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(54) **LOCATION-AWARE SELECTION OF PUBLIC TRANSPORTATION**

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(71) Applicant: **Microsoft Technology Licensing, LLP**,  
 Redmond, WA (US)

(57) **ABSTRACT**

(72) Inventor: **Dragos A. Manolescu**, Kirkland, WA (US)

(73) Assignee: **MICROSOFT TECHNOLOGY LICENSING, LLP**, Redmond, WA (US)

A mobile device such as a mobile phone, smart phone, personal music player, handheld game device and the like that is configured to be location-aware through GPS (Global Positioning System), cell tower positioning, or other means of determining location, is provided with a public transportation selector functionality that interfaces with one or more on-line public transportation schedule services. The public transportation selector passes the location of a user of the mobile device, the user's destination, and the targeted arrival time to the schedule services which responsively return information including, for example, station/stop location information, route identifier, departure and arrival times, and fare costs. The public transportation selector aggregates schedule information provided by the services for presentation to the user through a user interface on the mobile device. The user can then select the desired public transportation option and be provided with directions to the appropriate station or stop.

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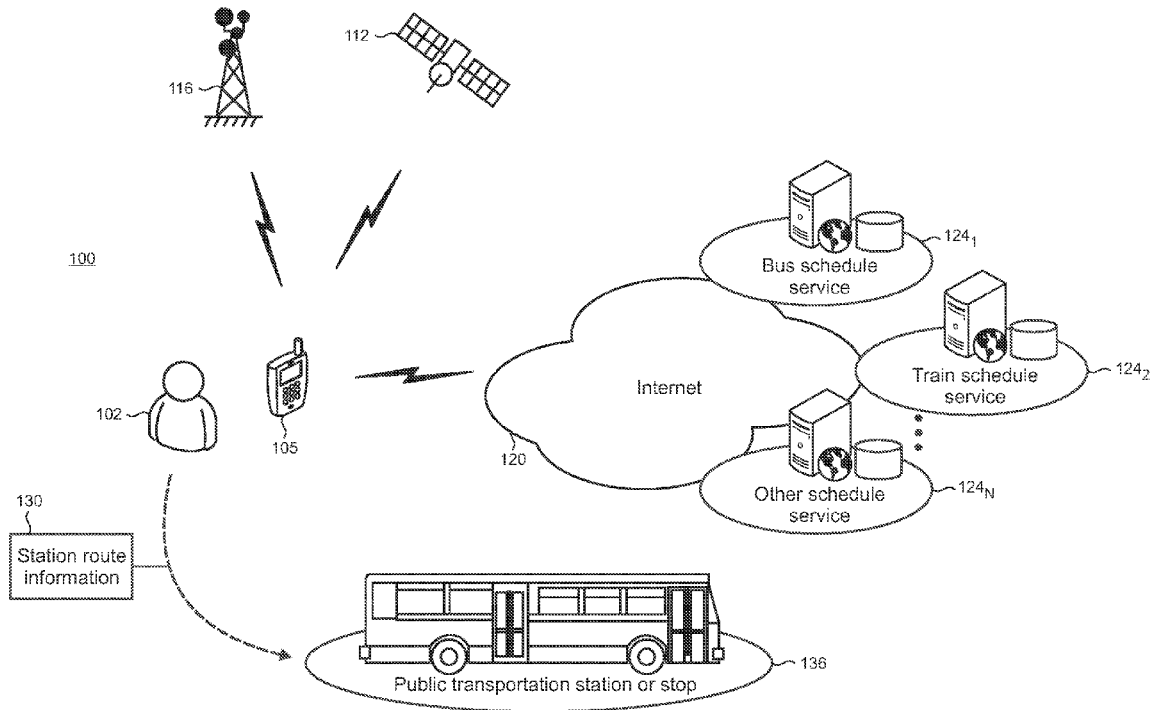


