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Frerking

(54) SYSTEM AND METHOD FOR NETWORK BASED HEARING AID COMPATIBLE MODE SELECTION

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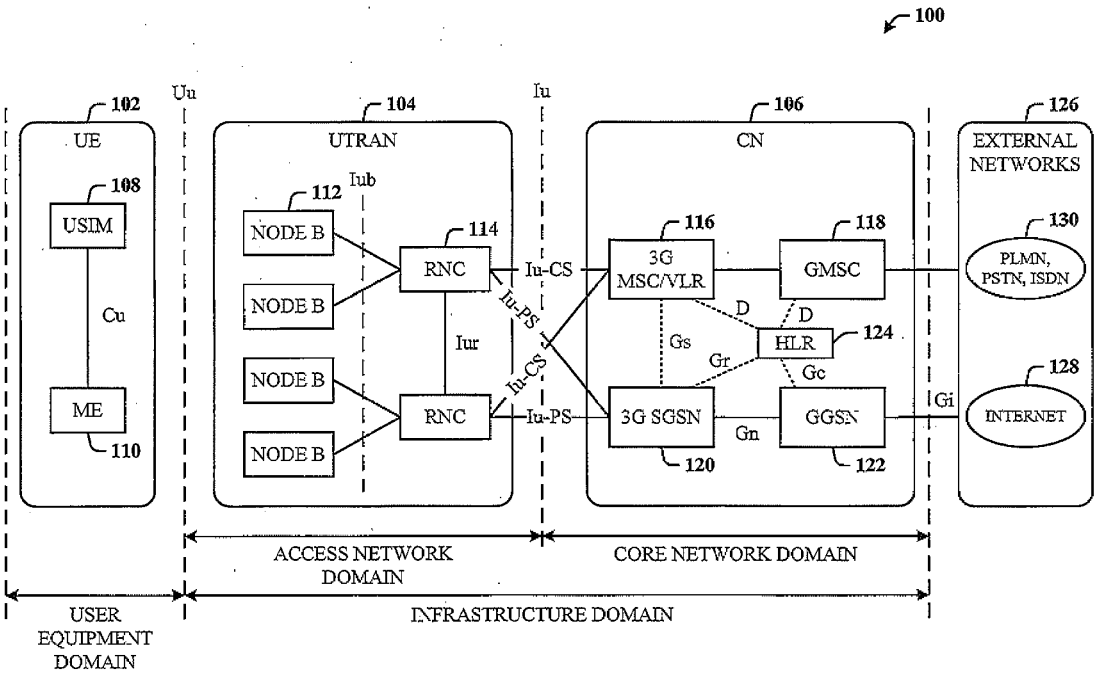
(57) ABSTRACT

A system and method for providing a hearing aid compatibility mode of communication service to hearing aid users is disclosed. The described system can store an indication at a communication network that a given account is used by a person who wears hearing aid equipment. Services provided to that account can then use communication parameters and network resources which tend to minimize interference with a hearing aid. The network can instruct the user equipment and the radio access network to communicate using hearing aid friendly parameters. In some cases, network resources beyond those allocated for accounts not indicated as hearing aid user accounts can be allocated. Parameters adjusted in hearing aid compatibility mode can include codec rates, operating power levels, and burst frame length, among others. In some described embodiments, the hearing aid compatibility mode can be selectively enabled as desired by an account user.



