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(54) **INTELLIGENT AUTOMATED ASSISTANT IN A HOME ENVIRONMENT**

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

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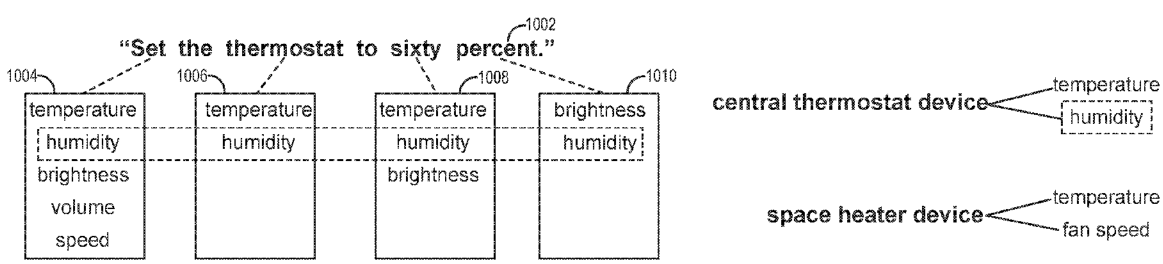
(57) **ABSTRACT**

Systems and processes for operating an intelligent automated assistant are provided. In one example process, discourse input representing a user request can be received. The process can determine one or more possible device characteristics corresponding to the discourse input. Data structure representing a set of devices of an established location can be retrieved. The process can determine, based on the data structure, one or more candidate devices from the set of devices. The one or more candidate devices can correspond to the discourse input. The process can determine, based on the one or more possible device characteristics and one or more actual device characteristics of the one or more candidate devices, a user intent corresponding to the discourse input. Instructions that cause a device of the one or more candidate devices to perform an action corresponding to the user intent can be provided.

46 Claims, 18 Drawing Sheets



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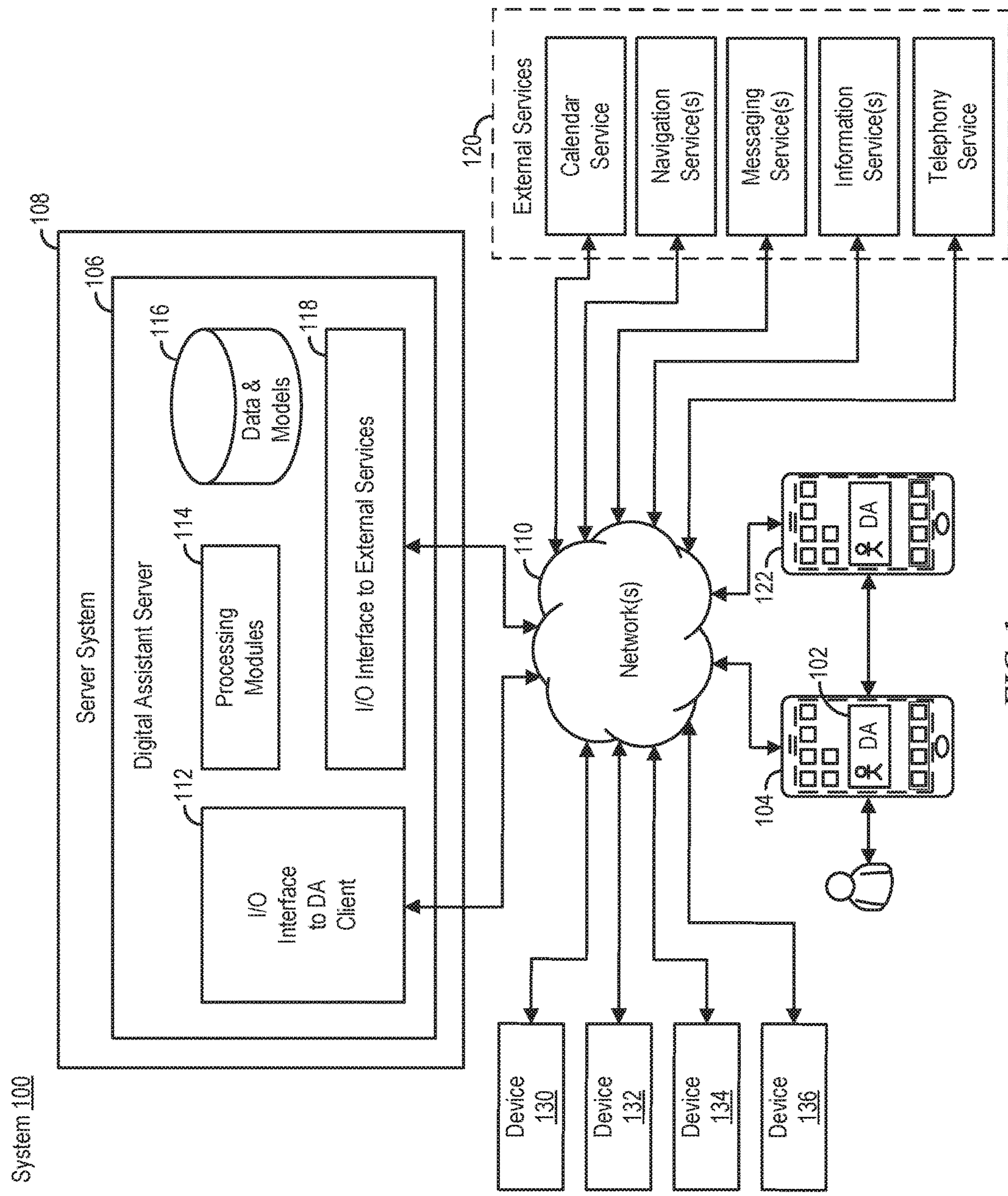
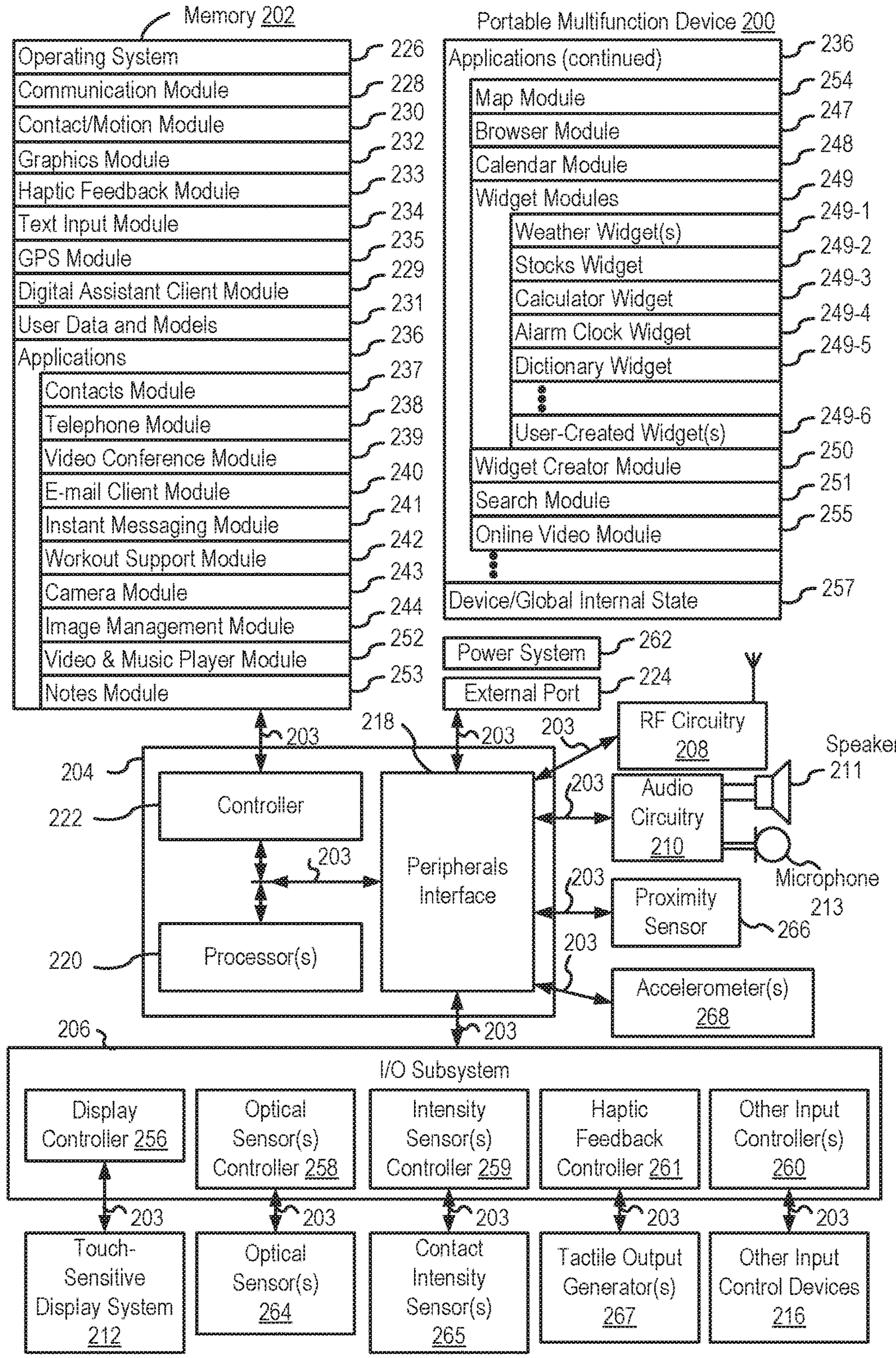

System 100
108
Server System
106
Digital Assistant Server
112
I/O Interface to DA Client
114
Processing Modules
116
Data & Models
118
I/O Interface to External Services
110
Network(s)
120
External Services
Calendar Service
Navigation Service(s)
Messaging Service(s)
Information Service(s)
Telephony Service
122
DA
102
104
DA
Device 130
Device 132
Device 134
Device 136

FIG. 1



Memory 202
Operating System
226
Communication Module
228
Contact/Motion Module
230
Graphics Module
232
Haptic Feedback Module
233
Text Input Module
234
GPS Module
235
Digital Assistant Client Module
229
User Data and Models
231
Applications
236
Contacts Module
237
Telephone Module
238
Video Conference Module
239
E-mail Client Module
240
Instant Messaging Module
241
Workout Support Module
242
Camera Module
243
Image Management Module
244
Video & Music Player Module
252
Notes Module
253
Portable Multifunction Device 200
Applications (continued)
236
Map Module
254
Browser Module
247
Calendar Module
248
Widget Modules
249
Weather Widget(s)
249-1
Stocks Widget
249-2
Calculator Widget
249-3
Alarm Clock Widget
249-4
Dictionary Widget
249-5
User-Created Widget(s)
249-6
Widget Creator Module
250
Search Module
251
Online Video Module
255
Device/Global Internal State
257
Power System
262
External Port
224
203
218
RF Circuitry 208
Speaker 211
204
Controller
222
Audio Circuitry 210
Peripherals Interface
Microphone 213
Proximity Sensor
266
Processor(s)
220
Accelerometer(s) 268
206
I/O Subsystem
Display Controller 256
Optical Sensor(s) Controller 258
Intensity Sensor(s) Controller 259
Haptic Feedback Controller 261
Other Input Controller(s) 260
Touch-Sensitive Display System 212
Optical Sensor(s) 264
Contact Intensity Sensor(s) 265
Tactile Output Generator(s) 267
Other Input Control Devices 216

FIG. 2A

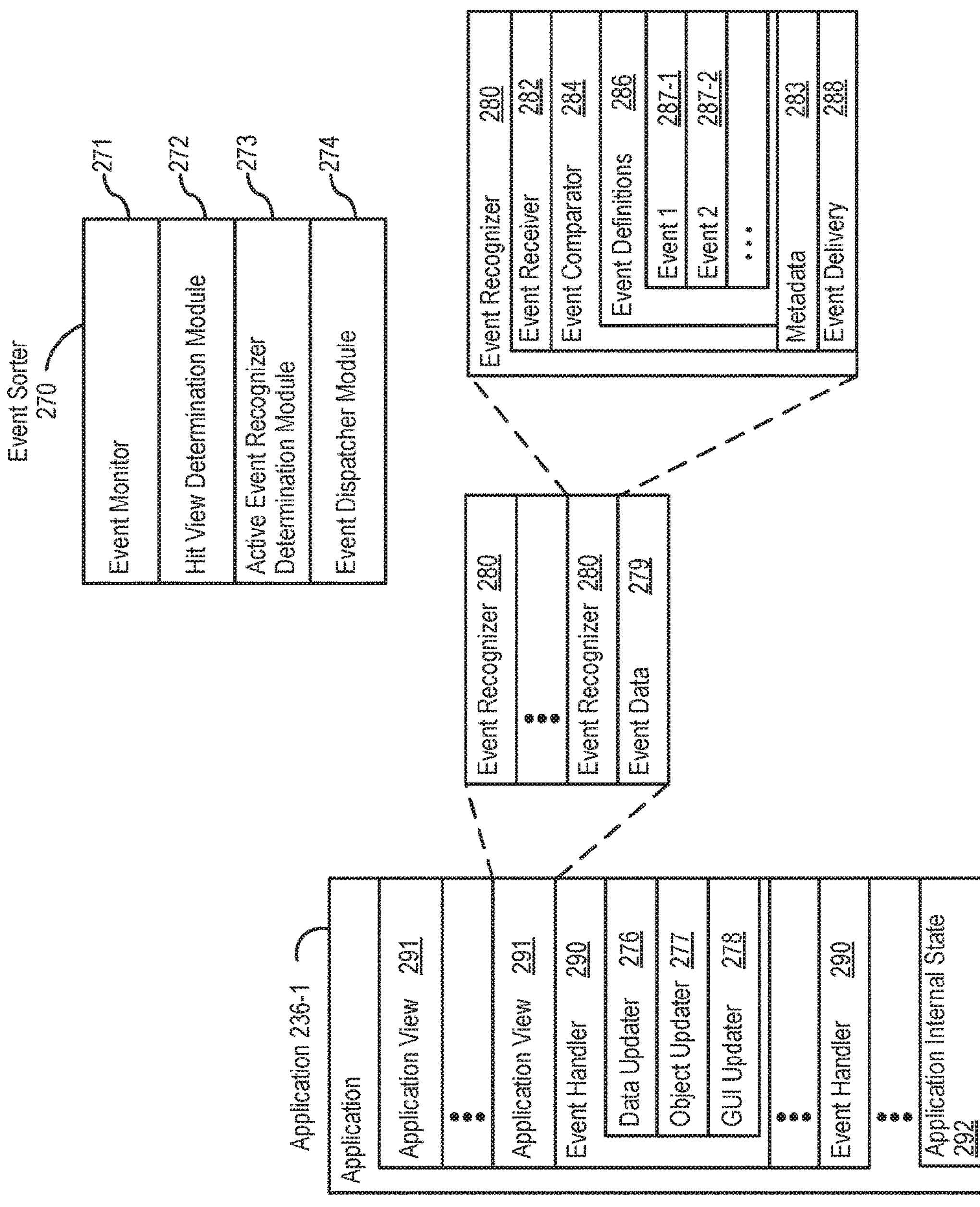

Event Sorter
270
Event Monitor
271
Hit View Determination Module
272
Active Event Recognizer Determination Module
273
Event Dispatcher Module
274
Application 236-1
Application
Application View 291
Application View 291
Event Handler 290
Data Updater 276
Object Updater 277
GUI Updater 278
Event Handler 290
Application Internal State 292
Event Recognizer 280
Event Recognizer 280
Event Data 279
Event Recognizer 280
Event Receiver 282
Event Comparator 284
Event Definitions 286
Event 1 287-1
Event 2 287-2
Metadata 283
Event Delivery 288

FIG. 2B

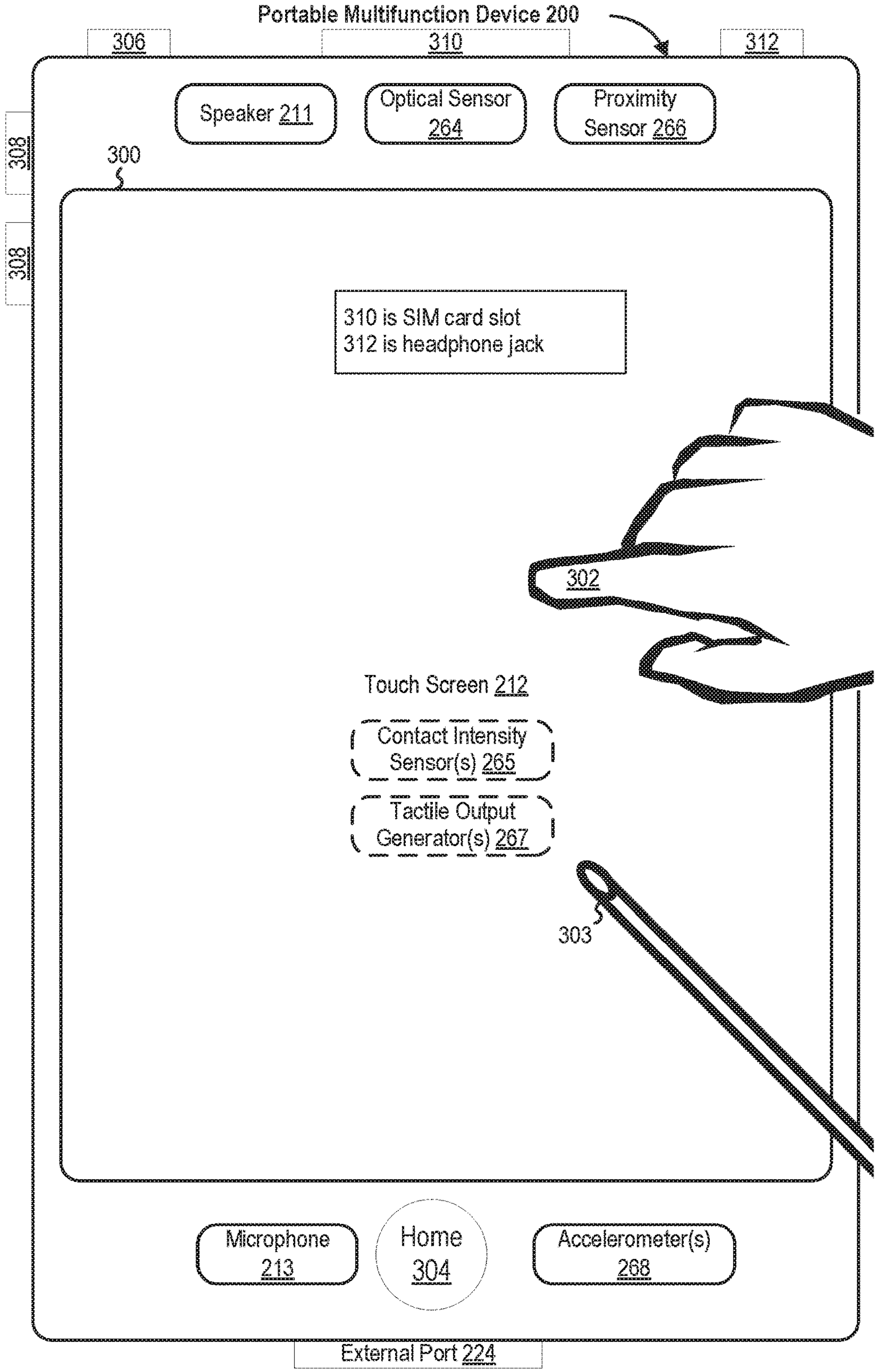

Portable Multifunction Device 200
306
310
312
308
308
Speaker 211
Optical Sensor 264
Proximity Sensor 266
300
310 is SIM card slot
312 is headphone jack
302
Touch Screen 212
Contact Intensity Sensor(s) 265
Tactile Output Generator(s) 267
303
Microphone 213
Home 304
Accelerometer(s) 268
External Port 224

FIG. 3

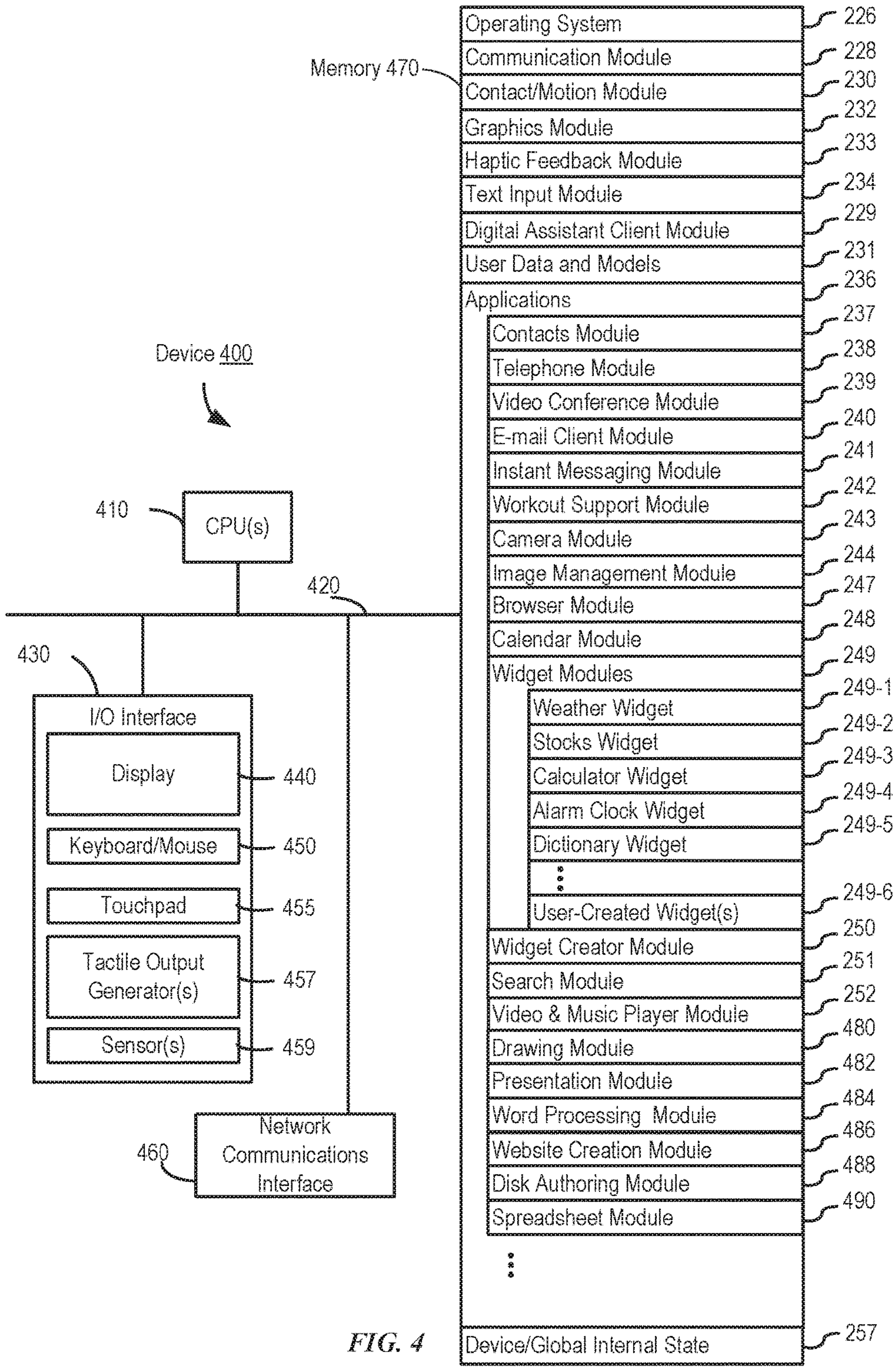
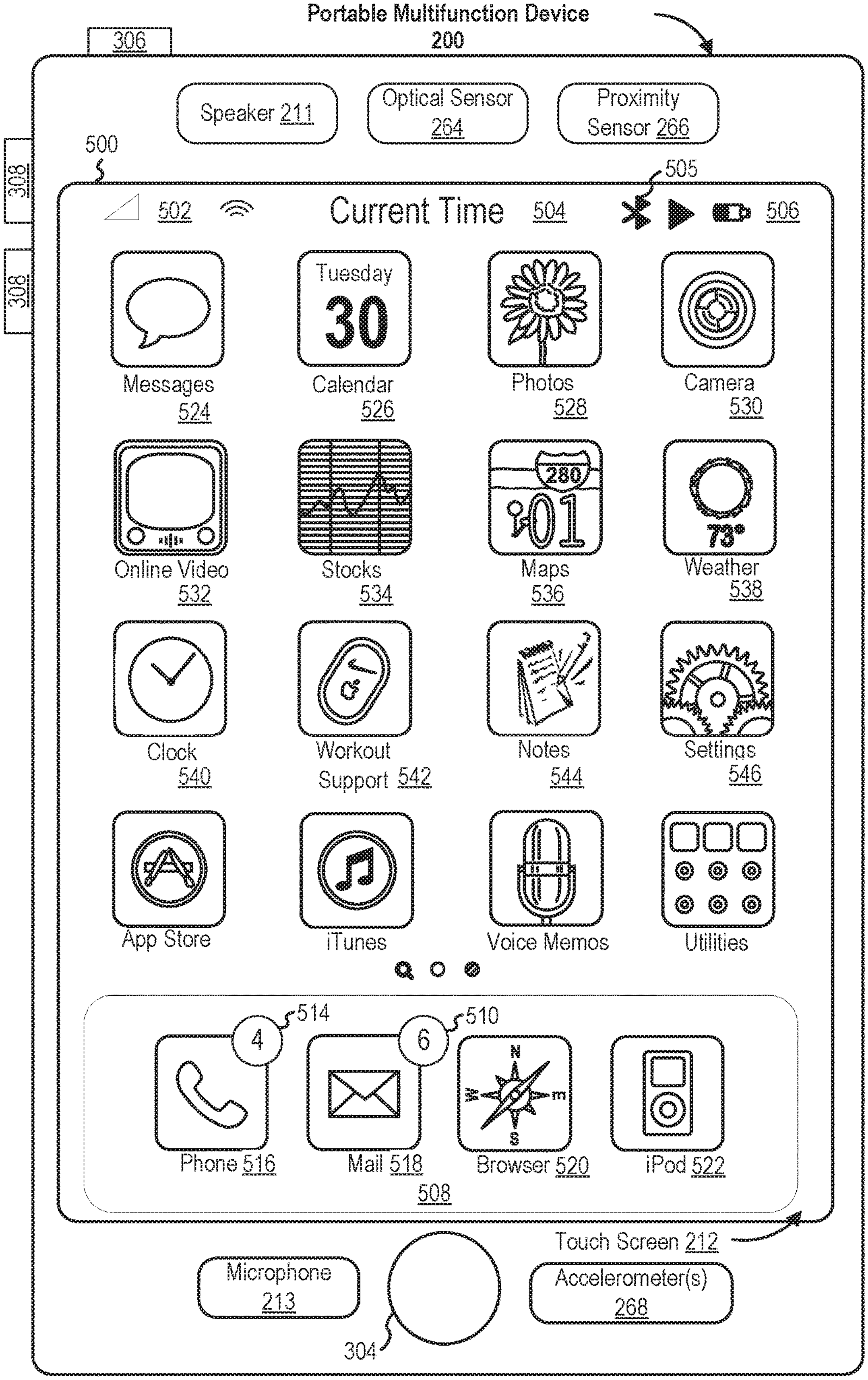

Device 400
410
CPU(s)
420
430
I/O Interface
Display
440
Keyboard/Mouse
450
Touchpad
455
Tactile Output Generator(s)
457
Sensor(s)
459
460
Network Communications Interface
Memory 470
Operating System
226
Communication Module
228
Contact/Motion Module
230
Graphics Module
232
Haptic Feedback Module
233
Text Input Module
234
Digital Assistant Client Module
229
User Data and Models
231
Applications
236
Contacts Module
237
Telephone Module
238
Video Conference Module
239
E-mail Client Module
240
Instant Messaging Module
241
Workout Support Module
242
Camera Module
243
Image Management Module
244
Browser Module
247
Calendar Module
248
Widget Modules
249
Weather Widget
249-1
Stocks Widget
249-2
Calculator Widget
249-3
Alarm Clock Widget
249-4
Dictionary Widget
249-5
User-Created Widget(s)
249-6
Widget Creator Module
250
Search Module
251
Video & Music Player Module
252
Drawing Module
480
Presentation Module
482
Word Processing Module
484
Website Creation Module
486
Disk Authoring Module
488
Spreadsheet Module
490
Device/Global Internal State
257

FIG. 4



Portable Multifunction Device
200
306
308
308
Speaker 211
Optical Sensor 264
Proximity Sensor 266
500
505
502
Current Time
504
506
Messages 524
Tuesday 30
Calendar 526
Photos 528
Camera 530
Online Video 532
Stocks 534
280
Maps 536
73°
Weather 538
Clock 540
Workout Support 542
Notes 544
Settings 546
App Store
iTunes
Voice Memos
Utilities
514
4
510
6
N
W
E
S
Phone 516
Mail 518
Browser 520
iPod 522
508
Touch Screen 212
Microphone 213
Accelerometer(s) 268
304

FIG. 5A

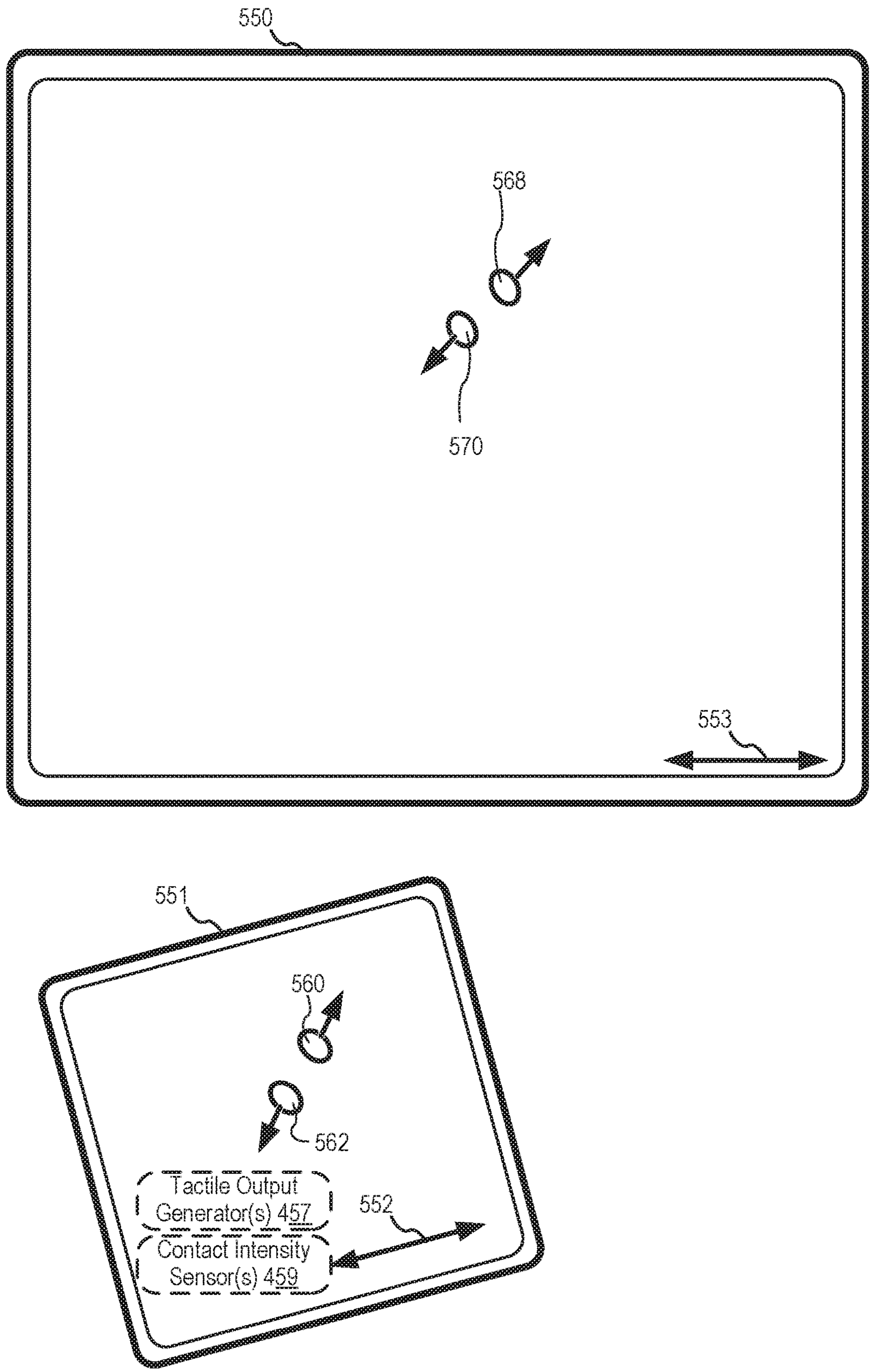

550
568
570
553
551
560
562
Tactile Output Generator(s) 457
Contact Intensity Sensor(s) 459
552

