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Naik

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(54) **NAME RECOGNITION SYSTEM**

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CPC ***G10L 15/187*** (2013.01); *G10L 15/30* (2013.01); *G10L 2015/025* (2013.01); *G10L 2015/0633* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

A speech recognition system uses, in one embodiment, an extended phonetic dictionary that is obtained by processing words in a user's set of databases, such as a user's contacts database, with a set of pronunciation guessers. The speech recognition system can use a conventional phonetic dictionary and the extended phonetic dictionary to recognize speech inputs that are user requests to use the contacts database, for example, to make a phone call, etc. The extended phonetic dictionary can be updated in response to changes in the contacts database, and the set of pronunciation guessers can include pronunciation guessers for a plurality of locales, each locale having its own pronunciation guesser.

42 Claims, 8 Drawing Sheets

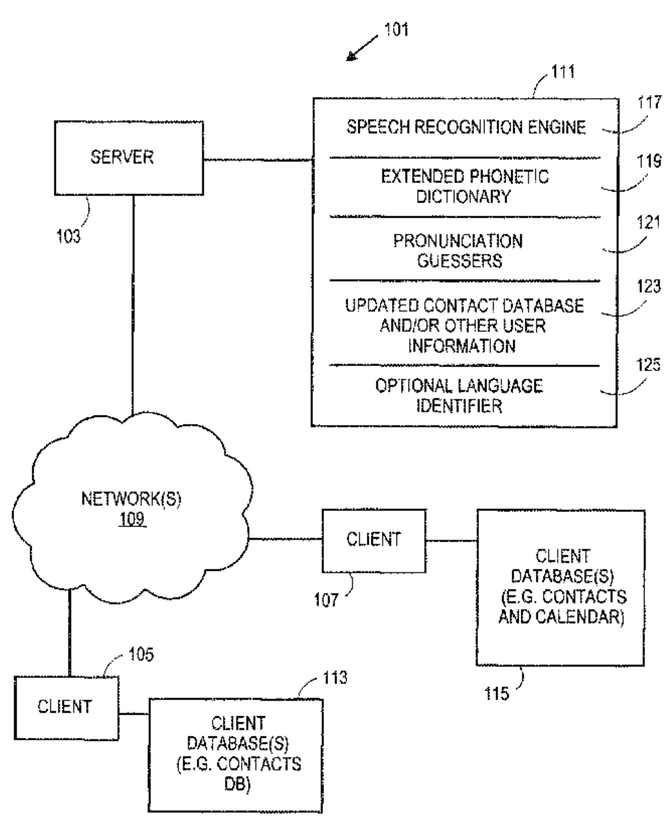

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FIG. 1

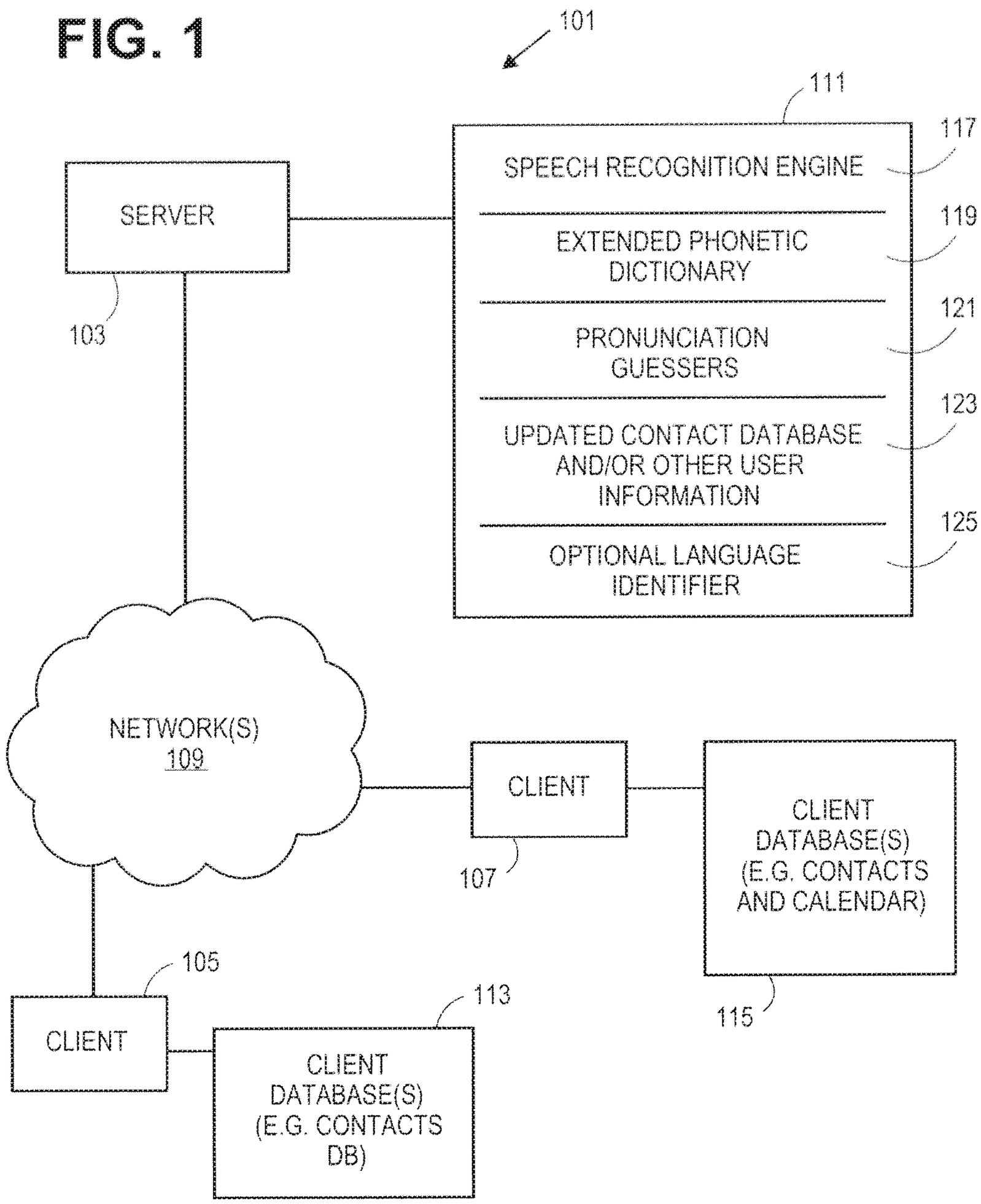

101
111
SPEECH RECOGNITION ENGINE
117
SERVER
EXTENDED PHONETIC DICTIONARY
119
103
PRONUNCIATION GUESSERS
121
UPDATED CONTACT DATABASE AND/OR OTHER USER INFORMATION
123
OPTIONAL LANGUAGE IDENTIFIER
125
NETWORK(S) 109
CLIENT
107
CLIENT DATABASE(S) (E.G. CONTACTS AND CALENDAR)
115
105
CLIENT
113
CLIENT DATABASE(S) (E.G. CONTACTS DB)

FIG. 2

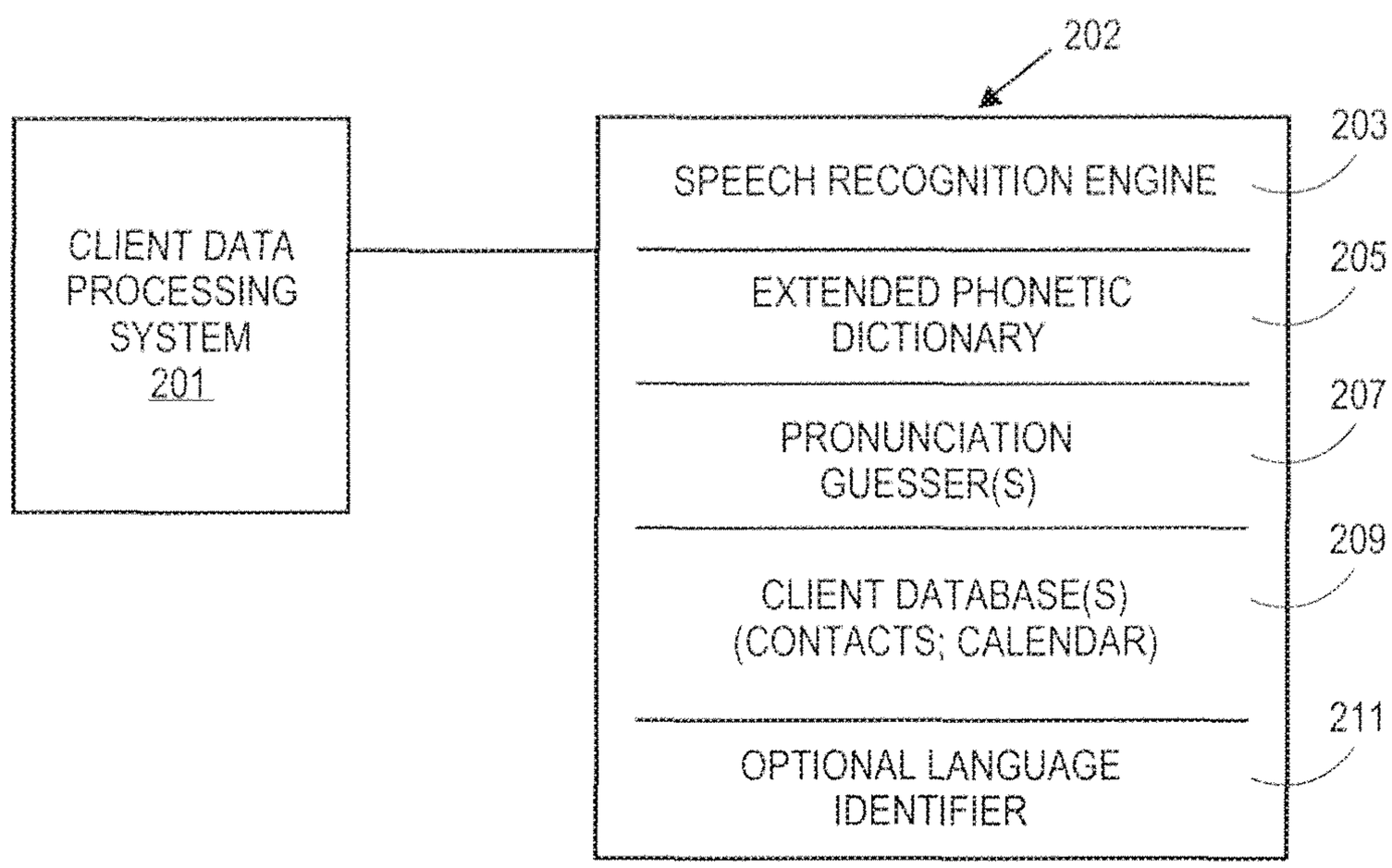

202
CLIENT DATA PROCESSING SYSTEM 201
SPEECH RECOGNITION ENGINE
203
EXTENDED PHONETIC DICTIONARY
205
PRONUNCIATION GUESSER(S)
207
CLIENT DATABASE(S) (CONTACTS; CALENDAR)
209
OPTIONAL LANGUAGE IDENTIFIER
211

