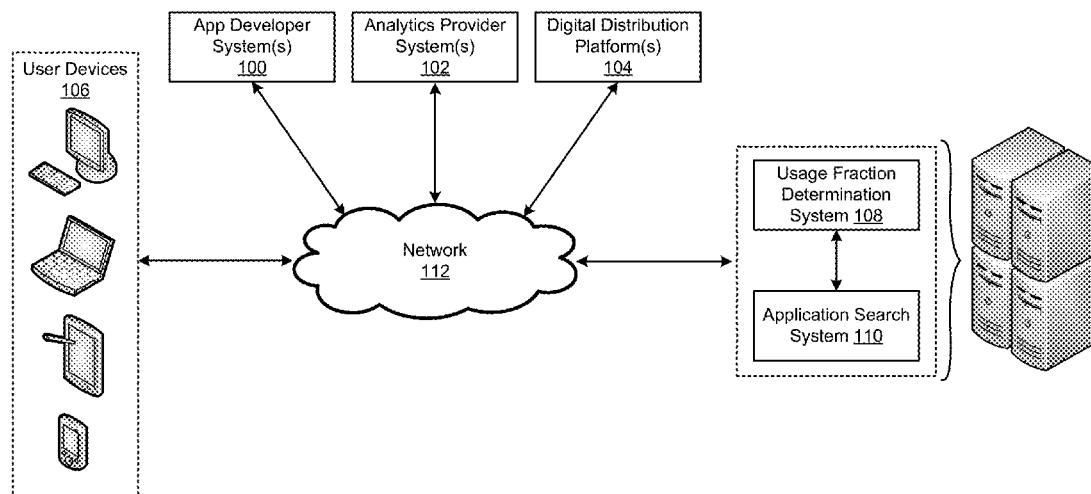




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GLOVER(10) **Pub. No.: US 2017/0192978 A1**(43) **Pub. Date: Jul. 6, 2017**(54) **SEARCHING FOR APPLICATIONS BASED
ON APPLICATION USAGE**(52) **U.S. CL.**
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(2013.01)(71) Applicant: **Quixey, Inc.**, Mountain View, CA (US)(72) Inventor: **Eric GLOVER**, Palo Alto, CA (US)(21) Appl. No.: **15/150,412**(22) Filed: **May 9, 2016****Related U.S. Application Data**(63) Continuation of application No. 14/985,605, filed on
Dec. 31, 2015, Continuation of application No.
14/985,667, filed on Dec. 31, 2015.**Publication Classification**(51) **Int. CL.**
G06F 17/30 (2006.01)(57) **ABSTRACT**

A method includes retrieving, at computing devices, event analytics data for a software application installed on user devices. The event analytics data indicates an amount of time each accessible application state was accessed by the user devices. The method includes mapping function names indicating functionality to the application states. The method includes determining an amount of time associated with application states corresponding to each function name. The method includes determining a usage fraction for each of the function names indicating the amount of time associated with the function name relative to the rest of the function names. The method includes assigning function keywords to an application search record associated with the software application based on the usage fractions. The method includes, in response to a search query, identifying and transmitting an application search record based on a match between terms of the search query and terms of the function keywords.



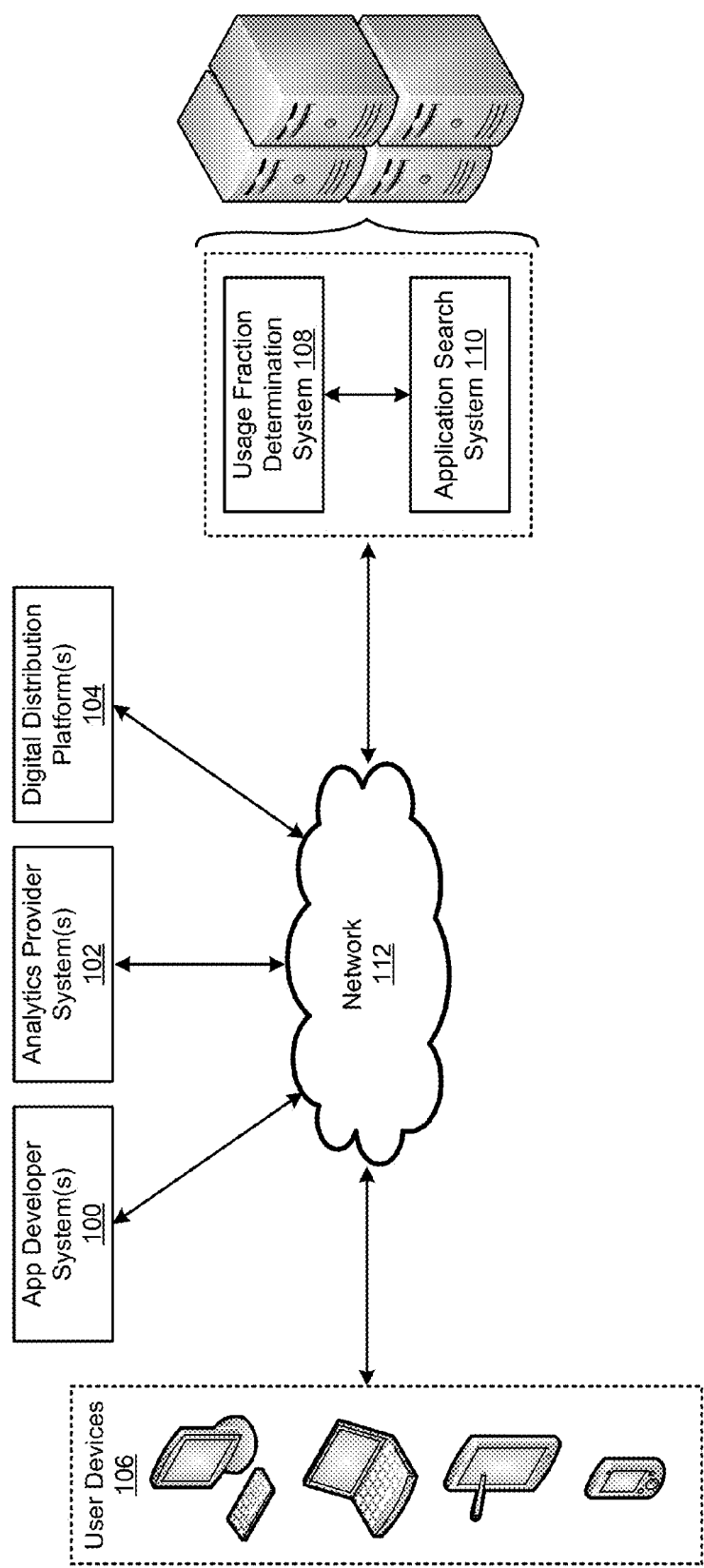


FIG. 1

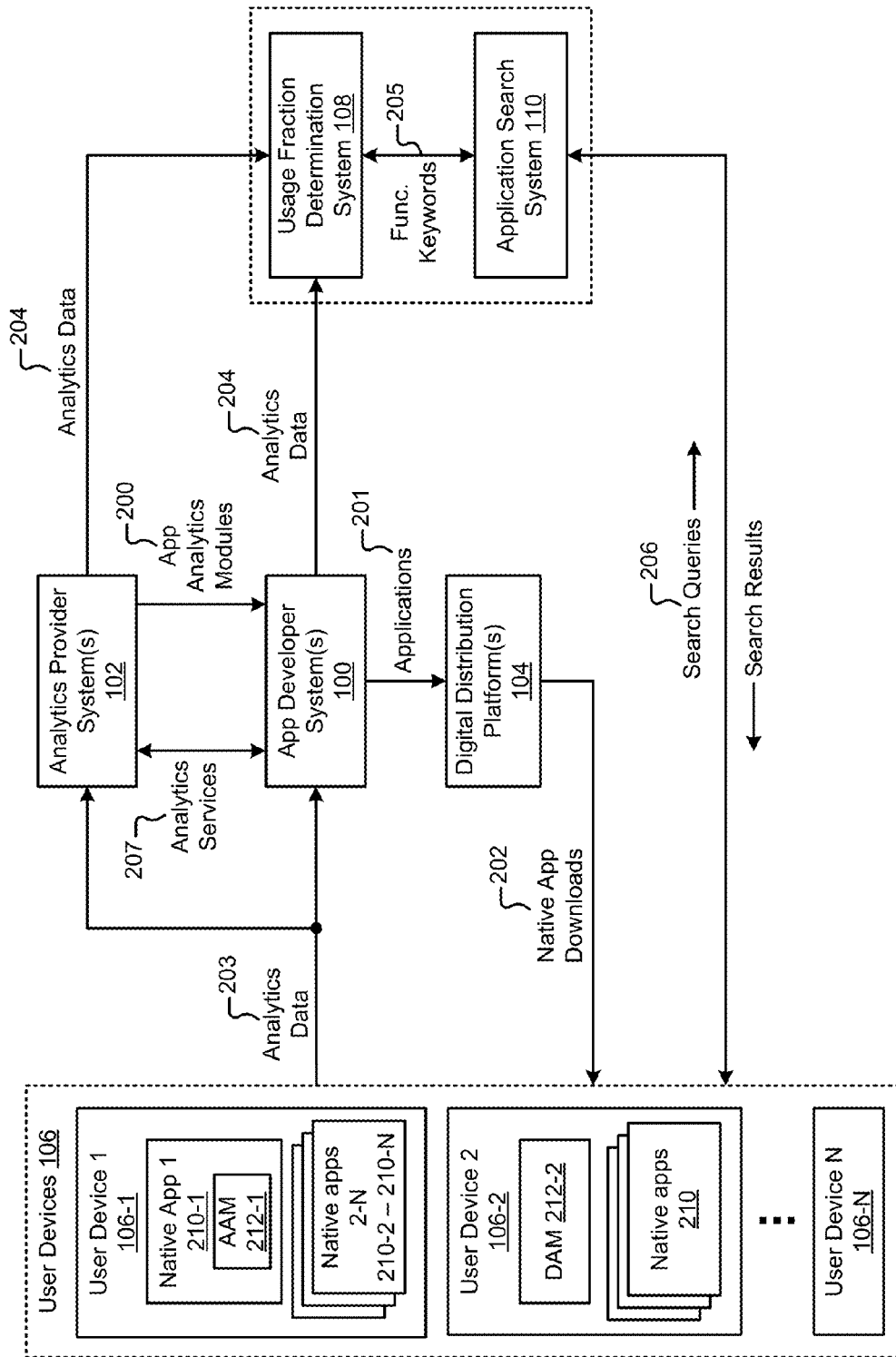
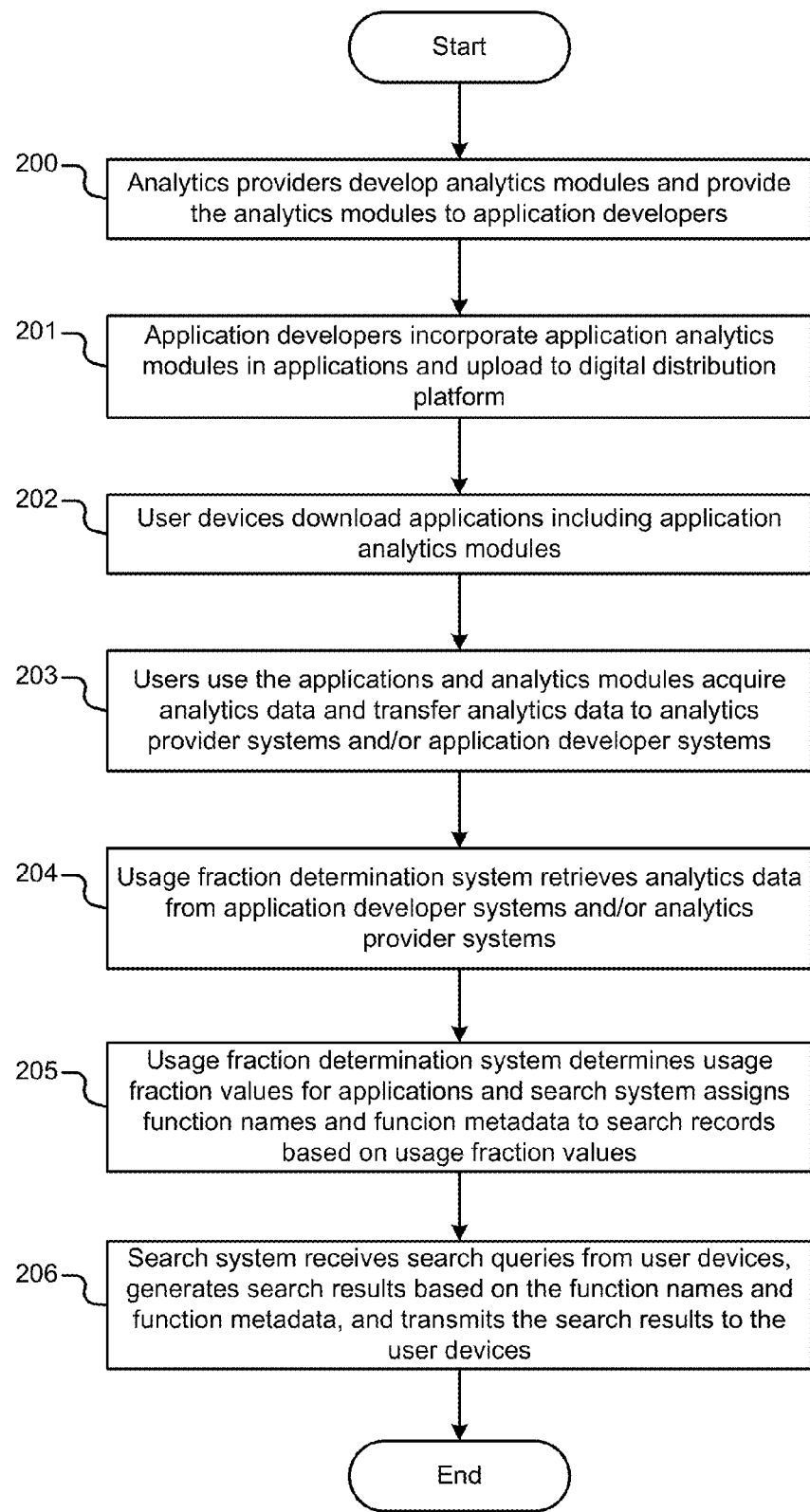


