September 2021

PROACTIVE CONTEXTUAL INFORMATION

Vidhya Bhat

Maryam Karimzadehgan

Alex Mang

Shashwat Razdan

PROACTIVE CONTEXTUAL INFORMATION

ABSTRACT

A computing device (e.g., a cellular phone, a smartphone, a desktop computer, a laptop computer, a tablet computer, a portable gaming device, a watch, etc.) may select and display one or more information objects based on contextual information (e.g., user behavior information, device behavior information, interaction information, user information, preference information, time information, news information, etc.) associated with user interactions (e.g., applications initialized by the user, instructions provided by the user, information requested by the user, etc.) with the computing device over time. For example, the computing device may utilize this contextual information to select, based on the current context of the computing device, one or more information objects that may be relevant or of interest to the user and output such information objects to the user. The computing device may present such information objects to the user at appropriate times and/or locations based on the contextual information and on various screens (e.g., always-on screen, lock screen, home screen, etc.) of the computing device. In some cases, the computing device may share an indication of the selected information objects to other devices associated with the user so that the other devices may similarly display the information objects.

DESCRIPTION

FIG. 1 below is a conceptual diagram illustrating a computing device 100 that provides information to a user of computing device 100 based on contextual information associated with user interactions with computing device 100. Computing device 100 may be any mobile or non-mobile computing device, such as a cellular phone, a smartphone, a desktop computer, a laptop computer, a tablet computer, a portable gaming device, a portable media player, an e-book

reader, a watch (including a so-called smartwatch), a gaming controller, and/or the like. As shown in FIG. 1, computing device 100 may include one or more processors 102, a presence-sensitive display 104, one or more communication components 106 ("COMM components 106"), one or more sensors 108, and one or more storage devices 110.