FIG 1

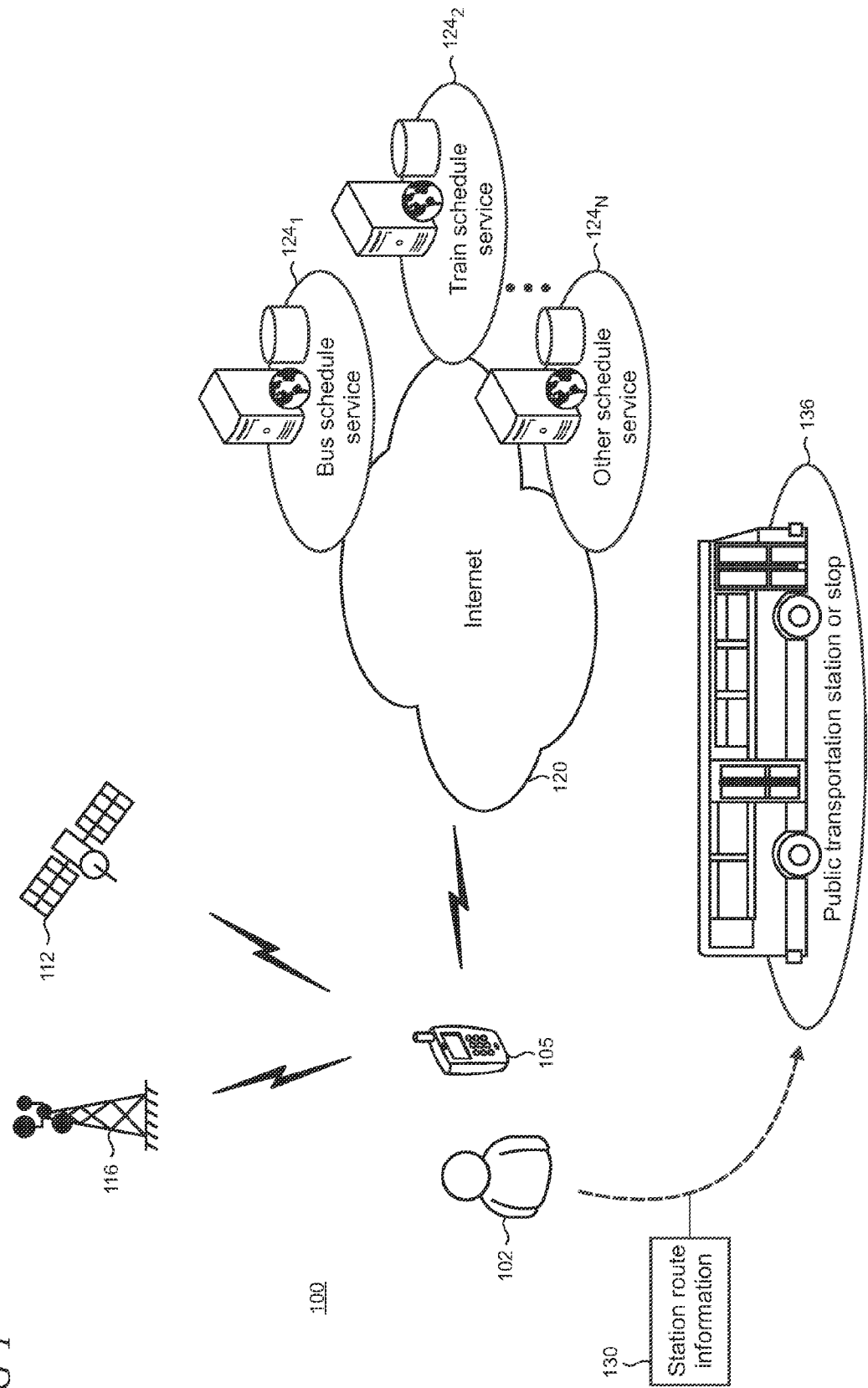


FIG 2

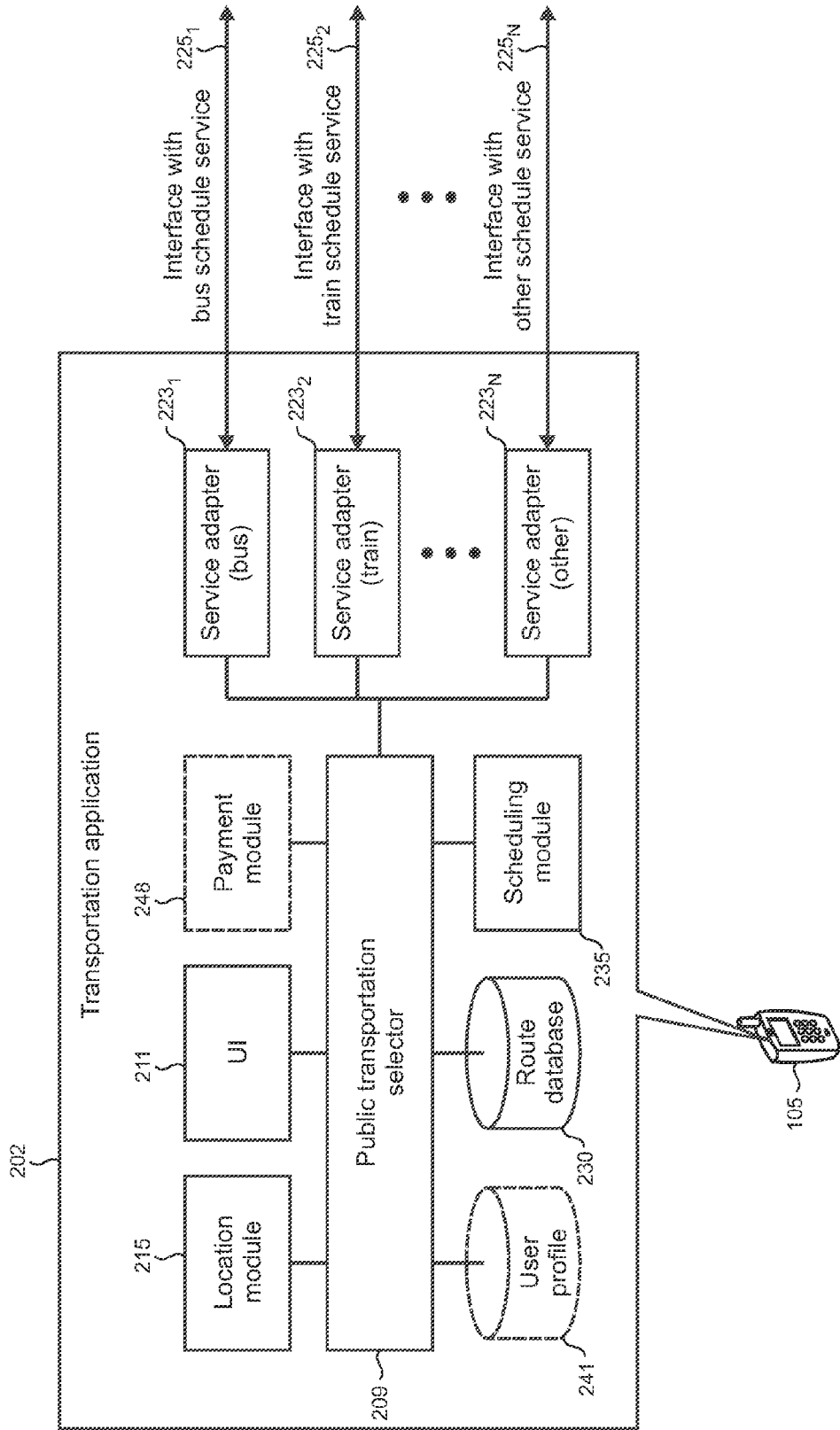


FIG 3

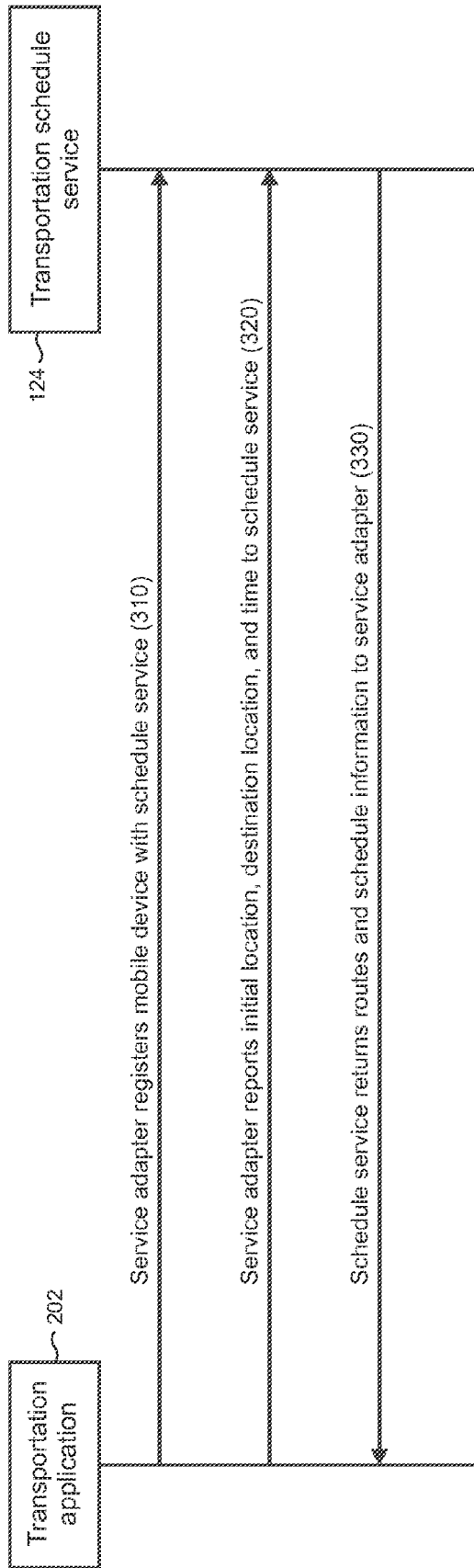


FIG 4

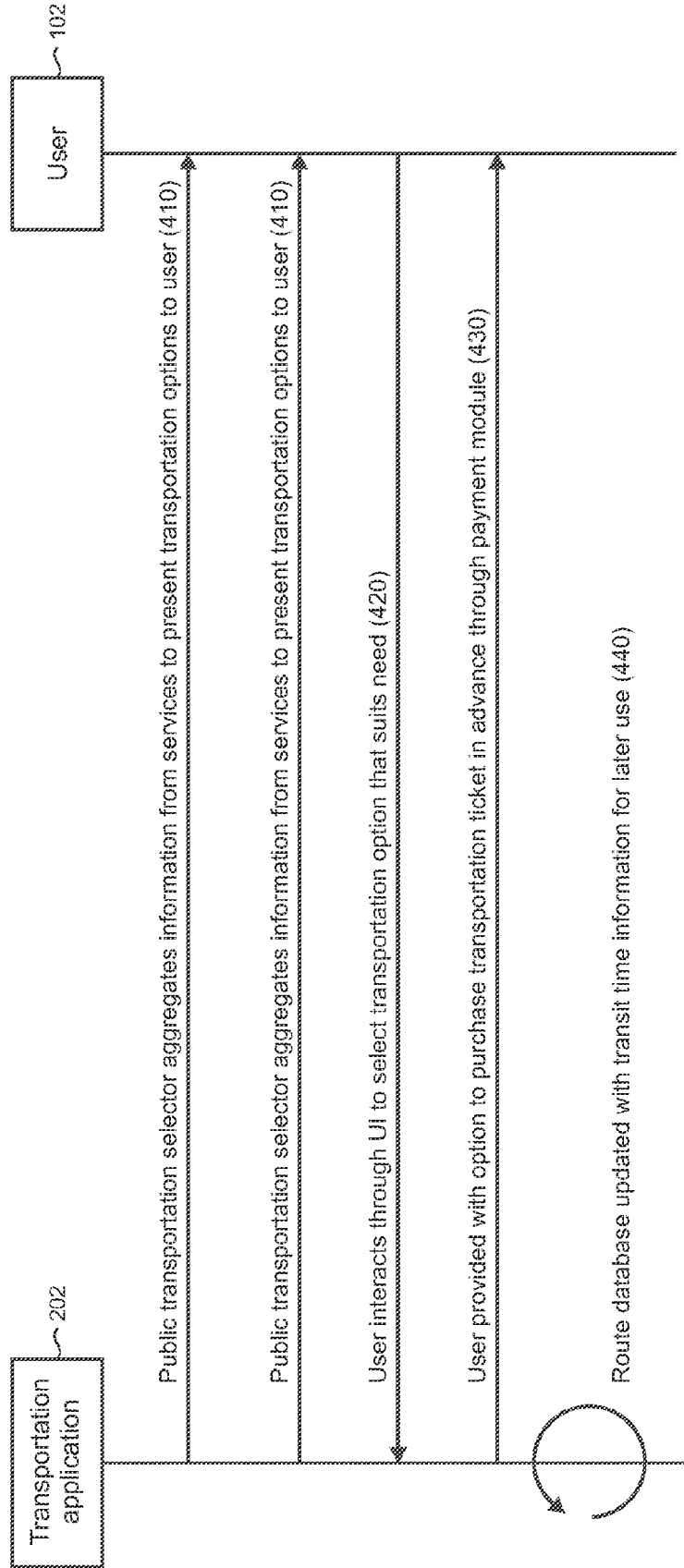
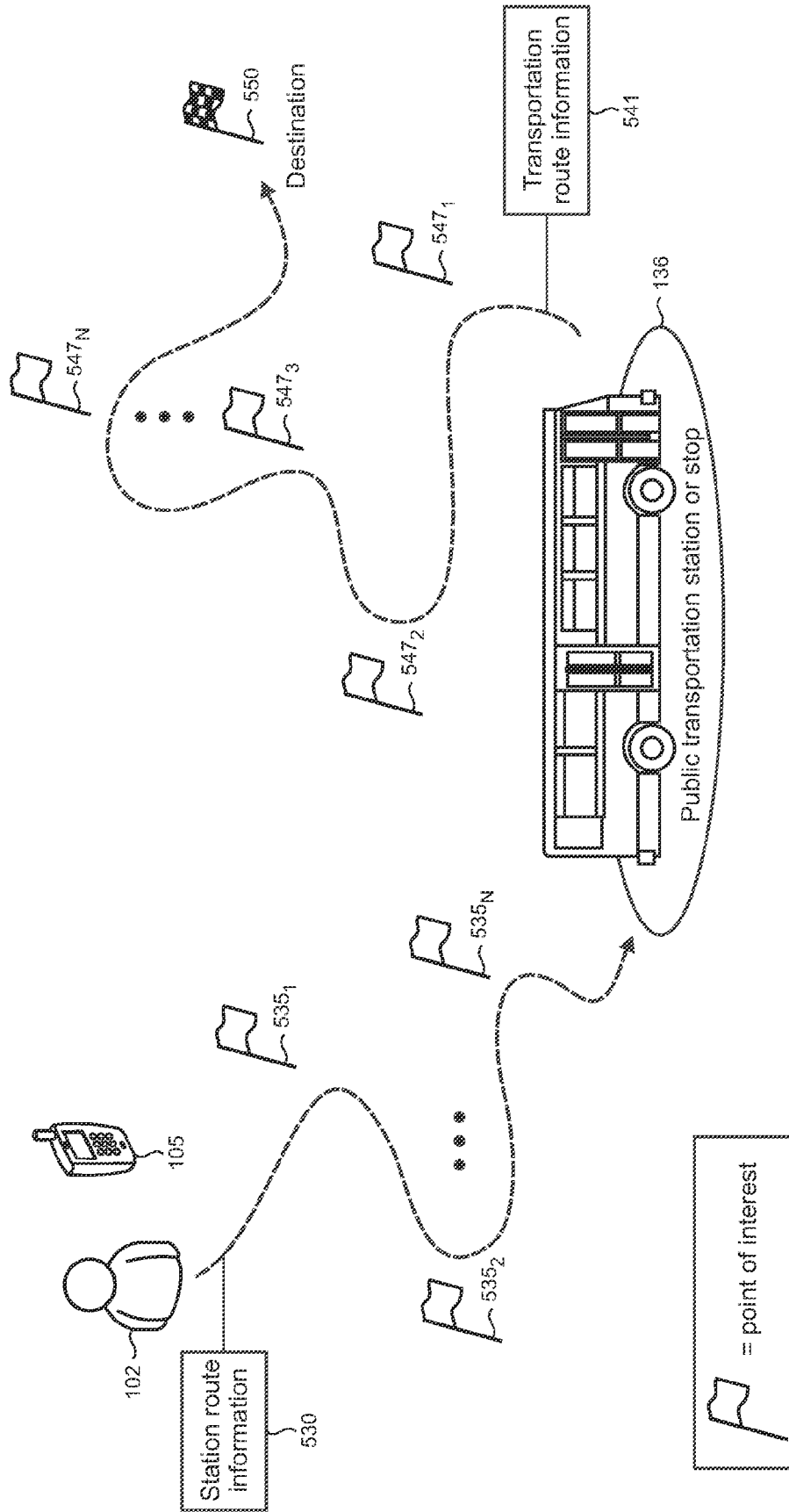


FIG 5



## LOCATION-AWARE SELECTION OF PUBLIC TRANSPORTATION

### BACKGROUND

**[0001]** People often rely on public transportation in many parts of the world as a safe, efficient, and cost effective way to travel in increasingly crowded urban and suburban areas. But it can often be difficult to quickly identify the available means of public transportation, particularly, for example, in unfamiliar geographic areas, or at times of the day that are not typical or usual for the traveler. Even if the traveler can find a bus or subway station, it is not always straightforward to determine which route to take that will ensure that the traveler will arrive at the desired destination at the desired time.

### SUMMARY

**[0002]** A mobile device such as a mobile phone, smart phone, personal music player, handheld game device, and the like, that is configured to be location-aware through GPS (Global Positioning System), cell tower positioning, or other means of determining location, is provided with a public transportation selector functionality (e.g., implemented using a software application) that interfaces with one or more on-line public transportation schedule services. The public transportation selector passes the location of a user of the mobile device, the user's destination, and the targeted arrival time to the schedule services which responsively return information including, for example, station/stop location information, route identifier (e.g., bus number, subway line, etc.), departure and arrival times, and fare costs relating to the available transportation options which may include bus, train, subway, ferry, and other forms of public transportation. The public transportation selector aggregates schedule information provided by the services for presentation to the user through a user interface ("UI") on the mobile device. The user can then select the desired public transportation option and be provided with directions to the appropriate station or stop.