FIG. 5B

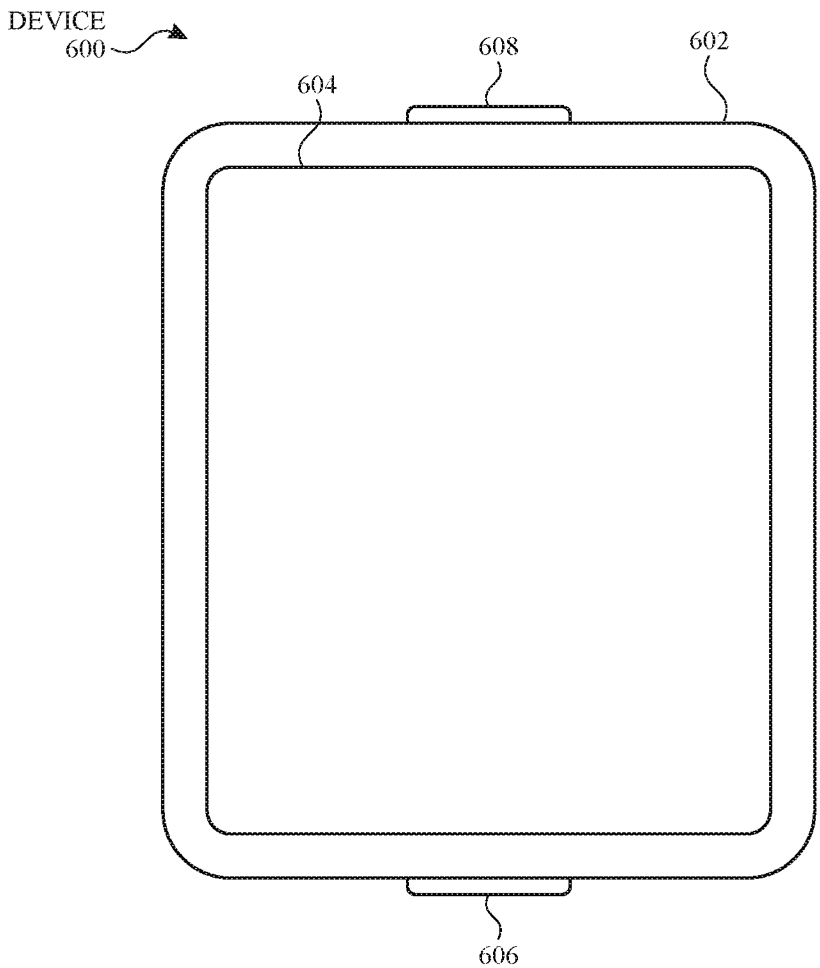


FIG. 6A

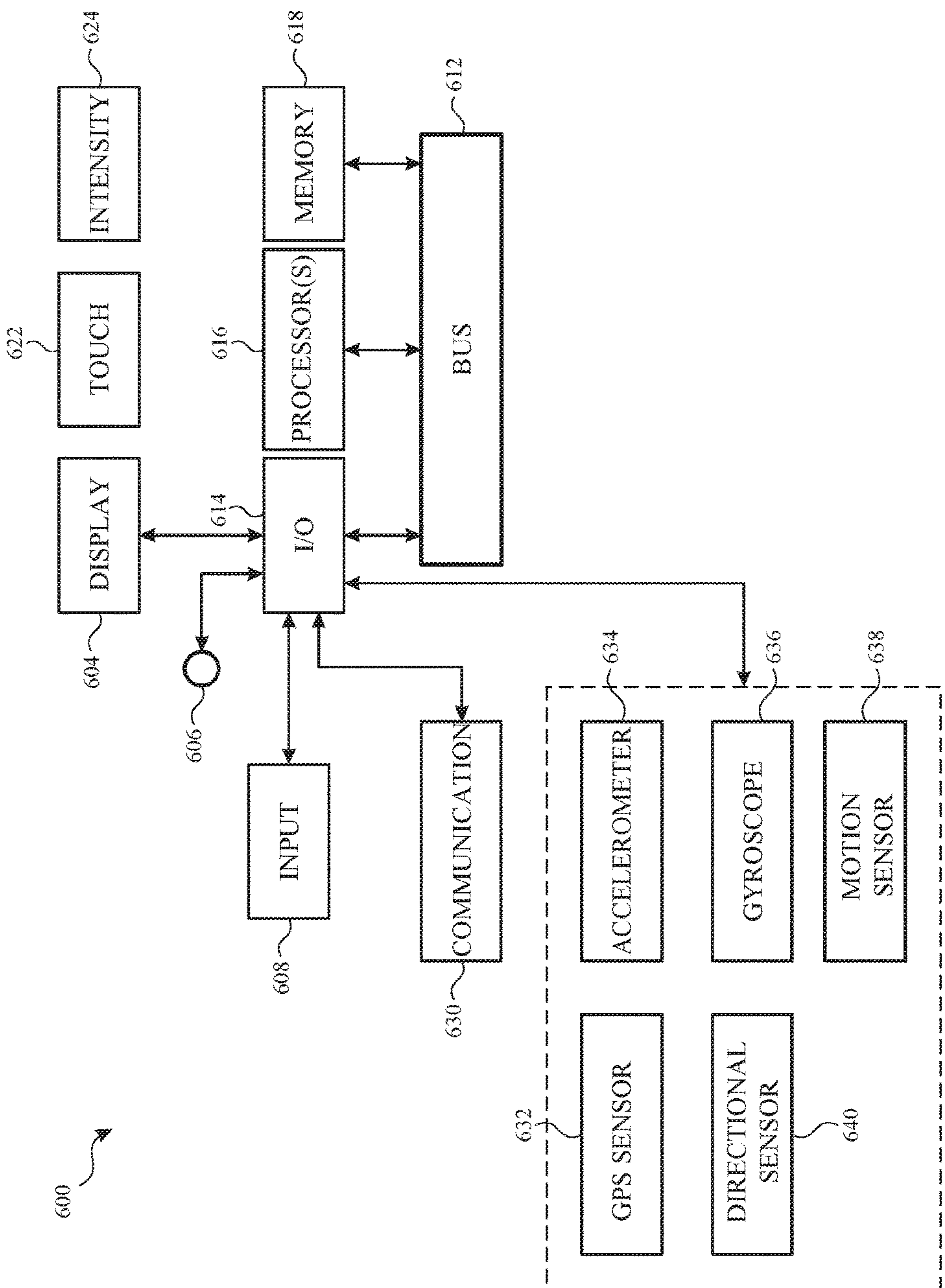

600
INTENSITY
624
TOUCH
622
DISPLAY
604
MEMORY
618
PROCESSOR(S)
616
I/O
614
BUS
612
606
INPUT
608
COMMUNICATION
630
ACCELEROMETER
634
GYROSCOPE
636
MOTION SENSOR
638
GPS SENSOR
632
DIRECTIONAL SENSOR
640

FIG. 6B

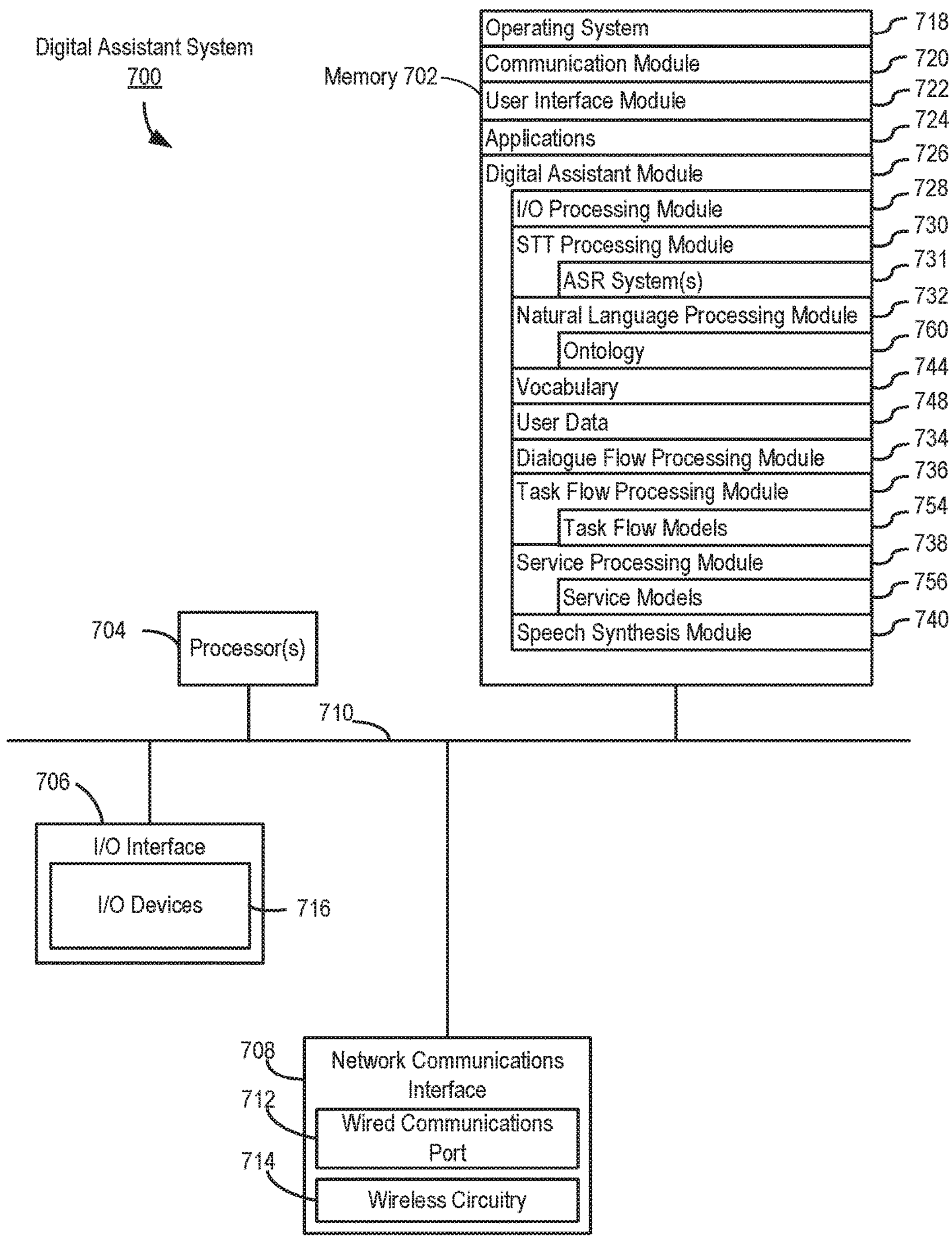

Digital Assistant System
700
Memory 702
Operating System
718
Communication Module
720
User Interface Module
722
Applications
724
Digital Assistant Module
726
I/O Processing Module
728
STT Processing Module
730
ASR System(s)
731
Natural Language Processing Module
732
Ontology
760
Vocabulary
744
User Data
748
Dialogue Flow Processing Module
734
Task Flow Processing Module
736
Task Flow Models
754
Service Processing Module
738
Service Models
756
Speech Synthesis Module
740
704
Processor(s)
710
706
I/O Interface
I/O Devices
716
708
Network Communications Interface
712
Wired Communications Port
714
Wireless Circuitry

FIG. 7A

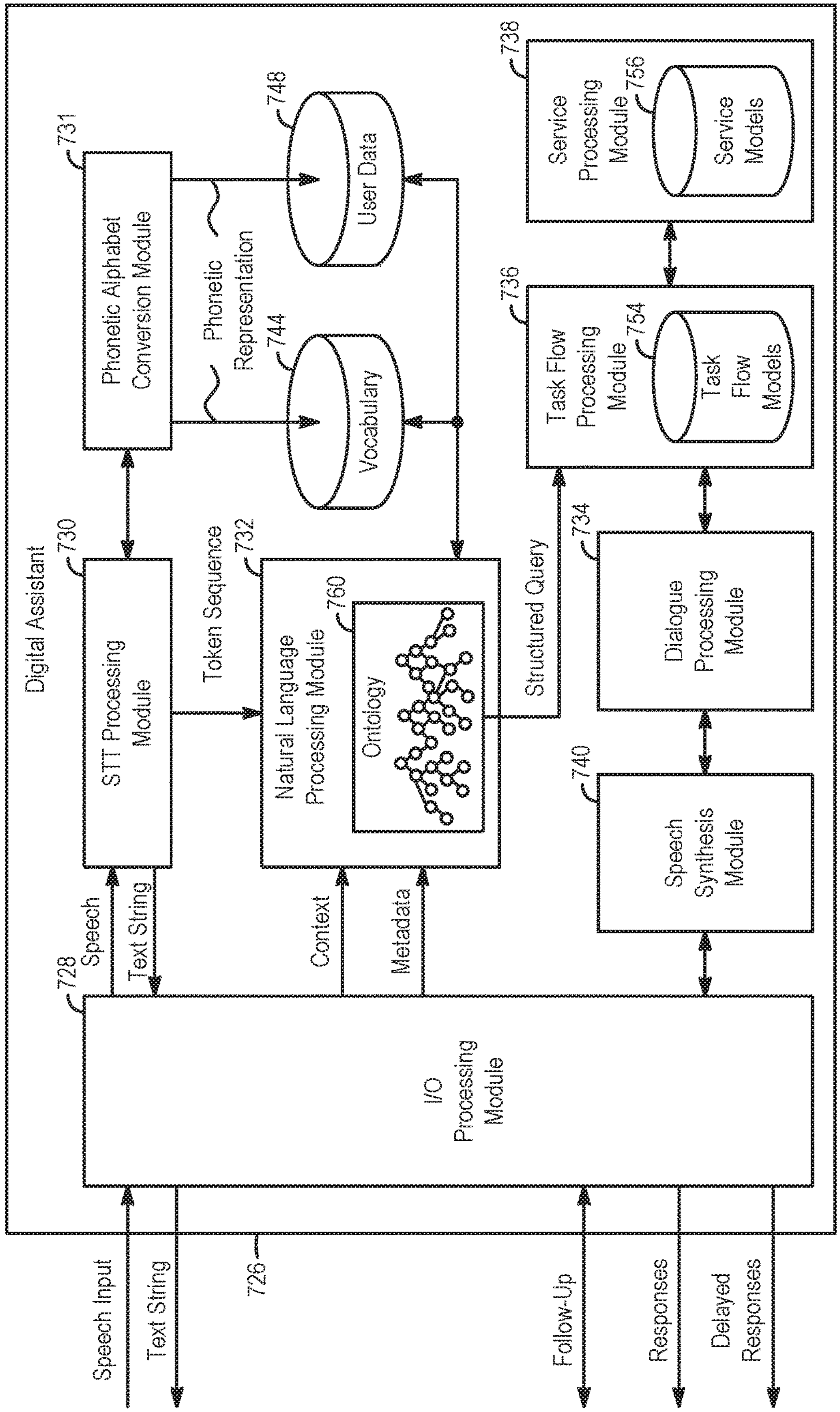

Digital Assistant
726
Speech Input
Text String
Follow-Up
Responses
Delayed Responses
728
I/O Processing Module
Speech
Text String
Context
Metadata
730
STT Processing Module
731
Phonetic Alphabet Conversion Module
Phonetic Representation
744
Vocabulary
748
User Data
Token Sequence
732
Natural Language Processing Module
760
Ontology
Structured Query
734
Dialogue Processing Module
740
Speech Synthesis Module
736
Task Flow Processing Module
754
Task Flow Models
738
Service Processing Module
756
Service Models

FIG. 7B

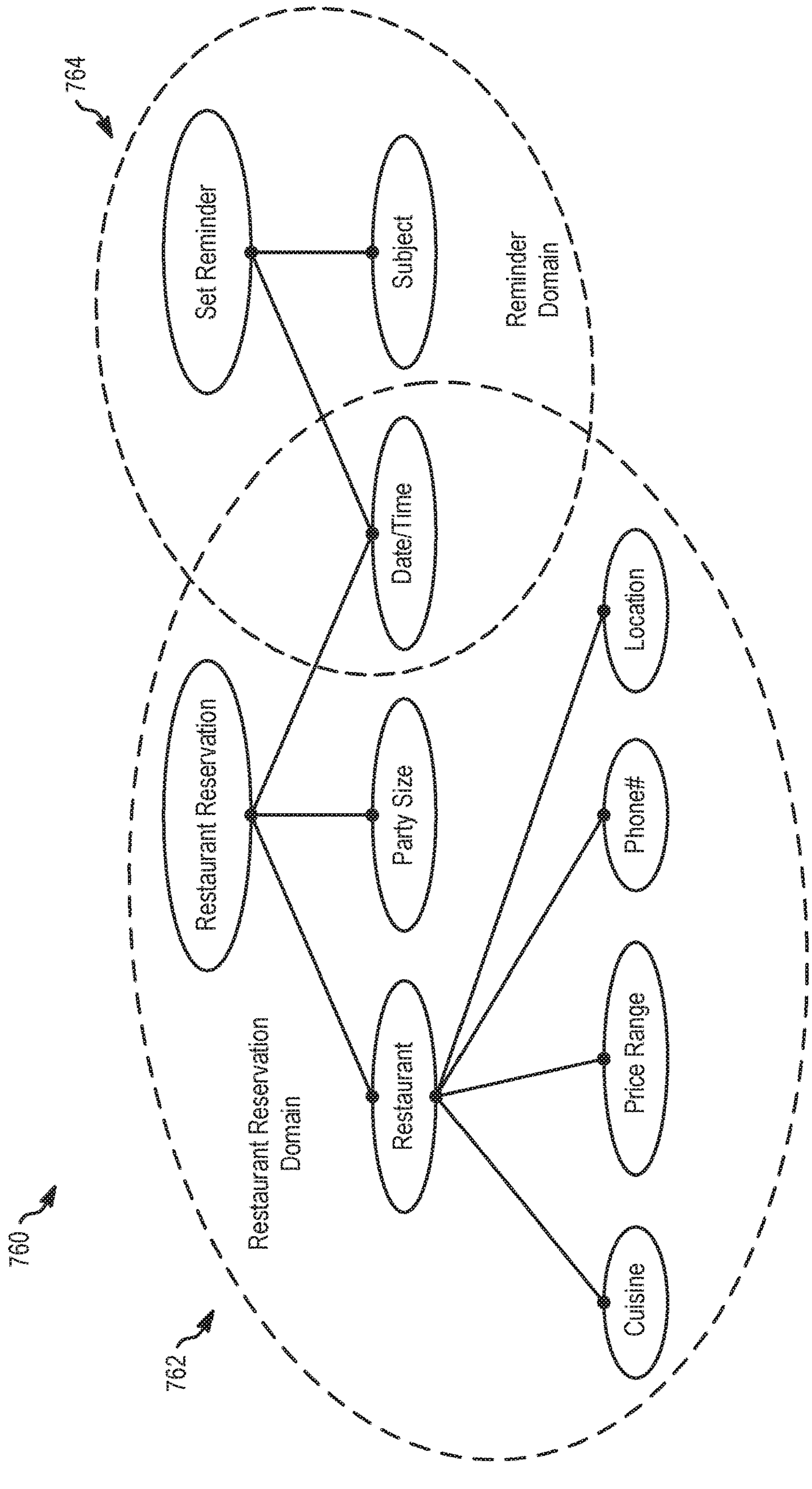

760
762
764
Set Reminder
Subject
Reminder Domain
Date/Time
Restaurant Reservation
Party Size
Location
Phone#
Price Range
Restaurant
Cuisine
Restaurant Reservation Domain

FIG. 7C

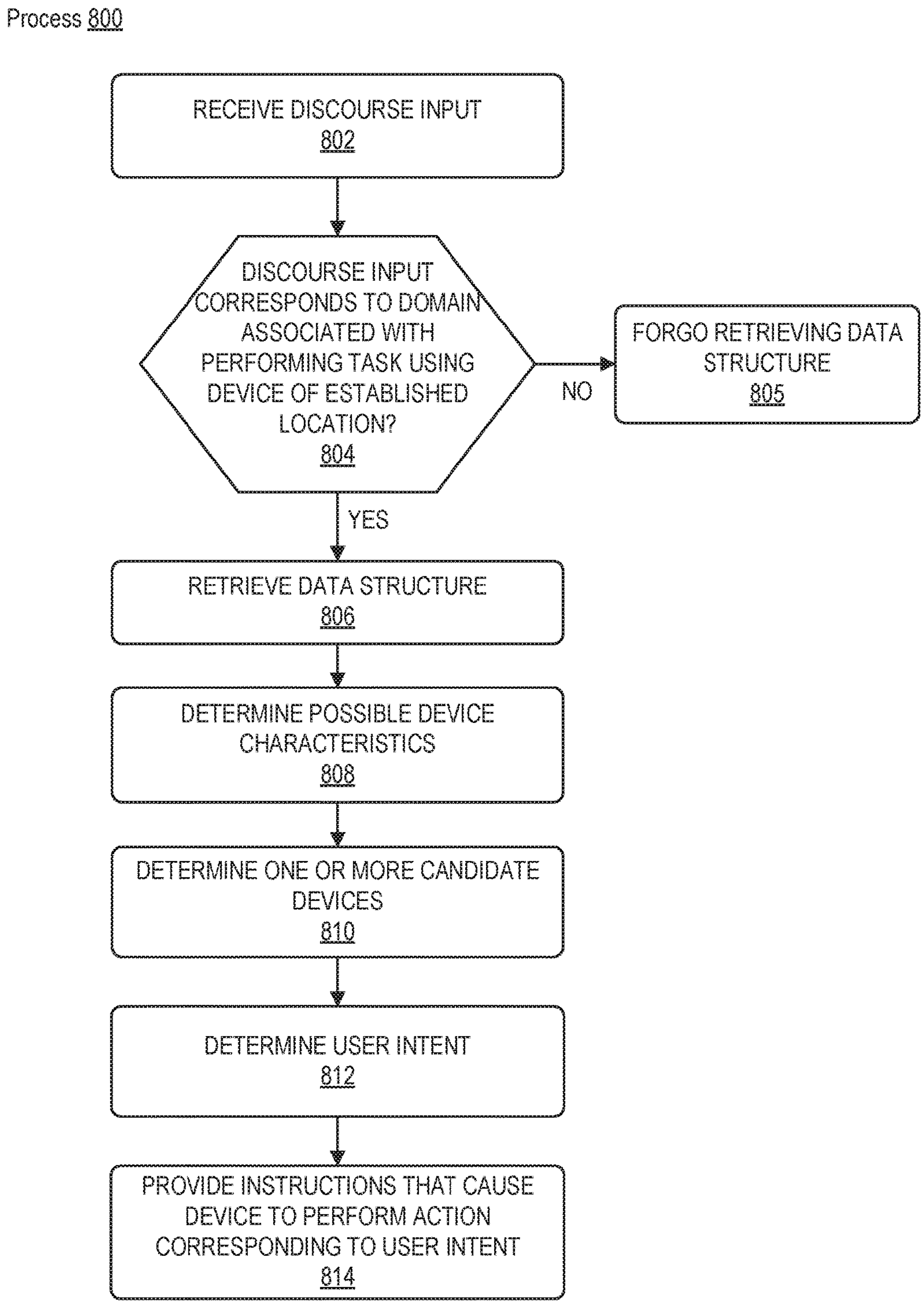

Process 800
RECEIVE DISCOURSE INPUT 802
DISCOURSE INPUT CORRESPONDS TO DOMAIN ASSOCIATED WITH PERFORMING TASK USING DEVICE OF ESTABLISHED LOCATION? 804
NO
FORGO RETRIEVING DATA STRUCTURE 805
YES
RETRIEVE DATA STRUCTURE 806
DETERMINE POSSIBLE DEVICE CHARACTERISTICS 808
DETERMINE ONE OR MORE CANDIDATE DEVICES 810
DETERMINE USER INTENT 812
PROVIDE INSTRUCTIONS THAT CAUSE DEVICE TO PERFORM ACTION CORRESPONDING TO USER INTENT 814

FIG. 8

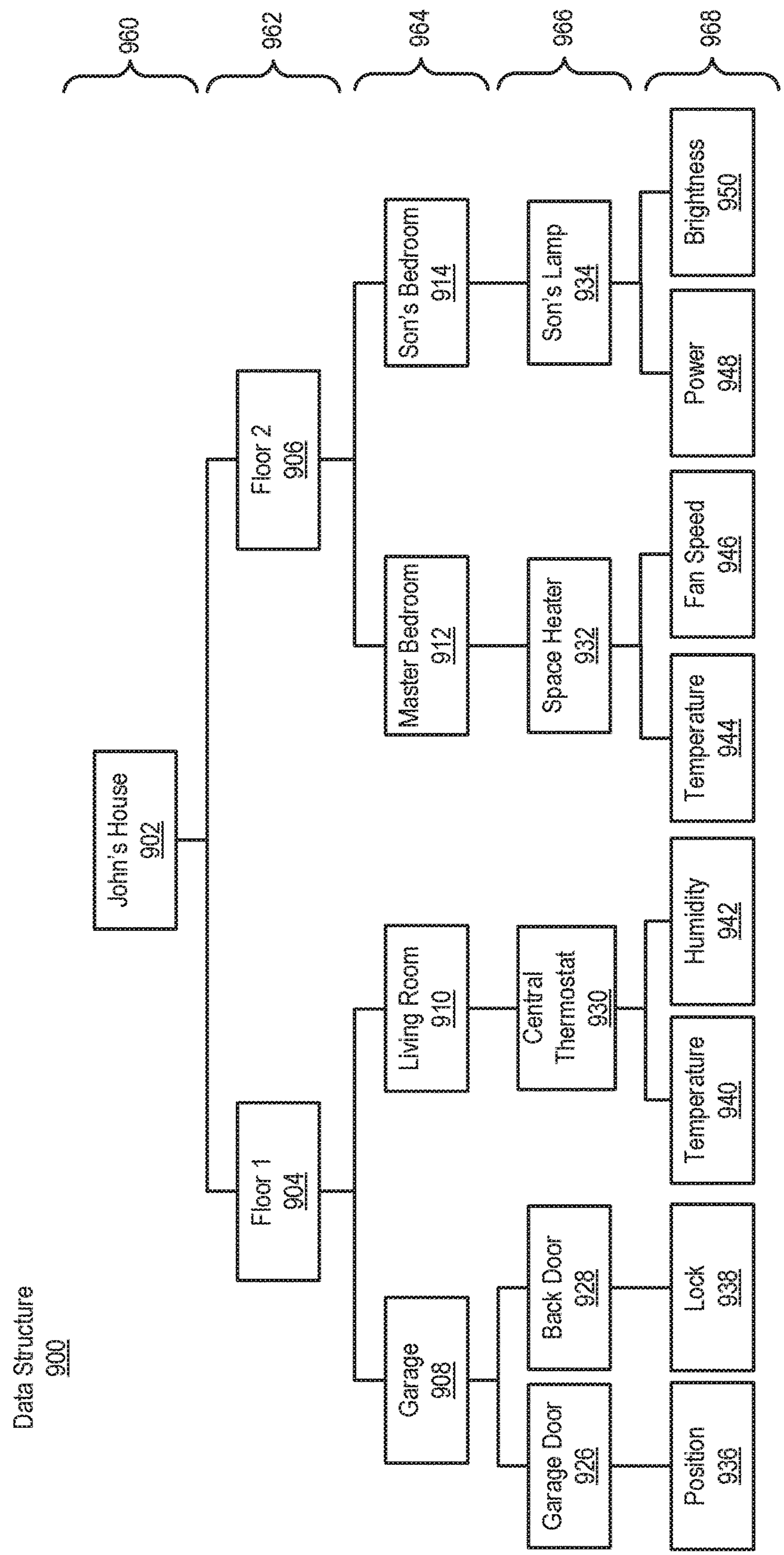

Data Structure
900
960
962
964
966
968
John's House
902
Floor 1
904
Floor 2
906
Garage
908
Living Room
910
Master Bedroom
912
Son's Bedroom
914
Garage Door
926
Back Door
928
Central Thermostat
930
Space Heater
932
Son's Lamp
934
Position
936
Lock
938
Temperature
940
Humidity
942
Temperature
944
Fan Speed
946
Power
948
Brightness
950

FIG. 9

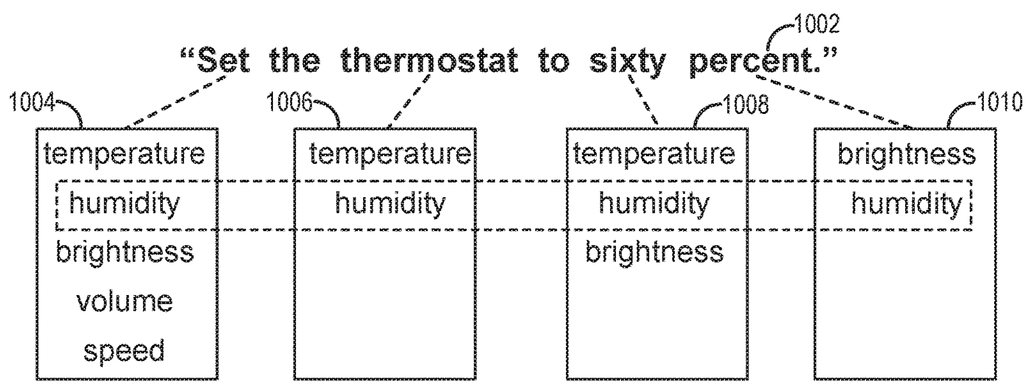


FIG. 10A

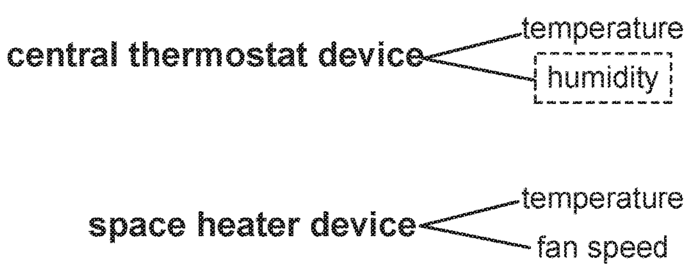


FIG. 10B

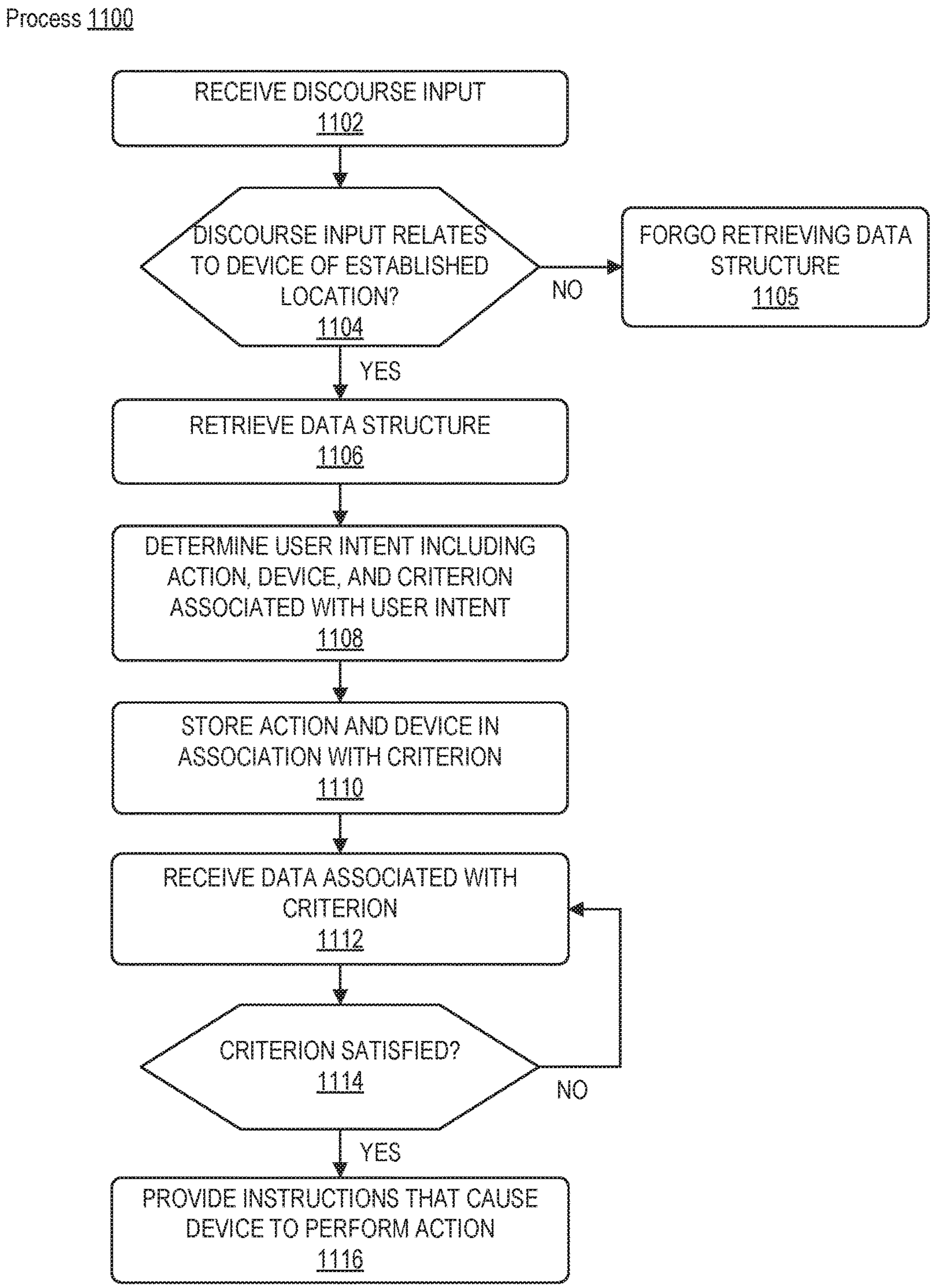

Process 1100
RECEIVE DISCOURSE INPUT
1102
DISCOURSE INPUT RELATES TO DEVICE OF ESTABLISHED LOCATION?
1104
NO
FORGO RETRIEVING DATA STRUCTURE
1105
YES
RETRIEVE DATA STRUCTURE
1106
DETERMINE USER INTENT INCLUDING ACTION, DEVICE, AND CRITERION ASSOCIATED WITH USER INTENT
1108
STORE ACTION AND DEVICE IN ASSOCIATION WITH CRITERION
1110
RECEIVE DATA ASSOCIATED WITH CRITERION
1112
CRITERION SATISFIED?
1114
NO
YES
PROVIDE INSTRUCTIONS THAT CAUSE DEVICE TO PERFORM ACTION
1116

