US 20170169013A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2017/0169013 A1**

Sarikaya et al. (43) **Pub. Date: Jun. 15, 2017**

(54) **PERSONALIZING NATURAL LANGUAGE UNDERSTANDING SYSTEMS**

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

(72) Inventors: **Ruhi Sarikaya**, Redmond, WA (US); **Xiaohu Liu**, Bellevue, WA (US)

(73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(21) Appl. No.: **14/966,031**

(22) Filed: **Dec. 11, 2015**

Publication Classification

(51) **Int. Cl.**

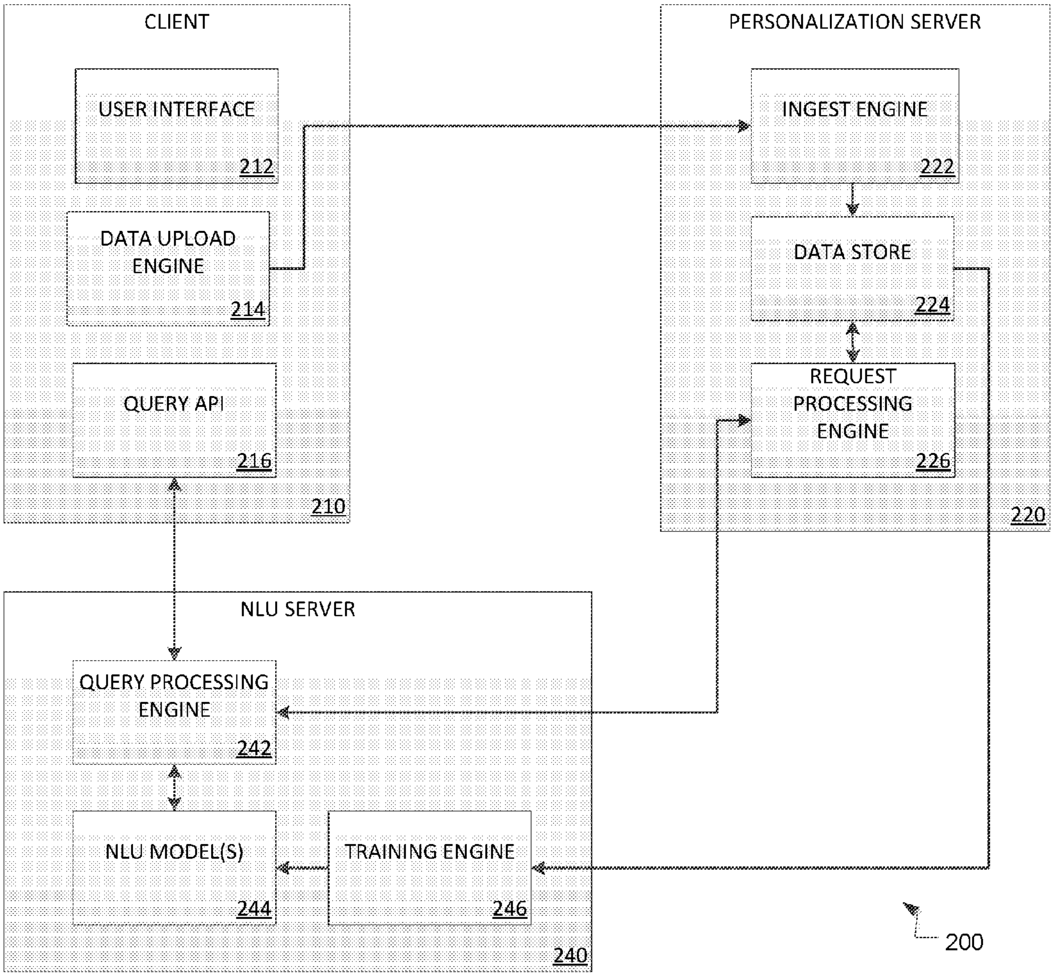
G06F 17/28	(2006.01)
G06N 99/00	(2006.01)
G06F 17/30	(2006.01)
G06F 17/27	(2006.01)
H04L 29/06	(2006.01)

(52) **U.S. Cl.**

CPC *G06F 17/28* (2013.01); *G06F 17/2705* (2013.01); *H04L 63/083* (2013.01); *G06F 17/30657* (2013.01); *G06N 99/005* (2013.01)

(57) **ABSTRACT**

Examples of the present disclosure describe systems and methods of personalizing natural language systems. In aspects, personal data may be uploaded to a personalization server. Upon receiving a data request, a server device may query the personalization server using a user's login information. The login data and the associated personal data may be paired and provided to the personalization server. The paired data may then be provided to a language understanding model to generate a response to the data request. The data in the response may be used to train the language understanding model.



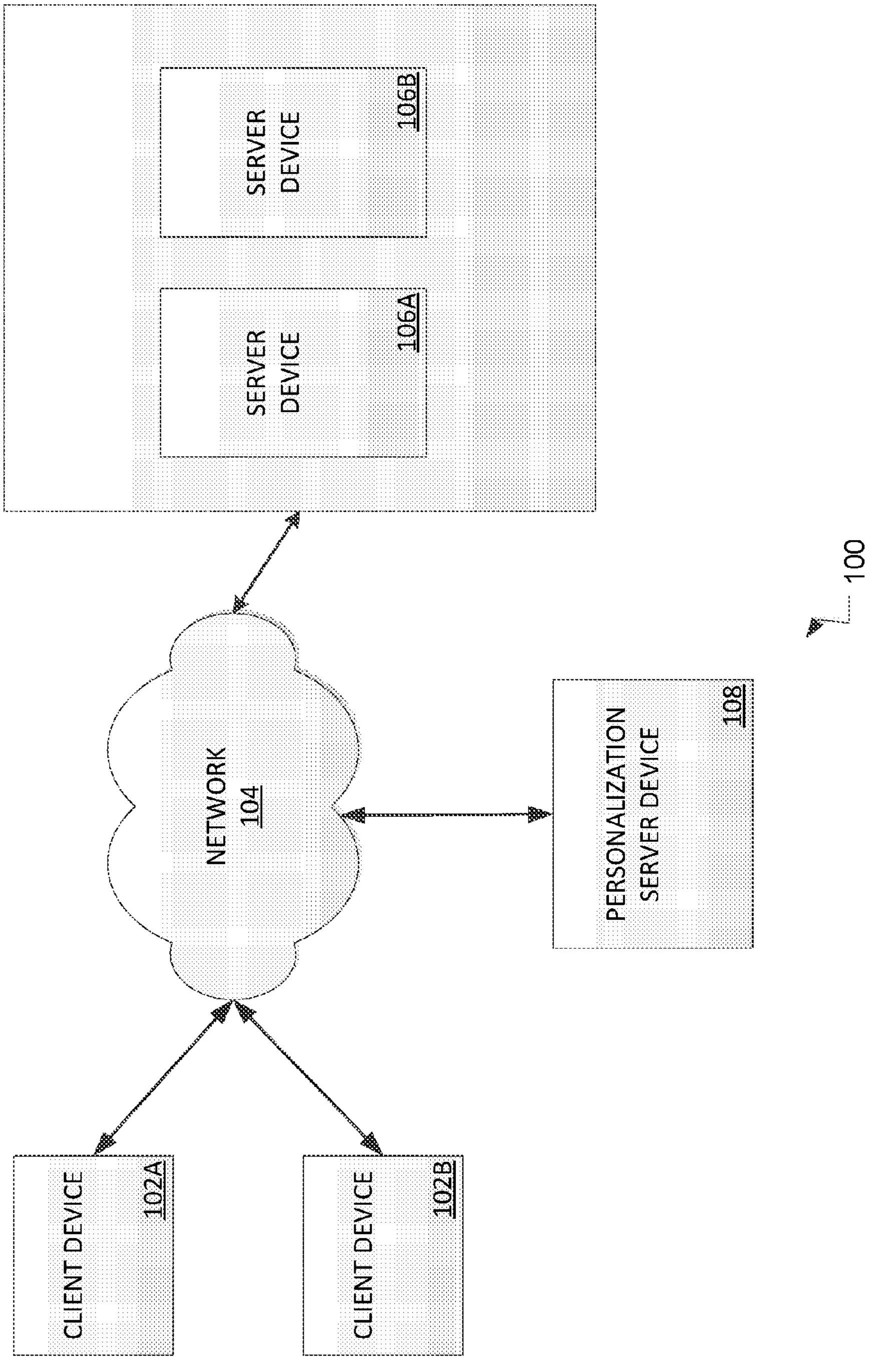

SERVER DEVICE
106B
SERVER DEVICE
106A
NETWORK
104
PERSONALIZATION SERVER DEVICE
108
100
CLIENT DEVICE
102A
CLIENT DEVICE
102B

FIG. 1

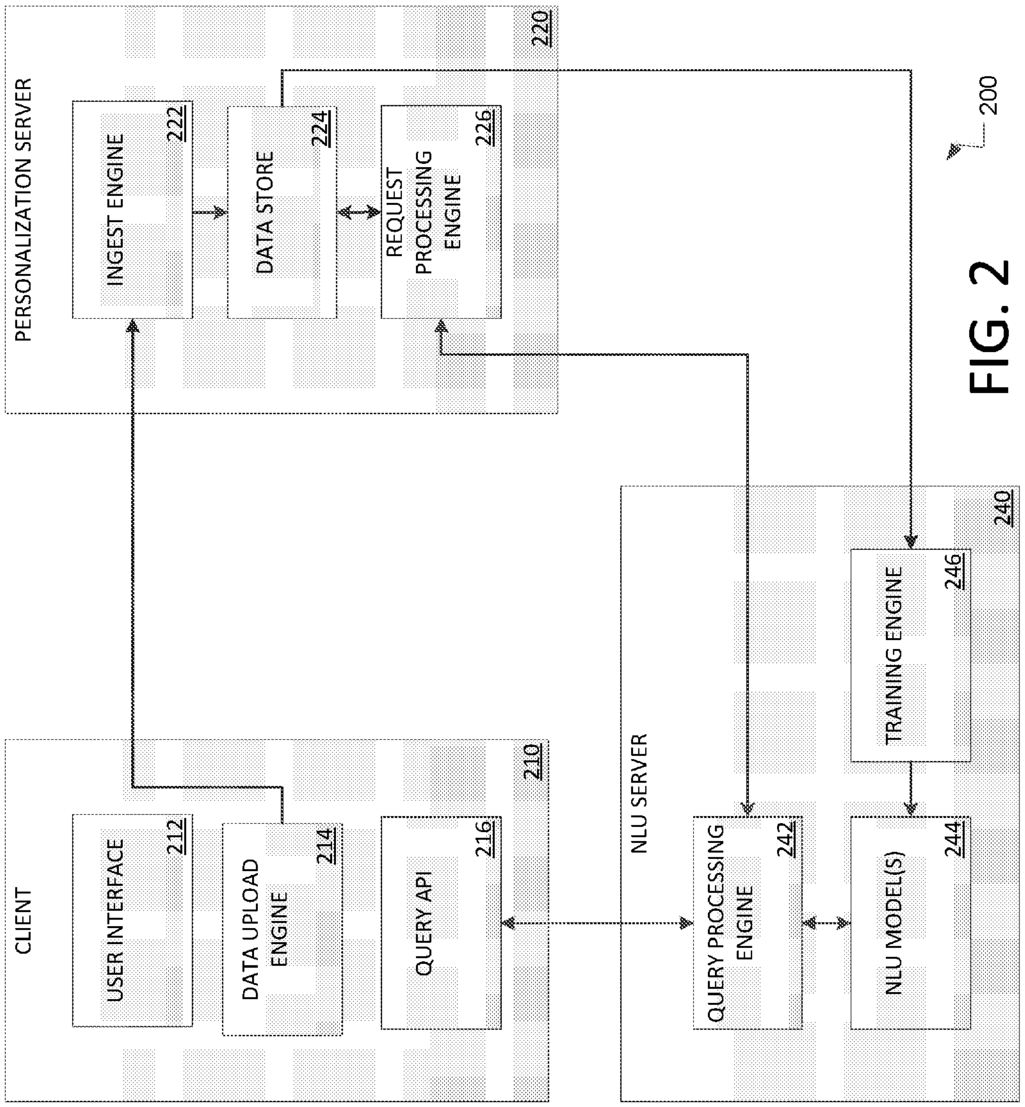

PERSONALIZATION SERVER
220
INGEST ENGINE
222
DATA STORE
224
REQUEST PROCESSING ENGINE
226
CLIENT
210
USER INTERFACE
212
DATA UPLOAD ENGINE
214
QUERY API
216
NLU SERVER
240
QUERY PROCESSING ENGINE
242
NLU MODEL(S)
244
TRAINING ENGINE
246
200

