCATION
t_s
LOCATION AS TIME
EMAIL DATA
PHOTO DATA
CHECK-IN DATA
PURCHASE DATA
CONTACT DATA

FIG. 4

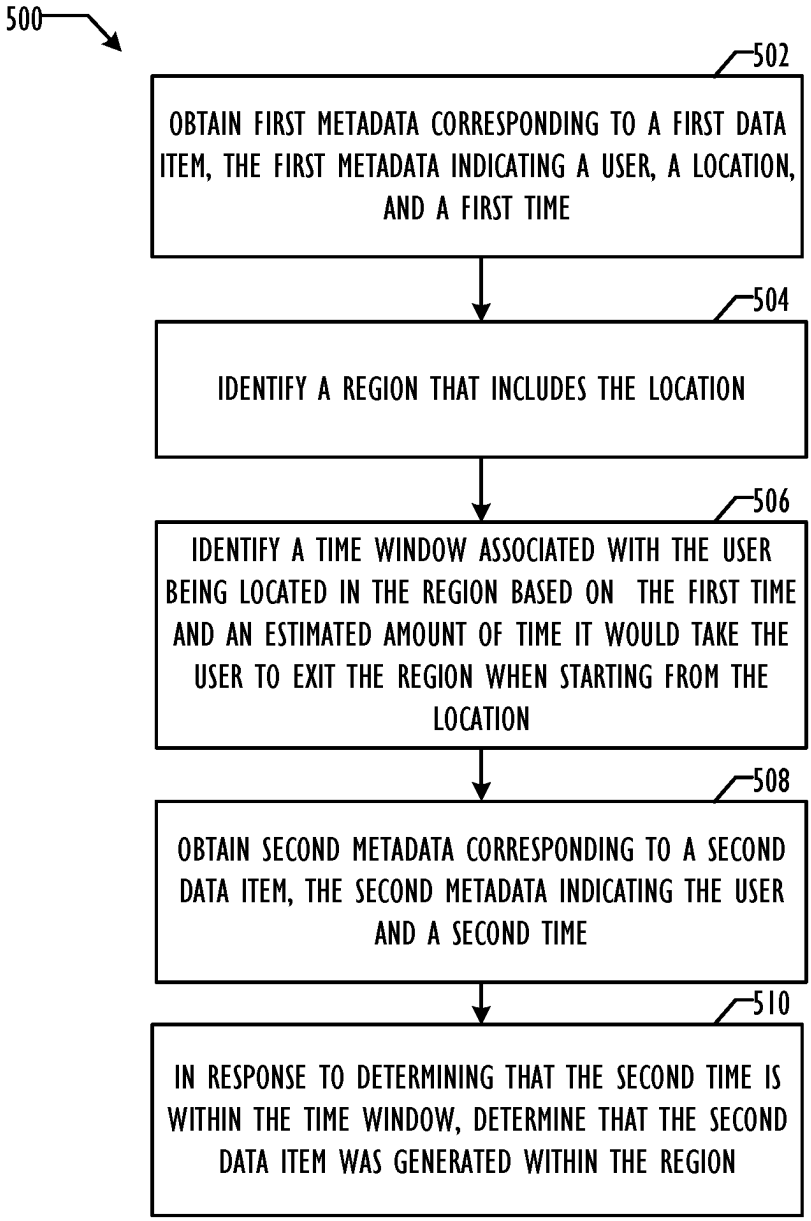
500
502
OBTAIN FIRST METADATA CORRESPONDING TO A FIRST DATA ITEM, THE FIRST METADATA INDICATING A USER, A LOCATION, AND A FIRST TIME
504
IDENTIFY A REGION THAT INCLUDES THE LOCATION
506
IDENTIFY A TIME WINDOW ASSOCIATED WITH THE USER BEING LOCATED IN THE REGION BASED ON THE FIRST TIME AND AN ESTIMATED AMOUNT OF TIME IT WOULD TAKE THE USER TO EXIT THE REGION WHEN STARTING FROM THE LOCATION
508
OBTAIN SECOND METADATA CORRESPONDING TO A SECOND DATA ITEM, THE SECOND METADATA INDICATING THE USER AND A SECOND TIME
510
IN RESPONSE TO DETERMINING THAT THE SECOND TIME IS WITHIN THE TIME WINDOW, DETERMINE THAT THE SECOND DATA ITEM WAS GENERATED WITHIN THE REGION

FIG. 5

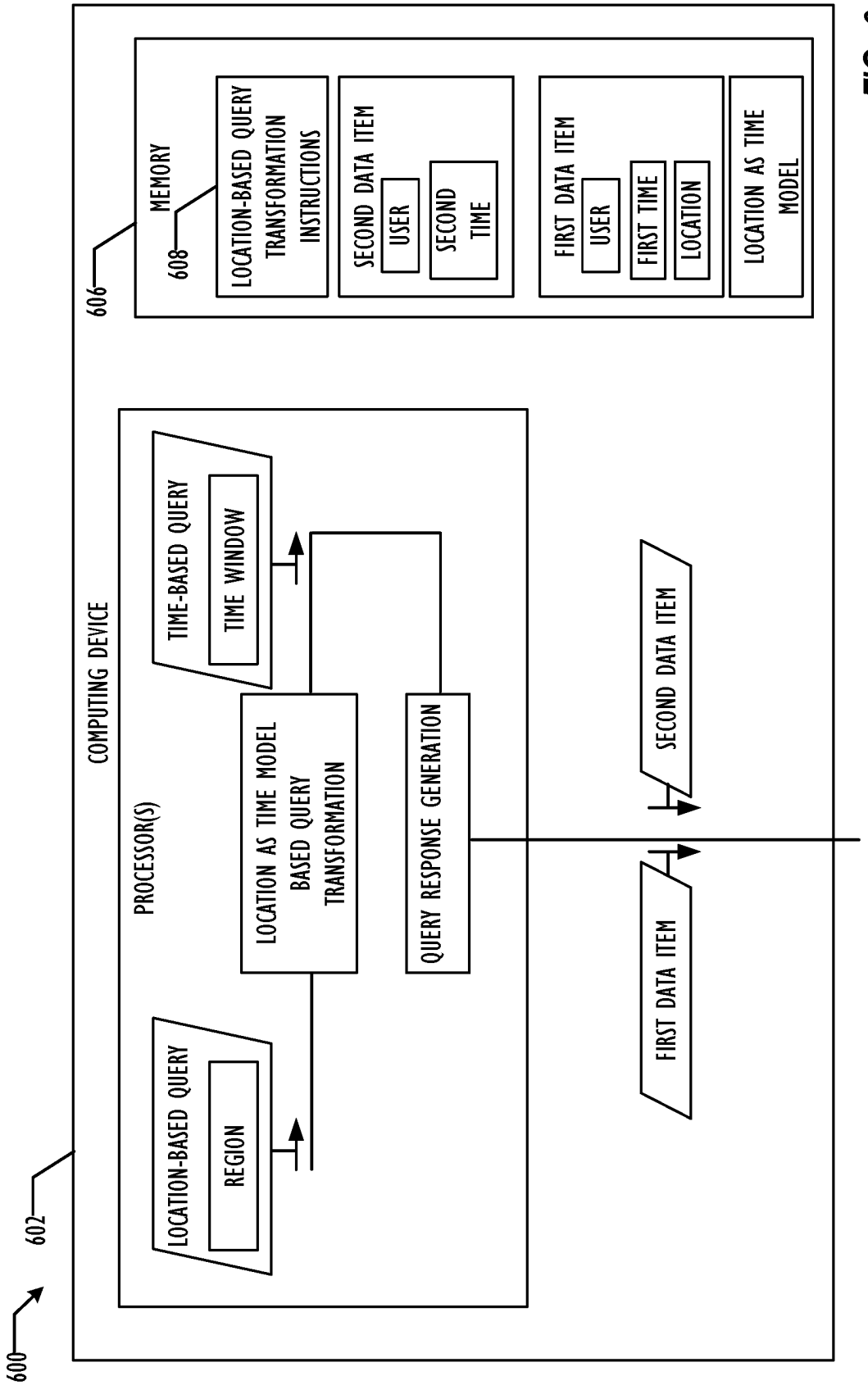
600
602
COMPUTING DEVICE
PROCESSOR(S)
LOCATION-BASED QUERY
REGION
TIME-BASED QUERY
TIME WINDOW
LOCATION AS TIME MODEL BASED QUERY TRANSFORMATION
QUERY RESPONSE GENERATION
FIRST DATA ITEM
SECOND DATA ITEM
606
MEMORY
608
LOCATION-BASED QUERY TRANSFORMATION INSTRUCTIONS
SECOND DATA ITEM
USER
SECOND TIME
FIRST DATA ITEM
USER
FIRST TIME
LOCATION
LOCATION AS TIME MODEL