**[0003]** In various illustrative examples, the user inputs a desired destination through the UI. Alternatively, the destination may be identified automatically through an interface with the user's scheduling tool (e.g., appointment book or calendar application) on the mobile device. Actual transit times may be collected and stored in a route database so that the public transportation selector may optimize the transportation options presented to the user. Published route information from the public transportation schedule services, stored user preferences, appointment and contact data, and/or user profile information may also be utilized when performing the optimization. In addition, the public transportation selector may utilize such information when generating suggested points of interest that the user may wish to visit on the way to the station or along the route from the station to the destination. The public transportation selector may also be configured with a functionality to enable the user to pay for the public transportation fare or make a reservation right from the mobile device.

**[0004]** Advantageously, the present location-aware selection of public transportation provides users with an easy to use way to find public transportation that meets their needs. The interfaces between the public transportation selector and other functionalities on the mobile device, such as scheduling applications and user preferences/profile data stores, further enable effective route selection and optimization options to be automatically and transparently generated for the user. The

user can thus effectively utilize public transportation in a way that suits their particular needs and preferences.

**[0005]** This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

### DESCRIPTION OF THE DRAWINGS

**[0006]** FIG. 1 shows an illustrative public transportation environment in which the present location-aware selection of public transportation may be practiced;

**[0007]** FIG. 2 is a simplified functional block diagram of a transportation application that is configured to run on a mobile device;

**[0008]** FIG. 3 shows an illustrative communication flow between the transportation application and a transportation schedule service in an example usage scenario;

**[0009]** FIG. 4 shows an illustrative communication flow between the transportation application and the mobile device user in an example usage scenario; and

**[0010]** FIG. 5 shows an illustrative public transportation route that is annotated with points of interest.

**[0011]** Like reference numerals indicate like elements in the drawings.

### DETAILED DESCRIPTION

**[0012]** FIG. 1 shows an illustrative public transportation environment 100 in which the present location-aware selection of public transportation may be practiced. In the environment 100, a user 102 employs a location-aware mobile device 105 such as a mobile phone, smart phone, PDA (personal data assistant), handheld game device, handheld computer, pocket PC (personal computer), portable media player such as those which can play MP3 (Moving Pictures Expert Group, MPEG-1, audio layer 3) files, or device which integrates several of such functions. It is noted that these types of mobile devices are intended to be illustrative and that other types of mobile devices may also be used in the present arrangement as may be required to meet the needs of a particular implementation.

**[0013]** The mobile device 105 may be configured with location-awareness using a variety of conventional techniques. These may include, for example, the use of GPS in which location is determined through a triangulation calculation based on signals from a network of satellites (as representatively indicated by reference numeral 112).

**[0014]** Alternatively, cell tower positioning may be utilized to approximate the position of the mobile device 105 by comparing the relative signal strength between the mobile device and multiple antenna towers (as representatively indicated by reference numeral 116). While cell tower positioning is a less accurate technology compared with GPS, it may still provide sufficient accuracy in many cases to provide location-awareness to the mobile device 105 in the present application. In addition, cell tower positioning often provides superior location determination compared with GPS when mobile devices are used indoors. In some implementations, it may be desirable to use both GPS and cell tower positioning technologies. It is emphasized that the foregoing examples of location-awareness are intended to be illustrative only and

that other methodologies may also be utilized as may be required to meet the needs of a particular implementation.

**[0015]** The mobile device **105** is further configured for wireless communication using a mobile data network to gain access to resources that are located on a public network such as the Internet **120**. The mobile data network could be arranged, for example, in accordance with GPRS (General Packet Radio Service), EVDO (Evolution Data Optimized), UMTS (Universal Mobile Telecommunications System), or other known arrangements. In alternative implementations, the resources may be accessed via private network infrastructure such as VPN (virtual private networks).

**[0016]** The Internet-accessible resources include public transportation schedule services **124** which include, in this illustrative example, a bus schedule service **124<sub>1</sub>**, a train schedule service **124<sub>2</sub>**, and transportation schedule service **124<sub>N</sub>** named “other” which is intended to represent a service that covers other forms of public transportation. These include, for example (but are not necessarily limited to) trains, light rail conveyances, subway, trams, trolleys, streetcars, ferries, water taxis, and similar types of transportation that may be provided by public or private entities for the benefit of the general public.

**[0017]** The transportation services **124** are configured to support databases of information that pertain to their respective type of transportation. So, for example, the bus schedule service **124<sub>1</sub>** will typically have access to bus routes, schedules, fare, and other information (e.g., general passenger, station, or accessibility information, the availability of special services, etc.) for one or more bus lines or providers that may service a particular geographic region. Such data can be populated into the databases using any of a variety of conventional methods including manual and automated data capture methods using schedule information that is typically published by the transportation provider.

**[0018]** It is noted that while separate schedule services **124** are shown in FIG. 1, in some implementations, the services may be combined or consolidated. For example, a single schedule service **124** might be used to provide information about more than one type of transportation. There is no requirement that schedule services be implemented on a one-to-one basis with the available types of transportation.

**[0019]** The location-aware mobile device **105** can interact with the transportation services **124** to receive schedule, public transportation station or stop locations, route identifiers (e.g., bus number, subway line, ferry dock number, etc.), fare or ticket price, and other information from the services in response to a query or request from the device. The query will typically specify the location of the user, the user’s destination, and the desired time of arrival. The mobile device **105** can thus receive, for example, a list of transit options, directions to route the user **102** (as indicated by reference numeral **130**) to the station or stop **136** of a train, bus, subway, etc., that is near to the location of the user **102** and identify the appropriate line, number, or route that can take him or her to the destination in the desired timeframe, and fare information.