FIG. 2

**FIG. 3**

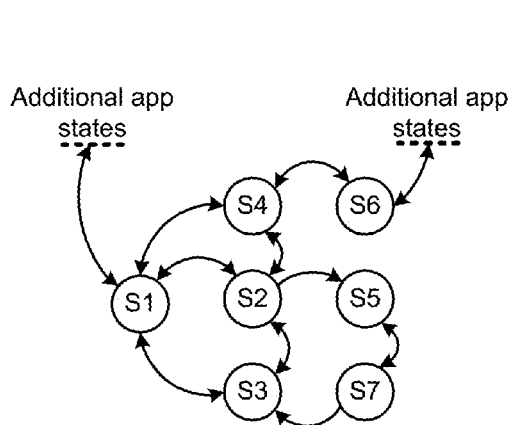


FIG. 4A

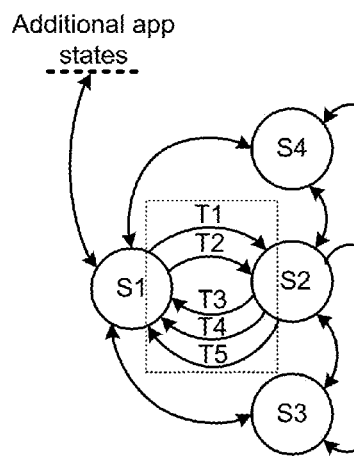


FIG. 4B

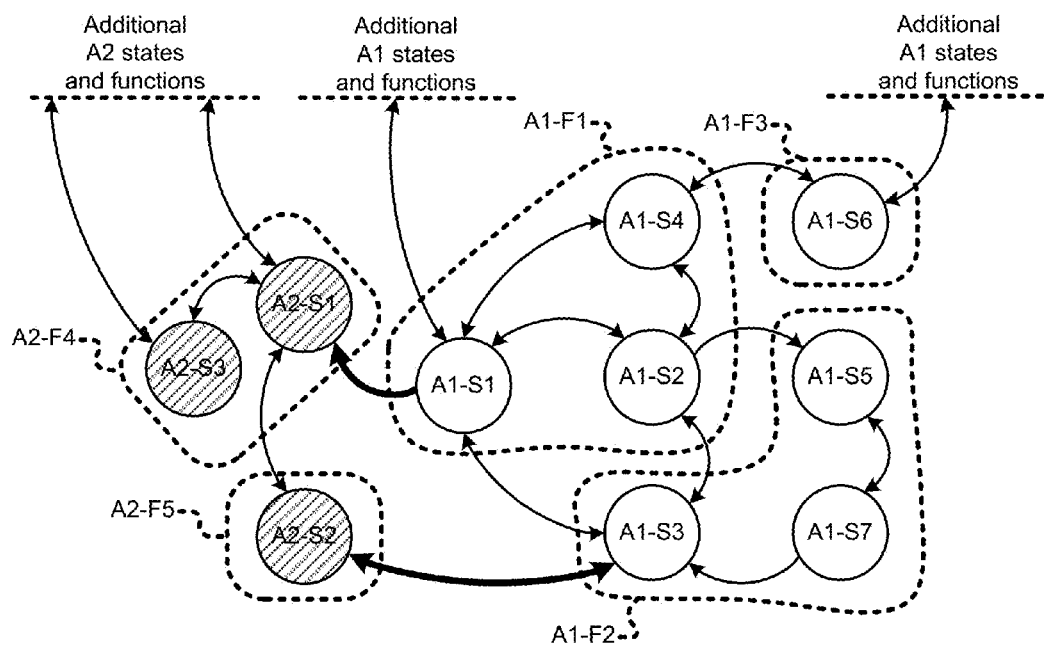


FIG. 4C

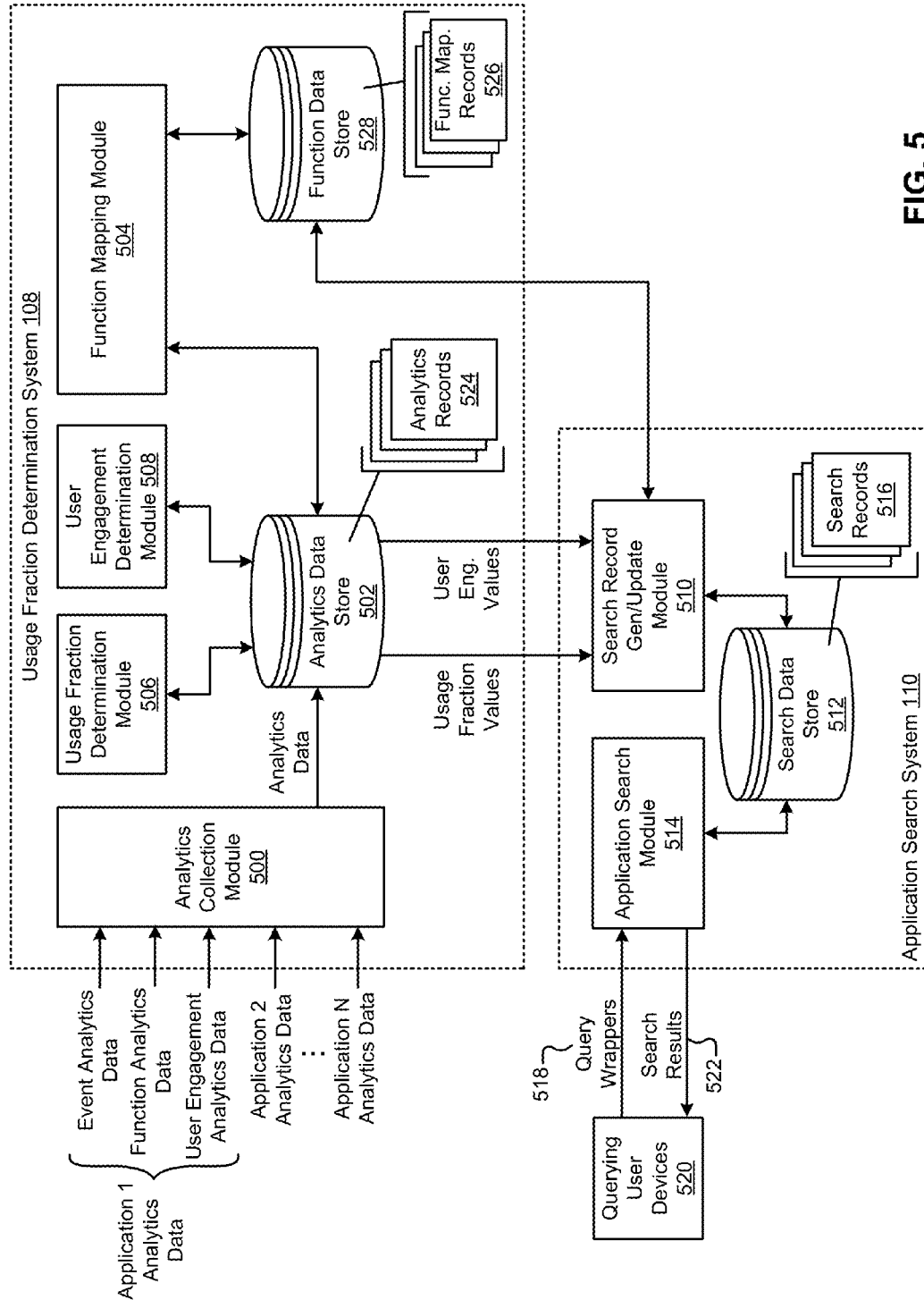


FIG. 5

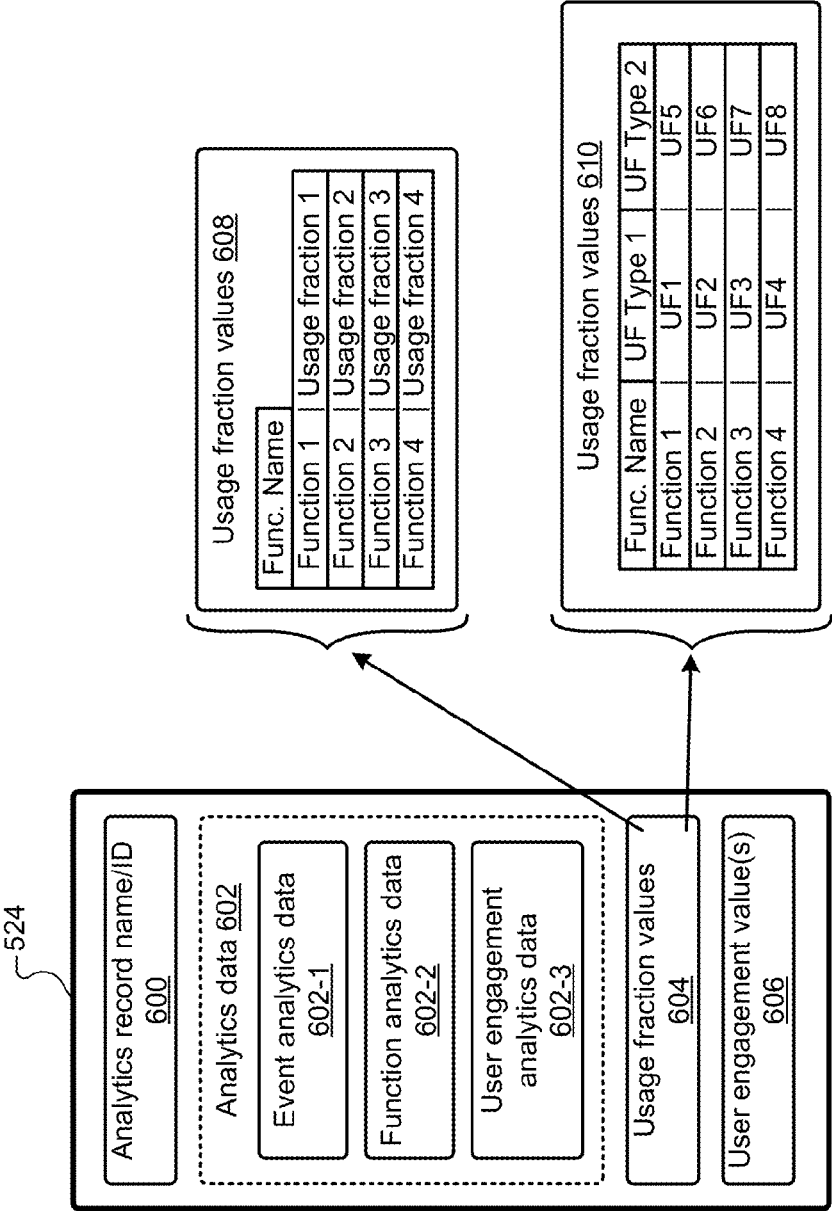


FIG. 6

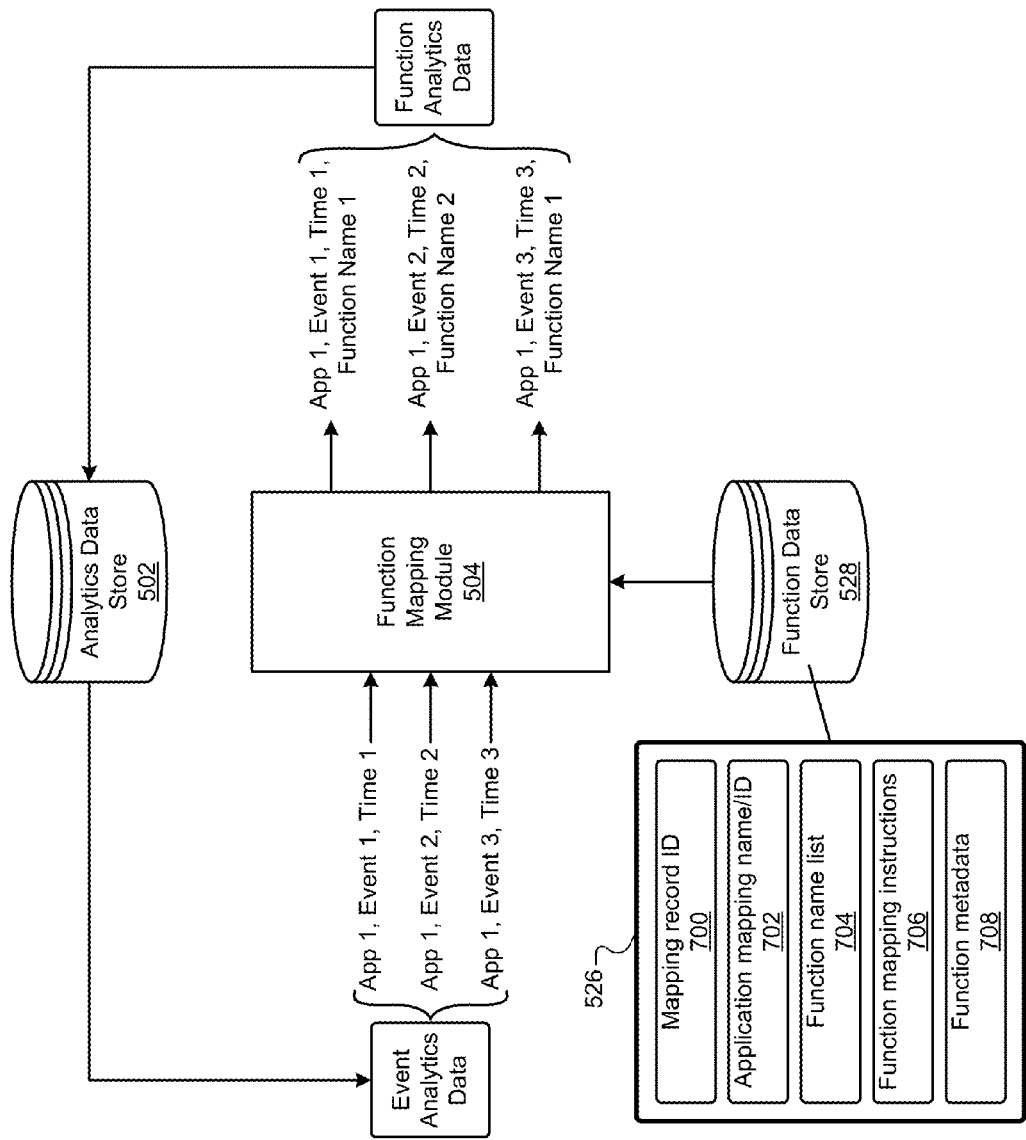
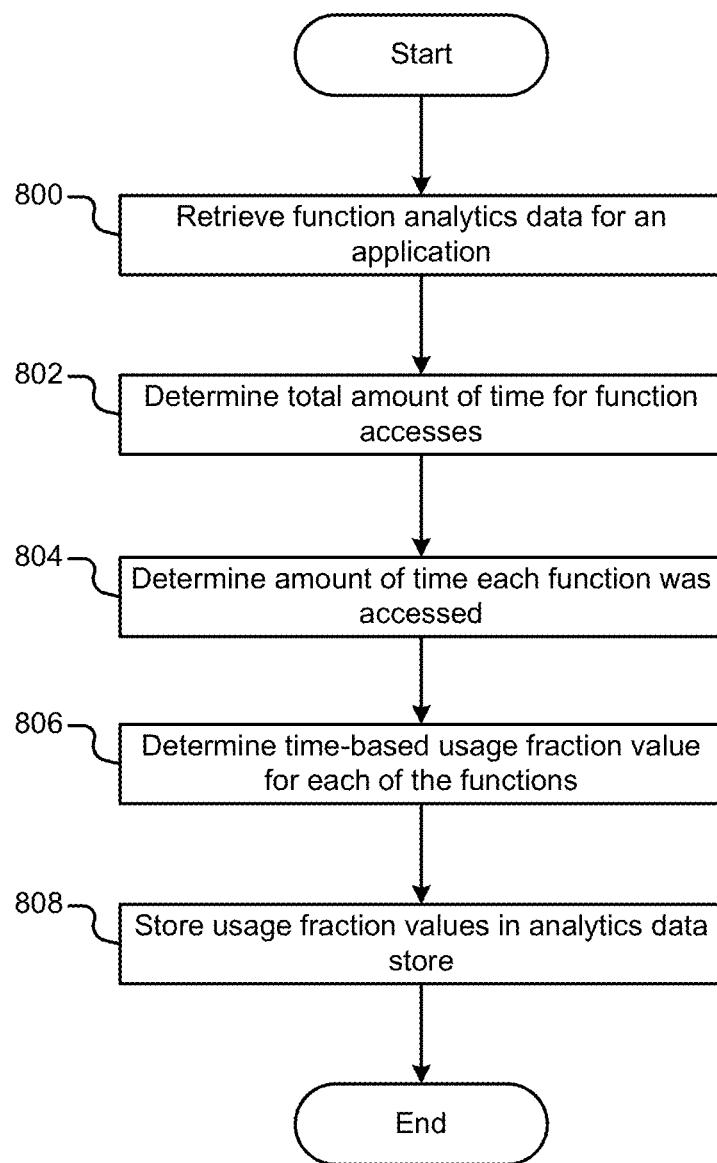
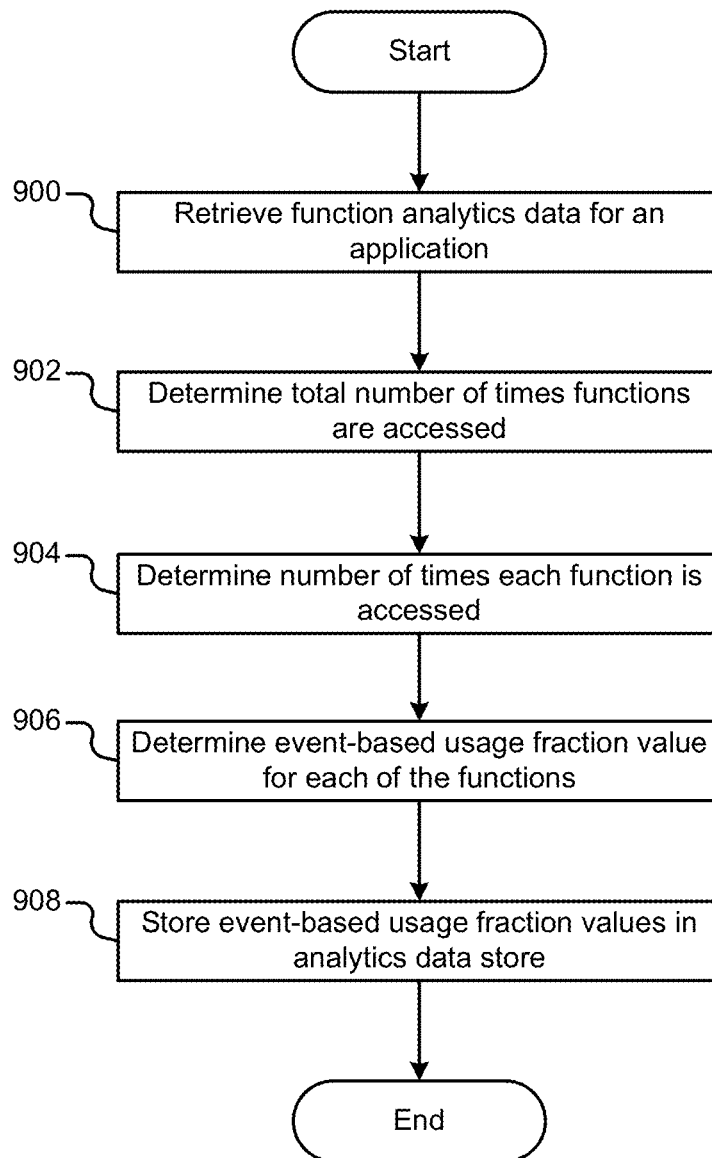
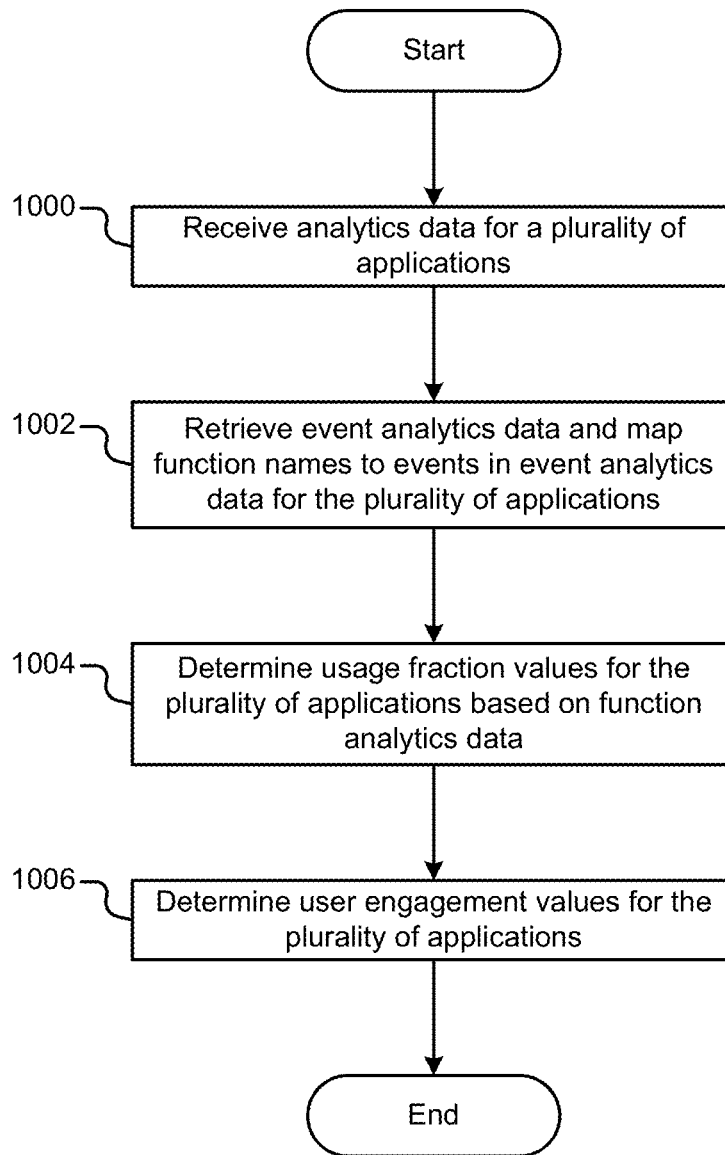