FIG. 11

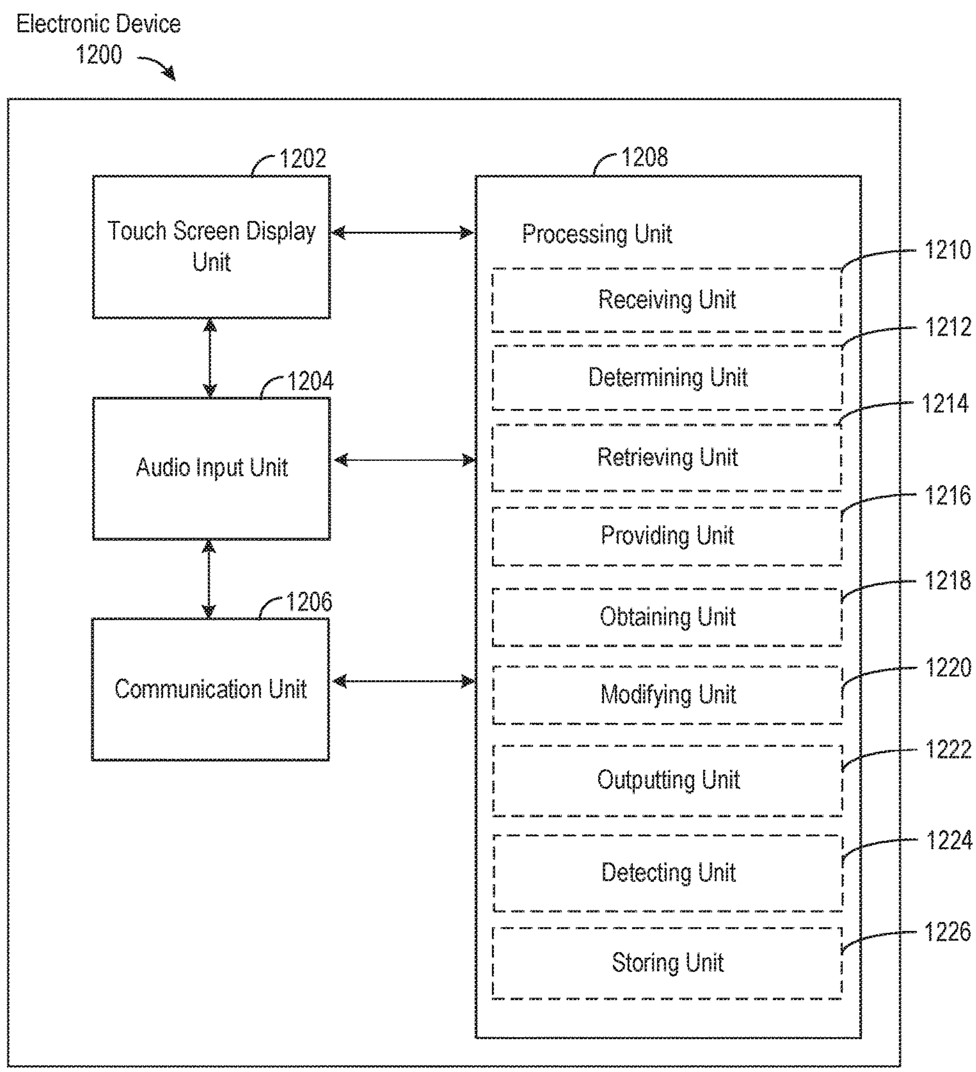

Electronic Device
1200
1202
Touch Screen Display Unit
1204
Audio Input Unit
1206
Communication Unit
1208
Processing Unit
1210
Receiving Unit
1212
Determining Unit
1214
Retrieving Unit
1216
Providing Unit
1218
Obtaining Unit
1220
Modifying Unit
1222
Outputting Unit
1224
Detecting Unit
1226
Storing Unit

FIG. 12

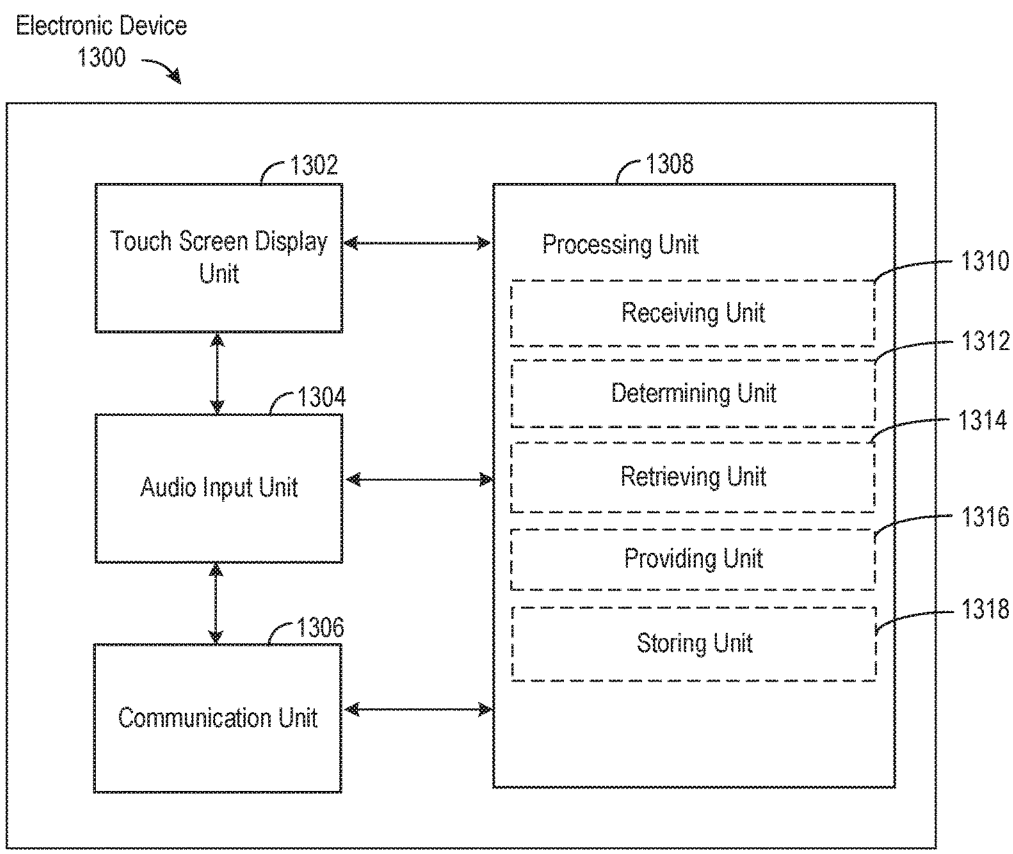

Electronic Device
1300
1302
Touch Screen Display Unit
1304
Audio Input Unit
1306
Communication Unit
1308
Processing Unit
1310
Receiving Unit
1312
Determining Unit
1314
Retrieving Unit
1316
Providing Unit
1318
Storing Unit

FIG. 13

INTELLIGENT AUTOMATED ASSISTANT IN A HOME ENVIRONMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Ser. No. 62/348,015, filed on Jun. 9, 2016, entitled INTELLIGENT AUTOMATED ASSISTANT IN A HOME ENVIRONMENT, which is hereby incorporated by reference in its entirety for all purposes.

This application also relates to the following co-pending applications: U.S. Non-Provisional patent application Ser. No. 14/503,105, "INTELLIGENT ASSISTANT FOR HOME AUTOMATION," filed Sep. 30, 2014, which is hereby incorporated by reference in its entirety for all purposes.

FIELD

This relates generally to intelligent automated assistants and, more specifically, to intelligent automated assistants in a home environment.

BACKGROUND

Intelligent automated assistants (or digital assistants) can provide a beneficial interface between human users and electronic devices. Such assistants can allow users to interact with devices or systems using natural language in spoken and/or text forms. For example, a user can provide a speech input containing a user request to a digital assistant operating on an electronic device. The digital assistant can interpret the user's intent from the speech input and operationalize the user's intent into tasks. The tasks can then be performed by executing one or more services of the electronic device, and a relevant output responsive to the user request can be returned to the user.

Devices (e.g., electronic device) of an established location (e.g., home, office, business, public institution) can be controlled remotely using software applications running on a computing device, such as a mobile phone, tablet computer, laptop computer, desktop computer, or the like. For example, numerous manufacturers create light bulbs that can be controlled by a software application running on a mobile phone to adjust the brightness and/or color of the bulb. Other devices, such as door locks, thermostats, and the like, having similar controls are also available.

While these devices can provide users with a greater level of control and convenience, it can become exceedingly difficult to manage these devices as the number of remotely controlled devices and the number of types of remotely controlled devices in the home increase. For example, a typical home can include 40-50 light bulbs placed throughout the various rooms of the home. Using conventional software applications, each light bulb is given a unique identifier, and a user attempting to control one of these devices must select the appropriate identifier from a list of available devices within a graphical user interface. Remembering the correct identifier for a particular light bulb and finding that identifier from a list of 40-50 identifiers can be a difficult and time-consuming process. For example, the user can confuse the identifier of one device with that of another and thus be unable to control the desired device. To add to the difficulty of managing and controlling a large number of remotely controlled devices, different manufactures typically provide different software applications that

must be used to control their respective devices. As a result, a user must locate and open one software application to turn on/off their light bulbs, and must then locate and open another software application to set the temperature of their thermostat.

SUMMARY

Systems and processes for operating an intelligent automated assistant are provided. In one example process, discourse input representing a user request is received. The process determines one or more possible device characteristics corresponding to the discourse input. A data structure representing a set of devices of an established location is retrieved. The process determines, based on the data structure, one or more candidate devices from the set of devices. The one or more candidate devices correspond to the discourse input. The process determines, based on the one or more possible device characteristics and one or more actual device characteristics of the one or more candidate devices, a user intent corresponding to the discourse input. Instructions that cause a device of the one or more candidate devices to perform an action corresponding to the user intent are provided.

In another example process, discourse input representing a user request is received. The process determines whether the discourse input relates to a device of an established location. In response to determining that the discourse input relates to a device of an established location, a data structure representing a set of devices of the established location is retrieved. The process determines, using the data structure, a user intent corresponding to the discourse input, the user intent associated with an action to be performed by a device of the set of devices, and a criterion to be satisfied prior to performing the action. The action and the device are stored in association with the criterion, where, in accordance with a determination that the criterion is satisfied, the action is performed by the device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating a system and environment for implementing a digital assistant according to various examples.

FIG. **2**A is a block diagram illustrating a portable multifunction device implementing the client-side portion of a digital assistant according to various examples.

FIG. **2**B is a block diagram illustrating exemplary components for event handling according to various examples.

FIG. **3** illustrates a portable multifunction device implementing the client-side portion of a digital assistant according to various examples.

FIG. **4** is a block diagram of an exemplary multifunction device with a display and a touch-sensitive surface according to various examples.

FIG. **5**A illustrates an exemplary user interface for a menu of applications on a portable multifunction device according to various examples.

FIG. **5**B illustrates an exemplary user interface for a multifunction device with a touch-sensitive surface that is separate from the display according to various examples.

FIG. **6**A illustrates a personal electronic device according to various examples.

FIG. **6**B is a block diagram illustrating a personal electronic device according to various examples.

FIG. 7A is a block diagram illustrating a digital assistant system or a server portion thereof according to various examples.

FIG. 7B illustrates the functions of the digital assistant shown in FIG. 7A according to various examples.

FIG. 7C illustrates a portion of an ontology according to various examples.

FIG. 8 illustrates a process for operating a digital assistant according to various examples.

FIG. 9 is a hierarchical chart illustrating a data structure that represents a set of devices of an established location according to various examples.

FIG. 10A illustrates possible device characteristics corresponding to an exemplary discourse input according to various examples.

FIG. 10B illustrates actual device characteristics associated with devices represented in a data structure according to various examples.

FIG. 11 illustrates a process for operating a digital assistant according to various examples.

FIG. 12 illustrates a functional block diagram of an electronic device according to various examples.

FIG. 13 illustrates a functional block diagram of an electronic device according to various examples.

DETAILED DESCRIPTION

In the following description of examples, reference is made to the accompanying drawings in which it is shown by way of illustration specific examples that can be practiced. It is to be understood that other examples can be used and structural changes can be made without departing from the scope of the various examples.

As discussed above, utilizing a digital assistant to control devices of an established location, such as devices in a user's home, can be convenient and beneficial to the user. Preferably, the user employs natural language to convey to the digital assistant the intended action and the intended device for performing the action without having to refer to predefined commands or predefined device identifiers. For example, if the user provides the natural language command "Open the door," it can be desirable for the digital assistant to understand exactly which door the user is referring to and whether the intended action is to open the door or unlock the door. The user thus would not need to remember a myriad of predefined commands and device identifiers in order to convey the user's intent to the digital assistant. This improves the user experience and allow for a more natural and personable interaction with the digital assistant.

Although natural language interactions are desirable to improve user experience, natural language often includes ambiguous terms which are difficult for the digital assistant to disambiguate. For example, for the natural language command "Open the door," the user's home could have several doors which can be opened or unlocked. The digital assistant therefore needs to rely on other information to supplement the natural language command in order to accurately determine the intended action and the intended device for performing the action. In accordance with some exemplary systems and processes described herein, a data structure defining the devices of an established location is utilized to assist with determining the user's intent from the user's natural language command. In one example process, discourse input representing a user request is received. The process determines one or more possible device characteristics corresponding to the discourse input. A data structure representing a set of devices of an established location is retrieved. The process determines, based on the data structure, one or more candidate devices from the set of devices. The one or more candidate devices correspond to the discourse input. The process determines, based on the one or more possible device characteristics and one or more actual device characteristics of the one or more candidate devices, a user intent corresponding to the discourse input. Instructions that cause a device of the one or more candidate devices to perform an action corresponding to the user intent are provided.

A digital assistant can also process user commands for performing a future action in response to a specified condition. The action or the condition is with respect to one or more devices in an established location. For example, the user provides the natural language command "Close the blinds when it reaches 80 degrees." In this example, the digital assistant determines that the user wishes to perform the action of closing the blinds in response to the condition of detecting a temperature equal to or greater than 80 degrees. In particular, the digital assistant would need to determine which "blinds" the user wishes to close and which thermometer the user wishes to monitor with respect to the "80 degrees" criterion. The data structure referred to above is also utilized to assist with making such a determination. For instance, in one example process, discourse input representing a user request is received. The process determines whether the discourse input relates to a device of an established location. In response to determining that the discourse input relates to a device of an established location, a data structure representing a set of devices of the established location is retrieved. The process determines, using the data structure, a user intent corresponding to the discourse input, the user intent associated with an action to be performed by a device of the set of devices and a criterion to be satisfied prior to performing the action. The action and the device are stored in association with the criterion where, in accordance with a determination that the criterion is satisfied, the action is performed by the device.

Although the following description uses terms "first," "second," etc. to describe various elements, these elements should not be limited by the terms. These terms are only used to distinguish one element from another. For example, a first device could be termed a second device, and, similarly, a second device could be termed a first device, without departing from the scope of the various described examples. The first device and the second device, in some examples, are both devices and, in some cases, are separate and different devices.

The terminology used in the description of the various described examples herein is for the purpose of describing particular examples only and is not intended to be limiting. As used in the description of the various described examples and the appended claims, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. It will be further understood that the terms "includes," "including," "comprises," and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The term "if" may be construed to mean "when" or "upon" or "in response to determining" or "in response to detecting," depending on the context. Similarly, the phrase "if it is determined" or "if [a stated condition or event] is detected" may be construed to mean "upon determining" or "in response to determining" or "upon detecting [the stated condition or event]" or "in response to detecting [the stated condition or event]," depending on the context.

1. System and Environment

FIG. **1** illustrates a block diagram of system **100** according to various examples. In some examples, system **100** implements a digital assistant. The terms "digital assistant," "virtual assistant," "intelligent automated assistant," or "automatic digital assistant" refer to any information processing system that interprets natural language input in spoken and/or textual form to infer user intent, and performs actions based on the inferred user intent. For example, to act on an inferred user intent, the system performs one or more of the following: identifying a task flow with steps and parameters designed to accomplish the inferred user intent, inputting specific requirements from the inferred user intent into the task flow; executing the task flow by invoking programs, methods, services, APIs, or the like; and generating output responses to the user in an audible (e.g., speech) and/or visual form.

Specifically, a digital assistant is capable of accepting a user request at least partially in the form of a natural language command, request, statement, narrative, and/or inquiry. Typically, the user request seeks either an informational answer or performance of a task by the digital assistant. A satisfactory response to the user request includes a provision of the requested informational answer, a performance of the requested task, or a combination of the two. For example, a user asks the digital assistant a question, such as "Where am I right now?" Based on the user's current location, the digital assistant answers, "You are in Central Park near the west gate." The user also requests the performance of a task, for example, "Please invite my friends to my girlfriend's birthday party next week." In response, the digital assistant can acknowledge the request by saying "Yes, right away," and then send a suitable calendar invite on behalf of the user to each of the user's friends listed in the user's electronic address book. During performance of a requested task, the digital assistant sometimes interacts with the user in a continuous dialogue involving multiple exchanges of information over an extended period of time. There are numerous other ways of interacting with a digital assistant to request information or performance of various tasks. In addition to providing verbal responses and taking programmed actions, the digital assistant also provides responses in other visual or audio forms, e.g., as text, alerts, music, videos, animations, etc.

As shown in FIG. **1**, in some examples, a digital assistant is implemented according to a client-server model. The digital assistant includes client-side portion **102** (hereafter "DA client **102**") executed on user device **104** and server-side portion **106** (hereafter "DA server **106**") executed on server system **108**. DA client **102** communicates with DA server **106** through one or more networks **110**. DA client **102** provides client-side functionalities such as user-facing input and output processing and communication with DA server **106**. DA server **106** provides server-side functionalities for any number of DA clients **102** each residing on a respective user device **104**.

In some examples, DA server **106** includes client-facing I/O interface **112**, one or more processing modules **114**, data and models **116**, and I/O interface to external services **118**. The client-facing I/O interface **112** facilitates the client-facing input and output processing for DA server **106**. One or more processing modules **114** utilize data and models **116** to process speech input and determine the user's intent based on natural language input. In some examples, data and model storage **116** stores a data structure (e.g., data structure **900**) and any other relevant information associated with one or more of devices (e.g., devices **130**, **132**, **134**, and **136**) that are configured to be controlled by user device **104** and/or server system **108**. Further, one or more processing modules **114** perform task execution based on inferred user intent. In some examples, DA server **106** communicates with external services **120** through network(s) **110** for task completion or information acquisition. I/O interface to external services **118** facilitates such communications.

User device **104** can be any suitable electronic device. In some examples, user device is a portable multifunctional device (e.g., device **200**, described below with reference to FIG. **2**A), a multifunctional device (e.g., device **400**, described below with reference to FIG. **4**), or a personal electronic device (e.g., device **600**, described below with reference to FIG. **6**A-B.) A portable multifunctional device is, for example, a mobile telephone that also contains other functions, such as PDA and/or music player functions. Specific examples of portable multifunction devices include the iPhone®, iPod Touch®, and iPad® devices from Apple Inc. of Cupertino, Calif. Other examples of portable multifunction devices include, without limitation, laptop or tablet computers. Further, in some examples, user device **104** is a non-portable multifunctional device. In particular, user device **104** is a desktop computer, a game console, a television, or a television set-top box. In some examples, user device **104** includes a touch-sensitive surface (e.g., touch screen displays and/or touchpads). Further, user device **104** optionally includes one or more other physical user-interface devices, such as a physical keyboard, a mouse, and/or a joystick. Various examples of electronic devices, such as multifunctional devices, are described below in greater detail.

Examples of communication network(s) **110** include local area networks (LAN) and wide area networks (WAN), e.g., the Internet. Communication network(s) **110** is implemented using any known network protocol, including various wired or wireless protocols, such as, for example, Ethernet, Universal Serial Bus (USB), FIREWIRE, Global System for Mobile Communications (GSM), Enhanced Data GSM Environment (EDGE), code division multiple access (CDMA), time division multiple access (TDMA), Bluetooth, Wi-Fi, voice over Internet Protocol (VoIP), Wi-MAX, or any other suitable communication protocol.

Server system **108** is implemented on one or more standalone data processing apparatus or a distributed network of computers. In some examples, server system **108** also employs various virtual devices and/or services of third-party service providers (e.g., third-party cloud service providers) to provide the underlying computing resources and/or infrastructure resources of server system **108**.

In some examples, user device **104** communicates with DA server **106** via second user device **122**. Second user device **122** is similar or identical to user device **104**. For example, second user device **122** is similar to devices **200**, **400**, or **600** described below with reference to FIGS. **2**A, **4**, and **6**A-B. User device **104** is configured to communicatively couple to second user device **122** via a direct communication connection, such as Bluetooth, NFC, BTLE, or the like, or via a wired or wireless network, such as a local Wi-Fi network. In some examples, second user device **122** is configured to act as a proxy between user device **104** and DA server **106**. For example, DA client **102** of user device

104 is configured to transmit information (e.g., a user request received at user device 104) to DA server 106 via second user device 122. DA server 106 processes the information and return relevant data (e.g., data content responsive to the user request) to user device 104 via second user device 122.

In some examples, user device 104 is configured to communicate abbreviated requests for data to second user device 122 to reduce the amount of information transmitted from user device 104. Second user device 122 is configured to determine supplemental information to add to the abbreviated request to generate a complete request to transmit to DA server 106. This system architecture can advantageously allow user device 104 having limited communication capabilities and/or limited battery power (e.g., a watch or a similar compact electronic device) to access services provided by DA server 106 by using second user device 122, having greater communication capabilities and/or battery power (e.g., a mobile phone, laptop computer, tablet computer, or the like), as a proxy to DA server 106. While only two user devices 104 and 122 are shown in FIG. 1, it should be appreciated that system 100, in some examples, includes any number and type of user devices configured in this proxy configuration to communicate with DA server system 106.

User device 104 and/or server system 108 are further coupled to devices 130, 132, 134, and 136 via network(s) 110. Devices 130, 132, 134, and 136 can include any type of remotely controlled device, such as a light bulb (e.g., having binary on/off operating states, numerical dimmable operating states, color operating state, etc.), garage door (e.g., having a binary open/closed operating state), door lock (e.g., having binary locked/unlocked operating state), thermostat (e.g., having one or more numerical temperature setpoint operating states, such as a high temperature, low temperature, time-based temperatures, etc.), electrical outlet (e.g., having a binary on/off operating state), switch (e.g., having a binary on/off operating state), a music player, a television set, or the like. Devices 130-136 are configured to receive instructions from server system 108 and/or user device 104. As discussed in greater detail below with respect to FIGS. 8-11, user device 104 can issue commands (or cause DA server 106 to issue commands) to control any of one of devices 130-136 in response to a natural language dialogue input provided by a user to user device 104.

While only four devices 130, 132, 134, and 136 are shown in FIG. 1, it should be appreciated that system 100 can include any number of devices. Additionally, although the digital assistant shown in FIG. 1 includes both a client-side portion (e.g., DA client 102) and a server-side portion (e.g., DA server 106), in some examples, the functions of a digital assistant are implemented as a standalone application installed on a user device. In addition, the divisions of functionalities between the client and server portions of the digital assistant can vary in different implementations. For instance, in some examples, the DA client is a thin-client that provides only user-facing input and output processing functions, and delegates all other functionalities of the digital assistant to a backend server.

2. Electronic Devices

Attention is now directed toward embodiments of electronic devices for implementing the client-side portion of a digital assistant. FIG. 2A is a block diagram illustrating portable multifunction device 200 with touch-sensitive display system 212 in accordance with some embodiments. Touch-sensitive display 212 is sometimes called a "touch screen" for convenience and is sometimes known as or called a "touch-sensitive display system." Device 200 includes memory 202 (which optionally includes one or more computer-readable storage mediums), memory controller 222, one or more processing units (CPUs) 220, peripherals interface 218, RF circuitry 208, audio circuitry 210, speaker 211, microphone 213, input/output (I/O) subsystem 206, other input control devices 216, and external port 224. Device 200 optionally includes one or more optical sensors 264. Device 200 optionally includes one or more contact intensity sensors 265 for detecting intensity of contacts on device 200 (e.g., a touch-sensitive surface such as touch-sensitive display system 212 of device 200). Device 200 optionally includes one or more tactile output generators 267 for generating tactile outputs on device 200 (e.g., generating tactile outputs on a touch-sensitive surface such as touch-sensitive display system 212 of device 200 or touchpad 455 of device 400). These components optionally communicate over one or more communication buses or signal lines 203.

As used in the specification and claims, the term "intensity" of a contact on a touch-sensitive surface refers to the force or pressure (force per unit area) of a contact (e.g., a finger contact) on the touch-sensitive surface, or to a substitute (proxy) for the force or pressure of a contact on the touch-sensitive surface. The intensity of a contact has a range of values that includes at least four distinct values and more typically includes hundreds of distinct values (e.g., at least 256). Intensity of a contact is, optionally, determined (or measured) using various approaches and various sensors or combinations of sensors. For example, one or more force sensors underneath or adjacent to the touch-sensitive surface are, optionally, used to measure force at various points on the touch-sensitive surface. In some implementations, force measurements from multiple force sensors are combined (e.g., a weighted average) to determine an estimated force of a contact. Similarly, a pressure-sensitive tip of a stylus is, optionally, used to determine a pressure of the stylus on the touch-sensitive surface. Alternatively, the size of the contact area detected on the touch-sensitive surface and/or changes thereto, the capacitance of the touch-sensitive surface proximate to the contact and/or changes thereto, and/or the resistance of the touch-sensitive surface proximate to the contact and/or changes thereto are, optionally, used as a substitute for the force or pressure of the contact on the touch-sensitive surface. In some implementations, the substitute measurements for contact force or pressure are used directly to determine whether an intensity threshold has been exceeded (e.g., the intensity threshold is described in units corresponding to the substitute measurements). In some implementations, the substitute measurements for contact force or pressure are converted to an estimated force or pressure, and the estimated force or pressure is used to determine whether an intensity threshold has been exceeded (e.g., the intensity threshold is a pressure threshold measured in units of pressure). Using the intensity of a contact as an attribute of a user input allows for user access to additional device functionality that may otherwise not be accessible by the user on a reduced-size device with limited real estate for displaying affordances (e.g., on a touch-sensitive display) and/or receiving user input (e.g., via a touch-sensitive display, a touch-sensitive surface, or a physical/mechanical control such as a knob or a button).

As used in the specification and claims, the term "tactile output" refers to physical displacement of a device relative to a previous position of the device, physical displacement of a component (e.g., a touch-sensitive surface) of a device relative to another component (e.g., housing) of the device, or displacement of the component relative to a center of mass of the device that will be detected by a user with the user's sense of touch. For example, in situations where the device or the component of the device is in contact with a surface of a user that is sensitive to touch (e.g., a finger, palm, or other part of a user's hand), the tactile output generated by the physical displacement will be interpreted by the user as a tactile sensation corresponding to a perceived change in physical characteristics of the device or the component of the device. For example, movement of a touch-sensitive surface (e.g., a touch-sensitive display or trackpad) is, optionally, interpreted by the user as a "down click" or "up click" of a physical actuator button. In some cases, a user will feel a tactile sensation such as an "down click" or "up click" even when there is no movement of a physical actuator button associated with the touch-sensitive surface that is physically pressed (e.g., displaced) by the user's movements. As another example, movement of the touch-sensitive surface is, optionally, interpreted or sensed by the user as "roughness" of the touch-sensitive surface, even when there is no change in smoothness of the touch-sensitive surface. While such interpretations of touch by a user will be subject to the individualized sensory perceptions of the user, there are many sensory perceptions of touch that are common to a large majority of users. Thus, when a tactile output is described as corresponding to a particular sensory perception of a user (e.g., an "up click," a "down click," "roughness"), unless otherwise stated, the generated tactile output corresponds to physical displacement of the device or a component thereof that will generate the described sensory perception for a typical (or average) user.

It should be appreciated that device **200** is only one example of a portable multifunction device, and that device **200** optionally has more or fewer components than shown, optionally combines two or more components, or optionally has a different configuration or arrangement of the components. The various components shown in FIG. **2**A are implemented in hardware, software, or a combination of both hardware and software, including one or more signal processing and/or application-specific integrated circuits.

Memory **202** includes one or more computer-readable storage mediums. The computer-readable storage mediums are, for example, tangible and non-transitory. Memory **202** includes high-speed random access memory and also includes non-volatile memory, such as one or more magnetic disk storage devices, flash memory devices, or other non-volatile solid-state memory devices. Memory controller **222** controls access to memory **202** by other components of device **200**.

In some examples, a non-transitory computer-readable storage medium of memory **202** is used to store instructions (e.g., for performing aspects of processes described below) for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions. In other examples, the instructions (e.g., for performing aspects of the processes described below) are stored on a non-transitory computer-readable storage medium (not shown) of the server system **108** or are divided between the non-transitory computer-readable storage medium of memory **202** and the non-transitory computer-readable storage medium of server system **108**.

Peripherals interface **218** is used to couple input and output peripherals of the device to CPU **220** and memory **202**. The one or more processors **220** run or execute various software programs and/or sets of instructions stored in memory **202** to perform various functions for device **200** and to process data. In some embodiments, peripherals interface **218**, CPU **220**, and memory controller **222** are implemented on a single chip, such as chip **204**. In some other embodiments, they are implemented on separate chips.

RF (radio frequency) circuitry **208** receives and sends RF signals, also called electromagnetic signals. RF circuitry **208** converts electrical signals to/from electromagnetic signals and communicates with communications networks and other communications devices via the electromagnetic signals. RF circuitry **208** optionally includes well-known circuitry for performing these functions, including but not limited to an antenna system, an RF transceiver, one or more amplifiers, a tuner, one or more oscillators, a digital signal processor, a CODEC chipset, a subscriber identity module (SIM) card, memory, and so forth. RF circuitry **208** optionally communicates with networks, such as the Internet, also referred to as the World Wide Web (WWW), an intranet and/or a wireless network, such as a cellular telephone network, a wireless local area network (LAN) and/or a metropolitan area network (MAN), and other devices by wireless communication. The RF circuitry **208** optionally includes well-known circuitry for detecting near field communication (NFC) fields, such as by a short-range communication radio. The wireless communication optionally uses any of a plurality of communications standards, protocols, and technologies, including but not limited to Global System for Mobile Communications (GSM), Enhanced Data GSM Environment (EDGE), high-speed downlink packet access (HSDPA), high-speed uplink packet access (HSDPA), Evolution, Data-Only (EV-DO), HSPA, HSPA+, Dual-Cell HSPA (DC-HSPDA), long term evolution (LTE), near field communication (NFC), wideband code division multiple access (W-CDMA), code division multiple access (CDMA), time division multiple access (TDMA), Bluetooth, Bluetooth Low Energy (BTLE), Wireless Fidelity (Wi-Fi) (e.g., IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, and/or IEEE 802.11ac), voice over Internet Protocol (VoIP), Wi-MAX, a protocol for e mail (e.g., Internet message access protocol (IMAP) and/or post office protocol (POP)), instant messaging (e.g., extensible messaging and presence protocol (XMPP), Session Initiation Protocol for Instant Messaging and Presence Leveraging Extensions (SIMPLE), Instant Messaging and Presence Service (IMPS)), and/or Short Message Service (SMS), or any other suitable communication protocol, including communication protocols not yet developed as of the filing date of this document.

Audio circuitry **210**, speaker **211**, and microphone **213** provide an audio interface between a user and device **200**. Audio circuitry **210** receives audio data from peripherals interface **218**, converts the audio data to an electrical signal, and transmits the electrical signal to speaker **211**. Speaker **211** converts the electrical signal to human-audible sound waves. Audio circuitry **210** also receives electrical signals converted by microphone **213** from sound waves. Audio circuitry **210** converts the electrical signal to audio data and transmits the audio data to peripherals interface **218** for processing. Audio data are retrieved from and/or transmitted to memory **202** and/or RF circuitry **208** by peripherals interface **218**. In some embodiments, audio circuitry **210** also includes a headset jack (e.g., **312**, FIG. **3**). The headset jack provides an interface between audio circuitry **210** and removable audio input/output peripherals, such as output-only headphones or a headset with both output (e.g., a headphone for one or both ears) and input (e.g., a microphone).

I/O subsystem **206** couples input/output peripherals on device **200**, such as touch screen **212** and other input control devices **216**, to peripherals interface **218**. I/O subsystem **206** optionally includes display controller **256**, optical sensor controller **258**, intensity sensor controller **259**, haptic feedback controller **261**, and one or more input controllers **260** for other input or control devices. The one or more input controllers **260** receive/send electrical signals from/to other input control devices **216**. The other input control devices **216** optionally include physical buttons (e.g., push buttons, rocker buttons, etc.), dials, slider switches, joysticks, click wheels, and so forth. In some alternate embodiments, input controller(s) **260** are, optionally, coupled to any (or none) of the following: a keyboard, an infrared port, a USB port, and a pointer device such as a mouse. The one or more buttons (e.g., **308**, FIG. **3**) optionally include an up/down button for volume control of speaker **211** and/or microphone **213**. The one or more buttons optionally include a push button (e.g., **306**, FIG. **3**).

A quick press of the push button disengages a lock of touch screen **212** or begin a process that uses gestures on the touch screen to unlock the device, as described in U.S. patent application Ser. No. 11/322,549, "Unlocking a Device by Performing Gestures on an Unlock Image," filed Dec. 23, 2005, U.S. Pat. No. 7,657,849, which is hereby incorporated by reference in its entirety. A longer press of the push button (e.g., **306**) turns power to device **200** on or off. The user is able to customize a functionality of one or more of the buttons. Touch screen **212** is used to implement virtual or soft buttons and one or more soft keyboards.

Touch-sensitive display **212** provides an input interface and an output interface between the device and a user. Display controller **256** receives and/or sends electrical signals from/to touch screen **212**. Touch screen **212** displays visual output to the user. The visual output includes graphics, text, icons, video, and any combination thereof (collectively termed "graphics"). In some embodiments, some or all of the visual output correspond to user-interface objects.

Touch screen **212** has a touch-sensitive surface, sensor, or set of sensors that accepts input from the user based on haptic and/or tactile contact. Touch screen **212** and display controller **256** (along with any associated modules and/or sets of instructions in memory **202**) detect contact (and any movement or breaking of the contact) on touch screen **212** and convert the detected contact into interaction with user-interface objects (e.g., one or more soft keys, icons, web pages, or images) that are displayed on touch screen **212**. In an exemplary embodiment, a point of contact between touch screen **212** and the user corresponds to a finger of the user.

Touch screen **212** uses LCD (liquid crystal display) technology, LPD (light emitting polymer display) technology, or LED (light emitting diode) technology, although other display technologies may be used in other embodiments. Touch screen **212** and display controller **256** detect contact and any movement or breaking thereof using any of a plurality of touch sensing technologies now known or later developed, including but not limited to capacitive, resistive, infrared, and surface acoustic wave technologies, as well as other proximity sensor arrays or other elements for determining one or more points of contact with touch screen **212**. In an exemplary embodiment, projected mutual capacitance sensing technology is used, such as that found in the iPhone® and iPod Touch® from Apple Inc. of Cupertino, Calif.

A touch-sensitive display in some embodiments of touch screen **212** is analogous to the multi-touch sensitive touchpads described in the following U.S. Pat. No. 6,323,846 (Westerman et al.), U.S. Pat. No. 6,570,557 (Westerman et al.), and/or U.S. Pat. No. 6,677,932 (Westerman), and/or U.S. Patent Publication 2002/0015024A1, each of which is hereby incorporated by reference in its entirety. However, touch screen **212** displays visual output from device **200**, whereas touch-sensitive touchpads do not provide visual output.