FIG. 3

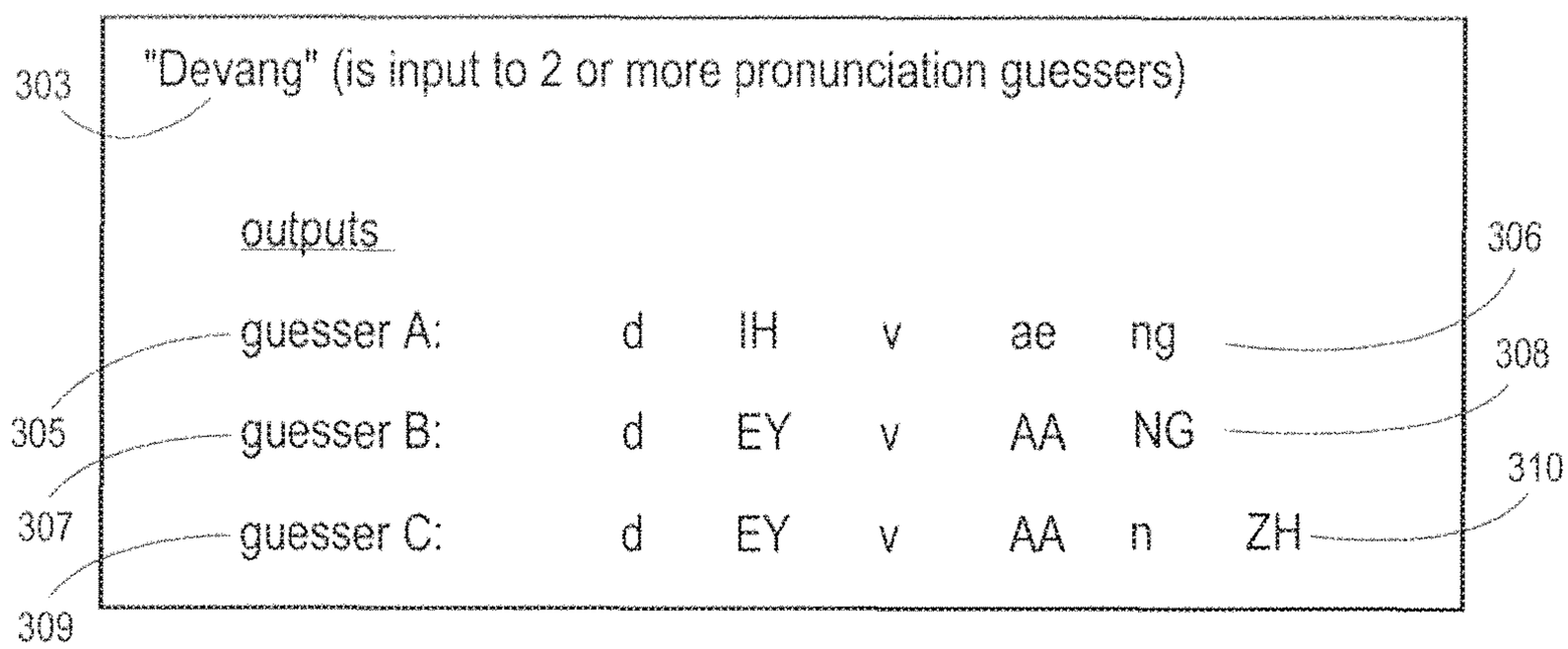
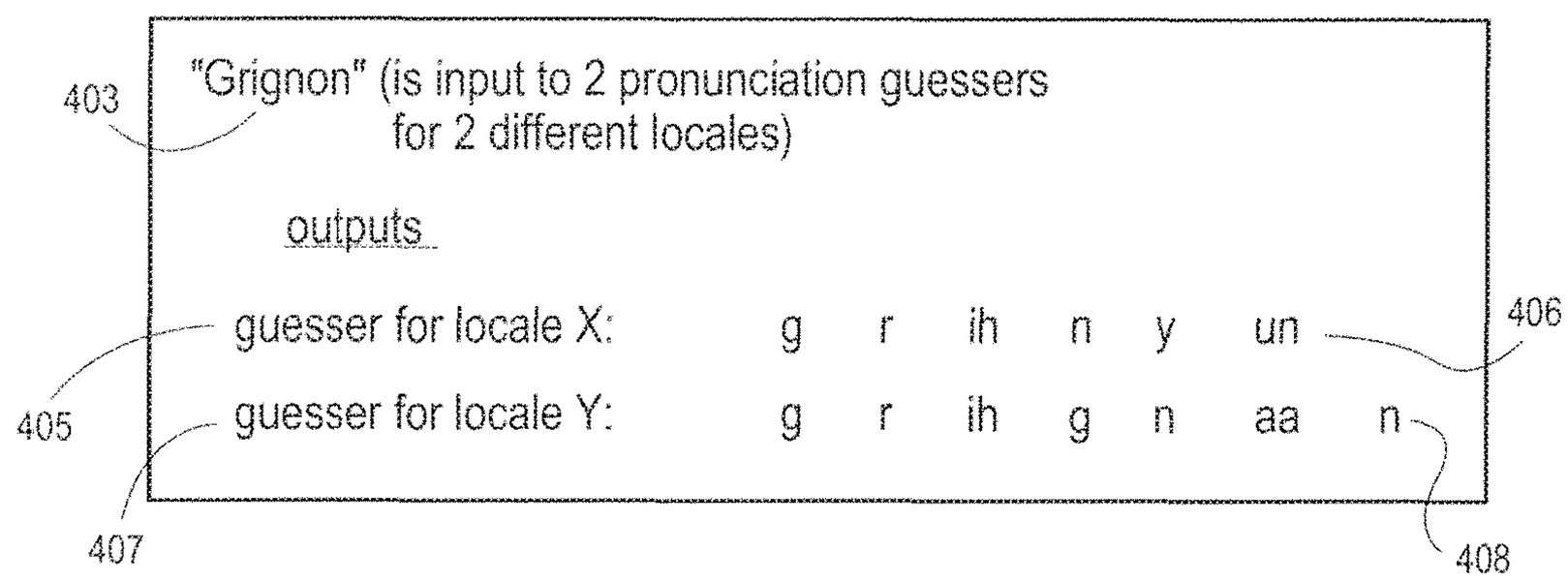

303
"Devang" (is input to 2 or more pronunciation guessers)
outputs
306
guesser A: d IH v ae ng
308
305
guesser B: d EY v AA NG
310
307
guesser C: d EY v AA n ZH
309

FIG. 4


403
"Grignon" (is input to 2 pronunciation guessers
for 2 different locales)
outputs
406
guesser for locale X: g r ih n y un
405
guesser for locale Y: g r ih g n aa n
407
408