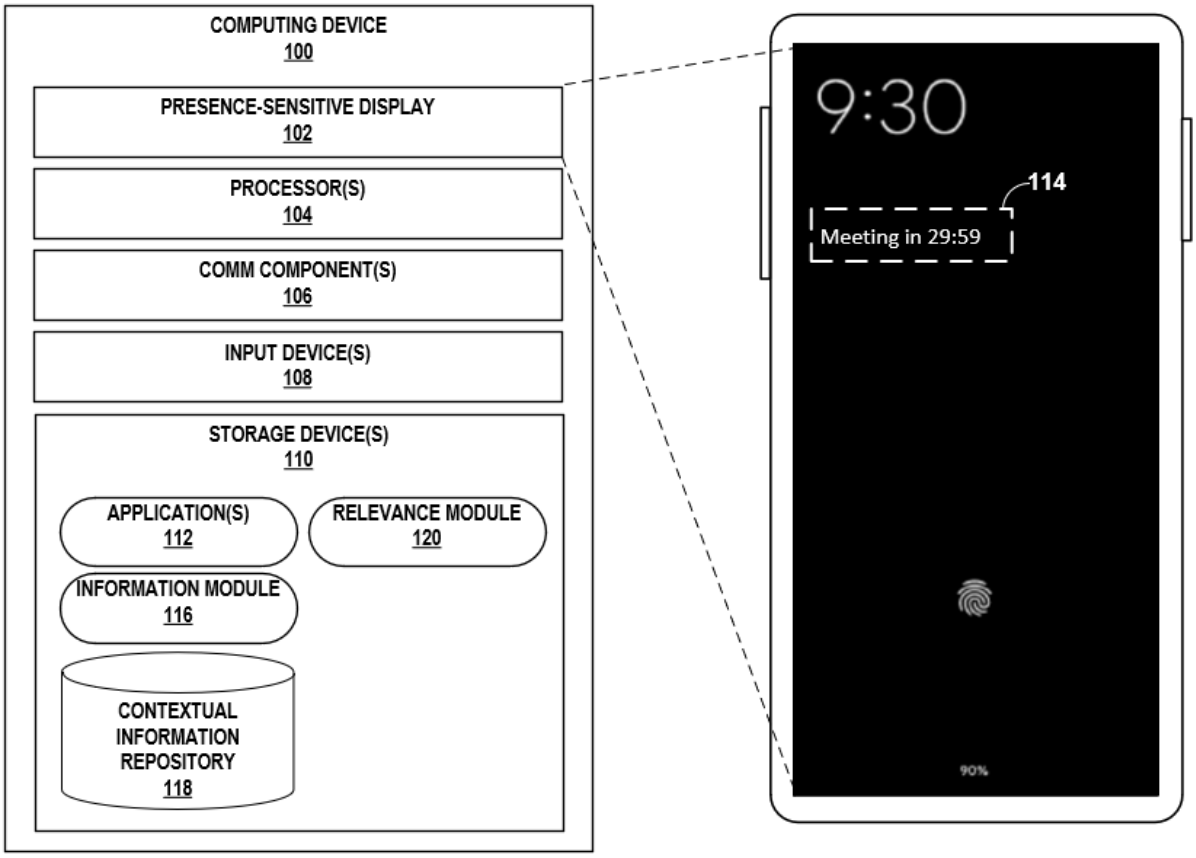

FIG. 1

Processors 102 may implement functionality and/or execute instructions associated with computing device 100. Examples of processors 102 may include one or more of an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), an application processor, a display controller, an auxiliary processor, a central processing unit (CPU), a graphics processing unit (GPU), one or more sensor hubs, and any other hardware configure to function as a processor, a processing unit, or a processing device.

Presence-sensitive display 104 of computing device 100 may be a presence-sensitive display that functions as an input device and as an output device. For example, presence-sensitive display 104 may function as an input device using a presence-sensitive input component, such as a resistive touchscreen, a surface acoustic wave touchscreen, a capacitive touchscreen, a projective capacitance touchscreen, a pressure sensitive screen, an acoustic pulse recognition touchscreen, or another presence-sensitive display technology. Additionally, presence-sensitive display 104 may function as an output (e.g., display) device using any of one or more display components, such as a liquid crystal display (LCD), dot matrix display, light emitting diode (LED) display, microLED display, organic light-emitting diode (OLED) display, e-ink, active-matrix organic light-emitting diode (AMOLED) display, or similar monochrome or color display capable of outputting visible information to a user of computing device 100.

COMM components 106 of computing device 100 may include wireless communication devices capable of transmitting and/or receiving communication signals, such as a cellular radio, a 3G radio, a 4G radio, a 5G radio, a Bluetooth® radio (or any other PAN radio), an NFC radio, or a Wi-Fi® radio (or any other wireless local area network (WLAN) radio). COMM components 106 may be configured to send and receive information via a network (e.g., a local area network (LAN), wide area network (WAN), a global network, such as the Internet, etc.).

Computing device 100 may include one or more input devices 108 to acquire a variety of data. Examples of input devices 108 may include one or more microphones, a presence-sensitive input device and/or touch-sensitive screen, a mouse, a keyboard, a voice responsive system, etc. In some cases, input devices 108 may include one or more location sensors (global positioning system (GPS) components, Wi-Fi® components, cellular components), one or more temperature sensors, one or more movement sensors (e.g., accelerometers, gyroscopes), a pressure sensor

(e.g., barometer), one or more ambient light sensors, one or more cameras, one or more infrared proximity sensors, a hygrometer sensor, a heart rate sensor, a magnetometer, a finger sensor, a glucose sensor, an olfactory sensor, a compass sensor, a step counter sensor, etc.

Storage devices 110 may include one or more computer-readable storage media. For example, storage devices 110 may be configured for long-term, as well as short-term storage of information, such as instructions, data, or other information used by computing device 100. In some examples, storage devices 110 may include non-volatile storage elements. Examples of such non-volatile storage elements include magnetic hard discs, optical discs, solid state discs, and/or the like. In other examples, in place of, or in addition to the non-volatile storage elements, storage devices 110 may include one or more so-called "temporary" memory devices, meaning that a primary purpose of these devices may not be long-term data storage. For example, the devices may comprise volatile memory devices, meaning that the devices may not maintain stored contents when the devices are not receiving power. Examples of volatile memory devices include random-access memories (RAM), dynamic random-access memories (DRAM), static random-access memories (SRAM), etc.

In general, computing device 100 may execute one or more applications 112 that generate information. Computing device 100 may output the information as information objects in a variety of formats (e.g., visually, audibly, etc.). Information associated with the information objects may include content of a calendar event (including time, date, location, attendees, etc.), content of a communication (including the identity of the sender, the body of the communication, etc.), a phone number (or caller identification), other information generated by other applications (e.g., a game, news application, weather application, application marketplace, social networking application, a navigation or map application, etc.) of applications 112, and so on.