FIG. 2

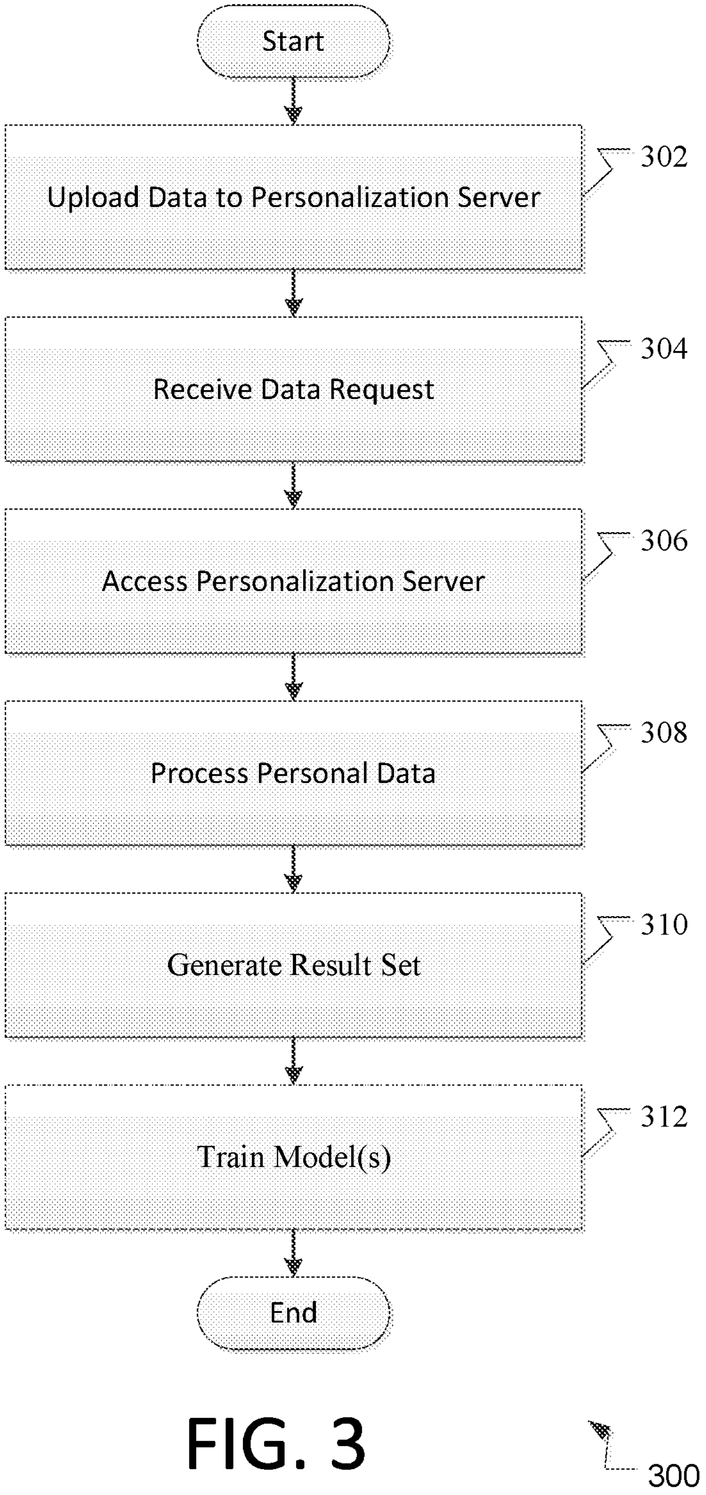

Start
Upload Data to Personalization Server
302
Receive Data Request
304
Access Personalization Server
306
Process Personal Data
308
Generate Result Set
310
Train Model(s)
312
End
300

FIG. 3

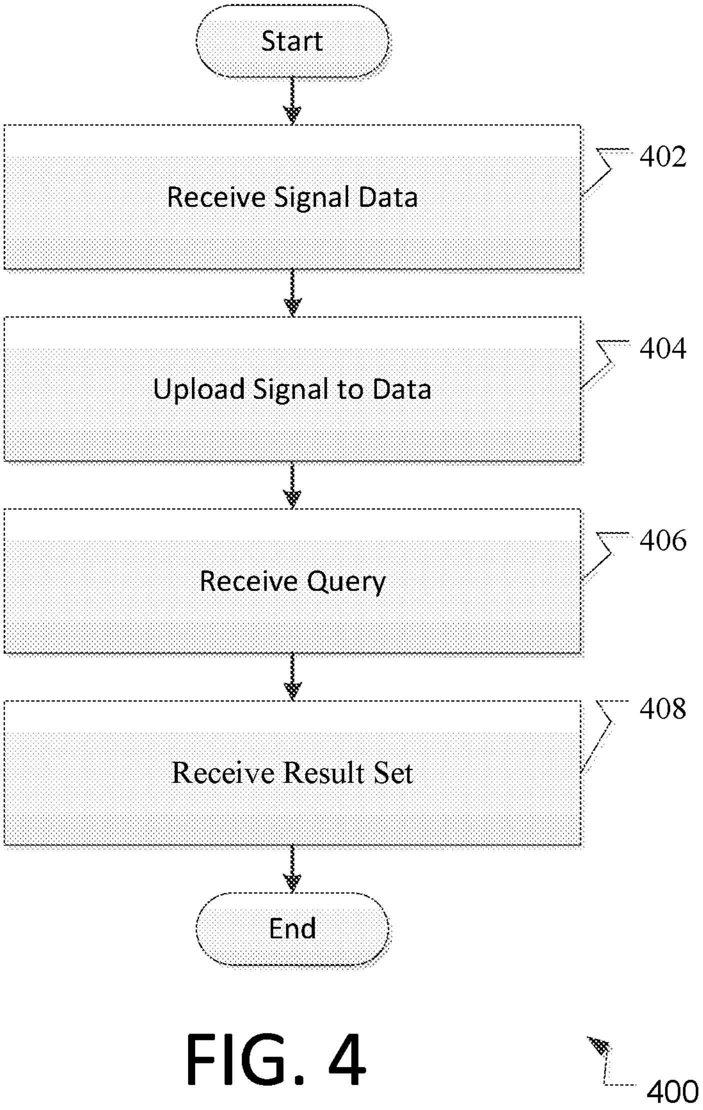

Start
Receive Signal Data
402
Upload Signal to Data
404
Receive Query
406
Receive Result Set
408
End
400

FIG. 4

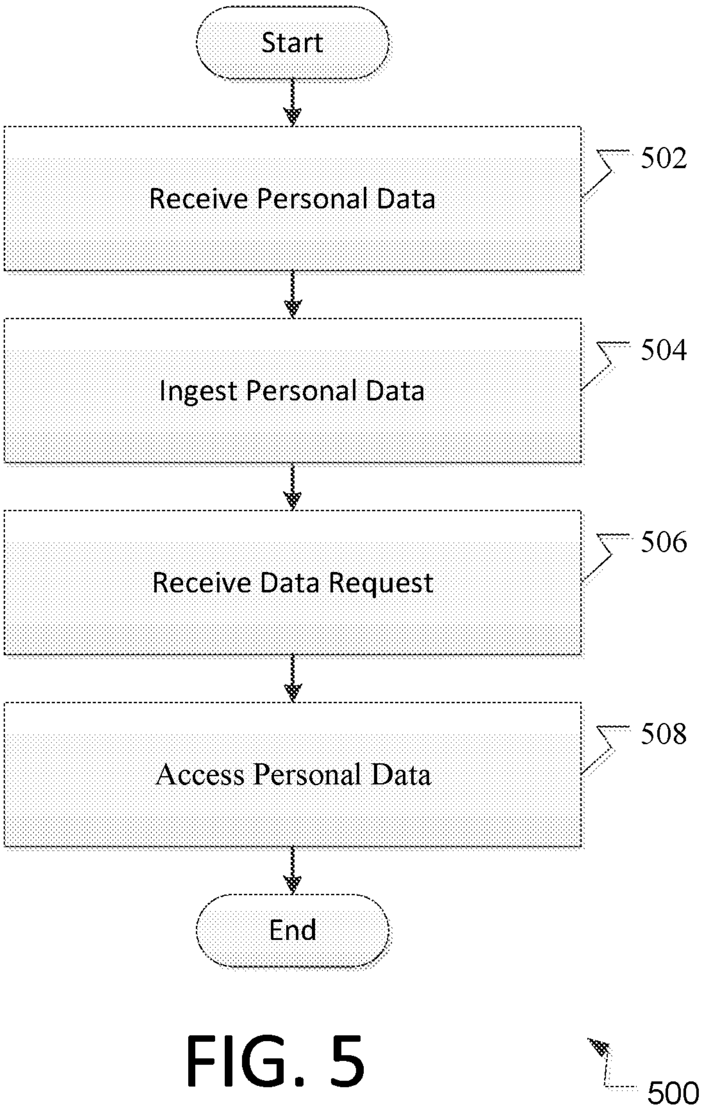

Start
Receive Personal Data
502
Ingest Personal Data
504
Receive Data Request
506
Access Personal Data
508
End
500

FIG. 5

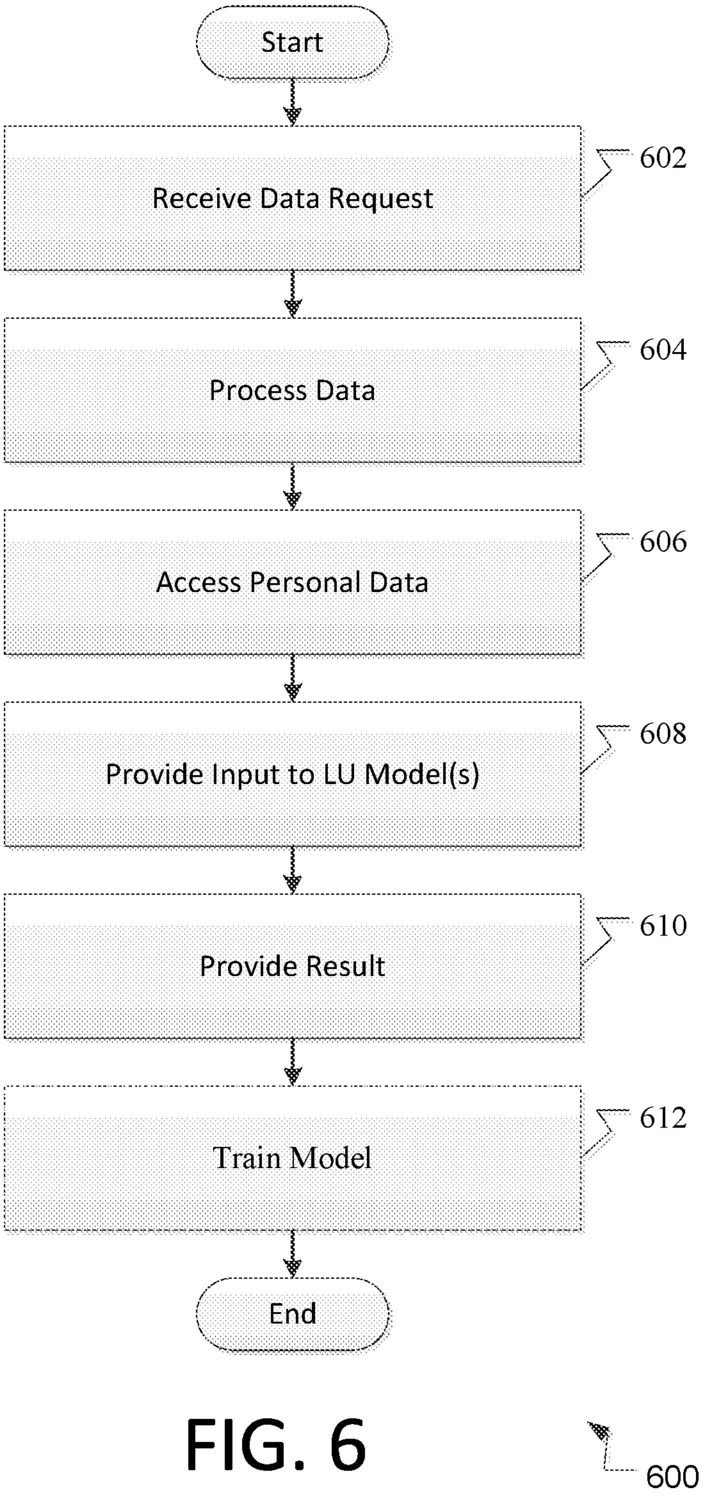

Start
Receive Data Request
602
Process Data
604
Access Personal Data
606
Provide Input to LU Model(s)
608
Provide Result
610
Train Model
612
End
600