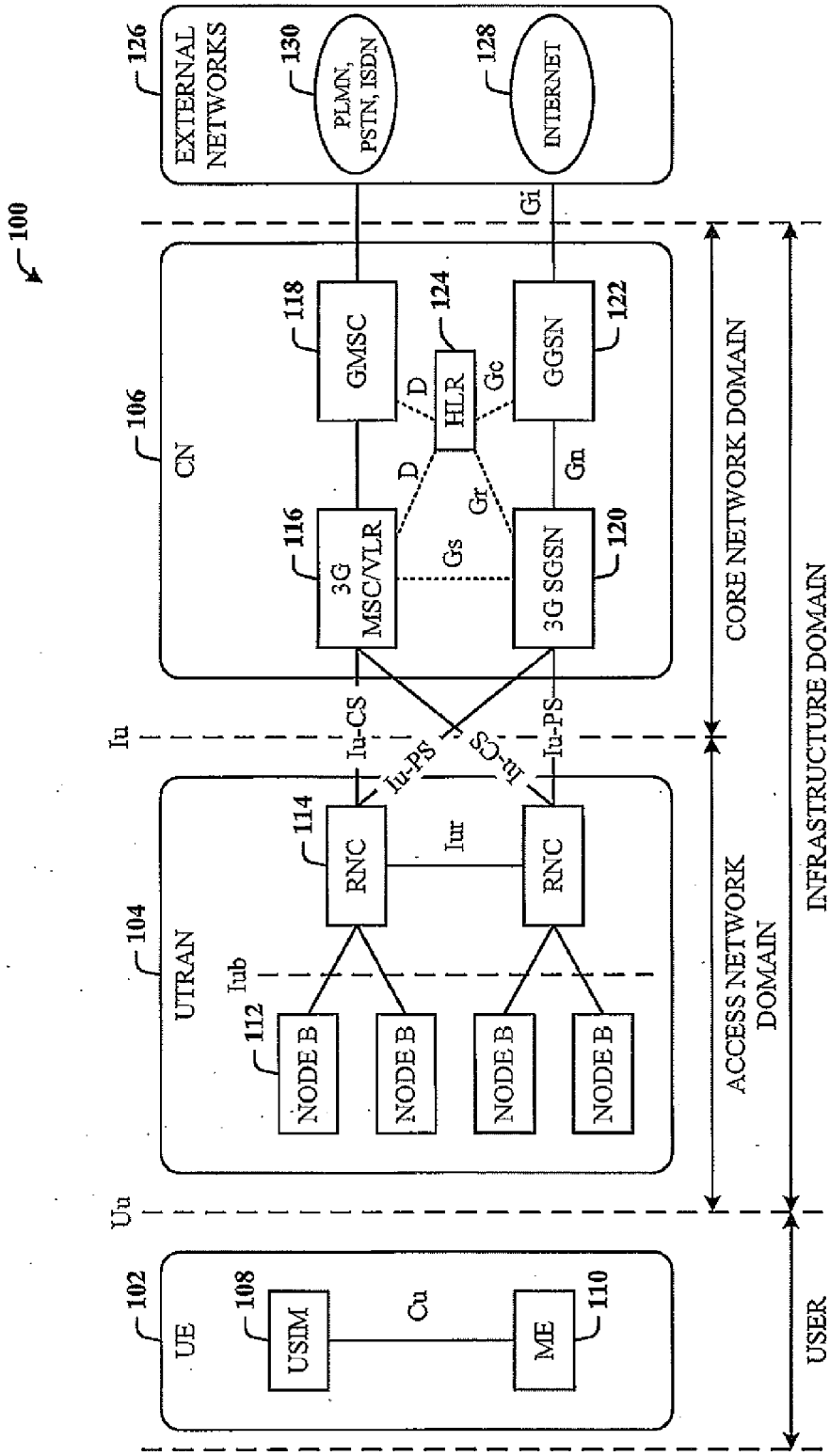

100
126
EXTERNAL NETWORKS
130
PLMN, PSTN, ISDN
128
INTERNET
Gi
106
CN
118
GMSC
124
HLR
122
GGSN
D
Gc
D
Gr
Gn
116
3G MSC/VLR
Gs
120
3G SGSN
Iu
Iu-CS
Iu-PS
Iu-PS
Iu-CS
Iu-PS
104
UTRAN
114
RNC
Iur
RNC
Iub
112
NODE B
NODE B
NODE B
NODE B
Uu
102
UE
108
USIM
Cu
ME
110
CORE NETWORK DOMAIN
ACCESS NETWORK DOMAIN
INFRASTRUCTURE DOMAIN
USER EQUIPMENT DOMAIN