As the number of applications installed at computing device 100 increases, the number of information objects associated with applications that computing device 100 outputs may also increase. This may result in a situation in which the user of computing device 100 can have difficulty managing all the information objects and identifying information that is relevant or of interest to the user (e.g., given a current context of computing device 100). In addition, as shown in FIG. 1, computing device 100 may display one or more information objects, such as information object 114, to alert the user of computing device 100 of information associated with the information objects. However, such information objects may not always be on display. For instance, computing device 100 may not display information object 114 when, for example, computing device 100 is in sleep mode. Accordingly, the user may need to "wake up" computing device 100 (by, e.g., pressing a power button, tapping display, etc.) to access the information contained in information object 114, which may be inconvenient and annoying given the potentially high frequency of this interaction. Together, these issues may reduce a likelihood that the user of computing device 100 becomes aware of information in a context (with respect to, e.g., a time, a location, a task, etc.) that is useful for the user.

In accordance with techniques of this disclosure, an information module 116 can select and output one or more information objects to a user of computing device 100 based on contextual information. The contextual information may include user behavior information, device behavior information, interaction information, user information, preference information, time information, news information, etc. In general, the contextual information may be associated with user interactions with computing device 100 over time, such as applications initialized by the user, instructions provided by the user, information requested by the user, etc. As described herein, computing device 100 collects the contextual information and information

module 116 analyzes the contextual information only after receiving explicit authorization from the user to do so. After receiving such authorization, computing device 100 and information module 116 begins to collect and analyze the contextual information.

Computing device 100 may utilize this contextual information to select, based on the current context of computing device 100, one or more information objects that may be relevant or of interest to the user and output such information objects to the user. Computing device 100 may present such information objects to the user at appropriate times and/or locations based on the contextual information and on various screens of computing device 100. In this way, the techniques of this disclosure may ensure that computing device 100 is displaying relevant information to the user of computing device 100 irrespective of the state (e.g., sleep state, locked state, unlocked state, etc.) and associated screen (e.g., always-on screen, lock screen, home screen, etc.) of computing device 100.

Information module 116 of computing device 100 may collect and make use of contextual information collected from computing device 100. The contextual information may be associated with interactions with applications 112, which may include one or more content delivery applications (e.g., one or more applications to deliver news content, video content, image content, map content, audiobook content, etc.), a search application, a navigation application, a productivity application, a health application, a calendar application, etc. Contextual information, including, but not limited to, any information or metadata associated with the user's interactions with applications 112, may be stored in a contextual information repository 118. Based on the contextual information stored in contextual information repository 118, information module 116 may generate one or more information objects for output to the user (e.g., via presence-sensitive display 102) as described in greater detail below.

In some examples, information module 116 may also obtain contextual information from an external computing system, such as contextual information about a user's social network, social actions or activities, a user's preferences, a user's current location, etc. A user may be provided with controls allowing the user to make an election as to both if and when devices, systems, programs, or features described herein may enable collection of user information (e.g., information about a user's social network, social actions, or screenshots of the user's screen), and if the user is sent content or communications from a server. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

In addition, the contextual information may be treated in one or more ways before it is stored or used such that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user, or a user's geographic location may be generalized here location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user may have control over what contextual information is collected about the user, how that contextual information is used, and what contextual information is provided to the user.

Information module 116 may determine a current context of computing device 100, for example, based on the contextual information in contextual information repository 118 and/or contextual information from the external computing system. Based on the current context of computing device 100, a relevance module 120 may analyze the contextual information to determine the relevance of the information to the user of computing device 100. In some

examples, the current context is based on a current time and/or date, a current location of the user, and a current task being performed by the user.

In some instances, relevance module 120 may predict the relevance of the information associated with information objects using a predefined algorithm, such as an algorithm that is not adaptive and does not change based on responses received from the user regarding the information objects generated and output by information module 116. In other examples, relevance module 120 may analyze the information associated with the information object using an adaptive algorithm, e.g., an algorithm that adjusts predictions about the relevance of information in response to user input received regarding the information objects. In some examples, relevance module 120 may use a machine learning algorithm to predict the urgency of information based on contextual signals, history information, and/or other information.

For example, relevance module 120 may adjust the algorithm based on whether the user interacts with the information objects generated by information module 116 to access the associated information, which may indicate a relative importance of the information to the user. In some instances, information module 116 may track user responses over time, and change assignment of future information objects based on the response of the user to past information objects of similar type. Information module 116 may consider, for example, the application from which the information originated, a person associated with the information (e.g., a sender of a communication), etc.