FIG. 6

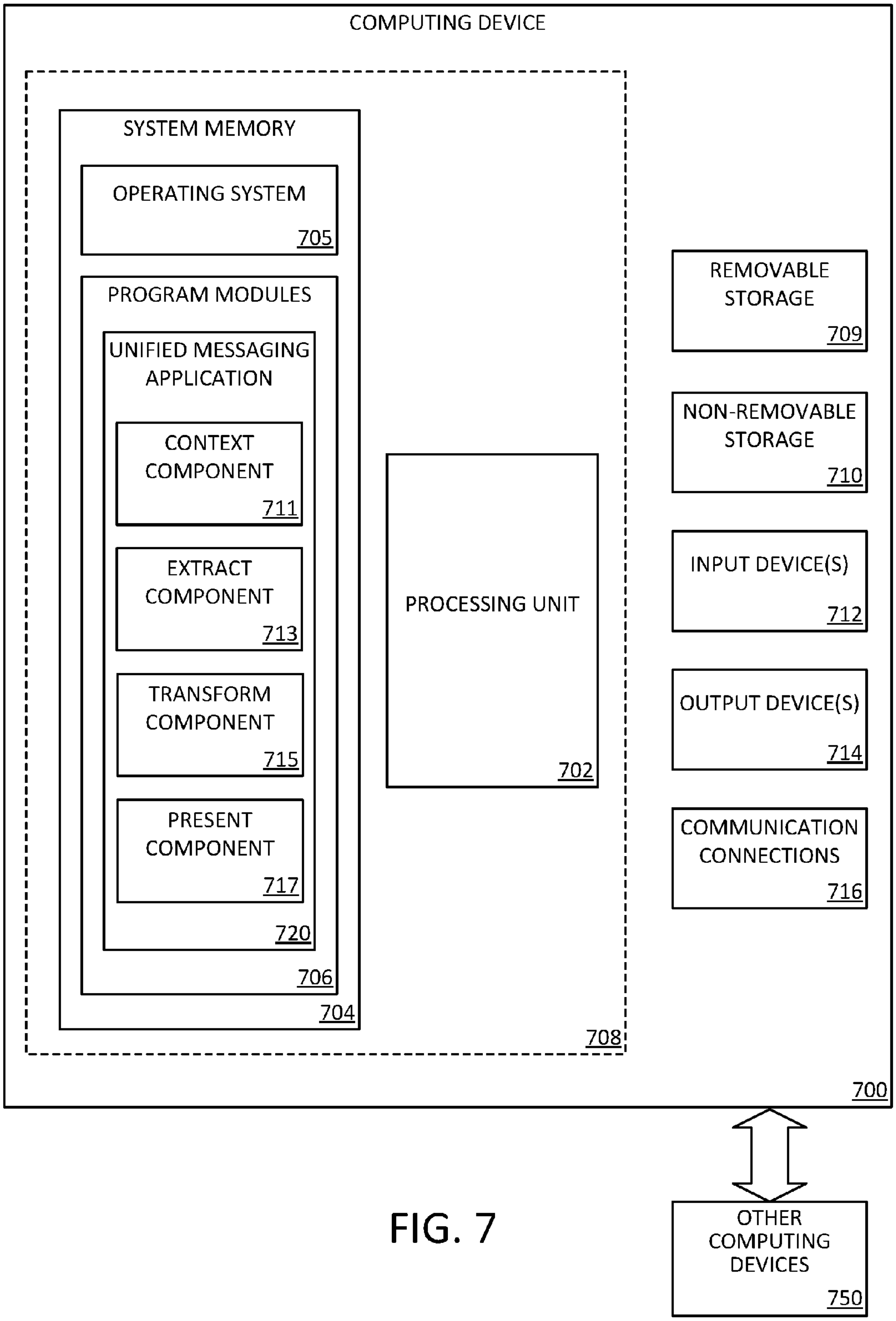

COMPUTING DEVICE
SYSTEM MEMORY
OPERATING SYSTEM
705
PROGRAM MODULES
UNIFIED MESSAGING APPLICATION
CONTEXT COMPONENT
711
EXTRACT COMPONENT
713
TRANSFORM COMPONENT
715
PRESENT COMPONENT
717
720
706
704
PROCESSING UNIT
702
708
REMOVABLE STORAGE
709
NON-REMOVABLE STORAGE
710
INPUT DEVICE(S)
712
OUTPUT DEVICE(S)
714
COMMUNICATION CONNECTIONS
716
700
OTHER COMPUTING DEVICES
750

FIG. 7

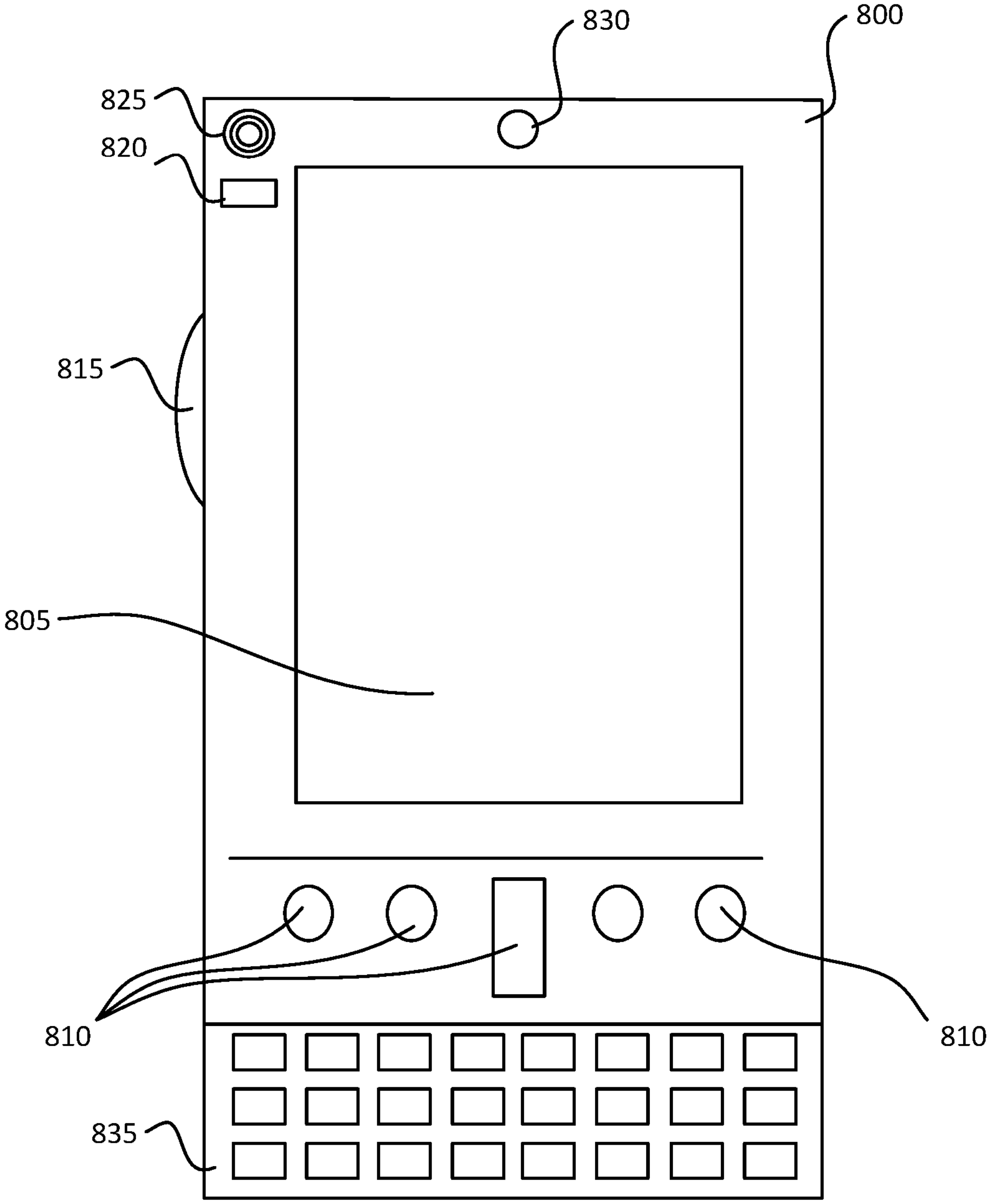


FIG. 8A

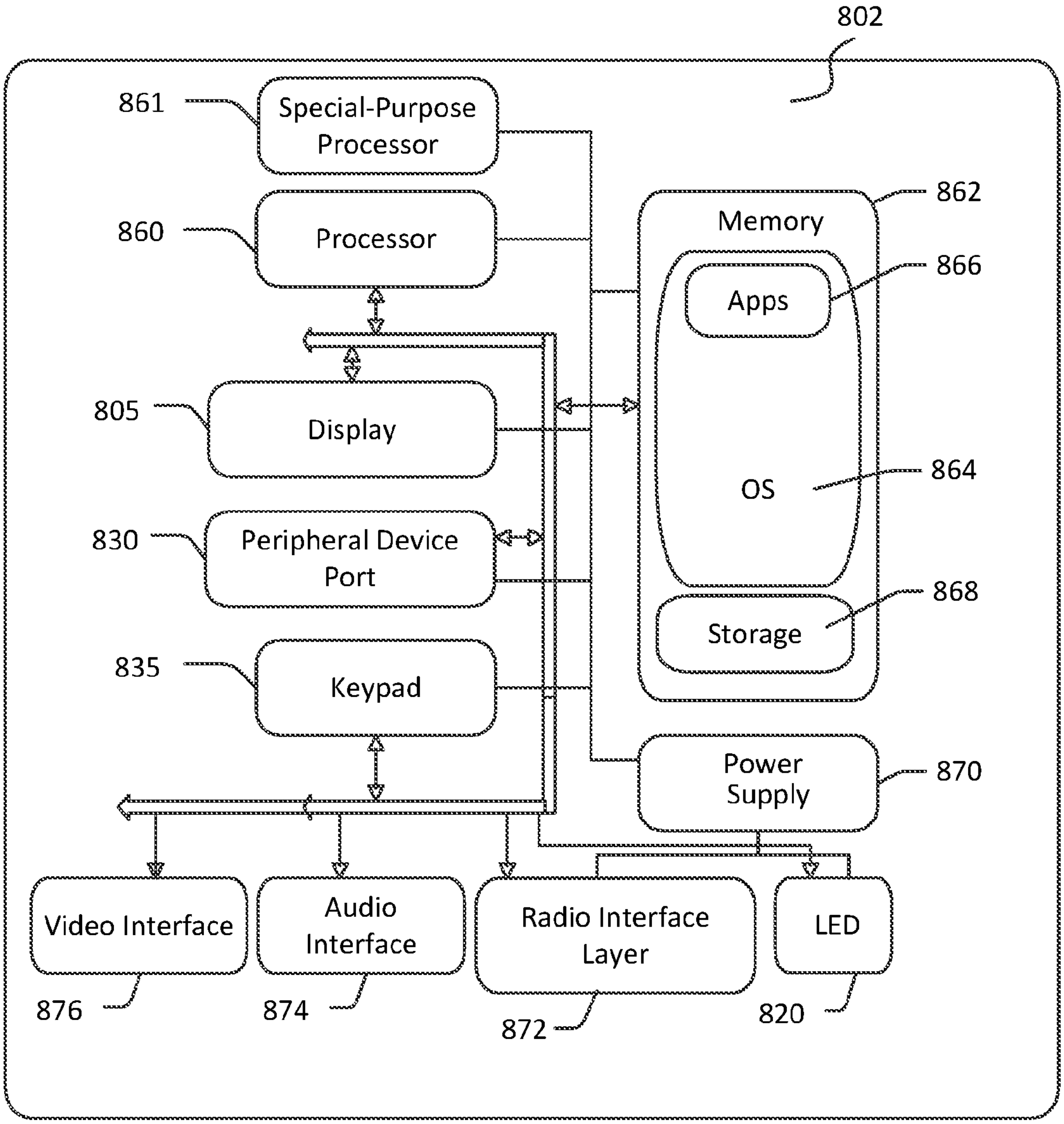

802
861
Special-Purpose Processor
860
Processor
805
Display
830
Peripheral Device Port
835
Keypad
Memory
862
Apps
866
OS
864
Storage
868
Power Supply
870
Video Interface
876
Audio Interface
874
Radio Interface Layer
872
LED
820

FIG. 8B

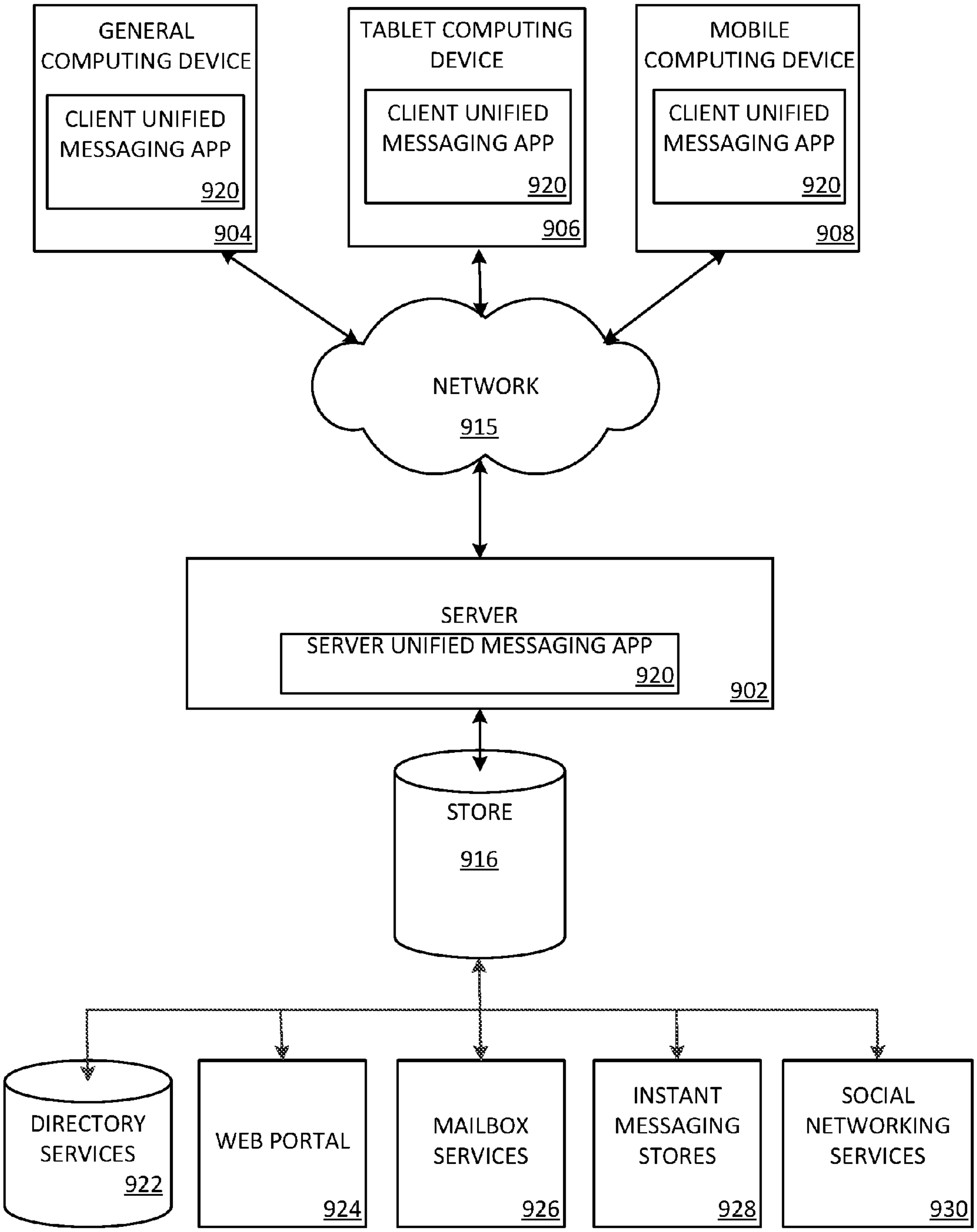

GENERAL COMPUTING DEVICE
CLIENT UNIFIED MESSAGING APP
920
904
TABLET COMPUTING DEVICE
CLIENT UNIFIED MESSAGING APP
920
906
MOBILE COMPUTING DEVICE
CLIENT UNIFIED MESSAGING APP
920
908
NETWORK
915
SERVER
SERVER UNIFIED MESSAGING APP
920
902
STORE
916
DIRECTORY SERVICES
922
WEB PORTAL
924
MAILBOX SERVICES
926
INSTANT MESSAGING STORES
928
SOCIAL NETWORKING SERVICES
930