FIG. 6

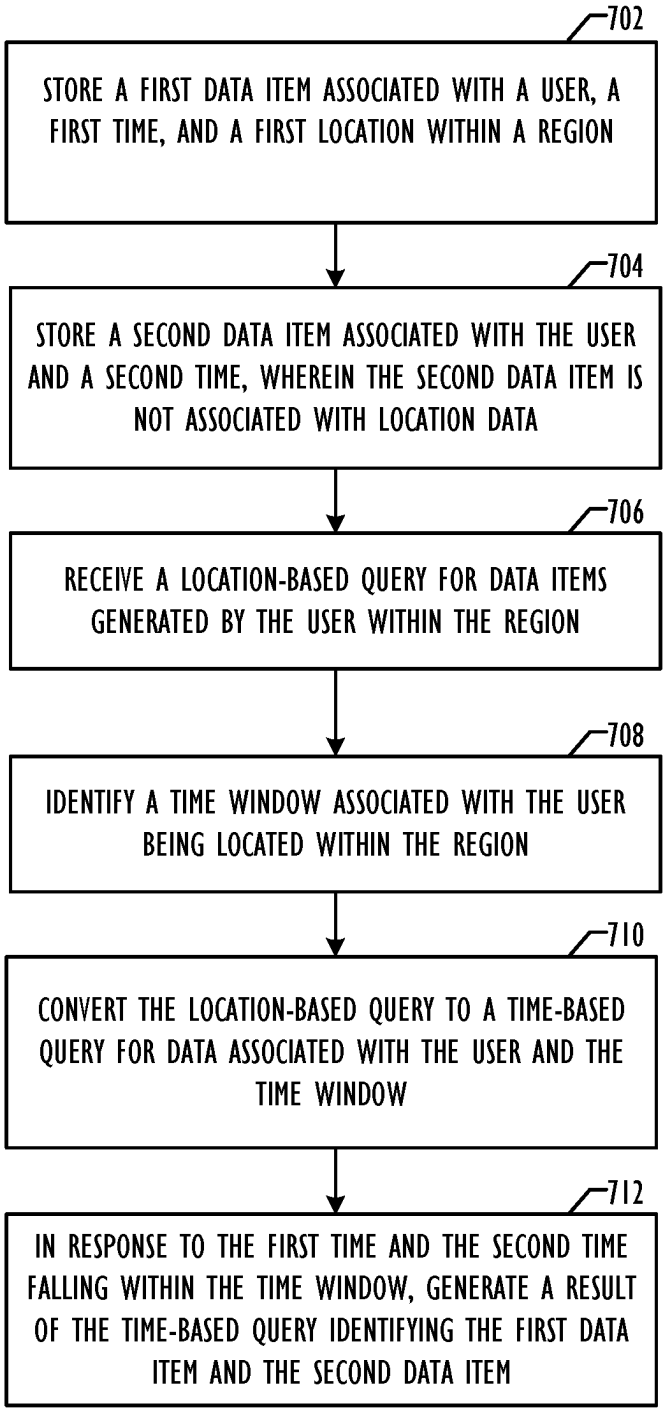
702
STORE A FIRST DATA ITEM ASSOCIATED WITH A USER, A FIRST TIME, AND A FIRST LOCATION WITHIN A REGION
704
STORE A SECOND DATA ITEM ASSOCIATED WITH THE USER AND A SECOND TIME, WHEREIN THE SECOND DATA ITEM IS NOT ASSOCIATED WITH LOCATION DATA
706
RECEIVE A LOCATION-BASED QUERY FOR DATA ITEMS GENERATED BY THE USER WITHIN THE REGION
708
IDENTIFY A TIME WINDOW ASSOCIATED WITH THE USER BEING LOCATED WITHIN THE REGION
710
CONVERT THE LOCATION-BASED QUERY TO A TIME-BASED QUERY FOR DATA ASSOCIATED WITH THE USER AND THE TIME WINDOW
712
IN RESPONSE TO THE FIRST TIME AND THE SECOND TIME FALLING WITHIN THE TIME WINDOW, GENERATE A RESULT OF THE TIME-BASED QUERY IDENTIFYING THE FIRST DATA ITEM AND THE SECOND DATA ITEM