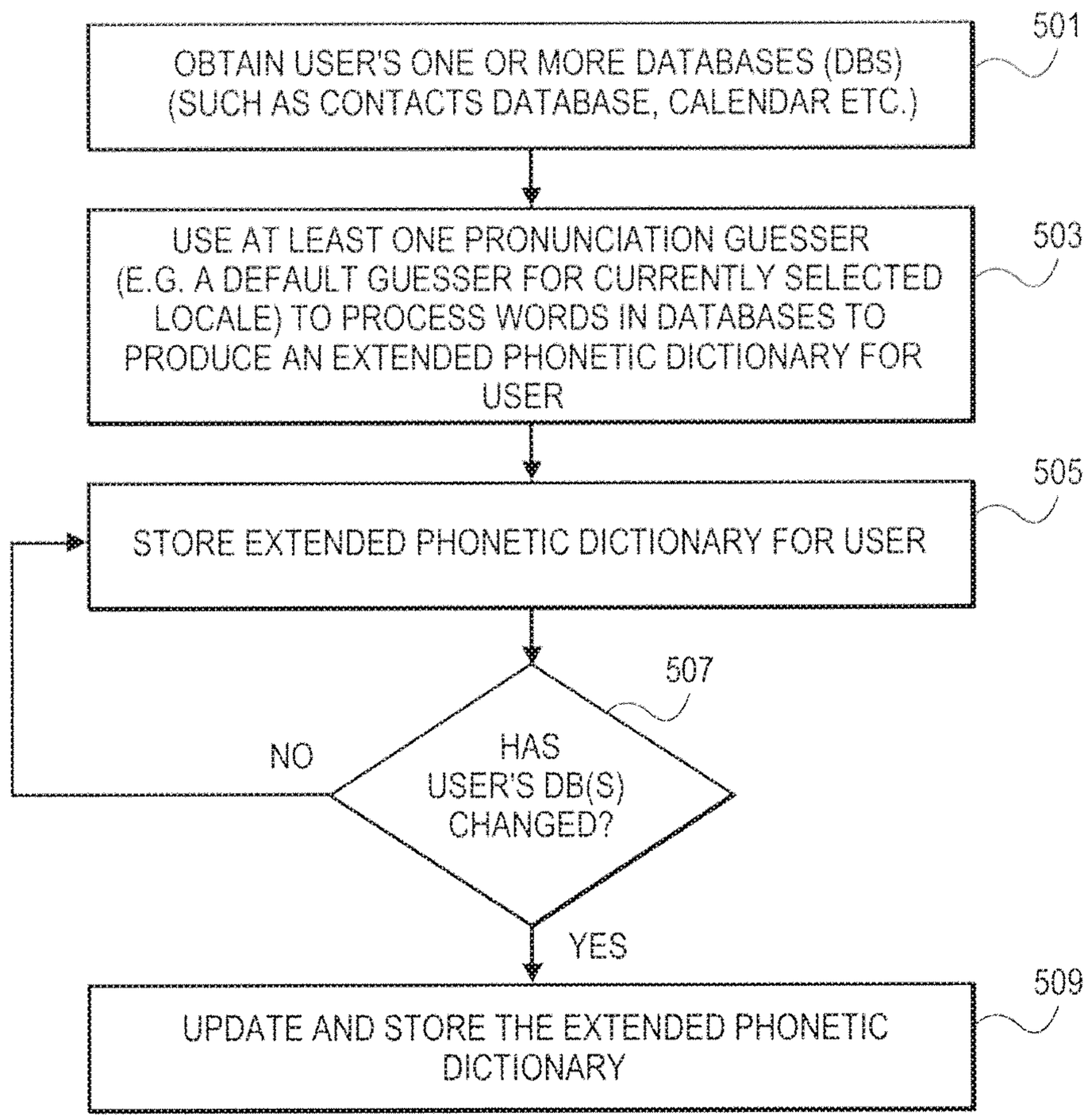

OBTAIN USER'S ONE OR MORE DATABASES (DBS) (SUCH AS CONTACTS DATABASE, CALENDAR ETC.)
501
USE AT LEAST ONE PRONUNCIATION GUESSER (E.G. A DEFAULT GUESSER FOR CURRENTLY SELECTED LOCALE) TO PROCESS WORDS IN DATABASES TO PRODUCE AN EXTENDED PHONETIC DICTIONARY FOR USER
503
STORE EXTENDED PHONETIC DICTIONARY FOR USER
505
HAS USER'S DB(S) CHANGED?
507
NO
YES
UPDATE AND STORE THE EXTENDED PHONETIC DICTIONARY
509

FIG. 5

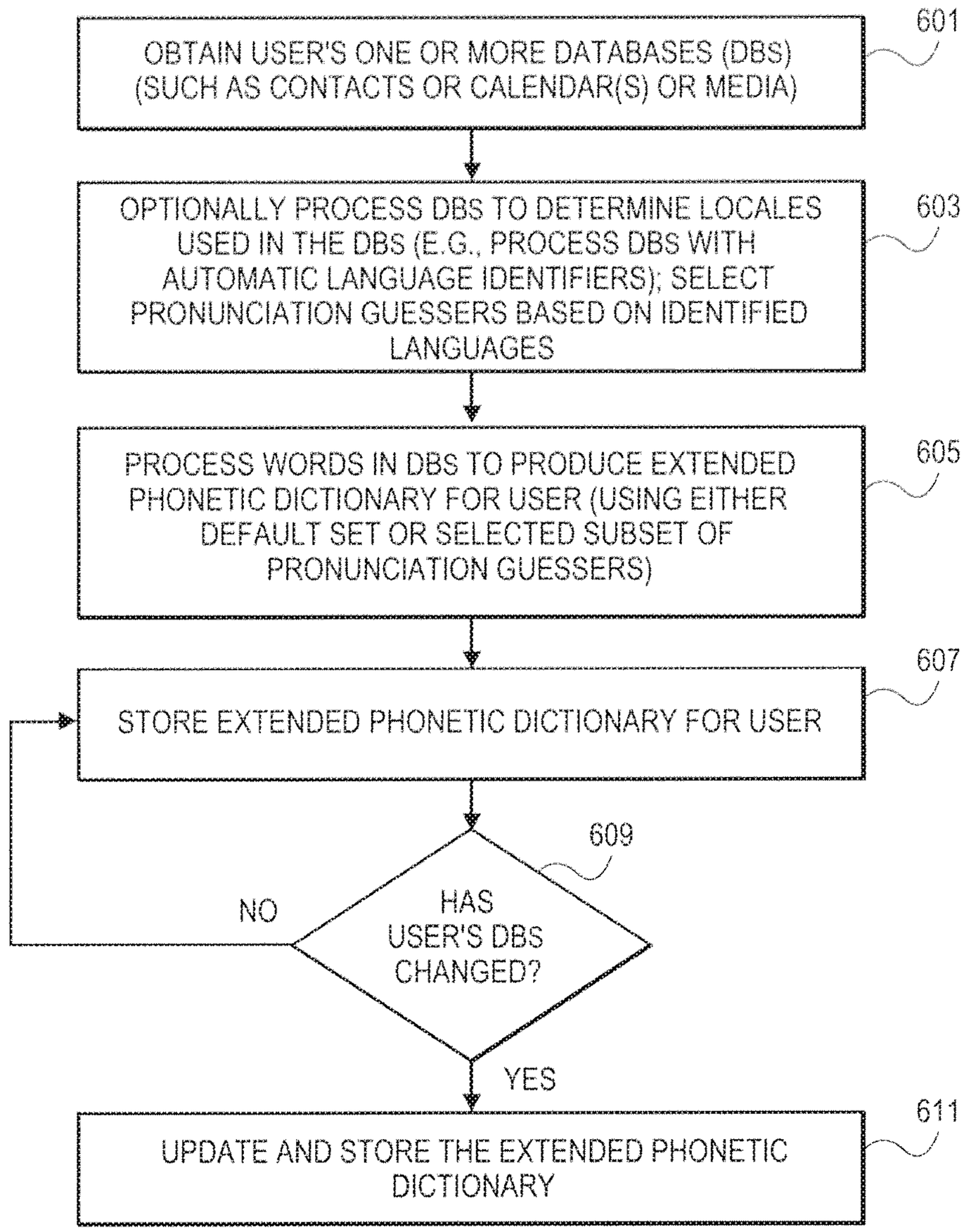

OBTAIN USER'S ONE OR MORE DATABASES (DBS) (SUCH AS CONTACTS OR CALENDAR(S) OR MEDIA)
601
OPTIONALLY PROCESS DBS TO DETERMINE LOCALES USED IN THE DBS (E.G., PROCESS DBS WITH AUTOMATIC LANGUAGE IDENTIFIERS); SELECT PRONUNCIATION GUESSERS BASED ON IDENTIFIED LANGUAGES
603
PROCESS WORDS IN DBS TO PRODUCE EXTENDED PHONETIC DICTIONARY FOR USER (USING EITHER DEFAULT SET OR SELECTED SUBSET OF PRONUNCIATION GUESSERS)
605
STORE EXTENDED PHONETIC DICTIONARY FOR USER
607
HAS USER'S DBS CHANGED?
609
NO
YES
UPDATE AND STORE THE EXTENDED PHONETIC DICTIONARY
611

FIG. 6

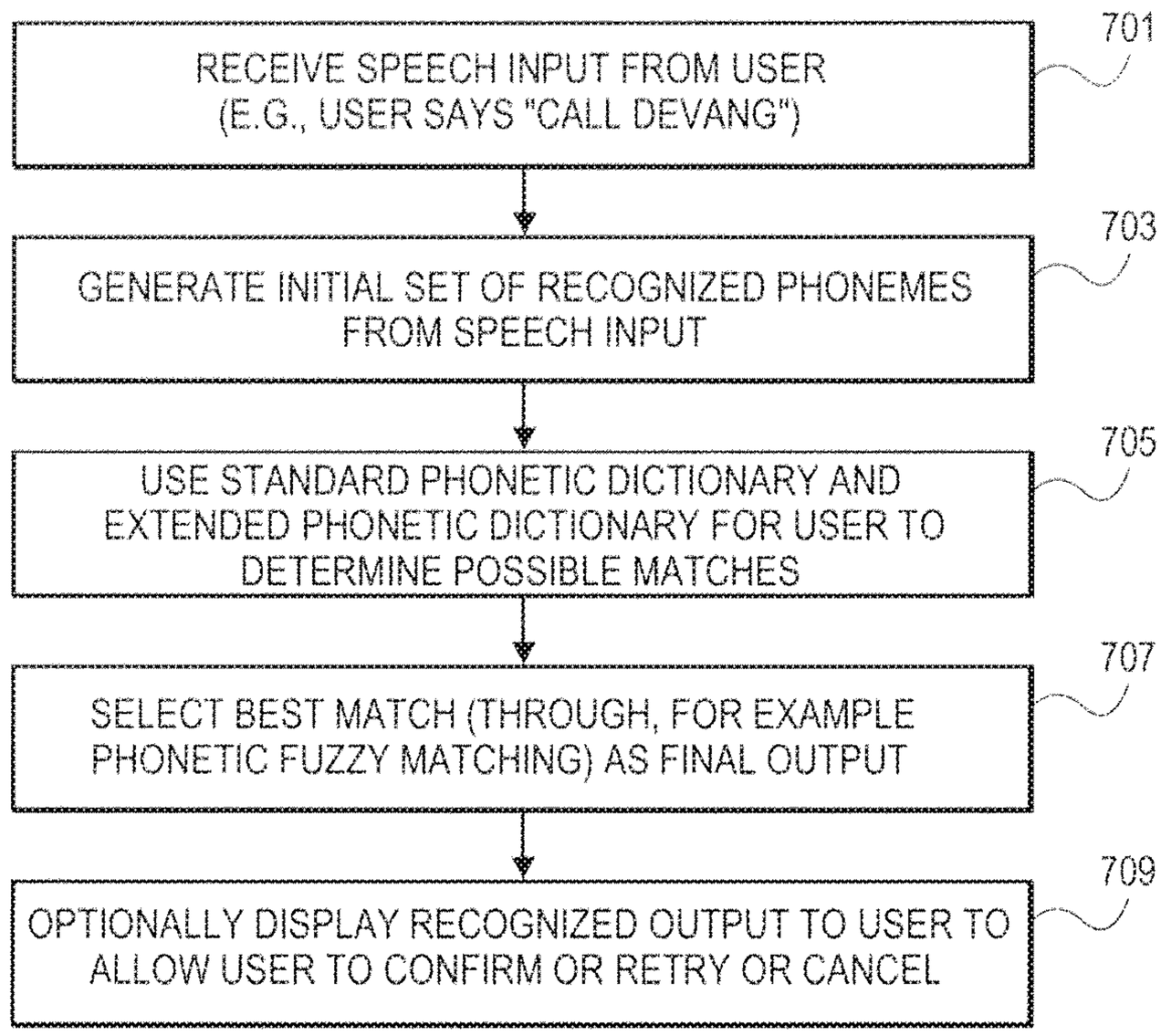

RECEIVE SPEECH INPUT FROM USER
(E.G., USER SAYS "CALL DEVANG")
701
GENERATE INITIAL SET OF RECOGNIZED PHONEMES
FROM SPEECH INPUT
703
USE STANDARD PHONETIC DICTIONARY AND
EXTENDED PHONETIC DICTIONARY FOR USER TO
DETERMINE POSSIBLE MATCHES
705
SELECT BEST MATCH (THROUGH, FOR EXAMPLE
PHONETIC FUZZY MATCHING) AS FINAL OUTPUT
707
OPTIONALLY DISPLAY RECOGNIZED OUTPUT TO USER TO
ALLOW USER TO CONFIRM OR RETRY OR CANCEL
709