**[0020]** More specifically, as shown in FIG. 2, the mobile device **105** includes a transportation application **202** that is configured to interact with one or more of the transportation services **124** to enable the present public transportation selection feature set when run on the device. Typically, the transportation application **202** will run as software code on the mobile device **105**, although it can also be implemented using firmware and/or hardware-based solution, or combinations of

software, firmware, and hardware in some implementations. In addition, the transportation application **105** can be supported by the mobile device **105** under various “software as services” models where all or a portion of the application runs on a remote server.

**[0021]** In this example, the transportation application is architected, as shown in FIG. 2, using a number of components. However, it is emphasized that the particular components shown in FIG. 2 and described below are intended to be illustrative and that the functionality supported therein may be provided by components or modules other than those shown, or be allocated among the components in a different manner than that described.

**[0022]** The transportation application **202** includes a public transportation selector **209** that is configured to provide the core location-aware selection functionality. The user **102** interacts with the public transportation selector through a UI **211**, typically through support of a graphical display and a means for input capture. A location module **215** provides the interface to the location-aware hardware in the mobile device such as GPS or cell tower positioning components.

**[0023]** A group of service adapters **223** provide interfaces **225** over the wireless data network to the respective schedule services **124** on the Internet **120** (FIG. 1). In particular, as shown, a service adapter (bus) **223<sub>1</sub>** provides an interface **225<sub>1</sub>** to the bus schedule service **124<sub>1</sub>**. Similarly, the service adapter (train) **223<sub>2</sub>** provides an interface **225<sub>2</sub>** to the train schedule service **124<sub>2</sub>**. And, the service adapter (other) **223<sub>N</sub>** provides an interface **225<sub>N</sub>** to the other schedule service **124<sub>N</sub>**. The particular number and type of service adapters **223** utilized in any given implementation can vary from that shown in FIG. 2. In addition, service adapters can be created by third parties (i.e., parties other than a mobile device maker, transportation application provider, or schedule service provider) and utilized to enhance the capabilities of the present arrangement in some applications.

**[0024]** A route database **230** is utilized locally on the mobile device **105** to store route information that is downloaded from the schedule services as well as to provide a store for actual transit times experienced by the user **102** when following a particular transportation route. Alternatively, the actual transit times can be collected for other users for a variety of routes at some central collection point (such as a data server) and then uploaded to the route database. As described in more detail below, such historical transit times can be utilized by the public transportation selector, alone or in combination with other data, as part of the optimization of transportation options that are presented to the user **102** through the UI **211**.

**[0025]** A scheduling module **235** is configured to provide an interface to the user’s scheduling or appointment application that may be running on the mobile device **105**. For example, the user may be running an instance of Microsoft Outlook® Mobile on the mobile device **105** to manage e-mail, calendars, contacts, and tasks. The scheduling module **235** enables the public transportation selector **209** to obtain information about the user’s schedule and appointments. Typically the user will be provided with an opportunity to synchronize such information with the transportation application. Knowledge of the user’s schedule and appointments, including for example, the time and location of such appointments, can assist the public transportation selector **209** to transparently (i.e., without requiring an affirmative or explicit action on the part of the user **102**) recognize a need for the user



to be at a particular place at a particular time. The public transportation selector **209** can then provide an appropriate set of transportation options that are responsive to such need.

**[0026]** In a similar manner as with the scheduling module, a user profile **241** may be optionally utilized (as indicated by its dashed outline) to further enhance the public transportation selector's ability to provide transportation options to the user **102** that suits the user's needs. As above, the user **102** will typically be provided with an opportunity to opt in to the collection of data regarding the user's usage of the mobile device **105**.

**[0027]** Various techniques and heuristics can be employed to infer a user preference from collected profile data. In some cases, user preferences may be explicitly solicited by the transportation application, or may be set, modified or updated by the user **102**. For example, if the user profile or preference indicates that buses are most preferred by the user, and subways least preferred, the public transportation selector **209** can act appropriately when providing transportation options for a given usage scenario.

**[0028]** Also optionally utilized in the transportation application **202** is the payment module **248**. This module can be used in those implementations where infrastructure is in place to facilitate secure payment transactions to the transportation providers (either directly or via third party service) using the mobile device **105**. Such transactions can utilize a pre-payment system or be tied to a traditional credit card, for example. Alternatively, the use of other known electronic payment systems such as near field communications ("NFC") may also be facilitated by the payment module **248** using the mobile device **105** as a delivery mechanism. In some implementations, it may be desirable to collect a fee for facilitating the ticket purchase transaction using the mobile device **105**. The recipient of the fee may be one of the schedule service providers, or a third party, for example.

**[0029]** Turning now to FIG. 3, an illustrative flow of communications between the transportation application **202** and a schedule service **124** is shown for an example usage scenario. The scenario starts by a service adapter **223** in the transportation application **202** registering with its corresponding schedule service **124** (as indicated by reference numeral **310**). Thus, for example, the service adapter (bus) **2231** will register with the bus schedule service **1241** and so forth. The service adapter **223** will typically perform the registration using a simple handshake with the service **124** when there is need to pull schedule data or status updates about service affecting issues. For example, the user **102** may work through the UI **211** to explicitly make a request to locate public transportation. Or, the scheduling module **235** may identify an upcoming appointment at a distant location which the public transportation selector **209** uses as an automatic trigger to initiate the registration in a manner that is transparent to the user.

**[0030]** The location module **215** determines the current location of the mobile device **105** (and hence the location of the user **102**) which is relayed via the service adapter **223** along with the destination and desired arrival time to the schedule service **124** (**320**). In response, the schedule service **124** will return a selection of possible transportation routes with associated schedules for the particular public transportation type and the corresponding fee information back to the service adapter **223** (**330**).