FIG. 9

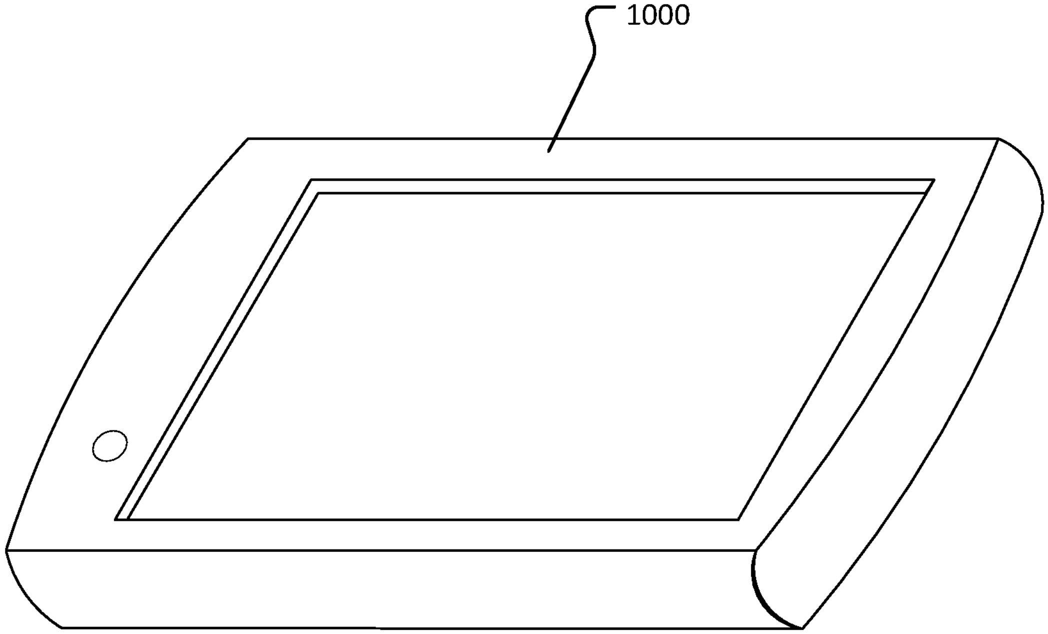


FIG. 10

PERSONALIZING NATURAL LANGUAGE UNDERSTANDING SYSTEMS

BACKGROUND

[0001] Natural language understanding (NLU) is the ability of a computer program to understand human speech and to extract the meaning of spoken or typed input. NLU systems have been used in conjunction with a variety of domains (e.g., places, weather, communication, reminders). Typically, NLU systems treat individual users anonymously (e.g., the system behaves the same for all users). As a result, users are provided a degraded user experience in which user-specific behavior and actions are ignored during query processing.

[0002] It is with respect to these and other general considerations that the aspects disclosed herein have been made. Also, although relatively specific problems may be discussed, it should be understood that the examples should not be limited to solving the specific problems identified in the background or elsewhere in this disclosure.

SUMMARY

[0003] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detail Description section. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0004] Examples of the present disclosure describe systems and methods of personalizing natural language systems. In aspects, personal data may be uploaded to a personalization server. Upon receiving a data request, a server device may query the personalization server using an identification data (e.g., a user's login information). The identification data and the associated personal data may be paired and provided to the personalization server. The paired data may then be provided to a language understanding model to generate a response to the data request. The data in the response may be used to further train the language understanding model.

[0005] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Additional aspects, features, and/or advantages of examples will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Non-limiting and non-exhaustive examples are described with reference to the following figures.

[0007] FIG. **1** illustrates an overview of an example system for implementing natural language personalization techniques as described herein.

[0008] FIG. **2** illustrates an exemplary interplay between a client device, a personalization server, and a language understanding server as described herein.

[0009] FIG. **3** illustrates an example method of personalizing a natural language understanding system as described herein.

[0010] FIG. **4** illustrates an example method of personalizing a natural language understanding system from the perspective of a client device as described herein.

[0011] FIG. **5** illustrates an example method of personalizing a natural language understanding system from the perspective of a personalization device as described herein.

[0012] FIG. **6** illustrates an example method of personalizing a natural language understanding system from the perspective of a language understanding device as described herein.

[0013] FIG. **7** is a block diagram illustrating example physical components of a computing device with which aspects of the disclosure may be practiced.

[0014] FIGS. **8**A and **8**B are simplified block diagrams of a mobile computing device with which aspects of the present disclosure may be practiced.

[0015] FIG. **9** is a simplified block diagram of a distributed computing system in which aspects of the present disclosure may be practiced.

[0016] FIG. **10** illustrates a tablet computing device for executing one or more aspects of the present disclosure.

DETAILED DESCRIPTION

[0017] Various aspects of the disclosure are described more fully below with reference to the accompanying drawings, which form a part hereof, and which show specific exemplary aspects. However, different aspects of the disclosure may be implemented in many different forms and should not be construed as limited to the aspects set forth herein; rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the aspects to those skilled in the art. Aspects may be practiced as methods, systems or devices. Accordingly, aspects may take the form of a hardware implementation, an entirely software implementation or an implementation combining software and hardware aspects. The following detailed description is, therefore, not to be taken in a limiting sense.

[0018] The present disclosure provides systems and methods of personalizing natural language systems. In examples, a client device may upload personal data to a personalization server. Personal data, as used herein, may refer to information in a user profile and/or user-specific signals. User signals (also referred to as signal data), as used herein, may refer to personal contacts, user files and documents, user locations, user applications, user social media information, user interests, user calendar information, user event data, user- and/or client-identifying information etc. A personalization server, as used herein, may refer to a device storing personal data for one or more users. One skilled in the art will recognize that any type of processing device may be utilized with examples of the present disclosure.

[0019] In some examples, after the personal data has been uploaded, the client device may send a data request to a natural language understanding (NLU) server. A data request, as used herein, may refer to a set of data comprising a query and/or identifying information for a user and/or the client device. One skilled in the art will recognize that examples of the present disclosure may be applied to any input understanding processing including input that is processed in a form such as voice/utterance, text, handwritten input, and touch, among other examples. An NLU server, as used herein, may refer to a device for extracting and/or processing semantic content from input in order to represent domain(s), intent(s) and/or slot(s) of the input. A domain, as used herein, may refer to a container and/or a boundary that isolates or defines an application, software functionality, or a set of data. For example, an "events" domain may be used to search and purchase event-related items; whereas a "places" domain may be used to search for places and directions to the places. An intent, as used herein, may refer to the goal or intention of user's utterance or other entered input. For example, a "show movies" intent may be assigned to the query "What new movies are playing?" A slot, as used herein, may refer to the actionable content within the user's utterance or other entered input. For example, the entity "The Avengers" may be assigned to the slot "movie_name" for the query "I want to see The Avengers tonight."

[0020] In aspects, the NLU server may process the received query and send at least a portion of the identifying information to the personalization server. The personalization server may match the identifying information to personal data associated with the user and provide the personal data to the NLU server. The NLU server may provide the personal data as input to one or more language understanding (LU) models. An LU model, as used herein, may refer to a statistical language model that may be used to determine a probability distribution over one or more word sequences. In examples, a model may be a rule-based model, a machine-learned regressor, a machine-learned classifier, or the like. The LU model(s) may output a result set for the data request and send the result set to the client device

[0021] In some examples, result set data may be used to train or retrain the LU model(s). Training a model, as used herein, may refer to using a set of data to fit, for example, a statistical machine learned model that can be used to predict a response value from one or more predictors. Various techniques, such as word N-gram, dictionaries, personalization, etc., may be used to train or retrain a model. The trained (or retrained) LU model(s) may provide more accurate, personalized, and/or efficient result sets for the user. In other examples, training data may be used to train the LU model(s). Training data, as used herein, may refer to fake (e.g., dummy) user profiles with randomly generated personal information. Although LU models trained with training data may not be personalized to a user initially, the LU model(s) may be trained to expect and/or recognize features of input and to assign statistical weights and/or probabilities to the features and/or expected features.

[0022] Accordingly, the present disclosure provides a plurality of technical benefits including but not limited to: personalizing natural language models and systems; improving detection, intent detection, and slot tagging; improvements to resolving tagged entities (e.g., mapping a name used in a query to a unique ID in the contact list); improving runtime feature extraction; increasing query processing speed; reducing the amount of training data needed to train language understanding models; reducing the time and resource cost required to annotate a domain; increasing the quality and accuracy of query results (thereby, reducing the amount of "follow-up" queries), reducing the bandwidth and power consumption of the devices within the system and improving efficiency and quality for applications/services utilizing examples of the present disclosure, among other examples.

[0023] FIG. **1** illustrates an overview of an example system for implementing personalization techniques for natural language systems as described herein. Exemplary system **100** presented is a combination of interdependent components that interact to form an integrated whole for personalizing natural language systems. Components of the systems may be hardware components or software implemented on and/or executed by hardware components of the systems. In examples, system **100** may include any of hardware components (e.g., used to execute/run operating system (OS)), and software components (e.g., applications, application programming interfaces (APIs), modules, virtual machines, runtime libraries, etc.) running on hardware. In one example, an exemplary system **100** may provide an environment for software components to run, obey constraints set for operating, and makes use of resources or facilities of the system **100**, where components may be software (e.g., application, program, module, etc.) running on one or more processing devices. For instance, software (e.g., applications, operational instructions, modules, etc.) may be run on a processing device such as a computer, mobile device (e.g., smartphone/phone, tablet) and/or any other electronic devices. As an example of a processing device operating environment, refer to the exemplary operating environments depicted in FIGS. **5**-**7**. In other examples, the components of systems disclosed herein may be spread across multiple devices. For instance, input may be entered on a client device and information may be processed or accessed from other devices in a network such as one or more server devices.

[0024] As one example, the system **100** comprises client device **102**A, client device **102**B, client device **102**C, distributed network **104**, a distributed server environment comprising one or more servers such as server device **106**A, server device **106**B and server device **106**C, and a personalization server device **108**. One of skill in the art will appreciate that the scale of systems such as system **100** may vary and may include more or fewer components than those described in FIG. **1**. In some examples, interfacing between components of the system **100** may occur remotely, for example where components of system **100** may be spread across one or more devices of a distributed network.

[0025] The client device **102**A, for example, may be configured to receive user input signals (e.g., input from a user or information related to personal data of the user) via a user interface component or other input means. Examples of input may include voice, visual, touch and text input. Client device **102**A may be further configured to transmit the input signals to a personalization server, such as personalization server device **108**, via distributed network **104**. In some examples, client device **102**A may transmit the input signals to personalization server device **108** periodically or according to a defined schedule. Further, the input signals may be transmitted at a later time when one or more of client device **102**A and personalization server device **108** is offline (e.g., not presently receiving queries from, for example, a user).

[0026] Client device **102**B may be a different device type from client device **102**A, but may be similarly configured to client device **102**A. For example, a user may have a user account on client device **102**A (e.g., a computer) and client device **102**B (e.g., a mobile phone). Client device **102**A may upload to personalization server device **108** user input signals related to browsed websites and accessed documents, and client device **102**B may upload user input signals related to contact lists and GPS signals. In aspects, personalization server device **108** may be configured to receive, aggregate, encrypt and/or store the data from client device **102**A and/or client device **102**B according to an identification of the user (e.g., account ID, username, client ID, biometrics, etc.). For example, personalization server device **108** may segment and store data from a plurality of user devices in one or more tables of a relational database, such that the tables are related by an identification of the user. In a particular example, the stored data may be encrypted using any known encryption technique.