FIG. 7

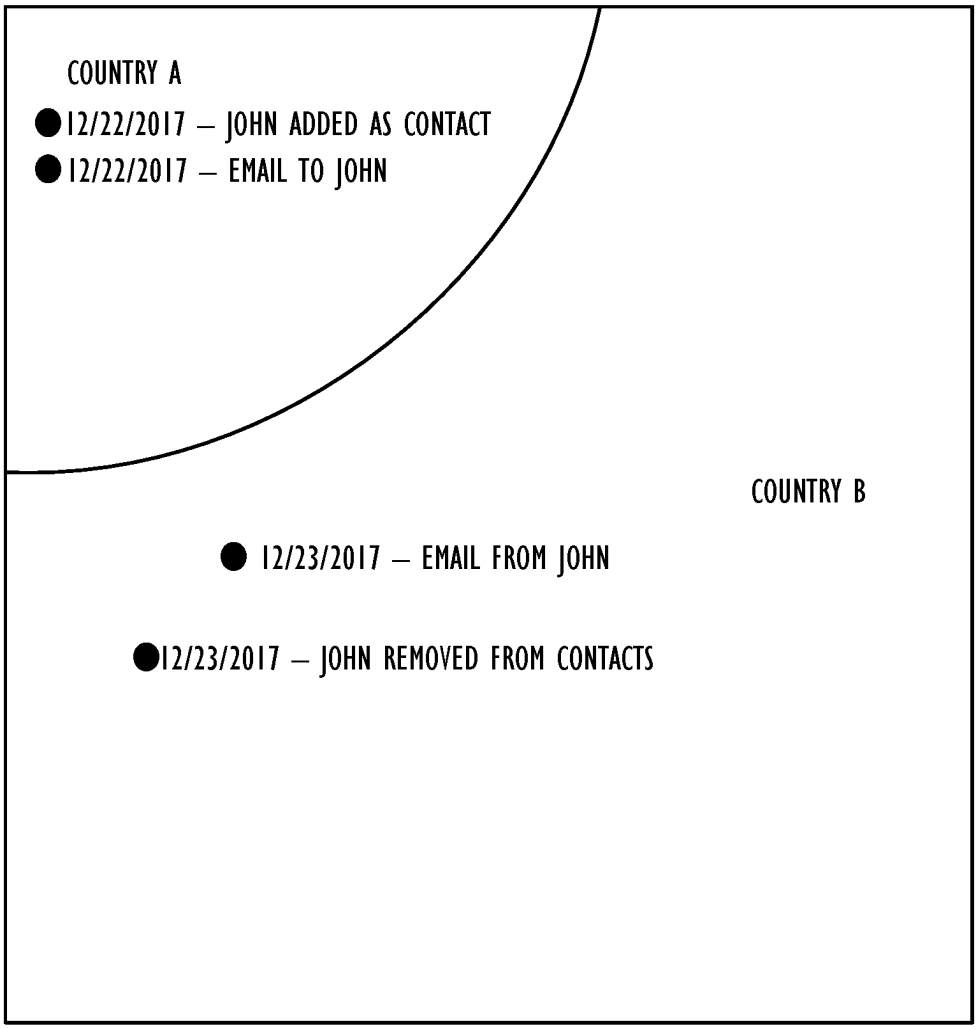
COUNTRY A
12/22/2017 – JOHN ADDED AS CONTACT
12/22/2017 – EMAIL TO JOHN
COUNTRY B
12/23/2017 – EMAIL FROM JOHN
12/23/2017 – JOHN REMOVED FROM CONTACTS

FIG. 8

TEMPORAL TRANSFORMATION OF LOCATION-BASED QUERIES

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 16/889,587, filed Jun. 1, 2020, which is a continuation of U.S. application Ser. No. 15/858,749, filed Dec. 29, 2017, all of which are incorporated herein in their entirety by reference.

TECHNICAL FIELD

This disclosure relates generally to converting a location-based query to a time-based query.

BACKGROUND

Many data items are generated with location information embedded as metadata. For example, an image file may include global positioning system (GPS) data indicating where the image file was created. Location data associated with data items may be used for a variety of purposes. For example, an individual may query a system that tracks data items to determine which data items the individual generated while on a trip to Europe. However, some data items may not be associated with location data. Such data items may not be considered by systems and applications that operate on such data based on location, therein reducing the scope or efficacy of location-based queries with regard to retrieval of diverse data in a given system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating a system for determining a region in which data was generated.

FIG. **2** is a first diagram illustrating generation of a location as time model.

FIG. **3** is a second diagram illustrating generation of the location as time model.

FIG. **4** is a diagram illustrating an updated version of the location as time model.

FIG. **5** is a flowchart illustrating a method of determining a region in which data was generated.

FIG. **6** is a block diagram illustrating a system for converting a location-based query to a time-based query.

FIG. **7** is a flowchart illustrating a method for converting a location-based query to a time-based query.

FIG. **8** is a diagram illustrating results of a time-based query displayed on a map.

DETAILED DESCRIPTION

In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the invention. It will be apparent, however, to one skilled in the art that the invention may be practiced without these specific details. In other instances, structure and devices are shown in block diagram form in order to avoid obscuring the invention. References to numbers without subscripts or suffixes are understood to reference all instance of subscripts and suffixes corresponding to the referenced number. Moreover, the language used in this disclosure has been principally selected for readability and instructional purposes, and may not have been selected to delineate or circumscribe the inventive subject matter, resort

to the claims being necessary to determine such inventive subject matter. Reference in the specification to "one embodiment" or to "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiments is included in at least one embodiment of the invention, and multiple references to "one embodiment" or "an embodiment" should not be understood as necessarily all referring to the same embodiment.

As used herein, the term "programmable device" can refer to a single programmable device or a plurality of programmable devices working together to perform the function described as being performed on or by the programmable device.

As used herein, the term "medium" refers to a single physical medium or a plurality of media that together store what is described as being stored on the medium.

The terms "a," "an," and "the" are not intended to refer to a singular entity unless explicitly so defined, but include the general class of which a specific example may be used for illustration. The use of the terms "a" or "an" may therefore mean any number that is at least one, including "one," "one or more," "at least one," and "one or more than one." The term "or" means any of the alternatives and any combination of the alternatives, including all of the alternatives, unless the alternatives are explicitly indicated as mutually exclusive. The phrase "at least one of" when combined with a list of items, means a single item from the list or any combination of items in the list. The phrase does not require all of the listed items unless explicitly so defined.

As used herein, the term "user device" can refer to any programmable device that is capable of communicating with another programmable device across any type of network.

As data items are generated by computing devices, some data items are tagged with location information. For example, an image file may include metadata indicating a location at which a camera device generated the image file. However, some data items do not include such location metadata. For example, a camera device may generate an image file that lacks location metadata because the camera device does not include a location sensor, because a location services option of the camera device is disabled, or for a variety of other reasons. In another example, a data item may not include location metadata because a file type of the data item may not support or may not be commonly associated with location data. Accordingly, common tools for editing the file type of the data item may not have the ability to tag the data item with location metadata. In one or more embodiments, a technique is provided which allows for identifying a region (e.g., a country, a state/province, a city, a neighborhood, etc.) associated with generation of a data item absent an explicit indication of the region. In addition to image files, data items may include electronic mail (E-mail) data, contact data, social media check-in data, purchase data, or any other type of data or metadata.