A touch-sensitive display in some embodiments of touch screen **212** is as described in the following applications: (1) U.S. patent application Ser. No. 11/381,313, "Multipoint Touch Surface Controller," filed May 2, 2006; (2) U.S. patent application Ser. No. 10/840,862, "Multipoint Touchscreen," filed May 6, 2004; (3) U.S. patent application Ser. No. 10/903,964, "Gestures For Touch Sensitive Input Devices," filed Jul. 30, 2004; (4) U.S. patent application Ser. No. 11/048,264, "Gestures For Touch Sensitive Input Devices," filed Jan. 31, 2005; (5) U.S. patent application Ser. No. 11/038,590, "Mode-Based Graphical User Interfaces For Touch Sensitive Input Devices," filed Jan. 18, 2005; (6) U.S. patent application Ser. No. 11/228,758, "Virtual Input Device Placement On A Touch Screen User Interface," filed Sep. 16, 2005; (7) U.S. patent application Ser. No. 11/228,700, "Operation Of A Computer With A Touch Screen Interface," filed Sep. 16, 2005; (8) U.S. patent application Ser. No. 11/228,737, "Activating Virtual Keys Of A Touch-Screen Virtual Keyboard," filed Sep. 16, 2005; and (9) U.S. patent application Ser. No. 11/367,749, "Multi-Functional Hand-Held Device," filed Mar. 3, 2006. All of these applications are incorporated by reference herein in their entirety.

Touch screen **212** has, for example, a video resolution in excess of 100 dpi. In some embodiments, the touch screen has a video resolution of approximately 160 dpi. The user makes contact with touch screen **212** using any suitable object or appendage, such as a stylus, a finger, and so forth. In some embodiments, the user interface is designed to work primarily with finger-based contacts and gestures, which can be less precise than stylus-based input due to the larger area of contact of a finger on the touch screen. In some embodiments, the device translates the rough finger-based input into a precise pointer/cursor position or command for performing the actions desired by the user.

In some embodiments, in addition to the touch screen, device **200** includes a touchpad (not shown) for activating or deactivating particular functions. In some embodiments, the touchpad is a touch-sensitive area of the device that, unlike the touch screen, does not display visual output. The touchpad is a touch-sensitive surface that is separate from touch screen **212** or an extension of the touch-sensitive surface formed by the touch screen.

Device **200** also includes power system **262** for powering the various components. Power system **262** includes a power management system, one or more power sources (e.g., battery, alternating current (AC)), a recharging system, a power failure detection circuit, a power converter or inverter, a power status indicator (e.g., a light-emitting diode (LED)) and any other components associated with the generation, management and distribution of power in portable devices.

Device **200** also includes one or more optical sensors **264**. FIG. **2**A shows an optical sensor coupled to optical sensor controller **258** in I/O subsystem **206**. Optical sensor **264** includes charge-coupled device (CCD) or complementary metal-oxide semiconductor (CMOS) phototransistors. Optical sensor **264** receives light from the environment, projected through one or more lenses, and converts the light to data representing an image. In conjunction with imaging module **243** (also called a camera module), optical sensor

264 captures still images or video. In some embodiments, an optical sensor is located on the back of device **200**, opposite touch screen display **212** on the front of the device so that the touch screen display is used as a viewfinder for still and/or video image acquisition. In some embodiments, an optical sensor is located on the front of the device so that the user's image is obtained for video conferencing while the user views the other video conference participants on the touch screen display. In some embodiments, the position of optical sensor **264** can be changed by the user (e.g., by rotating the lens and the sensor in the device housing) so that a single optical sensor **264** is used along with the touch screen display for both video conferencing and still and/or video image acquisition.

Device **200** optionally also includes one or more contact intensity sensors **265**. FIG. **2**A shows a contact intensity sensor coupled to intensity sensor controller **259** in I/O subsystem **206**. Contact intensity sensor **265** optionally includes one or more piezoresistive strain gauges, capacitive force sensors, electric force sensors, piezoelectric force sensors, optical force sensors, capacitive touch-sensitive surfaces, or other intensity sensors (e.g., sensors used to measure the force (or pressure) of a contact on a touch-sensitive surface). Contact intensity sensor **265** receives contact intensity information (e.g., pressure information or a proxy for pressure information) from the environment. In some embodiments, at least one contact intensity sensor is collocated with, or proximate to, a touch-sensitive surface (e.g., touch-sensitive display system **212**). In some embodiments, at least one contact intensity sensor is located on the back of device **200**, opposite touch screen display **212**, which is located on the front of device **200**.

Device **200** also includes one or more proximity sensors **266**. FIG. **2**A shows proximity sensor **266** coupled to peripherals interface **218**. Alternately, proximity sensor **266** is coupled to input controller **260** in I/O subsystem **206**. Proximity sensor **266** is performed as described in U.S. patent application Ser. No. 11/241,839, "Proximity Detector In Handheld Device"; Ser. No. 11/240,788, "Proximity Detector In Handheld Device"; Ser. No. 11/620,702, "Using Ambient Light Sensor To Augment Proximity Sensor Output"; Ser. No. 11/586,862, "Automated Response To And Sensing Of User Activity In Portable Devices"; and Ser. No. 11/638,251, "Methods And Systems For Automatic Configuration Of Peripherals," which are hereby incorporated by reference in their entirety. In some embodiments, the proximity sensor turns off and disables touch screen **212** when the multifunction device is placed near the user's ear (e.g., when the user is making a phone call).

Device **200** optionally also includes one or more tactile output generators **267**. FIG. **2**A shows a tactile output generator coupled to haptic feedback controller **261** in I/O subsystem **206**. Tactile output generator **267** optionally includes one or more electroacoustic devices such as speakers or other audio components and/or electromechanical devices that convert energy into linear motion such as a motor, solenoid, electroactive polymer, piezoelectric actuator, electrostatic actuator, or other tactile output generating component (e.g., a component that converts electrical signals into tactile outputs on the device). Contact intensity sensor **265** receives tactile feedback generation instructions from haptic feedback module **233** and generates tactile outputs on device **200** that are capable of being sensed by a user of device **200**. In some embodiments, at least one tactile output generator is collocated with, or proximate to, a touch-sensitive surface (e.g., touch-sensitive display system **212**) and, optionally, generates a tactile output by moving the touch-sensitive surface vertically (e.g., in/out of a surface of device **200**) or laterally (e.g., back and forth in the same plane as a surface of device **200**). In some embodiments, at least one tactile output generator sensor is located on the back of device **200**, opposite touch screen display **212**, which is located on the front of device **200**.

Device **200** also includes one or more accelerometers **268**. FIG. **2**A shows accelerometer **268** coupled to peripherals interface **218**. Alternately, accelerometer **268** is coupled to an input controller **260** in I/O subsystem **206**. Accelerometer **268** performs, for example, as described in U.S. Patent Publication No. 20050190059, "Acceleration-based Theft Detection System for Portable Electronic Devices," and U.S. Patent Publication No. 20060017692, "Methods And Apparatuses For Operating A Portable Device Based On An Accelerometer," both of which are incorporated by reference herein in their entirety. In some embodiments, information is displayed on the touch screen display in a portrait view or a landscape view based on an analysis of data received from the one or more accelerometers. Device **200** optionally includes, in addition to accelerometer(s) **268**, a magnetometer (not shown) and a GPS (or GLONASS or other global navigation system) receiver (not shown) for obtaining information concerning the location and orientation (e.g., portrait or landscape) of device **200**.

In some embodiments, the software components stored in memory **202** include operating system **226**, communication module (or set of instructions) **228**, contact/motion module (or set of instructions) **230**, graphics module (or set of instructions) **232**, text input module (or set of instructions) **234**, Global Positioning System (GPS) module (or set of instructions) **235**, Digital Assistant Client Module **229**, and applications (or sets of instructions) **236**. Further, memory **202** stores data and models, such as user data and models **231**. Furthermore, in some embodiments, memory **202** (FIG. **2**A) or **470** (FIG. **4**) stores device/global internal state **257**, as shown in FIGS. **2**A and **4**. Device/global internal state **257** includes one or more of: active application state, indicating which applications, if any, are currently active; display state, indicating what applications, views or other information occupy various regions of touch screen display **212**; sensor state, including information obtained from the device's various sensors and input control devices **216**; and location information concerning the device's location and/or attitude.

Operating system **226** (e.g., Darwin, RTXC, LINUX, UNIX, OS X, iOS, WINDOWS, or an embedded operating system such as VxWorks) includes various software components and/or drivers for controlling and managing general system tasks (e.g., memory management, storage device control, power management, etc.) and facilitates communication between various hardware and software components.

Communication module **228** facilitates communication with other devices over one or more external ports **224** and also includes various software components for handling data received by RF circuitry **208** and/or external port **224**. External port **224** (e.g., Universal Serial Bus (USB), FIREWIRE, etc.) is adapted for coupling directly to other devices or indirectly over a network (e.g., the Internet, wireless LAN, etc.). In some embodiments, the external port is a multi-pin (e.g., 30-pin) connector that is the same as, or similar to and/or compatible with, the 30-pin connector used on iPod® (trademark of Apple Inc.) devices.

Contact/motion module **230** optionally detects contact with touch screen **212** (in conjunction with display controller **256**) and other touch-sensitive devices (e.g., a touchpad or physical click wheel). Contact/motion module **230** includes various software components for performing various operations related to detection of contact, such as determining if contact has occurred (e.g., detecting a finger-down event), determining an intensity of the contact (e.g., the force or pressure of the contact or a substitute for the force or pressure of the contact), determining if there is movement of the contact and tracking the movement across the touch-sensitive surface (e.g., detecting one or more finger-dragging events), and determining if the contact has ceased (e.g., detecting a finger-up event or a break in contact). Contact/motion module **230** receives contact data from the touch-sensitive surface. Determining movement of the point of contact, which is represented by a series of contact data, optionally includes determining speed (magnitude), velocity (magnitude and direction), and/or an acceleration (a change in magnitude and/or direction) of the point of contact. These operations are, optionally, applied to single contacts (e.g., one finger contacts) or to multiple simultaneous contacts (e.g., "multitouch"/multiple finger contacts). In some embodiments, contact/motion module **230** and display controller **256** detect contact on a touchpad.

In some embodiments, contact/motion module **230** uses a set of one or more intensity thresholds to determine whether an operation has been performed by a user (e.g., to determine whether a user has "clicked" on an icon). In some embodiments, at least a subset of the intensity thresholds are determined in accordance with software parameters (e.g., the intensity thresholds are not determined by the activation thresholds of particular physical actuators and can be adjusted without changing the physical hardware of device **200**). For example, a mouse "click" threshold of a trackpad or touch screen display can be set to any of a large range of predefined threshold values without changing the trackpad or touch screen display hardware. Additionally, in some implementations, a user of the device is provided with software settings for adjusting one or more of the set of intensity thresholds (e.g., by adjusting individual intensity thresholds and/or by adjusting a plurality of intensity thresholds at once with a system-level click "intensity" parameter).

Contact/motion module **230** optionally detects a gesture input by a user. Different gestures on the touch-sensitive surface have different contact patterns (e.g., different motions, timings, and/or intensities of detected contacts). Thus, a gesture is, optionally, detected by detecting a particular contact pattern. For example, detecting a finger tap gesture includes detecting a finger-down event followed by detecting a finger-up (liftoff) event at the same position (or substantially the same position) as the finger-down event (e.g., at the position of an icon). As another example, detecting a finger swipe gesture on the touch-sensitive surface includes detecting a finger-down event followed by detecting one or more finger-dragging events, and subsequently followed by detecting a finger-up (liftoff) event.

Graphics module **232** includes various known software components for rendering and displaying graphics on touch screen **212** or other display, including components for changing the visual impact (e.g., brightness, transparency, saturation, contrast, or other visual property) of graphics that are displayed. As used herein, the term "graphics" includes any object that can be displayed to a user, including, without limitation, text, web pages, icons (such as user-interface objects including soft keys), digital images, videos, animations, and the like.

In some embodiments, graphics module **232** stores data representing graphics to be used. Each graphic is, optionally, assigned a corresponding code. Graphics module **232** receives, from applications etc., one or more codes specifying graphics to be displayed along with, if necessary, coordinate data and other graphic property data, and then generates screen image data to output to display controller **256**.

Haptic feedback module **233** includes various software components for generating instructions used by tactile output generator(s) **267** to produce tactile outputs at one or more locations on device **200** in response to user interactions with device **200**.

Text input module **234**, which is, in some examples, a component of graphics module **232**, provides soft keyboards for entering text in various applications (e.g., contacts **237**, email **240**, IM **241**, browser **247**, and any other application that needs text input).

GPS module **235** determines the location of the device and provides this information for use in various applications (e.g., to telephone **238** for use in location-based dialing; to camera **243** as picture/video metadata; and to applications that provide location-based services such as weather widgets, local yellow page widgets, and map/navigation widgets).

Digital assistant client module **229** includes various client-side digital assistant instructions to provide the client-side functionalities of the digital assistant. For example, digital assistant client module **229** is capable of accepting voice input (e.g., speech input), text input, touch input, and/or gestural input through various user interfaces (e.g., microphone **213**, accelerometer(s) **268**, touch-sensitive display system **212**, optical sensor(s) **229**, other input control devices **216**, etc.) of portable multifunction device **200**. Digital assistant client module **229** is also capable of providing output in audio (e.g., speech output), visual, and/or tactile forms through various output interfaces (e.g., speaker **211**, touch-sensitive display system **212**, tactile output generator(s) **267**, etc.) of portable multifunction device **200**. For example, output is provided as voice, sound, alerts, text messages, menus, graphics, videos, animations, vibrations, and/or combinations of two or more of the above. During operation, digital assistant client module **229** communicates with DA server **106** using RF circuitry **208**.

User data and models **231** include various data associated with the user (e.g., user-specific vocabulary data, user preference data, user-specified name pronunciations, data from the user's electronic address book, to-do lists, shopping lists, etc.) to provide the client-side functionalities of the digital assistant. Further, user data and models **231** include various models (e.g., speech recognition models, statistical language models, natural language processing models, ontology, task flow models, service models, etc.) for processing user input and determining user intent.

In some examples, digital assistant client module **229** utilizes the various sensors, subsystems, and peripheral devices of portable multifunction device **200** to gather additional information from the surrounding environment of the portable multifunction device **200** to establish a context associated with a user, the current user interaction, and/or the current user input. In some examples, digital assistant client module **229** provides the contextual information or a subset thereof with the user input to DA server **106** to help infer the user's intent. In some examples, the digital assistant also uses the contextual information to determine how to prepare and deliver outputs to the user. Contextual information is referred to as context data.

In some examples, the contextual information that accompanies the user input includes sensor information, e.g., lighting, ambient noise, ambient temperature, images or videos of the surrounding environment, etc. In some examples, the contextual information can also includes the physical state of the device, e.g., device orientation, device location, device temperature, power level, speed, acceleration, motion patterns, cellular signals strength, etc. In some examples, information related to the software state of DA server **106**, e.g., running processes, installed programs, past and present network activities, background services, error logs, resources usage, etc., and of portable multifunction device **200** is provided to DA server **106** as contextual information associated with a user input.

In some examples, the digital assistant client module **229** selectively provides information (e.g., user data **231**) stored on the portable multifunction device **200** in response to requests from DA server **106**. In some examples, digital assistant client module **229** also elicits additional input from the user via a natural language dialogue or other user interfaces upon request by DA server **106**. Digital assistant client module **229** passes the additional input to DA server **106** to help DA server **106** in intent deduction and/or fulfillment of the user's intent expressed in the user request.

A more detailed description of a digital assistant is described below with reference to FIGS. 7A-C. It should be recognized that digital assistant client module **229** can include any number of the sub-modules of digital assistant module **726** described below.

Applications **236** include the following modules (or sets of instructions), or a subset or superset thereof:

- Contacts module **237** (sometimes called an address book or contact list);
- Telephone module **238**;
- Video conference module **239**;
- E-mail client module **240**;
- Instant messaging (IM) module **241**;
- Workout support module **242**;
- Camera module **243** for still and/or video images;
- Image management module **244**;
- Video player module;
- Music player module;
- Browser module **247**;
- Calendar module **248**;
- Widget modules **249**, which includes, in some examples, one or more of: weather widget **249-1**, stocks widget **249-2**, calculator widget **249-3**, alarm clock widget **249-4**, dictionary widget **249-5**, and other widgets obtained by the user, as well as user-created widgets **249-6**;
- Widget creator module **250** for making user-created widgets **249-6**;
- Search module **251**;
- Video and music player module **252**, which merges video player module and music player module;
- Notes module **253**;
- Map module **254**; and/or
- Online video module **255**.

Examples of other applications **236** that are stored in memory **202** include other word processing applications, other image editing applications, drawing applications, presentation applications, JAVA-enabled applications, encryption, digital rights management, voice recognition, and voice replication.

In conjunction with touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, and text input module **234**, contacts module **237** are used to manage an address book or contact list (e.g., stored in application internal state **292** of contacts module **237** in memory **202** or memory **470**), including: adding name(s) to the address book; deleting name(s) from the address book; associating telephone number(s), e-mail address(es), physical address(es) or other information with a name; associating an image with a name; categorizing and sorting names; providing telephone numbers or e-mail addresses to initiate and/or facilitate communications by telephone **238**, video conference module **239**, e-mail **240**, or IM **241**; and so forth.

In conjunction with RF circuitry **208**, audio circuitry **210**, speaker **211**, microphone **213**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, and text input module **234**, telephone module **238** are used to enter a sequence of characters corresponding to a telephone number, access one or more telephone numbers in contacts module **237**, modify a telephone number that has been entered, dial a respective telephone number, conduct a conversation, and disconnect or hang up when the conversation is completed. As noted above, the wireless communication uses any of a plurality of communications standards, protocols, and technologies.

In conjunction with RF circuitry **208**, audio circuitry **210**, speaker **211**, microphone **213**, touch screen **212**, display controller **256**, optical sensor **264**, optical sensor controller **258**, contact/motion module **230**, graphics module **232**, text input module **234**, contacts module **237**, and telephone module **238**, video conference module **239** includes executable instructions to initiate, conduct, and terminate a video conference between a user and one or more other participants in accordance with user instructions.

In conjunction with RF circuitry **208**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, and text input module **234**, e-mail client module **240** includes executable instructions to create, send, receive, and manage e-mail in response to user instructions. In conjunction with image management module **244**, e-mail client module **240** makes it very easy to create and send e-mails with still or video images taken with camera module **243**.

In conjunction with RF circuitry **208**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, and text input module **234**, the instant messaging module **241** includes executable instructions to enter a sequence of characters corresponding to an instant message, to modify previously entered characters, to transmit a respective instant message (for example, using a Short Message Service (SMS) or Multimedia Message Service (MMS) protocol for telephony-based instant messages or using XMPP, SIMPLE, or IMPS for Internet-based instant messages), to receive instant messages, and to view received instant messages. In some embodiments, transmitted and/or received instant messages include graphics, photos, audio files, video files and/or other attachments as are supported in an MMS and/or an Enhanced Messaging Service (EMS). As used herein, "instant messaging" refers to both telephony-based messages (e.g., messages sent using SMS or MMS) and Internet-based messages (e.g., messages sent using XMPP, SIMPLE, or IMPS).

In conjunction with RF circuitry **208**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, text input module **234**, GPS module **235**, map module **254**, and music player module, workout support module **242** includes executable instructions to create workouts (e.g., with time, distance, and/or calorie burning goals); communicate with workout sensors (sports devices); receive workout sensor data; calibrate sensors used to monitor a workout; select and play music for a workout; and display, store, and transmit workout data.

In conjunction with touch screen **212**, display controller **256**, optical sensor(s) **264**, optical sensor controller **258**, contact/motion module **230**, graphics module **232**, and image management module **244**, camera module **243** includes executable instructions to capture still images or video (including a video stream) and store them into memory **202**, modify characteristics of a still image or video, or delete a still image or video from memory **202**.

In conjunction with touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, text input module **234**, and camera module **243**, image management module **244** includes executable instructions to arrange, modify (e.g., edit), or otherwise manipulate, label, delete, present (e.g., in a digital slide show or album), and store still and/or video images.

In conjunction with RF circuitry **208**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, and text input module **234**, browser module **247** includes executable instructions to browse the Internet in accordance with user instructions, including searching, linking to, receiving, and displaying web pages or portions thereof, as well as attachments and other files linked to web pages.

In conjunction with RF circuitry **208**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, text input module **234**, e-mail client module **240**, and browser module **247**, calendar module **248** includes executable instructions to create, display, modify, and store calendars and data associated with calendars (e.g., calendar entries, to-do lists, etc.) in accordance with user instructions.

In conjunction with RF circuitry **208**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, text input module **234**, and browser module **247**, widget modules **249** are mini-applications that can be downloaded and used by a user (e.g., weather widget **249-1**, stocks widget **249-2**, calculator widget **249-3**, alarm clock widget **249-4**, and dictionary widget **249-5**) or created by the user (e.g., user-created widget **249-6**). In some embodiments, a widget includes an HTML (Hypertext Markup Language) file, a CSS (Cascading Style Sheets) file, and a JavaScript file. In some embodiments, a widget includes an XML (Extensible Markup Language) file and a JavaScript file (e.g., Yahoo! Widgets).

In conjunction with RF circuitry **208**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, text input module **234**, and browser module **247**, the widget creator module **250** are used by a user to create widgets (e.g., turning a user-specified portion of a web page into a widget).

In conjunction with touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, and text input module **234**, search module **251** includes executable instructions to search for text, music, sound, image, video, and/or other files in memory **202** that match one or more search criteria (e.g., one or more user-specified search terms) in accordance with user instructions.

In conjunction with touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, audio circuitry **210**, speaker **211**, RF circuitry **208**, and browser module **247**, video and music player module **252** includes executable instructions that allow the user to download and play back recorded music and other sound files stored in one or more file formats, such as MP3 or AAC files, and executable instructions to display, present, or otherwise play back videos (e.g., on touch screen **212** or on an external, connected display via external port **224**). In some embodiments, device **200** optionally includes the functionality of an MP3 player, such as an iPod (trademark of Apple Inc.).

In conjunction with touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, and text input module **234**, notes module **253** includes executable instructions to create and manage notes, to-do lists, and the like in accordance with user instructions.

In conjunction with RF circuitry **208**, touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, text input module **234**, GPS module **235**, and browser module **247**, map module **254** are used to receive, display, modify, and store maps and data associated with maps (e.g., driving directions, data on stores and other points of interest at or near a particular location, and other location-based data) in accordance with user instructions.

In conjunction with touch screen **212**, display controller **256**, contact/motion module **230**, graphics module **232**, audio circuitry **210**, speaker **211**, RF circuitry **208**, text input module **234**, e-mail client module **240**, and browser module **247**, online video module **255** includes instructions that allow the user to access, browse, receive (e.g., by streaming and/or download), play back (e.g., on the touch screen or on an external, connected display via external port **224**), send an e-mail with a link to a particular online video, and otherwise manage online videos in one or more file formats, such as H.264. In some embodiments, instant messaging module **241**, rather than e-mail client module **240**, is used to send a link to a particular online video. Additional description of the online video application can be found in U.S. Provisional Patent Application No. 60/936,562, "Portable Multifunction Device, Method, and Graphical User Interface for Playing Online Videos," filed Jun. 20, 2007, and U.S. patent application Ser. No. 11/968,067, "Portable Multifunction Device, Method, and Graphical User Interface for Playing Online Videos," filed Dec. 31, 2007, the contents of which are hereby incorporated by reference in their entirety.

Each of the above-identified modules and applications corresponds to a set of executable instructions for performing one or more functions described above and the methods described in this application (e.g., the computer-implemented methods and other information processing methods described herein). These modules (e.g., sets of instructions) need not be implemented as separate software programs, procedures, or modules, and thus various subsets of these modules can be combined or otherwise rearranged in various embodiments. For example, video player module can be combined with music player module into a single module (e.g., video and music player module **252**, FIG. **2**A). In some embodiments, memory **202** stores a subset of the modules and data structures identified above. Furthermore, memory **202** stores additional modules and data structures not described above.

In some embodiments, device **200** is a device where operation of a predefined set of functions on the device is performed exclusively through a touch screen and/or a touchpad. By using a touch screen and/or a touchpad as the primary input control device for operation of device **200**, the number of physical input control devices (such as push buttons, dials, and the like) on device **200** is reduced.

The predefined set of functions that are performed exclusively through a touch screen and/or a touchpad optionally include navigation between user interfaces. In some embodiments, the touchpad, when touched by the user, navigates device **200** to a main, home, or root menu from any user interface that is displayed on device **200**. In such embodiments, a "menu button" is implemented using a touchpad. In some other embodiments, the menu button is a physical push button or other physical input control device instead of a touchpad.

FIG. **2**B is a block diagram illustrating exemplary components for event handling in accordance with some embodiments. In some embodiments, memory **202** (FIG. 2A) or **470** (FIG. **4**) includes event sorter **270** (e.g., in operating system **226**) and a respective application **236-1** (e.g., any of the aforementioned applications **237-251**, **255**, **480-490**).

Event sorter **270** receives event information and determines the application **236-1** and application view **291** of application **236-1** to which to deliver the event information. Event sorter **270** includes event monitor **271** and event dispatcher module **274**. In some embodiments, application **236-1** includes application internal state **292**, which indicates the current application view(s) displayed on touch-sensitive display **212** when the application is active or executing. In some embodiments, device/global internal state **257** is used by event sorter **270** to determine which application(s) is (are) currently active, and application internal state **292** is used by event sorter **270** to determine application views **291** to which to deliver event information.

In some embodiments, application internal state **292** includes additional information, such as one or more of: resume information to be used when application **236-1** resumes execution, user interface state information that indicates information being displayed or that is ready for display by application **236-1**, a state queue for enabling the user to go back to a prior state or view of application **236-1**, and a redo/undo queue of previous actions taken by the user.

Event monitor **271** receives event information from peripherals interface **218**. Event information includes information about a sub-event (e.g., a user touch on touch-sensitive display **212**, as part of a multi-touch gesture). Peripherals interface **218** transmits information it receives from I/O subsystem **206** or a sensor, such as proximity sensor **266**, accelerometer(s) **268**, and/or microphone **213** (through audio circuitry **210**). Information that peripherals interface **218** receives from I/O subsystem **206** includes information from touch-sensitive display **212** or a touch-sensitive surface.

In some embodiments, event monitor **271** sends requests to the peripherals interface **218** at predetermined intervals. In response, peripherals interface **218** transmits event information. In other embodiments, peripherals interface **218** transmits event information only when there is a significant event (e.g., receiving an input above a predetermined noise threshold and/or for more than a predetermined duration).

In some embodiments, event sorter **270** also includes a hit view determination module **272** and/or an active event recognizer determination module **273**.

Hit view determination module **272** provides software procedures for determining where a sub-event has taken place within one or more views when touch-sensitive display **212** displays more than one view. Views are made up of controls and other elements that a user can see on the display.

Another aspect of the user interface associated with an application is a set of views, sometimes herein called application views or user interface windows, in which information is displayed and touch-based gestures occur. The application views (of a respective application) in which a touch is detected correspond to programmatic levels within a programmatic or view hierarchy of the application. For example, the lowest level view in which a touch is detected is called the hit view, and the set of events that are recognized as proper inputs is determined based, at least in part, on the hit view of the initial touch that begins a touch-based gesture.

Hit view determination module **272** receives information related to sub events of a touch-based gesture. When an application has multiple views organized in a hierarchy, hit view determination module **272** identifies a hit view as the lowest view in the hierarchy which should handle the sub-event. In most circumstances, the hit view is the lowest level view in which an initiating sub-event occurs (e.g., the first sub-event in the sequence of sub-events that form an event or potential event). Once the hit view is identified by the hit view determination module **272**, the hit view typically receives all sub-events related to the same touch or input source for which it was identified as the hit view.

Active event recognizer determination module **273** determines which view or views within a view hierarchy should receive a particular sequence of sub-events. In some embodiments, active event recognizer determination module **273** determines that only the hit view should receive a particular sequence of sub-events. In other embodiments, active event recognizer determination module **273** determines that all views that include the physical location of a sub-event are actively involved views, and therefore determines that all actively involved views should receive a particular sequence of sub-events. In other embodiments, even if touch sub-events were entirely confined to the area associated with one particular view, views higher in the hierarchy would still remain as actively involved views.

Event dispatcher module **274** dispatches the event information to an event recognizer (e.g., event recognizer **280**). In embodiments including active event recognizer determination module **273**, event dispatcher module **274** delivers the event information to an event recognizer determined by active event recognizer determination module **273**. In some embodiments, event dispatcher module **274** stores in an event queue the event information, which is retrieved by a respective event receiver **282**.

In some embodiments, operating system **226** includes event sorter **270**. Alternatively, application **236-1** includes event sorter **270**. In yet other embodiments, event sorter **270** is a stand-alone module, or a part of another module stored in memory **202**, such as contact/motion module **230**.

In some embodiments, application **236-1** includes a plurality of event handlers **290** and one or more application views **291**, each of which includes instructions for handling touch events that occur within a respective view of the application's user interface. Each application view **291** of the application **236-1** includes one or more event recognizers **280**. Typically, a respective application view **291** includes a plurality of event recognizers **280**. In other embodiments, one or more of event recognizers **280** are part of a separate module, such as a user interface kit (not shown) or a higher level object from which application **236-1** inherits methods and other properties. In some embodiments, a respective event handler **290** includes one or more of: data updater **276**, object updater **277**, GUI updater **278**, and/or event data **279** received from event sorter **270**. Event handler **290** utilizes or calls data updater **276**, object updater **277**, or GUI updater **278** to update the application internal state **292**. Alternatively, one or more of the application views **291** include one or more respective event handlers **290**. Also, in some embodiments, one or more of data updater **276**, object updater **277**, and GUI updater **278** are included in a respective application view **291**.

A respective event recognizer **280** receives event information (e.g., event data **279**) from event sorter **270** and identifies an event from the event information. Event recognizer **280** includes event receiver **282** and event comparator **284**. In some embodiments, event recognizer **280** also includes at least a subset of: metadata **283**, and event delivery instructions **288** (which include sub-event delivery instructions).

Event receiver **282** receives event information from event sorter **270**. The event information includes information about a sub-event, for example, a touch or a touch movement. Depending on the sub-event, the event information also includes additional information, such as location of the sub-event. When the sub-event concerns motion of a touch, the event information also includes speed and direction of the sub-event. In some embodiments, events include rotation of the device from one orientation to another (e.g., from a portrait orientation to a landscape orientation, or vice versa), and the event information includes corresponding information about the current orientation (also called device attitude) of the device.

Event comparator **284** compares the event information to predefined event or sub-event definitions and, based on the comparison, determines an event or sub event, or determines or updates the state of an event or sub-event. In some embodiments, event comparator **284** includes event definitions **286**. Event definitions **286** contain definitions of events (e.g., predefined sequences of sub-events), for example, event **1** (**287-1**), event **2** (**287-2**), and others. In some embodiments, sub-events in an event (**287**) include, for example, touch begin, touch end, touch movement, touch cancellation, and multiple touching. In one example, the definition for event **1** (**287-1**) is a double tap on a displayed object. The double tap, for example, comprises a first touch (touch begin) on the displayed object for a predetermined phase, a first liftoff (touch end) for a predetermined phase, a second touch (touch begin) on the displayed object for a predetermined phase, and a second liftoff (touch end) for a predetermined phase. In another example, the definition for event **2** (**287-2**) is a dragging on a displayed object. The dragging, for example, comprises a touch (or contact) on the displayed object for a predetermined phase, a movement of the touch across touch-sensitive display **212**, and liftoff of the touch (touch end). In some embodiments, the event also includes information for one or more associated event handlers **290**.

In some embodiments, event definition **287** includes a definition of an event for a respective user-interface object. In some embodiments, event comparator **284** performs a hit test to determine which user-interface object is associated with a sub-event. For example, in an application view in which three user-interface objects are displayed on touch-sensitive display **212**, when a touch is detected on touch-sensitive display **212**, event comparator **284** performs a hit test to determine which of the three user-interface objects is associated with the touch (sub-event). If each displayed object is associated with a respective event handler **290**, the event comparator uses the result of the hit test to determine which event handler **290** should be activated. For example, event comparator **284** selects an event handler associated with the sub-event and the object triggering the hit test.

In some embodiments, the definition for a respective event (**287**) also includes delayed actions that delay delivery of the event information until after it has been determined whether the sequence of sub-events does or does not correspond to the event recognizer's event type.

When a respective event recognizer **280** determines that the series of sub-events do not match any of the events in event definitions **286**, the respective event recognizer **280** enters an event impossible, event failed, or event ended state, after which it disregards subsequent sub-events of the touch-based gesture. In this situation, other event recognizers, if any, that remain active for the hit view continue to track and process sub-events of an ongoing touch-based gesture.

In some embodiments, a respective event recognizer **280** includes metadata **283** with configurable properties, flags, and/or lists that indicate how the event delivery system should perform sub-event delivery to actively involved event recognizers. In some embodiments, metadata **283** includes configurable properties, flags, and/or lists that indicate how event recognizers interact, or are enabled to interact, with one another. In some embodiments, metadata **283** includes configurable properties, flags, and/or lists that indicate whether sub-events are delivered to varying levels in the view or programmatic hierarchy.

In some embodiments, a respective event recognizer **280** activates event handler **290** associated with an event when one or more particular sub-events of an event are recognized. In some embodiments, a respective event recognizer **280** delivers event information associated with the event to event handler **290**. Activating an event handler **290** is distinct from sending (and deferred sending) sub-events to a respective hit view. In some embodiments, event recognizer **280** throws a flag associated with the recognized event, and event handler **290** associated with the flag catches the flag and performs a predefined process.

In some embodiments, event delivery instructions **288** include sub-event delivery instructions that deliver event information about a sub-event without activating an event handler. Instead, the sub-event delivery instructions deliver event information to event handlers associated with the series of sub-events or to actively involved views. Event handlers associated with the series of sub-events or with actively involved views receive the event information and perform a predetermined process.

In some embodiments, data updater **276** creates and updates data used in application **236-1**. For example, data updater **276** updates the telephone number used in contacts module **237**, or stores a video file used in video player module. In some embodiments, object updater **277** creates and updates objects used in application **236-1**. For example, object updater **277** creates a new user-interface object or updates the position of a user-interface object. GUI updater **278** updates the GUI. For example, GUI updater **278** prepares display information and sends it to graphics module **232** for display on a touch-sensitive display.

In some embodiments, event handler(s) **290** includes or has access to data updater **276**, object updater **277**, and GUI updater **278**. In some embodiments, data updater **276**, object updater **277**, and GUI updater **278** are included in a single module of a respective application **236-1** or application view **291**. In other embodiments, they are included in two or more software modules.