FIG. 1A

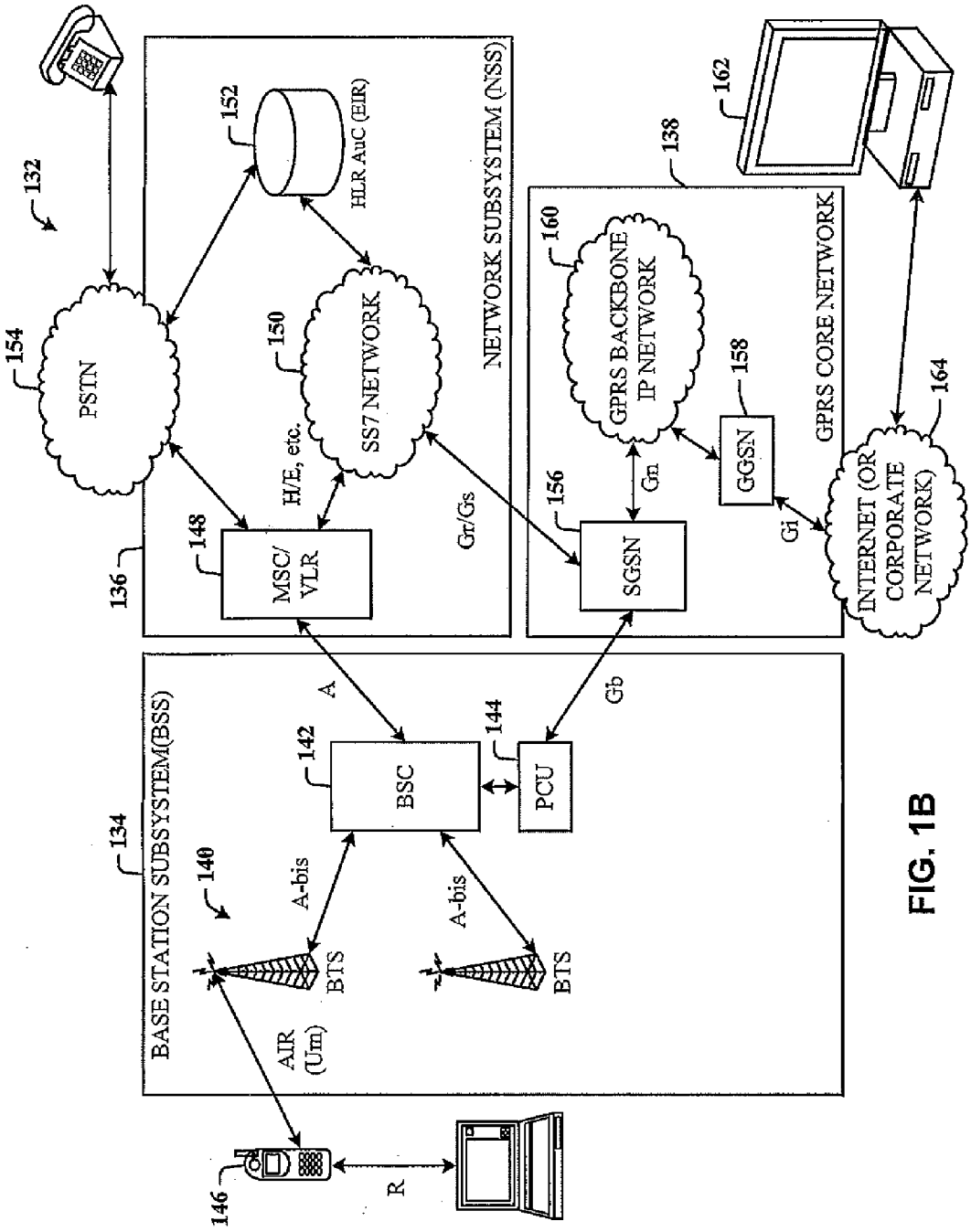

132
154
PSTN
152
HLR AuC (EIR)
150
SS7 NETWORK
H/E, etc.
NETWORK SUBSYSTEM (NSS)
136
148
MSC/
VLR
Gr/Gs
138
162
160
GPRS BACKBONE
IP NETWORK
158
GGSN
GPRS CORE NETWORK
156
SGSN
Gn
Gi
164
INTERNET (OR
CORPORATE
NETWORK)
A
Gb
134
BASE STATION SUBSYSTEM(BSS)
142
BSC
144
PCU
140
A-bis
A-bis
BTS
BTS
AIR
(Um)
146
R