FIG. 7

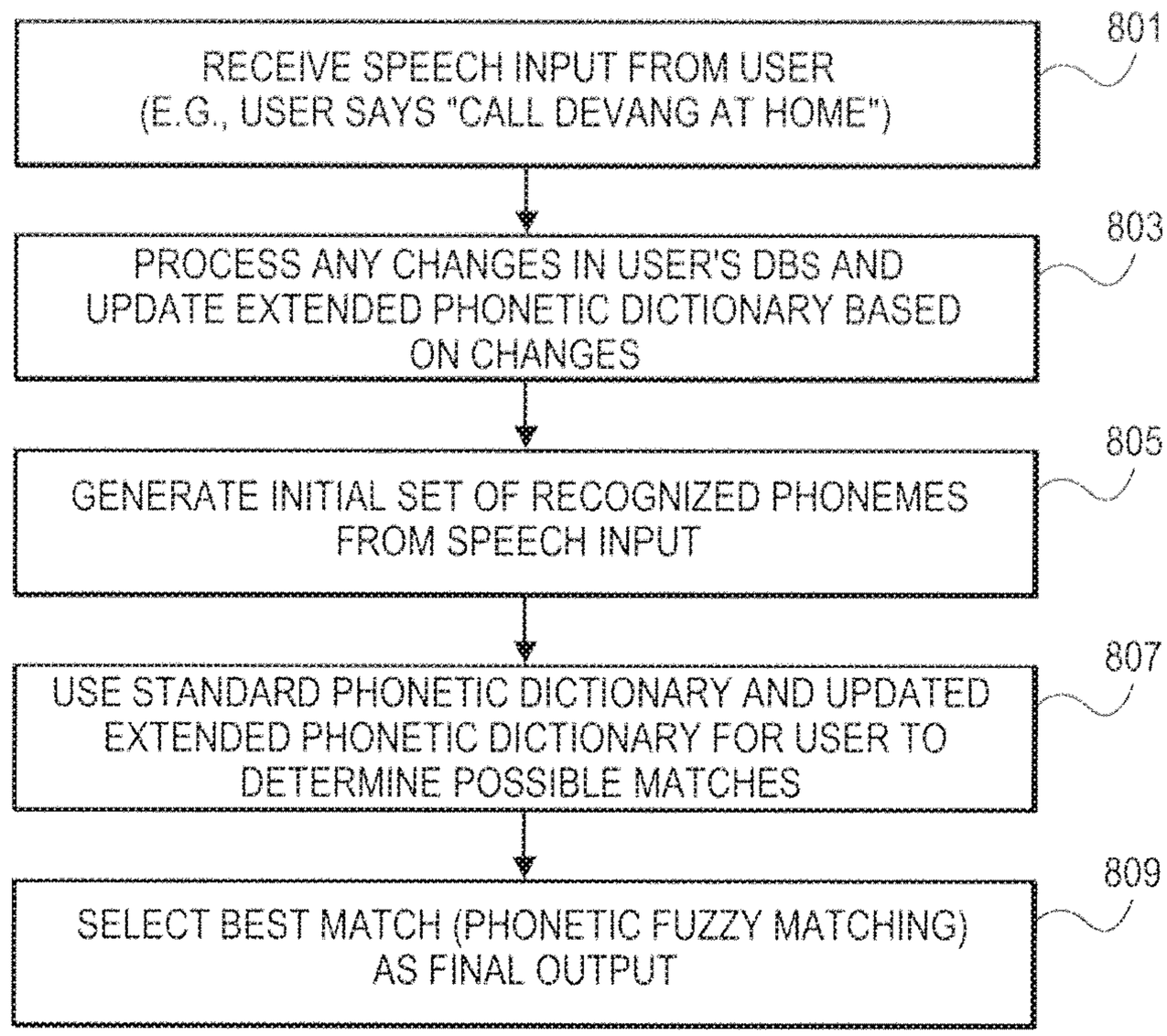

RECEIVE SPEECH INPUT FROM USER
(E.G., USER SAYS "CALL DEVANG AT HOME")
801
PROCESS ANY CHANGES IN USER'S DBS AND UPDATE EXTENDED PHONETIC DICTIONARY BASED ON CHANGES
803
GENERATE INITIAL SET OF RECOGNIZED PHONEMES FROM SPEECH INPUT
805
USE STANDARD PHONETIC DICTIONARY AND UPDATED EXTENDED PHONETIC DICTIONARY FOR USER TO DETERMINE POSSIBLE MATCHES
807
SELECT BEST MATCH (PHONETIC FUZZY MATCHING) AS FINAL OUTPUT
809

FIG. 8

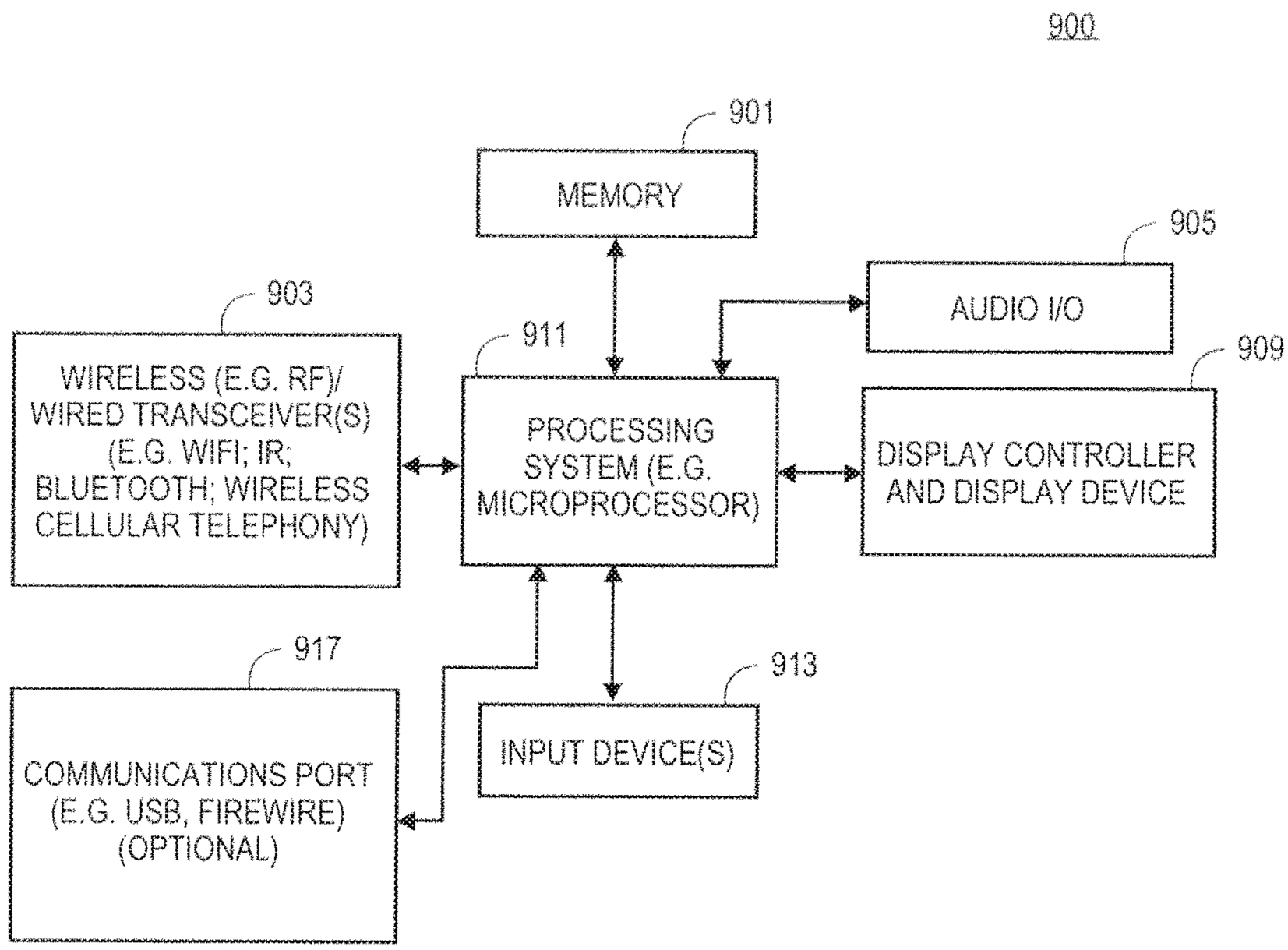

900
901
MEMORY
905
AUDIO I/O
903
WIRELESS (E.G. RF)/ WIRED TRANSCEIVER(S) (E.G. WIFI; IR; BLUETOOTH; WIRELESS CELLULAR TELEPHONY)
911
PROCESSING SYSTEM (E.G. MICROPROCESSOR)
909
DISPLAY CONTROLLER AND DISPLAY DEVICE
917
COMMUNICATIONS PORT (E.G. USB, FIREWIRE) (OPTIONAL)
913
INPUT DEVICE(S)

FIG. 9

NAME RECOGNITION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13/492,720, filed on Jun. 8, 2012, entitled NAME RECOGNITION SYSTEM, which is hereby incorporated by reference in its entirety for all purposes.