[0027] Client device **102**A may be further configured to provide a query-generation interface, such as a digital personal assistant, a search engine webpage, and the like. The query-generation interface may be used to receive a data request from, for example, a user. In aspects, client device **102**A may send the data for processing to a language understanding server, such as server device **106**A. Server device **106**A may be configured to receive and process a data request from a client device. In aspects, processing the data request may include parsing the data request to identify, for example, a query and/or identifying information associated with a user, and transmitting at least the personal data to personalization server device **108**. Personalization server device **108** may be further configured to receive the identifying information and to authenticate a user with the identifying information. In aspects, after authenticating the user, personalization server device **108** may use the identifying information to identify whether a user associated with the identifying information has stored personal data on personalization server device **108**. If stored personal data for the user is identified, personalization server device **108** may allow access to the corresponding the personal data or transmit a data structure comprising at least a portion of the personal data to server device **106**A. In alternate aspects, after parsing the personal data, the personal data may be transmitted to a client device, such as client devices **102**A and **102**B, instead of, or in addition to, the personalization server device **108**. In such aspects, the client device may be further configured to identify and allow server device **106**A access to personal data stored on the client device.

[0028] Server device **106**A may be further configured to process personal data from personalization server device **108**. For example, server device **106**A may include, or have access to, one or more language understanding (LU) models. In aspects, server device **106**A may receive and decrypt the personal data and/or data request within the data structure, and provide at least a portion of this data as input to the LU model(s). The LU model(s) may use the input to, for example, identify features for one or more domains, intents and/or slots associated with the data request. The identified features may then be designated (e.g., tagged) for a corresponding domains, intents and/or slots. In some aspects, the LU model(s) may use the input to determine and/or assign weights (e.g., scored probabilities) to one or more of the features; thereby training the LU model(s) for data requests in the same or related domains. In other aspects, the LU model(s) may additionally or alternatively use training data to determine and/or assign weights to features. In a particular example, the training data may be used when the LU model(s) have not been previously trained (e.g., during a new install of the model or where personal information was not previously applied to the model) or are being retrained (e.g., during a reinstall of the model). Based at least in part on the input, the LU model(s) may determine a provisional response to be used with the data request. In one example, a provisional response may take the form of a query comprising features that have been filled in using the input.

[0029] In some aspects, server device **106**A may access personal data on one or more of the client devices **102**A and **102**B and/or personalization server device **108** in order to resolve (e.g., verify) whether one or more of the determined and/or tagged features in the provisional response exists within the personal data. In examples, this resolution may be performed using, for example, a lookup mechanism (e.g., a table lookup, hash lookup, etc.) or a more sophisticated machine-learned model. In examples, when the tagged features are found in the personal data, the provisional response may be finalized into a final response. In an example, a final response may take the form of a query comprising features that have been verified using personal data. Server device **106**A may send the final response to a search component, such as a search engine, to generate a result set. The result set may be transmitted to the query-generation interface of client device **102**A for presentation.

[0030] FIG. **2** illustrates an overview of an exemplary interplay between a client device **210**, a personalization server **220**, and a language understanding server **240** as described herein. The natural language personalization techniques implemented by client device **210**, personalization server **220**, and/or language understanding server **240** may comprise the natural language personalization techniques and input described in FIG. **1**. In alternative examples, a single system (comprising one or more components such as processor and/or memory) may perform processing described in systems **100** and **200**, respectively. Further, client device **210**, personalization server **220**, and/or language understanding server **240** may comprise a user interface component as described in the description of FIG. **1**.

[0031] Exemplary client device **210** may comprise user interface (UI) component **212**, a data store, data upload engine **214**, and query API **216**, each having one or more additional components. The UI component **212** may be configured to receive signals from a client device. Signals, as used herein, may refer to user input (e.g., key presses, screen swipes, pauses, etc.), personal contacts, files and documents, location data, applications, application data, social media information, user interests and behavior data, user search data, calendar data, etc. In a particular example, UI component **212** may be configured to store received signals in a data store located on, or accessible by, client device **210**. The data upload engine **214** may be configured to access the stored signals and transmit the stored signals to a personalization server, such as personalization server **220**. In a particular example, data upload engine **214** may be operable to determine the last time an upload was performed and transmit only the data in the data store that has been added or modified after that time. In a separate example, data upload engine **214** may be operable to transmit all of the signals currently stored in the data store. In aspects, data upload engine **214** may upload the signals to a personalization server "offline" (e.g., when client device **210** is not actively communicating data to or from an LU server). For example, data upload engine **214** may automatically upload the signals according to a defined schedule or upon determining sufficient connectivity, or data upload engine **214** may only upload the signals according to a manual instruction.

[0032] The query API **216** may be configured to receive a data request. In aspects, the query may be received from a separate device or directly from a user. The data request may be associated with one or more domains and may comprise a query, a statement, a string of words, one or more labels, data associated with one or more intents and/or slots, and/or identifying information. An intent, as used herein, may refer to the goal or intention of an utterance or other entered input. A slot, as used herein, may refer to the actionable content within the utterance or other entered input. Identifying information, as used herein, may refer to information that identifies a user (e.g., user ID, account ID, username, etc.) and/or a client device (e.g., client ID, IP address, MAC address, etc.). The query API **216** may be further configured to transmit one or more portions of the data request to an LU server, such as NLU server **240**. In one example, query API **216** may transmit a query and a user ID to the LU server.

[0033] Exemplary personalization server **220** may comprise ingest engine **222**, a data store **224** and a request processing engine **226**, each having one or more additional components. The ingest engine **222** may be configured to receive and/or process signals stored on, or accessible to, a client device, such as client device **210**. For example, after receiving the signals, ingest engine **222** may configured to parse query data into one or more domains, intents and/or slots. Associations within the domains, intents and/or slots may be identified and/or established such that a plurality of slots may be associated with an intent, and a plurality of intents may be associated with a domain. The ingest engine **222** may encrypt the parsed data using any known encryption method and store the parsed data within a data store, such as data store **224**. In examples, encrypting the data may preclude unauthorized users from viewing and/or accessing the data. In a particular example, the encryption may preclude a first user who is authorized to view the data of the first user from viewing the data of a second user. Data store **224** may be configured to store the parsed and/or encrypted data according to a user identification associated with the parsed data. For example, data store **224** may store the parsed data in one or more tables of a database according to a user ID in the parsed data.

[0034] The request processing engine **226** may be configured to receive and process a lookup request from a computing device, such as NLU server **240** and client device **210**. In aspects, a lookup request may comprise at least a portion of a query, user-identifying information and/or client-identifying information. After receiving the lookup request, request processing engine **226** may attempt to authenticate the user identified by the identifying information. Authentication may be performed using any know authentication technique. When the user has been authenticated, request processing engine **226** may access data store **224**. In some examples, request processing engine **226** may use the identifying information to identify corresponding personal data in the data store. In a particular example, a user ID may be used to identify a plurality of database rows comprising personal data corresponding to an identified user and/or domain. The identified personal data may be paired or otherwise associated with at least a portion of the identifying information. The request processing engine **226** may then transmit the paired information to the NLU server. In another example, a user ID and a slot value (for example, entity name) may be used to match personal data corresponding to the user ID and/or the slot value. The request processing engine **226** may then transmit a verification or similar acknowledgement to the NLU server.

[0035] Exemplary NLU server **240** may comprise query processing engine **242**, NLU model(s) **244** and training engine **246**, each having one or more additional components. The query processing engine **242** may be configured to receive and/or process data requests from a client device, such as client device **210**. In aspects, query processing engine **242** may parse a data request into identifying information, one or more domains, intents and/or slots. Associations within the parsed data may be identified and/or established, as described above with respect to ingest engine **222**. In some aspects, query processing engine **242** may comprise a ranking component. The ranking component may be a machine-learned classifier, a statistical ranking model, or the like. The ranking component may receive signal data and other information (e.g., personal data, user behavior data, application data, etc.) from one or more devices in systems **100** and **200**. In a particular aspect, the ranking component may arbitrate between one or more LU models, such as NLU model(s) **244**, and/or determine rankings for at least a portion of the parsed data. The rankings may determine, for example, the most accurate and/or most likely understanding for the data request (and, ultimately, the query), the most accurate resolution of domains, intents and/or slots, etc. In examples, portions of the parsed data may be transmitted to a personalization server, such as personalization server **220**, to identify personal data corresponding to a user. In some aspects, NLU server **240** may receive personal data, identifying information, and/or a verification of identified personal data from the personalization server. The NLU server **240** may be further configured to parse the received personal data as discussed above. For example, query processing engine **242** may identify one or more domains, intents and/or slots in the received personal data.

[0036] The NLU model(s) **244** may be configured to receive data, such as personal data and/or training data, as input. In aspects, the NLU model(s) **244** may use the data as features for domain classification (e.g., places, weather, travel, movies, etc.) intent detection (e.g., find places, find directions, check weather, find movie time, etc.), and/or slot labeling (e.g., place name, application, user name, movie name, etc.). Using the input, NLU model(s) **244** may output, for example, a provisional query that is personalized to the user identified by the identifying information. In some examples, NLU server **240** may attempt to determine (e.g., resolve) whether the tagged features of the provisional query exist in the personal data. In such examples, this determination (e.g., resolution) process may include the use of one or more lookup operations or a machine-learned model. In a particular example, the determination process may include matching tagged features against the personal data using exact match, partial match, n-gram match, the number of matches, non-zero entity match (e.g., whether a non-zero entity is found in the personal data), etc. In such an example, any matched tagged features may be give more weight or a higher importance than unmatched tagged features.

[0037] In aspects, when the resolution is complete (e.g., zero or more tagged features have been matched against entries in the personal data), the provisional query may be finalized into a final query. In a particular example, the final query may include matched tagged features but may exclude unmatched tagged features. In another example, the final query may include both matched and unmatched tagged features, but the unmatched tagged features may be determined to be optional or less important to the final query. In some examples, NLU model(s) **244** may transmit the final query to query processing engine **242** for processing. In other examples, NLU model(s) **244** may transmit the final query to a query search component, such as a search engine. The NLU model(s) **244** may transmit the search result provided by the query search component to query processing engine **242** or to client device **210**.

[0038] The NLU model(s) **244** may also be configured to be trained for particular domains and/or intents using one or more data sets. In aspects, the personal data received as input may also be used by NLU model(s) **244** to assign statistical weights and/or probabilities to one or more features in the personal data. The assigned values may be used in an algorithm to determine, for example, the likelihood that a particular tagged slot value (e.g., "John") corresponds to a particular entity type (e.g., contact name), or to determine the most relevant set of features. The algorithm may additionally or alternately use the information associated with the resolution process described above to make determinations. In other aspects, training data (instead of a "real" user's personal data) may be used to train NLU model(s) **244**. For example, training profiles comprising randomly generated signals may be used as input to NLU model(s) **244**. In such an example, the NLU model(s) **244** may be able to assign statistical weights and/or probabilities to one or more features in the training data as described above. However, because the NLU model(s) **244** may not have the benefit of the resolution process, the statistical weights and/or probabilities assigned, and the features used to make the assignments may vary from those of the personal data. In such aspects, NLU model(s) **244** may be trained based on a defined schedule or upon the determination of specific criteria (e.g., the NLU server **240** is not currently being queried by a client device, or is below a specified level of processing activity, etc.).

[0039] FIGS. **3-6** illustrates example methods of personalizing a natural language understanding system as described herein. In aspects, methods **300-600** may be executed by an exemplary system such as system **100** of FIG. **1**. In examples, methods **300-600** may be executed on a device comprising at least one processor configured to store and execute operations, programs or instructions. However, methods **300-600** are not limited to such examples. In other examples, methods **300-600** may be performed on an application or service for providing query resolution. In at least one example, methods **300-600** may be executed (e.g., computer-implemented operations) by one or more components of a distributed network, for instance, a web service/distributed network service (e.g. cloud service) to leverage natural language personalization techniques for a language understanding system.

[0040] Exemplary method **300** begins at operation **302** where data may be uploaded to a personalization server. In aspects, the data may be uploaded from, for example, a client device or a data store accessible to a one or more client devices. The data may be uploaded to a personalization server in response to a manual instruction from a device within exemplary system **100**. Alternately, the data may be automatically uploaded to a personalization server according to a defined upload schedule or upon the determination of specific criteria. In a particular example, the data may uploaded be to a personalization server three times a day, as long as the client device that is initiating the upload is not currently receiving a query via the natural language understanding interface. In another example, the data may uploaded be to a personalization server upon a manual instruction from the client device as long as there is sufficient connectivity between the uploading device and the personalization server. In some aspects, the uploaded data may comprise input signals, usage and/or behavioral information, etc. from one or more client devices. For example, a first client device having a first set of input signals (e.g., browsed websites and accessed documents) for a user and a second client device having a second set of input signals (e.g., contact lists and GPS signals) for the user may upload their respective input signals and/or user-identifying information to a personalization server. In aspects, the personalization server may organize and store the received input signals in a data store. For example, the personalization server may parse and group the input signals according to one or more of user, domain, application, creation/modification date, etc., and may store the grouped data by user ID (or a similar user identifier) in one or more tables of a database. In some examples, the personalization server may encrypt the input signals and/or the grouped data.