FIG. 7

**FIG. 8**

**FIG. 9**

**FIG. 10**

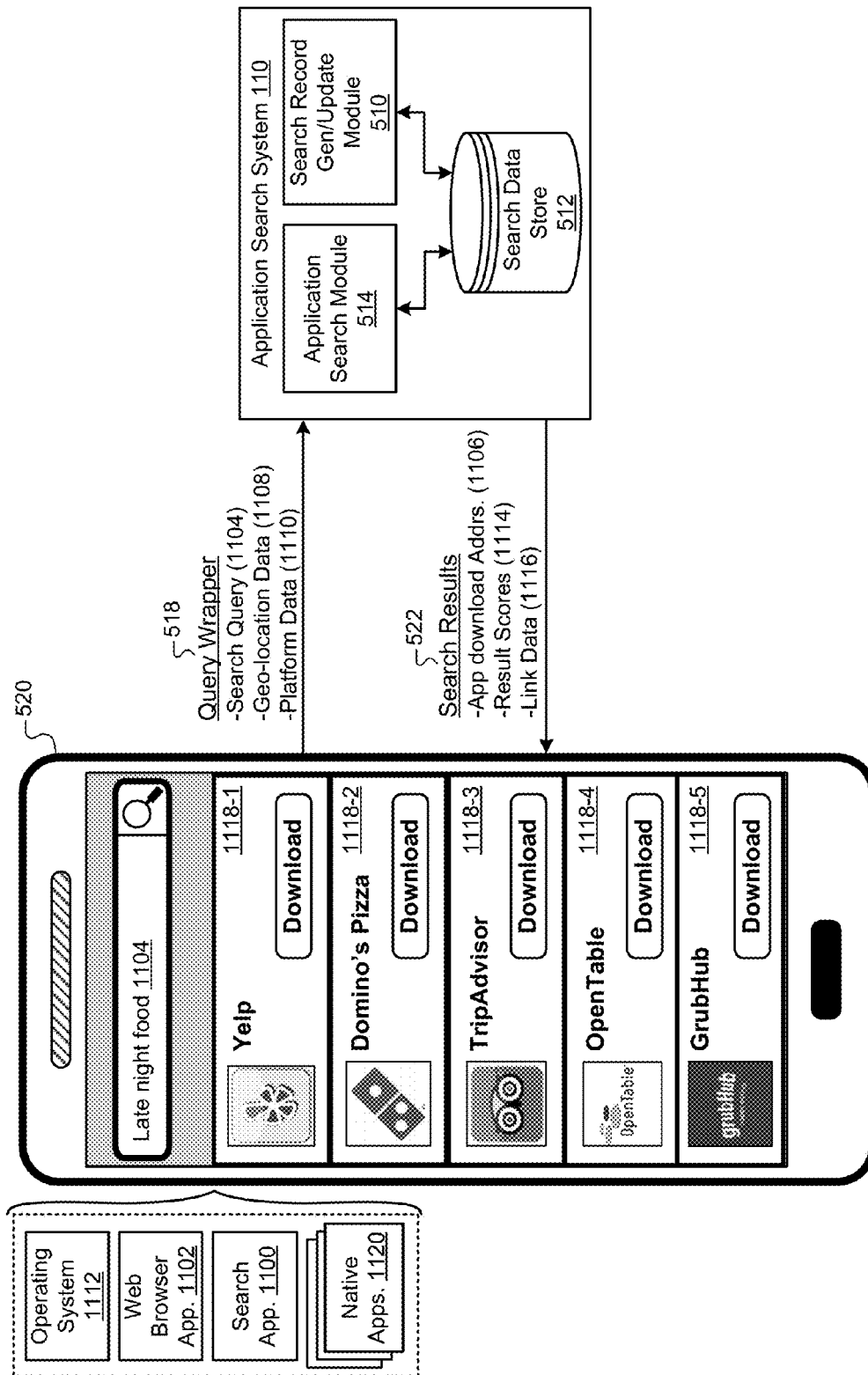


FIG. 11

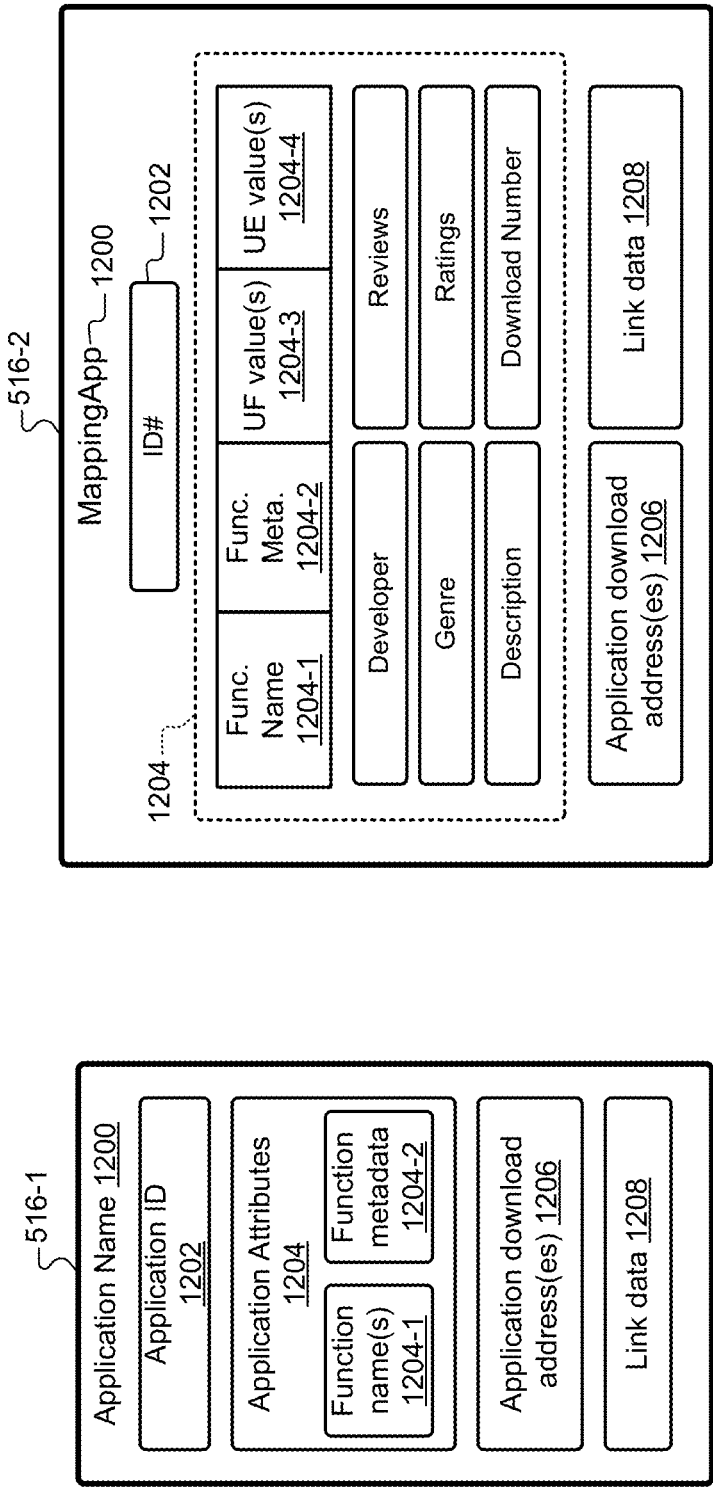
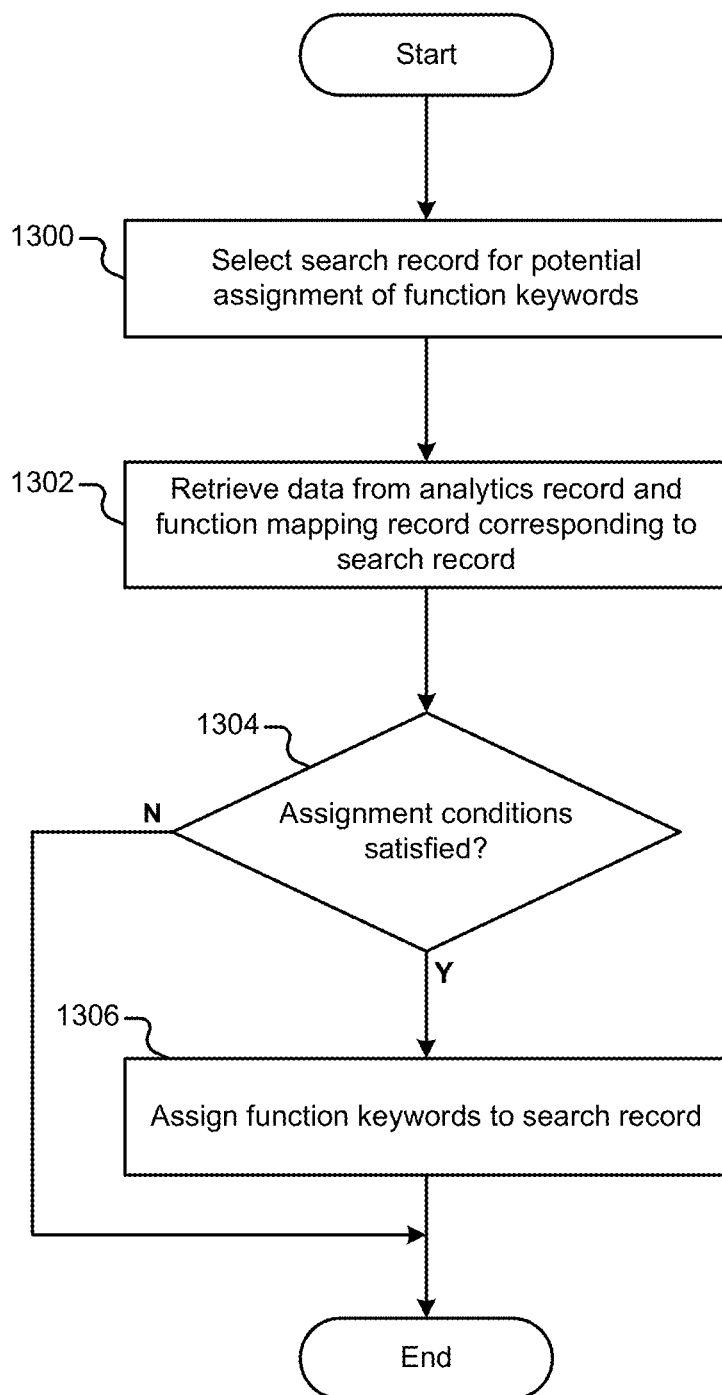


FIG. 12A

FIG. 12B

**FIG. 13**

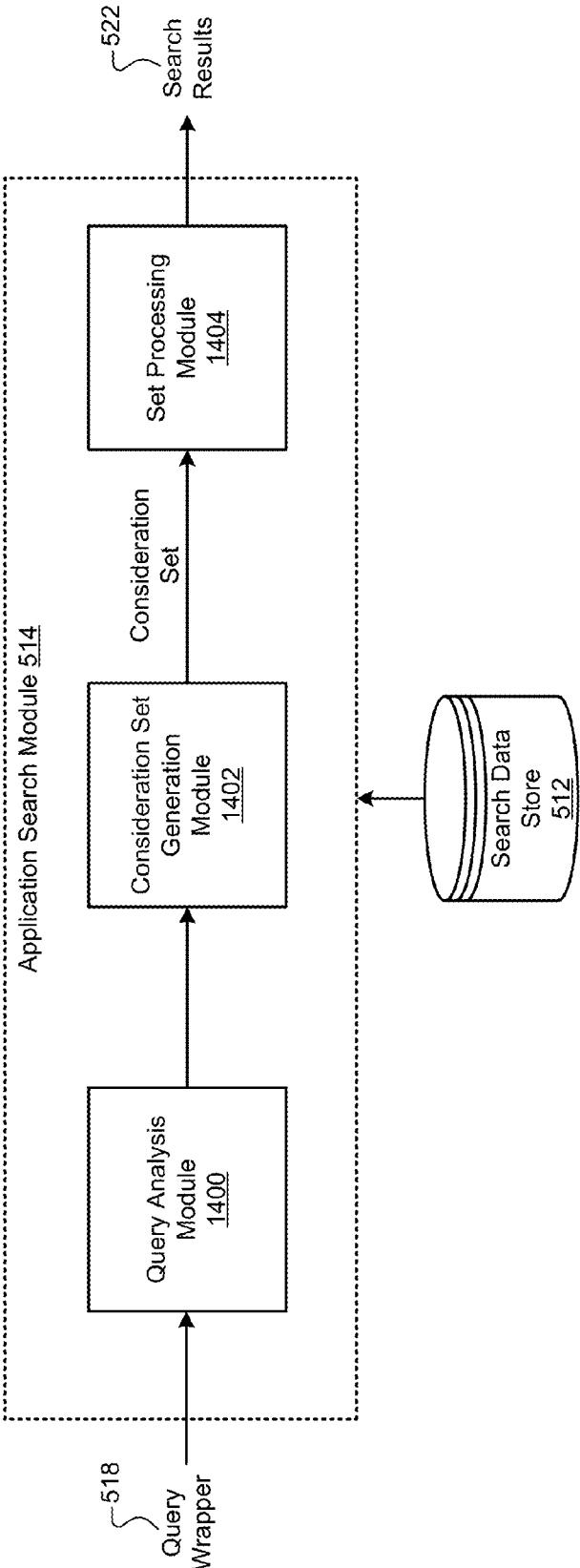
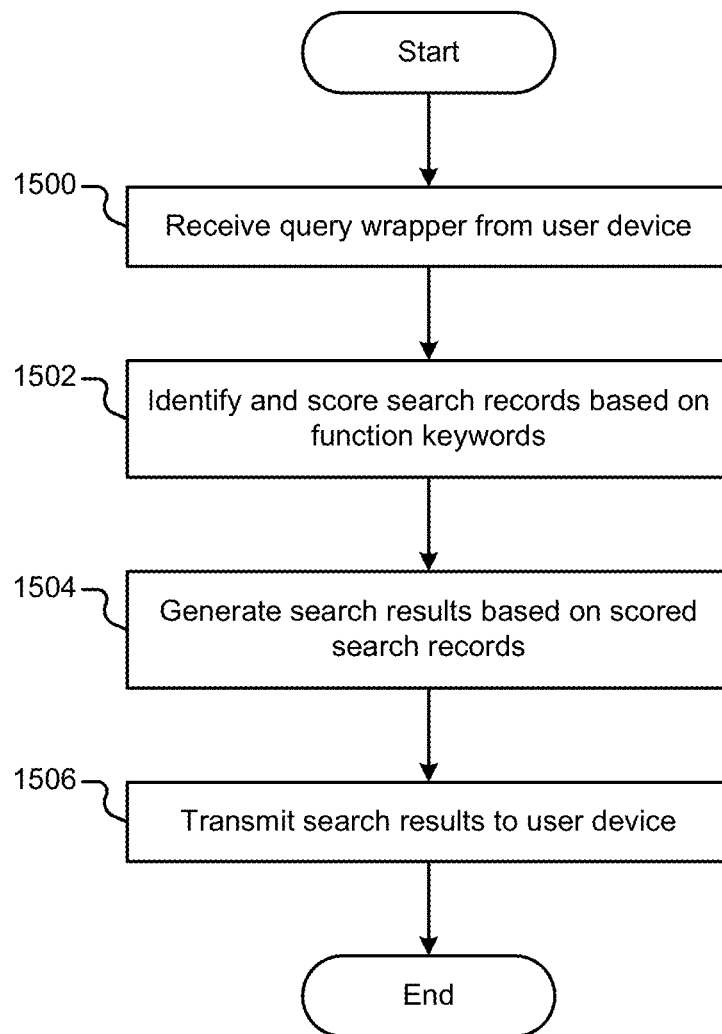


FIG. 14

**FIG. 15**

SEARCHING FOR APPLICATIONS BASED ON APPLICATION USAGE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation of U.S. patent application Ser. No. 14/985,605 filed on Dec. 31, 2015 and U.S. patent application Ser. No. 14/985,667 filed on Dec. 31, 2015. The entire disclosures of the applications referenced above are incorporated by reference.

FIELD

[0002] This disclosure relates to techniques for searching, and more particularly to performing searches for applications based on application usage.

BACKGROUND

[0003] In recent years, use of computers, smartphones, and other Internet-connected devices has grown exponentially. Correspondingly, the number of available software applications for such devices has also grown. Today, many diverse native and web software applications can be accessed on any number of different devices, including, but not limited to, smartphones, personal computers, automobiles, and televisions. These diverse applications can range from business driven applications, games, educational applications, news applications, shopping applications, messaging applications, media streaming applications, social networking applications, and much more. Furthermore, application developers develop vast amounts of applications within each genre and each application may have numerous editions. As a result, users of these Internet-connected devices have encountered the problem of finding the correct native or web software application offering the information and/or functionality that they seek.