BACKGROUND OF THE INVENTION

Embodiments of the present invention relate to the field of speech recognition. Speech recognition systems have been deployed for many years on various types of devices including desktop and laptop computer systems as well as telephone systems, such as cellular telephones and/or smartphones which include cellular telephones. One use of speech recognition systems in telephones, such as smart phones, is the use of name dialing which allows a user to speak a name in a contacts database in order to cause the telephone to initiate a telephone call. Speech recognition systems can use phonetic dictionaries or lexicons in order to recognize spoken words. Some speech recognition systems, particularly those which are adapted to provide natural language recognition, use a large phonetic dictionary to model a large set of words. These systems can be used to recognize names in an address book or contacts database, but these systems often have difficulty with names due to the fact that the names are often not modeled in a phonetic dictionary or the names are in a different locale from the locale used in the phonetic dictionary.

SUMMARY OF THE DESCRIPTION

A speech recognition system can, in one embodiment of the invention, use an extended phonetic dictionary that is obtained by processing words in a user's set of databases, such as a user's contacts database or calendar or media database, etc., with a set of one or more pronunciation guessers. The speech recognition system can use a conventional phonetic dictionary and the extended phonetic dictionary to recognize speech inputs such as a speech input in which a user requests to use the contacts database, for example, to make a telephone call, etc. The extended phonetic dictionary can be updated in response to changes in the contacts database, and the set of pronunciation guessers can include pronunciation guessers for a plurality of locales, each locale having its own pronunciation guesser. In one embodiment, the extended phonetic dictionary can be updated at runtime based on changes to the user's databases, such as changes to the contacts databases, etc.

In one embodiment of the invention, a data processing system can perform a method which includes storing a phonetic dictionary for speech recognition; obtaining words from a user's set of one or more databases; processing, using a set of one or more pronunciation guessers, the words from the user's set of one or more databases, the processing producing additional phonetic data derived from the words, the additional phonetic data forming an extended phonetic dictionary for the user; receiving a speech input; and processing the speech input by comparing phonemes detected in the speech input to the phonetic dictionary and to the extended phonetic dictionary to determine a set of one or more matches, from which a best match can be determined. Phonetic fuzzy matching can be used to determine the best match. In one embodiment, the user's set of one or more

databases can include a contacts database, which can also be referred to as an address book, which includes names of people and telephone numbers and email addresses, etc. In one embodiment, the phonetic dictionary can be for a natural language speech recognition system, and the speech input from the user can be a request to call a telephone number or to send a text message to another user's device or to play a song or movie on the user's device. The user's set of one or more databases can also include one or more calendar databases, and databases for medias, such as songs or movies or pictures, etc. In one embodiment, the method can also include obtaining changes in the contacts database and processing, using the set of one or more pronunciation guessers, the changes to update the extended phonetic dictionary based on the changes; the obtaining of the changes can occur in response to the changes being made or can occur in response to a speech input which causes the system to determine whether or not such changes exist and to thereby then process those changes using the set of one or more pronunciation guessers. In one embodiment, the set of one or more pronunciation guessers include pronunciation guessers for a plurality of locales, each locale having its own pronunciation guesser. For example, if the user's device has been set for a USA English locale, then the pronunciation guessers can include, in one embodiment, pronunciation guessers for American English, Spanish, and potentially other languages which are commonly used in the United States of America (USA). If the user's device has been set for a locale in Europe, then the set of pronunciation guessers for a set of locales can include pronunciation guessers for English, French, German, and Italian. In one embodiment, the set of pronunciation guessers can include different types of pronunciation guessers for the same locale in order to provide a more robust selection of pronunciation guesses. In one embodiment, a locale can be considered to be a language or a dialect of a language.

In one embodiment, the method can also include determining automatically a set of languages or locales from the words in the user's set of one or more databases. Automatic language detection systems and modules currently exist which can analyze words in a document or database and determine, from that analysis, the languages used. An example of such an automatic language identification system is provided in published U.S. Application US2009/0307584. A subset of the set of pronunciation guessers can be selected based upon the languages identified by an automatic language identifier system, and this selected subset can then be used to process words in the user's databases, such as contacts databases, calendar databases, media databases, etc., in order to generate an extended phonetic dictionary based upon a selected subset of locales which are derived from the analysis performed by the automatic language identifier. In one embodiment, the processing of a speech input can use only that subset of pronunciation identifiers which are selected as a result of the analysis performed by the automatic language identifier.

In one embodiment, the method can be performed by a server that is coupled through a wireless network to the user's device which includes the contacts database and other databases in the user's set of databases. The wireless network can be a local WiFi network or a cellular telephone network or a combination of such wireless networks. The server can obtain the words in the user's databases through the wireless network and can receive the speech input from the user's device through the wireless network, via a network interface (at the server) which is coupled to the wireless network. The server can transmit the best match as

the result of the speech recognition operation to the user's device through the wireless network in this embodiment.

In another embodiment, all of the operations in a method according to an embodiment of the present invention can be performed on the user's device without the use of a server. In yet another embodiment, the user's device and the server can split the processing between the two devices and perform various parts of the methods described herein on each of the two devices.

The embodiments described herein can be implemented as machine readable non-transitory storage media or as methods or as one or more data processing systems.

The above summary does not include an exhaustive list of all aspects of the present invention. It is contemplated that the invention includes all systems and methods that can be practiced from all suitable combinations of the various aspects summarized above, and also those disclosed in the Detailed Description below.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings in which like references indicate similar elements.

FIG. **1** shows an example of a system in which a server provides speech recognition services to a plurality of client devices according to one embodiment of the present invention.

FIG. **2** shows an example of an embodiment of the invention in which a client data processing system implements all aspects or a portion of the aspects of one or more embodiments described herein.

FIG. **3** provides an example of the use of two or more pronunciation guessers according to one embodiment of the present invention.

FIG. **4** provides an example of the use of two pronunciation guessers for two different locales according to another embodiment of the present invention.

FIG. **5** is a flowchart which illustrates a method according to one embodiment of the present invention.

FIG. **6** is a flowchart which illustrates another method according to an embodiment of the present invention.

FIG. **7** is a flowchart which illustrates a method according to an embodiment of the present invention.

FIG. **8** is a flowchart which shows a method according to one embodiment of the present invention.

FIG. **9** is a block diagram of a data processing system which can be used to implement one or more embodiments of the present invention.

DETAILED DESCRIPTION

Various embodiments and aspects of the inventions will be described with reference to details discussed below, and the accompanying drawings will illustrate the various embodiments. The following description and drawings are illustrative of the invention and are not to be construed as limiting the invention. Numerous specific details are described to provide a thorough understanding of various embodiments of the present invention. However, in certain instances, well-known or conventional details are not described in order to provide a concise discussion of embodiments of the present inventions.

Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in conjunction with the embodiment can be included in at least one embodiment of the invention. The appearances of the phrase "in one embodiment" in various places in the specification do not necessarily all refer to the same embodiment. The processes depicted in the figures that follow are performed by processing logic that comprises hardware (e.g. circuitry, dedicated logic, etc.), software, or a combination of both. Although the processes are described below in terms of some sequential operations, it should be appreciated that some of the operations described may be performed in a different order. Moreover, some operations may be performed in parallel rather than sequentially.

FIG. **1** shows a client/server system in which a server system provides speech recognition services for one or more client devices, each of which can be a data processing system such as a smartphone or other cellular telephones. In the client/server system **101** shown in FIG. **1**, at least two client devices **105** and **107** are shown coupled through one or more networks **109** to a server system **103**. Server system **103** can be a general purpose computer system or a special purpose computer system or other types of data processing systems (such as the system shown in FIG. **9**) which can be configured to provide speech recognition services; for example these systems can be configured by using software that programs the data processing system to perform the speech recognition services. This software can include a speech recognition engine **117** stored in a storage device **111**. The speech recognition engine **117** can, in one embodiment, be a natural language speech recognition system that uses a conventional phonetic lexicon such as a phonetic dictionary as is known in the art. Storage device **111** also includes other components which can be used by the server system **103** and which will be described further below. In the system shown in FIG. **1**, each of the clients, such as clients **105** and **107** can send a digitized speech input to the server system **103** which then processes the digitized speech input using the speech recognition system at the server system **103**. Each of the clients, such as clients **105** and **107** can be a desktop computer system or a laptop computer system or a cellular telephone, or a smartphone, or other data processing systems or consumer electronic devices, including embedded electronic devices. These clients can include one or more databases for each of the clients. For example, client **105** can be a smartphone for a particular user that includes databases for that user such as a contacts or address book database and a calendar database, and media databases, and potentially other databases storing information for that particular user, which can be unique for that particular user relative to other users of other client systems.

In the example shown in FIG. **1**, the client databases **113** can be stored on storage device, such as flash memory of client **105** and can be local storage only at client **105** system; in another embodiment, the client databases, such as client database **113** can be stored remotely on a server system which is accessible through a network. Similarly, client **107** includes client databases **115** which can be unique for the user of client system **107** and can include a contacts database and a calendar database and potentially other databases. Each of the client systems, such as client systems **105** and **107** can include a speech input hardware system such as one or more microphones designed to capture the user's speech input and then a system which processes and digitizes that speech input and then transmits that speech input through one or more networks **109** to the server system **103**. In one embodiment, one or more of the client systems, such as client systems **105** or **107** or a server system such as server **103** may include a speech repair system, such as the system described in pending U.S. patent application Ser. No.

13/247,912, filed Sep. 28, 2011, and entitled "Speech Recognition Repair Using Contextual Information", and this application is hereby incorporated herein by reference.

Each of the clients in system **101** can be configured to transmit data representing the content of each of the client databases so that the server system **103** can process the words in the databases according to the methods described herein using the pronunciation guessers to generate one or more extended phonetic dictionaries according to the embodiments described herein.