FIG. 1B

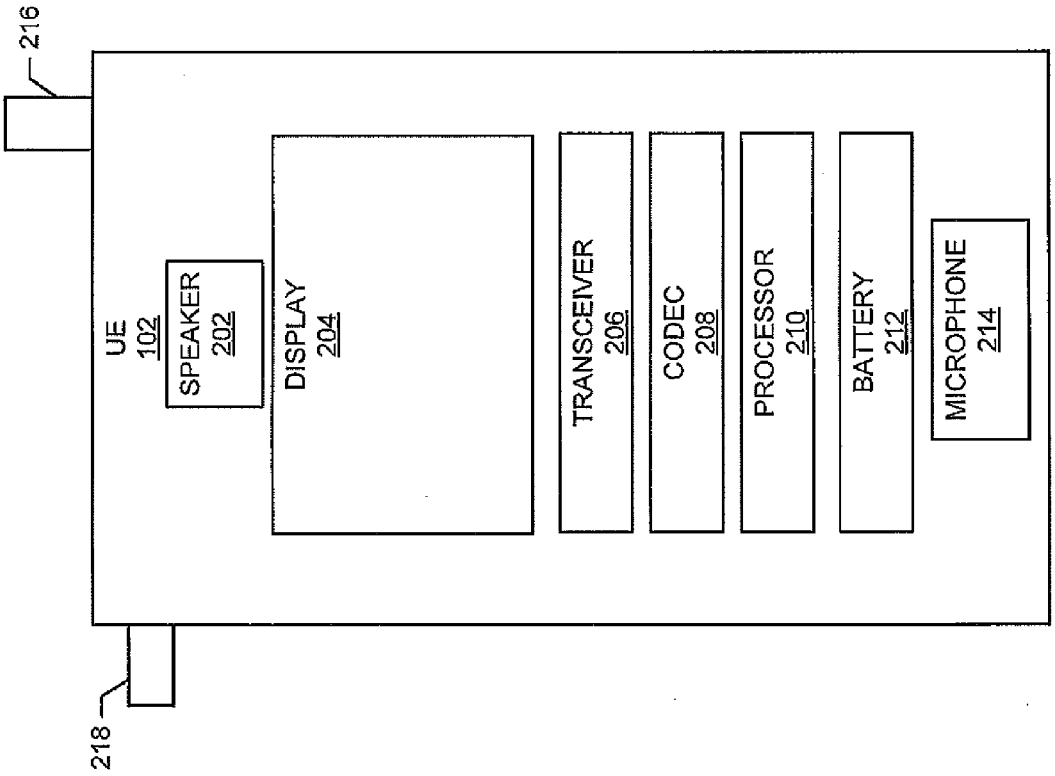

216
UE
102
SPEAKER
202
DISPLAY
204
TRANSCEIVER
206
CODEC
208
PROCESSOR
210
BATTERY
212
MICROPHONE
214
218

FIG. 2

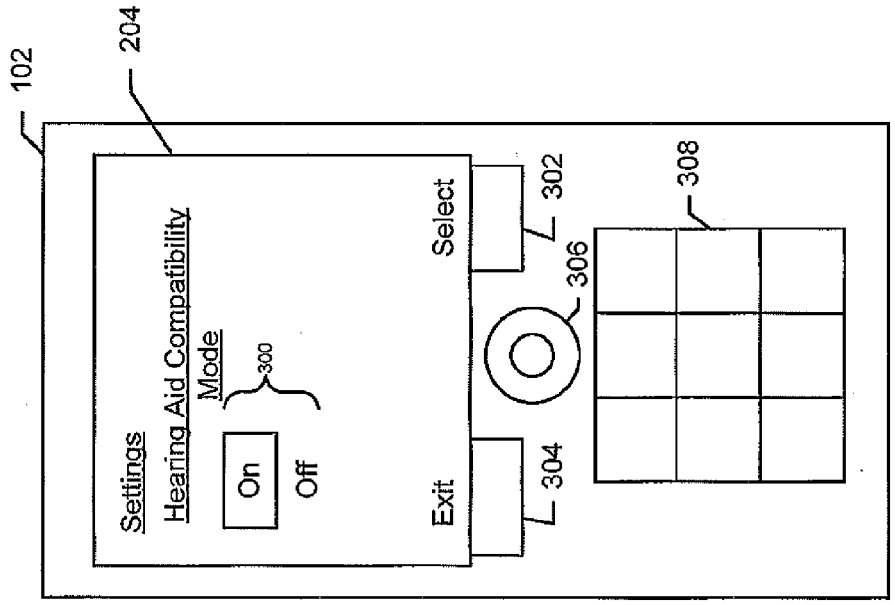

102
204
Settings
Hearing Aid Compatibility
Mode
300
On
Off
Select
302
306
308
Exit
304