SUMMARY

[0004] In one example, the present disclosure is directed to a method comprising retrieving event analytics data for a software application installed on a plurality of user devices. The software application includes a plurality of accessible application states. The event analytics data indicates a number of times each of the accessible application states were accessed by the user devices. The method further comprises mapping function names to the application states accessed by the user devices. Each of the function names indicates a functionality associated with the software application. The method further comprises determining a usage fraction value for each of the function names of the software application based on the number of times each of the function names was mapped, the usage fraction value for each function name indicating the number of times the function name was mapped relative to the number of times each of the function names was mapped. The method further comprises assigning function keywords to an application search record associated with the software application based on the usage fraction values associated with the function names of the software application. Additionally, the method comprises receiving a search query from a querying user device and identifying the application search record based on a match between terms of the search query and terms of the function keywords assigned to the application search record. The method further comprises generating search

results based on the identified application search record and transmitting the search results to the querying user device.

[0005] In another example, the present disclosure is directed to a system comprising one or more computing devices configured to retrieve event analytics data for a software application installed on a plurality of user devices. The software application includes a plurality of accessible application states. The event analytics data indicates a number of times each of the accessible application states were accessed by the user devices. The one or more computing devices are configured to map function names to the application states accessed by the user devices. Each of the function names indicates a functionality associated with the software application. The one or more computing devices are configured to determine a usage fraction value for each of the function names of the software application based on the number of times each of the function names was mapped, the usage fraction value for each function name indicating the number of times the function name was mapped relative to the number of times each of the function names was mapped. The one or more computing devices are configured to assign function keywords to an application search record associated with the software application based on the usage fraction values associated with the function names of the software application. Additionally, the one or more computing devices are configured to receive a search query from a querying user device, identify the application search record based on a match between terms of the search query and terms of the function keywords assigned to the application search record, generate search results based on the identified application search record, and transmit the search results to the querying user device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The details of one or more examples are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

[0007] FIG. 1 illustrates an example environment including a usage fraction determination system and an application search system of the present disclosure.

[0008] FIG. 2 is an example functional block diagram of the environment of FIG. 1.

[0009] FIG. 3 is a flow diagram illustrating an example method describing the operation of the environment of FIG. 1.

[0010] FIGS. 4A-4C illustrate example state graphs and function graphs.

[0011] FIG. 5 is a functional block diagram of an example usage fraction determination system and an example application search system.

[0012] FIG. 6 illustrates an example analytics record.

[0013] FIG. 7 illustrates an example function mapping module that retrieves event analytics data and generates function analytics data.

[0014] FIGS. 8-9 are flow diagrams illustrating example methods for generating time-based usage fraction values and event-based usage fraction values.

[0015] FIG. 10 is a flow diagram illustrating example operations performed by a usage fraction determination system.

[0016] FIG. 11 illustrates an example user device in communication with an application search system.

[0017] FIGS. 12A-12B illustrate example application search records.

[0018] FIG. 13 is a flow diagram illustrating a method for assigning function names and function metadata to an application search record.

[0019] FIG. 14 illustrates an example application search module.

[0020] FIG. 15 is a flow diagram illustrating an example method for performing a search for applications.

DETAILED DESCRIPTION

[0021] The figures and the following description relate to example implementations by way of illustration only. It should be noted that from the following discussion, alternative implementations of the structures and methods disclosed herein will be readily recognized as viable alternatives that may be employed without departing from the scope of the disclosure.

[0022] An application search system (hereinafter “search system”) of the present disclosure receives a search query from a user device and generates search results including a list of links for previewing/downloading applications from a digital distribution platform. The search system stores a plurality of application search records (hereinafter “search records”) used during the search. Each search record may correspond to a single application and may include application attributes that are descriptive of the application associated with the search record. The search system can identify and score the search records based on matches between the search query and terms included in the application attributes along with other scoring features. The search system can then generate search results including a list of links retrieved from the scored search records. For example, the search results may include link data (e.g., text/images) for rendering the search results on a user device and application download addresses for previewing and/or downloading the applications.

[0023] The application attributes of the search records can include function names and/or function metadata (referred to herein generally as “function keywords”) along with a variety of other data (e.g., an application description and application statistics). The function names and function metadata may include terms that describe the various functions of the application. For example an application directed mapping and navigation may provide functions (e.g., function names), such as “Find transportation,” “Driving directions,” and “Walking directions.” Each of the function names may be associated with function metadata. For example, the “Driving directions” function may be associated with terms such as “map,” “car,” “traffic,” “construction,” and “shortest.” The search system may assign the function names and function metadata to the search records based on how users engage with the applications (e.g., based on which states of the applications are accessed). The search system can identify and score the search records during a search based on the function names and/or the function metadata.

[0024] A usage fraction determination system of the present disclosure determines usage fraction values for applications that indicate how users engage with the applications’ different functionalities. The search system may use the usage fraction values to determine how to assign function metadata to the search records. For example, the search system may assign function names and function metadata to

a search record based on which functions of the applications are used, as indicated by the usage fraction values. The additional function names and function metadata in the search records may help to surface the search records during search because the function names and function metadata may provide keyword matches to search queries that may not otherwise have occurred based on the other application attributes. Additionally, the additional description provided by the function names and function metadata may improve relevance by providing relevant keywords for matching with the search query. In some implementations, the usage fraction values associated with function names and function metadata may be used by the search system in order to improve relevance.

[0025] Applications provide a variety of different functions for users. In the present disclosure, each application (e.g., native/web application) is associated with a set of functions (e.g., a set of function names). For example, a review application that provides reviews of businesses may have a plurality of functions, such as “Read Restaurant Review,” “Read Store Review,” “Provide Restaurant Info,” “Show menu,” and “Show food photos.” As another example, a mapping and navigation application may have a plurality of functions, such as “Find transportation to location,” “Driving Directions,” “Walking Directions,” and “Show nearby gas stations.” Each function of an application can be associated with (e.g., assigned to) one or more states of the application. As described herein, each function name can be descriptive of the states with which the function is associated. For example, the review application described above may include a plurality of application states that show menu items for different restaurants. In this example, each of the application states that show menu items may be associated with the “Show menu” function.

[0026] The usage fraction determination system determines the usage fraction values based on analytics data describing how users use the applications (e.g., which application states are accessed). A usage fraction value associated with a function may indicate the relative usage of the function among the plurality of other functions provided by the application. In some cases, usage fraction values for the same/similar functions from a plurality of different applications can be used to compare the functions across the plurality of different applications. For example, those functions that have higher usage fraction values and user engagement may be more relevant than those functions that have lower usage fraction values and/or less user engagement. Information yielded by the usage fraction values, along with other information, can be used in a variety of different ways. In some implementations, a search system of the present disclosure may leverage the usage fraction values to generate relevant search results.

[0027] Each function of an application can be assigned a usage fraction value indicating how much the function is used (e.g., across a group of users). For example, for a set of functions, each of the functions can be assigned a usage fraction value indicating the respective amount of usage for each function. In a more specific example, if an application has four functions, each of the four functions can be assigned a respective usage fraction value. The usage fraction values for an application may be percentage values that indicate an amount of usage of a single function relative to the other functions of the application. The usage fraction values may add up to 100 percent.

[0028] The usage fraction determination system may determine different types of usage fraction values for the same application. Example usage fraction types may include a time-based usage fraction type and an event-based usage fraction type. An application may have a plurality of usage fraction values for each type of usage fraction. For example, for a single usage fraction type, an application may have a single usage fraction value for each of the functions of the application. In a specific example, if an application has four functions and two usage fraction types, the application may have two sets of usage fraction values, one set of four usage fraction values for a first type of usage fraction and another set of four usage fraction values for a second type of usage fraction. In this example, each function of the application can be assigned two usage fraction values.

[0029] In some implementations, the usage fraction determination system may determine one or more user engagement values that indicate an amount of users (e.g., number of user devices) that engaged with the application (e.g., the popularity of the application). For example, a user engagement value may indicate the number of users for which analytics data was collected (e.g., the analytics data upon which the usage fraction values are based). Additionally, or alternatively, user engagement values may include, but are not limited to, a number of application downloads, a number of daily active users, and a number of monthly active users. In some implementations, a search system of the present disclosure may leverage both usage fraction values and user engagement values to generate relevant search results (e.g., using a normalized usage fraction value).

[0030] FIGS. 1-10 are directed to determining usage fraction values and user engagement values that may be used by the search system to assign function keywords to search records. FIG. 11 illustrates an example user device searching for applications. FIGS. 12A-12B illustrate example search records including function names, function metadata, usage fraction values, user engagement values, and other data. FIG. 13 illustrates an example method for assigning function names, function metadata, and other data to a search record. FIGS. 14-15 describe operation of an example application search module that generates application search results based on the function names, function metadata, and other data of the search records.

[0031] FIG. 1 illustrates an example environment that includes one or more application developer systems 100, one or more analytics provider systems 102, and one or more digital distribution platforms 104. The application developer systems 100 represent computing systems of native application developers. The native application developers develop native applications that execute on user devices 106 and then provide the native applications for download on the digital distribution platforms 104. The digital distribution platforms 104 may represent computing systems that are configured to distribute native applications to user devices 106. Example digital distribution platforms 104 include, but are not limited to, the GOOGLE PLAY® digital distribution platform by Google, Inc. and the APP STORE® digital distribution platform by Apple, Inc. In some cases, the same party may own a digital distribution platform 104 and the application search system 110. In this case, the same party may operate the application search system 110 as a search system for the digital distribution platform 104.

[0032] The analytics provider systems 102 represent computing systems that may be operated by analytics software

developers. The analytics software developers may develop analytics modules (e.g., application analytics modules 212-1 and/or device analytics modules 212-2 of FIG. 2) and provide the analytics modules for inclusion in native applications and in user devices 106. For example, the analytics software developers may provide the analytics modules for download on the analytics provider systems 102.

[0033] FIG. 1 includes a usage fraction determination system 108 (hereinafter “UF determination system 108”) and an application search system 110 (hereinafter “search system 110”). The UF determination system 108 retrieves the analytics data from the application developers systems 100 and/or the analytics provider systems 102 and determines usage fraction values based on the retrieved analytics data. In some implementations, the UF determination system 108 may also determine user engagement values. The search system 110 assigns function names and function metadata to search records (e.g., illustrated at 1204-1, 1204-2 in FIGS. 12A-12B) based on the usage fraction values associated with various functions of the applications. The search system 110 receives search queries from user devices 106 and generates search results based on the assigned function names and function metadata, and then transmits the search results to the user devices 106.

[0034] The user devices 106, application developer systems 100, analytics provider systems 102, digital distribution platforms 104, UF determination system 108, and search system 110 may communicate via a network 112. The network 112 may include various types of networks, such as a local area network (LAN), wide area network (WAN), and/or the Internet.

[0035] User devices 106 include, but are not limited to, smart phones, tablet computers, laptop computers, and desktop computers. User devices 106 may also include other computing devices having other form factors, such as computing devices included in vehicles, gaming devices, televisions, or other appliances (e.g., networked home automation devices and home appliances). The user devices 106 may use a variety of different operating systems (illustrated at 1112 in FIG. 11). In an example where a user device 106 is a mobile device, the user device 106 may run an operating system including, but not limited to, ANDROID® developed by Google Inc. or IOS® developed by Apple Inc. In an example where a user device 106 is a laptop or desktop computing device, the user device 106 may run an operating system including, but not limited to, MICROSOFT WINDOWS® by Microsoft Corporation, MAC OS® by Apple, Inc., or Linux.

[0036] User devices 106 may have a plurality of installed native applications (illustrated at 1120 in FIG. 11). In some examples, native applications may function without communication with other remote computing devices (e.g., via the Internet). In other examples, a native application installed on a user device may access information from other remote computing devices during operation. For example, a weather application installed on a user device may access the latest weather information via the Internet and display the accessed weather information to the user through the installed weather application. In still other examples, an application (e.g., a web based application) may be partially executed by the user’s computing device and partially executed by a remote computing device. For example, a web application may be an application that is executed, at least in part, by a web server and accessed by a web browser on

the user device (e.g., a native installed web browser application illustrated at **1102** in FIG. **11**). Example web applications may include, but are not limited to, web-based email, online auctions, and online retail sites.

[0037] FIG. **2** illustrates a functional block diagram including the systems of FIG. **1**. FIG. **3** illustrates a method describing operation of the systems included in FIGS. **1-2**. Example communication between the systems and user devices are labeled with callouts **200-206**. The callouts **200-206** illustrate an example sequence of communications between the systems and user devices. The method of FIG. **3** also includes callouts **200-206** that correspond to the callouts of FIG. **2**. Example operations performed by the systems are now described with respect to FIGS. **2-3**.

[0038] Referring to FIG. **3**, the analytics providers develop analytics modules **210** and provide the analytics modules **212** to the application developer systems **100** at **200**. For example, the analytics providers may provide application analytics modules **212-1** (AAM **212-1** in FIG. **2**) to the developers for download on the analytics provider systems **102**. In this example, the application developer systems **100** may retrieve the application analytics modules **212-1** from the analytics provider systems **102** and include the application analytics modules **212-1** in the native applications **210** under development. Although the analytics developers may provide application analytics modules **212-1** to the application developers for insertion into native applications **210**, in some implementations, analytics provider systems **102** can provide device analytics modules **212-2** (DAM **212-2** in FIG. **2**) for inclusion on the one or more user devices **106** outside of native applications **210** provided on the digital distribution platforms **104**.

[0039] At **201**, the application developers incorporate the application analytics modules **212-1** into the native applications **210** and upload the native applications **210** to the digital distribution platforms **104**. At **202**, a plurality of user devices **106** download and install the native applications **210** including the application analytics modules **212-1**. At **203**, users use the native applications **210** on the user devices **106** and the application analytics modules **212-1** acquire analytics data (e.g., event analytics data) associated with usage of the applications. The application analytics modules **212-1** transfer the acquired analytics data to the respective analytics provider systems **102** and/or the respective application developer systems **100**. In some cases, the application developer systems **100** can store the analytics data. In other cases, the analytics provider systems **102** may store the analytics data and allow the application developer systems **100** to access the analytics data, as indicated by the analytics services provided at **207**. Example analytics services may include formatting analytics data, analyzing the analytics data, displaying analytics data (e.g., via a dashboard), and providing the analytics data to developers for download.

[0040] At **204**, the UF determination system **108** retrieves the analytics data from the application developer systems **100** and/or the analytics provider systems **102**, depending on which systems store the analytics data acquired by the user devices **106** (e.g., application analytics modules **212-1** and/or device analytics modules **212-2**). At **205**, the UF determination system **108** determines usage fraction values based on the retrieved analytics data and the search system **205** assigns function names and function metadata to search records based on the usage fraction values. At **206**, the search system **110** receives search queries from the user

devices **106**, generates search results based on the function names and/or function metadata, and then transmits the search results to the user devices **106**.

[0041] FIGS. **4A-4C** illustrate example application state/function graphs including application states, application functions, and transitions between the application states and application functions. Application states, functions, and transitions are described hereinafter with respect to FIGS. **4A-4C**.

[0042] An application state can refer to a page/screen within an application. In some cases, an application state can be reached as a result of user interaction with the user device on which the native application is installed (e.g., selection of a user selectable link). A user device can access an application state using an access mechanism (e.g., a URL). Access mechanisms may include at least one of a native application access mechanism (hereinafter “application access mechanism”) and a web access mechanism. The user device **106** may use the access mechanisms to access functionality of applications.

[0043] An application access mechanism may be a string that includes a reference to a native application (e.g., one of native applications **210** installed on the user devices **106**) and indicates one or more operations for the user device **106** to perform. If a user selects a user selectable link including an application access mechanism, the user device **106** may launch the native application referenced in the application access mechanism and set the application into a state specified by the application access mechanism. In some cases the application access mechanisms can include application resource identifiers (e.g., defined by the application developers). Such application resource identifiers may have a format similar to a web URL schema including a domain and a path. For example, an application resource identifier for the OPENTABLE® application developed by OpenTable, Inc. may be “vnd.opentable.deeplink://opentable.com/restaurant/profile?rid=1180&refid=1.” This specific application resource identifier may cause the OPENTABLE® Android native application to launch a restaurant table reservation page for a restaurant named “The French Laundry.” In some cases, an application access mechanism may include operations for the user device **106** to perform (e.g., a script) in addition to, or in place of, the application resource identifiers. Example operations may include, but are not limited to, launching a native application, waiting for the native application to start, creating and sending a search request to a server, setting a current geo-location in a native application, making a restaurant reservation, sending a text message, and adding an appointment to a calendar.

[0044] A web access mechanism may include a resource identifier that includes a reference to a web resource (e.g., a page of a web application/website). For example, a web access mechanism may include a uniform resource locator (URL) (i.e., a web address) used with hypertext transfer protocol (HTTP). If a user selects a user selectable link including a web access mechanism, the user device **106** may launch the web browser application (e.g., illustrated at **1102** in FIG. **11**) and retrieve the web resource indicated in the resource identifier. Put another way, if a user selects a user selectable link including a web access mechanism, the user device **106** may launch the web browser application and access a state (e.g., a page) of a web application/website. In some examples, web access mechanisms may include URLs for mobile-optimized sites and/or full sites.

[0045] A user device **106** can access native application states in a variety of different ways from within the native application or from outside of the native application. In one example, a user can select a search result link (associated with an access mechanism) on a webpage or a search result link within a native search application that causes a native application to launch to an application home page or into another state of the native application. In another example, a user can select a web link (e.g., a web page hyperlink) that causes a native application to be set into an application state specified by the web link. In another example, a user can select a link within a native application that sets the native application to a different state within the same native application or accesses a state within a different native application. Although the user device **106** may launch application states in response to the selection of links, in other examples, other types of user interactions with other GUI elements (within or outside of the native application) may cause the user device to access application states. Example interactions may include user interaction with other GUI elements within/outside of the application, such as GUI buttons (e.g., an OK button, a back button, etc.), menus (e.g., drop down menus), or other navigational GUI elements.

[0046] A user can interact with the user device **106** to transition from one application state to another. For example, a user can transition from a first state of a first application to a second state of the first application via a user interaction with the first state (e.g., selection of a link in the first state or interaction with a GUI element of the first state). As another example, a user can transition from a state of a first application to a state of a second application via a user interaction with the state of the first application (e.g., via selection of a link in the state of the first application or interaction with a GUI element of the state). Since different states may include different pages/screens, at least a portion (or all) of the page/screen may change during a transition between states.