In a particular example, a system or method generates a data structure (e.g., a timeline) associated with a user based on data items associated with the user that do include location information. For example, the system or method may generate a timeline indicating that the user was in Region 1 at Time 1 based on location metadata associated with an E-mail (such as an IP address lookup) generated by a device or account associated with the user. The system or method may further update the timeline to indicate that the user was in Region 2 at Time 2 based on location metadata associated with an image file generated by a device or account associated with the user. Using the data structure, the system or method may determine region information

associated with a data item that lacks location information. To illustrate, the system or method may determine that a contact was added to an account associated with the user while the user was in Region 1 by comparing time information (e.g., a timestamp) associated with the contact to the timeline associated with the user. Accordingly, the system or method enables identification of region information associated with a data item that is not associated with location metadata.

In some examples, a system or method may support transformation of queries for data items from a location domain into a time domain. For example, the system or method may receive a location-based query for data items generated by a user while the user was in Location 1. Using the timeline described above, the system or method may transform the location-based query into a time-based query for data items generated by the user between Time 1 and Time 3. Accordingly, the system or method enables searching for data items that were generated in a region even in cases where one or more of the data items generated in the region are not tagged with location metadata. The time domain query may be resolved locally or transmitted to another device or service for resolution. To illustrate, location domain to time domain query transformation may be provided by one system/device to another system/device as a service.

Referring now to FIG. **1**, a block diagram illustrating a system **100** for determining a region in which data was generated, according to one or more embodiments, is presented. FIG. **1** includes a computing device **102**. The computing device **102** may correspond to a server device or to any other type of computing device. According to some embodiments, the computing device **102** may be responsible for storing, indexing, managing, searching, relating, and/or retrieving content (including communications messages and data files of all types) for various users of a communication system. The computing device **102** includes one or more processors **104** and a memory **106**. The processor(s) **104** may include a central processor unit (CPU), a digital signal processor (DSP), a graphics processing unit (GPU), some other type of processor, or a combination thereof. The memory **106** includes a hard disk drive, a flash drive, random access memory, any other type of computer readable storage device, or a combination thereof. As used herein, a computer readable storage device refers to a machine, manufacture, or composition of matter. A computer readable storage device is not a signal. The memory **106** may store data and executable code. In the illustrated example, the memory **106** stores region identification instructions **108**. The region identification instructions **108** may be executable by the processor(s) **104** to perform any of the operations or methods described herein.

The processor(s) **104** include a region determination module **114**, a time window determination module **116**, a model generation/updating module **110**, and a model comparison module **112**. The region determination module **114** is configured to determine a region associated with a data item based on location data (e.g., location metadata) included in metadata associated with the data item. The time window determination module **116** is configured to determine a time window associated with a user being in the region based on time data (e.g., a timestamp) included in the data item and an estimated amount of time it would take the user to exit the region. The model generation/updating module **110** is configured to generate or update a model (e.g., a timeline) that indicates regions associated with the user over time-based on the time window. The model comparison module **112** is configured to compare time data of a data item that does not include location information (e.g., location metadata) to the model to determine a region in which the data item was generated. Each of the modules **110-116** may correspond to software executed by the processor(s) **104** responsive to the region identification instructions **108**, dedicated hardware of the processor(s) **104**, or a combination thereof. While illustrated as distinct modules, functionality of one or more of the modules **110-116** may be combined. Further, functionality of one or more of the modules **110-116** may be separated into multiple distinct modules.

In the illustrated example of FIG. **1**, the computing device **102** receives first metadata **118** associated with a first data item. The first metadata **118** includes data indicating a user **122**, a location **124**, and a first time **126**. The computing device **102** may or may not receive the first data item. The computing device **102** may store the first metadata **118** (e.g., in the memory **106**).

The data indicating the user **122** may correspond to a globally unique user identifier, a user name, an account name, another type of identifier or a combination thereof. In some implementations, the data indicating the user **122** may indicate an account or device rather than an individual. The data indicating the location **124** may correspond to global positioning system (GPS) data generated by a GPS sensor, an access point (e.g., cellular tower) identifier, to semantic content-based location identifier, to an internet protocol (IP) address, to some other type of location data, or a combination thereof. A semantic content-based location identifier is a location identifier derived from semantic content of a data item. The data indicating the first time **126** may correspond to a timestamp. In a particular example, the first metadata **118** corresponds to an image file and indicates that the image file was generated by User 1 at Location 1 at Time 1.

While FIG. **1** illustrates the computing device **102** receiving the first metadata **118**, in some examples, the computing device **102** generates the first metadata **118** or a portion thereof based on the first data item or other associated metadata. For example, the computing device **102** may generate the data indicating the user **122** based on metadata identifying a particular device or account and a mapping of the particular device or account to the user **122**. To illustrate, the computing device **102** may generate data indicating User 1 generated an image file in response to metadata of the image file indicating that a camera of User 1 generated the image file. As another example of metadata generation, the computing device **102** may generate the data indicating the location **124** based on semantic content of the data item. To illustrate, the computing device **102** may generate location data indicating that an E-mail was written in Region 1 in response to determining that a body of the E-mail refers to Region 1 (or a particular location within Region 1). In another illustrative example, the computing device **102** may generate location data indicating that an E-mail was written in Region 1 in response to determining that the E-mail originated from an IP address in Region 1. In a further illustrative example, the computing device **102** may generate location data indicating that an E-mail was written in Region 1 in response to determining that the E-mail was transmitted through a cellular tower in Region 1.

The region determination module **114** receives the first metadata **118** and identifies a region **130** that includes the location **124**. For example, the region determination module **114** may determine that an image file that was generated in

Region 1 in response to associated metadata indicating that the image file was generated at a location (e.g., a city) within Region 1.

Based the first time **126** and an estimated amount of time it would take the user **122** to exit the region **130** when starting at the location **124**, the time window determination module **116** determines a time window **132** during which the user **122** is predicted to have been in the region **130**. For example, in response to determining that User 1 was located at Location 1 at Time 1 and that exiting Region 1 from Location 1 while traveling at a predicted speed of User 1 would take 1 day, the time window determination module **116** may determine that User 1 was located in Region 1 at least from Time 1±1 day. In some examples, the computing device **102** determines the estimated amount of time by analyzing historical locations of the user with respect to time to determine an average predicted speed of the user **122**. In addition, or in the alternative, the computing device **102** may determine the predicted speed of the user **122** by analyzing a context associated with the user **122** and stored in the memory **106**. The context may include information such as whether the user **122** owns a car, has bought a plane ticket, is scheduled to travel, etc.