FIG. 3

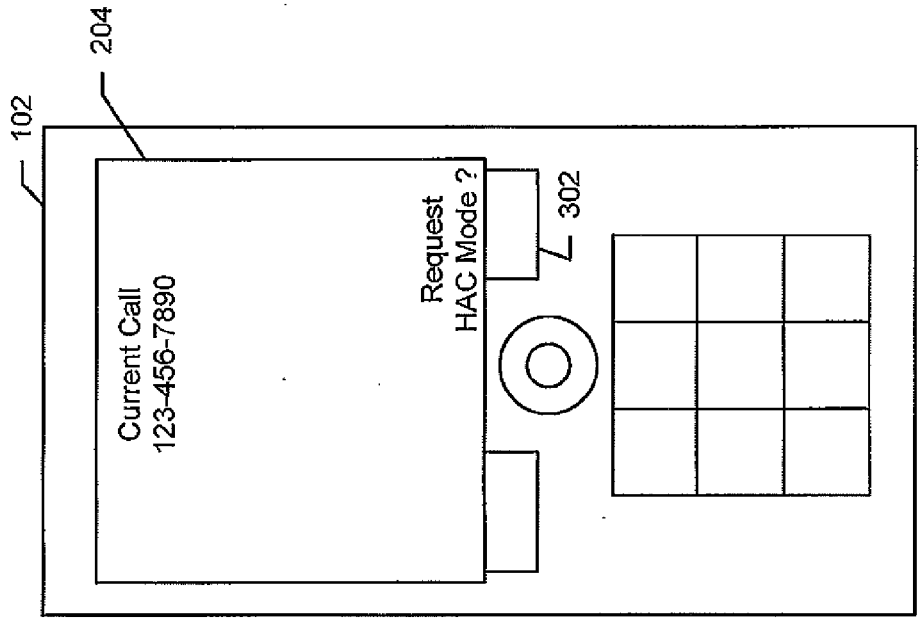

102
204
Current Call
123-456-7890
Request
HAC Mode ?
302

FIG. 4B

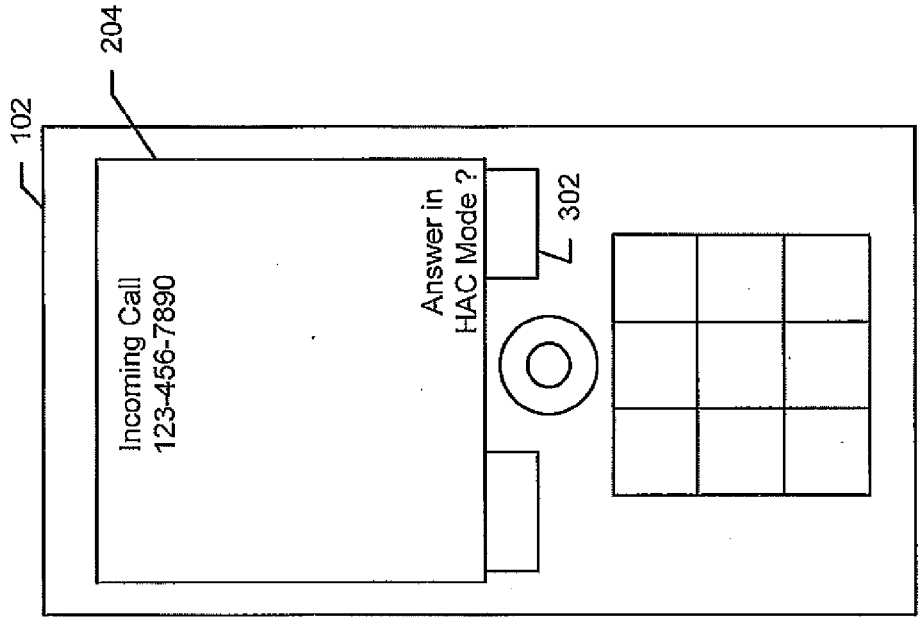

102
204
Incoming Call
123-456-7890
Answer in
HAC Mode ?
302

FIG. 4A

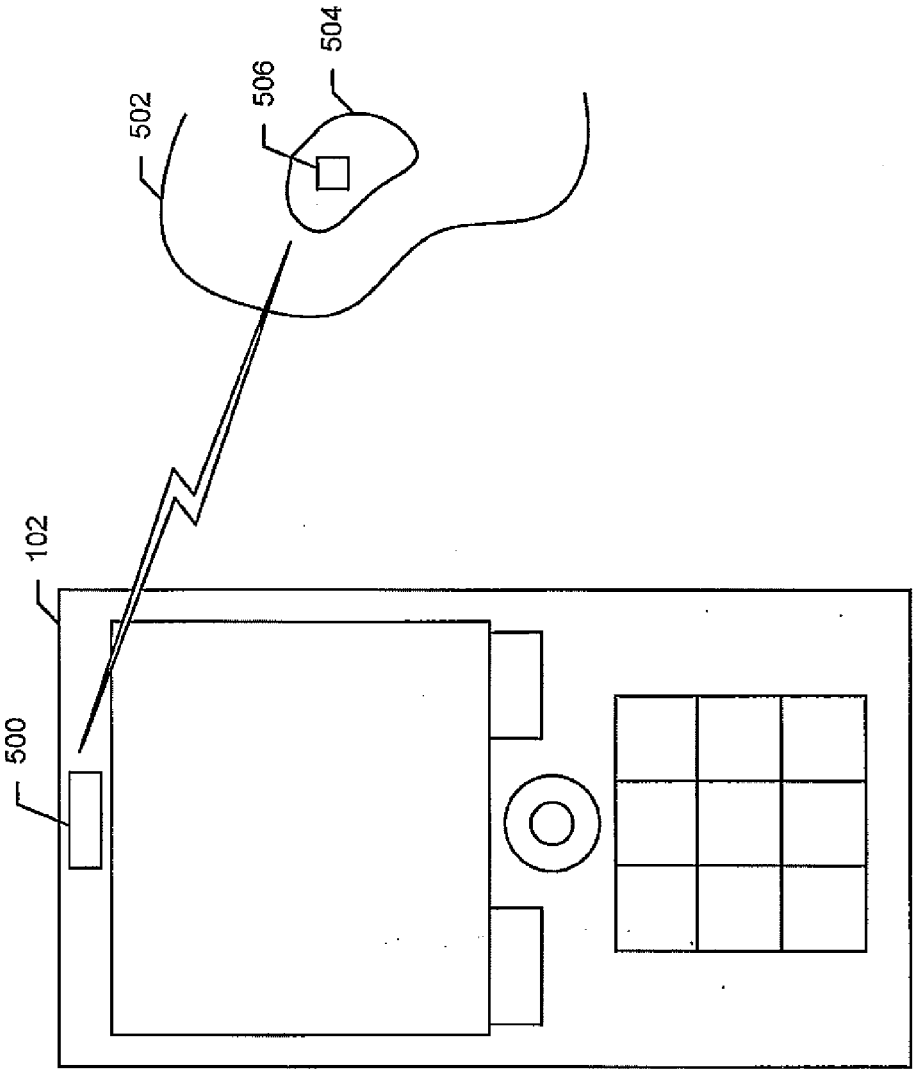


FIG. 5

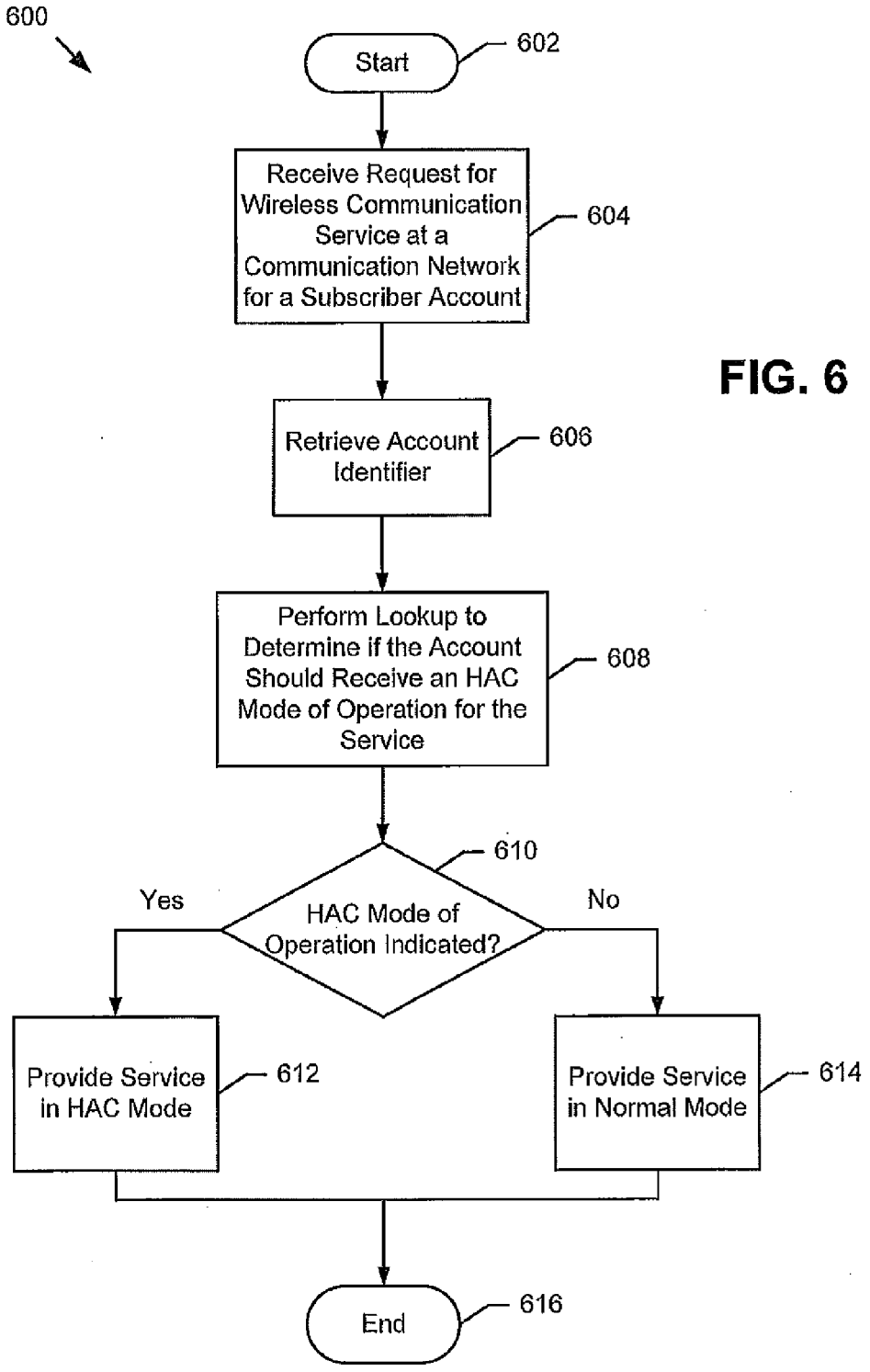

600
Start
602