[0047] Application states may differ among different applications. For example, application states may display information retrieved from the internet (or the user device **106**), provide interactive GUI elements, play media (audio/video), and provide other features. The number of application states for a single application can vary, depending on the application. In some cases, applications can have thousands or millions of different states. An example application that provides restaurant reviews can have one or more states for each restaurant. Similarly, an example application that provides movie reviews can have one or more states for each movie, actor, and director.

[0048] FIGS. 4A-4B illustrate an example application state graph that represents an application's states (nodes labeled S#) and transitions (labeled T#) between the states. The transitions between application states are represented by arrows. Double ended arrows may indicate that the user can go back and forth between states (e.g., using the GUI). For example, a user can navigate back and forth between states S1 and S2. Single ended arrows may indicate that a user can transition from a first state to a second state, but may not directly navigate back to the first state from within the second state (e.g., via the GUI). For example, in FIG. 4A, a user may transition from state S7 to state S3, but may not access state S7 directly from state S3. FIG. 4A may only show a portion of the application states available in the

application. Accordingly, the presence of additional application states is indicated in FIG. 4A.

[0049] FIG. 4B illustrates example transitions T1-T5 between states S1 and S2. As described above, the specific transitions in both directions can be condensed into a single double ended arrow, as illustrated in FIG. 4A. A user may transition between states in a variety of different manners. The transitions T1-T5 may represent any of a variety of ways to transition between states in an application, such as selecting a link, pushing a GUI button, and/or making a menu selection.

[0050] The analytics modules **212** can log various events described herein. In some implementations, the analytics modules **212** can log a user accessing states of an application, such as when a user enters a state, leaves a state (e.g., closes the application/window and/or powers off the device), and transitions from one state to another. For example, the analytics modules **212** may log access mechanisms (e.g., accessed URLs and/or selected web/app links) that are indicative of the states/functions a user has accessed. In some implementations, the analytics modules **212** may log a user's interactions (e.g., clicks) with various GUI elements that indicate which states/functions the user has accessed. Example GUI elements may include, but are not limited to, GUI buttons (e.g., an OK button, a back button, etc.), menus (e.g., drop down menus), and other navigational GUI elements. In some implementations, the analytics modules **212** may log application specific and/or OS specific operations indicating the states/functions accessed by the user. For example, the analytics modules **212** may log Android intents/activities that are indicative of states/functions. In some implementations, the analytics modules **212** may log when a user views a state of an application. For example, in some cases, a user may scroll through an application, revealing different states that are viewed during the scrolling. The analytics modules **212** may timestamp the events included in the logs. The timestamps may indicate when the events occurred.

[0051] The UF determination system **108** may implement a function ontology that may be used to map function names to application states (e.g., map function names to event analytics data to generate function analytics data as illustrated in FIG. 7). The UF determination system **108** may map function names from the function ontology to one or more applications states. For example the UF determination system **108** may map a single function name to multiple states (e.g., thousands of states). As described herein, the mapping of function names to application states can be used for analytics (e.g., to determine usage fraction values) and/or search.

[0052] Each application can be associated with a plurality of function names (e.g., a list of function names). The function names associated with an application may be descriptive of the different functionalities provided by the application. The UF determination system **108** can map function names associated with an application to application states of the application (e.g., using mapping instructions **706** of FIG. 7). The function name mapped to a specific state may be descriptive of the state to which the function name is mapped. For example, for a review application (e.g., business and restaurant reviews), the UF determination system **108** can map the function names "show restaurant review" and "show business review" to individual states showing restaurant and business reviews, respectively. As

another example, for a movie database application (e.g., the internet movie database IMDb® application), the UF determination system 108 can map the function names “show actor information” and “show movie information” to individual states that show actor information and individual states that show movie information, respectively. As another example, if an application allows the user to reserve restaurant tables, the list of functions associated with the application may include “Reserve Restaurant,” and the UF determination system 108 can map the function name “Reserve Restaurant” to different states of the application that provide reservation functionality for different restaurants. As described herein, the search system 110 may assign function names to search records used to search for applications.

[0053] Although the UF determination system 108 may map a single function name to multiple different states in an application, in some cases, the UF determination system 108 may map a single function name to only a single state instead of multiple states. For example, if a movie application includes a single search page, the UF determination system 108 can map the function “Search Movies” to the single search page and may not map the function “Search Movies” to any other states within the application.

[0054] In some implementations, the UF determination system 108 and the search system 110 may use a function ontology that is specific (e.g., proprietary) to the systems 108, 110. For example, the search system operator and/or the UF determination system operator may implement a specific function ontology that may or may not be used by other parties. In these cases, the UF determination system 108 can map functions to states according to instructions developed by the UF determination system operator and the search system operator (e.g., the same party in some cases). In some implementations, the UF determination system 108 may use a function ontology provided by another party that assigns functions to states (e.g., an application developer, analytics provider, or other ontology source). In these cases, the UF determination system 108 may map function names according to the other party’s rules and the search system 108 may implement the techniques described herein according to the ontology used by the UF determination system 108.

[0055] In some implementations, the UF determination system 108 may implement a function ontology that is applicable across multiple applications such that different applications may use the same function names. In this implementation, the UF determination system 108 can apply the same function name to states of different applications. Such a function ontology applied uniformly across a plurality of applications may be referred to as a generic function ontology. The function names of a generic function ontology may be referred to as generic function names. The mapping of generic function names using a generic function ontology may result in a uniform mapping of functions across different applications. This may be the case when application developers (or operators of the UF determination system 108) map function names from the same function name schema. Uniform mapping of function names across different applications may allow for comparison of states from different applications based on the function names assigned to the states. In some implementations, function names used for an application may not be selected from a uniform function ontology that is applied across a plurality of applications. Instead, different applications may use different function naming schemes. Function names used in this type

of scheme may be application-specific function names instead of generic function names. Application-specific function names may include the application name along with the function name, thereby indicating the application with which the function is associated.

[0056] FIG. 4C illustrates a state/function graph including states and functions from two different applications (A1 and A2). In FIG. 4C, the notation indicating the application and state is A#-S#. For example, a first state of a first application is labeled A1-S1. A first state of a second application is labeled A2-S1. Note that the states associated with application A2 are shaded.

[0057] Functions are illustrated as broken lines around one or more states. The graph shows functions F1-F3 and F4-F5 for applications A1 and A2, respectively, although other functions may be included in applications A1 and A2. The states included with the same function may be assigned the same function name. For example, states A1-S1, A1-S2, and A1-S4 are assigned the function name F1 (e.g., by the UF determination system 108). States A1-S1, A1-S2, and A1-S4 may perform similar functions.

[0058] In some cases, a user can transition from a first state having a first function name to a second state having a second function name that is different than the first function name. For example, a transition from state A1-S2 to A1-S3 is a transition from function name F1 to function name F2. In other cases, transitions between states can be within the same function name (e.g., between state A1-S4 and state A1-S2).

[0059] The state/function graphs of FIGS. 4A-4C are for illustration purposes only. For example, applications and functions may include a much larger number of states than illustrated. In some cases, a single function may include thousands or millions of different states. Accordingly, the functions and states included in the state/function graphs of FIGS. 4A-4C are merely representations that an application can include one or more functions and each function can include one or more states. The states available in an application and the functions associated with the states may change over time. The UF determination system 108 and the search system 110 may update over time to reflect the changes in application states and functions.

[0060] The analytics data may initially be acquired by the user devices 106. Analytics data can be acquired by the user devices in a variety of different manners. In some implementations, a user device 106 can include one or more analytics modules 212 that acquire analytics data. For example, with respect to FIG. 2, native applications 210 can include application analytics modules 212-1 that acquire analytics data. As another example, the user devices 106 may include other modules outside of the installed native applications (e.g., a launcher application or a native application dedicated to analytics acquisition) that acquire analytics data, which may be referred to as device analytics modules 212-2. With respect to device analytics modules 212-2, the analytics provider systems 102 may provide device analytics modules 212-2 for installation on the user devices 106. For example, the analytics provider systems 102 may provide the device analytics modules 212-2 to device manufacturers, launcher application developers, or other parties that may include the device analytics modules 212-2 on the user device 106 outside of other native applications on the user device 106. In some examples, a user device 106 may include a device analytics module 212-2 and

one or more application analytics modules **212-1** in one or more applications that acquire analytics data.

[0061] Analytics data may be categorized herein as event analytics data, function analytics data, and user engagement analytics data (hereinafter “user analytics data”). Event analytics data, function analytics data, and user analytics data are now described in turn.

[0062] Event analytics data refers to analytics data at the event level (e.g., accessing an application state). For example, the event analytics data may describe application usage in terms of application states accessed by users (e.g., in terms of access mechanisms or other device operations). The event analytics data may indicate which states were accessed by users, the time at which the states were accessed by the users (e.g., based on timestamps associated with an event), the amount of time spent by the users within the states, and users’ selection of GUI elements (e.g., user selectable links) within the states. Event analytics data may also include data indicating a user’s path through states of one or more applications, such as a sequence of states accessed by the users. The events included in the events analytics data may correspond to entry into (e.g., rendering of) an application state or exit from an application state. The UF determination system **108** (e.g., the function mapping module **504**) may map function names to the events.

[0063] Function analytics data refers to analytics data at the application function level. For example, the function analytics data may describe application usage in terms of functions accessed by users (e.g., in terms of function names). The function analytics data may indicate which functions were accessed by users (e.g., function names), the time at which the functions were accessed by the users (e.g., timestamps associated with function names), the amount of time spent by the users within the functions, and users’ selection of GUI elements within the functions. Function analytics data may also include data indicating a user’s path through functions of one or more applications, such as a sequence of functions accessed by the users. In some implementations, function analytics data may indicate when a user enters a function and/or exists from a function. The UF determination system **108** can determine usage fraction values based on the function analytics data.

[0064] In some implementations, the UF determination system **108** can receive event analytics data and generate function analytics data based on the event analytics data. For example, the UF determination system **108** may map function names to events (e.g., accessing an application state) included in the event analytics data in order to generate the function analytics data. The mappings of functions to events may be stored as function analytics data at the UF determination system **108**. In general, the analytics data received at the UF determination system **108** may include event analytics data that is then converted into function analytics data by the UF determination system **108**. In some cases, however, the UF determination system **108** may receive function analytics data directly. For example, the UF determination system **108** may receive function analytics data in cases where the analytics modules **212** generate function analytics data at the user devices **106**. In other examples, the UF determination system **108** may receive function analytics data in cases where the application developer systems **100** and/or the analytics provider systems **102** map function names to events in the event analytics data received from user devices **106**.

[0065] User analytics data refers to analytics data indicating an amount of user engagement with an application (e.g., across a plurality of the states/functions of the application). The user analytics data can be generated by the analytics providers, application developers, and/or the UF determination system **108**. In some implementations, user analytics data may include the number of users associated with the analytics data received by the UF determination system **108**. For example, if event analytics data is collected for one thousand users, then the user analytics data may indicate that one thousand users generated the event analytics data. As another example, the user analytics data may indicate the number of user devices that generated the analytics data. In some implementations, user analytics data may include a number of active users of the application (e.g., number of active monthly users), which may be provided by the application developer systems **100**. In some implementations, the analytics data may include other usage metrics, such as the number of times the application was downloaded, which may be provided by the digital distribution platforms **104**.

[0066] An application analytics module **212-1** may include code inserted into a native application **210** that causes the native application to acquire analytics data. For example, the application analytics modules **212-1** may acquire the event analytics data described herein. In some implementations, the application analytics modules **212-1** may acquire function analytics data. The application analytics modules **212-1** may also acquire user analytics data (e.g., data used to determine user engagement values) indicating an amount of user engagement with the application.

[0067] After acquiring the analytics data, the application analytics module **212-1** may store the analytics data on the user device **106** (e.g., in memory of the user device **106**) and/or transmit the analytics data for storage and analysis on other systems. In some implementations, the application developer systems **100** may store the analytics data. For example, an application developer system **100** can have a storage system for storing the analytics data acquired from their applications. In some implementations, an analytics provider system **102** can store the analytics data acquired using their analytics modules. For example, an analytics provider system **102** can store analytics data for a plurality of native applications and provide the analytics data to application developer systems upon request.

[0068] A device analytics module **212-2** may include a program that acquires analytics data similar to the application analytics modules **212-1** (e.g., event analytics data, function analytics data, and/or user analytics data). After acquiring the analytics data, the device analytics module **212-2** may store the analytics data on the user device **106** (e.g., in memory of the user device **106**) and/or transmit the analytics data for storage and analysis on other systems. For example, the device analytics module **212-2** may provide analytics data for a specific application to the application developer system associated with the application. As another example, the analytics provider system can store the analytics data acquired using their analytics module and provide it to the application developer systems **100** and/or the UF determination system **108** upon request.

[0069] In some implementations, analytics data may be collected by advertisers (not illustrated) that may then provide the analytics data to the UF determination system **108**. For example, the advertisers may advertise links to

application states and collect analytics indicating which states were accessed by users. Additional sources of analytics data may be provided by search systems (e.g., search systems that provide access to states of applications). For example, search systems may deliver links to states of applications and collect analytics data indicating which links the users selected. Additional sources of analytics data may be provided by operators of other computing systems that provide user selectable links to users in any manner, such as feeds (e.g., news feeds).

[0070] As described above, the analytics data collected by the analytics modules 212 can be stored on at least one of the user devices 106, the application developer systems 100, and the analytics provider systems 102. The UF determination system 108 can retrieve the analytics data from the user devices 106, the application developer systems 100, and/or the analytics provider systems 102. For example, the operators of the UF determination system 108 may enter into partnership arrangements where application developers provide analytics data to the owners of the search system 110 and the UF determination system 108 in order to improve relevance of search results associated with their applications. Although the search system 110 and UF determination system 108 can be operated by the same party (e.g., the same business), in some implementations, the search system 110 and UF determination system 108 can be operated by separate parties. For example, one or more of the analytics provider systems 102 may include the functionality of the UF determination system 108 described herein. In these implementations, the search system 110 may receive the function names and function metadata from the UF determination system 108 according to an agreement between the search system operator and the UF determination system operator.

[0071] The UF determination system 108 can retrieve the analytics data in batches. For example, the UF determination system 108 can retrieve batches of analytics data at preset times (e.g., at regular time intervals). Additionally, or alternatively, the UF determination system 108 can retrieve the analytics data when a predetermined amount of analytics data is available, such as when analytics data is available for a predetermined number of users, predetermined number of events, and/or predetermined number of functions. The batches of analytics data may include data for a plurality of users that have accessed a plurality of different states in different applications. In some cases, the batches of data may include data from a single application (e.g., analytics data for a plurality of users that accessed a plurality of states in the application). In some implementations, the UF determination system 108 can retrieve the analytics data in real time as the data is collected for an application, instead of in batches.

[0072] The UF determination system 108 (e.g., the UF determination module 506) determines the usage fraction values for a plurality of applications based on the analytics data (e.g., the event analytics data, function analytics data, and user analytics data). For example, the UF determination system 108 can determine event-based and/or time-based usage fraction values based on the analytics data. The UF determination system 108 may also determine user engagement values based on the user analytics data. The search system 110 (e.g., the record generation/update module 510) can update the search records (e.g., search records 516) with function names and function metadata based on the deter-

mined usage fraction values and the determined user engagement values. An example UF determination system 108 and search system 110 are described with respect to FIG. 5.

[0073] Referring to FIG. 5, the UF determination system 108 includes an analytics collection module 500, an analytics data store 502, a function mapping module 504, and a usage fraction determination module 506 (hereinafter “UF determination module 506”). The analytics collection module 500 retrieves analytics data and stores the analytics data in the analytics data store 502. The function mapping module 504 maps function names to the events (e.g., states) of the analytics data to generate function analytics data. The UF determination module 506 determines usage fraction values based on the function analytics data. A user engagement determination module 508 (hereinafter “engagement determination module 508”) may determine user engagement values based on the user analytics data.

[0074] The search system 110 includes a record generation/update module 510 (hereinafter “record generation module 510”), a search data store 512, and an application search module 514 (hereinafter “search module 514”). The record generation module 510 retrieves function names and function metadata from the UF determination system 108 and updates search records 516 stored in the search data store 512 to include the function names and the function metadata. The search module 514 receives a query wrapper 518 (e.g., including a search query) from a querying user device 520 and generates search results 522 based on the received query wrapper 518 and the function names/metadata included in the search records 516. The search module 514 then transmits the search results 522 to the querying user device 520.

[0075] The analytics collection module 500 retrieves analytics data from at least one of the user devices 106, the analytics provider systems 102, and the application developer systems 100. In general, the analytics data received by the analytics collection module 500 may include any data that can be used by the UF determination system 108 to determine the various usage fraction values described herein. The analytics collection module 500 may store the analytics data in analytics records 524 in the analytics data store 502. The analytics data retrieved by the analytics collection module 500 may include event analytics data, function analytics data, and/or user analytics data. In some cases, the analytics collection module 500 may retrieve event analytics data and the function mapping module 504 may generate function analytics data based on the event analytics data. In other cases, the analytics collection module 500 may receive function analytics data directly from the user devices 106, the analytics provider systems 102, and/or the application developer systems 100.

[0076] FIG. 6 illustrates an example analytics record 524. The analytics record 524 may represent analytics data and various values associated with a single application. The analytics data store 502 stores a plurality of such analytics records 524, each of which may correspond to a different application. The analytics data store 502 (e.g., the analytics records 524) may be updated and/or accessed by modules of the UF determination system 108 and the search system 110. The records described herein (e.g., the analytics records 524, function mapping records 526, and search records 516) represent data stored in the data stores (e.g., the analytics data store 502, function data store 528, and search data store

512). The data stores may include a variety of different data structures that are used to implement the techniques of the present disclosure, such as one or more databases, indices (e.g., inverted indices), tables, files, or other data structures.