[0041] At operation **304**, a data request may be received at a language understanding server. In aspects, the data request may be initiated by one or more of the client devices described in operation **302**. For example, a client device may use a query UI or API (e.g., a personal digital assistant, a search engine, etc.) to submit the query "Get May, please" to the language understanding server. In such an example, the client device may transmit information identifying the user and/or the client device that originated the query as part of the data request. In some aspects, the language understanding server may process the received query by extracting sematic frames to represent the domain, intents and/or slots of the query. For example, using the above query, the language understanding server may determine that "May" may refer to the 'contact' domain (e.g., contact name "May Lee"), the 'calendar' domain (e.g., month of "May"), or the 'music' domain (e.g., music song "May Pleas"). Based on this determination, the language understanding server may provisionally assign (e.g., tag) the corresponding domain (e.g., domain=' contact' or domain='calendar', etc.) and further determine the intents and/or slots of the query. For example, if the language understanding server determines that "May" most likely refers to the 'contact' domain, "Get" may be provisionally assigned the intent "place call," and "May" may be provisionally assigned the slot "contact name." On the other hand, if the language understanding server determines that "May" most likely refers to the 'music domain, "Get" may be provisionally assigned the intent "play song," and "May Pleas" may be provisionally assigned the slot "song name."

[0042] In some aspects, a plurality of provisional values (e.g., rankings, scores, etc.) may be generated by the language understanding server for one or more of the extracted semantic frames using one or more language understanding hypotheses. A language understanding hypothesis, as used herein, may refer to a proposed solution for a natural language expression or an aspect thereof. For example, using the above query, a first language understanding rule set (or language understanding model) may be used to determine that "May" refers to the 'contact' domain; a second language understanding rule set may be used to determine that "May" refers to the 'music domain; and a third language understanding rule set may be used to determine that "May" refers to the ‘calendar’ domain. In a particular example, each of the determined domain values (e.g., contact, music and calendar) may be provisionally assigned a score (such as of 0.33) based on the number of domain values. In another example, the determined domain values may be provisionally assigned a score based on one or more rules in a corresponding language understanding rule set. In such examples, although the scores may be assigned for the various domain values, a particular domain value may not be assigned (provisionally or otherwise) to the domain. In other examples, the determined domain values (e.g., contact, music and calendar) may not be assigned scores. Instead, the determined domain values may be stored for further processing.

[0043] In some aspects, the language understanding server may use at least a portion of the data request to acquire a credential to facilitate accessing the personalization server for input signals associated with the user initiating the data request (e.g., personal data). For example, the language understanding server may use the user-identifying information to generate (or otherwise acquire) a user token representing the encrypted identity of the user. In some examples, the user token may also include at least a portion of the assigned values (e.g., tagged domains, intents and/or slots). In a particular example, the language understanding server may comprise or have access to a token issuing authority that generates and issues the user tokens to the language understanding server. The token issuing authority may be operable to expire the user token after a specified time period and/or to revoke the user token based on specified criteria.

[0044] At operation **306**, the language understanding server may access the personalization server. In aspects, language understanding server may use the user token described in operation **304** to access personal data on the personalization server. For example, the personalization server may use the received user token to authenticate a user corresponding to the user token. If the user has been successfully authenticated, the personalization server may make at least a portion of the personal data for that user accessible to the language understanding server. In a particular example, making the personal data accessible may include searching the data store for one or more domains (e.g., ‘contacts,’‘calendar’ and/or ‘music’ domains) and/or strings (e.g., “May”), decrypting the personal data found in the searched data, and providing the (e.g., physical and/or logical) location of the decrypted data to the language understanding server. In another example, making the personal data accessible may additionally or alternately include extracting the searched personal data to a data structure (e.g., a hash, an array, etc.), decrypting the personal data in the data structure, and providing the data structure to the language understanding server. In such examples, searching the data store may include matching the user token (or the information represented by the user token) to identifying information (e.g., username, user ID, etc.) and associated personal data in the data store.

[0045] At operation **308**, the language understanding server may process the personal data accessed on the personalization server. In aspects, the language understanding server may search the accessed personal data to resolve (e.g., verify) whether one or more tagged values exists within the accessed personal data. For example, when the language understanding server determines that “May” most likely refers to the ‘contact’ domain, the language understanding server may search the accessed personal data to determine whether the string “May” appears in data associated with one or more domains. In a particular example, the language understanding server may determine that only the ‘contact’ domain includes an entry or value corresponding to the string “May” (e.g., contact_name=“May Lee”). As a result, the language understanding server may modify the provisional assignments (e.g., domain=’contact,’ intent=“place call,” slot=“May Lee”) to final assignments. In another example, the language understanding server may determine that only the ‘music’ domain includes an entry or value corresponding to the string “May” (e.g., song_name=“May Pleas”). As a result, the language understanding server may modify the provisional assignments (e.g., domain=’contact,’ intent=“place call,” slot=“May”) such that the domain is assigned ‘music,’ the intent is assigned “play song,” and the slot is assigned “May Pleas.” The modified provisional assignments may be considered as final assignments. In yet another example, the language understanding server may determine that the ‘contact,’ calendar’ and ‘music’ domains includes an entry or value corresponding to the string “May” (e.g., contact name=“May Lee,” month=“May,” and song name=“May Pleas”). As a result, the language understanding server may not be able to make a definitive determination about the provisional assignments and further processing of the provisional assignments (using, for example, an LU model) may be required.

[0046] In other aspects, the language understanding server may search the accessed personal data to analyze and/or rank one or more potential values for a feature in the data request. For example, the language understanding server may determine that the domain of a data request may correspond to one of a plurality of values (e.g., contacts, movie, calendar). As a result, the language understanding server may use the personal data to resolve whether one or more of the plurality of values exists within the accessed personal data. The output of this resolution process may be provided to a ranking component to determine and/or rank one or more features of the data request. In examples, the ranking component may use signal data, user information and/or device information to determine rankings. In a particular example, the ranking component may use personal data to arbitrate between a plurality of values. The arbitration may include identifying entries in the personal data and applying one or more rule and/or rule sets to the identified entries. For example, the ranking component may use application data in the communication domains (e.g., email data, phone call data, messaging data, etc.) to determine that the contact “May Lee” has not been contacted in the last three months; application data in the notifications domains (e.g., calendar data, alerts data, notification data, etc.) to determine that the month is currently December and that there are currently no events scheduled for the month of May; and application data in the multimedia domains (e.g., video data, image data, music data, messaging data, etc.) to determine that the song “May Pleas” has been played **20** times in the last week using a music app on the client device and the corresponding music video has been played twice in the last two weeks using a video streaming app on the client device. Accordingly, the ranking component may rank ‘music’ as the mostly likely domain, ‘contacts’ as the second mostly likely domain, and ‘calendar’ as the least likely domain. In at least one example, the ranking component or another component of the language understanding server may then assign 'music' to the domain.

[0047] At operation **310**, the language understanding server may generate a finalized query. In aspects, the language understanding server may provide the provisional assignments, the final assignments, and/or the data request information as input to one or more LU models accessible to the language understanding server. In examples, an LU model may use the input as features for domain classification, intent detection, and/or slot labeling. For example, if a set of final assignments targeting the 'contact' domain (e.g., domain='contact,' intent="place call," slot="May Lee") is input to an LU model, the LU model may use 'contact' as the feature for the domain, "place call" as a feature for the intent, and "May Lee" as the feature for the slot. In some aspects, as a result, the LU model may output a final query comprising the necessary features, formatting, and/or instructions to execute the final query. The final query may be executed by a client device, a component of the language understanding server or by a query processing component accessible to the language understanding server or client device. In one example, the final query may include the instructions (e.g., open music application, play song, etc.) and/or information (e.g., song_name="May Pleas") to enable a client device to play the requested song. In another example, the final query may include the information (e.g., telephone number=555-555-5555), elements of the data request (e.g., "Get May") and/or elements of the finalized query (e.g., Call May Lee). In other aspects, as a result, the LU models may use the assigned features to perform the determined intent. In a particular example, the input may include 'movies' as the feature for the domain, "find movies" as a feature for the intent, and "new releases" as the feature for the slot. The LU models may use the input to query a search engine or data repository for a result set comprising recently released movie titles, and may transmit the result set to the requesting client device. In another example, the input may include 'calendar' as the feature for the domain, "show events" as a feature for the intent, and "May" as the feature for the slot. The LU models may use the input to query a calendaring application or data repository for a result set comprising appointments and/or meetings for the month of May. The result set may be transmitted to the client device and displayed on a query UI or API as described in operation **304**.

[0048] In optional operation **312**, the LU models may be trained using input signals. In some aspects, the LU models may be trained using the provisional assignments, the final assignments, the ranking information, and/or the final query. For example, an LU model may use final assignments to identify and/or determine the input expected for particular queries, query types, domains, etc. In a particular example, an LU model may determine that the "place call" intent is associated with the 'contacts' domain in 95% of the queries received from a user. As a result, the LU model may assign a weight or score to the 'contacts' domain (for example, 0.95 out of 1.00) and a lower weight or score (for example, 0.05 out of 1.00) to all other domains, collectively. This assigned weight or score may indicate a higher probability that a tagged slot value corresponding to a query comprising the "place call" intent will be located in the 'contacts' domain of the user's personal data. Consequently, the LU may establish or modify a search strategy of the language understanding server to search the 'contacts' domain prior to other domains when such a query is received.

[0049] In another example, the LU model may receive input (e.g., "Call May") that exists in multiple entries of one or more domains (e.g., 'contacts' domain, contact names="May Lee," "May Winters," "Aunt May," and "May" (referring to "Michael May")). The LU model may use behavioral information, data from other domains, or the like to assign a probability score to each contact name. In a particular example, the LU model may search a recent call history, a recent messages folder, and a travel log. The search may reveal that over the past month a user has contacted May Winters 20 times (e.g., via phone, instant message, email, etc.), visited the residence of May Winters 3 times, contacted May Lee twice, and not contacted or visited Aunt May and Michael May. As a result, the LU model may assign a score to each of the contacts, such that the score for the May Winters contact is higher than that score the May Lee contact, which is higher than scores for the Aunt May and Michael May contacts. Consequently, when the LU receives a provisional assignment comprising a "place call" intent and the string "May," the LU may modify the provisional assignment according to the assigned scores (which may be stored by the LU model) or generate and provide a ranked list of possible assignments (e.g., contacts) to a client device.

[0050] In yet another example, the LU model may receive input corresponding to more than one domain and/or having more than one slots. In a particular example, the query "Call May tonight" may be processed by the language understanding server such that the domain is provisionally assigned 'contacts', the intent is provisionally assigned "place call", a first slot is provisionally assigned "May" and a second slot is provisionally assigned "tonight." The LU model may use, for example, usage and/or behavioral information, previous queries and/or result sets, etc. determine that one of the provisionally assigned slots is more relevant to the assigned intent than the other provisionally assigned slot. For instance, the LU model may determine that temporal slot features (e.g., tonight) more clearly indicate user intent than entity slot features (e.g., May). This determination may include identifying that a query requesting an action to be performed "tonight" (or at a later time) most likely corresponds to a "set reminder" or "set alarm" intent than to a "place call" intent. As a result, the LU model may assign a score to the associated domain, intent and/or slots indicating this likelihood. As an example, when a temporal slot feature is detected, the LU model may assign a score of 0.75 out of 1.00 (indicating a 75% probability) to the "set reminder" intent, a 0.50 out of 1.00 (indicating a 50% probability) to the "set alarm" intent, and a 0.05 out of 1.00 (indicating a 5% probability) to the "place call" intent. Consequently, the LU model may use the scores to determine the features to be used to output a final query or to produce a result set.

[0051] In other aspects, the LU models may be trained using training data. For example, an LU model may use training data to identify and/or determine the input expected for particular queries, query types, domains, etc. The training data may include randomly generated personal information and may be used to train an LU model without using a user's personal data. In an example, an LU model may receive as input a final query comprising training where the domain is assigned 'contact,' the intent is assigned "place call," and the slot is assigned "Tom." Although, the string

"Tom" may not exist in the user's contact list, the LU model may determine that "Tom" exists in the 'contacts' domain of the training data. As a result, the LU model may correlate the "place call" intent with the 'contacts' domain, such that there is a high probability (e.g., 90% likelihood) that the tagged slot for a query comprising the "place call" intent is a contact in the user's contact list. Further, the LU model may assign a score to the domain and/or slot according to probability. Consequently, the LU may establish or modify a search strategy of the language understanding server to search the 'contacts' domain prior to other domains when such a query is received.

[0052] In aspects, the assigned weights and/or scores described above may be used to determine probable correlations between one or more of domains, intents and slot values. In examples, this determination may include the use of one or more algorithms. For example, the scores may be input to an algorithm accessible to the language understanding server. The algorithm may be used to determine the most relevant final query, the most probable value associated with a particular domain, intent and/or slot values, or the like. In a particular example, the algorithm may be used to determine the most probable values of one or more input features by selecting the values from domain, intent and/or slot with the highest scores. In another example, the algorithm may assign weighted values to one or more features to determine a most probable result. As an example, for the query "Call May tonight," the "calendar" domain may be assigned a probability score of 0.75 out of 1.00, the "music" domain may be assigned a probability score of 0.15 out of 1.00, the "set reminder" intent may be assigned a probability score of 0.75 out of 1.00, the "place call" intent may be assigned a probability score of 0.25 out of 1.00, the "play song" intent may be assigned a probability score of 0.10 out of 1.00, the "May Lee" slot may be assigned a probability score of 0.40, and the "Aunt May" slot may be assigned a probability score of 0.10. The algorithm may assign a weight of 3.0 out of 3.0 to the combination of the "calendar" domain (0.75), the "set reminder" intent (0.75), and the "May Lee" slot (0.40) based on the highest aggregate score (1.90), such that the weighted score is 5.70 (e.g., 3.0*1.90). The algorithm may assign a weight of 2.5 out of 3.0 to the combination of the "calendar" domain (0.75), the "set reminder" intent (0.75), and the "Aunt May" slot (0.10) based on the aggregate score (1.60), such that the weighted score is 4.0 (e.g., 1.6*2.5). The algorithm may further assign a weight of 1.0 out of 3.0 to the combination of the "music" domain (0.15), the "play song" intent (0.10), and the "Aunt May" slot (0.10) based on the aggregate score (0.45), such that the weighted score is 0.45 (e.g., 0.45*1.0). Based on these weighted scores (e.g., 5.70, 4.0 and 0.45), the algorithm may calculate and/or determine that the probable values of features for a particular query (e.g., "Call May tonight") are "calendar" for the domain, "set reminder" for the intent, and "May Lee" for the slot.