Receive Request for Wireless Communication Service at a Communication Network for a Subscriber Account
604
Retrieve Account Identifier
606
Perform Lookup to Determine if the Account Should Receive an HAC Mode of Operation for the Service
608
HAC Mode of Operation Indicated?
610
Yes
No
Provide Service in HAC Mode
612
Provide Service in Normal Mode
614
End
616

FIG. 6

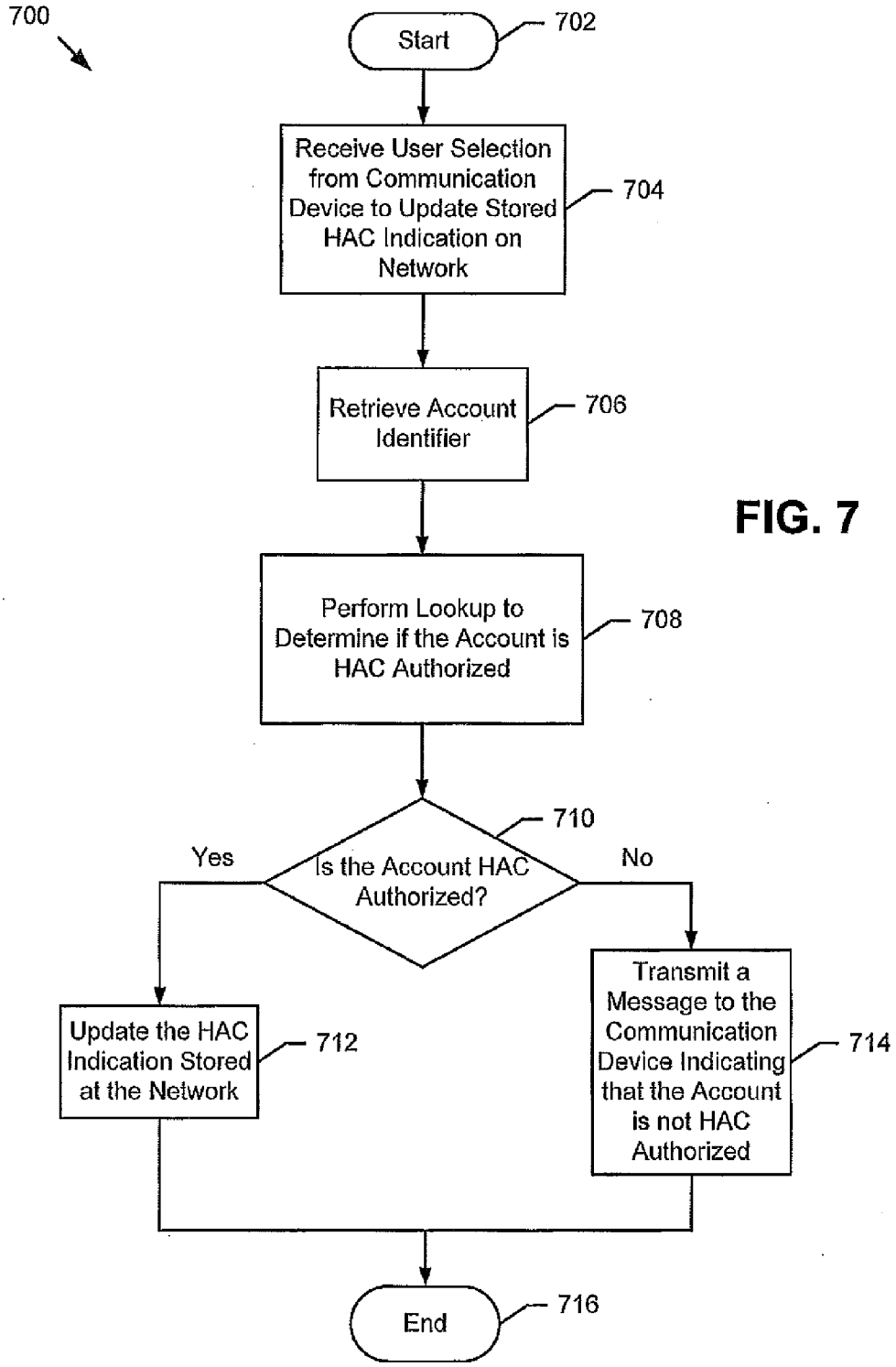

700
Start
702
Receive User Selection from Communication Device to Update Stored HAC Indication on Network
704
Retrieve Account Identifier
706
Perform Lookup to Determine if the Account is HAC Authorized
708
Is the Account HAC Authorized?
710
Yes
No
Update the HAC Indication Stored at the Network
712
Transmit a Message to the Communication Device Indicating that the Account is not HAC Authorized
714
End
716