The one or more networks **109** can be one or more cellular telephone networks or one or more local area wireless networks, such as one or more WiFi networks or a combination of such networks and can include both wired and wireless portions. The one or more networks **109** serve to provide a data connection to transmit data, such as words in the client databases, such as names and telephone numbers in the contacts databases of the various users using the client devices, and the one or more networks **105** can also provide, in one embodiment, voice telephony services allowing users to talk over their cellular telephones as well as provide text messaging services and other services known in the art in connection with cellular telephones or smartphones.

Storage device **111** is coupled to server system **103** either as part of the server system **103** (e.g., a local hard drive of server system **103**) or as a storage device on a network which is coupled to server system **103**. Server system **103** can be a set of servers in a server farm and storage device **111** can be a set of storage devices in a Storage Area Network (SAN). Storage device **111** can be one or more hard drives containing software and data to provide the speech recognition services described in conjunction with the one or more embodiments herein. Speech recognition engine, as noted above, can be a conventional speech recognition system which uses a conventional phonetic dictionary. In addition, the present invention provides an extension to that phonetic dictionary through one or more extended phonetic dictionaries **119**. In one embodiment, each user which is provided speech recognition services by server system **103** can have their own dedicated extended phonetic dictionary **119** which is produced according to one or more methods described herein. The server system **103** can also include one or more pronunciation guessers **121** which are used to process words in the client databases retrieved from (e.g., dynamically uploaded from) client devices. As shown in FIG. **1**, storage device **111** can include an updated contacts database and/or other user information for each of the users of client devices, such as client devices **105** and **107**. In one embodiment, each client device can upload the latest version of contact databases and other databases from each client device or can upload just the last set of changes that were made since the last upload of the client database or changes to the client database. In one embodiment, each client device can upload a contacts database, a calendar database, a media database, and potentially other databases containing unique user information, and these databases are stored as, for example, updated contact database **123** in the storage device **111**. In one embodiment, storage device **111** can also include one or more optional language identifier systems, such as optional language identifier **125** which can be a software module that performs automatic language identification, such as the automatic language identification described in published U.S. Patent Application US2009/0307584 which application is hereby incorporated herein by reference. The optional language identifier can analyze the words in the client's databases to determine the languages or locales used in the those databases and to thereby select the subset of pronunciation guessers which are appropriate for those locales and which match those locales; further aspects with respect to automatic language identification are described further below.

While FIG. **1** shows an example of a client/server architecture in which a server performs at least a portion of the speech recognition services according to one embodiment, FIG. **2** represents an alternative embodiment in which a client device performs all those services without the need for a server system to perform speech recognition services. In this embodiment, a client data processing system such as the system **201** can have all the resources stored on a local storage device **201**. These resources can include a speech recognition engine **203** which can be, in one embodiment, software and data designed to provide natural language speech recognition and can include a standard or conventional phonetic dictionary used in the process of providing natural language speech recognition. In addition, storage device **201** can include an extended phonetic dictionary **205** which is derived from one or more user databases **209**, such as a contacts database or a calendar database or a media database or other databases specific to and unique to the user of the client system **201**. The extended phonetic dictionary **205** can be derived by using one or more pronunciation guessers, such as pronunciation guessers **207** which process words in the one or more client databases **209** on the storage device **201**. In one embodiment, the client databases can include a contacts or address book database or other data structures that include names, telephone numbers, addresses, email addresses, and other contact information and other pertinent information for one or more people or businesses for the user of the data processing system **201**. In addition, other databases can include a calendar, database or a plurality of calendar databases, a media database, such as a song, movie, etc. database, and other user databases which may be the subject of speech input commands from the user of data processing system **201**. Data storage **202** may also include an optional language identifier **211** which can be an automatic language identification module, such as the systems described in published U.S. Patent Application 2009/0307584.

It will be appreciated that the system shown in FIG. **1** or **2** can be employed with a variety of the different embodiments described herein, such as the embodiments described in conjunction with FIGS. **5**, **6**, **7**, and **8** as well as other embodiments described herein. Moreover it will be appreciated that the processing operations in any one of the methods described herein may be split among a client and server architecture such that a client system can perform some of the operations while the server performs other of the operations in order to achieve a result of any one of the methods described herein.

FIGS. **3** and **4** show two examples of the use of a plurality of pronunciation guessers when words in a user's database, such as a contacts or address book database are being processed. In the example shown in FIG. **3**, an input word "Devang" is used as an input to two or more pronunciation guessers. This input word **303** results in three different outputs from three different pronunciation guessers **305** and **307** and **309**. In particular, outputs **306** and **308** and **310** result from the processing performed by three different pronunciation guessers, guessers **305** and **307** and **309** respectively, based upon the input. The three different pronunciation guessers can be pronunciation guessers that use different techniques in processing the inputs to derive an output. There are a plurality of known pronunciation guessers that can be used in various embodiments of the present

invention. For example, one known pronunciation guesser uses a classification and regression tree to guess the pronunciation of words which in effect converts letters to sound rules. Another example of a known pronunciation guesser which can convert letters to sound rules is a pronunciation guesser which employs a maximum likelihood estimation technique. Yet another pronunciation guesser which can be used is a character language modeling pronunciation guesser which can also provide an output at a phoneme level based upon an input word. In the example shown in FIG. **3**, each of the pronunciation guesser **305** and **307** and **309** may be for the same locale, such as an American English locale or a French locale or a European Spanish locale. In another embodiment, the example of FIG. **3** shows the use of pronunciation guessers for three different locales (for example, A=USA locale; B=Spanish locale; and C=French locale), and each of these pronunciation guessers can use the same technique (for example, maximum likelihood estimation) for their corresponding locale.

FIG. **4** shows another example which can be employed in various embodiments of the present invention in which an input word from a user's database, such as a contacts database, is processed using two different pronunciation guessers for two different locales. In this case, the same pronunciation guesser technique, such as a maximum likelihood estimation technique can be used for two different locales. This approach is advantageous when a user's device is likely to contain names or other words that are from different locales. For example, it is often the case in the United States that individual names in a user's contacts or address book can be Spanish names or Chinese names or certain other locales. In this case, it is advantageous that pronunciation guessers for different locales be employed to analyze the names and words in the user's databases in order to generate different outputs which can then be matched using known techniques, such as phonetic fuzzy matching techniques, in order to derive a best match from a set of possible matches, as will be explained further below. In this example shown in FIG. **4**, an input word **403** is provided as an input to two pronunciation guessers for two different locales. For example, one locale can be for American English and another locale can be for American Spanish. Each guesser for each locale can then provide an output, such as the outputs **406** and **408** from the guessers **405** and **407** respectively as shown in FIG. **4** and these outputs can be mapped, as explained herein, to the target locale of the standard phonetic dictionary. These outputs can then be used as part of the extended phonetic dictionary for the user when speech recognition is performed. In one embodiment, these extended phonetic dictionaries can be embedded within a conventional or standard phonetic dictionary or can be maintained and processed separately from a standard or conventional phonetic dictionary. In either case, the use of the extended phonetic dictionary can improve the accuracy of speech recognition when the speech recognizer is attempting to recognize names in one or more locales in a user's set of databases, such as a contacts database. In one embodiment, a standard phonetic dictionary will be configured or designed to work in a particular locale which can be referred to as a target locale; for example, a user who lives in the USA and speaks American English would have a system that uses a standard phonetic dictionary that uses American English as the target locale. Further, pronunciation guessers for other locales that were used to create the extended phonetic dictionary may use a mapping from phonemes in the other locales to phonemes in the target locale, and this mapping can be done using an aligner or a set of manually setup rules that were prepared by a linguist who is familiar with the languages used in the target locale and one or more of the other locales. For example, if a Finnish pronunciation guesser is used to create outputs for the extended phonetic dictionary then a mapping from Finnish phonemes to phonemes in the target locale can be used to create the final output for the extended phonetic dictionary.

FIGS. **5** and **6** illustrate two exemplary methods for maintaining an extended phonetic dictionary even after the user makes one or more changes to the user's databases. For example, the methods shown in FIGS. **5** and **6** can maintain the extended phonetic dictionary while the user adds names to a contacts database or changes the names (for example when someone gets married) or deletes names from their contacts or address book. A method as in FIG. **5** can begin in operation **501** in which the data processing system obtains a user's one or more databases such as the user's contacts database and calendar database, and/or media database. These databases can be obtained by uploading the databases from the user's device through a network to a server, such as the server system **103** in the case of FIG. **1** or can be obtained by localing retrieving the databases from the user's data processing system as in the case of FIG. **2**. It will be appreciated that the term "database" is meant to cover any data structure containing the user data such as contacts or address book data or calendar data or media data or other types of user data. These data structures can be a structured data structure in which data is entered into fields or can be an unstructured data structure as in, for example, a sequence or string of text. Then in operation **503**, the data processing system can use at least one pronunciation guesser, such as a default guesser for the currently selected locale on the data processing system, to process words in databases to produce an extended phonetic dictionary for the user. FIG. **4** shows one such example in which a set of pronunciation guessers for different locales is used to process words in the user's databases. In the case of the architecture shown in FIG. **1**, the server system **103** can perform operation **503** by processing words in the databases, after the databases have been retrieved through the uploading process. In the case of the architecture shown in FIG. **2**, the client data processing system can perform operation **503** by using its local versions of one or more pronunciation guessers **207** to create a local extended phonetic dictionary **205** which is derived from the processing of the pronunciation guesser **207** on words in client database **209**. After operation **503**, the system can then store the extended phonetic dictionary for the user in operation **505**; the storage of the extended phonetic dictionary can either be a local storage as in the case of the architecture shown in FIG. **2** or a remote storage, relative to the user's device, as in the case of the architecture shown in FIG. **1**. After an initial or updated version of an extended phonetic dictionary has been stored, the system in operation **507** can determine whether or not the user's databases have changed. Operation **507** may be performed as a periodic or intermittent task (e.g. at every system start-up or wake from sleep) or may be performed in response to a notification from a daemon software component that a user's database has changed or can be performed in response to a speech input which can then determine whether or not the user's database has changed since the last time that the extended phonetic dictionary was updated. If no change has occurred then, the extended phonetic dictionary last created can be maintained in storage, but if a change has occurred in one of the user's databases, then operation **509** can be performed in which the extended phonetic dictionary is updated by performing

operation **503** again and storing the result of the updated extended phonetic dictionary. Operation **509** can involve using at least one pronunciation guesser on the entire user's databases without regard the changes (if the prior extended phonetic dictionary is to be discarded) or can be performed on just the portions of the databases that have changed.