The model generation/updating module **110** generates or updates a location as time model **134** (e.g., a timeline) based on the region **130** and the time window **132**. For example, the model generation/updating module **110** may update a timeline to indicate that User 1 was in Region 1 from Time 1-Time 3 in response to the time window **132** indicating that User 1 was in Region 1 during that time. In some implementations, the location as time model **134** (e.g., the timeline) specific to the user **122** and the computing device **102** generates a location as time model for each user associated with data items for which the computing device **102** obtains metadata. In some implementations, the computing device **102** may maintain a location as time model for registered users (e.g., subscribers of a communication service) as well as unregistered users. In response to each new user registration, the computing device **102** may determine whether the new user corresponds to an unregistered user for which a location as time model has been generated.

Updating the location as time model **134** may include reconciling conflicting time windows. For example, if the model generation/updating unit **110** receives an indication that User 1 was in Region 1 from Time 1-Time 3 but the timeline includes a second time window indicating that User 1 was in Region 2 at Time 2, the model generation/updating unit **110** may reconcile the conflicting time windows. In some examples, the model generation/updating module **110** may update the location as time model **134** to indicate both time windows in response to a conflict. For example, the model generation/updating unit **110** may update the timeline to indicate both that User 1 was in Region 1 from Time 1-Time 3 and that User 1 was in Region 2 at Time 2. In other examples, the model generation/updating module **110** may reconcile conflicting time windows based on priorities associated with the conflicting time windows. In some implementations, the model generation/updating module **110** determines priority of a time window based on a type of location data used to identify a region associated with the time window. In particular, GPS data may have a first priority, access point data may have a second priority, semantic-content based location data may have a third priority, and IP address based location data may have a fourth priority. Thus, if the time window determination module **116** generated a first time window indicating that User 1 was in Region 1 at Time 2 based on an E-mail originating from an IP address in Region 1 (e.g., fourth priority data) and generated a second time window indicating that User 1 was in Region 2 from Time 1-Time 3 based on an image file that included GPS metadata (e.g., first priority data), the second time window may take priority. Accordingly, the model generation/updating module **110** may update the timeline by discarding the first time window and adding the second time window.

Updating the location as time model **134** may further include merging two time windows that overlap in time and indicate the same region. For example, if the timeline includes a first time window indicating that User 1 was in Region 1 from Time 3-Time 6 and the model generation/updating module **110** receives a second time window indicating that User 1 was in Region 1 from Time 1-Time 3, the model generation/updating module **110** may merge the time windows to indicate that User 1 was in Region 1 from Time 1-Time 6.

Using the location as time model **134**, the model comparison module **112** may determine regions in which data items associated with the user **122** but that do not include location data were generated. In the illustrated example, the computing device **102** receives second metadata **120** associated with a second data item. As with the first data item, the computing device **102** may or may not receive the second data item. Further, as explained above with reference to the first metadata **118**, elements of the second metadata **120** may be generated at the computing device **102**. The second metadata **120** includes data indicating the user **122** and a second time **128**. However, the second metadata **120** may not include allocation data. Based on the data indicating the user **122**, the model comparison module **112** may access the location as time model **134** to determine a region in which the second metadata **120** was generated. The model comparison module **112** compares the second time **128** to the location as time model **134** to identify a region in which the second data item was generated. In particular, in response to determining that the second time **128** falls within the time window **132**, as indicated by the location as time model **134**, the model comparison module **112** may determine that the second data item was generated within the region **130**. To illustrate, in response to determining that that contact data was added to User 1's contacts list at Time 2 and that User 1's timeline indicates User 1 was in Region 1 at Time 2, the model comparison module **112** may determine that the contact data was generated while User 1 was in Region 1.

In situations in which the second time **128** does not match any time window identified by the location as time model, the model comparison module **112** may be configured to indicate that a region associated with the second metadata **120** is unknown. Alternatively, the model comparison module **112** may determine a probability matrix of possible regions to associate with the second metadata **120** based on a proximity of the second time **128** to one or more time windows included in the location as time model **134**.

In some implementations, in response to the model comparison module **112** identifying a region to associate with a data item, the computing device **102** may update the data item's metadata to indicate the region. In addition, or in the alternative, the computing device **102** may maintain the location as time model **134** and perform region determinations for data items on demand. In some examples, the computing device **102** stores the location as time model **134** in the memory **106**. While not illustrated, the computing device **102** may be configured to output an indication that the second data item originated in the region **130** to a display

or to another device. In addition, or in the alternative, the computing device **102** may trigger one or more location-based services based on the determination. For example, the computing device **102** may embed location-based advertisements into the second data item.

Thus, FIG. **1** illustrates a system that may determining a region in which data was generated. In particular, the system relates location of a user to time and uses this relationship to identify regions in which data items are generated. Thus, the system may provide a more complete understanding of where data items are generated or transacted as compared to other systems.

Referring to FIG. **2**, a first diagram **200** illustrating generation a location as time model is shown. The diagram **200** depicts a location as time model **202** associated with a user. The location as time model **202** may be generated by the system **100** of FIG. **1** and may correspond to the location as time model **134** of FIG. **1**. In the example of FIG. **2**, the location as time model **202** is generated by a system that monitors email data **204**, photo data **206**, check-in data **208**, purchase data **210**, and contact data **212**.

The photo data includes a photo data item **214**. The photo data item **214** corresponds to metadata (e.g., the first metadata **118**) indicating a first time and a location. Based on the location associated with the photo data item **214**, the system determines a region in which the photo data item **214** was generated. In the illustrated example, the system (e.g., the region determination module **114**) determines that the photo data item **214** was generated in Region 1 based on location data of the photo data item **214** identifying a location in Region 1 (e.g., a particular city within Region 1). The system (e.g., the time window determination module **116**) further determines a time window **216** based on the time at which the photo data item **214** was generated and an estimated amount of time it would take the user to exit Region 1 when starting from the location. The system (e.g., the model generation/updating module **110**) updates the location as time model **202** by adding the time window **216** to the location as time model **202**. Accordingly, the illustrated example of FIG. **2** shows that the user was in Region 1 during the time window **216**. Based on the location as time model **202**, the system (e.g., the model comparison module **112**) may determine that a contact data item **218** generated by the user (e.g., a device or account of the user) during the time window **216** was also generated in Region 1.