[0077] The analytics record **524** includes an analytics record name/ID **600** (hereinafter “analytics record ID **600**”) that identifies the analytics record **524** (e.g., uniquely identifies) among the other analytics records in the analytics data store **502**. In implementations where the analytics data store **502** includes a single analytics record **524** for a single application, the analytics record ID **600** may identify the application with which the analytics data and values of the analytics record **524** is associated. In some cases, the analytics record ID **600** may include the application name and application edition with which the analytics record **524** is associated. For example, the analytics record ID **600** may include an application ID that uniquely identifies the application edition with which the analytics record **524** is associated. As described hereinafter, it can be assumed that an analytics record **524** represents analytics data and values for a single application.

[0078] The analytics record **524** includes analytics data **602** for the application. For example, the analytics record **524** may include event analytics data **602-1**, function analytics data **602-2**, and user analytics data **602-3**. The analytics data **602** included in the analytics record **524** may be retrieved from a variety of different sources. The analytics record **524** may also include usage fraction values **604** and user engagement values **606** for the application. Retrieval and determination of the analytics data, usage fraction values, and engagement values is described herein.

[0079] Referring to FIG. 5, the function mapping module **504** maps function names to events (e.g., accessed application states). As described herein, the analytics data including function names (e.g., mapped to events) may be referred to as function analytics data. Accordingly, an example source of function analytics data may be the mapping of function names to event analytics data, as provided by the function mapping module **504**. In other cases, function analytics data may be provided by at least one of the user devices **106**, the analytics provider systems **102**, and the application developer systems **100**. The function mapping module **504** may retrieve event analytics data from the analytics data store **502** (e.g., analytics records **524**) and map function names to events in the events analytics data. The function mapping module **504** may map function names to events based on data included in function mapping records **526** stored in the function data store **528**.

[0080] FIG. 7 illustrates an example function mapping record **526**. A function mapping record **526** may include data indicating how to map function names to events (e.g., an opening of an application state) for an application (e.g., a single native application). The function data store **528** may include a plurality of function mapping records similar to the function mapping record **526** of FIG. 7, each of which may include data indicating how to map function names to events for a respective application.

[0081] The function mapping record **526** may include a mapping record ID **700** that identifies the mapping record **526** (e.g., uniquely identifies) among the other mapping records in the function data store **528**. The function mapping record **526** may also include an application mapping name/ID (hereinafter “app mapping ID **702**”). The app mapping ID **702** may indicate the application with which the function

mapping record **526** is associated. For example, the app mapping ID **702** may indicate the application with which the function name list **704** and the function mapping instructions **706** are associated. In some implementations, the app mapping ID **702** may correspond to an application named in the analytics record name/ID **600** and an application name/ID in a search record **516**. For example, if an application that provides restaurant reviews is named “ReviewsApp,” then the analytics record and the function mapping record for the “ReviewsApp” may include an analytics record ID and an app mapping ID that reference the “ReviewsApp” (e.g., include an identifier for the ReviewsApp and/or the name “ReviewsApp”). Additionally, the search data store **512** may include a search record **516** for the “ReviewsApp” application.

[0082] The function name list **704** includes list of function names associated with the application referenced by the app mapping ID **702**. The list of functions may include those functions that can be mapped to event analytics data by the function mapping module **504**. For example, a review application that provides reviews of businesses (e.g., the YELP® application developed by Yelp, Inc.) may have a list of function names that include “Read Restaurant Review,” “Read Store Review,” “Provide Restaurant Info,” “Show menu,” and “Show food photos.” As another example, a mapping and navigation application may have a list of function names that include “Find transportation to location,” “Driving Directions,” “Walking Directions,” and “Show nearby gas stations.”

[0083] The function mapping record **526** includes function mapping instructions **706** (hereinafter “mapping instructions **706**”). The mapping instructions **706** (e.g., rules) indicate how the function names of the function name list **704** can be mapped to events included in the event analytics data. The function mapping module **504** maps the function names of the function name list **704** to events in the event analytics data based on the mapping instructions **706**. For example, the function mapping module **504** may retrieve an event for an application from event analytics data, retrieve the function mapping record for the application, and then map (e.g., assign) a function name to the event based on mapping instructions that indicate which function name to map to the event. The function mapping module **504** may store the mapping of the function name to the event in the analytics data store **502** as function analytics data. In this manner, the function mapping module **504** may generate function analytics data based on event analytics data. For example, the function mapping module **504** may perform mappings for batches of events (e.g., for single or multiple applications). As another example, the function mapping module **504** may perform mappings for events as the events are received by the analytics collection module **500** (e.g., in real time).

[0084] As described above, events may indicate accessed application/web states (e.g., access mechanisms such as URLs) that correspond to functions, application/OS operations that are indicative of functions (e.g., an Android intent/activity that launches a screen of an application), user inputs that are indicative of a state/function (e.g., selection of GUI input elements), and/or other types of events, such as analytics module specific events (e.g., specific events coded by the analytics developers). The mapping instructions **706** may vary depending on what information is included in the event analytics data. In some implementations, the mapping instructions **706** may include instructions for mapping func-

tion names to application/web states (e.g., access mechanisms) if application/web states are indicated in the event analytics data. For example, the mapping instructions **706** may instruct the function mapping module **504** to map function names based on the domain of the access mechanism and the path of the access mechanism. In some implementations, the mapping instructions **706** may include instructions for mapping function names to application/OS operations if application operations are indicated in the event analytics data. For example, the mapping instructions **706** may instruct the function mapping module **504** to map function names to specific operations, such as specific Android intents/activities. In some implementations, the mapping instructions **706** may include instructions for mapping function names to user inputs, such as the selection of GUI elements having specific functionality (e.g., a search button or a category selection button), if the selection of GUI elements is indicated in the events analytics data. The types of events included in the event analytics data may also vary based on the level of access the analytics module **212** has to acquire analytics data. For example, an application analytics module **212-1** included in a native application may have a greater level of access to determine particular application states and operations of the native application than a device analytics module **212-2** that is not associated with (e.g., coded into) the application.

[0085] In some cases, the analytics data received by the analytics collection module **500** includes function analytics data (e.g., analytics data with mapped function names). In these cases, the function analytics data may include mapped function names upon receipt at the analytics collection module **500** and may be stored in the analytics records **524** without any additional mapping operations being performed by the function mapping module **504**.

[0086] FIG. 7 illustrates the function mapping module **504** mapping function names to various events. Specifically, the function mapping module **504** retrieves three events from event analytics data. The retrieved events are for an application named “App 1.” Each of the events includes a timestamp, labeled as Time 1, Time 2, and Time 3. The timestamps indicate the time at which the events occurred. The function mapping module **504** retrieves the function mapping record for App 1 and maps function names from the function name list to the events according to the function mapping instructions for App 1. In FIG. 7, Function name 1 maps to Event 1 and Event 3. Function name 2 maps to Event 2. The function mapping module **504** may generate function analytics data for a plurality of events for each of a plurality of applications as described above. In terms of the graph of FIG. 4C, the sequence of 3 events may be the entry into state A1-S2 at Time 1 followed by entry into state A1-S3 at Time 2 and the return to either state A1-S2 or transition to A1-S1 at Time 3. Such a path through the graph of FIG. 4C would transition from A1-F1 to A1-F2 and back to A1-F1.

[0087] The UF determination module **506** may determine the amount of time that was spent in an event (e.g., in a state/function) based on the timestamps for single events indicating when the events occurred. For example, assuming that Event 1, Event 2, and Event 3 occur in sequence, the timestamps Time 1, Time 2, and Time 3 may be sequential. The difference between Time 3 and Time 2 may indicate an amount of time the user spent in Function Name 2. Accordingly, the UF determination module **506** can determine the

amount of time spent in Function Name 2 based on the difference between Time 3 and Time 2. Although the UF determination module **506** may determine the amount of time spent in an event/function in some cases, in other cases, the event/function analytics data received by the analytics collection module **500** may already indicate the amount time spent in the event/function.

[0088] The function mapping record **526** includes function metadata **708**. The function metadata **708** may include metadata associated with each of the function names in the function name list. The metadata associated with a function name may include various terms (e.g., words and/or phrases) that are associated with the function name and may provide context as to the meaning of the function name. For example, if the function name is “Navigate to a location,” the metadata associated with the function name may include terms related to navigating to a location, such as “transit,” “directions,” “map,” “car,” “on foot,” and “by bike.” As another example, if the function name is “Order food,” the metadata associated with the function name may include terms related to ordering food, such as “takeout,” “pickup,” “order online,” “delivery,” and “local restaurant.” The terms in the function metadata **708** may be words that are commonly associated with the functions. In some examples, the function metadata **708** may include terms that are commonly used to search for applications that provide the functions. For example, the function metadata **708**, along with the function name, may include terms indicating the functions a user wants to perform with the application. As such, the function metadata **708** may include a group of terms that may enhance application search relevance when assigned to the search records **516**. The function metadata can be generated manually and/or automatically.

[0089] Referring to FIG. 5, the UF determination module **506** determines usage fraction values based on the function analytics data. For example, the UF determination module **506** may retrieve function analytics data for a single application and determine one or more types of usage fraction values for the application. The UF determination module **506** may store the usage fraction values in the analytics record **524** for the application.

[0090] As described herein, each application has a set of associated function names. The UF determination module **506** can determine a usage fraction value for each of the function names associated with the application. The usage fraction value may indicate an amount of usage of the function with which the usage fraction value is associated. Put another way, a usage fraction value may indicate the amount of interaction a user has with an application function relative to other functions of the application. The usage fraction value may be expressed as a percentage value indicating how much the function is used relative to other functions of the application. The usage fraction values for a list of functions may add up to one (e.g., 100%). For example, for an application that has three functions (i.e., function names), there may be three usage fraction values (i.e., one for each function). In this example, the three usage fraction values may add up to one.

[0091] The UF determination module **506** may calculate different types of usage fraction values (e.g., a time-based usage fraction value and/or an event-based usage fraction value). The different types of usage fraction values may reflect the different ways in which application usage can be quantified. One type of usage fraction value described herein

may be referred to as a time-based usage fraction value. The time-based usage fraction value may indicate the amount of time users spent accessing one function of an application relative to other functions of the application. For example, a time-based usage fraction value may indicate how much time users spent in states associated with a particular function relative to the time the users spent in states associated with other functions of the application.

[0092] Another type of usage fraction value described herein may be referred to as an event-based usage fraction value. An event-based usage fraction value may indicate how users access states associated with an application's functions and navigate through states associated with the functions. An example event-based usage fraction value may indicate how many times states of a first function are accessed relative to states of other functions. For example, the UF determination module 506 may calculate a total number of times functions (e.g., states) of the application were accessed and then determine an event-based usage fraction value for each function by determining the fraction of total accesses that are attributable to each function. The UF determination module 506 can determine a variety of different types of event-based usage fractions.

[0093] In some cases, a set of function names can be associated with more than one type of usage fraction value in the analytics record 524. For example, if the UF determination module 506 calculates two different usage fraction values for an application, each function name for the application may have two assigned usage fraction values. More specifically, if an application includes three functions, each of the three functions may be assigned two usage fraction values. The sum of usage fraction values for each type of usage fraction may be one (e.g., 100%). In an example where an application includes three functions and two types of usage fraction values, the sum of the usage fraction values for the first type may be one. Additionally, the sum of the usage fraction values for the second type of usage fraction value may be one. FIG. 6 illustrates two different examples of usage fraction values assigned to function names. In a first example at 608, the application is associated with four function names. Each of the function names is associated with one usage fraction value. The four usage fraction values at 608 may add up to one. In a second example at 610, the application is associated with two different types of usage fraction values. Usage fraction values UF1-UF4 are a first type of usage fraction value. Usage fraction values UF1-UF4 may add up to one. Usage fraction values UF5-UF8 are a second type of usage fraction value that is different than the first usage fraction value. Usage fraction values UF5-UF8 may add up to one.

[0094] FIGS. 8-9 illustrate methods for determining usage fraction values. FIG. 8 illustrates an example method for generating time-based usage fraction values for an application. The method of FIG. 8 is now described with reference to the UF determination system of FIG. 5. At block 800, the analytics collection module 500 retrieves function analytics data for an application. At block 802, the UF determination module 506 determines a total amount of time spent by users across the set of functions for the application. At block 804, the UF determination module 506 determines the amount of time spent by users within each of the functions for the application. At block 806, for each function of the application, the UF determination module 506 determines a time-based usage fraction value by dividing the time spent in the

function by the total amount of time spent by users across the set of functions for the application. In block 808, the UF determination module 506 stores the time-based usage fraction values in the analytics data store 502. The UF determination module 506 can perform the method of FIG. 8 for a plurality of applications to generate time-based usage fraction values for the plurality of applications.

[0095] FIG. 9 illustrates an example method for generating event-based usage fraction values for an application. The method of FIG. 9 is now described with reference to the UF determination system of FIG. 5. At block 900, the analytics collection module 500 retrieves function analytics data for an application. At block 902, the UF determination module 506 determines a total number of times users accessed the set of functions for the application. At block 904, the UF determination module 506 determines the number of times each of the functions was accessed. At block 906, for each function of the application, the UF determination module 506 determines an event-based usage fraction value by dividing the number of times the function was accessed by the total number of times users accessed the set of functions for the application. At block 908, the UF determination module 506 stores the event-based usage fraction values in the analytics data store 502. The UF determination module 506 can perform the method of FIG. 9 for a plurality of applications to generate event-based usage fraction values for the plurality of applications.

[0096] Although the method of FIG. 9 describes calculating an event-based usage fraction value based on the total number of times functions were accessed, in other examples, other types of event-based usage fractions can be determined. For example, in some implementations, the event-based usage fraction values can be based on the total number of times users entered into functions, as opposed to the number of times the functions were accessed. More specifically, if a user first enters a function and then transitions to other states of the same function, such a series of transitions may be counted as a single event for the purposes of calculating an event-based usage fraction value. This is in contrast to the calculation of FIG. 9 where the UF determination module 506 may count each accessed function as an event for the purposes of calculating the event-based usage fraction values.

[0097] Although usage fraction values may be determined based on analytics data collected for a plurality of different users, in some implementations, the UF determination system 108 may determine usage fraction values for a single user. For example, the UF determination module 506 may determine time-based usage fraction values and/or event-based usage fraction values for an individual user based on event analytics data and function analytics data collected for the individual user.

[0098] The engagement determination module 508 determines one or more user engagement values for each application. The user engagement values indicate an amount of users that have engaged with an application. The engagement determination module 508 may determine a user engagement value that indicates the number of users for which analytics data was collected for the application. For example, the engagement determination module 508 may determine the user engagement value based on the number of users associated with the analytics data used to determine the usage fraction values. Additionally, or alternatively, the engagement determination module 508 may determine user

engagement values using other data. In some implementations, the engagement determination module 508 may determine a user engagement value based on the number of times the application was downloaded from a digital distribution platform 104. In some implementations, the engagement determination module 508 may determine a user engagement value based on the number of active users of the application (e.g., the number of daily active users and/or monthly active users). The engagement determination module may store one or more user engagement values in the analytics data store 502.

[0099] FIG. 10 illustrates an example method describing operation of the UF determination system 108 with respect to a plurality of applications. At 1000, the analytics collection module 500 receives analytics data for a plurality of applications over time and may store the analytics data in the analytics data store 502. At 1002, the function mapping module 504 retrieves event analytics data and maps (e.g., assigns) function names to events in the event analytics data to generate function analytics data. At 1004, the UF determination module 506 determines usage fraction values for the plurality of applications based on the function analytics data. At 1006, the engagement determination module 508 may optionally determine one or more user engagement values for the plurality of applications.

[0100] Referring to FIG. 5, the search system 110 receives query wrappers 518 (e.g., search queries) from user devices 520 (which may be referred to as “querying user devices 520”), generates search results 522 in response to the query wrappers 518, and transmits the search results to the user devices 520. The search system 110 may use function names, function metadata, usage fraction values, and/or user engagement values in order to generate the search results 522. The user device 520 may render the search results 522 as user selectable links on a search engine results page (SERP) (e.g., FIG. 11) which the user may select in order to preview/download native applications included in the search results 522.

[0101] The search module 514 receives the query wrapper 518 (e.g., including a search query) from a user device 520 and generates search results 522 based on data included in the search data store 512. The search data store 512 includes search records 516 (e.g., search records 516-1, 516-2 of FIGS. 12A-12B) that include data used during search and for generating search results 522. For example, the search records 516 can include data (e.g., function names and/or function metadata) related to applications that may be downloaded from the digital distribution platforms 104.

[0102] The record generation module 510 generates the search records 516. The record generation module 510 may retrieve data from data sources and generate the search records 516. The record generation module 510 may also retrieve data from the UF determination system 108 and generate portions of the search records 516 to enhance the data included in the search records 516 with data generated by the UF determination system 108. For example, the record generation module 510 may insert function names, function metadata, one or more usage fraction values, and/or one or more user engagement values in the search records 516.

[0103] Search system operation is described hereinafter in detail with respect to FIGS. 11-15. FIG. 11 illustrates an environment including a querying user device 520 and a search system 110 that generates search results 522 for the

user device 520. FIGS. 12A-12B illustrate example search records 516-1, 516-2 stored in the search data store 512. FIG. 13 illustrates a method for assigning function names and/or function metadata to search records. FIGS. 14-15 describe operation of an example search module 514.

[0104] FIG. 11 illustrates an example user device 520 that transmits a query wrapper 518 to the search system 110 via the network 112 and receives search results 522 from the search system 110. As described herein, analytics data may be retrieved from a plurality of user devices 106. Some of the plurality of user devices 106 may optionally interact with the search system 110. A user device 520 that interacts with the search system 110 to retrieve search results 522 may be referred to herein as a “querying user device 520.” In some cases, querying user devices 520 may provide analytics data via analytics modules 212. In other cases, querying user devices 520 may not include the analytics modules 212 and/or provide analytics data. For example, the UF determination system 108 may generate the usage fraction values, user engagement values, function names, and function metadata based on interaction with a first set of user devices 106 that provide analytics data and the search system 110 may provide results to a plurality of querying user devices 520 not included within the first set of user devices 106 that provided the analytics data.