**[0031]** The route identifies the starting and destination points and, in most cases, schedule information that includes published or approximate departure and arrival times for each

route. The number, line, route, or other identifying information will also be provided (e.g., bus #6, the yellow subway line, ferry slip 3, etc.) Typically, as multiple service adapters are used to interface with multiple transportation schedule services, the steps of registration, reporting, and information return are performed with each service adapter and schedule service pair, and the transportation application **202** may assemble a multi-segment route out of segments provided by different types of transportation—for example, a leg of the route by ferry, then by bus, then by subway. Depending upon the particular circumstances, it may be possible for a relatively large amount of information to be passed back from the various transportation schedule services **124** to the transportation application **202** running on the mobile device **105**. That is, there may be multiple ways for the user **102** to get to a particular destination using different forms of public transportation that traverse different routes, and within some reasonable interval to the desired arrival time.

**[0032]** Other types of information can also be returned by a schedule service **124**. While it may vary by implementation, the information may be drawn from the information databases supported by the schedule service **124** and include general passenger, station, or accessibility information, the availability of special services, etc., as noted above.

**[0033]** The public transportation selector **209** is responsible for taking the route and schedule information returned from the schedule services **124** and presenting it to the user through the UI **211**. In some cases, as noted above, the information can aggregate a multi-segment route using different public transportation types. FIG. 4 shows an illustrative flow of communications between the transportation application **202** and the user **102** for the example usage scenario shown in FIG. 3 and described above.

**[0034]** Generally in most implementations it will be desirable for the public transportation selector **209** to apply rules or heuristics to sort or rank order the returned information. In this way the public transportation selector **209** can optimize the routes and schedules to present the user **102** with a select subset of all the available transportation options (as indicated by reference numeral **410**). Alternatively, the optimization can be performed remotely by one of the schedule services **124** or by another remote service. Optimization may also be shared between the locally running transportation application and a remote service.

**[0035]** The optimization techniques may vary by implementation. In some cases, the public transportation selector **209** will consider locally stored information such as historic transit times from the route database **230**, or profile and/or user preferences from the user profile **241**.

**[0036]** With the route database **230**, the stored historical transit times for a particular route (or any other information provided by the user) enable the public transportation selector **209** to determine the likelihood of a transportation option getting the user **102** to the destination by the desired time. Thus, for example, while published schedule information may indicate that a bus running on a city's west side route is supposed to arrive at the central station at 2 pm, the historical data may show that this bus typically runs late.

**[0037]** The historical transit time information may also be particularly useful for public transportation that does not provide published departure and arrival times. With some subway lines, for example, subway cars arrive at each station on a periodic basis but not at a set time. In this case, the historical transit time information will typically help the pub-

lic transportation selector **209** in determining whether that particular subway route is an appropriate option to present to the user **102** and further enable the public transportation selector to provide approximate departure and/or arrival times.

**[0038]** The public transportation selector **209** may use data from the user profile **241** to optimize route selection by filtering or weighting transportation options based on explicitly generated user preferences or preferences that may be inferred from the collected user profile data. Thus, transportation by subway may be considered a more optimized solution for the user **102** in light of the profile or preference, even if a bus stop, for example, may be physically closer to the user's current location at the time of the query. Accordingly, the public transportation selector **209** will typically rank order subway routes over bus routes when presenting transportation options to the user **102** when it is determined that subways are the user's preferred type of transportation.

**[0039]** When presented with the transportation options, the user **102** can work through the UI to pick an option that is desired and meets the user's needs (**420**). Responsively to the user's selection of the transportation option, station route information (i.e., direction) will be provided through the UI **211** (**430**). The user **102** may also be optionally presented with the ability to make an electronic payment for the fare associated with the selected transportation option, or make a reservation (**440**). In this case, the functionality from the payment module **248** will typically be invoked.

**[0040]** As the user **102** makes the trip using the selected transportation option, the actual transit time associated with the route will be collected so that the route database **230** can be updated. The transit time can be calculated once the location module **215** indicates that the mobile device **105** (and hence the user **102** as well) has arrived at the destination.

**[0041]** Additional value-added features may also be advantageously implemented using the present location-aware public transportation selection arrangement. As shown in FIG. 5, the public transportation selector **209** can annotate the station route information **530** (i.e., the directions to the station or stop **136**) with various points of interest **535**<sub>1,2,...N</sub> along the route. The points of interest **535** may vary by implementation and may include, for example, friends of the user **102**, retail stores, museums, restaurants, and the like. The points of interest **535** can be automatically generated by the public transportation selector **209** using locally available data. Alternatively, the points of interest **535** can be generated remotely using an external service.

**[0042]** So, for example, the public transportation selector **209** might determine from the user's contact list that is available from the scheduling module **235** that a friend or acquaintance of the user **102** resides or works near the route to the station **136**. If so, the UI **211** can include an annotation with the station route information **530** that there is an opportunity for a visit with the friend or acquaintance.

**[0043]** If the current time is close to a meal time, the public transportation selector **209** may also include an annotation with the station route information **530** that a restaurant that the user **102** may like is along the route to the station **136**. The public transportation selector **209** may use data from the user profile **241** when making this annotation.

**[0044]** If the scheduling module **235** indicates that the user **102** has created a task to purchase a gift, for example, for a friend's upcoming birthday, the public transportation selector

**209** can make an annotation that an appropriate retail store is along the route to the station **136**.

**[0045]** Data from the user profile **241** or scheduling module **235** may be used in a similar manner as in the examples above to generate annotations about other points of interest for the user **102** (e.g., museums, memorials, historical sites, recreation and entertainment, and the like). Should the user **102** wish to take time to accommodate a point of interest, the public transportation selector **209** can re-query the schedule services **124**, if necessary and then determine additional transportation options that may be presented to the user **102** that take into account the additional time.