Referring to FIG. **3**, a diagram **300** illustrating a process to update the location as time model **202** of FIG. **2** is shown. In the illustrated example, the system generating and maintaining the location as time model **202** identifies a second photo data item **320**. The second photo data item **320** corresponds to metadata indicating a third time and a second location. Based on the second location associated with the second photo data item **320**, the system determines a region in which the second photo data item **320** was generated. In the illustrated example, the system (e.g., the region determination module **114**) determines that the second photo data item **320** was generated at a second location (e.g., a second city) in Region 1. The system (e.g., the time window determination module **116**) further determines a second time window **322** based on the third time at which the photo data item **214** was generated and a second estimated amount of time it would take the user to exit Region 1 when starting from the second location. The system (e.g., the model generation/updating module **110**) updates the location as time model **202** by adding the second time window **322** to the location as time model **202**. In response to determining that the time window **216** and the second time window **322** overlap in time and are associated with the same region, the system may merge the time windows **216**, **322** in the location as time model **202**.

Referring to FIG. **4**, a diagram **400** illustrating an updated version of the location as time model **202** of FIG. **2** is shown. As illustrated in FIG. **4**, the location as time model **202** indicates that a user was located in Region 1 during a first time window **404** and located in Region 2 during a second time window **406**. In the illustrated example, the first time window **404** is identified (e.g., by the processor(s) **104**) based on the photo data items **214**, **320**, additional photo data items **430-438**, and purchase data item **442**. The second window time **406** is identified (e.g., by the processor(s) **104**) based on a social media check-in data item **440**.

Thus, the location as time model **202** identifies time windows during which the user was in particular regions. Using the location as time model **202**, a system (e.g., the model comparison module **112**) may determine a region for a data item that does not include location data by identifying a corresponding time window. In the illustrated example, such a system may determine that the contact data item **218** and a second contact data item **460** were generated in Region 1 by determining that timestamps associated with the contact data items **218**, **460** fall within the first time window **404**. Similarly, the system may determine that a first E-mail data item **462** and a third photo data item **464** were generated while the user was in Region 2 by determining that timestamps associated with the first E-mail data item **462** and the third photo data item **464** fall within the second time window **406**.

Further, the system (e.g., the model comparison module **112**) may predict a region for a data item associated with a time that does not fall within any time windows identified by the location as time model **202**. The prediction may be based on regions identified by the location as time model **220** as occurring before and/or after the time associated with the data item, a predicted speed of the user, travel history of the user, etc. For example, a second purchase data item **480** may fall outside of the time windows **404**, **406** of the location as time model **202** depicted in FIG. **4**. The system (e.g., the model comparison module **112**) may identify that the user was in Region 1 before and in Region 2 after the second purchase data item **480** was generated. Based on a travel history of the user, a predicted speed of the user, a proximity in time of the second purchase data item **480** to the first time window **404** and/or the second time window **406**, or a combination thereof, the system (e.g., the model comparison module **112**) may determine a probability that the second purchase data item **480** was generated in Region 1 and a probability that the second purchase data item **480** was generated in Region 1. The system (e.g., the model comparison module **112**) may further determine probabilities that the second purchase data item **480** was generated in a region proximate to or in between Region 1 and/or Region 2.

Thus, FIG. **2-4** illustrate specific examples of a location as time model. The location as time model may be used to identify a region in which a data item that is not associated with location data was generated

Referring to FIG. **5**, a flowchart illustrating a method **500** of determining a region in which data was generated is shown. The method **500** may be performed by a computing device, such as the computing device **102** of FIG. **1**. The method **500** includes obtaining first metadata corresponding to a first data item, the first metadata indicating a user, a location, and a first time, at **502**. For example, the processor(s) **104** may receive and/or generate the first metadata **118**.

The first metadata **118** is associated with a first data item, such as an image file, an E-mail, a social media check-in event, a purchase event, a contact entry, etc. The first metadata **118** indicates the user **122**, the location **124**, and the first time **126**.

The method **500** further includes identifying a region that includes the location, at **504**. For example, the region determination module **114** may determine the region **130** that includes the location **124** indicated by the first metadata **118**. To illustrate, the region determination module **114** may track a particular list of regions and may perform a search of the tracked regions to identify which tracked region includes the location **124**.

The method **500** further includes identifying a time window associated with the user being located in the region based on the first time and an estimated amount of time it would take the user to exit the region when starting from the location, at **504**. For example, the time window determination module **116** may determine the time window **132** based on the first time **126** and an estimated amount of time it would take the user **122** to exit the region **130** when starting from the location **124**. To illustrate, the time window determination module **116** may determine (e.g., estimate) that exiting the region **130** while traveling from the location **124** at a predicted speed would take a particular amount of time and set the time window **132** to be the first time **126**±the particular amount of time. The time window **132** identifies a period of time during which the user **122** is identified as having been in the region **130**.

The method **500** further includes obtaining second metadata corresponding to a second data item, the second metadata indicating the user and a second time, at **508**. For example, the processor(s) **104** may receive and/or generate the second metadata **120**. The second metadata **120** is associated with a second data item, such as an image file, an E-mail, a social media check-in event, a purchase event, a contact entry, etc. The second metadata **120** indicates the user **122** and the second time **128**.

The method **500** further includes, in response to determining that the second time is within the time window, determine that the second data item was generated with the region, at **510**. For example, the model comparison module **112** may compare the second time **128** to the location as time model **134** to determine that the second time **128** corresponds to the time window **132**. Accordingly, the model comparison module **112** may determine that the second metadata **120** was generated by the user **122** in the region **130**.

Thus, FIG. **5** illustrates an example of a method that may be used to determine a region in which data was generated. Accordingly, the method may be used to provide one or more location-based services associated with data even in situations where the data does not include location information.

Referring to FIG. **6**, a block diagram illustrating a system **600** for converting a location-based query to a time-based query, according to one or more embodiments, is presented. The system **600** includes a computing device **602**. The computing device **102** may correspond to a server device or to any other type of computing device. In some implementations, the system **600** corresponds to the system **100**. For example, the computing device **602** may correspond to the computing device **102**.

The computing device **602** includes one or more processors **604** and a memory **606**.

The processor(s) **604** may include a central processor unit (CPU), a digital signal processor (DSP), a graphics processing unit (GPU), some other type of processor, or a combination thereof. The memory **606** includes a hard disk drive, a flash drive, random access memory, any other type of computer readable storage device, or a combination thereof. The memory **606** may store data and executable code. In the illustrated example, the memory **606** stores location-based query transformation instructions **608**. The location-based query transformation instructions **608** may be executable by the processor(s) **604** to perform any of the operations or methods described herein. The memory **606** further stores first metadata **622** corresponding to a first data item. The first metadata **622** indicates a user **610**, a first time **614**, and a location **616** associated with the first data item. The first metadata **622** may correspond to the first metadata **118** of FIG. **1**. The memory **606** further stores second metadata **620**. The second metadata **620** indicates the user **610** and a second time **612** associated with a second data item. The second metadata **620** may correspond to the second metadata **120** of FIG. **1**. The second metadata **620** further includes a location as time model **624** generated by the processor(s) **604** based on the first metadata **622** as described herein with reference to FIGS. **1-5**. The location as time model **624** may correspond to the location as time model **134** of FIG. **1** or the location as time model **202** of FIGS. **2-4**.