[0105] In some examples, user devices 520 may communicate with the search system 110 via a partner computing system (not illustrated). The partner computing system may be a computing system of a third party that may leverage the search functionality of the search system 110. The partner computing system may belong to a company or organization other than that which operates the search system 110. Example third parties that may leverage the functionality of the search system 110 may include, but are not limited to, internet search providers and wireless communications service providers. The user devices 520 may send search queries to the search system 110 and receive search results 522 via the partner computing system. The partner computing system may provide a user interface to the user devices 520 in some examples and/or modify the search experience provided on the user devices 520.

[0106] In general, a user device 520 may communicate with the search system 110 using any application that can transmit search queries to the search system 110. In some examples, a user device 520 may execute a native application that is dedicated to interfacing with the search system 110, such as a native application dedicated to searches (e.g., search application 1100). In some examples, a user device 520 may communicate with the search system 110 using a more general application, such as a web-based application accessed using the web browser application 1102 (e.g., a web search). In still other examples, the functionality attributed to the search application 1100 herein may be included as a searching component of a larger application that has additional functionality. For example, the functionality attributed to the search application 1100 may be included as part of a native/web application as a feature that provides search for the native/web application. Although the user device 520 may communicate with the search system 110 using a web based application and/or a native search application, the user device 520 may be described hereinafter as using the native search application 1100 to communicate with the search system 110.

[0107] The search application 1100 may display a search field on a graphical user interface (GUI) in which the user can enter search queries 1104. The user may enter a search query 1104 into the search field (e.g., a search box) using a touchscreen or physical keyboard, a speech-to-text program, or other form of user input. In general, a search query 1104 may be a request for information retrieval (e.g., search results 522) from the search system 110. For example, a search query may 1104 be directed to retrieving a list of links to preview/download applications from the search system 110. A search query 1104 may include text, numbers, and/or symbols (e.g., punctuation) entered into the user device 520 by the user. A user may enter a variety of different types of search queries. In some cases, a user may enter a search query indicating what they want to do with an application. For example, a user may enter terms in the search query 1104 that describe functions the user wants an application to perform (e.g., navigate, provide business reviews, etc.) and/or terms associated with the functions that the user wants an application to perform (e.g., “directions,” “map,” “car,” “on foot,” and “by bike”). Including function names and/or function metadata in the search records 516 may increase the likelihood that search records are matched to such queries.

[0108] The user device transmits a query wrapper 518 to the search system 110 that may include a search query 1104. The query wrapper 518 may include additional data along with the search query 1104. For example, the query wrapper 518 may include geo-location data 1108 that indicates the location of the user device 520 (e.g., latitude/longitude coordinates). The query wrapper 518 may also include additional data, including, but not limited to, platform data 1110 (e.g., version of the operating system 1112, device type, and web-browser version), an identity of a user of the user device 520 (e.g., a username), partner specific data, ISP/hostname, and other data.

[0109] A user device 520 receives a set of search results 522 from the search module 514 that are responsive to the query wrapper 518. The search results 522 received from the search module 514 may include one or more application download addresses 1106, result scores 1114, and link data 1116. The user device 520 (e.g., the search application 1100) renders user selectable links 1118 based on the received search results 522 (e.g., links 1118-1, 1118-2, . . . , 1118-5 of FIG. 11). For example, the user device 520 may render user selectable links based on the link data 1116. The link data 1116 may include data for rendering the user selectable links, such as text and/or image data to be included in the user selectable link 1118. Example link data 1116 may include text and images including, but not limited to, application names associated with the application download addresses 1106, text describing the application, and images associated with the application (e.g., application icons).

[0110] Each user selectable link 1118 displayed to the user may include one or more application download addresses 1106 (e.g., for different digital distribution platforms 104 and/or operating systems) and be associated with a result score 1114 that indicates the relevance of the user selectable link 1118 (e.g., the application to be downloaded) to the search query 1104. A user may select a user selectable link 1118 by interacting with the link (e.g., touching or clicking the link). In response to selection of a link, the user device 520 may access the digital distribution platform 104 referenced by the application download address 1106 associated

with the user selectable link 1118. In some implementations, the application download address 1106 may initiate a download of the application. In other implementations, the application download address may access a site where the application can be downloaded. For example, the site may provide a preview of the application (e.g., screenshots), a description of the application, ratings, a number of downloads, user reviews, and a link for downloading the application. In some cases, the site may be operated by the digital distribution platform 104 that provides the application for download. In other cases, the site may be operated by the search system 110, which may provide application search services for a plurality of digital distribution platforms 104.

[0111] FIG. 11 illustrates an example list of user selectable links 1118 that a user device 520 may display to a user. Specifically, FIG. 11 includes user selectable links 1118 included in search results for the search query “Late night food.” The user selectable links 1118 include links to native applications including the YELP® native application, the DOMINOS PIZZA® native application developed by Domino’s Pizza LLC, the TRIPADVISOR® native application developed by TripAdvisor, Inc., the OPENTABLE® restaurant reservation native application, and the GRUB-HUB® Food Delivery native application developed by GrubHub, Inc. The user selectable links 1118 are rendered based on link data 1116 including application icons and application names indicating the application that will be previewed/downloaded in response to selection of the links 1118.

[0112] The search data store 512 includes a plurality of search records 516. The search module 514 may use data included in search records 516 and the query wrapper 518 in order to generate the search results 522. For example, the search module 514 may identify a plurality of search records 516 based on the data included in the query wrapper 518 and then filter/score the identified search records 516 based on the data included in the search records 516 and the query wrapper 518. The search module 514 may then generate search results 522 based on the scored search records 516.

[0113] FIGS. 12A-12B illustrate example search records 516-1, 516-2 that may be included in the search data store 512. Each search record 516 may include data related to an application. The record generation module 510 may generate and update the search records 516 based on data retrieved from a plurality of data sources (not illustrated). For example, the record generation module 510 may automatically create new search records 516 and update existing search records 516 based on data retrieved from the data sources. The record generation module 510 can extract and/or infer the data included in the search records 516 (e.g., application attributes 1204) from documents retrieved from the data sources. Additionally, or alternatively, the data included in the search records 516 (e.g., the application attributes 1204) may be manually generated data. The record generation module 510 may update the search records (e.g., application attributes 1204) over time so that up-to-date search results can be provided in response to a search query.

[0114] The data sources may include a variety of different data providers and the types of data retrieved from the data sources can include a variety of different types of data related to applications. The data sources may include data from application developers, such as application developers’ websites and data feeds provided by developers. The data sources may include operators of digital distribution plat-

forms **104** configured to distribute native applications to user devices **520**. The data sources may also include other websites, such as websites that include web logs (i.e., blogs), application review websites, or other websites including data related to applications. Additionally, the data sources may include social networking sites, such as “FACEBOOK®” by Facebook, Inc. (e.g., Facebook posts) and “TWITTER®” by Twitter Inc. (e.g., text from tweets). Data sources may also include online databases that include, but are not limited to, data related to movies, television programs, music, and restaurants. Data sources may also include additional types of data sources in addition to the data sources described above. Different data sources may have their own content and update rate.

[0115] Examples of data related to applications include, but are not limited to, a name of an application, a description of an application, a substantive review of an application, a quality rating of an application, a developer name, an excerpt from a blog post about an application, a tweet about an application, and one or more images (e.g., icons and/or screenshots) associated with the application. The record generation module **510** may also retrieve statistical data from the data sources. Statistical data may include any numerical data related to an application, such as a number of downloads, download rates (e.g., downloads per month), a number of reviews, and a number of ratings. In some examples, data retrieved from the data sources may include information regarding the functionalities of applications.

[0116] FIGS. 12A-12B illustrate example search records **516**. Referring now to FIG. 12A, an example search record **516-1** includes an application name **1200**, an application identifier (ID) **1202**, application attributes **1204**, one or more application download addresses **1206**, and link data **1208**. The search record **516-1** represents data stored in the search data store **512** that is related to an application. The search data store **512** may include a plurality of search records having a similar structure as the search record **516-1**. Put another way, the search data store **512** may include a plurality of search records having an application name **1200**, an application ID **1202**, application attributes **1204**, one or more application download addresses **1206**, and link data **1208**.

[0117] The application name **1200** may be the name of the application represented by the data in the search record **516-1**. Example application names may include, Yelp, OpenTable, Google Maps, Facebook, Twitter, Microsoft Word, or Angry Birds. The application ID **1202** identifies the search record **516-1** among the other search records included in the search data store **512**. For example, the application ID **1202** may uniquely identify the search record **516-1**. The application ID **1202** may be a string of alphabetic, numeric, and/or symbolic characters (e.g., punctuation marks).

[0118] The one or more application download addresses **1208** may indicate a site(s) (e.g., web/native, such as the GOOGLE PLAY® digital distribution platform) where the native application referenced in the search record **516-1** can be downloaded and/or previewed. Link data **1208** may include data used by the user device **520** to generate the user selectable links **1118** (e.g., text and/or images) in the SERP (e.g., FIG. 11).

[0119] The application attributes **1204** may include any type of data which may be associated with the application represented by the search record **516-1**. The application attributes **1204** may include a variety of different types of

data. For example, the application attributes **1204** may include structured, semi-structured, and/or unstructured data. The application attributes **1204** may include information that is extracted or inferred from documents retrieved from the data sources. In some examples, the application attributes **1204** may include data that is manually generated. The application attributes **1204** may be updated so that up to date results can be provided in response to a search query **1104**.

[0120] The application attributes **1204** may include the name of the developer of the application, the publisher of the application, a category (e.g., genre) of the application, a description of the application (e.g., a developer’s description), a version of the application, the operating system for the application, and the price of the application. The application attributes **1204** may also indicate security or privacy data about the application, battery usage of the application, and bandwidth usage of the application.

[0121] The application attributes **1204** may include application statistics. Application statistics may refer to numerical data related to the application. For example, application statistics may include, but are not limited to, a number of downloads, a download rate (e.g., downloads per month), a number of ratings, and a number of reviews. The application attributes **1204** may also include information retrieved from websites such as reviews associated with the application, articles associated with the application (e.g., wiki articles), or other information. The application attributes **1204** may also include digital media related to the application, such as images (e.g., icons and/or screenshots).

[0122] The application attributes **1204** may also include the function names, function metadata, usage fraction values, and/or user engagement values described herein. The record generation module **510** may retrieve the function names, function metadata, usage fraction values, and/or user engagement values from the UF determination system **108** (e.g. from analytics records **524** and/or function mapping records **526**). For example, the record generation module **510** may retrieve the data from the analytics records **524** by identifying matches between the application name **1200** and/or the application ID **1202** of the search record **516-1** and the analytics record name/ID **600** of the analytics records **524**. As another example, the record generation module **510** may retrieve the data from the function mapping records **526** by identifying matches between the application name **1200** and/or the application ID **1202** of the search record **516-1** and the app mapping ID **702** of the function mapping record **526**.

[0123] In some cases, the record generation module **510** may be configured to assign each of the function names, associated function metadata, and associated usage fraction values to the search record **516**. In other cases, the record generation module **510** may be configured to assign a subset of the function names, associated function metadata, and associated usage fraction values to the search record **516-1** (e.g., based on assignment conditions described herein). In some cases, some search records **516** may not include function names and function metadata.

[0124] FIG. 12B illustrates an example search record **516-2** for an application called “MappingApp.” The search record **516-2** includes the application name “MappingApp” **1202** and an application ID “ID#” **1202**. The search record **516-2** also includes link data **1208** for generating a user selectable link **1118** for the MappingApp and one or more

application download addresses **1206** for downloading the MappingApp. The search record **516-2** also includes application attributes **1204**. The application attributes **1204** include the developer of the MappingApp, a genre of the MappingApp (e.g., travel), a description of the MappingApp (e.g., a developer's provided description), reviews of the MappingApp (e.g., user reviews), ratings (e.g., user ratings), and a number of times the MappingApp was downloaded.

[0125] The application attributes **1204** includes a single function name **1204-1** associated with the MappingApp along with associated function metadata **1204-2** and one or more usage fraction values **1204-3**. The application attributes **1204** also includes one or more user engagement values **1204-4** associated with the MappingApp. An example function name may be "Navigate to a location." Example function metadata associated with the "Navigate to a location" function name may be "directions," "map," "car," "on foot," and "by bike." The usage fraction values **1204-3** may be values between 0-100%, depending on how much the function "Navigate to a location" is accessed by users of the MappingApp. Other example function names that may be associated with the MappingApp, but were not included in the search record **516-2** (e.g., due to low usage fraction values) may include "show traffic," "show terrain," and "show public transit," for example.

[0126] As described herein, the record generation module **510** may communicate with the UF determination system **108** in order to retrieve function names, function metadata, usage fraction values, and user engagement values for assignment to search records **516**. The function names and/or function metadata may be generally referred to hereinafter as "function keywords." The function keywords, associated usage fraction values, and associated user engagement values may be used in identification and scoring of search records **516** during search.

[0127] The record generation module **510** may assign function keywords to the search records **516** based on the satisfaction of function keyword assignment conditions (hereinafter "assignment conditions") associated with the function keywords. In some implementations, the search system operator may set the assignment conditions. A variety of assignment conditions are described hereinafter. In some implementations, the search system operator may use only a single assignment condition. In other cases, the search system operator may use multiple assignment conditions from the assignment conditions described hereinafter. The assignment conditions may be stored in the record generation module **510** and applied across a plurality of the search records **516**. In other implementations, a search record may include app-specific assignment conditions (not illustrated in FIGS. **12A-12B**) indicating conditions for assigning function keywords to the search record.

[0128] Assignment conditions may vary, depending on how the search system operator implements the assignment conditions. In some implementations, the assignment conditions may include conditions regarding the magnitude of usage fraction values associated with functions. In one example, an assignment condition may include a threshold usage fraction value. For example, the record generation module **510** may be configured to assign function keywords to the search record **516** if the usage fraction value associated with the function keywords (e.g., the function name) is greater than a threshold value (e.g., >50%). As another example, the record generation module **510** may be config-

ured to assign function keywords to the search record **516** if the usage fraction value associated with the function keywords indicates that the function is used a threshold amount more than the other functions of the application (e.g., the usage fraction value is a threshold amount greater than the other usage fraction values). A function that is used a threshold amount more than other functions may be referred to as a "dominant function" or a "specialized function" of the application, as the users may tend to associate the application with that particular functionality. In some implementations, the record generation module **510** may be configured to assign function keywords to the search record **516** if multiple usage fraction values of different types are greater than a threshold value. For example, the record generation module **510** may assign function keywords to a search record if an event-based usage fraction value and a time-based usage fraction value associated with the function keywords are both greater than a threshold value. In some cases, the different types of usage fraction values may be compared against the same threshold value. In other cases, each type of usage fraction value may be compared against a different threshold value.

[0129] In some implementations, the assignment conditions may include conditions associated with a combination of a usage fraction value and user engagement value. For example, the record generation module **510** may be configured to assign function keywords to a search record **516** if the product of the usage fraction value and the user engagement value (referred to herein as a "normalized usage fraction value") is greater than a threshold value. In a more specific example, if the usage fraction value (e.g., time or event-based usage fraction value) is 25% and the user engagement value (e.g., total monthly active users) is 20000, then the normalized usage fraction value may equal 5000. If the assignment conditions include a threshold normalized usage fraction value of 4000, then the record generation module **510** may assign the function keywords associated with the normalized usage fraction value to the search record **516**.

[0130] In some cases, the assignment conditions may include a threshold user engagement value. For example, the record generation module **510** may be configured to assign function keywords to a search record **516** if the user engagement value is greater than a minimum threshold user engagement value (e.g., a minimum number of active users and/or downloads). In cases where the assignment conditions include a minimum user engagement value, the record generation module **510** may refrain from assigning function keywords to a search record **516** if the minimum user engagement value is not satisfied. This may prevent unpopular applications from being assigned function keywords.

[0131] The record generation module **510** may assign additional data to the search records **516** along with the function keywords. For example, the record generation module **510** may assign usage fraction values and/or user engagement values to the search records **510** along with the function keywords. The record generation module **510** may assign this additional data to the search records **516** based on the assignment conditions described above. The search system owner may configure the record generation module **510** to assign the additional data (e.g., which data to assign) and the conditions for assignment.

[0132] FIG. **13** illustrates a method for assigning function keywords and other data (e.g., usage fraction values and/or

user engagement values) to search records **516**. The method is directed to assigning function keywords and other data to a single search record. The record generation module **510** may repeat the method for each search record **516** in the search data store **512**. The method is described with reference to the search system **110** and the UF determination system **108** of FIG. 5.

[0133] In block **1300**, the record generation module **510** selects a search record **516** for potential assignment of function keywords. In block **1302**, the record generation module **510** retrieves data from the UF determination system **108** associated with the application of the search record **516**. For example, the record generation module **510** may retrieve data from an analytics record **524** (e.g., the usage fraction values and/or the user engagement values) for the application and a function mapping record **526** (e.g., the function names and function metadata) for the application.

[0134] In block **1304**, the record generation module **510** determines whether assignment conditions are satisfied for the search record **516**. If the assignment conditions are not satisfied, the record generation module **510** may refrain from assigning function keywords and other data to the search record **516**. If the assignment conditions are satisfied, the record generation module **510** may assign the function keywords and other data (e.g., usage fraction values and/or user engagement values) to the search record **516** in block **1306**. Note that the record generation module **510** may update the function keywords and other data over time based on changes in usage of the application.

[0135] Referring to FIG. 5, the search module **514** can use the search query **1104** and the additional data included in the query wrapper **518** to generate the search results **522**. The search module **514** performs a search for search records **516** included in the search data store **512** in response to the received query wrapper **518**. In some implementations, the search module **514** generates result scores **1114** for search records **516** identified during the search. The result score **1114** associated with a search record **516** may indicate the relevance of the search record **516** to the search query **1104**. A larger result score may indicate that the search record **516** is more relevant to the search query **1104**. The search module **514** may retrieve application download addresses **1106** from the scored search records **516**. The search module **514** can transmit a result score **1114** along with one or more application download addresses **1106** retrieved from a scored search record **516** in order to indicate the rank of the application download addresses among other transmitted application download addresses.