It shall be understood that the foregoing discussion regarding event handling of user touches on touch-sensitive displays also applies to other forms of user inputs to operate multifunction devices **200** with input devices, not all of which are initiated on touch screens. For example, mouse movement and mouse button presses, optionally coordinated with single or multiple keyboard presses or holds; contact movements such as taps, drags, scrolls, etc. on touchpads; pen stylus inputs; movement of the device; oral instructions; detected eye movements; biometric inputs; and/or any combination thereof are optionally utilized as inputs corresponding to sub-events which define an event to be recognized.

FIG. **3** illustrates a portable multifunction device **200** having a touch screen **212** in accordance with some embodiments. The touch screen optionally displays one or more graphics within user interface (UI) **300**. In this embodiment, as well as others described below, a user is enabled to select one or more of the graphics by making a gesture on the graphics, for example, with one or more fingers **302** (not drawn to scale in the figure) or one or more styluses **303** (not drawn to scale in the figure). In some embodiments, selection of one or more graphics occurs when the user breaks contact with the one or more graphics. In some embodiments, the gesture optionally includes one or more taps, one or more swipes (from left to right, right to left, upward and/or downward), and/or a rolling of a finger (from right to left, left to right, upward and/or downward) that has made contact with device **200**. In some implementations or circumstances, inadvertent contact with a graphic does not select the graphic. For example, a swipe gesture that sweeps over an application icon optionally does not select the corresponding application when the gesture corresponding to selection is a tap.

Device **200** also includes one or more physical buttons, such as "home" or menu button **304**. As described previously, menu button **304** is used to navigate to any application **236** in a set of applications that is executed on device **200**. Alternatively, in some embodiments, the menu button is implemented as a soft key in a GUI displayed on touch screen **212**.

In one embodiment, device **200** includes touch screen **212**, menu button **304**, push button **306** for powering the device on/off and locking the device, volume adjustment button(s) **308**, subscriber identity module (SIM) card slot **310**, headset jack **312**, and docking/charging external port **224**. Push button **306** is, optionally, used to turn the power on/off on the device by depressing the button and holding the button in the depressed state for a predefined time interval; to lock the device by depressing the button and releasing the button before the predefined time interval has elapsed; and/or to unlock the device or initiate an unlock process. In an alternative embodiment, device **200** also accepts verbal input for activation or deactivation of some functions through microphone **213**. Device **200** also, optionally, includes one or more contact intensity sensors **265** for detecting intensity of contacts on touch screen **212** and/or one or more tactile output generators **267** for generating tactile outputs for a user of device **200**.

FIG. **4** is a block diagram of an exemplary multifunction device with a display and a touch-sensitive surface in accordance with some embodiments. Device **400** need not be portable. In some embodiments, device **400** is a laptop computer, a desktop computer, a tablet computer, a multimedia player device, a navigation device, an educational device (such as a child's learning toy), a gaming system, or a control device (e.g., a home or industrial controller). Device **400** typically includes one or more processing units (CPUs) **410**, one or more network or other communications interfaces **460**, memory **470**, and one or more communication buses **420** for interconnecting these components. Communication buses **420** optionally include circuitry (sometimes called a chipset) that interconnects and controls communications between system components. Device **400** includes input/output (I/O) interface **430** comprising display **440**, which is typically a touch screen display. I/O interface **430** also optionally includes a keyboard and/or mouse (or other pointing device) **450** and touchpad **455**, tactile output generator **457** for generating tactile outputs on device **400** (e.g., similar to tactile output generator(s) **267** described above with reference to FIG. **2**A), sensors **459** (e.g., optical, acceleration, proximity, touch-sensitive, and/or contact intensity sensors similar to contact intensity sensor(s) **265** described above with reference to FIG. **2**A). Memory **470** includes high-speed random access memory, such as DRAM, SRAM, DDR RAM, or other random access solid state memory devices; and optionally includes non-volatile memory, such as one or more magnetic disk storage devices, optical disk storage devices, flash memory devices, or other non-volatile solid state storage devices. Memory **470** optionally includes one or more storage devices remotely located from CPU(s) **410**. In some embodiments, memory **470** stores programs, modules, and data structures analogous to the programs, modules, and data structures stored in memory **202** of portable multifunction device **200** (FIG. **2**A), or a subset thereof. Furthermore, memory **470** optionally stores additional programs, modules, and data structures not present in memory **202** of portable multifunction device **200**. For example, memory **470** of device **400** optionally stores drawing module **480**, presentation module **482**, word processing module **484**, website creation module **486**, disk authoring module **488**, and/or spreadsheet module **490**, while memory **202** of portable multifunction device **200** (FIG. **2**A) optionally does not store these modules.

Each of the above-identified elements in FIG. **4** is, in some examples, stored in one or more of the previously mentioned memory devices. Each of the above-identified modules corresponds to a set of instructions for performing a function described above. The above-identified modules or programs (e.g., sets of instructions) need not be implemented as separate software programs, procedures, or modules, and thus various subsets of these modules are combined or otherwise rearranged in various embodiments. In some embodiments, memory **470** stores a subset of the modules and data structures identified above. Furthermore, memory **470** stores additional modules and data structures not described above.

Attention is now directed towards embodiments of user interfaces that can be implemented on, for example, portable multifunction device **200**.

FIG. **5**A illustrates an exemplary user interface for a menu of applications on portable multifunction device **200** in accordance with some embodiments. Similar user interfaces are implemented on device **400**. In some embodiments, user interface **500** includes the following elements, or a subset or superset thereof:

- Signal strength indicator(s) **502** for wireless communication(s), such as cellular and Wi-Fi signals;
- Time **504**;
- Bluetooth indicator **505**;
- Battery status indicator **506**;
- Tray **508** with icons for frequently used applications, such as:
  - Icon **516** for telephone module **238**, labeled "Phone," which optionally includes an indicator **514** of the number of missed calls or voicemail messages;
  - Icon **518** for e-mail client module **240**, labeled "Mail," which optionally includes an indicator **510** of the number of unread e-mails;
  - Icon **520** for browser module **247**, labeled "Browser;" and
  - Icon **522** for video and music player module **252**, also referred to as iPod (trademark of Apple Inc.) module **252**, labeled "iPod;" and
- Icons for other applications, such as:
  - Icon **524** for IM module **241**, labeled "Messages;"
  - Icon **526** for calendar module **248**, labeled "Calendar;"
  - Icon **528** for image management module **244**, labeled "Photos;"
  - Icon **530** for camera module **243**, labeled "Camera;"

Icon **532** for online video module **255**, labeled "Online Video;"

Icon **534** for stocks widget **249-2**, labeled "Stocks;"

Icon **536** for map module **254**, labeled "Maps;"

Icon **538** for weather widget **249-1**, labeled "Weather;"

Icon **540** for alarm clock widget **249-4**, labeled "Clock;"

Icon **542** for workout support module **242**, labeled "Workout Support;"

Icon **544** for notes module **253**, labeled "Notes;" and

Icon **546** for a settings application or module, labeled "Settings," which provides access to settings for device **200** and its various applications **236**.

It should be noted that the icon labels illustrated in FIG. **5**A are merely exemplary. For example, icon **522** for video and music player module **252** is optionally labeled "Music" or "Music Player." Other labels are, optionally, used for various application icons. In some embodiments, a label for a respective application icon includes a name of an application corresponding to the respective application icon. In some embodiments, a label for a particular application icon is distinct from a name of an application corresponding to the particular application icon.

FIG. **5**B illustrates an exemplary user interface on a device (e.g., device **400**, FIG. **4**) with a touch-sensitive surface **551** (e.g., a tablet or touchpad **455**, FIG. **4**) that is separate from the display **550** (e.g., touch screen display **212**). Device **400** also, optionally, includes one or more contact intensity sensors (e.g., one or more of sensors **457**) for detecting intensity of contacts on touch-sensitive surface **551** and/or one or more tactile output generators **459** for generating tactile outputs for a user of device **400**.

Although some of the examples which follow will be given with reference to inputs on touch screen display **212** (where the touch-sensitive surface and the display are combined), in some embodiments, the device detects inputs on a touch-sensitive surface that is separate from the display, as shown in FIG. **5**B. In some embodiments, the touch-sensitive surface (e.g., **551** in FIG. **5**B) has a primary axis (e.g., **552** in FIG. **5**B) that corresponds to a primary axis (e.g., **553** in FIG. **5**B) on the display (e.g., **550**). In accordance with these embodiments, the device detects contacts (e.g., **560** and **562** in FIG. **5**B) with the touch-sensitive surface **551** at locations that correspond to respective locations on the display (e.g., in FIG. **5**B, **560** corresponds to **568** and **562** corresponds to **570**). In this way, user inputs (e.g., contacts **560** and **562**, and movements thereof) detected by the device on the touch-sensitive surface (e.g., **551** in FIG. **5**B) are used by the device to manipulate the user interface on the display (e.g., **550** in FIG. **5**B) of the multifunction device when the touch-sensitive surface is separate from the display. It should be understood that similar methods are, optionally, used for other user interfaces described herein.

Additionally, while the following examples are given primarily with reference to finger inputs (e.g., finger contacts, finger tap gestures, finger swipe gestures), it should be understood that, in some embodiments, one or more of the finger inputs are replaced with input from another input device (e.g., a mouse-based input or stylus input). For example, a swipe gesture is, optionally, replaced with a mouse click (e.g., instead of a contact) followed by movement of the cursor along the path of the swipe (e.g., instead of movement of the contact). As another example, a tap gesture is, optionally, replaced with a mouse click while the cursor is located over the location of the tap gesture (e.g., instead of detection of the contact followed by ceasing to detect the contact). Similarly, when multiple user inputs are simultaneously detected, it should be understood that multiple computer mice are, optionally, used simultaneously, or a mouse and finger contacts are, optionally, used simultaneously.

FIG. **6**A illustrates exemplary personal electronic device **600**. Device **600** includes body **602**. In some embodiments, device **600** includes some or all of the features described with respect to devices **200** and **400** (e.g., FIGS. **2**A-**4**B). In some embodiments, device **600** has touch-sensitive display screen **604**, hereafter touch screen **604**. Alternatively, or in addition to touch screen **604**, device **600** has a display and a touch-sensitive surface. As with devices **200** and **400**, in some embodiments, touch screen **604** (or the touch-sensitive surface) has one or more intensity sensors for detecting intensity of contacts (e.g., touches) being applied. The one or more intensity sensors of touch screen **604** (or the touch-sensitive surface) provide output data that represents the intensity of touches. The user interface of device **600** responds to touches based on their intensity, meaning that touches of different intensities can invoke different user interface operations on device **600**.

Techniques for detecting and processing touch intensity are found, for example, in related applications: International Patent Application Serial No. PCT/US2013/040061, titled "Device, Method, and Graphical User Interface for Displaying User Interface Objects Corresponding to an application," filed May 8, 2013, and International Patent Application Serial No. PCT/US2013/069483, titled "Device, Method, and Graphical User Interface for Transitioning Between Touch Input to Display Output Relationships," filed Nov. 11, 2013, each of which is hereby incorporated by reference in their entirety.

In some embodiments, device **600** has one or more input mechanisms **606** and **608**. Input mechanisms **606** and **608**, if included, are physical. Examples of physical input mechanisms include push buttons and rotatable mechanisms. In some embodiments, device **600** has one or more attachment mechanisms. Such attachment mechanisms, if included, can permit attachment of device **600** with, for example, hats, eyewear, earrings, necklaces, shirts, jackets, bracelets, watch straps, chains, trousers, belts, shoes, purses, backpacks, and so forth. These attachment mechanisms permit device **600** to be worn by a user.

FIG. **6**B depicts exemplary personal electronic device **600**. In some embodiments, device **600** includes some or all of the components described with respect to FIGS. **2**A, **2**B, and **4**. Device **600** has bus **612** that operatively couples I/O section **614** with one or more computer processors **616** and memory **618**. I/O section **614** is connected to display **604**, which can have touch-sensitive component **622** and, optionally, touch-intensity sensitive component **624**. In addition, I/O section **614** is connected with communication unit **630** for receiving application and operating system data, using Wi-Fi, Bluetooth, near field communication (NFC), cellular, and/or other wireless communication techniques. Device **600** includes input mechanisms **606** and/or **608**. Input mechanism **606** is a rotatable input device or a depressible and rotatable input device, for example. Input mechanism **608** is a button, in some examples.

Input mechanism **608** is a microphone, in some examples. Personal electronic device **600** includes, for example, various sensors, such as GPS sensor **632**, accelerometer **634**, directional sensor **640** (e.g., compass), gyroscope **636**, motion sensor **638**, and/or a combination thereof, all of which are operatively connected to I/O section **614**.

Memory **618** of personal electronic device **600** is a non-transitory computer-readable storage medium, for storing computer-executable instructions, which, when executed by one or more computer processors **616**, for example, cause the computer processors to perform the techniques and processes described below. The computer-executable instructions, for example, are also stored and/or transported within any non-transitory computer-readable storage medium for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions. Personal electronic device **600** is not limited to the components and configuration of FIG. **6**B, but can include other or additional components in multiple configurations.

As used here, the term "affordance" refers to a user-interactive graphical user interface object that is, for example, displayed on the display screen of devices **200**, **400**, and/or **600** (FIGS. **2**, **4**, and **6**). For example, an image (e.g., icon), a button, and text (e.g., hyperlink) each constitutes an affordance.

As used herein, the term "focus selector" refers to an input element that indicates a current part of a user interface with which a user is interacting. In some implementations that include a cursor or other location marker, the cursor acts as a "focus selector" so that when an input (e.g., a press input) is detected on a touch-sensitive surface (e.g., touchpad **455** in FIG. **4** or touch-sensitive surface **551** in FIG. **5**B) while the cursor is over a particular user interface element (e.g., a button, window, slider or other user interface element), the particular user interface element is adjusted in accordance with the detected input. In some implementations that include a touch screen display (e.g., touch-sensitive display system **212** in FIG. **2**A or touch screen **212** in FIG. **5**A) that enables direct interaction with user interface elements on the touch screen display, a detected contact on the touch screen acts as a "focus selector" so that when an input (e.g., a press input by the contact) is detected on the touch screen display at a location of a particular user interface element (e.g., a button, window, slider, or other user interface element), the particular user interface element is adjusted in accordance with the detected input. In some implementations, focus is moved from one region of a user interface to another region of the user interface without corresponding movement of a cursor or movement of a contact on a touch screen display (e.g., by using a tab key or arrow keys to move focus from one button to another button); in these implementations, the focus selector moves in accordance with movement of focus between different regions of the user interface. Without regard to the specific form taken by the focus selector, the focus selector is generally the user interface element (or contact on a touch screen display) that is controlled by the user so as to communicate the user's intended interaction with the user interface (e.g., by indicating, to the device, the element of the user interface with which the user is intending to interact). For example, the location of a focus selector (e.g., a cursor, a contact, or a selection box) over a respective button while a press input is detected on the touch-sensitive surface (e.g., a touchpad or touch screen) will indicate that the user is intending to activate the respective button (as opposed to other user interface elements shown on a display of the device).

As used in the specification and claims, the term "characteristic intensity" of a contact refers to a characteristic of the contact based on one or more intensities of the contact. In some embodiments, the characteristic intensity is based on multiple intensity samples. The characteristic intensity is, optionally, based on a predefined number of intensity samples, or a set of intensity samples collected during a predetermined time period (e.g., 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10 seconds) relative to a predefined event (e.g., after detecting the contact, prior to detecting liftoff of the contact, before or after detecting a start of movement of the contact, prior to detecting an end of the contact, before or after detecting an increase in intensity of the contact, and/or before or after detecting a decrease in intensity of the contact). A characteristic intensity of a contact is, optionally based on one or more of: a maximum value of the intensities of the contact, a mean value of the intensities of the contact, an average value of the intensities of the contact, a top 10 percentile value of the intensities of the contact, a value at the half maximum of the intensities of the contact, a value at the 90 percent maximum of the intensities of the contact, or the like. In some embodiments, the duration of the contact is used in determining the characteristic intensity (e.g., when the characteristic intensity is an average of the intensity of the contact over time). In some embodiments, the characteristic intensity is compared to a set of one or more intensity thresholds to determine whether an operation has been performed by a user. For example, the set of one or more intensity thresholds includes a first intensity threshold and a second intensity threshold. In this example, a contact with a characteristic intensity that does not exceed the first threshold results in a first operation, a contact with a characteristic intensity that exceeds the first intensity threshold and does not exceed the second intensity threshold results in a second operation, and a contact with a characteristic intensity that exceeds the second threshold results in a third operation. In some embodiments, a comparison between the characteristic intensity and one or more thresholds is used to determine whether or not to perform one or more operations (e.g., whether to perform a respective operation or forgo performing the respective operation) rather than being used to determine whether to perform a first operation or a second operation.

In some embodiments, a portion of a gesture is identified for purposes of determining a characteristic intensity. For example, a touch-sensitive surface receives a continuous swipe contact transitioning from a start location and reaching an end location, at which point the intensity of the contact increases. In this example, the characteristic intensity of the contact at the end location is based on only a portion of the continuous swipe contact, and not the entire swipe contact (e.g., only the portion of the swipe contact at the end location). In some embodiments, a smoothing algorithm is applied to the intensities of the swipe contact prior to determining the characteristic intensity of the contact. For example, the smoothing algorithm optionally includes one or more of: an unweighted sliding-average smoothing algorithm, a triangular smoothing algorithm, a median filter smoothing algorithm, and/or an exponential smoothing algorithm. In some circumstances, these smoothing algorithms eliminate narrow spikes or dips in the intensities of the swipe contact for purposes of determining a characteristic intensity.

The intensity of a contact on the touch-sensitive surface is characterized relative to one or more intensity thresholds, such as a contact-detection intensity threshold, a light press intensity threshold, a deep press intensity threshold, and/or one or more other intensity thresholds. In some embodiments, the light press intensity threshold corresponds to an intensity at which the device will perform operations typically associated with clicking a button of a physical mouse or a trackpad. In some embodiments, the deep press intensity threshold corresponds to an intensity at which the device will perform operations that are different from operations typically associated with clicking a button of a physical mouse or a trackpad. In some embodiments, when a contact is detected with a characteristic intensity below the light press intensity threshold (e.g., and above a nominal contact-detection intensity threshold below which the contact is no longer detected), the device will move a focus selector in accordance with movement of the contact on the touch-sensitive surface without performing an operation associated with the light press intensity threshold or the deep press intensity threshold. Generally, unless otherwise stated, these intensity thresholds are consistent between different sets of user interface figures.

An increase of characteristic intensity of the contact from an intensity below the light press intensity threshold to an intensity between the light press intensity threshold and the deep press intensity threshold is sometimes referred to as a "light press" input. An increase of characteristic intensity of the contact from an intensity below the deep press intensity threshold to an intensity above the deep press intensity threshold is sometimes referred to as a "deep press" input. An increase of characteristic intensity of the contact from an intensity below the contact-detection intensity threshold to an intensity between the contact-detection intensity threshold and the light press intensity threshold is sometimes referred to as detecting the contact on the touch-surface. A decrease of characteristic intensity of the contact from an intensity above the contact-detection intensity threshold to an intensity below the contact-detection intensity threshold is sometimes referred to as detecting liftoff of the contact from the touch-surface. In some embodiments, the contact-detection intensity threshold is zero. In some embodiments, the contact-detection intensity threshold is greater than zero.

In some embodiments described herein, one or more operations are performed in response to detecting a gesture that includes a respective press input or in response to detecting the respective press input performed with a respective contact (or a plurality of contacts), where the respective press input is detected based at least in part on detecting an increase in intensity of the contact (or plurality of contacts) above a press-input intensity threshold. In some embodiments, the respective operation is performed in response to detecting the increase in intensity of the respective contact above the press-input intensity threshold (e.g., a "down stroke" of the respective press input). In some embodiments, the press input includes an increase in intensity of the respective contact above the press-input intensity threshold and a subsequent decrease in intensity of the contact below the press-input intensity threshold, and the respective operation is performed in response to detecting the subsequent decrease in intensity of the respective contact below the press-input threshold (e.g., an "up stroke" of the respective press input).

In some embodiments, the device employs intensity hysteresis to avoid accidental inputs sometimes termed "jitter," where the device defines or selects a hysteresis intensity threshold with a predefined relationship to the press-input intensity threshold (e.g., the hysteresis intensity threshold is X intensity units lower than the press-input intensity threshold or the hysteresis intensity threshold is 75%, 90%, or some reasonable proportion of the press-input intensity threshold). Thus, in some embodiments, the press input includes an increase in intensity of the respective contact above the press-input intensity threshold and a subsequent decrease in intensity of the contact below the hysteresis intensity threshold that corresponds to the press-input intensity threshold, and the respective operation is performed in response to detecting the subsequent decrease in intensity of the respective contact below the hysteresis intensity threshold (e.g., an "up stroke" of the respective press input). Similarly, in some embodiments, the press input is detected only when the device detects an increase in intensity of the contact from an intensity at or below the hysteresis intensity threshold to an intensity at or above the press-input intensity threshold and, optionally, a subsequent decrease in intensity of the contact to an intensity at or below the hysteresis intensity, and the respective operation is performed in response to detecting the press input (e.g., the increase in intensity of the contact or the decrease in intensity of the contact, depending on the circumstances).

For ease of explanation, the descriptions of operations performed in response to a press input associated with a press-input intensity threshold or in response to a gesture including the press input are, optionally, triggered in response to detecting either: an increase in intensity of a contact above the press-input intensity threshold, an increase in intensity of a contact from an intensity below the hysteresis intensity threshold to an intensity above the press-input intensity threshold, a decrease in intensity of the contact below the press-input intensity threshold, and/or a decrease in intensity of the contact below the hysteresis intensity threshold corresponding to the press-input intensity threshold. Additionally, in examples where an operation is described as being performed in response to detecting a decrease in intensity of a contact below the press-input intensity threshold, the operation is, optionally, performed in response to detecting a decrease in intensity of the contact below a hysteresis intensity threshold corresponding to, and lower than, the press-input intensity threshold.

3. Digital Assistant System

FIG. **7**A illustrates a block diagram of digital assistant system **700** in accordance with various examples. In some examples, digital assistant system **700** is implemented on a standalone computer system. In some examples, digital assistant system **700** is distributed across multiple computers. In some examples, some of the modules and functions of the digital assistant are divided into a server portion and a client portion, where the client portion resides on one or more user devices (e.g., devices **104**, **122**, **200**, **400**, or **600**) and communicates with the server portion (e.g., server system **108**) through one or more networks, e.g., as shown in FIG. **1**. In some examples, digital assistant system **700** is an implementation of server system **108** (and/or DA server **106**) shown in FIG. **1**. It should be noted that digital assistant system **700** is only one example of a digital assistant system, and that digital assistant system **700** can have more or fewer components than shown, can combine two or more components, or can have a different configuration or arrangement of the components. The various components shown in FIG. **7**A are implemented in hardware, software instructions for execution by one or more processors, firmware, including one or more signal processing and/or application specific integrated circuits, or a combination thereof.

Digital assistant system **700** includes memory **702**, one or more processors **704**, input/output (I/O) interface **706**, and network communications interface **708**. These components can communicate with one another over one or more communication buses or signal lines **710**.

In some examples, memory **702** includes a non-transitory computer-readable medium, such as high-speed random access memory and/or a non-volatile computer-readable storage medium (e.g., one or more magnetic disk storage devices, flash memory devices, or other non-volatile solid-state memory devices).

In some examples, I/O interface **706** couples input/output devices **716** of digital assistant system **700**, such as displays, keyboards, touch screens, and microphones, to user interface module **722**. I/O interface **706**, in conjunction with user interface module **722**, receives user inputs (e.g., voice input, keyboard inputs, touch inputs, etc.) and processes them accordingly. In some examples, e.g., when the digital assistant is implemented on a standalone user device, digital assistant system **700** includes any of the components and I/O communication interfaces described with respect to devices **200**, **400**, or **600** in FIGS. **2**A, **4**, **6**A-B, respectively. In some examples, digital assistant system **700** represents the server portion of a digital assistant implementation, and can interact with the user through a client-side portion residing on a user device (e.g., devices **104**, **200**, **400**, or **600**).

In some examples, the network communications interface **708** includes wired communication port(s) **712** and/or wireless transmission and reception circuitry **714**. The wired communication port(s) receives and send communication signals via one or more wired interfaces, e.g., Ethernet, Universal Serial Bus (USB), FIREWIRE, etc. The wireless circuitry **714** receives and sends RF signals and/or optical signals from/to communications networks and other communications devices. The wireless communications use any of a plurality of communications standards, protocols, and technologies, such as GSM, EDGE, CDMA, TDMA, Bluetooth, Wi-Fi, VoIP, Wi-MAX, or any other suitable communication protocol. Network communications interface **708** enables communication between digital assistant system **700** with networks, such as the Internet, an intranet, and/or a wireless network, such as a cellular telephone network, a wireless local area network (LAN), and/or a metropolitan area network (MAN), and other devices.

In some examples, memory **702**, or the computer-readable storage media of memory **702**, stores programs, modules, instructions, and data structures including all or a subset of: operating system **718**, communications module **720**, user interface module **722**, one or more applications **724**, and digital assistant module **726**. In particular, memory **702**, or the computer-readable storage media of memory **702**, stores instructions for performing the processes described below. One or more processors **704** execute these programs, modules, and instructions, and reads/writes from/to the data structures.

Operating system **718** (e.g., Darwin, RTXC, LINUX, UNIX, iOS, OS X, WINDOWS, or an embedded operating system such as VxWorks) includes various software components and/or drivers for controlling and managing general system tasks (e.g., memory management, storage device control, power management, etc.) and facilitates communications between various hardware, firmware, and software components.

Communications module **720** facilitates communications between digital assistant system **700** with other devices over network communications interface **708**. For example, communications module **720** communicates with RF circuitry **208** of electronic devices such as devices **200**, **400**, and **600** shown in FIG. **2**A, **4**, **6**A-B, respectively. Communications module **720** also includes various components for handling data received by wireless circuitry **714** and/or wired communications port **712**.

User interface module **722** receives commands and/or inputs from a user via I/O interface **706** (e.g., from a keyboard, touch screen, pointing device, controller, and/or microphone), and generate user interface objects on a display. User interface module **722** also prepares and delivers outputs (e.g., speech, sound, animation, text, icons, vibrations, haptic feedback, light, etc.) to the user via the I/O interface **706** (e.g., through displays, audio channels, speakers, touch-pads, etc.).

Applications **724** include programs and/or modules that are configured to be executed by one or more processors **704**. For example, if the digital assistant system is implemented on a standalone user device, applications **724** include user applications, such as games, a calendar application, a navigation application, or an email application. If digital assistant system **700** is implemented on a server, applications **724** include resource management applications, diagnostic applications, or scheduling applications, for example.

Memory **702** also stores digital assistant module **726** (or the server portion of a digital assistant). In some examples, digital assistant module **726** includes the following submodules, or a subset or superset thereof: input/output processing module **728**, speech-to-text (STT) processing module **730**, natural language processing module **732**, dialogue flow processing module **734**, task flow processing module **736**, service processing module **738**, and speech synthesis module **740**. Each of these modules has access to one or more of the following systems or data and models of the digital assistant module **726**, or a subset or superset thereof: ontology **760**, vocabulary index **744**, user data **748**, task flow models **754**, service models **756**, and ASR systems.

In some examples, using the processing modules, data, and models implemented in digital assistant module **726**, the digital assistant can perform at least some of the following: converting speech input into text; identifying a user's intent expressed in a natural language input received from the user; actively eliciting and obtaining information needed to fully infer the user's intent (e.g., by disambiguating words, games, intentions, etc.); determining the task flow for fulfilling the inferred intent; and executing the task flow to fulfill the inferred intent.

In some examples, as shown in FIG. **7**B, I/O processing module **728** interacts with the user through I/O devices **716** in FIG. **7**A or with a user device (e.g., devices **104**, **200**, **400**, or **600**) through network communications interface **708** in FIG. **7**A to obtain user input (e.g., a speech input) and to provide responses (e.g., as speech outputs) to the user input. I/O processing module **728** optionally obtains contextual information associated with the user input from the user device, along with or shortly after the receipt of the user input. The contextual information includes user-specific data, vocabulary, and/or preferences relevant to the user input. In some examples, the contextual information also includes software and hardware states of the user device at the time the user request is received, and/or information related to the surrounding environment of the user at the time that the user request was received. In some examples, I/O processing module **728** also sends follow-up questions to, and receive answers from, the user regarding the user request. When a user request is received by I/O processing module **728** and the user request includes speech input, I/O processing module **728** forwards the speech input to STT processing module **730** (or speech recognizer) for speech-to-text conversions.

STT processing module **730** includes one or more ASR systems. The one or more ASR systems can process the speech input that is received through I/O processing module **728** to produce a recognition result. Each ASR system includes a front-end speech pre-processor. The front-end speech pre-processor extracts representative features from the speech input. For example, the front-end speech pre-processor performs a Fourier transform on the speech input to extract spectral features that characterize the speech input as a sequence of representative multi-dimensional vectors. Further, each ASR system includes one or more speech recognition models (e.g., acoustic models and/or language models) and implements one or more speech recognition engines. Examples of speech recognition models include Hidden Markov Models, Gaussian-Mixture Models, Deep Neural Network Models, n-gram language models, and other statistical models. Examples of speech recognition engines include the dynamic time warping based engines and weighted finite-state transducers (WFST) based engines. The one or more speech recognition models and the one or more speech recognition engines are used to process the extracted representative features of the front-end speech pre-processor to produce intermediate recognitions results (e.g., phonemes, phonemic strings, and sub-words), and ultimately, text recognition results (e.g., words, word strings, or sequence of tokens). In some examples, the speech input is processed at least partially by a third-party service or on the user's device (e.g., device **104**, **200**, **400**, or **600**) to produce the recognition result. Once STT processing module **730** produces recognition results containing a text string (e.g., words, or sequence of words, or sequence of tokens), the recognition result is passed to natural language processing module **732** for intent deduction.

More details on the speech-to-text processing are described in U.S. Utility application Ser. No. 13/236,942 for "Consolidating Speech Recognition Results," filed on Sep. 20, 2011, the entire disclosure of which is incorporated herein by reference.

In some examples, STT processing module **730** includes and/or accesses a vocabulary of recognizable words via phonetic alphabet conversion module **731**. Each vocabulary word is associated with one or more candidate pronunciations of the word represented in a speech recognition phonetic alphabet. In particular, the vocabulary of recognizable words includes a word that is associated with a plurality of candidate pronunciations. For example, the vocabulary includes the word "tomato" that is associated with the candidate pronunciations of /tə'meɪroʊ/ and /tə'mɑtoʊ/. Further, vocabulary words are associated with custom candidate pronunciations that are based on previous speech inputs from the user. Such custom candidate pronunciations are stored in STT processing module **730** and are associated with a particular user via the user's profile on the device. In some examples, the candidate pronunciations for words are determined based on the spelling of the word and one or more linguistic and/or phonetic rules. In some examples, the candidate pronunciations are manually generated, e.g., based on known canonical pronunciations.

In some examples, the candidate pronunciations are ranked based on the commonness of the candidate pronunciation. For example, the candidate pronunciation /tə'meɪroʊ/ is ranked higher than /tə'mɑtoʊ/, because the former is a more commonly used pronunciation (e.g., among all users, for users in a particular geographical region, or for any other appropriate subset of users). In some examples, candidate pronunciations are ranked based on whether the candidate pronunciation is a custom candidate pronunciation associated with the user. For example, custom candidate pronunciations are ranked higher than canonical candidate pronunciations. This can be useful for recognizing proper nouns having a unique pronunciation that deviates from canonical pronunciation. In some examples, candidate pronunciations are associated with one or more speech characteristics, such as geographic origin, nationality, or ethnicity. For example, the candidate pronunciation /tə'meɪroʊ/ is associated with the United States, whereas the candidate pronunciation /tə'meɪroʊ/ is associated with Great Britain. Further, the rank of the candidate pronunciation is based on one or more characteristics (e.g., geographic origin, nationality, ethnicity, etc.) of the user stored in the user's profile on the device. For example, it can be determined from the user's profile that the user is associated with the United States. Based on the user being associated with the United States, the candidate pronunciation /tə'meɪroʊ/ (associated with the United States) is ranked higher than the candidate pronunciation /tə'mɑtoʊ/ (associated with Great Britain). In some examples, one of the ranked candidate pronunciations is selected as a predicted pronunciation (e.g., the most likely pronunciation).

When a speech input is received, STT processing module **730** is used to determine the phonemes corresponding to the speech input (e.g., using an acoustic model), and then attempt to determine words that match the phonemes (e.g., using a language model). For example, if STT processing module **730** first identifies the sequence of phonemes /tə'meɪroʊ/ corresponding to a portion of the speech input, it can then determine, based on vocabulary index **744**, that this sequence corresponds to the word "tomato."

In some examples, STT processing module **730** uses approximate matching techniques to determine words in an utterance. Thus, for example, the STT processing module **730** can determine that the sequence of phonemes /tə'meɪroʊ/corresponds to the word "tomato," even if that particular sequence of phonemes is not one of the candidate sequence of phonemes for that word.

Natural language processing module **732** ("natural language processor") of the digital assistant can take the sequence of words or tokens ("token sequence") generated by STT processing module **730**, and attempt to associate the token sequence with one or more "actionable intents" recognized by the digital assistant. An "actionable intent" represents a task that can be performed by the digital assistant, and can have an associated task flow implemented in task flow models **754**. The associated task flow is a series of programmed actions and steps that the digital assistant takes in order to perform the task. The scope of a digital assistant's capabilities is dependent on the number and variety of task flows that have been implemented and stored in task flow models **754**, or in other words, on the number and variety of "actionable intents" that the digital assistant recognizes. The effectiveness of the digital assistant, however, also dependents on the assistant's ability to infer the correct "actionable intent(s)" from the user request expressed in natural language.

In some examples, in addition to the sequence of words or tokens obtained from STT processing module **730**, natural language processing module **732** also receives contextual information associated with the user request, e.g., from I/O processing module **728**. The natural language processing module **732** optionally uses the contextual information to clarify, supplement, and/or further define the information contained in the token sequence received from STT processing module **730**. The contextual information includes, for example, user preferences, hardware, and/or software states of the user device, sensor information collected before, during, or shortly after the user request, prior interactions (e.g., dialogue) between the digital assistant and the user, and the like. As described herein, contextual information is, in some examples, dynamic, and changes with time, location, content of the dialogue, and other factors.

In some examples, the natural language processing is based on, e.g., ontology **760**. Ontology **760** is a hierarchical structure containing many nodes, each node representing either an "actionable intent" or a "property" relevant to one or more of the "actionable intents" or other "properties." As noted above, an "actionable intent" represents a task that the digital assistant is capable of performing, i.e., it is "actionable" or can be acted on. A "property" represents a parameter associated with an actionable intent or a sub-aspect of another property. A linkage between an actionable intent node and a property node in ontology **760** defines how a parameter represented by the property node pertains to the task represented by the actionable intent node.