The processor(s) **604** include a location as time model query transformation module **630** and a query response generation module **632**. The location as time model based query transformation module **630** is configured to transform location-based queries into time-based queries based on the location as time model **624**. The query response generation module **632** is configured to generate results that identify data items satisfying a time-based query. Each of the modules **630-632** may correspond to software executed by the processor(s) **604** responsive to the location-based query transformation instructions **608**, dedicated hardware of the processor(s) **604**, or a combination thereof. While illustrated as distinct modules, functionality the modules **630-632** may be combined. Further, functionality of one or more of the modules **630-632** may be separated into multiple distinct modules.

In operation, the computing device **602** receives a location-based query **634** for data items generated within a region **638**. In some implementations, the location-based query **634** is received from another computing device (e.g., via network). For example, the computing device **602** may expose to the Internet an application programming interface (API) configured to receive location-based queries. In other examples, the location-based query **634** is received via a graphical user interface generated and displayed by the computing device **602**.

The location as time model based query transformation module **630** identifies a time window **640** associated with region **638** based on the location as time model **624** and converts the location-based query **634** into a time-based query **636** for data items generated within the time window **640**. In an illustrative example, the location-based query **634** is for all data items generated by User 1 in Region 1. Accordingly, the location as time model based query transformation module **630** may identify the time window **640** based on the location as time model **624** indicating the time window **640** corresponds to User 1 being in Region 1.

In some implementations, the location as time model based query transformation module **630** may include more than one time window in a time-based query. For example, in response to determining that User 1 was in Region 1 during both a first time window and a second time window,

the location as time model based query transformation module **630** may generate a time-based query for data items generated during the first time window or the second time window.

It should be noted that in some examples, the location-based query **634** includes a time-based component and that the location as time model based query transformation module **630** may identify the time window **640** based further on the time-based component. For example, the location-based query **634** may be for data items generated by User 1 in Region 1 during a particular time period (e.g., a year). Accordingly, the location as time model based query transformation module **630** may identify the time window **640** in the time-based query **636** in response to determining that the time window **640** corresponds to both Region 1 and the particular time period.

The query response generation module **632** generates a result **642** based on the time-based query **636**. For example, the query response generation module **632** may generate the result **642** indicating the first data item corresponding to the first metadata **622** and the second data item corresponding to the second metadata **620** in response to the first time **614** and the second time **612** respectively falling within the time window **640**. The query response generation module **632** may initiate transmission of the result **642** to a querying device, initiate display of the result **642** at the computing device **602**, or a combination thereof. In some examples, the computing device **602** transmits the time-based query **636** to a querying device in addition to or instead of the result **642**. Thus, the computing device **602** may provide a location-based query resolution service and/or a location-based query transformation service.

Therefore, FIG. **6** illustrates a system for converting a location-based query to a time-based query that may be resolved for data items that do not include location data. The time-based query may be used to identify data items predicted to have been generated within a particular region even if the data items are not associated with location data.

Referring to FIG. **7**, a flowchart illustrating a method **700** of converting a location-based query to a time-based query is shown. The method **700** may be performed by a computing device, such as the computing device **602** of FIG. **6**. The method **700** includes storing first metadata corresponding to a first data item, the first metadata indicating a user, a first time, and a first location within a particular region, at **702**. For example, the computing device **602** may store the first metadata **622** in the memory **606**. The first metadata **622** is associated with a first data item and indicates the user **610**, the first time **614**, and the location **616**.

The method **700** further includes storing second metadata corresponding to a second data item, the second metadata indicating the user and a second time, wherein the second metadata does not include the location data, at **704**. For example, the computing device **602** may store the second metadata **620** in the memory **606**. The second metadata **620** is associated with a second data item and indicates the user **610** and the second time **612**. The second metadata **620** may not include location data.

The method **700** further includes identifying a time window associated with the user being located within the particular region based on the first metadata, at **706**. For example, the processor(s) **604** may construct the location as time model **624** identifying that the time window **640** corresponds to the region **638** based on the first metadata **622** according to the process described with reference to FIGS. **1-5**.

The method **700** further includes receiving a location-based query for data items generated by the user within a queried region, at **708**. For example, the computing device **602** may receive the location-based query **634** for data items generated by the user **610** within the region **638**.

The method **700** further includes, in response to the queried region matching the particular region, converting the location-based query to a time-based query for data items generated by the user within the time window, at **710**. For example, in response to determining that the region **638** included in the location-based query **634** matches a region included in the location as time model **624**, the location as time model based query transformation module **630** may transform the location-based query **634** into the time-based query **636** based on the location as time model **624**. The time-based query **636** may correspond to a request for data items generated by the user **610** within the time window **640**.

The method **700** further includes, in response to the first time and the second time falling within the time window, generating a result of the time-based query identifying the first data item and the second data item, at **712**. For example, the query response generation module **632** may generate the result **642** identifying the first data item and the second data item based on the first time **614** and the second time **612** respectively falling within the time window **640** identified by the time-based query **636**.

Thus, the method **700** may be used by a device to transform location-based queries for data items into time-based queries for data items. Accordingly, the method **700** may be used to generate a query that may identify data items that may have been generated in a region even in cases where the data items do not include location data.

Results generated by the computing device **602** and/or the method **700** may be displayed on a map. For example, the result **642** may correspond to a graphical user interface depicting a map illustrating data items generated in the region **638**. FIG. **8** depicts a map **800** that illustrates results one or more query results. While the map **800** illustrates data items generated in a country A (e.g., a first region) and a country B (e.g., a second region), the data items depicted on the map **800** may not have included location data when identified (e.g., by the processor(s) **604**) for inclusion in the map **800**. For example, in response to receiving a location-based query for data items generated by User 1 in country A or in country B, the processor(s) **604** may use the location as time model **624** to identify a first time window during which User 1 was in country A and a second time window during which User 1 was in country B. The processor(s) **604** may then transform the location-based query into a time-based query for data items generated by User 1 during the first time window or during the second time window. The processor(s) **604** may determine results of the time-based query and generate the map **800** accordingly. Thus, data items that do not include location data may be placed on a map according to some embodiments.