FIG. **6** shows an example of another method for creating and maintaining an extended phonetic dictionary for a user's one or more databases, such as contacts or calendars or media databases or a combination of such databases. In operation **601**, a data processing system can obtain the user's one or more databases from either a local storage as in the case of the architecture shown in FIG. **2** or by receiving the databases when the client device uploads the one or more databases as in the architecture shown in FIG. **1**. After the databases are obtained, operation **603** can optionally be performed in order to determine the locales that are used in the databases. This can be performed with the use of automatic language identifiers which are known in the art; see for example published U.S. Patent Application US2009/0307584. These automatic language identifiers can process the words in the user's one or more databases and determine the locales based on those words. The result of operation **603**, if performed, can allow a system to select a subset of available pronunciation guessers based on the identified languages so that the system need only use that subset rather than all of the pronunciation guessers which are available to the system. For example, if the system has ten pronunciation guessers for ten different locales, and the language identifier determines that only three locales are used in the user's databases, then only those three pronunciation guessers can be used when processing the words in the user's database in order to create the extended phonetic dictionary. If operation **603** is not performed, then the system can use a default set of pronunciation guessers based upon a currently selected locale. For example, if the United States of America is the currently selected locale, then the default pronunciation guessers could be a pronunciation guesser for American English and American Spanish (i.e., Spanish spoken in the USA), and no other pronunciation guessers are used when processing the user's set of one or more databases to create the extended phonetic dictionary. In operation **605**, the data processing system processes the words in the databases to produce the extended phonetic dictionary for the user, again using either a default set of pronunciation guessers or a selected subset of pronunciation guessers. It will be appreciated that in addition to using different pronunciation guessers for different locales, the system can also use different types of pronunciation guessers. As described herein there are at least three different types of pronunciation guessers which are currently available. After the words are processed in operation **605**, the system can store the extended phonetic dictionary for the user in operation **607**, and then operation **609**, which resembles operation **507**, can be performed. In response to determining in operation **609** that the user's database has changed, then the extended phonetic dictionary is updated based upon those changes by either processing just the changes or by repeating the entire processing of the entire database and discarding the previously created extended phonetic dictionary.

FIGS. **7** and **8** provide examples of methods in which the extended phonetic dictionary is used in conjunction with speech recognition. In one embodiment, the speech recognition system used in both FIGS. **7** and **8** can be a natural language speech recognition system which uses a large and conventional phonetic dictionary as part of the speech recognition engine, such as speech recognition engine **117** in FIG. **1** or **203** in FIG. **2**. The method shown in FIG. **7** can begin in operation **701** in which a data processing system receives a speech input from the user; for example the user can say (by speaking into a microphone of a client device) "call Devang" and the client system can receive and digitize the speech input using known techniques and then process the speech input using a speech recognition engine such as the speech recognition engine **117** or the speech recognition engine **203**. In the case of the use of speech recognition **203**, the speech input is received and processed at the client data processing system **201**, whereas in the embodiment shown in FIG. **1**, the speech input is received and digitized and then transmitted through network **109** to the server system **103** which then processes the digitized speech input, after having received it through a network interface at the server system **103**. The speech recognition engine can then generate in operation **703** an initial set of recognized phonemes from the speech input received in operation **701**. Then the system can in operation **705** use the standard phonetic dictionary and the extended phonetic dictionary (which can be embedded in the standard phonetic dictionary) for the user to determine possible matches. In one embodiment, the determining of possible matches can use a technique to obtain a priori knowledge about where, in a recognized sequence of phonemes, names are expected to be and to use the extended phonetic dictionary on at least the portion of phonemes where names are expected to be. For example, as explained in the "Speech Recognition Repair Using Contextual Information" U.S. patent application (Ser. No. 13/247,912, filed Sep. 28, 2011) referred to herein, contextual information can be used to predict the location of a name between two recognized words "call" and "mobile" when the user says "call Devang mobile". In this case, the recognized words "call" and "mobile" can be used to determine that the phonemes between those recognized words are likely to be phonemes for a name; in other words, the system can use the context of the words "call" and "mobile" (as indicating a request to make a phone call to someone's mobile phone) to infer that the phonemes between those words are for a name and then use the extended phonetic dictionary, having multiple locales, on at least those phonemes. In operation **707**, the system can then select the best match as a final recognized output; the selection of a best match can utilize phonetic fuzzy matching techniques which are known in the art. Then in operation **709** a client data processing system, such as client system **105** or **107** or **201** can optionally display the recognized output from operation **707** to the user to allow the user to confirm or to retry by speaking the input again or to cancel the operation requested by the user.

FIG. **8** shows another example of a method according to an embodiment of the invention in which speech is processed using an extended phonetic dictionary in combination with a standard phonetic dictionary. In operation **801**, the speech input is received from the user; this input can be, for example, "call Devang at home". The words "call" and "at" and "home" can be recognized by the standard phonetic dictionary and the word "Devang" can be recognized by the extended phonetic dictionary. Operation **801** can be similar to operation **701** in which the speech input can be received at a client device and then transmitted through a network to a server system or can be received at the client device and processed at the client device as in the architecture shown in FIG. **2**. In response to operation **801**, the system can then in operation **803** process any changes in the user's databases and update the extended phonetic dictionary based on those changes. In the embodiment shown in FIG. **8**, it is assumed that the data processing system will be fast enough to

perform operation **803** after having received the speech input. Then in operation **805** the system generates an initial set of recognized phonemes from the received speech input. These recognized phonemes are then processed using a standard phonetic dictionary and the updated extended phonetic dictionary for the user to determine possible matches. The best match can then be selected in operation **809** by using, for example, conventional phonetic fuzzy matching to derive the final output from the speech recognition system. As in the method shown in FIG. **7**, the method of FIG. **8** can also include an optional operation in which the recognized output is displayed to the user to allow the user to confirm the operation requested in the speech input or to retry the speech input process again or to cancel operation.

FIG. **9** shows an example of data processing system **900** which may be used with one or more embodiments of the present invention. For example and in one embodiment, system **900** may be implemented as a portable data processing device such as a smartphone or tablet (e.g., iPad) device or a laptop or an entertainment system and client systems **105**, **107**, and **201** can be implemented as shown in FIG. **9**. The data processing system **900** shown in FIG. **9** includes a processing system **911**, which may be one or more microprocessors or which may be a system on a chip (integrated circuit) and the system also includes memory **901** for storing data and programs for execution by the processing system. The memory **901** can store, for example, the software components described in conjunction with FIG. **1** or **2** and memory **901** can be any known form of a machine readable non-transitory storage medium, such as semiconductor memory (e.g., flash; DRAM; SRAM; etc.) The system **900** also includes an audio input/output subsystem **905** which may include a microphone and a speaker for, for example, playing back music or providing telephone functionality through the speaker and microphone. The microphone can receive the speech input described herein and that input can be digitized and provided to a speech recognizer system as described herein.

A display controller and display device **909** can provide a visual user interface for the user; this interface may include a graphical user interface which is similar to that shown on a Macintosh computer when running OS X operating system software or iOS software on an iPhone or iPad. The system **900** also includes one or more wireless transceivers **903** to communicate with another data processing system. A wireless transceiver may be a WLAN transceiver (e.g. WiFi), an infrared transceiver, a Bluetooth transceiver, and/or a wireless cellular telephony transceiver. It will be appreciated that additional components, not shown, may also be part of the system **900** in certain embodiments, and in certain embodiments fewer components than shown in FIG. **9** may also be used in a data processing system. The system **900** further can include one or more communications ports **917** to communicate with another data processing system. The communications port may be a USB port, Firewire port, Bluetooth interface, a docking port, etc.

The data processing system **900** also includes one or more input devices **913** which are provided to allow a user to provide input to the system. These input devices may be a keypad or a keyboard or a touch panel or a multi-touch panel which is overlaid and integrated with a display device such as display device **909**. The data processing system **900** can also include an optional input/output device which may be a connector for a dock. It will be appreciated that one or more buses, not shown, may be used to interconnect the various components as is well known in the art. The data processing system shown in FIG. **9** may be a handheld computer or a personal digital assistant (PDA), or a cellular telephone with PDA-like functionality, or a handheld computer which includes a cellular telephone, or a media player, such as an iPod, or a game or entertainment device, or devices which combine aspects or functions of these devices, such as a media player combined with a PDA and a cellular telephone in one device or an embedded device or other consumer electronic devices. In other embodiments, the data processing system **900** may be a network computer or an embedded processing device within another device, or other types of data processing systems which have fewer components or perhaps more components than that shown in FIG. **9**.

Data processing system **900** can optionally include one or more hardware devices designed to digitize and store human speech received by the microphone in Audio I/O **905**.

At least certain embodiments of the inventions may be part of a digital media player, such as a portable music and/or video media player, which may include a media processing system to present the media, a storage device to store the media and may further include a radio frequency (RF) transceiver (e.g., an RF transceiver for a cellular telephone) coupled with an antenna system and the media processing system. In certain embodiments, media stored on a remote storage device may be transmitted to the media player through the RF transceiver. The media may be, for example, one or more of music or other audio, still pictures, or motion pictures.

Examples of a portable media player are described in published U.S. Pat. No. 7,345,671 and U.S. published patent application number 2004/0224638, both of which are incorporated herein by reference.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will be evident that various modifications may be made thereto without departing from the broader spirit and scope of the invention as set forth in the following claims. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

What is claimed is:

1. A non-transitory machine-readable storage medium storing one or more programs, comprising instructions, which when executed by one or more processors of an electronic device, cause the electronic device to:

detect a change in a user's set of one or more databases;

responsive to detecting the change in the user's set of one or more databases,

obtain words from the user's set of one or more databases; and

process, using a set of one or more pronunciation guessers, the words from the user's set of one or more databases, the processing producing additional phonetic data derived from the words, the additional phonetic data forming an extended phonetic dictionary for the user;

receive a speech input;

perform speech recognition on the speech input to determine phonemes in the speech input and to determine a set of one or more matches using the determined phonemes, a phonetic dictionary, and the extended phonetic dictionary;

determine a best match from the set of one or more matches; and

provide an output associated with the best match.