In some examples, ontology **760** is made up of actionable intent nodes and property nodes. Within ontology **760**, each actionable intent node is linked to one or more property nodes either directly or through one or more intermediate property nodes. Similarly, each property node is linked to one or more actionable intent nodes either directly or through one or more intermediate property nodes. For example, as shown in FIG. **7**C, ontology **760** includes a "restaurant reservation" node (i.e., an actionable intent node). Property nodes "restaurant," "date/time" (for the reservation), and "party size" are each directly linked to the actionable intent node (i.e., the "restaurant reservation" node).

In addition, property nodes "cuisine," "price range," "phone number," and "location" are sub-nodes of the property node "restaurant," and are each linked to the "restaurant reservation" node (i.e., the actionable intent node) through the intermediate property node "restaurant." For another example, as shown in FIG. **7**C, ontology **760** also includes a "set reminder" node (i.e., another actionable intent node). Property nodes "date/time" (for setting the reminder) and "subject" (for the reminder) are each linked to the "set reminder" node. Since the property "date/time" is relevant to both the task of making a restaurant reservation and the task of setting a reminder, the property node "date/time" is linked to both the "restaurant reservation" node and the "set reminder" node in ontology **760**.

An actionable intent node, along with its linked concept nodes, is described as a "domain." In the present discussion, each domain is associated with a respective actionable intent, and refers to the group of nodes (and the relationships there between) associated with the particular actionable intent. For example, ontology **760** shown in FIG. **7**C includes an example of restaurant reservation domain **762** and an example of reminder domain **764** within ontology **760**. The restaurant reservation domain includes the actionable intent node "restaurant reservation," property nodes "restaurant," "date/time," and "party size," and sub-property nodes "cuisine," "price range," "phone number," and "location." Reminder domain **764** includes the actionable intent node "set reminder," and property nodes "subject" and "date/time." In some examples, ontology **760** is made up of many domains. Each domain shares one or more property nodes with one or more other domains. For example, the "date/time" property node is associated with many different domains (e.g., a scheduling domain, a travel reservation domain, a movie ticket domain, etc.), in addition to restaurant reservation domain **762** and reminder domain **764**.

While FIG. **7**C illustrates two example domains within ontology **760**, other domains include, for example, "find a movie," "initiate a phone call," "find directions," "schedule a meeting," "send a message," and "provide an answer to a question," "read a list," "providing navigation instructions," "provide instructions for a task" and so on. A "send a message" domain is associated with a "send a message" actionable intent node, and further includes property nodes such as "recipient(s)," "message type," and "message body." The property node "recipient" is further defined, for example, by the sub-property nodes such as "recipient name" and "message address."

In some examples, ontology **760** includes all the domains (and hence actionable intents) that the digital assistant is capable of understanding and acting upon. In some examples, ontology **760** is modified, such as by adding or removing entire domains or nodes, or by modifying relationships between the nodes within the ontology **760**.

In some examples, nodes associated with multiple related actionable intents are clustered under a "super domain" in ontology **760**. For example, a "travel" super-domain includes a cluster of property nodes and actionable intent nodes related to travel. The actionable intent nodes related to travel includes "airline reservation," "hotel reservation," "car rental," "get directions," "find points of interest," and so on. The actionable intent nodes under the same super domain (e.g., the "travel" super domain) have many property nodes in common. For example, the actionable intent nodes for "airline reservation," "hotel reservation," "car rental," "get directions," and "find points of interest" share one or more of the property nodes "start location," "destination," "departure date/time," "arrival date/time," and "party size."

In some examples, each node in ontology **760** is associated with a set of words and/or phrases that are relevant to the property or actionable intent represented by the node. The respective set of words and/or phrases associated with each node are the so-called "vocabulary" associated with the node. The respective set of words and/or phrases associated with each node are stored in vocabulary index **744** in association with the property or actionable intent represented by the node. For example, returning to FIG. **7**B, the vocabulary associated with the node for the property of "restaurant" includes words such as "food," "drinks," "cuisine," "hungry," "eat," "pizza," "fast food," "meal," and so on. For another example, the vocabulary associated with the node for the actionable intent of "initiate a phone call" includes words and phrases such as "call," "phone," "dial," "ring," "call this number," "make a call to," and so on. The vocabulary index **744** optionally includes words and phrases in different languages.

Natural language processing module **732** receives the token sequence (e.g., a text string) from STT processing module **730**, and determines what nodes are implicated by the words in the token sequence. In some examples, if a word or phrase in the token sequence is found to be associated with one or more nodes in ontology **760** (via vocabulary index **744**), the word or phrase "triggers" or "activates" those nodes. Based on the quantity and/or relative importance of the activated nodes, natural language processing module **732** selects one of the actionable intents as the task that the user intended the digital assistant to perform. In some examples, the domain that has the most "triggered" nodes is selected. In some examples, the domain having the highest confidence value (e.g., based on the relative importance of its various triggered nodes) is selected. In some examples, the domain is selected based on a combination of the number and the importance of the triggered nodes. In some examples, additional factors are considered in selecting the node as well, such as whether the digital assistant has previously correctly interpreted a similar request from a user.

User data **748** includes user-specific information, such as user-specific vocabulary, user preferences, user address, user's default and secondary languages, user's contact list, and other short-term or long-term information for each user.

In some examples, natural language processing module **732** uses the user-specific information to supplement the information contained in the user input to further define the user intent. For example, for a user request "invite my friends to my birthday party," natural language processing module **732** is able to access user data **748** to determine who the "friends" are and when and where the "birthday party" would be held, rather than requiring the user to provide such information explicitly in his/her request.

Other details of searching an ontology based on a token string is described in U.S. Utility application Ser. No. 12/341,743 for "Method and Apparatus for Searching Using An Active Ontology," filed Dec. 22, 2008, the entire disclosure of which is incorporated herein by reference.

In some examples, once natural language processing module **732** identifies an actionable intent (or domain) based on the user request, natural language processing module **732** generates a structured query to represent the identified actionable intent. In some examples, the structured query includes parameters for one or more nodes within the domain for the actionable intent, and at least some of the parameters are populated with the specific information and requirements specified in the user request. For example, the user says "Make me a dinner reservation at a sushi place at 7." In this case, natural language processing module **732** is able to correctly identify the actionable intent to be "restaurant reservation" based on the user input. According to the ontology, a structured query for a "restaurant reservation" domain includes parameters such as {Cuisine}, {Time}, {Date}, {Party Size}, and the like. In some examples, based on the speech input and the text derived from the speech input using STT processing module **730**, natural language processing module **732** generates a partial structured query for the restaurant reservation domain, where the partial structured query includes the parameters {Cuisine="Sushi"} and {Time="7 pm"}. However, in this example, the user's utterance contains insufficient information to complete the structured query associated with the domain. Therefore, other necessary parameters such as {Party Size} and {Date} is not specified in the structured query based on the information currently available. In some examples, natural language processing module **732** populates some parameters of the structured query with received contextual information. For example, in some examples, if the user requested a sushi restaurant "near me," natural language processing module **732** populates a {location} parameter in the structured query with GPS coordinates from the user device.

In some examples, natural language processing module **732** is configured to determine user intents (e.g., actionable intents) associated with performing a task using a device of an established location. In particular, ontology **760** includes domains or nodes related to performing a task using a device of an established location. For example, ontology **760** includes a "home" domain related to controlling a device associated with the user's home, or an "office" domain related to controlling a device associated with the user's office. Vocabulary index **744** includes words and phrases associated with devices in one or more established locations (e.g., homes, offices, businesses, and public institutions). For example, the words and phrases include command words such as "set," "open," "lock," "activate," "print," "turn on," or the like. Additionally, the words and phrases include device-related words such as "door," "thermostat," "toaster," "humidifier," or the like. In some examples, vocabulary index includes look-up tables, models, or classifiers that enable natural language process module **732** to determine one or more alternative terms for a given term. For example, vocabulary index **744** maps the term "thermostat" to one or more alternative terms such as "heater," "air conditioning," "A/C," "HVAC" and "climate control." User data **748** includes one or more data structures (e.g., data structure **900**) that each represents a set of devices of a respective established location.

To determine an actionable intent associated with performing a task using a device of an established location, natural language processing module **732** is configured to determine one or more possible device characteristics and one or more candidate devices corresponding to user speech input. Natural language processing module **732** is further configured to determine overlapping device characteristics common to the one or more possible device characteristics and the actual device characteristics of the one or more candidate devices.

In some examples, natural language process module **732** is configured to determine one or more criteria defined in the user speech input. The one or more criteria are identified based on recognizing conditional terms (e.g., "when," "if" "once," "upon," etc.) in the user speech input. In some examples, determining the one or more criteria includes determining quantitative criteria corresponding to ambiguous qualitative phrases in the user speech input. For example, natural language process module **732** is configured to access one or more knowledge sources to determine that the ambiguous qualitative phrase "too hot" in the user speech input corresponds to the quantitative criteria of "greater than 90 degrees Fahrenheit." The one or more knowledge sources can, for example, include look-up tables that map qualitative terms (e.g., adjectives) to specific values or ranges of measurable characteristics. The one or more knowledges sources are stored on the digital assistant system (e.g., in memory **702**) or on a remote system. In some examples, the one or more criteria are associated with a device of an established location. Natural language process module **732** is configured to determine the device associated with the one or more criteria using ontology **760**, vocabulary index **744**, and one or more data structures stored in user data **748**.

In some examples, natural language processing module **732** passes the generated structured query (including any completed parameters) to task flow processing module **736** ("task flow processor"). Task flow processing module **736** is configured to receive the structured query from natural language processing module **732**, complete the structured query, if necessary, and perform the actions required to "complete" the user's ultimate request. In some examples, the various procedures necessary to complete these tasks are provided in task flow models **754**. In some examples, task flow models **754** include procedures for obtaining additional information from the user and task flows for performing actions associated with the actionable intent.

As described above, in order to complete a structured query, task flow processing module **736** needs to initiate additional dialogue with the user in order to obtain additional information, and/or disambiguate potentially ambiguous utterances. When such interactions are necessary, task flow processing module **736** invokes dialogue flow processing module **734** to engage in a dialogue with the user. In some examples, dialogue flow processing module **734** determines how (and/or when) to ask the user for the additional information and receives and processes the user responses. The questions are provided to and answers are received from the users through I/O processing module **728**. In some examples, dialogue flow processing module **734** presents dialogue output to the user via audio and/or visual output, and receives input from the user via spoken or physical (e.g., clicking) responses. Continuing with the example above, when task flow processing module **736** invokes dialogue flow processing module **734** to determine the "party size" and "date" information for the structured query associated with the domain "restaurant reservation," dialogue flow processing module **734** generates questions such as "For how many people?" and "On which day?" to pass to the user. Once answers are received from the user, dialogue flow processing module **734** then populates the structured query with the missing information, or pass the information to task flow processing module **736** to complete the missing information from the structured query.

Once task flow processing module **736** has completed the structured query for an actionable intent, task flow processing module **736** proceeds to perform the ultimate task associated with the actionable intent. Accordingly, task flow processing module **736** executes the steps and instructions in the task flow model according to the specific parameters contained in the structured query. For example, the task flow model for the actionable intent of "restaurant reservation" includes steps and instructions for contacting a restaurant and actually requesting a reservation for a particular party size at a particular time. For example, using a structured query such as: {restaurant reservation, restaurant=ABC Café, date=Mar. 12, 2012, time=7 pm, party size=5}, task flow processing module **736** performs the steps of: (1) logging onto a server of the ABC Café or a restaurant reservation system such as OPENTABLE®, (2) entering the date, time, and party size information in a form on the website, (3) submitting the form, and (4) making a calendar entry for the reservation in the user's calendar.

In some examples, task flow processing module **736** employs the assistance of service processing module **738** ("service processing module") to complete a task requested in the user input or to provide an informational answer requested in the user input. For example, service processing module **738** acts on behalf of task flow processing module **736** to make a phone call, set a calendar entry, invoke a map search, invoke or interact with other user applications installed on the user device, and invoke or interact with third-party services (e.g., a restaurant reservation portal, a social networking website, a banking portal, etc.). In some examples, the protocols and application programming interfaces (API) required by each service are specified by a respective service model among service models **756**. Service processing module **738** accesses the appropriate service model for a service and generate requests for the service in accordance with the protocols and APIs required by the service according to the service model.

For example, if a restaurant has enabled an online reservation service, the restaurant submits a service model specifying the necessary parameters for making a reservation and the APIs for communicating the values of the necessary parameter to the online reservation service. When requested by task flow processing module **736**, service processing module **738** establishes a network connection with the online reservation service using the web address stored in the service model, and send the necessary parameters of the reservation (e.g., time, date, party size) to the online reservation interface in a format according to the API of the online reservation service.

In some examples, natural language processing module **732**, dialogue flow processing module **734**, and task flow processing module **736** are used collectively and iteratively to infer and define the user's intent, obtain information to further clarify and refine the user intent, and finally generate a response (i.e., an output to the user, or the completion of a task) to fulfill the user's intent. The generated response is a dialogue response to the speech input that at least partially fulfills the user's intent. Further, in some examples, the generated response is output as a speech output. In these examples, the generated response is sent to speech synthesis module **740** (e.g., speech synthesizer) where it can be processed to synthesize the dialogue response in speech form. In yet other examples, the generated response is data content relevant to satisfying a user request in the speech input.

For actionable intents and structured queries associated with performing one or more tasks using one or more devices of an established location, service processing module **738** is configured to cause the one or more tasks to be performed by the one or more devices of the established location. For example, service processing module **738** is configured to provide instructions or commands (e.g., via network(s) **110**) to the one or more devices of the established location to cause the one or more devices to perform the one or more tasks.

Speech synthesis module **740** is configured to synthesize speech outputs for presentation to the user. Speech synthesis module **740** synthesizes speech outputs based on text provided by the digital assistant. For example, the generated dialogue response is in the form of a text string. Speech synthesis module **740** converts the text string to an audible speech output. Speech synthesis module **740** uses any appropriate speech synthesis technique in order to generate speech outputs from text, including, but not limited, to concatenative synthesis, unit selection synthesis, diphone synthesis, domain-specific synthesis, formant synthesis, articulatory synthesis, hidden Markov model (HMM) based synthesis, and sinewave synthesis. In some examples, speech synthesis module **740** is configured to synthesize individual words based on phonemic strings corresponding to the words. For example, a phonemic string is associated with a word in the generated dialogue response. The phonemic string is stored in metadata associated with the word. Speech synthesis model **740** is configured to directly process the phonemic string in the metadata to synthesize the word in speech form.

In some examples, instead of (or in addition to) using speech synthesis module **740**, speech synthesis is performed on a remote device (e.g., the server system **108**), and the synthesized speech is sent to the user device for output to the user. For example, this can occur in some implementations where outputs for a digital assistant are generated at a server system. And because server systems generally have more processing power or resources than a user device, it is possible to obtain higher quality speech outputs than would be practical with client-side synthesis.

Additional details on digital assistants can be found in the U.S. Utility application Ser. No. 12/987,982, entitled "Intelligent Automated Assistant," filed Jan. 10, 2011, and U.S. Utility application Ser. No. 13/251,088, entitled "Generating and Processing Task Items That Represent Tasks to Perform," filed Sep. 30, 2011, the entire disclosures of which are incorporated herein by reference.

4. Processes for Operating a Digital Assistant

FIG. **8** illustrates process **800** for operating a digital assistant according to various examples. Process **800** is performed, for example, using one or more electronic devices (e.g., devices **104**, **106**, **200**, **400**, or **600**) implementing a digital assistant. In some examples, the processes is performed at a client-server system (e.g., system **100**) implementing a digital assistant. The blocks of the processes can be divided up in any manner between the server (e.g., DA server **106**) and the client (e.g., user device **104**). In process **800**, some blocks are, optionally, combined, the order of some blocks is, optionally, changed, and some blocks are, optionally, omitted. In some examples, only a subset of the features or blocks described below with reference to FIG. **8** is performed.

At block **802**, discourse input representing a user request is received (e.g., at microphone **213** or at I/O processing module **728**). The discourse input is, for example, speech input or text input. In addition, the discourse input is, for example, in natural language form. In some examples, the user request is a request for a device (e.g., devices **130**, **132**, **134**, or **136**) to perform an action. The device is a separate and different device from the electronic device (e.g., devices **104**, **106**, **200**, **400**, or **600**) receiving or processing the discourse input. In some examples, the discourse input contains one or more ambiguous terms by virtue of being in natural language form. The one or more ambiguous terms, for example, each has more than one possible interpretation. For example, the discourse input is "Set the thermostat to sixty." In this example, the discourse input is ambiguous with respect to defining the device for performing the requested action. Specifically, in the context of an established location, such as the user's home, there can be several devices associated with the term "thermostat," such as a central heating unit, a bedroom space heater, or a living room air conditioning unit. It is thus ambiguous as to which device the user is referring to in the discourse input. Additionally, in the same example, the discourse input is ambiguous with respect to defining the specific action being requested. For example, one or more devices in the established location are capable of adjusting the temperature as well as the humidity. The discourse input is thus ambiguous as to whether the user wishes to adjust the temperature of a device to sixty degrees Fahrenheit or to adjust the humidity of a device to sixty percent relative humidity.

At block **804**, a determination is made as to whether the discourse input corresponds to a domain that is associated with an actionable intent of performing a task using a device of an established location (e.g., the user's primary home, the user's office, the user's vacation home, etc.). The domain is a domain of an ontology (e.g., ontology **760**). In one example, the domain is an "automation" domain corresponding to the actionable intent of controlling one or more devices in an established location. The determination at block **804** is, for example, performed using natural language processing (e.g., with natural language processing module **732**, vocabulary **744**, and user data **748**). For instance, in the example "Set the thermostat to sixty," it can be determined based on the words "set," "thermostat," and "sixty" that the discourse input likely corresponds to the actionable intent of controlling a device (e.g., a thermostat) in the user's home. In this example, the actionable intent is thus associated with the "automation" domain.

As shown in FIG. **8**, in response to determining that the discourse input corresponds to a domain that is associated with an actionable intent of performing a task with a device of an established location, block **806** is performed. In particular, block **806** is performed automatically without further input from the user in response to determining that the discourse input corresponds to a domain that is associated with an actionable intent of performing a task with a device of an established location. Alternatively, in response to determining that the discourse input does not correspond to a domain that is associated with an actionable intent of performing a task with a device of an established location, block **805** is performed. Specifically, at block **805**, process **800** forgoes retrieving a data structure representing a set of devices of the established location.

At block **806**, a data structure representing a set of devices of an established location is retrieved. In some examples, the data structure is retrieved from the user device (e.g., user data and models **231** of user device **200**). In other examples, the data structure is retrieved from the server (e.g., data & models **116** of DA server **106**). The data structure defines, for example, a hierarchical relationship between a plurality of regions in the established location. The data structure further defines the relationship of each device of the set of devices with respect to the plurality of regions.

The established location is a location associated with an establishment, such as a business organization, a household, or a public institution. For example, the established location is associated with the user who provided the discourse input (e.g., user's home, user's workplace, or user's vacation home). In other examples, the established location is associated with a public institution (e.g., a church, a school, or a library). In yet other examples, the established location is associated with a business (e.g., store, company office, restaurant, etc.).

In some examples, process **800** determines which data structure from among a plurality of data structures to retrieve. Each data structure of the plurality of data structures is associated with a respective established location. Process **800** determines a location corresponding to the discourse input. For example, process **800** determines a location of the user device (e.g., using GPS module **235**) at the time the discourse input is received. An established location is then identified based on the location of the user device. For instance, in one example, it is determined that the location of the user device corresponds to the location of the user's home. Based on the determined established location, the corresponding data structure is identified and retrieved from the plurality of data structures. For example, the data structure representing the devices in the user's home is identified and retrieved.

FIG. **9** is a hierarchical chart illustrating exemplary data structure **900** that represents a set of devices of an established location, according to various examples. As shown, data structure **900** includes a plurality of nodes **902-950** organized in a hierarchical structure across levels **960-968**. The organization of nodes **902-950** defines how the various devices (e.g., garage door, back door, central thermostat, space heater, and son's lamp) of the established location relate to the various regions (e.g., floor 1, floor 2, garage, living room, mater bedroom, and son's bedroom) of the established location. Specifically, the nodes of levels **960-964** define how the various regions of the established location are organized. The root node of level **960** represents the established location (e.g., John's house) and the nodes of level **962** represent the major regions (e.g., floor 1 and floor 2) of the established location. The nodes of level **964** represent the sub-regions within each of the major regions. In the present example, the sub-regions include the separate rooms or living areas (garage, living room, master bedroom, and son's bedroom) in John's house. Although in the present example, data structure **900** includes one level (level **960**) for the major regions and one level (level **964**) for the sub-regions, it should be recognized that in other examples, the data structure includes any number of levels for organizing the various regions of an established location.

The nodes of level **966** define the device(s) associated with each region of level **964**. For example, nodes **926** and **928** indicate that there is a garage door device and a back door device associated with the garage of John's house.

Similarly, node **930** indicates that a thermostat is associated with the living room of John's house. The devices represented by nodes **908-914** are similar or identical to devices **130-136** of FIG. **1**. For example, the devices represented by nodes **908-914** are communicatively coupled to an electronic device (e.g., user device **104**) or server (e.g., DA server **106**) via one or more networks (e.g., network(s) **110**). The electronic device provides commands via the one or more networks that cause one or more of the devices of nodes **908-914** to perform an action defined by the user.

The nodes of level **968** define the actual device characteristics associated with each device of level **966**. For example, node **936** indicates that the garage door device has the actual device characteristic of "position." Similarly, node **938** indicates that the back door device has the actual device characteristic of "lock." An actual device characteristic describes, for example, an actual function or characteristic of the device that can be controlled using the electronic device (e.g., devices **104**, **200**, **400**, or **600**). For example, the "position" of the garage door can be changed by controlling the garage door device or the back door can be "locked" or "unlocked" by controlling the back door device.

Each node of data structure **900** includes one or more stored attributes. For example, as shown in FIG. **9**, user-defined identifiers (IDs) are stored in association with each node of levels **960-966**. Specifically, node **902** includes the user-defined ID "John's house" that describes the established location. Similarly, each of nodes **904-914** includes a user-defined ID describing the respective region of the established location. For example, node **912** includes the user-defined ID "master bedroom" and node **914** includes the user-defined ID "son's bedroom." Further, each of nodes **926-934** includes a user-defined ID describing the respective device. For example, node **930** includes the user-defined ID "central thermostat" and node **934** includes the user-defined ID "son's lamp." In some examples, only data structures stored on the user device (e.g., user device **104**) include user-defined IDs. Data structures stored on the server (e.g., DA server **106**) include, for example, generic IDs such as "region 1" or "region 2" for nodes representing regions in the established location and "device 1" or "device 2" for nodes representing devices. In other examples, each device and each region in the data structure is identified with respect to a temporary session key associated with the received discourse input. This is desirable to preserve the user's privacy when data structure is stored on the server.

Each of nodes **902-934** further includes stored attributes (not shown) that define, for example, the region type for each region in the established location or the device type for each device in the established location. For example, "master bedroom" (node **912**) and "son's bedroom" (node **914**) each has a region type of "bedroom." Similarly, "central thermostat" (node **930**) has a device type of "thermostat" and "son's lamp" (node **934**) has a device type of "light." The region type and device type are standardized descriptions based on a list of standard region types and device types. Other examples of region types include "basement," "store room," "attic," "kitchen," or the like. Further examples of device types include "door lock," "humidifier," "music player," "toaster," or the like.

Nodes **926-934** further include additional stored attributes that indicate the operating states of each device with respect to the relevant device characteristic. For example, the "garage door" (node **936**) has an operating status "open" or "closed" for the device characteristic "position." In another example, the "central thermostat" (node **930**) has an operating status "73 degrees Fahrenheit" for the device characteristic "temperature" and "60%" with respect to the device characteristic "humidity." Additional examples of operating status include "locked" or "unlocked" with respect to the device characteristic "lock" (e.g., for a door lock device), "on" or "off" with respect to the device characteristic "power" (e.g., for a music player device), and "75%" with respect to the device characteristic "brightness" (e.g., for a dimmable lighting device).

The data structure is created (e.g., using devices **104** or **200** or server system **108**) based on user input and/or data received from the devices of the established location. For example, a user device provides a user interface that enables the user to enter information for creating the data structure. Specifically, the user device receives, via the user interface, information regarding the various regions in the established location and the various devices of the established location. Further, the user device receives information that associates a particular device of the established location to one or more regions of the established location. For example, user input received via the user interface defines a region named "master bedroom" (e.g., node **912**) and a device named "space heater" in the established location. The user input further associates the "space heater" device to the "master bedroom" region. In some examples, information in the data structure is auto-populated based on data received from the devices of the established location. For example, each device of the established location transmits various attributes associated with the device of the established location to the user device. Specifically, device IDs, device characteristics, operating statuses, or device types are transmitted to the user device. The user device then auto-populates this data into the respective data structure.

In some examples, the digital assistant of the user device automatically proposes additions or modifications to the data structure based on information received regarding the various devices of the established location. The received information includes, for example, device information defining a first device of the established location having a device ID "bedroom1_light" and a second device of the established location having a device ID "bedroom1_radio." Based on the common phrase "bedroom1" in each of the device IDs of the first and second devices, process **800** determines that both devices are likely associated with a common region "bedroom1" in the established location. Additionally or alternatively, the received information includes location information of the first and second devices. For example, the location information indicates that the first and second devices are disposed within a common region of the established location. In another example, the location information indicates that the first device and the second device are positioned within a threshold distance apart in the established location. Based on the location information, a relationship between the first device and the second device is determined with respect to one or more regions of the established location. For example, it is determined that the first and second devices are associated with the "bedroom1" region of the established location. Based on the determined relationship between the first and second devices, a prompt is provided to the user suggesting a modification to the data structure. For example, a prompt is provided asking the user "Would you like to create the room 'bedroom1' that includes the devices 'bedroom1_light' and 'bedroom1_radio'?" A user input (e.g., selection of a user interface button) is received responsive to the provided prompt. The user input confirms the modification proposed by the prompt. In response to receiving the user input, the data structure is modified to define the determined relationship between the first device and the second device with respect to the established location. For example, a node representing the region "bedroom1" in the established location is created in the data structure. Additionally, the nodes representing the devices "bedroom1_light" and "bedroom1_radio" are associated with the node representing the region "bedroom1."

It should be appreciated that data structure **900**, described above, is a non-limiting example of a data structure representing a set of devices of an established location and that various modifications and variations of data structure **900** are possible in view of the above description. For example, the data structure can include any number of nested levels of nodes. In some examples, one or more of the levels of nodes in data structure **900** are optionally removed, and/or additional levels of nodes are optionally added. In one example, the nodes of level **962** are optionally removed in data structure **900** and the nodes of level **964** are nested directly under the root node **902**. In other examples, one or more additional levels of nodes representing sub-regions are optionally added to data structure **900**. Specifically, one or more additional levels of nodes representing sub-regions are optionally included between levels **962** and **964**, or between levels **964** and **966** of data structure **900**. Further, it should be recognized that that in some examples, the nodes representing devices need not be nested under a node representing a major region or a sub region. For instance, in some examples, any one of nodes **926-934** in data structure **900** is optionally nested directly under root node **960** or a node of level **962**.

At block **808**, one or more possible device characteristics corresponding to the discourse input are determined. In particular, the words of the discourse input are parsed and analyzed to identify possible device characteristics related to the words and/or phrases in the discourse input. Block **808** is performed, for example, using a natural language processing module (e.g., natural language processing module **732**) utilizing suitable models and vocabulary (e.g., vocabulary **744**). In particular, a machine learning classifier of the natural language processing module, for example, processes the words of the discourse input and determine possible device characteristics associated with the words. In one example, the discourse input is "Open the door." In this example, the terms "open" and "door" are determined to each correspond to the possible device characteristics of "position" and "lock/unlock."

In some examples, each term of the discourse input is initially analyzed individually. For example, with reference to FIG. **10**A, discourse input **1002** is "Set the thermostat to sixty percent." In this example, the term "set" is determined to correspond to a first set of possible device characteristics **1004** that includes "temperature," "humidity," "brightness," "volume," and "speed." The term "thermostat" is determined to correspond to a second set of possible device characteristics **1006** that include "temperature" and "humidity." The term "sixty" is determined to correspond to a third set of possible device characteristics **1008** that include "temperature," "humidity," and "brightness." The term "percent" is determined to correspond to a fourth set of possible device characteristics **1010** that include "brightness" and "humidity."

The one or more possible device characteristics are determined based on the sets of possible device characteristics (e.g., **1004**, **1006**, **1008**, **1010**) corresponding to the individual terms in the discourse input. For example, the one or more possible device characteristics determined at block **808** are a combination of the sets of possible device characteristics. In some examples, the one or more possible device characteristics are determined based on the frequency of each possible device characteristic among the sets of possible device characteristics. For example, the one or more possible device characteristics are determined to include the possible device characteristic "humidity," which has the greatest frequency across the sets of possible device characteristics **1004**, **1006**, **1008**, **1010**.

In some examples, the one or more possible device characteristics are determined based on the popularity of each possible device characteristic in the sets of possible device characteristics (e.g., **1004**, **1006**, **1008**, **1010**). The popularity refers to how frequently actions associated with a device characteristic are requested by a population of users. For example, if actions related to "temperature" are more frequently requested than actions related to the other device characteristics, the possible device characteristic "temperature" is weighted more heavily when determining the one or more possible device characteristics at block **808**. In other examples, the one or more possible device characteristics are determined based on the salience of each term in the discourse input. For example, the term "thermostat" has the greatest salience among the terms in the discourse input and thus set of possible device characteristics **1006** is weighted more heavily than other sets of possible device characteristics when determining the one or more possible device characteristics at block **808**. Thus, in this example, the one or more possible device characteristics more likely include the possible device characteristics of "temperature" and "humidity" from set of possible device characteristics **1006**.

At block **810**, one or more candidate devices from the set of devices are determined based on the data structure. The one or more candidate devices correspond to the discourse input. In some examples, block **808** is performed using a natural language processing module (e.g., natural language processing module **732**) based on suitable models and vocabulary (e.g., vocabulary **744**). In particular, a machine learning classifier of the natural language processing module, for example, processes the words of the discourse input and determine candidate devices from the set of devices in the data structure that most likely correspond to the discourse input. For example, in the discourse input "Set the thermostat to sixty percent," the word "thermostat" in the discourse input is recognized as being relevant and compared (e.g., based on semantic or syntactic similarity) to the various attributes and IDs of the nodes in the data structure to determine candidate devices corresponding to the discourse input. In particular, the devices "central thermostat" (e.g., node **930**) and "space heater" (e.g., node **932**) are determined as the one or more candidate devices based on the word "thermostat" in the discourse input.

In another example, the discourse input is "Set the living room to sixty percent." In this example, the word "living room" is recognized as being relevant and compared to the various attributes and IDs of the nodes in the data structure. In this example, "living room" in the discourse input is determined to correspond to the "living room" region (e.g., node **910**) defined in data structure **900**. Because "living room" region (e.g., node **910**) is associated with the "central thermostat" device (e.g., node **930**) in data structure **900**, the one or more candidate devices are determined to include the "central thermostat device."

In some examples, the one or more candidate devices are determined based on one or more alternative terms derived from one or more terms in the discourse input. Returning to the example of the discourse input, "Set the thermostat to sixty percent," one or more alternative terms associated with "thermostat" are determined. In particular, "thermostat" is determined to be associated with the alternative terms "heater," "A/C," "radiator," "regulator," "thermometer," and "humidifier." In this example, the alternative terms are used to search the nodes of the data structure to determine the one or more candidate devices. For example, devices having user-defined device IDs "John's heater" and "office A/C" are identified based on the alternative terms, and the devices are included in the one or more candidate devices determined at block **808**.

In some examples, the one or more alternative terms are based on phrases commonly used to refer to an action or device. For example, the discourse input "Open the door" can commonly be expressed as "Open the back," "Open the back door," "Open the back lock," "Open the lock," "Open the door lock," or "Open the bolt." In this example, the term "door" is determined to be associated with the alternative terms "back," "back door," "lock," "door lock," "back lock," "back door lock," and "bolt." Candidate devices are identified from the data structure using the alternative terms. For example, devices associated with user-defined IDs or other attributes containing the alternative terms "back," "lock," or "back door" in the data structure are identified and included in the one or more candidate devices.

The one or more alternative terms are determined using a look-up table, a model, or a classifier. In particular, the look-up table, model, or classifier associates a term with one or more alternative terms. The association is based on semantic mapping. In some examples, the association is user-defined. For example, prior to receiving the discourse input at block **802**, a user input defining an alternative term is received. The user input can, for example, include speech stating "The 'television' can be called the 'telly.'" Based on the user input, the relevant look-up table, model, or classifier is updated such that "television" is associated with the alternative term "telly" and vice versa. Thus, the one or more alternative terms are based on the received user input.

In some examples, the one or more candidate devices are determined using retrieved context information. In one example, the discourse input is "Turn on John's lights." Process **800** determines that "lights" is associated with a lighting device represented in the data structure. However, there can be several lighting devices represented in the data structure. In this example, retrieved context information serves to reduce the number of identified candidate devices. Specifically, the term "John" is determined to be associated with contact information, and, in response, contact information on the user device is searched in accordance with the term "John." Through searching the contact information, information indicating that the user has a son named "John" is retrieved. The one or more candidate devices are thus determined based on this retrieved contact information. In particular, process **800** identifies from the data structure that the established location includes a region named "son's bedroom" (e.g., node **914** in FIG. **9**), which is associated with the lighting device "son's lamp" (e.g., node **934**). Thus, in this example, the one or more candidate devices are determined to include the device "son's lamp" in the son's bedroom.

It should be recognized that, in some examples, block **808** or **810** is integrated into block **812**. For example, block **808** or **810** is performed as part of determining the user intent at block **812**.

At block **812**, a user intent corresponding to the discourse input is determined. The user intent refers to the inferred intent of the user in providing the discourse input. For example, the user intent is the actionable intent described above with reference to FIG. **7**B. In a specific example, the inferred user intent corresponding to the discourse input "Open the door" is to have the back door of the user's house unlocked. The user intent is determined based on the one or more possible device characteristics of block **808** and one or more actual device characteristics of the one or more candidate devices of block **810**.