[0053] FIG. **4** illustrates an example method of personalizing a natural language understanding system from the perspective of a client device as described herein. Exemplary method **400** begins at operation **402** where user signal data and associated information may be received via a user interface, such as user interface **212**, of a client device. In aspects, the client device may process and store the signal data in a data store accessible to the client device. Processing the signal data may include parsing the signal data and/or grouping the signal data by user identification, application, domain, time period, etc. For example, the user of a client device may access a word processing application and a social media application from a user interface of the client device. The client device may store new and/or modified documents in a data store configured to store word processing application and may store contact information, event data, and/or behavioral data in a data store configured to be store data from various application.

[0054] At operation **404**, the signal data may be uploaded to a personalization server. In aspects, the client device may use a upload component, such as data upload engine **214**, to upload the signal data to a personalization server. In some examples, the upload component may access one or more data stores accessible to one or more client devices to retrieve signal data for a user. The upload component may retrieve all of the data for a particular user or only the data that has been modified in a specified period (e.g., since the last signal data upload). In other examples, the upload component may access and/or receive signal data on one or more client devices for a plurality of users. The upload component may additionally access information on the client device that identifies the user(s) and/or the client device(s). In a particular example, the upload component may pair or otherwise associate the retrieved signal data with the identifying information, and may transmit the paired data to the personalization server. In some aspects, the upload component may perform the upload periodically, according to a defined schedule, or upon receiving a manual instruction.

[0055] At operation **406**, a query may be received by the client device. In aspects, a user may submit a query to an application executing on the client device (e.g., a personal digital assistant, a web browser, etc.) via a query UI or API, such as query API **216**. The query API may parse the received query to identify a category, subject, and/or domain of the query. The query API may use an identification of the user (e.g., a user ID, username, etc.) to associate the query and/or the identified parts of the query with the identification. The query API may then transmit the received query and associated information to a language understanding server for processing and resolution.

[0056] At operation **408**, a result set may be received by the client device. In aspects, the query API may receive query results from the language understanding server or from a service or device accessible to the language understanding server. In some examples, the query results may include a data set that corresponds to data that resolves the query. For instance, the query result may include several move times and theatre locations. In other examples, the query results may include instructions that allow the client device to satisfy the query. For example, the query results may include the necessary features, formatting, and/or instructions for the client device to execute a query. In some aspects, the query API presents the query results or the data that is generated using the query results to the user.

[0057] FIG. **5** illustrates an example method of personalizing a natural language understanding system from the perspective of a personalization device as described herein. Exemplary method **500** begins at operation **502** where personal data is received by the personalization server. In aspects, the personal data may be received from one or more client devices and/or data stores accessible to the client devices. The personal data may include signal data and/or identifying information for one or more users. In some examples, a data ingest component, such as ingest engine **222**, may receive the personal data.

[0058] At operation **504**, the personal data may be processed. In some aspects, a data ingest component may process the received personal data. Processing the personal data may include parsing the personal data by user, query subject, query domain, and the like. In examples, the data ingest component may store the parsed data into a data store, such as data store **224**. The parsed data may be grouped and stored according to one or more of the categories identified during parsing (e.g., user, query subject, query domain, etc.). For example, personal data comprising data from a word processing application and a social media application may be inserted into a database accessible to the personalization server. The database may include one or more tables for the word processing application data and one or more tables for the social media application data. The data in each table may be associated using, for example, a primary key associated with a particular user, date, or some combination thereof. In some aspects, the personal data may be encrypted when the personal data is received by the data ingest component, such that the personal data is encrypted before being stored in the data store. In other aspects, the personal data may be encrypted by an encryption component associated with the data store after being stored the data store.

[0059] At operation **506**, the personalization server may receive a data request for personal data. In aspects, the personalization server may receive a data request for personal data from, for example, a client device or a language understanding server. The data request may include a query, one or more tagged terms, and/or identifying information for a user and/or a client device. In some examples, a request processing component, such as request processing engine **226**, may parse the data request to identify the included data. For example, the request processing component may identify a user token within the data request. In some aspects, the personalization server may use the user token to attempt to authenticate the user that generated the data request. In such example, if the user token cannot be authenticated, the requesting device (e.g., client device or language understanding server) is denied access to the personal data. If the user token can be authenticated, the requesting device may be provided to the personal data.

[0060] At operation **508**, the personal data may be accessed. In aspects, the parsed data request data may be used to search one or more data stores comprising personal data for a user. For example, the request processing component may use the identifying information (e.g., user ID) and/or an identified query domain (e.g., contacts) to identify the tables that correspond to at least a portion of the a user's personal data. In aspects, the personal data identified in the data store may be made accessible to the requesting device. In a particular example, the request processing component may decrypt (or cause to be decrypted) the personal data as part of making the personal data accessible to the requesting device. In some aspects, the identified data may be temporarily marked as readable to the user making the request, such that the requesting device may freely submit queries concerning the user's personal data. In other aspects, the personal data identified in the data store may be used to populate a data structure (e.g., an array, a hash, etc.) that may be transmitted to the requesting device. In such an aspect, the personalization server's data store may not be configured to be directly queried by the requesting device. In yet other aspects, the personalization server may transmit to the requesting device an acknowledgment that the searched data has been identified in the data store.

[0061] FIG. **6** illustrates an example method of personalizing a natural language understanding system from the perspective of a language understanding device as described herein. Exemplary method **600** begins at operation **602** where a data request is received by a language understanding device. In aspects, the data request may be received by a query processing component, such as query processing engine **242**. The query processing component may be accessible to one or more client devices and/or a personalization server. In some examples, the data request may include a query and/or identifying information for a user and/or one or more client devices.

[0062] At operation **604**, the language understanding device may process the data request. In aspects, the language understanding device may use a component, such as query processing component, to parse the data request into user- and/or client-identifying information and values for one or more domains, intents and/or slots. In some examples, the parsed data may be used to determine probable associations between the values and the corresponding domains, intents and/or slots. For example, the parsed data may be used as input to, or in conjunction with, an algorithm for assigning statistical weights and/or probabilities to one or more features in the personal data. In some aspects, the probable values may then be provisionally (e.g., temporarily) assigned (e.g., tagged) to the corresponding features. A portion of the identifying information and the provisionally-assigned values may then be transmitted to a personalization server.

[0063] At operation **606**, the language understanding device may access the personal data. In aspects, the query processing component may use the accessed personal data to determine the accuracy of the provisionally values assigned at operation **604**. For example, the language understanding device may determine whether one or more provisionally-assigned values exists in the accessed personal data. If the value is determined to exist, the language understanding device may convert the provisional value into a final or non-provisional value, thereby verifying the accuracy of the assignment. If the value is determined not to exist, the language understanding device may perform additional processing on the provisional value. For example, the language understanding device may use the data request data and/or the algorithm described at operation **604** to reassign one or more of the provisional values to one or more corresponding features in the personal data.

[0064] At operation **608**, the assigned values may be provided to a language understanding (LU) model. In aspects, an LU model, such as NLU model(s) **244**, may use the assigned values as input features for domain classification, intent detection, and/or slot labeling. In some examples, the LU model may use the input to query a search engine or data repository for a result set to satisfy the search query. For example, the LU model may use the input to query a search engine, content provider, or the like. In other examples, the LU model may use the input to generate a finalized query comprising the necessary features, formatting, and/or instructions to execute the finalized query. In such an example, the finalized query may be customized to be executed on the requesting device.

[0065] At operation **610**, the language understanding device may provide output to the requesting device. In aspects, the LU model may provide a result set, a finalized query or the like to a component of the language understanding device, such as query processing engine **242**. The output may be transmitted to the client device and received by a component that is capable of executing the final query and/or presenting the result set to the user.

[0066] At optional operation **612**, the LU model may be trained. In aspects, the LU model may be trained by a training component, such as training engine **246**, using the provisional assignments, the final assignments, and/or the finalized query. In some examples, an LU model may use final assignments to identify and/or determine the input expected for particular queries, query types, domains, etc. and/or to determine the probable accuracy of the one or more assigned values. In other examples, an LU model may be trained using training data. The training data may comprise randomly generated personal information and may not include signal data from the requesting user. In some aspects, the LU model may be trained according to a manual instruction, periodically or according to a defined schedule. For example, the LU model may be trained at any time that the language understanding device is not actively processing a user request received. As another example, the LU model may be trained when the language understanding device is in low use or maintenance mode.

[0067] FIGS. **7-10** and the associated descriptions provide a discussion of a variety of operating environments in which aspects of the disclosure may be practiced. However, the devices and systems illustrated and discussed with respect to FIGS. **7-10** are for purposes of example and illustration and are not limiting of a vast number of computing device configurations that may be utilized for practicing aspects of the disclosure, described herein.

[0068] FIG. **7** is a block diagram illustrating physical components (e.g., hardware) of a computing device **700** with which aspects of the disclosure may be practiced. The computing device components described below may have computer executable instructions for implementing a unified messaging application on a server computing device **106** (or server computing device **308**), including computer executable instructions for unified messaging application **720** that can be executed to employ the methods disclosed herein. In a basic configuration, the computing device **700** may include at least one processing unit **702** and a system memory **704**. Depending on the configuration and type of computing device, the system memory **704** may comprise, but is not limited to, volatile storage (e.g., random access memory), non-volatile storage (e.g., read-only memory), flash memory, or any combination of such memories. The system memory **704** may include an operating system **705** and one or more program modules **706** suitable for running unified messaging application **720**, such as one or more components in regards to FIG. **3** and, in particular, context component **711**, extract component **713**, transform component **715**, or present component **717**. The operating system **705**, for example, may be suitable for controlling the operation of the computing device **700**. Furthermore, embodiments of the disclosure may be practiced in conjunction with a graphics library, other operating systems, or any other application program and is not limited to any particular application or system. This basic configuration is illustrated in FIG. **7** by those components within a dashed line **708**. The computing device **700** may have additional features or functionality. For example, the computing device **700** may also include additional data storage devices (removable and/or non-removable) such as, for example, magnetic disks, optical disks, or tape. Such additional storage is illustrated in FIG. **7** by a removable storage device **709** and a non-removable storage device **710**.

[0069] As stated above, a number of program modules and data files may be stored in the system memory **704**. While executing on the processing unit **702**, the program modules **706** (e.g., unified messaging application **720**) may perform processes including, but not limited to, the aspects, as described herein. Other program modules that may be used in accordance with aspects of the present disclosure, and in particular for providing a unified messaging platform, may include context component **711**, extract component **713**, transform component **715**, or present component **717**, etc.

[0070] Furthermore, embodiments of the disclosure may be practiced in an electrical circuit comprising discrete electronic elements, packaged or integrated electronic chips containing logic gates, a circuit utilizing a microprocessor, or on a single chip containing electronic elements or microprocessors. For example, embodiments of the disclosure may be practiced via a system-on-a-chip (SOC) where each or many of the components illustrated in FIG. **7** may be integrated onto a single integrated circuit. Such an SOC device may include one or more processing units, graphics units, communications units, system virtualization units and various application functionality all of which are integrated (or "burned") onto the chip substrate as a single integrated circuit. When operating via an SOC, the functionality, described herein, with respect to the capability of client to switch protocols may be operated via application-specific logic integrated with other components of the computing device **700** on the single integrated circuit (chip). Embodiments of the disclosure may also be practiced using other technologies capable of performing logical operations such as, for example, AND, OR, and NOT, including but not limited to mechanical, optical, fluidic, and quantum technologies. In addition, embodiments of the disclosure may be practiced within a general purpose computer or in any other circuits or systems.

[0071] The computing device **700** may also have one or more input device(s) **712** such as a keyboard, a mouse, a pen, a sound or voice input device, a touch or swipe input device, etc. The output device(s) **714** such as a display, speakers, a printer, etc. may also be included. The aforementioned devices are examples and others may be used. The computing device **700** may include one or more communication connections **716** allowing communications with other computing devices **750**. Examples of suitable communication connections **716** include, but are not limited to, radio frequency (RF) transmitter, receiver, and/or transceiver circuitry; universal serial bus (USB), parallel, and/or serial ports.

[0072] The term computer readable media as used herein may include computer storage media. Computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, or program modules. The system memory **704**, the removable storage device **709**, and the non-removable storage device **710** are all computer storage media examples (e.g., memory storage). Computer storage media may include RAM, ROM, electrically erasable read-only memory (EEPROM), flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other article of manufacture which can be used to store information and which can be accessed by the computing device **700**. Any such computer storage media may be part of the computing device **700**. Computer storage media does not include a carrier wave or other propagated or modulated data signal.