It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments may be used in combination with each other. As another example, the above-described flow diagrams include a series of actions which may not be performed in the particular order depicted in the drawings. Rather, the various actions may occur in a different order, or even simultaneously. Further, the various actions may occur in a different grouping, or by different devices. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should therefore be determined with

reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

What is claimed is:

1. A computer-implemented method, the method comprising:

receiving, from a user, a location-based query associated with a first region, wherein the location-based service generates different data items determined by a device or via a sensor in the first region;

determining that the location-based query is required to be converted to a time-based query for a determination of a data item as a response to the location-based query;

retrieving a time model associated with the user based on a first time window associated with a first location in the first region where the user is located, wherein the first time window is based on first metadata generated when the user is located at the first location and a first estimated amount of time for the user to exit the first region when starting from the first location;

determining a second time window associated with a second location is the first region based on second metadata generated when the user is located at the first location and a second estimated amount of time for the user to exit the first region when starting from the second location;

resolving a conflicting portion of the first time window and the second time window based on a priority of each of the first location and the second location;

updating the time model based on the resolved first and second time windows;

determining at least one additional time model associated with a second region and having second metadata associated with the user located in the second region;

converting the location-based query to the time-based query based on the updated time model and the at least one additional time model;

determining that the data item was generated in the first region by the device or via the sensor in association with the user being located at one or more of the first location or the second location based on the time model and the location-based service; and

predicting that the data item is the response to the location-based query based on the determining that the data item was generated in the first region.

2. The computer-implemented method of claim 1, wherein the first metadata comprises at least one of an email, a text message communication, a photo, a video, check-in data, a purchase, or a contact of the user.

3. The computer-implemented method of claim 1, wherein, prior to the retrieving the time model, the computer-implemented method further comprises:

acquiring the first metadata comprising a first time when the first metadata was generated and the first location; and

identifying the first location in the first region based on the first metadata.

4. The computer-implemented method of claim 3, wherein, prior to the determining the second time window, the computer-implemented method further comprises:

acquiring the second metadata comprising a second time when the second metadata was generated and the second location; and

identifying the second location in the first region based on the second metadata.

5. The computer-implemented method of claim 1, wherein the resolving the conflicting portion of the first time window and the second time window comprises:

merging the first time window and the second time window during the conflicting portion based on the priority; and

removing a corresponding conflicting portion of one of the first time window or the second time window after the merging.

6. The computer-implemented method of claim 1, wherein the first time window is based on a first time when the first metadata was generated using a mobile device of the user, and wherein the first estimated amount of time is based on an estimated time of day when the user exits the first region after starting from the first location.

7. A system comprising:

a non-transitory memory; and

one or more hardware processors coupled to the non-transitory memory and configured to read instructions from the non-transitory memory to cause the system to perform operations comprising:

receiving, from a user, a location-based query associated with a location-based service for a first region, wherein the location-based service generates different data items determined by a device or via a sensor in the first region;

determining that the location-based query is required to be converted to a time-based query for a determination of a data item as a response to the location-based query;

retrieving a time model associated with the user based on a first time window associated with a first location in the first region where the user is located, wherein the first time window is based on first metadata generated when the user is located at the first location and a first estimated amount of time for the user to exit the first region when starting from the first location;

determining a second time window associated with a second location is the first region based on second metadata generated when the user is located at the first location and a second estimated amount of time for the user to exit the first region when starting from the second location;

resolving a conflicting portion of the first time window and the second time window based on a priority of each of the first location and the second location;

updating the time model based on the resolved first and second time windows;

determining at least one additional time model associated with a second region and having second metadata associated with the user located in the second region;

converting the location-based query to the time-based query based on the updated time model and the at least one additional time model;

determining that the data item was generated in the first region by the device or via the sensor in association with the user being located at one or more of the first location or the second location based on the time model and the location-based service; and

predicting that the data item is the response to the location-based query based on the determining that the data item was generated in the first region.

8. The system of claim 7, wherein the first metadata comprises at least one of an email, a text message communication, a photo, a video, check-in data, a purchase, or a contact of the user.

9. The system of claim 7, wherein, prior to the retrieving the time model, the operations further comprise:

acquiring the first metadata comprising a first time when the first metadata was generated and the first location; and

identifying the first location in the first region based on the first metadata.

10. The system of claim **9**, wherein, prior to the determining the second time window, the operations further comprise:

acquiring the second metadata comprising a second time when the second metadata was generated and the second location; and

identifying the second location in the first region based on the second metadata.

11. The system of claim **7**, wherein the resolving the conflicting portion of the first time window and the second time window comprises:

merging the first time window and the second time window during the conflicting portion based on the priority; and

removing a corresponding conflicting portion of one of the first time window or the second time window after the merging.

12. The system of claim **7**, wherein the first time window is based on a first time when the first metadata was generated using a mobile device of the user, and wherein the first estimated amount of time is based on an estimated time of day when the user exits the first region after starting from the first location.

13. A non-transitory computer-readable medium having stored thereon instructions executable by a computer system to cause the computer system to perform operations comprising:

receiving, from a user, a location-based query associated with a location-based service for a first region, wherein the location-based service generates different data items determined by a device or via a sensor in the first region;

determining that the location-based query is required to be converted to a time-based query for a determination of a data item as a response to the location-based query;

retrieving a time model associated with the user based on a first time window associated with a first location in the first region where the user is located, wherein the first time window is based on first metadata generated when the user is located at the first location and a first estimated amount of time for the user to exit the first region when starting from the first location;

determining a second time window associated with a second location is the first region based on second metadata generated when the user is located at the first location and a second estimated amount of time for the user to exit the first region when starting from the second location;

resolving a conflicting portion of the first time window and the second time window based on a priority of each of the first location and the second location;

updating the time model based on the resolved first and second time windows;

determining at least one additional time model associated with a second region and having second metadata associated with the user located in the second region;

converting the location-based query to the time-based query based on the updated time model and the at least one additional time model;

determining that the data item was generated in the first region by the device or via the sensor in association with the user being located at one or more of the first location or the second location based on the time model and the location-based service; and

predicting that the data item is the response to the location-based query based on the determining that the data item was generated in the first region.

14. The non-transitory computer-readable medium of claim **13**, wherein the first metadata comprises at least one of an email, a text message communication, a photo, a video, check-in data, a purchase, or a contact of the user.

15. The non-transitory computer-readable medium of claim **13**, wherein, prior to the retrieving the time model, the operations further comprise:

acquiring the first metadata comprising a first time when the first metadata was generated and the first location; and

identifying the first location in the first region based on the first metadata.

16. The non-transitory computer-readable medium of claim **15**, wherein, prior to the determining the second time window, the operations further comprise:

acquiring the second metadata comprising a second time when the second metadata was generated and the second location; and

identifying the second location in the first region based on the second metadata.

17. The non-transitory computer-readable medium of claim **13**, wherein the resolving the conflicting portion of the first time window and the second time window comprises:

merging the first time window and the second time window during the conflicting portion based on the priority; and

removing a corresponding conflicting portion of one of the first time window and the second time window after the merging.

* * * * *