[0136] FIG. 14 illustrates an example search module **514** that includes a query analysis module **1400**, a consideration set generation module **1402** (hereinafter “set generation module **1402**”), and a consideration set processing module **1404** (hereinafter “set processing module **1404**”).

[0137] The query analysis module **1400** receives the query wrapper **518**. The query analysis module **1400** analyzes the received search query **1104**. For example, the query analysis module **1400** may perform various analysis operations on the received search query **1104**, such as tokenization of the search query **1104**, filtering of the search query **1104**, stemming, synonymization, and stop word removal. In some implementations, the query analysis module **1400** may perform analysis targeted at identifying query terms associated with function names. In these implementations, the query analysis module **1400** may indicate whether the search query

1104 includes query terms associated with function names and/or may indicate the function names associated with the query terms. For example, if the query analysis module **1400** receives a search query “transit maps,” the query analysis module **1400** may identify the terms “transit” and/or “maps” as being associated with the “Navigate to a location” function name. In some cases, a determination that query terms are associated with function names may be used by the set generation module **1402** and/or the set processing module **1404** for scoring (e.g., as part of a query scoring feature indicating that query terms are associated with certain function names).

[0138] The set generation module **1402** identifies a plurality of search records **516** based on the output of the query analysis module **1400** (e.g., search query tokens). For example, the set generation module **1402** may identify a plurality of search records **516** based on matches between terms of the search query **1104** and terms in the application attributes **1204**. In one example, the set generation module **1402** may identify a plurality of search records **516** based on matches between terms of the search query **1104** and terms included in the function keywords (e.g., function names and/or function metadata). Inclusion of the function keywords may result in the surfacing of search records **516** that may not otherwise have been found during the search. Additionally, or alternatively, the set generation module **1402** may identify a plurality of search records **516** based on matches between terms of the search query **1104** and other terms included in the application attributes **1204**, such as terms included in a description of the application, the developer of the application, the genre of the application, and/or reviews of the application.

[0139] In some implementations, the set generation module **1402** may calculate a preliminary score for the identified search records **516** of the consideration set. In these implementations, the set generation module **1402** may calculate the preliminary scores based on which fields of the search records **516** matched terms of the search query **1104**. Different fields of the search records **516** may have different weightings for the purposes of calculating the preliminary scores. For example, the function keyword field (e.g., the function name and/or function metadata) may have a first weighting for the purposes of calculating a preliminary score while the other fields of the application attributes **1204** (e.g., the description, genre, etc.) have different weightings for the purposes of calculating a preliminary score. In examples where the set generation module **1402** calculates a preliminary score for a search record **516**, the set generation module **1402** may calculate the preliminary score for the search record **516** based on which fields include terms that match terms of the search query **1104**. For example, the set generation module **1402** may boost a preliminary score if one or more terms from the function keyword field matches one or more terms of the search query **1104**.

[0140] In some implementations, the set generation module **1402** may calculate the preliminary score based on the usage fraction value associated with the function name and/or function metadata that matches the search query **1104**. For example, the usage fraction value may be used as a weighting (e.g., a boosting value) for the purposes of calculating the preliminary score. In some implementations, the set generation module **1402** may calculate the preliminary score based on the user engagement value and the usage fraction value associated with the function name and/or

function metadata that matches the search query **1104**. For example, the normalized usage fraction value may be used as a weighting (e.g., a boosting value) for the purposes of calculating the preliminary score.

[0141] The set processing module **1404** may score the search records in the consideration set in order to generate a set of search results **522**. The scores associated with the search records **516** may be referred to as “result scores.” The set processing module **1404** may determine a result score for each of the search records in the consideration set. The result scores associated with a search record may indicate the relative rank of the search record (e.g., the application download addresses) among other search records. When ordering search results **522** (e.g., at the set processing module **1404** and/or the user device **520**), the search results **522** may be ordered from the highest result score to the lowest result score from the top of the display to the bottom.

[0142] The set processing module **1404** may generate result scores **1114** for search records **516** in a variety of different ways. For example, as described herein, the set processing module **1404** may generate result scores **1114** for search records **516** based on function keywords (e.g., function metadata and/or function names), usage fraction values **1204-3**, user engagement values **1204-4**, and/or other data included in the application attributes **1204**.

[0143] In some implementations, the set processing module **1404** generates a result score **1114** for a search record **516** based on one or more scoring features. The scoring features may be associated with the search record **516** and/or the search query **1104**. A search record scoring feature (hereinafter “record scoring feature”) may be based on any data associated with a search record **516**. For example, record scoring features may be based on any data included in the application attributes **1204**, such as data indicating the popularity of an application (e.g., number of downloads), the ratings (e.g., number of stars) associated with an application, and other application statistics.

[0144] A query scoring feature may include any data associated with the search query **1104**. For example, query scoring features may include, but are not limited to, a number of words in the search query **1104**, the popularity of the search query **1104**, and the expected frequency of the words in the search query **1104**. As described above, the identification of query terms that are associated with function names may be used as a query scoring feature. For example, the query scoring feature may be a binary feature (e.g., 0/1) indicating whether the query terms are associated with a function name, as determined by the query analysis module **1400**.

[0145] A record-query scoring feature may include any data generated based on data associated with both the search record **516** and the search query **1104** that resulted in identification of the search record **516** by the set generation module **1402**. For example, record-query scoring features may include, but are not limited to, parameters that indicate how well the terms of the search query **1104** match the terms of the application attributes **1202**, such as the function keywords (e.g., the function name **1204** and/or the function metadata **1206**). In some implementations, record-query scoring features may include the preliminary scores calculated by the set generation module **1402**. The record-query scoring features may also include binary features (e.g., 0/1) indicating whether terms of the search query **1104** match terms of the function keywords and/or whether terms of the

search query **1104** match function keywords associated with a dominant/specialized function. In some implementations, record-query features (e.g., binary features) can be weighted by the usage fraction values (e.g., normalized usage fraction values) associated with the matched function keywords. The record-query scoring features may also include a feature indicating how many terms from the search query match the function keywords. In some implementations, a record-query scoring feature may be an indication of the coverage of the function keywords by the search query (e.g., the coverage indicating a percentage of function keywords included in the query terms).

[0146] The set processing module **1404** may generate a result score **1114** for a search record **516** based on at least one of the record scoring features, the query scoring features, and the record-query scoring features. For example, the set processing module **1404** may determine a result score **1114** based on one or more of the scoring features listed herein and/or additional scoring features not explicitly listed. In some examples, the set processing module **1404** may include one or more machine learned models (e.g., a supervised learning model) configured to receive one or more scoring features. The one or more machine learned models may generate result scores **1114** based on at least one of the record scoring features, the query scoring features, and the record-query scoring features. For example, the set processing module **1404** may pair the search query **1104** with each search record **516** and calculate a vector of features for each (query, record) pair. The vector of features may include one or more record scoring features, one or more query scoring features, and one or more record-query scoring features. The set processing module **1404** may then input the vector of features into a machine-learned regression model to calculate a result score **1114** for the search record. In some examples, the machine-learned regression model may include a set of decision trees (e.g., gradient boosted decision trees). In another example, the machine-learned regression model may include a logistic probability formula. In some examples, the machine learned task can be framed as a semi-supervised learning task, where a minority of the training data is labeled with human curated scores and the rest are used without human labels.

[0147] FIG. 15 illustrates an example method for performing a search according to the present disclosure. The method is described with reference to the search module **514** of FIG. 14. In block **1500**, the query analysis module **1400** receives a query wrapper **518** from a user device **520** and analyzes the search query **1104**. In block **1502**, the set generation module **1402** identifies a consideration set of search records based on the query wrapper **518** and the set processing module **1404** scores the search records of the consideration set. Put another way, the set processing module **1404** may generate result scores **1114** for the search records of the consideration set. For example, the set processing module **1404** may generate result scores **1114** for the search records based on at least one of the assigned function metadata, function names, usage fraction values, and the user engagement values included in the search record, along with other scoring features. In block **1504**, the set processing module **1404** generates search results **522** based on the scored search records. The search results **522** may include application download addresses **1106** and link data **1116** from the scored search records, along with result scores **1114** corresponding

to the search records. In block **1506**, the set processing module **1404** transmits search results **522** to the user device **520**.

[0148] Although the function names described herein may be human readable function names that indicate the functionality provided by different application (e.g., application states), in some implementations, function names may include, or be replaced by, identifiers that may not be human readable. Such identifiers may be used in place of the function names. For example, event analytics data, function analytics data, usage fraction values, and user engagement values may be calculated based on the unique identifiers in a similar manner described above. Furthermore, the search system **110** of the present disclosure may receive a query wrapper and generate search results in a similar manner described above when such identifiers are used.

[0149] Modules and data stores included in the systems (e.g., **108**, **110**) represent features that may be included in the systems of the present disclosure. The modules and data stores described herein may be embodied by electronic hardware, software, firmware, or any combination thereof. Depiction of different features as separate modules and data stores does not necessarily imply whether the modules and data stores are embodied by common or separate electronic hardware or software components. In some implementations, the features associated with the one or more modules and data stores depicted herein may be realized by common electronic hardware and software components. In some implementations, the features associated with the one or more modules and data stores depicted herein may be realized by separate electronic hardware and software components.

[0150] The modules and data stores may be embodied by electronic hardware and software components including, but not limited to, one or more processing units, one or more memory components, one or more input/output (I/O) components, and interconnect components. Interconnect components may be configured to provide communication between the one or more processing units, the one or more memory components, and the one or more I/O components. For example, the interconnect components may include one or more buses that are configured to transfer data between electronic components. The interconnect components may also include control circuits (e.g., a memory controller and/or an I/O controller) that are configured to control communication between electronic components.

[0151] The one or more processing units may include one or more central processing units (CPUs), graphics processing units (GPUs), digital signal processing units (DSPs), or other processing units. The one or more processing units may be configured to communicate with memory components and I/O components. For example, the one or more processing units may be configured to communicate with memory components and I/O components via the interconnect components.

[0152] A memory component may include any volatile or non-volatile media. For example, memory may include, but is not limited to, electrical media, magnetic media, and/or optical media, such as a random access memory (RAM), read-only memory (ROM), non-volatile RAM (NVRAM), electrically-erasable programmable ROM (EEPROM), Flash memory, hard disk drives (HDD), magnetic tape

drives, optical storage technology (e.g., compact disc, digital versatile disc, and/or Blu-ray Disc), or any other memory components.

[0153] Memory components may include (e.g., store) data described herein. For example, the memory components may include the data (e.g., records) included in the data stores. Memory components may also include instructions that may be executed by one or more processing units. For example, memory may include computer-readable instructions that, when executed by one or more processing units, cause the one or more processing units to perform the various functions attributed to the modules and data stores described herein.

[0154] The I/O components may refer to electronic hardware and software that provides communication with a variety of different devices. For example, the I/O components may provide communication between other devices and the one or more processing units and memory components. In some examples, the I/O components may be configured to communicate with a computer network. For example, the I/O components may be configured to exchange data over a computer network using a variety of different physical connections, wireless connections, and protocols. The I/O components may include, but are not limited to, network interface components (e.g., a network interface controller), repeaters, network bridges, network switches, routers, and firewalls. In some examples, the I/O components may include hardware and software that is configured to communicate with various human interface devices, including, but not limited to, display screens, keyboards, pointer devices (e.g., a mouse), touchscreens, speakers, and microphones. In some examples, the I/O components may include hardware and software that is configured to communicate with additional devices, such as external memory (e.g., external HDDs).

[0155] In some implementations, the systems may include one or more computing devices (e.g., a computer search system) that are configured to implement the techniques described herein. Put another way, the features attributed to the modules and data stores described herein may be implemented by one or more computing devices. Each of the one or more computing devices may include any combination of electronic hardware, software, and/or firmware described above. For example, each of the one or more computing devices may include any combination of processing units, memory components, I/O components, and interconnect components described above. The one or more computing devices of the systems may also include various human interface devices, including, but not limited to, display screens, keyboards, pointing devices (e.g., a mouse), touchscreens, speakers, and microphones. The computing devices may also be configured to communicate with additional devices, such as external memory (e.g., external HDDs).

[0156] The one or more computing devices of the systems may be configured to communicate with the network **112**. The one or more computing devices of the systems may also be configured to communicate with one another (e.g., via a computer network). In some examples, the one or more computing devices of the systems may include one or more server computing devices configured to communicate with user devices (e.g., receive query wrappers and transmit search results), gather data from data source, index data, store the data, and store other documents. The one or more computing devices may reside within a single machine at a

single geographic location in some examples. In other examples, the one or more computing devices may reside within multiple machines at a single geographic location. In still other examples, the one or more computing devices of the systems may be distributed across a number of geographic locations.

1. A method comprising:
 - retrieving, at one or more computing devices, event analytics data for a software application installed on a plurality of user devices, wherein the software application includes a plurality of accessible application states, and wherein the event analytics data indicates an amount of time each of the accessible application states was accessed by the user devices;
 - mapping function names to the application states accessed by the user devices, wherein each of the function names indicates a functionality associated with the software application;
 - for each of the function names, determining an amount of time associated with the function name based on the amount of time associated with the application states to which the function name is mapped;
 - determining a usage fraction value for each of the function names based on the amount of time associated with the function names, the usage fraction value for each function name indicating the amount of time associated with the function name relative to the amount of time associated with each of the function names;
 - assigning function keywords to an application search record associated with the software application based on the usage fraction values associated with the function names of the software application;
 - receiving a search query from a querying user device;
 - identifying the application search record based on a match between terms of the search query and terms of the function keywords assigned to the application search record;
 - generating search results based on the identified application search record; and
 - transmitting the search results to the querying user device.
2. The method of claim 1, wherein the function keywords include one or more of the function names.
3. The method of claim 1, wherein the function keywords include function metadata that includes a plurality of terms that are associated with one or more of the function names.
4. The method of claim 1, wherein each of the function names is associated with a different set of function keywords and a different usage fraction value.
5. The method of claim 4, wherein assigning the function keywords to the application search record comprises:
 - determining whether the usage fraction value associated with the function keywords is greater than a threshold value; and
 - assigning the function keywords to the application search record when the usage fraction value is greater than the threshold value.
6. The method of claim 4, wherein assigning the function keywords to the application search record comprises:
 - determining whether the usage fraction value associated with the function keywords is the greatest usage fraction value among the usage fraction values associated with the function names; and

assigning the function keywords to the application search record when the usage fraction value is the greatest usage fraction value.

7. The method of claim 4, wherein generating the search results comprises scoring the application search record based on the usage fraction value associated with the function keywords.

8. The method of claim 1, wherein generating the search results comprises scoring the application search record based on the match between the terms of the search query and the terms of the function keywords.

9. The method of claim 1, wherein generating the search results comprises generating a single search result for the identified application search record, the single search result including an application download address configured to set the querying user device into a state that provides a preview of the software application and/or provides the software application for download.

10. The method of claim 1, wherein generating the search results comprises:

- determining the number of user devices from which the event analytics data was retrieved; and

- scoring the identified application search record based on the number of user devices.

11. A system comprising:

- one or more memory components configured to store computer-readable instructions; and one or more computing devices including one or more processing units that execute the computer-readable instructions, the computer-readable instructions, when executed by the one or more processing units, cause the one or more computing devices to:

- retrieve event analytics data for a software application installed on a plurality of user devices, wherein the software application includes a plurality of accessible application states, and wherein the event analytics data indicates an amount of time each of the accessible application states was accessed by the user devices;

- map function names to the application states accessed by the user devices, wherein each of the function names indicates a functionality associated with the software application;

- for each of the function names, determine an amount of time associated with the function name based on the amount of time associated with the application states to which the function name is mapped;

- determine a usage fraction value for each of the function names based on the amount of time associated with the function names, the usage fraction value for each function name indicating the amount of time associated with the function name relative to the amount of time associated with each of the function names;

- assign function keywords to an application search record associated with the software application based on the usage fraction values associated with the function names of the software application;

- receive a search query from a querying user device;

- identify the application search record based on a match between terms of the search query and terms of the function keywords assigned to the application search record;

generate search results based on the identified application search record; and

transmit the search results to the querying user device.

12. The system of claim **11**, wherein the function keywords include one or more of the function names.

13. The system of claim **11**, wherein the function keywords include function metadata that includes a plurality of terms that are associated with one or more of the function names.

14. The system of claim **11**, wherein each of the function names is associated with a different set of function keywords and a different usage fraction value.

15. The system of claim **14**, wherein the one or more computing devices are configured to assign the function keywords to the application search record by:

determining whether the usage fraction value associated with the function keywords is greater than a threshold value; and

assigning the function keywords to the application search record when the usage fraction value is greater than the threshold value.

16. The system of claim **14**, wherein the one or more computing devices are configured to assign the function keywords to the application search record by:

determining whether the usage fraction value associated with the function keywords is the greatest usage fraction value among the usage fraction values associated with the function names; and

assigning the function keywords to the application search record when the usage fraction value is the greatest usage fraction value.

17. The system of claim **14**, wherein the one or more computing devices are configured to generate the search results by scoring the application search record based on the usage fraction value associated with the function keywords.

18. The system of claim **11**, wherein the one or more computing devices are configured to generate the search results by scoring the application search record based on the match between the terms of the search query and the terms of the function keywords.

19. The system of claim **11**, wherein the one or more computing devices are configured to generate the search results by generating a single search result for the identified application search record, the single search result including an application download address configured to set the querying user device into a state that provides a preview of the software application and/or provides the software application for download.

20. The system of claim **11**, wherein the one or more computing devices are configured to generate the search results by:

determining the number of user devices from which the event analytics data was retrieved; and

scoring the identified application search record based on the number of user devices.

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