[0073] Communication media may be embodied by computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as a carrier wave or other transport mechanism, and includes any information delivery media. The term "modulated data signal" may describe a signal that has one or more characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media may include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, radio frequency (RF), infrared, and other wireless media.

[0074] FIGS. **8**A and **8**B illustrate a mobile computing device **800**, for example, a mobile telephone, a smart phone, wearable computer (such as a smart watch), a tablet computer, a laptop computer, and the like, with which embodiments of the disclosure may be practiced. In some aspects, the client may be a mobile computing device. With reference to FIG. **8**A, one aspect of a mobile computing device **800** for implementing the aspects is illustrated. In a basic configuration, the mobile computing device **800** is a handheld computer having both input elements and output elements. The mobile computing device **800** typically includes a display **805** and one or more input buttons **810** that allow the user to enter information into the mobile computing device **800**. The display **805** of the mobile computing device **800** may also function as an input device (e.g., a touch screen display). If included, an optional side input element **815** allows further user input. The side input element **815** may be a rotary switch, a button, or any other type of manual input element. In alternative aspects, mobile computing device **800** may incorporate more or less input elements. For example, the display **805** may not be a touch screen in some embodiments. In yet another alternative embodiment, the mobile computing device **800** is a portable phone system, such as a cellular phone. The mobile computing device **800** may also include an optional keypad **835**. Optional keypad **835** may be a physical keypad or a "soft" keypad generated on the touch screen display. In various embodiments, the output elements include the display **805** for showing a graphical user interface (GUI), a visual indicator **820** (e.g., a light emitting diode), and/or an audio transducer **825** (e.g., a speaker). In some aspects, the mobile computing device **800** incorporates a vibration transducer for providing the user with tactile feedback. In yet another aspect, the mobile computing device **800** incorporates input and/or output ports, such as an audio input (e.g., a microphone jack), an audio output (e.g., a headphone jack), and a video output (e.g., a HDMI port) for sending signals to or receiving signals from an external device.

[0075] FIG. **8**B is a block diagram illustrating the architecture of one aspect of a mobile computing device. That is, the mobile computing device **800** can incorporate a system (e.g., an architecture) **802** to implement some aspects. In one embodiment, the system **802** is implemented as a "smart phone" capable of running one or more applications (e.g., browser, e-mail, calendaring, contact managers, messaging clients, games, and media clients/players). In some aspects, the system **802** is integrated as a computing device, such as an integrated personal digital assistant (PDA) and wireless phone.

[0076] One or more application programs **866** may be loaded into the memory **862** and run on or in association with the operating system **864**. Examples of the application programs include phone dialer programs, e-mail programs, personal information management (PIM) programs, word processing programs, spreadsheet programs, Internet browser programs, messaging programs, and so forth. The system **802** also includes a non-volatile storage area **868** within the memory **862**. The non-volatile storage area **868** may be used to store persistent information that should not be lost if the system **802** is powered down. The application programs **866** may use and store information in the non-volatile storage area **868**, such as e-mail or other messages used by an e-mail application, and the like. A synchronization application (not shown) also resides on the system **802** and is programmed to interact with a corresponding synchronization application resident on a host computer to keep the information stored in the non-volatile storage area **868** synchronized with corresponding information stored at the host computer. As should be appreciated, other applications may be loaded into the memory **862** and run on the mobile computing device **800**, including the instructions for providing a unified messaging platform as described herein (e.g., search engine, extractor module, relevancy ranking module, answer scoring module, etc.).

[0077] The system **802** has a power supply **870**, which may be implemented as one or more batteries. The power supply **870** might further include an external power source, such as an AC adapter or a powered docking cradle that supplements or recharges the batteries.

[0078] The system **802** may also include a radio interface layer **872** that performs the function of transmitting and receiving radio frequency communications. The radio interface layer **872** facilitates wireless connectivity between the system **802** and the "outside world," via a communications carrier or service provider. Transmissions to and from the radio interface layer **872** are conducted under control of the operating system **864**. In other words, communications received by the radio interface layer **872** may be disseminated to the application programs **866** via the operating system **864**, and vice versa.

[0079] The visual indicator **820** may be used to provide visual notifications, and/or an audio interface **874** may be used for producing audible notifications via the audio transducer **825**. In the illustrated embodiment, the visual indicator **820** is a light emitting diode (LED) and the audio transducer **825** is a speaker. These devices may be directly coupled to the power supply **870** so that when activated, they remain on for a duration dictated by the notification mechanism even though the processor **860** and other components might shut down for conserving battery power. The LED may be programmed to remain on indefinitely until the user takes action to indicate the powered-on status of the device. The audio interface **874** is used to provide audible signals to and receive audible signals from the user. For example, in addition to being coupled to the audio transducer **825**, the audio interface **874** may also be coupled to a microphone to receive audible input, such as to facilitate a telephone conversation. In accordance with embodiments of the present disclosure, the microphone may also serve as an audio sensor to facilitate control of notifications, as will be described below. The system **802** may further include a video interface **876** that enables an operation of an on-board camera **830** to record still images, video stream, and the like.

[0080] A mobile computing device **800** implementing the system **802** may have additional features or functionality. For example, the mobile computing device **800** may also include additional data storage devices (removable and/or non-removable) such as, magnetic disks, optical disks, or tape. Such additional storage is illustrated in FIG. **8**B by the non-volatile storage area **868**.

[0081] Data/information generated or captured by the mobile computing device **800** and stored via the system **802** may be stored locally on the mobile computing device **800**, as described above, or the data may be stored on any number of storage media that may be accessed by the device via the radio interface layer **872** or via a wired connection between the mobile computing device **800** and a separate computing device associated with the mobile computing device **800**, for example, a server computer in a distributed computing network, such as the Internet. As should be appreciated such data/information may be accessed via the mobile computing device **800** via the radio interface layer **872** or via a distributed computing network. Similarly, such data/information may be readily transferred between computing devices for storage and use according to well-known data/information transfer and storage means, including electronic mail and collaborative data/information sharing systems.

[0082] FIG. **9** illustrates one aspect of the architecture of a system for processing data received at a computing system from a remote source, such as a personal computer **904**, tablet computing device **906**, or mobile computing device **908**, as described above. Content displayed at server device **902** may be stored in different communication channels or other storage types. For example, various documents may be stored using a directory service **922**, a web portal **924**, a mailbox service **926**, an instant messaging store **928**, or a social networking site **930**. The unified messaging application **920** may be employed by a client that communicates with server device **902**, and/or the unified messaging application **920** may be employed by server device **902**. The server device **902** may provide data to and from a client computing device such as a personal computer **904**, a tablet computing device **906** and/or a mobile computing device **908** (e.g., a smart phone) through a network **915**. By way of example, the computer system described above with respect to FIGS. **1-6** may be embodied in a personal computer **904**, a tablet computing device **906** and/or a mobile computing device **908** (e.g., a smart phone). Any of these embodiments of the computing devices may obtain content from the store **916**, in addition to receiving graphical data useable to be either pre-processed at a graphic-originating system, or post-processed at a receiving computing system.

[0083] FIG. **10** illustrates an exemplary tablet computing device **1000** that may execute one or more aspects disclosed herein. In addition, the aspects and functionalities described herein may operate over distributed systems (e.g., cloud-based computing systems), where application functionality, memory, data storage and retrieval and various processing functions may be operated remotely from each other over a distributed computing network, such as the Internet or an intranet. User interfaces and information of various types may be displayed via on-board computing device displays or via remote display units associated with one or more computing devices. For example user interfaces and information of various types may be displayed and interacted with on a wall surface onto which user interfaces and information of various types are projected. Interaction with the multitude of computing systems with which embodiments of the invention may be practiced include, keystroke entry, touch screen entry, voice or other audio entry, gesture entry where an associated computing device is equipped with detection (e.g., camera) functionality for capturing and interpreting user gestures for controlling the functionality of the computing device, and the like.

[0084] Aspects of the present disclosure, for example, are described above with reference to block diagrams and/or operational illustrations of methods, systems, and computer program products according to aspects of the disclosure. The functions/acts noted in the blocks may occur out of the order as shown in any flowchart. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

[0085] The description and illustration of one or more aspects provided in this application are not intended to limit or restrict the scope of the disclosure as claimed in any way. The aspects, examples, and details provided in this application are considered sufficient to convey possession and enable others to make and use the best mode of claimed disclosure. The claimed disclosure should not be construed as being limited to any aspect, example, or detail provided in this application. Regardless of whether shown and described in combination or separately, the various features (both structural and methodological) are intended to be selectively included or omitted to produce an embodiment with a particular set of features. Having been provided with the description and illustration of the present application, one skilled in the art may envision variations, modifications, and alternate aspects falling within the spirit of the broader aspects of the general inventive concept embodied in this application that do not depart from the broader scope of the claimed disclosure.

What is claimed is:

1. A system comprising:

at least one processor; and

memory coupled to the at least one processor, the memory comprising computer executable instructions that, when executed by the at least one processor, performs a method for performing personalized natural language understanding, the method comprising:

receiving, at a server device, a request, the request comprising at least a query and login information for a user;

assessing a personalization server storing personal data of the user, the personal data associated with a user ID for the user;

comparing the login information to the user ID stored on a personalization server;

when the login information matches the user ID, accessing the personal data;

using the personal data as input to a language understanding model to generate a response to the query; and

providing the response to the user.

2. The system of claim **1**, further comprising:

parsing the query to identify a plurality of values associated with at least one of a domain, an intent and a slot;

arbitrating between the plurality of values, wherein the arbitrating includes using the personal data to resolve one or more slots for the plurality of values;

based on the arbitration, ranking the plurality of values, wherein the ranking comprises using the resolved one or more slots to determine a most likely value; and

providing at least one of the ranked plurality of values to the language understanding model.

3. The system of claim **1**, further comprising: uploading, from a client device, the personal data to the personalization server wherein the personal data includes at least one of: personal contacts, user files and documents, user locations, user applications, user social media information, user interests, user calendar information, user event data and user- and/or client-identifying information.

4. The system of claim **1**, wherein receiving the request includes:

parsing the query to identify one or more values associated with at least one of a domain, an intent and a slot; and

provisionally assigning the identified one or more values to a respective domain, intent or slot.

5. The system of claim **4**, wherein accessing the personal data includes:

searching the personal data for matches to one or more of the provisionally assigned values,

identifying one or more matches; and

making the data associated with the matches accessible to the server device.

6. The system of claim **5**, further including, for each provisionally assigned values matched to the personal data on the personalization server, converting the provisionally assigned values to final values.

7. The system of claim **1**, wherein the login information is used to generate a token, the token representing an encrypted identity of the user, and wherein the token is transmitted to the personalization server.

8. The system of claim **1**, wherein assessing the personalization server comprises using the token to authenticate the user on the personalization server.

9. The system of claim **1**, wherein using the personal data as input includes using the language understanding model to determine and assign one or more features of the personal data, the one or more features corresponding to at least one of a domain, an intent and a slot.

10. The system of claim **9**, wherein determining one or more features of the personal data includes using at least one of exact match, partial match, n-gram match, the number of matches, and non-zero entity match.

11. The system of claim **1**, wherein generating the response to the query includes retrieving a result set from a search engine, the result set comprising data satisfying the query.

12. The system of claim **1**, wherein the response comprises a set of instructions operable to enable the client device to satisfy the request.

13. The system of claim **1**, further comprising:

training the language understanding model using the personal data.

14. The system of claim **13**, wherein the training includes generating, by the language understanding model, one or more scores corresponding to a probability that one or more values in the personal data corresponds to at least one of a domain, an intent and a slot for the query.

15. The system of claim **14**, further comprising:

training the language understanding model using training data, the training data comprising fake user information;

wherein the language understanding model is trained when the language server is not processing the request from the user.

16. A method for performing personalized natural language understanding, the method comprising:

receiving, at a server device, a request, the request comprising at least a query and login information for a user;

assessing a personalization server storing personal data of the user, the personal data associated with a user ID for the user;

comparing the login information to the user ID stored on a personalization server;

when the login information matches the user ID, accessing the personal data;

using the personal data as input to a language understanding model to generate a response to the query;

providing the response to the user; and

training the model using the personal data.

17. The method of claim **16**, wherein receiving the request includes:

parsing the query to identify one or more values associated with at least one of a domain, an intent and a slot; and

provisionally assigning the identified one or more values to a respective domain, intent or slot.

18. The method of claim **17**, wherein accessing the personal data includes:

searching the personal data for matches to one or more of the provisionally assigned values,

identifying one or matches; and

making the data associated with the matches accessible to the server device.

19. The method of claim **1**, wherein using the personal data as input includes using the language understanding model to determine and assign one or more features of the personal data, the one or more features corresponding to at least one of a domain, an intent and a slot.

20. A system for performing personalized natural language understanding, the system comprising:

a query processing engine configured to:

receive a request, the request comprising at least a query and login information for a user;

parsing the query to identify one or more values corresponding to at least one of a domain, an intent and a slot associated with the query;

provisionally assign the identified values to their respective domains, intents or slots;

assess a personalization server storing personal data of the user; and

match the assigned values to one or more corresponding values in the personal data;

a language understanding model configured to:
accept the matched values as input; and
using the input, generate a response to the query; and
a training engine configured to:
train the language understanding model using at least one of the personal data and training data.

* * * * *