As one example of the operation of relevance module 120, if calendar information from a calendar application indicates that the user has a meeting at 3 p.m., relevance module 120 may determine (e.g., using a predefined algorithm, an adaptive algorithm, a machine learning algorithm, etc.) that a reminder generated by the calendar information before the meeting (e.g.,

30 minutes before the meeting) is particularly relevant. Information module 116 may output for display an information object associated with the reminder but no other information objects or only a selection of other relevant information objects.

As another example, if the location sensors of computing device 100 indicate that the user is in the city of Mountain View, relevance module 120 may determine that information related to the city of Mountain View is particularly relevant. Information module 116 may output for display an information object associated with the information related to the city of Mountain View but no other information objects or only a selection of other relevant information objects.

As yet another example, if the user routinely uses a finance application to obtain stock information, relevance module 120 may determine that stock market information at the time when the stock market opens (e.g., 8:30 a.m. Eastern time) is particularly relevant. Accordingly, information module 116 may output for display an information object associated with the stock market information but no other information objects or only a selection of other relevant information objects.

Thus, based on the current context of computing device 100 and in accordance with the determinations by relevance module 120, information module 116 may output instructions to presence-sensitive display 102 to display, for example, the most relevant information as an information object.

As shown in FIGS. 2A-2C below, computing device 100 may display information objects 214A-214C (collectively, “information objects 214”) in a variety of formats and on a variety of user interface screens, such as an always-on screen 216, a lock screen 218, a home screen 220, etc.). For example, information module 116 may provide instructions to presence-sensitive display 104 to display information object 214A on always-on screen 216, information object

214B on lock screen 218, and information object 214C on home screen 220. The information associated with information objects 214 may be the information that relevance module 120 determined to be the most relevant to the user at a particular time and/or for a particular task. In this way, information module 116 may output important information to the user of computing device 100 in a context-aware manner. This may increase a chance that the user becomes aware of the information in a context that is useful to the user.

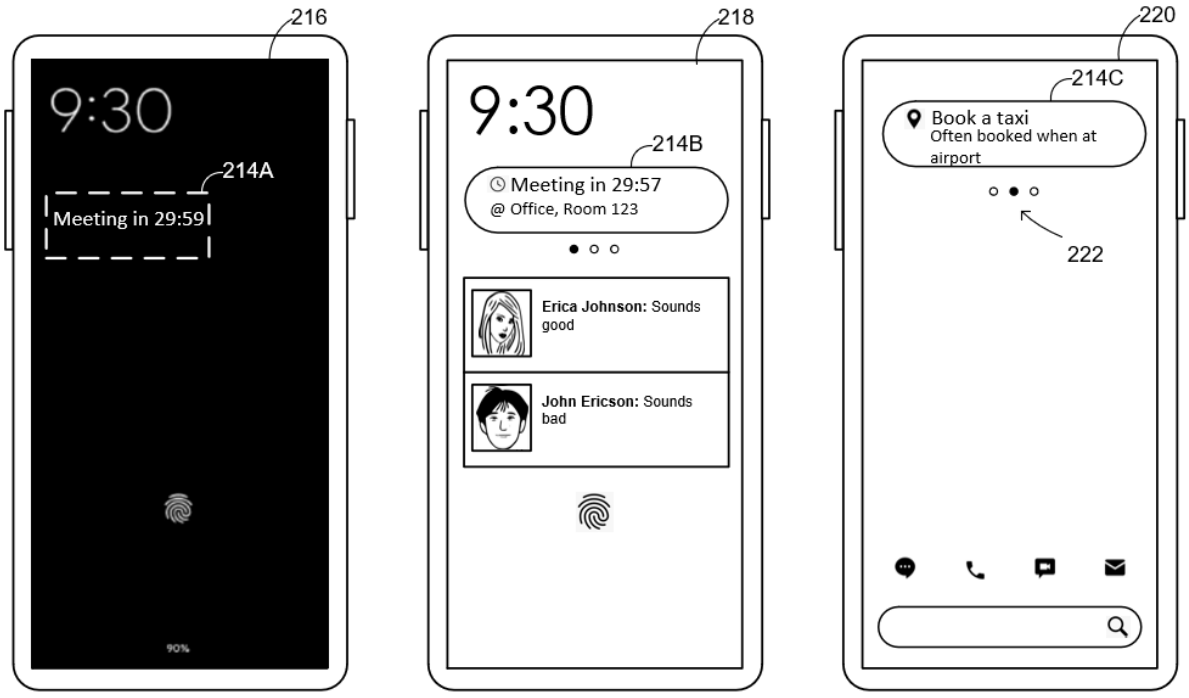

FIG. 2A FIG. 2B FIG. 2C

In some examples, presence-sensitive display 102 may display only the most relevant information object, a carousel of the most relevant information objects, all the information objects exceeding a relevance threshold, etc. In the example of FIG. 2, the information about an upcoming meeting may be particularly relevant and other information, such as information relating to a game application, may be less relevant. Accordingly, presence-sensitive display 102 may display the information about an upcoming meeting as information object 214.