In some examples, determining the user intent at block **812** includes determining a device from the one or more candidate devices. In particular, the candidate devices are narrowed down to the device that the user is most likely referring to. The determination is based on the one or more possible device characteristics and the one or more actual device characteristics of the one or more candidate devices of block **810**. For example, one or more overlapping device characteristics that are common between one or more possible device characteristics and the one or more actual device characteristics are determined, and the device is determined based on the overlapping device characteristics.

In the example shown FIG. **10**B, the one or more candidate devices are determined to include "central thermostat" (e.g., node **930**) and "space heater" (e.g., node **932**) based on the discourse input "Set the thermostat to sixty percent." According to data structure **900**, the actual device characteristics of the candidate device "central thermostat" include "temperature" and "humidity" and the actual device characteristics of the candidate device "space heater" include "temperature" and "fan speed." Additionally, based on the most frequent device characteristic among the sets of possible device characteristics **1004-1010**, the one or more possible device characteristic corresponding to the discourse input "Set the thermostat to sixty percent" are determined to be "humidity" (FIG. **10**A). Thus, in this example, the one or more overlapping device characteristics that are common between one or more possible device characteristics and the one or more actual device characteristics are determined to be "humidity." Because the overlapping device characteristic "humidity" corresponds to a device characteristic of "central thermostat" (e.g., node **930**) but not to any device characteristic of "space heater" (e.g., node **932**), the one or more candidate devices are narrowed down to the device "central thermostat" (e.g., node **930**) in the living room of the user's house. The user intent is thus determined based on the device "central thermostat" (e.g., node **930**). Specifically, based on the device "central thermostat," the overlapping device characteristic "humidity," and the words "sixty percent" in the discourse input, it is determined that the user intent is to program the humidity setpoint of the central thermostat in the user's living room to the value of sixty percent.

In some examples, more than one candidate user intent is determined. For example, it may not be possible to narrow down the candidate devices to a single device based on the one or more overlapping characteristics. In one such example, based on the discourse input "Open the door," the one or more possible device characteristics are determined to include "position" and "lock." Additionally, based on data structure **900**, the candidate devices "garage door" (e.g., node **926**) and "back door" (e.g., node **928**) having actual device characteristics "position" and "lock," respectively, are determined to correspond to the discourse input. In this example, the overlapping device characteristics that are common between the one or more possible device characteristics and the one or more actual device characteristics are determined to include "position" and "lock." It is thus not possible to narrow down the candidate devices "garage door" (e.g., node **926**) and "back door" (e.g., node **928**) based on these overlapping device characteristics. Specifically, two candidate user intents are determined based on the candidate devices "garage door" (e.g., node **926**) and "back door" (e.g., node **928**), the overlapping device characteristics "position" and "lock," and the word "open" in the discourse input. The first candidate user intent is to activate the garage door motor to lift open the garage door. The second candidate user intent is to unlock the back door entrance at the garage. In this example, additional information is required to disambiguate the user intent. In particular, the digital assistant retrieves additional information to determine a single user intent from the first and second candidate user intents. In some examples, the digital assistant automatically retrieves the additional information in response to determining more than one candidate user intent that cannot be disambiguated using the data structure.

In some examples, the user intent is disambiguated based on the position of the user at the time the discourse input was received. For example, a relative position of the user with respect to a region in the established location is determined. The user intent is then determined based on the determined relative position. For example, continuing with the discourse input of "Open the door," a determination is made that when the discourse input was received, the user was closer to the garage door (e.g., node **926**) than the back door (e.g., node **928**). The relative position of the user is determined based on location data (e.g., GPS data, etc.) from the user device or data from various sensors (e.g., proximity sensors, image sensors, infrared sensors, motion sensors, etc.) disposed in and around the established location. For example, a motion sensor in front of the garage door is triggered and thus it is determined based on data obtained from the motion sensor that that the user is outside of the house on the driveway in front of the garage door. Because the user is closer to the garage door than the back door, it is determined that the first candidate user intent is more likely than the second candidate user intent. As a result, the user intent is determined to be activating the garage door motor to lift open the garage door.

In other examples, the user intent is disambiguated based on the operating states of the candidate devices. In particular, the operating state of each of the one or more candidate devices is obtained. In some examples, the operating state is obtained from the data structure. In some examples, the devices of the established location transmit their operating states (e.g., periodically or when a change in operating state occurs) to the user device and the operating states is updated in the data structure. Referring back to the example where the discourse input is "Open the door," the operating states of the garage door (e.g., node **926**) and the back door (e.g., node **928**) are obtained from the data structure. The operating states indicate, for example, that the garage door is already open but the back door is locked. Because the garage door is already open, it is determined that the second candidate user intent of unlocking the back door entrance at the garage is more likely than the first candidate user intent of activating the garage door motor to lift open the garage door. Thus, based on the obtained operating states of the garage door and the back door, the user intent is determined to be unlocking the back door entrance at the garage.

In yet other examples, the user intent is disambiguated based on the salience of each action associated with the respective candidate user intent. For example, a first salience associated with opening the garage door and a second salience associated with unlocking the back door is determined. In the present example, the first salience is greater than the second salience because fewer users may request the back door to be unlocked than request the garage door to be opened. Also, the garage door is considered a more prominent feature of the garage than the back door. The candidate user intents are then ranked. In particular, based on the first salience being greater than the second salience, the first candidate user intent of activating the garage door motor to lift open the garage door is ranked higher than and the second candidate user intent of unlocking the back door entrance at the garage. As a result of the higher ranked first candidate user intent, the user intent is determined to be activating the garage door motor to lift open the garage door.

In some examples, the user intent is disambiguated based on additional information from the user. For example, dialogue (e.g., speech or text) is outputted on the user device. The dialogue requests clarification from the user regarding the user intent. For example, the dialogue asks the user whether the user wishes to "open the garage door" or "unlock the back door entrance." User input that is responsive to the output dialogue is received. For example, the user input is a selection of the user intent of "open the garage door" received via a user interface of the user device. Based on the user input, the user intent is disambiguated between the first and second candidate user intents. Specifically, consistent with the user's selection, the user intent is determined to be activating the garage door motor to lift open the garage door. It should be appreciated that disambiguating based on additional information from the user is disruptive to the user and can, in some cases, negatively impact user experience. Therefore, in some examples, prompting the user for additional information to disambiguate the user intent is performed as a last resort only when the user intent cannot be disambiguated based on other available sources of information (e.g., contextual information, operating state of the candidate device, salience of the action, position of the user, etc.). For example, a determination is made as to whether the two or more candidate user intents are disambiguated based on information accessible to the user device. Dialogue requesting for additional information is outputted only in response to determining that the two or more candidate user intents cannot be disambiguated based on information accessible to the user device.

At block **814**, instructions that cause a device of the one or more candidate devices to perform an action corresponding to the user intent are provided. In particular, for the example discourse input of "Set the thermostat to sixty percent," the provided instructions cause the "central thermostat" (e.g., node **930**) to change its humidity setpoint to sixty percent. For the other example discourse input of "Open the door," the provided instructions cause the garage door motor to lift open the garage door. In some examples, the instructions are transmitted directly to the respective device (e.g., the thermostat or the garage door motor) to cause the device to perform the relevant action. In other examples, the instructions are transmitted to the user device and the instructions cause the user device to transmit a command to the respective device to perform the relevant action.

In some examples, the instructions are provided in response to receiving a user confirmation. In particular, prior to providing the instructions, dialogue (e.g., speech or text) confirming the action to be performed and the device performing the action is outputted. For example, the dialogue asks the user "Would you like to set the humidity of the living room thermostat to sixty percent?" or "Open the garage door?" A user input that is responsive to the output dialogue is received. The user input confirms or rejects the output dialogue. In one example, the user input is the speech input "yes." In response to receiving user input confirming the output dialogue, the instructions are provided. Conversely, in response to receiving user input rejecting the output dialogue, process **800** forgoes providing the instructions.

In some examples, the user programs the user device to recognize a custom command that causes the operating states of a plurality of devices in the established location to be set in a predetermined manner. Such a set of predetermined operating states for the plurality of devices is referred to as a scene. For example, the user creates the custom scene command "party time" where in response to receiving this custom command, instructions are provided that cause the living room music player to turn on, the living room lights to dim to a brightness of 15%, and the living room disco ball to turn on. These predefined operating states of the living room music player, the living room lights, and the living room disco ball are stored in association with the custom scene command "party time."

In some examples, the digital assistant detects, in associated with an event, one or more user inputs for setting the operating states of a plurality of devices and then prompts the user to create a corresponding custom scene command. For example, the one or more user inputs are provided by the user to, for example, turn on the kitchen and living room lights, set the thermostat to 75 degrees, and turn on the living room television. In some examples, the one or more user inputs are detected by detecting one or more corresponding changes in the operating states of the devices. In addition, the one or more user inputs are associated with the event of the user arriving home. For example, the one or more user inputs are detected within a predetermined duration after detecting one or more events related to the user arriving home. The one or more events include, for example, detecting a proximity sensor being activated in the garage or detecting the back door entrance being opened. In response to detecting the one or more user inputs in associated with the event, a prompt is provided. The prompt asks whether the user wishes to store the respective operating states of the plurality of devices in association with a custom scene command. For example, the prompt is "I noticed that upon arriving home, you turned on the kitchen and living room lights, set the thermostat to 75 degrees, and turned on the living room television. Would you like to create an "arrive home" scene with these device settings?" User input responsive to the prompt is received. For example, the user confirms or rejects the prompt to create a custom scene command associated with a set of operating states of a plurality of devices. In response to receiving a user input that confirms the prompt, the respective operating states of the plurality of devices are stored in association with the custom scene command such that in response to receiving the custom scene command, the user device causes the plurality of devices to be set to the respective operating states. Conversely, in response to receiving a user input that rejects the prompt, process **800** forgoes storing the respective operating states of the plurality of devices in association with the custom scene command.

In some examples, the digital assistant detects, in association with an existing scene, user input that causes an additional device in the set of devices to be set to a particular operating state and then prompt the user to modify the existing scene to include setting the additional device to the particular operating state. For example, the scene command "party time" is received from the user and in response to receiving the scene command, instruction are provided to cause the living room music player to turn on, the living room lights to dim to a brightness of 15%, and the living room disco ball to turn on. Then, within a predetermined duration of receiving the "party time" scene command, user input that causes the living room air conditioning to be set to 70 degrees is detected. For example, a change in the setpoint of the living room air conditioning to 70 degrees is detected. In response to detecting the user input, a prompt is provided to the user. The prompt asks whether the user wishes to store the operating state "70 degrees" of the living room air conditioning device in association with the custom scene command "party time." For example, the prompt asks "Do you wish to add setting the living room air conditioning to 70 degrees to the 'party time' scene?" User input that is responsive to the prompt is received. The user input confirms or rejects the prompt. In response to receiving user input confirming the prompt, the operating state "70 degrees" of the living room air conditioning device is stored in association with the custom "scene" command. After the storing, in response to receiving the custom scene command "party time," instructions are provided (e.g., by the user device or server) to cause the living room music player to turn on, the living room lights to dim to a brightness of 15%, the living room disco ball to turn on, and the living room air conditioning to be set to 70 degrees. Conversely, in response to receiving user input rejecting the prompt, process **800** forgoes storing the operating state "70 degrees" of the living room air conditioning device in association with the custom "scene" command.

FIG. **11** illustrates process **1100** for operating a digital assistant according to various examples. Process **1100** is performed, for example, using one or more electronic devices (e.g., devices **104**, **106**, **200**, **400**, or **600**) implementing a digital assistant. In some examples, the processes is performed at a client-server system (e.g., system **100**) implementing a digital assistant. The blocks of the processes can be divided up in any manner between the server (e.g., DA server **106**) and the client (e.g., user device **104**). In process **1100**, some blocks are, optionally, combined, the order of some blocks is, optionally, changed, and some blocks are, optionally, omitted. In some examples, only a subset of the features or blocks described below with reference to FIG. **11** is performed. Further, one of ordinary skill would appreciate that the details of process **800** described above are also applicable in an analogous manner to process **1100** described below. For example, process **1100** optionally includes one or more of the characteristics of process **800** described above (and vice versa). For brevity, these details are not repeated below

At block **1102**, discourse input representing a user request is received. Block **1102** is similar or identical to block **802** described above. For example, the discourse input is speech input or text input and is in natural language form. In some examples, the user request defines a request for a device of an established location (e.g., devices **130**, **132**, **134**, or **136**) to perform an action. Additionally, the user request defines a criterion that is required to be satisfied prior to performing the action. In some examples, the criterion is associated with a second device of the established location. For example, the discourse input is "Close the blinds when it reaches 80 degrees."

At block **1104**, a determination is made as to whether the discourse input relates to a device of an established location. Specifically, the determination includes determining whether the discourse input is requesting for a device of an established location to perform an action. Block **1104** is similar or identical to block **804**, described above. For example, a determination is made as to whether the discourse input corresponds to a domain that is associated with an actionable intent of performing a task using a device of the established location. The discourse input is determined to relate to a device of the established location if the discourse input is determined to correspond to such a domain. In response to determining that the discourse input relates to a device of an established location, block **1106** is performed. Conversely, in response to determining that the discourse input does not relate to a device of an established location, block **1105** is performed. In particular, at block **1105**, process **1100** forgoes retrieving a data structure representing a set of devices of the established location.

At block **1106**, a data structure representing a set of devices of the established location is retrieved. Block **1106** is similar or identical to block **806**, discussed above. In particular, the data structure is retrieved from the user device (e.g., user data and models **231** of user device **200**) or from the server (e.g., data & models **116** of DA server **106**). In some examples, the data structure defines a hierarchical relationship between a plurality of regions in the established location. The data structure further defines the relationship of each device of the set of devices with respect to the plurality of regions. The data structure is similar or identical to data structure **900** described with reference to FIG. **9**.

At block **1108**, a user intent corresponding to the discourse input is determined using the data structure retrieved at block **1106**. Block **1108** is performed using natural language processing (e.g., with natural language processing module **732**, vocabulary **744**, and user data **748**). The user intent is associated with an action to be performed by a device of the established location. Determining the user intent thus includes determining, based on the discourse input and the data structure, the action to be performed by the device (e.g., as described in block **812**). For example, it is determined from the discourse input of "Close the blinds when it reaches 80 degrees" and based on the data structure that the action to be performed by the device is actuating the blinds to cause the blinds to close.

Determining the action to be performed by the device includes determining one or more possible device characteristics corresponding to the discourse input (e.g., as described in block **808**). For example, based on the phrase "close the blinds" in the discourse input, the one or more possible device characteristics are determined to include "position." Determining the action to be performed by the device further includes determining, based on the data structure, one or more candidate devices of the established location (e.g., as described in block **810**) that correspond to the discourse input. For example, based on the phrase "close the blinds" in the discourse input, the one or more candidate devices are determined to include one or more "blinds" represented in the data structure that have an operating status of "open." The device performing the action is then determined from the one or more candidate devices. For example, the device is determined from the one or more candidate devices based on one or more overlapping device characteristics that are common between the one or more possible device characteristics and one or more actual device characteristics of the one or more candidate devices (e.g., as described in block **812**). In examples where disambiguation is required between multiple actions or devices, additional information (e.g., context information, operating state of the candidate devices, salience of the actions, position of the user, etc.) is retrieved. As discussed above in block **812**, the additional information is used to disambiguate between the multiple actions or devices and determine an intended action to be performed by a device of the established location.

The action to be performed by the device of the established location includes causing at least a portion of the device to change positions. In particular, the action includes actuating the device to cause at least a portion of the device to change positions. For example, based on the discourse input of "Close the blinds when it reaches 80 degrees," the action is determined to include actuating the blinds to cause the blinds to change from an open position to a closed position. Similarly, for the discourse input "Close the garage door after I enter the house," the action is determined to include activating the garage motor to cause the garage door to change from an open position to a closed position.

In some examples, the action to be performed by the device causes a device to lock or unlock. For example, based on the discourse input of "Open the gate when the gardener arrives," the action is determined to include unlocking the side gate of the established location. Other example discourse inputs that correspond to an action that causes a device of the established location to lock or unlock include "Lock the safe when I leave the house" or "Lock all the doors and windows when I go to bed."

In some examples, the action to be performed by the device causes the device to be activated or deactivated. For example, based on the discourse input of "Turn on the alarm when I leave the house," the action is determined to include activating the house alarm. Other exemplary actions that cause the device to activate or deactivate include turning the power of a device on or off, placing a device in an "active" mode or a "sleep," or causing a device to "arm" or "disarm."

In some examples, the action to be performed by the device causes a setpoint of the device to change. For example, based on the discourse input of "Set the thermostat to 76 when I get home," the action is determined to include causing the temperature setpoint of the thermostat to change. Other exemplary actions that cause a setpoint of the device to change include setting the humidity of a humidifier or setting the temperature of an oven. In yet other examples, the action to be performed by the device causes a parameter value of the device to change. For example, the action causes the volume level of a music player to change to a particular value (e.g., 1-10), the fan speed of a fan to change to a particular setting (e.g., high, medium, low), the sprinkler duration of a sprinkler station to change to a particular duration, or a window to open by a certain percentage. In some examples, the action is defined in the discourse input using relative or ambiguous terms. For example, in the discourse input "Make the television louder when the train goes by," the term "louder" is a relative term that is ambiguous. Process **1100** can determine a definite action corresponding to such a discourse input having relative or ambiguous terms. Specifically, in the present example, process **1100** can determine that the action includes causing the volume level of the television to increase by a predetermined amount relative to the current volume level or relative to a detected ambient noise level.

In some examples, the user intent is associated with a criterion to be satisfied prior to performing the action. In these examples, determining the user intent further includes determining, based on the discourse input and the data structure, the criterion to be satisfied prior to performing the action. For example, returning to the discourse input of "Close the blinds when it reaches 80 degrees," it is determined based on the discourse input and the data structure that the criterion to be satisfied prior to closing the blinds is the detecting of a temperature value being equal to or greater than 80 degrees Fahrenheit at a particular temperature sensor in the established location.

The criterion is associated with a device characteristic of a second device of the established location. For example, the criterion of the discourse input "Close the blinds when it reaches 80 degrees," is associated with the device characteristic "temperature" of the temperature sensor in the established location. Determining the user intent includes determining, based on the discourse input and data structure, the device characteristic of the second device associated with the criterion. The second device is determined in a similar manner as discussed above in blocks **808-812**. In particular, one or more second possible device characteristics and one or more second candidate devices are determined from the portion of the discourse input defining the criterion. The second device is then determined based on one or more second overlapping device characteristics that are common between the one or more second possible device characteristics and one or more actual device characteristics of the one or more candidate devices (e.g., as described in block **812**). Further, in some examples, the relationship of the second device with respect to the device performing the action is considered when determining the second device. For example, if there are two thermostats that cannot be disambiguated based on the data structure, the second device is determined to be the thermostat that is positioned closer to the blinds or associated with the same region as the blinds.

In some examples, the criterion is associated with an operating state of the second device. In particular, the criterion includes the requirement that the operating state of the second device be equal to a reference operating state. For example, the discourse input is "Set the thermostat to 72 degrees when the garage door is open." In this example, the criterion is detecting the garage door having the operating status of "open." More specifically, the criterion includes the requirement that the operating state of the second device transitions from a second reference operating state to a third reference operating state. For example, the criterion includes detecting the operating state of the garage door transitioning from a "closed" operating state to an "open" operating state. In another example where the discourse input is "Turn on the living room lights when the television is turned on," the criterion includes detecting the operating state of the television transitioning from an "off" operating state to an "on" operating state.

In some examples, the criterion includes the requirement that an actual value representing the device characteristic be greater than, equal to, or less than a threshold value. For example, the discourse input is "Close the window when the temperature drops below 68 degrees." In this example, the criterion is associated with the device characteristic of "temperature" for a temperature sensor of the established location. Specifically, the criterion includes detecting that the actual value (e.g., the temperature reading) representing the device characteristic "temperature" of an electronic thermometer is less than the threshold value of 68 degrees.

In some examples, the criterion is defined in the discourse input using one or more relative or ambiguous terms. Examples of discourse input that define the criterion using one or more relative or ambiguous terms include "Close the blinds when it's sunny outside," "turn on the heater when it's cold," "turn up the volume of the television when it gets noisy." Specifically, in these examples, the criterion is defined in the discourse input using relative or ambiguous terms, such as "sunny," "cold," and "noisy." As discussed in greater detail below, process **1100** can determine a definite criterion from the discourse input despite the use of relative or ambiguous terms in the discourse input to define the criterion.

In some examples, determining the user intent includes determining, based on the discourse input, the threshold value associated with the criterion. In particular, the threshold value is ambiguous in the discourse input and thus a quantitative threshold value may need to be interpreted from the discourse input. For example, the discourse input is "Turn on the kitchen fan when it gets too hot." In this example, based on the words "when it gets too hot," the criterion is determined to be detecting the temperature of an electronic thermometer exceeding a threshold value. The threshold value is determined based on the phrase "too hot" and one or more knowledge sources. Specifically, information from the one or more knowledge sources is retrieved in accordance with the phrase "too hot." The knowledge sources can, for example, provide the historical temperature distribution of the established location and thus the threshold value is determined to be a predetermined percentile (e.g., 80^{th} percentile or 90^{th} percentile) of the temperature distribution. In another example, the knowledge source associates the term "hot" to a numeric threshold value of a corresponding device characteristic. For example, "hot" is associated with greater than 90 degrees measured at an electronic thermometer of the established location. Similarly, for other example discourse inputs where a criterion is defined based on an ambiguous adjective, the knowledge sources provide a corresponding threshold value for the respective device characteristic. For example, based on the knowledge sources, the criterion "when it's dark" is associated with less than 0.2 lux and the criterion "when it's noisy" is associated with greater than 90 decibels.

It should be recognized that the criterion can be associated with any device characteristic of any sensor of the established location. The sensor, for example, is a standalone sensor of the established location (e.g., standalone electronic thermometer, standalone light sensor, standalone motion sensor, etc.) or a sensor integrated in a device of the established location (e.g., thermometer of the thermostat for the central heater, photodiode of the nightlight, etc.) For example, the criterion is associated with the device characteristic of "humidity" for a humidity sensor of the established location. In particular, the discourse input is "Close the bathroom window when it starts raining," or "Turn on the humidifier when it gets too dry." As discussed above, corresponding quantitative values for the ambiguous criterion "too dry" or "starts raining" are determined based on the one or more knowledge sources. For example, "too dry" is determined to correspond to the criterion of detecting a relative humidity of less than a predetermined threshold value (e.g., 25%). Similarly, "starts raining" is determined to correspond to the criterion of detecting a relative humidity equal to 100% at a humidity sensor or detecting moisture content greater than a predetermined threshold value (e.g., 50%) at a moisture sensor of the established location.

In some examples, the criterion is associated with the device characteristic of "brightness" for a brightness sensor (e.g., light sensor, photodiode) of the established location. In particular, the discourse input is "Turn on the living room lights once it gets dark," "Close the blinds if there's direct sunlight," or "Bring down the shades half way when it gets too bright." In these examples, corresponding quantitative values for the ambiguous criteria "dark," "direct sunlight," or "too bright" are determined. For example, "dark" is determined to correspond to the criterion of detecting a brightness of less than a predetermined value (e.g., 0.2 lux) at a brightness sensor of the established location. Similarly, "direct sunlight" or "too bright" corresponds to the criterion of detecting a brightness of greater than a second predetermined value (e.g., 25000 lux).

In some examples, the criterion is associated with the device characteristic of "air quality" for an air quality sensor of the established location. The air quality sensor can, for example, be a particulate sensor that measures the size and concentration of particles in the air or a gas sensor for measuring the concentration of one or more specific gases (e.g., carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, acetone, alcohols, etc.). Exemplary discourse inputs having criteria associated with the device characteristic of "air quality" for an air quality sensor of the established location include "Turn on the air filter when the air quality is unsafe" or "Close the window when dangerous gases are detected." In these examples, the criterion is detecting (e.g., at an air quality sensor of the established location) a particulate level or a concentration level of a specific gas in the air that exceeds a predetermined threshold value.

In some examples, the criterion is associated with an authentication characteristic of an authentication device at the established location. The authentication characteristic is for example, a voiceprint, passcode, fingerprint, personal identification number, or the like. The authentication device is a device configured to obtain or receive authentication data (e.g., camera, capacitive touch sensor, microphone, keypad, security console, etc.). For example, the discourse input is "Open the door when the baby sitter arrives," or "Unlock the door when John arrives." In these examples, the criterion includes a requirement that a confidence value associated with the authentication characteristic of the authentication device be greater than or equal to a predetermined threshold value. For example, the baby sitter or John interacts with an authentication device at the front door of the established location to provide authentication data (e.g., voice sample, fingerprint, passcode, facial image, etc.). The authentication data is processed and compared with reference authentication data (e.g., reference voiceprint, reference fingerprint, reference passcode, etc.) to determine a confidence value. Specifically, the confidence value represents a probability that authentication data received from the authentication device matches reference authentication data. In these examples, the criterion for opening or unlocking the door is obtaining a confidence value that is greater than or equal to a predetermined threshold value.

In some examples, the criterion is determined using retrieved context information. In particular, the discourse input defines the criterion using one or more relative or ambiguous terms and determining the criterion requires, for example, utilizing context information to disambiguate the one or more relative or ambiguous terms. For instance, in one example, the discourse input is "Open the door when she arrives." In this example, the discourse input defines the criterion for opening the door using the ambiguous term "she." Determining the criterion thus requires disambiguating the term "she" using, for example, context information. In one example, prior to receiving the discourse input, a text message is received from the babysitter stating that she will be arriving in 15 minutes. Specifically, while the electronic device is displaying the text message from the babysitter, the discourse input "Open the front door when she arrives" is received from the user. In this example, the text message from the babysitter is context information that can be used to disambiguate the term "she" in the discourse input. In particular, based on the text message, a determination is made that "she" refers to the babysitter. Thus, in this example, based on the discourse input and the text message, the criterion is determined to include receiving authentication data corresponding to the babysitter at an authentication device associated with the front door of the user's house.

In some examples, the criterion includes the requirement that the action was performed less than a predetermined number of times within a predetermined period of time. For example, the discourse input is "Allow Owen access to the TV three times a week." In this example, the criterion requires the determination that access to the TV was provided less than three times to an individual identified as Owen within the current week. In another example, the discourse input is "Allow the babysitter in once a day from 3-4 pm." In this example, the criterion includes the determination that the front door was unlocked for less than one time from 3-4 pm that day for an individual identified as the baby sitter. It should be recognized that in these examples, the criterion further includes confirming the identity of the individual (e.g., "Owen" and "baby sitter"). In particular, the identity of the individual (e.g., Owen or the baby sitter) is confirmed based on authentication data received from the individual. For example, it is determined that authentication data received from an individual at the front door between 3-4 pm corresponds to the baby sitter. The front door is then unlocked if it is determined that the front door was unlocked for less than one time from 3-4 pm that day for the baby sitter.

In some examples, the criterion includes the requirement that a time indicated on the electronic device be equal to or after a reference time or within a range of reference times. The reference time is with respect to hours and minutes or with respect to a particular date. In some examples, the reference time is an absolute time. For example, the discourse input is "Turn on the porch light at 7 pm." In this example, the criterion includes detecting that the current time is equal to 7 pm. In another example, the discourse input is "Close the garage door after 7 pm." In this example, the criterion is detecting that the current time is after 7 pm. In yet another example, the discourse input is "Turn on the night light from 10 pm to 7 am." In this example, the criterion is detecting that the current time is within the range of times 10 pm to 7 am.

In some examples, determining the user intent includes determining the reference time from the discourse input. In particular, for the discourse input "Turn on the Christmas lighting on Christmas Eve," a database search is performed to determine that "Christmas Eve" refers to December 24th. Further, a determination is made that the action of turning on the lights is one that is typically performed in the evening. Based on this determination, it is determined that the reference time is at dusk (e.g., 5 pm) on December 24th. In other examples, the discourse input is "Disable the sprinklers on Chinese New Year" or "Turn off the porch light during the next full moon." In these examples, the relevant date corresponding to "Chinese New Year" and "next full moon" is obtained and thus the reference time is determined based on the relevant date.

In some examples, the discourse input specifies a relative time rather than an absolute time. For example, the discourse input is "Turn on the Christmas lights two weeks before Christmas." In this example, process **1100** first determines an initial reference time corresponding to "Christmas" (December 25th) and then determine a duration associated with the initial reference time in the discourse input (e.g., two weeks). The reference time associated with the criterion is thus determined based on the initial reference date and the duration. Specifically, the reference time is determined to be December 11th, which is two weeks before Christmas (December 25th). In this example, the determined criterion in the discourse input is thus detecting that the current time is equal to the reference time of December 11^{th}.

In some examples, the user intent is associated with more than one criterion to be satisfied prior to performing the action. For example, the discourse input "Allow John to turn on the television once a day between 3 to 5 pm" includes three criteria: an authentication criterion of successfully authenticating that the requestor is "John," a time criterion of being within the time range of 3 to 5 pm, and a frequency criterion of having turned on the television for John less than once within the time range of 3 to 5 pm that day. In another example, the discourse input "Let the house cleaner in between 9 to 10 am" includes multiple authentication criteria, which include detecting by a proximity sensor a person standing at the front door, successfully authenticating the person based on authentication data received at an authentication device by the front door, and receiving a text message from a device associated with the house cleaner.

In some examples, the user intent is associated with a first criterion and a second criterion and satisfying the second criterion requires the first criterion to be satisfied. For example, the discourse input is "Turn on the sprinklers 15 minutes after I leave the house." In this example, the discourse input defines two criteria. The first criterion requires detecting the user leaving the house (e.g., using motion sensors and/or based on the garage door opening and closing). The second criterion requires the current time be equal to a reference time that is 15 minutes after the time when the user is detected to leave the house. In this example, the second criterion cannot be satisfied without the first criterion being satisfied since the second criterion is based on a reference time that is relative to the first criterion being satisfied.

Although the examples described above are mainly directed to actions performed by devices of an established location, it should be recognized that, in some examples, the user intent is associated with an action performed by a device separate from the set of devices of the established location. In particular, the device may not be represented in the data structure. For example, the user intent is associated with an action performed by the user device (e.g., user device **104**) or the server (e.g., DA server **106**). In one such example, the action includes causing a notification associated with the criterion to be provided. For example, based on the discourse input "Tell me when the front door is open," the determined user intent is associated with the criterion of detecting the front door being opened. The action to be performed by the user device upon determining that the criterion is satisfied includes causing a notification (e.g., text or speech) to be provided at the user device. The notification indicates that the front door has been opened. Other examples of discourse inputs corresponding to actions performed by the user device include "Text the baby sitter the entry passcode when she arrives," "Alert me when the home alarm is triggered," "Tell me when someone turns on the television," "Call the fire department when the smoke detector goes off." In these examples, the criterion is associated with a device of the established location, whereas the action is to be performed by the user device.

At block **1110**, the determined action and the determined device to perform the action are stored in association with the determined criterion. For example, instructions are stored based on the determined action, device, and criterion. In particular, the instructions cause the user device to continuously or periodically monitor data associated with the criterion to determine whether the criterion is satisfied. The data associated with the criterion is, for example, data of the user device, data from a sensor of the established location, or data indicating the operating state of a device at the established location. In some examples, the data associated with the criterion is actively retrieved by the device. In some examples, the device passively receives the data associated with the criterion and analyzes the data to determine whether the criterion is satisfied.

The stored instructions further cause the user device to perform a task in response to determining that the criterion is satisfied. For example, the instructions cause the user device to transmit a command that causes the action to be performed by the device. The action is thus performed by the device in accordance with a determination that the criterion is satisfied.

At block **1112**, data associated with the criterion is received. As discussed above, the data is received from a device of the established location. In particular, returning to the example discourse input "Close the blinds when it reaches 80 degrees," the received data is temperature data from the thermostat of the established location. The temperature data is periodically transmitted by the thermostat and received by the user device. In some examples, the user device actively retrieves the temperature data from the thermostat. In other examples, the data is data generated or obtained from the user device (e.g., time data, email data, messages data, location data, sensors data, etc.). In yet other examples, the data is retrieved from the data structure (e.g., operating state, such as on/off, locked/unlocked, open/close, etc.)

At block **1114**, a determination is made from the received data of block **1112** whether the criterion is satisfied. In particular, the received data is analyzed to determine whether the criterion is satisfied. For example, the received data indicates that the thermostat is detecting a temperature of 84 degrees. Based on the discourse input "Close the blinds when it reaches 80 degrees," the criterion is detecting a temperature of the thermostat that is equal to or greater than the reference temperature of 80 degrees. In this example, a determination is made from the received data that the criterion has been satisfied.

In response to determining that the criterion has been satisfied, block **1116** is performed. Conversely, in response to determining that the criterion is not satisfied, process **1100** returns to block **1112** where new or updated data associated with the criterion is received. Process **1100** thus forgoes performing block **1116** in response to determining that the criterion has not been satisfied.

At block **1116**, instructions that cause the device of the set of devices to perform the action are provided. Returning to the example discourse input "Close the blinds when it reaches 80 degrees," instructions are provided that cause the blinds to close. Block **1116** is similar or identical to block **814**, described above.

5. Electronic Devices

FIG. **12** shows a functional block diagram of electronic device **1200** configured in accordance with the principles of the various described examples. The functional blocks of the device can be optionally implemented by hardware, software, or a combination of hardware and software to carry out the principles of the various described examples. It is understood by persons of skill in the art that the functional blocks described in FIG. **12** can be optionally combined or separated into sub-blocks to implement the principles of the various described examples. Therefore, the description herein optionally supports any possible combination, separation, or further definition of the functional blocks described herein.

As shown in FIG. 12, electronic device **1200** includes touch screen display unit **1202** configured to display a graphical user interface and to receive input (e.g., text input) from the user, audio input unit **1204** configured to receive audio input (e.g., speech input) from the user, and communication unit **1206** configured to transmit and receive information. Electronic device **1200** further includes processing unit **1208** coupled to touch screen display unit **1202**, audio input unit **1204**, and communication unit **1206**. In some examples, processing unit **1208** includes receiving unit **1210**, determining unit **1212**, retrieving unit **1214**, providing unit **1216**, obtaining unit **1218**, modifying unit **1220**, outputting unit **1222**, detecting unit **1224**, and storing unit **1226**.