**[0046]** The constellation of potential points of interest **535** can be stored locally in the mobile device **105** and be periodically updated through interaction with a remote service, for example, so that the annotations reflect current and valid information. Alternatively, the points of interest **535** can be dynamically received in real time by an appropriate query to the remote service.

**[0047]** The public transportation selector **209** can also be configured to generate annotations that are applicable to the route taken by the selected mode of public transportation. As shown in FIG. 5, the transportation route information **541** may include annotations of various points of interest **547**<sub>1,2,...N</sub> that the user **102** may wish to visit along the transportation route to the destination **550**. The public transportation selector **209** can utilize a similar methodology, as described above for annotating station route information, when generating annotations for points of interest **547** to the transportation route information **541**. That is, the public transportation selector **209** can take into account locally available information such as data from the scheduling module **235** and user profile **241** when making the annotation for the points of interest **547**. And, as with the example above, the public transportation selector **209** can re-query the schedule services **124**, if necessary, and determine additional transportation options that may be presented to the user **102** that take into account the additional time required to accommodate a point of interest **547**.

**[0048]** Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. A computer-readable medium not comprising a propagated data signal containing instructions which, when executed by one or more processors on a mobile device associated with a user, implement a transportation application for providing public transportation options to the user, the transportation application comprising:

- a service adapter, the service adapter configured to:
  - interface with one or more of a plurality of schedule services;
  - receive public transportation information from the one or more respective schedule services of the plurality of schedule services in regard to a destination; and
  - store the received public transportation information from the one or more respective schedule services in a route database;
- a public transportation selector, the public transportation selector configured to provide a set of transportation

- options to the user in response to a query regarding transportation from a start location to a destination location with a target time of arrival at the destination location, wherein the public transportation selector determines the set of transportation options according to the received public transportation information; and a user interface, the user interface configured to present the set of transportation options provided by the public transportation selector to the user.
2. The computer-readable medium of claim 1, wherein the transportation application further comprises a location module that interfaces with location-aware functionality disposed in the mobile device, the location module identifying the present location of the mobile phone to the public transportation selector.
3. The computer-readable medium of claim 2, wherein the transportation application further comprises a scheduling module, the scheduling module configured to interface with scheduling data having applicability to the user, the scheduling data including at least one of an appointment, a calendar, a contact, or a task.
4. The computer-readable medium of claim 3, wherein the scheduling module is further configured to generate the query according to the scheduling data having applicability to the user.
5. The computer-readable medium of claim 3, wherein the transportation application further comprises a user profile configured for storing profile data that is collected about the user.
6. The computer-readable medium of claim 5, wherein at least one of the route database, scheduling module, or user profile is used by the public transportation selector for filtering transportation information from a schedule service of the plurality of schedule services.
7. The computer-readable medium of claim 1, wherein the location functionality is one of a global positioning system (GPS) or a cell tower positioning functionality.
8. The computer-readable medium of claim 1, wherein the transportation application further comprises a payment module, the payment module being configured to facilitate an electronic payment of a fare associated with a public transportation route.
9. The computer-readable medium of claim 8, wherein the public transportation selector applies one or more heuristics to the information from the plurality of schedule services to optimize the public transportation options presented to the user through the user interface.
10. A method, configured for execution on a mobile device, for identifying and presenting public transportation information to a user associated with the mobile device, the method comprising the steps of:
- obtaining public transportation information of one or more types of public transportation that are available for use within a given geographic region
  - storing the public transportation information in a route database;
  - receiving a query, the query requesting route information for navigating to a target destination to arrive at a target arrival time at the target destination;
  - identifying one or more transportation options of the public transportation information from the route database, the one or more transportation options for navigation to the target destination to arrive at the target arrival time at the target destination; and
  - presenting the one or more transportation options to the user via the mobile device.
11. The method of claim 10 further comprising:
- receiving a selection of a first transportation option of the one or more transportation options for navigation to the target destination to arrive at the target arrival time at the target destination;
  - transacting a purchase between a public transportation provider associated with the first transportation option and the user associated with the mobile device.
12. The method of claim 10, wherein each of the one or more transportation options for navigation to the target destination to arrive at the target arrival time at the target destination include at least one public transportation service.
13. The method of claim 12, wherein the least one public transportation service comprise one of a bus, a rail, a light rail, a subway, a trolley, a streetcar, a tram, a ferry, or a water taxi.
14. The method of claim 10, wherein the public transportation information is obtained by the mobile device from a plurality of schedule services via a wireless data network.
15. The method of claim 10, wherein identifying one or more transportation options of the public transportation information from the route database and a source information, the one or more transportation options for navigation to the target destination from the source location to arrive at the target arrival time at the target destination.
16. The method of claim 15 further comprising obtaining a present location information of the mobile device from a location-aware functionality disposed in the mobile device, wherein the present location is the source location.
17. The method of claim 15, further comprising receiving the source location from the user associated with the mobile device.
18. The method of claim 10 further comprising obtaining scheduling data having applicability to the user of the mobile device, the scheduling data including at least one of an appointment, a calendar, a contact, or a task.
19. The method of claim 18, wherein the query is automatically generated according to the scheduling data having applicability to the user.
20. A mobile device associated with a user and configured to provide transportation information to the user, the mobile device comprising:
- a location module disposed in the mobile device for determining location information of the mobile device;
  - a route database, the route database configured to store public transportation information from one or more schedule services; and
  - a transportation application, the transportation application comprising:
    - one or more of service adapters, wherein each of the one or more service adapters interfaces over a network with at least one schedule service of a plurality of schedule services to receive public transportation information from the at least one schedule service of the plurality of schedule services, and stores the public transportation information in the route database; and
    - a public transportation selector, wherein the public transportation selector provides transportation options for navigating to a target destination to arrive at a target time according to the public transportation

information in the route database in response to a query identifying the target destination and the target time.

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