2. The non-transitory medium as in claim **1**, wherein providing the output associated with the best match com-

prises displaying a speech recognition output associated with the best match on a screen of the electronic device.

3. The non-transitory medium as in claim **1**, wherein the change in the user's set of one or more databases comprises a change in at least one of: a contacts database, a calendar database, and a media database.

4. The non-transitory medium as in claim **1**, wherein the user's set of one or more databases comprises a contacts database and wherein the change in the user's set of one or more databases comprises an addition of a name of a contact to the contacts database.

5. The non-transitory medium as in claim **1**, wherein the user's set of one or more databases comprises a contacts database with names of people and telephone numbers, wherein the change comprises a change in the contacts database, wherein the phonetic dictionary is for natural language speech recognition, and wherein the speech input is for calling a telephone number or sending a text message to another device.

6. The non-transitory medium as in claim **5**, wherein the non-transitory computer-readable storage medium further comprises instructions, which when executed by the one or more processors of the electronic device, cause the device to:

obtain the change in the contacts database in response to the change being made; and

process, using the set of one or more pronunciation guessers, the change in the contacts database to update the extended phonetic dictionary based on the change in the contacts database.

7. The non-transitory medium as in claim **6**, wherein the set of one or more pronunciation guessers comprise pronunciation guessers for a plurality of locales, each locale having its own pronunciation guesser.

8. The non-transitory medium as in claim **7**, wherein the non-transitory computer-readable storage medium further comprises instructions, which when executed by the one or more processors of the electronic device, cause the device to:

automatically determine a set of languages or locales from the words in the user's set of one or more databases;

select a subset of the set of one or more pronunciation guessers, wherein the subset is selected based upon the set of languages or locales that were automatically determined from the words in the user's set of one or more databases; and

wherein the processing which produces the additional phonetic data uses only the subset of the set of one or more pronunciation guessers when producing the additional phonetic data.

9. The non-transitory medium as in claim **6**, wherein the set of one or more pronunciation guessers comprises different pronunciation guessers for a same locale.

10. The non-transitory medium as in claim **6**, wherein obtaining the words from the user's set of one or more databases comprises obtaining the words in the contacts database from an external electronic device, wherein receiving the speech input comprises receiving the speech input from the external electronic device, and wherein providing the output associated with the best match comprises transmitting the best match to the external electronic device.

11. The non-transitory medium as in claim **10**, wherein the electronic device executes the one or more programs for a plurality of users, and each user of the plurality of users has a dedicated extended phonetic dictionary that is unique to each user.

12. The non-transitory medium as in claim **1**, wherein determining the best match from the set of one or more matches is based on phonetic fuzzy matching.

13. The non-transitory medium as in claim **1**, wherein the non-transitory computer-readable storage medium further comprises instructions, which when executed by the one or more processors of the electronic device, cause the device to:

identify a portion of the determined phonemes using contextual information associated with the speech input, wherein performing speech recognition on the speech input to determine the set of one or more matches includes performing speech recognition on the portion of the determined phonemes using the extended phonetic dictionary.

14. The non-transitory medium as in claim **1**, wherein the non-transitory computer-readable storage medium further comprises instructions, which when executed by the one or more processors of the electronic device, cause the device to:

based on the best match, play a media item or send a communication to another electronic device.

15. A machine implemented method comprising:

detecting a change in a user's set of one or more databases;

responsive to detecting the change in the user's set of one or more databases, obtaining words from the user's set of one or more databases; and

processing, using a set of one or more pronunciation guessers, the words from the user's set of one or more databases, the processing producing additional phonetic data derived from the words, the additional phonetic data forming an extended phonetic dictionary for the user;

receiving a speech input;

performing speech recognition on the speech input to determine phonemes in the speech input and to determine a set of one or more matches using the determined phonemes, a phonetic dictionary, and the extended phonetic dictionary:

determining a best match from the set of one or more matches; and

providing an output associated with the best match.

16. The method of claim **15**, wherein the method is performed by an electronic device and wherein providing the output associated with the best match comprises displaying a speech recognition output associated with the best match on a screen of the electronic device.

17. The method of claim **15**, wherein the change in the user's set of one or more databases comprises a change in at least one of: a contacts database, a calendar database, and a media database.

18. The method of claim **15**, wherein the user's set of one or more databases comprises a contacts database and wherein the change in the user's set of one or more databases comprises an addition of a name of a contact to the contacts database.

19. The method of claim **15**, wherein the user's set of one or more databases comprises a contacts database with names of people and telephone numbers, wherein the change comprises a change in the contacts database, wherein the phonetic dictionary is for natural language speech recognition, and wherein the speech input is for calling a telephone number or sending a text message to another device.

20. The method of claim **19**, further comprising:

obtaining the change in the contacts database in response to the change being made; and

processing, using the set of one or more pronunciation guessers, the change in the contacts database to update the extended phonetic dictionary based on the change in the contacts database.

21. The method of claim **20**, wherein the set of one or more pronunciation guessers comprise pronunciation guessers for a plurality of locales, each locale having its own pronunciation guesser.

22. The method of claim **21**, further comprising:

automatically determining a set of languages or locales from the words in the user's set of one or more databases;

selecting a subset of the set of one or more pronunciation guessers, wherein the subset is selected based upon the set of languages or locales that were automatically determined from the words in the user's set of one or more databases; and

wherein the processing which produces the additional phonetic data uses only the subset of the set of one or more pronunciation guessers when producing the additional phonetic data.

23. The method of claim **20**, wherein the set of one or more pronunciation guessers comprises different pronunciation guessers for a same locale.

24. The method of claim **20**, wherein the method is performed by a server, wherein obtaining the words from the user's set of one or more databases comprises obtaining the words in the contacts database from an external electronic device, wherein receiving the speech input comprises receiving the speech input from the external electronic device, and wherein providing the output associated with the best match comprises transmitting the best match to the external electronic device.

25. The method of claim **24**, wherein the method is performed for a plurality of users, and each user of the plurality of users has a dedicated extended phonetic dictionary that is unique to each user.

26. The method of claim **15**, wherein determining the best match from the set of one or more matches is based on phonetic fuzzy matching.

27. The method of claim **15**, further comprising:

identifying a portion of the determined phonemes using contextual information associated with the speech input, wherein performing speech recognition on the speech input to determine the set of one or more matches includes performing speech recognition on the portion of the determined phonemes using the extended phonetic dictionary.

28. The method of claim **15**, wherein the method is performed by an electronic device, the method further comprising:

based on the best match, playing a media item or sending a communication to another electronic device.

29. A data processing system comprising:

an input device for receiving a speech input from a user;

a set of one or more processors coupled to the input device; and

a memory coupled to the set of one or more processors, the memory storing a phonetic dictionary for speech recognition and storing an extended phonetic dictionary for the user;

wherein the extended phonetic dictionary is produced by:

responsive to detecting a change in a user's set of one or more databases, processing, using the set of one or more processors, words in the user's set of one or more databases using a set of one or more pronunciation guessers, and

wherein the set of one or more processors performs speech recognition on the speech input to determine phonemes in the speech input and to determine a best match using the determined phonemes, the phonetic dictionary, and the extended phonetic dictionary.

30. The system of claim **29**, wherein the memory stores one or more programs, comprising instructions, which when executed by the set of one or more processors, cause the system to:

provide an output associated with the best match, wherein providing the output associated with the best match comprises displaying a speech recognition output associated with the best match on a screen of the system.

31. The system of claim **29**, wherein the change in the user's set of one or more databases comprises a change in at least one of: a contacts database, a calendar database, and a media database.

32. The system of claim **29**, wherein the user's set of one or more databases comprises a contacts database and wherein the change in the user's set of one or more databases comprises an addition of a name of a contact to the contacts database.

33. The system of claim **29**, wherein the user's set of one or more databases comprises a contacts database with names of people and telephone numbers, wherein the change comprises a change in the contacts database, wherein the phonetic dictionary is for natural language speech recognition, and wherein the speech input is for calling a telephone number or sending a text message to another device.

34. The system of claim **33**, wherein the memory stores one or more programs, comprising instructions, which when executed by the set of one or more processors, cause the system to:

obtain the change in the contacts database in response to the change being made; and

process, using the set of one or more pronunciation guessers, the change in the contacts database to update the extended phonetic dictionary based on the change in the contacts database.

35. The system of claim **34**, wherein the set of one or more pronunciation guessers comprise pronunciation guessers for a plurality of locales, each locale having its own pronunciation guesser.

36. The system of claim **35**, wherein the one or more programs further comprise instructions, which when executed by the set of one or more processors, cause the system to:

automatically determine a set of languages or locales from the words in the user's set of one or more databases;

select a subset of the set of one or more pronunciation guessers, wherein the subset is selected based upon the set of languages or locales that were automatically determined from the words in the user's set of one or more databases; and

wherein processing the words in the user's set of one or more databases uses only the subset of the set of one or more pronunciation guessers.

37. The system of claim **35**, wherein the system executes the one or more programs for a plurality of users, and each user of the plurality of users has a dedicated extended phonetic dictionary that is unique to each user.

38. The system of claim **34**, wherein the set of one or more pronunciation guessers comprises different pronunciation guessers for a same locale.

39. The system of claim **34**, wherein receiving the speech input comprises receiving the speech input from an external electronic device.

40. The system of claim **29**, wherein determining the best match is based on phonetic fuzzy matching.

41. The system of claim **29**, wherein the memory stores one or more programs, comprising instructions, which when executed by the set of one or more processors, cause the system to:

identify a portion of the determined phonemes using contextual information associated with the speech input, wherein performing speech recognition on the speech input to determine the best match includes performing speech recognition on the portion of the determined phonemes using the extended phonetic dictionary.

42. The system of claim **29**, wherein the memory stores one or more programs, comprising instructions, which when executed by the set of one or more processors, cause the system to:

based on the best match, play a media item or send a communication to an electronic device external to the system.

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