Information module 116 may output information objects 214 in a variety of formats and on a variety of user interface screens. For example, as shown in FIG. 2A, when computing device 100 is in a sleep state, computing device 100 may display always-on screen 216 and show information object 214A. To protect user privacy, minimize energy consumption, and/or comply with design constraints of computing device 100, information object 214A may be formatted to only include general and/or basic information, such as an amount of time remaining until a scheduled meeting. Information object 214A may not include the attendees of the meeting, the agenda of the meeting, and/or other details that may be sensitive or specific. In the example of FIG. 2A, information object 214A includes text but not images. It should be understood, however, that other formats are contemplated by this disclosure.

As shown in FIG. 2B, computing device 100 may display lock screen 218 (e.g., in response to actuation of a power button of computing device 100) and show information object 214B. The format of information object 214B may be different from the format of information object 214A. For example, rather than only include general information, information object 214B may show additional information such as a location of the meeting. That said, information object 214B may not display sensitive information to protect privacy because computing device 100 is still locked. In the example of FIG. 2B, information object 214B includes both text and images.

As shown in FIG. 2C, computing device 100 may display home screen 220 (e.g., in response to computing device 100 being unlocked) and show information object 214C. The format of information object 214C may or may not be substantially similar to the format of information object 214B. In other words, in some examples, the format of information object 214C may be different from the format of information object 214B. For instance, information object 214C may include more or less information (e.g., in the form of text, images, videos,

graphical elements for controlling functions of computing device 100, such as opening an application associated with information object 214C, etc.) than information object 214B.

As shown in FIGS. 2B and 2C, information module 116 may generate multiple information objects and output instructions to presence-sensitive display 102 to display the information objects as a carousel 222. For example, home screen 220 may initially display a first information (e.g., about a scheduled meeting) associated with information object 214C, and a user may provide a touch input (e.g., a swipe) to cause presence-sensitive display 102 to display another information, such as a second information (e.g., about booking a taxi) associated with information object 214C. In some examples, carousel 222 may only include a limited selection of the information objects to avoid overwhelming a user of computing device 100 with information.

The various information (e.g., the first information, the second information, etc.) may correspond to an indicator (e.g., icons, symbols, graphical elements, etc.) of carousel 222. For instance, the first information may correspond to a leftmost circle icon of carousel 222, the second information may correspond to the second leftmost circle icon of carousel 222, and so on. In some cases, the order of the information (e.g., as indicated by the order in carousel 222) may be based on a ranking of the urgency of the various information by information module 116.

One or more advantages of the techniques of this disclosure include outputting important information to the user of computing device 100 in a context-aware manner and across a variety of user interface screens. This may increase a chance that the user becomes aware of the information in a context that is useful to the user. Furthermore, by performing the analysis for determining the relevance of contextual information locally (i.e., on computing device 100), sensitive user information may not be transmitted to remote servers and may, as a result, be kept more private than if the analysis were done on remote servers.

It is noted that the techniques of this disclosure may be combined with any other suitable technique or combination of techniques. As one example, the techniques of this disclosure may be combined with the techniques described in U.S. Patent Application Publication No. 2018/0157811A1. In another example, the techniques of this disclosure may be combined with the techniques described in U.S. Patent Application Publication No. 2016/0155426A1. In yet another example, the techniques of this disclosure may be combined with the techniques described in U.S. Patent Application Publication No. 2010/0146384A1. In yet another example, the techniques of this disclosure may be combined with the techniques described in CN Patent Application Publication No. 107343096A. In yet another example, the techniques of this disclosure may be combined with the techniques described in U.S. Patent Application Publication No. 2018/0139317A1. In yet another example, the techniques of this disclosure may be combined with the techniques described in U.S. Patent Application Publication No. 2018/0088892A1. In yet another example, the techniques of this disclosure may be combined with the techniques described in Koponen, "AI on your lock screen," Tech Crunch, June 13, 2017.