In accordance with some embodiments, processing unit **1208** is configured to receive (e.g., with receiving unit **1212** and via touch screen display unit **1202** or audio input unit) discourse input (e.g., discourse input of block **802**) representing a user request. Processing unit **1208** is further configured to determine (e.g., with determining unit **1212**) one or more possible device characteristics (e.g., possible device characteristics of block **808**) corresponding to the discourse input. Processing unit **1208** is further configured to retrieve (e.g., with retrieving unit **1214**) a data structure (e.g., data structure of block **806**) representing a set of devices of an established location. Processing unit **1208** is further configured to determine (e.g., with determining unit **1212**), based on the data structure, one or more candidate devices (e.g., candidate devices of block **810**) from the set of devices. The one or more candidate devices correspond to the discourse input. Processing unit **1208** is further configured to determine (e.g., with determining unit **1212**), based on the one or more possible device characteristics and one or more actual device characteristics of the one or more candidate devices, a user intent (e.g., user intent of block **812**) corresponding to the discourse input. Processing unit **1208** is further configured to provide (e.g., with providing unit **1216** and communication unit **1206**) instructions (e.g., instructions of block **814**) that cause a device of the one or more candidate devices to perform an action corresponding to the user intent.

In some examples, determining the user intent further comprises determining one or more candidate user intents (e.g., candidate user intents of block **812**) corresponding to the discourse input, and determining the user intent from the one or more candidate user intents based on the one or more possible device characteristics and the one or more actual device characteristics.

In some examples, determining the user intent further comprises determining the device (e.g., device of block **812**) from the one or more candidate devices based on the one or more possible device characteristics and the one or more actual device characteristics.

In some examples, processing unit **1208** is further configured to determine (e.g., with determining unit **1212**) one or more overlapping device characteristics (e.g., overlapping device characteristics of block **812**) that are common between one or more possible device characteristics and the one or more actual device characteristics. The user intent is determined based on the one or more overlapping device characteristics.

In some examples, processing unit **1208** is further configured to determine (e.g., with determining unit **1212**) a relative position of a user with respect to a region in the established location (e.g., block **812**). The discourse input is associated with the user and the user intent is determined based on the relative position.

In some examples, processing unit **1208** is further configured to obtain (e.g., with obtaining unit **1218**) an operating state of each of the one or more candidate devices (e.g., block **812**). The user intent is determined based on the operating state of each of the one or more candidate devices.

In some examples, determining the user intent further comprises determining, based on the one or more possible device characteristics and the one or more actual device characteristics, a first candidate user intent corresponding to the discourse input and a second candidate user intent corresponding to the discourse input, determining a first salience of a first action associated with the first candidate user intent and a second salience of a second action associated with the second candidate user intent, and ranking the first user intent and the second user intent based on the first salience and the second salience (e.g., block **812**). The user intent is determined based on the ranking.

In some examples, determining the user intent further comprises determining, based on the one or more possible device characteristics and the one or more actual device characteristics, two or more candidate user intents corresponding to the discourse input and determining whether the two or more candidate user intents can be disambiguated (e.g., block **812**). Determining the user intent further comprises, in response to determining that the two or more candidate user intents cannot be disambiguated, outputting dialogue that requests for additional information (e.g., block **812**). Determining the user intent further comprises receiving user input responsive to the output dialogue, and disambiguating the two or more candidate user intents based on the user input to determine the user intent (e.g., block **812**).

In some examples, determining the one or more possible device characteristics further comprises determining one or more second possible device characteristics corresponding to a first term in the discourse input, and determining one or more third possible device characteristics corresponding to a second term in the discourse input, wherein the one or more possible device characteristics is determined based on the one or more second possible device characteristics and the one or more third possible device characteristics (e.g., block **808**).

In some examples, processing unit **1208** is further configured to determine (e.g., with determining unit **1212**) whether the discourse input corresponds to a domain (e.g., block **804**), the domain associated with an actionable intent of performing a task based on a device of the established location. Retrieving the data structure representing the set of devices of the established location is performed in response to determining that the discourse input corresponds to the domain.

In some examples, processing unit **1208** is further configured to retrieve (e.g., with retrieving unit **1214**) contact information based on a term in the discourse input, wherein the one or more candidate devices of the set of devices is determined based on the retrieved contact information (e.g., block **810**).

In some examples, determining the one or more candidate devices of the set of devices further comprises determining one or more alternative terms associated with a second term in the discourse input, wherein the one or more candidate devices is determined based on the one or more alternative terms (e.g., block **810**).

In some examples, an alternative term of the one or more alternative terms is based on second user input received at the electronic device prior to receiving the discourse input (e.g., block **810**).

In some examples, processing unit **1208** is further configured to determine (e.g., with determining unit **1212**) a location corresponding to the discourse input. Processing unit **1208** is further configured to determine (e.g., with determining unit **1212**), based on the location, the established location from a plurality of established locations (e.g., block **806**).

In some examples, the data structure defines a hierarchical relationship between a plurality of regions in the established location, and a relationship between each device of the set of devices and the plurality of regions (e.g., block **806**).

In some examples, each device in the set of devices and each region in the plurality of regions are identified in the data structure with respect to a temporary session key associated with the received discourse input (e.g., block **806**).

In some examples, the data structure defines one or more actual device characteristics associated with each device in the set of devices (e.g., block **806**). In some examples, the data structure defines an operating state of each device in the set of devices (e.g., block **806**).

In some examples, processing unit **1208** is further configured to receive (e.g., with receiving unit **1210**) a first attribute of a first device in the established location and a second attribute of a second device in the established location. Processing unit **1208** is further configured to determine (e.g., with determining unit **1212**), based on the first attribute and the second attribute, a relationship between the first device and the second device with respect to the established location. Processing unit **1208** is further configured to provide (e.g., with providing unit **1216**) a prompt to modify the data structure based on the determined relationship. Processing unit **1208** is further configured to receive (e.g., with receiving unit **1210** and via touch screen display unit **1202** or audio input unit **1204**) a third user input responsive to the prompt. Processing unit **1208** is further configured to, in response to receiving the third user input, modify (e.g., with modifying unit **1220**) the data structure to define the determined relationship between the first device and the second device with respect to the established location (e.g., block **806**).

In some examples, the discourse input is in natural language form, and the discourse input is ambiguous with respect to defining the action (e.g., block **802**). In some examples, the discourse input is in natural language form, and the discourse input is ambiguous with respect to defining the device for performing the action (e.g., block **802**).

In some examples, processing unit **1208** is further configured to, prior to providing the instructions, output (e.g., outputting unit **1222**) second dialogue confirming the action to be performed and the device performing the action (e.g., block **814**). Processing unit **1208** is further configured to, prior to providing the instructions, receive (e.g., with receiving unit **1210** and via touch screen display unit **1202** or audio input unit **1204**) a fourth user input responsive to the second output dialogue (e.g., block **814**). The instructions are provide in response to receiving the fourth user input.

In some examples, processing unit **1208** is further configured to detect (e.g., with detecting unit **1224**), in association with an event, one or more user inputs that cause a plurality of devices in the set of devices to be set to respective operating states. Processing unit **1208** is further configured to, in response to detecting the one or more user inputs, provide (e.g., with providing unit **1216**) a second prompt to store the respective operating states of the plurality of devices in association with a custom command. Processing unit **1208** is further configured to, receive (e.g., with receiving unit **1210** and via touch screen display unit **1202** or audio input unit **1204**) a user input responsive to the second prompt. Processing unit **1208** is further configured to, in response to receiving the fifth user input, store (e.g., with storing unit) the respective operating states of the plurality of devices in association with the custom command, wherein in response to receiving the custom command, the electronic device causes the plurality of devices to be set to the respective operating states (e.g., block **814**).

In some examples, processing unit **1208** is further configured to detect (e.g., with detecting unit **1224**), in association with a second plurality of devices in the set of devices being set to second respective operating states, a sixth user input that causes a third device in the set of devices to be set to a third operating state, wherein the second respective operating states of the second plurality of devices are stored in association with a second custom command. Processing unit **1208** is further configured to, in response to detecting the sixth user input, provide (e.g., with providing unit **1216**) a third prompt to store the third operating state of the third device in association with the second custom command. Processing unit **1208** is further configured to receive (e.g., with receiving unit **1210** and via touch screen display unit **1202** or audio input unit **1204**) a seventh user input responsive to the third prompt. Processing unit **1208** is further configured to, in response to receiving the seventh user input, store storing the third operating state of the third device in association with the second custom command, wherein in response to receiving the second custom command after storing the third operating state of the third device in association with the second custom command, the electronic device causes the second plurality of devices to be set to the second respective operating states and the third device to be set to the third operating state (e.g., block **814**).

The operations described above with reference to FIG. **8** are optionally implemented by components depicted in FIGS. **1-4**, **6**A-B, **7**A, and **12**. For example, the operations of process **800** may be implemented by one or more of operating system **718**, applications module **724**, I/O processing module **728**, STT processing module **730**, natural language processing module **732**, task flow processing module **736**, service processing module **738**, or processor(s) **220**, **410**, **704**. It would be clear to a person having ordinary skill in the art how other processes are implemented based on the components depicted in FIGS. **1-4**, **6**A-B, and **7**A.

FIG. **13** shows a functional block diagram of electronic device **13200** configured in accordance with the principles of the various described examples. The functional blocks of the device can be optionally implemented by hardware, software, or a combination of hardware and software to carry out the principles of the various described examples. It is understood by persons of skill in the art that the functional blocks described in FIG. **13** can be optionally combined or separated into sub-blocks to implement the principles of the various described examples. Therefore, the description herein optionally supports any possible combination, separation, or further definition of the functional blocks described herein.

As shown in FIG. **13**, electronic device **1300** includes touch screen display unit **1302** configured to display a graphical user interface and to receive input (e.g., text input) from the user, audio input unit **1304** configured to receive audio input (e.g., speech input) from the user, and communication unit **1306** configured to transmit and receive information. Electronic device **1300** further includes processing unit **1308** coupled to touch screen display unit **1302**, audio input unit **1304**, and communication unit **1306**. In some examples, processing unit **1308** includes receiving unit **1310**, determining unit **1312**, retrieving unit **1314**, providing unit **1316**, and storing unit **1318**.

In accordance with some embodiments, processing unit **1308** is configured to receive (e.g., with receiving unit **1310** and via touch screen display unit **1302** or audio input unit **1304**) discourse input (e.g., discourse input of block **1102**) representing a user request. Processing unit **1708** is further configured to determine (e.g., with determining unit **1312**) whether the discourse input relates to a device of an established location (e.g., block **1104**). Processing unit **1308** is further configured to, in response to determining that the discourse input relates to a device of an established location, retrieve (e.g., with retrieving **1314**) a data structure (e.g., data structure of block **1106**) representing a set of devices of the established location. Processing unit **1308** is further configured to determine (e.g., with determining unit **1312**), using the data structure, a user intent (e.g., user intent of block **1108**) corresponding to the discourse input. The user intent is associated with an action to be performed by a device of the set of devices and a criterion to be satisfied prior to performing the action. Processing unit **1308** is further configured to store (e.g., with storing unit **1318**) the action and the device in association with the criterion, wherein the action is performed by the device in accordance with a determination that the criterion is satisfied (e.g., block **1110**).

In some examples, the criterion is associated with an actual device characteristic of a second device of the set of devices (e.g., block **1108**).

In some examples, determining the user intent further comprises 1) determining, based on the discourse input and data structure, the actual device characteristic of the second device (e.g., block **1108**), and 2) determining, based on the data structure and the discourse input, the second device from the set of devices (e.g., block **1108**).

In some examples, the criterion comprises a requirement that an actual value representing the actual device characteristic is greater than, equal to, or less than a threshold value (e.g., threshold value of block **1108**).

In some examples, determining the user intent further comprises determining, based on the discourse input, the threshold value (e.g., block **1108**).

In some examples, the actual device characteristic is humidity, and the second device includes a humidity sensor (e.g., block **1108**). In some examples, the actual device characteristic is temperature, and the second device includes a temperature sensor (e.g., block **1108**). In some examples, the actual device characteristic is brightness, and the second device includes a brightness sensor (e.g., block **1108**). In some examples, the actual device characteristic is air quality, and wherein the second device includes an air quality sensor (e.g., block **1108**). In some examples, the actual device characteristic is an authentication characteristic, and the second device includes an authentication device (e.g., block **1108**).

In some examples, the criterion comprises a requirement that a confidence value is greater than or equal to a threshold value (e.g., block **1108**). The confidence value represents a probability that authentication data received from the authentication device matches reference authentication data.

In some examples, the criterion is associated with an operating state of a third device of the set of devices (e.g., block **1108**). In some examples, the criterion comprises a requirement that the operating state of the third device is equal to a reference operating state (e.g., block **1108**). In some examples, the criterion comprises a requirement that the operating state of the third device transitions from a second reference operating state to a third reference operating state (e.g., block **1108**). In some examples, the criterion comprises a requirement that the action was performed less than a predetermined number of times within a predetermined period of time (e.g., block **1108**).

In some examples, the criterion comprises a requirement that a time of electronic device **1300** is equal to or greater than a reference time (e.g., block **1108**). In some examples, determining the user intent further comprises determining the reference time from the discourse input (e.g., block **1108**). In some examples, determining the reference time further comprises 1) determining a second reference time from the discourse input (e.g., block **1108**), and 2) determining a duration associated with the reference time, wherein the reference time is determined based on the second reference time and the duration (e.g., block **1108**).

In some examples, processing unit **1308** is further configured to receive (e.g., with receiving unit **1310** and via communication unit **1306**) data (e.g., data of block **1112**) associated with the criterion. Processing unit **1308** is further configured to determine (e.g., with determining unit **1312**) from the received data whether the criterion is satisfied (e.g., block **1114**). Processing unit **1308** is further configured to, in response to determining that the criterion is satisfied, provide (e.g., with providing unit **1316**) instructions (e.g., instructions of block **1116**) that cause the device of the set of devices to perform the action.

In some examples, the user intent is associated with a second criterion to be satisfied prior to performing the action (e.g., block **1108**). In some examples, satisfying the second criterion requires the criterion to be satisfied (e.g., block **1108**).

In some examples, processing unit **1308** is further configured to receive (e.g., with receiving unit **1310** and via communication unit **1306**) second data associated with the second criterion (e.g., block **1112**). Processing unit **1308** is further configured to determine (e.g., with determining unit **1312**) from the received second data whether the second criterion is satisfied (e.g., block **1114**), where the instructions are provided in response to determining that the second criterion is satisfied (e.g., block **1116**).

In some examples, the action includes providing a notification associated with the criterion (e.g., block **1108**). In some examples, performing the action by the device causes a portion of the device to change positions (e.g., block **1108**). In some examples, performing the action by the device causes a device to lock or unlock (e.g., block **1108**). In some examples, performing the action by the device causes the device to be activated or deactivated (e.g., block **1108**). In some examples, performing the action by the device causes a setpoint of the device to change (e.g., block **1108**).

In some examples, processing unit **1308** is further configured to, in response to determining that the criterion is satisfied, provide (e.g., with providing unit **1316**) a prompt to perform the action using the device (e.g., block **1116**). Processing unit **1308** is further configured to receive (e.g., with receiving unit **1310**) a user input responsive to the prompt (e.g., block **1116**). Processing unit **1308** is further configured to, in response to receiving the user input, provide (e.g., with providing unit **1316**) instructions that cause the device to perform the action (e.g., block **1116**).

The operations described above with reference to FIG. **11** are optionally implemented by components depicted in FIGS. **1-4**, **6**A-B, **7**A, and **13**. For example, the operations of process **1100** are implemented by one or more of operating system **718**, applications module **724**, I/O processing module **728**, STT processing module **730**, natural language processing module **732**, task flow processing module **736**, service processing module **738**, or processor(s) **220**, **410**, **704**. It would be clear to a person having ordinary skill in the art how other processes are implemented based on the components depicted in FIGS. **1-4**, **6**A-B, and **7**A.

In accordance with some implementations, a computer-readable storage medium (e.g., a non-transitory computer readable storage medium) is provided, the computer-readable storage medium storing one or more programs for execution by one or more processors of an electronic device, the one or more programs including instructions for performing any of the methods or processes described herein.

In accordance with some implementations, an electronic device (e.g., a portable electronic device) is provided that comprises means for performing any of the methods or processes described herein.

In accordance with some implementations, an electronic device (e.g., a portable electronic device) is provided that comprises a processing unit configured to perform any of the methods or processes described herein.

In accordance with some implementations, an electronic device (e.g., a portable electronic device) is provided that comprises one or more processors and memory storing one or more programs for execution by the one or more processors, the one or more programs including instructions for performing any of the methods or processes described herein.

The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the techniques and their practical applications. Others skilled in the art are thereby enabled to best utilize the techniques and various embodiments with various modifications as are suited to the particular use contemplated.

Although the disclosure and examples have been fully described with reference to the accompanying drawings, it is to be noted that various changes and modifications will become apparent to those skilled in the art. Such changes and modifications are to be understood as being included within the scope of the disclosure and examples as defined by the claims.

As described above, one aspect of the present technology is the gathering and use of data available from various sources to improve the delivery to users of invitational content or any other content that may be of interest to them. The present disclosure contemplates that in some instances, this gathered data may include personal information data that uniquely identifies or can be used to contact or locate a specific person. Such personal information data can include demographic data, location-based data, telephone numbers, email addresses, home addresses, device characteristics of personal devices, or any other identifying information.

The present disclosure recognizes that the use of such personal information data, in the present technology, can be used to the benefit of users. For example, the personal information data can be used to deliver targeted content that is of greater interest to the user. Accordingly, use of such personal information data enables calculated control of the delivered content. Further, other uses for personal information data that benefit the user are also contemplated by the present disclosure.

The present disclosure further contemplates that the entities responsible for the collection, analysis, disclosure, transfer, storage, or other use of such personal information data will comply with well-established privacy policies and/or privacy practices. In particular, such entities should implement and consistently use privacy policies and practices that are generally recognized as meeting or exceeding industry or governmental requirements for maintaining personal information data private and secure. For example, personal information from users should be collected for legitimate and reasonable uses of the entity and not shared or sold outside of those legitimate uses. Further, such collection should occur only after receiving the informed consent of the users. Additionally, such entities would take any needed steps for safeguarding and securing access to such personal information data and ensuring that others with access to the personal information data adhere to their privacy policies and procedures. Further, such entities can subject themselves to evaluation by third parties to certify their adherence to widely accepted privacy policies and practices.

Despite the foregoing, the present disclosure also contemplates embodiments in which users selectively block the use of, or access to, personal information data. That is, the present disclosure contemplates that hardware and/or software elements can be provided to prevent or block access to such personal information data. For example, in the case of advertisement delivery services, the present technology can be configured to allow users to select to "opt in" or "opt out" of participation in the collection of personal information data during registration for services. In another example, users can select not to provide location information for targeted content delivery services. In yet another example, users can select to not provide precise location information, but permit the transfer of location zone information.

Therefore, although the present disclosure broadly covers use of personal information data to implement one or more various disclosed embodiments, the present disclosure also contemplates that the various embodiments can also be implemented without the need for accessing such personal information data. That is, the various embodiments of the present technology are not rendered inoperable due to the lack of all or a portion of such personal information data. For example, content can be selected and delivered to users by inferring preferences based on non-personal information data or a bare minimum amount of personal information, such as the content being requested by the device associated with a user, other non-personal information available to the content delivery services, or publically available information.

What is claimed is:

1. A method for operating a digital assistant, the method comprising:

at an electronic device with a processor, and memory:

receiving an utterance representing a current user request;

determining a plurality of sets of possible device characteristics, each corresponding to a respective term in the utterance;

selecting a possible device characteristic from the plurality of sets of possible device characteristics based on a frequency of occurrence of the possible device characteristic in the plurality of sets of possible device characteristics;

retrieving a data structure representing a set of devices of an established location;

determining, based on the data structure, one or more candidate devices from the set of devices, the one or more candidate devices corresponding to the utterance;

determining an overlapping device characteristic that is common between the selected possible device characteristic and one or more actual device characteristics of the one or more candidate devices;

determining, based on the overlapping device characteristic, a user intent corresponding to the utterance; and

providing instructions that cause a device of the one or more candidate devices to perform an action corresponding to the user intent.

2. The method of claim **1**, wherein determining the user intent further comprises:

determining one or more candidate user intents corresponding to the utterance; and

determining the user intent from the one or more candidate user intents based on the overlapping device characteristic.

3. The method of claim **1**, wherein determining the user intent further comprises:

determining the device from the one or more candidate devices based on the overlapping device characteristic.

4. The method of claim **1**, further comprising:

determining a relative position of a user with respect to a region in the established location, wherein the utterance is associated with the user, and wherein the user intent is determined based on the relative position.

5. The method of claim **1**, further comprising:

obtaining an operating state of each of the one or more candidate devices, wherein the user intent is determined based on the operating state of each of the one or more candidate devices.

6. The method of claim **1**, wherein determining the user intent further comprises:

determining, based on the overlapping device characteristic, a first candidate user intent corresponding to the utterance and a second candidate user intent corresponding to the utterance;

determining a first salience of a first action associated with the first candidate user intent and a second salience of a second action associated with the second candidate user intent; and

ranking the first candidate user intent and the second candidate user intent based on the first salience and the second salience, wherein the user intent is determined based on the ranking.

7. The method of claim **1**, wherein determining the user intent further comprises:

determining, based on the overlapping device characteristic, two or more candidate user intents corresponding to the utterance;

determining whether the two or more candidate user intents can be disambiguated;

in response to determining that the two or more candidate user intents cannot be disambiguated, outputting dialogue that requests for additional information;

receiving user input responsive to the output dialogue; and

disambiguating the two or more candidate user intents based on the user input to determine the user intent.

8. The method of claim **1**, wherein determining the plurality of sets of possible device characteristics further comprises:

determining one or more second possible device characteristics corresponding to a first term in the utterance; and

determining one or more third possible device characteristics corresponding to a second term in the utterance, wherein the possible device characteristic is selected based on the one or more second possible device characteristics and the one or more third possible device characteristics.

9. The method of claim **1**, further comprising:

determining whether the utterance corresponds to a domain, the domain associated with an actionable intent of performing a task based on a device of the established location, wherein retrieving the data structure representing the set of devices of the established location is performed in response to determining that the utterance corresponds to the domain.

10. The method of claim **1**, further comprising:

retrieving contact information based on a term in the utterance, wherein the one or more candidate devices of the set of devices are determined based on the retrieved contact information.

11. The method of claim **1**, wherein determining the one or more candidate devices of the set of devices further comprises:

determining one or more alternative terms associated with a second term in the utterance, wherein the one or more candidate devices is determined based on the one or more alternative terms.

12. The method of claim **1**, further comprising:

determining a location corresponding to the utterance; and

determining, based on the location, the established location from a plurality of established locations.

13. The method of claim **1**, wherein the data structure defines:

a hierarchical relationship between a plurality of regions in the established location; and

a relationship between each device of the set of devices and the plurality of regions.

14. The method of claim **1**, wherein the data structure defines one or more actual device characteristics associated with each device in the set of devices.

15. The method of claim **1**, wherein the data structure defines an operating state of each device in the set of devices.

16. The method of claim **1**, further comprising:

receiving a first attribute of a first device in the established location and a second attribute of a second device in the established location;

determining, based on the first attribute and the second attribute, a relationship between the first device and the second device with respect to the established location;

providing a prompt to modify the data structure based on the determined relationship;

receiving a third user input responsive to the prompt; and

in response to receiving the third user input, modifying the data structure to define the determined relationship between the first device and the second device with respect to the established location.

17. The method of claim **1**, wherein the utterance is in natural language form, and wherein the utterance is ambiguous with respect to defining the action.

18. The method of claim **1**, wherein the utterance is in natural language form, and wherein the utterance is ambiguous with respect to defining the device for performing the action.

19. The method of claim 1, further comprising:
detecting, in association with an event, one or more user inputs that cause a plurality of devices in the set of devices to be set to respective operating states;
in response to detecting the one or more user inputs, providing a second prompt to store the respective operating states of the plurality of devices in association with a custom command;
receiving a fifth user input responsive to the second prompt; and
in response to receiving the fifth user input, storing the respective operating states of the plurality of devices in association with the custom command, wherein in response to receiving the custom command, the electronic device causes the plurality of devices to be set to the respective operating states.

20. The method of claim 1, further comprising:
detecting, in association with a second plurality of devices in the set of devices being set to second respective operating states, a sixth user input that causes a third device in the set of devices to be set to a third operating state, wherein the second respective operating states of the second plurality of devices are stored in association with a second custom command;
in response to detecting the sixth user input, providing a third prompt to store the third operating state of the third device in association with the second custom command;
receiving a seventh user input responsive to the third prompt; and
in response to receiving the seventh user input, storing the third operating state of the third device in association with the second custom command, wherein in response to receiving the second custom command after storing the third operating state of the third device in association with the second custom command, the electronic device causes the second plurality of devices to be set to the second respective operating states and the third device to be set to the third operating state.

21. An electronic device comprising:
one or more processors; and
memory storing one or more programs, the one or more programs including instructions which, when executed by the one or more processors, cause the one or more processors to:
receive an utterance representing a current user request;
determine a plurality of sets of possible device characteristics, each corresponding to a respective term in the utterance;
select a possible device characteristic from the plurality of sets of possible device characteristics based on a frequency of occurrence of the possible device characteristic in the plurality of sets of possible device characteristics;
retrieve a data structure representing a set of devices of an established location;
determine, based on the data structure, one or more candidate devices from the set of devices, the one or more candidate devices corresponding to the utterance;
determine an overlapping device characteristic that is common between the selected possible device characteristic and one or more actual device characteristics of the one or more candidate devices;
determine, based on the overlapping device characteristic, a user intent corresponding to the utterance; and
provide instructions that cause a device of the one or more candidate devices to perform an action corresponding to the user intent.

22. A non-transitory computer-readable storage medium storing one or more programs, the one or more programs comprising instructions which, when executed by one or more processors of an electronic device, cause the electronic device to:
receive an utterance representing a current user request;
determine a plurality of sets of possible device characteristics, each corresponding to a respective term in the utterance;
select a possible device characteristic from the plurality of sets of possible device characteristics based on a frequency of occurrence of the possible device characteristic in the plurality of sets of possible device characteristics;
retrieve a data structure representing a set of devices of an established location;
determine, based on the data structure, one or more candidate devices from the set of devices, the one or more candidate devices corresponding to the utterance;
determine an overlapping device characteristic that is common between the selected possible device characteristic and one or more actual device characteristics of the one or more candidate devices;
determine, based on the overlapping device characteristic, a user intent corresponding to the utterance; and
provide instructions that cause a device of the one or more candidate devices to perform an action corresponding to the user intent.

23. The device of claim 21, wherein determining the user intent further comprises:
determining the device from the one or more candidate devices based on the overlapping device characteristic.

24. The device of claim 21, wherein the data structure defines:
a hierarchical relationship between a plurality of regions in the established location; and
a relationship between each device of the set of devices and the plurality of regions.

25. The computer-readable storage medium of claim 22, wherein determining the user intent further comprises:
determining the device from the one or more candidate devices based on the overlapping device characteristic.

26. The computer-readable storage medium of claim 22, wherein the data structure defines:
a hierarchical relationship between a plurality of regions in the established location; and
a relationship between each device of the set of devices and the plurality of regions.

27. The device of claim 21, wherein the instructions further cause the one or more processors to:
determine a relative position of a user with respect to a region in the established location, wherein the utterance is associated with the user, and wherein the user intent is determined based on the relative position.

28. The device of claim 21, wherein determining the user intent further comprises:
determining, based on the overlapping device characteristic, a first candidate user intent corresponding to the utterance and a second candidate user intent corresponding to the utterance;
determining a first salience of a first action associated with the first candidate user intent and a second salience of a second action associated with the second candidate user intent; and

ranking the first candidate user intent and the second candidate user intent based on the first salience and the second salience, wherein the user intent is determined based on the ranking.

29. The device of claim **21**, wherein determining the user intent further comprises:

determining, based on the overlapping device characteristic, two or more candidate user intents corresponding to the utterance;

determining whether the two or more candidate user intents can be disambiguated;

in response to determining that the two or more candidate user intents cannot be disambiguated, outputting dialogue that requests for additional information;

receiving user input responsive to the output dialogue; and

disambiguating the two or more candidate user intents based on the user input to determine the user intent.

30. The device of claim **21**, wherein determining the plurality of sets of possible device characteristics further comprises:

determining one or more second possible device characteristics corresponding to a first term in the utterance; and

determining one or more third possible device characteristics corresponding to a second term in the utterance, wherein the possible device characteristic is selected based on the one or more second possible device characteristics and the one or more third possible device characteristics.

31. The device of claim **21**, wherein the instructions further cause the one or more processors to:

determine whether the utterance corresponds to a domain, the domain associated with an actionable intent of performing a task based on a device of the established location, wherein retrieving the data structure representing the set of devices of the established location is performed in response to determining that the utterance corresponds to the domain.

32. The device of claim **21**, wherein determining the one or more candidate devices of the set of devices further comprises:

determining one or more alternative terms associated with a second term in the utterance, wherein the one or more candidate devices is determined based on the one or more alternative terms.

33. The device of claim **21**, wherein the instructions further cause the one or more processors to:

determine a location corresponding to the utterance; and

determine, based on the location, the established location from a plurality of established locations.

34. The device of claim **21**, wherein the instructions further cause the one or more processors to:

receive a first attribute of a first device in the established location and a second attribute of a second device in the established location;

determine, based on the first attribute and the second attribute, a relationship between the first device and the second device with respect to the established location;

provide a prompt to modify the data structure based on the determined relationship;

receive a third user input responsive to the prompt; and

in response to receiving the third user input, modify the data structure to define the determined relationship between the first device and the second device with respect to the established location.

35. The device of claim **21**, wherein the instructions further cause the one or more processors to:

detect, in association with an event, one or more user inputs that cause a plurality of devices in the set of devices to be set to respective operating states;

in response to detecting the one or more user inputs, provide a second prompt to store the respective operating states of the plurality of devices in association with a custom command;

receive a fifth user input responsive to the second prompt; and

in response to receiving the fifth user input, store the respective operating states of the plurality of devices in association with the custom command, wherein in response to receiving the custom command, the electronic device causes the plurality of devices to be set to the respective operating states.

36. The device of claim **21**, wherein the instructions further cause the one or more processors to:

detect, in association with a second plurality of devices in the set of devices being set to second respective operating states, a sixth user input that causes a third device in the set of devices to be set to a third operating state, wherein the second respective operating states of the second plurality of devices are stored in association with a second custom command;

in response to detecting the sixth user input, provide a third prompt to store the third operating state of the third device in association with the second custom command;

receive a seventh user input responsive to the third prompt; and

in response to receiving the seventh user input, store the third operating state of the third device in association with the second custom command, wherein in response to receiving the second custom command after storing the third operating state of the third device in association with the second custom command, the electronic device causes the second plurality of devices to be set to the second respective operating states and the third device to be set to the third operating state.

37. The computer-readable storage medium of claim **22**, wherein the instructions further cause the electronic device to:

determine a relative position of a user with respect to a region in the established location, wherein the utterance is associated with the user, and wherein the user intent is determined based on the relative position.

38. The computer-readable storage medium of claim **22**, wherein determining the user intent further comprises:

determining, based on the overlapping device characteristic, a first candidate user intent corresponding to the utterance and a second candidate user intent corresponding to the utterance;

determining a first salience of a first action associated with the first candidate user intent and a second salience of a second action associated with the second candidate user intent; and

ranking the first candidate user intent and the second candidate user intent based on the first salience and the second salience, wherein the user intent is determined based on the ranking.

39. The computer-readable storage medium of claim **22**, wherein determining the user intent further comprises:

determining, based on the overlapping device characteristic, two or more candidate user intents corresponding to the utterance;

determining whether the two or more candidate user intents can be disambiguated;

in response to determining that the two or more candidate user intents cannot be disambiguated, outputting dialogue that requests for additional information;

receiving user input responsive to the output dialogue; and

disambiguating the two or more candidate user intents based on the user input to determine the user intent.

40. The computer-readable storage medium of claim **22**, wherein determining the plurality of sets of possible device characteristics further comprises:

determining one or more second possible device characteristics corresponding to a first term in the utterance; and

determining one or more third possible device characteristics corresponding to a second term in the utterance, wherein the possible device characteristic is selected based on the one or more second possible device characteristics and the one or more third possible device characteristics.

41. The computer-readable storage medium of claim **22**, wherein the instructions further cause the electronic device to:

determine whether the utterance corresponds to a domain, the domain associated with an actionable intent of performing a task based on a device of the established location, wherein retrieving the data structure representing the set of devices of the established location is performed in response to determining that the utterance corresponds to the domain.

42. The computer-readable storage medium of claim **22**, wherein determining the one or more candidate devices of the set of devices further comprises:

determining one or more alternative terms associated with a second term in the utterance, wherein the one or more candidate devices is determined based on the one or more alternative terms.

43. The computer-readable storage medium of claim **22**, wherein the instructions further cause the electronic device to:

determine a location corresponding to the utterance; and

determine, based on the location, the established location from a plurality of established locations.

44. The computer-readable storage medium of claim **22**, wherein the instructions further cause the electronic device to:

receive a first attribute of a first device in the established location and a second attribute of a second device in the established location;

determine, based on the first attribute and the second attribute, a relationship between the first device and the second device with respect to the established location;

provide a prompt to modify the data structure based on the determined relationship;

receive a third user input responsive to the prompt; and

in response to receiving the third user input, modify the data structure to define the determined relationship between the first device and the second device with respect to the established location.

45. The computer-readable storage medium of claim **22**, wherein the instructions further cause the electronic device to:

detect, in association with an event, one or more user inputs that cause a plurality of devices in the set of devices to be set to respective operating states;

in response to detecting the one or more user inputs, provide a second prompt to store the respective operating states of the plurality of devices in association with a custom command;

receive a fifth user input responsive to the second prompt; and

in response to receiving the fifth user input, store the respective operating states of the plurality of devices in association with the custom command, wherein in response to receiving the custom command, the electronic device causes the plurality of devices to be set to the respective operating states.

46. The computer-readable storage medium of claim **22**, wherein the instructions further cause the electronic device to:

detect, in association with a second plurality of devices in the set of devices being set to second respective operating states, a sixth user input that causes a third device in the set of devices to be set to a third operating state, wherein the second respective operating states of the second plurality of devices are stored in association with a second custom command;

in response to detecting the sixth user input, provide a third prompt to store the third operating state of the third device in association with the second custom command;

receive a seventh user input responsive to the third prompt; and

in response to receiving the seventh user input, store the third operating state of the third device in association with the second custom command, wherein in response to receiving the second custom command after storing the third operating state of the third device in association with the second custom command, the electronic device causes the second plurality of devices to be set to the second respective operating states and the third device to be set to the third operating state.

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