FIG. 7

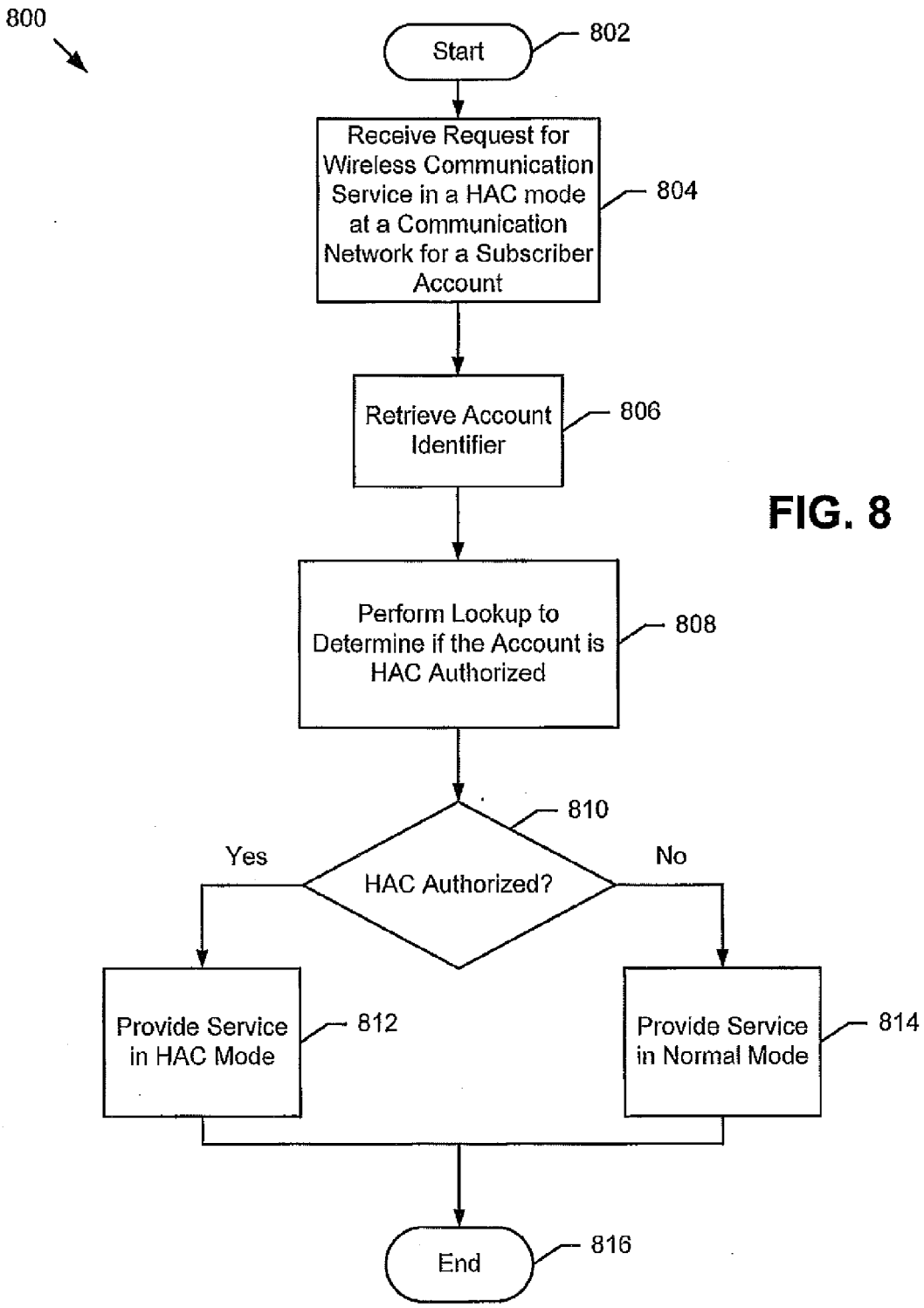

800
Start
802
Receive Request for Wireless Communication Service in a HAC mode at a Communication Network for a Subscriber Account
804
Retrieve Account Identifier
806
Perform Lookup to Determine if the Account is HAC Authorized
808
HAC Authorized?
810
Yes
No
Provide Service in HAC Mode
812
Provide Service in Normal Mode
814
End
816

FIG. 8

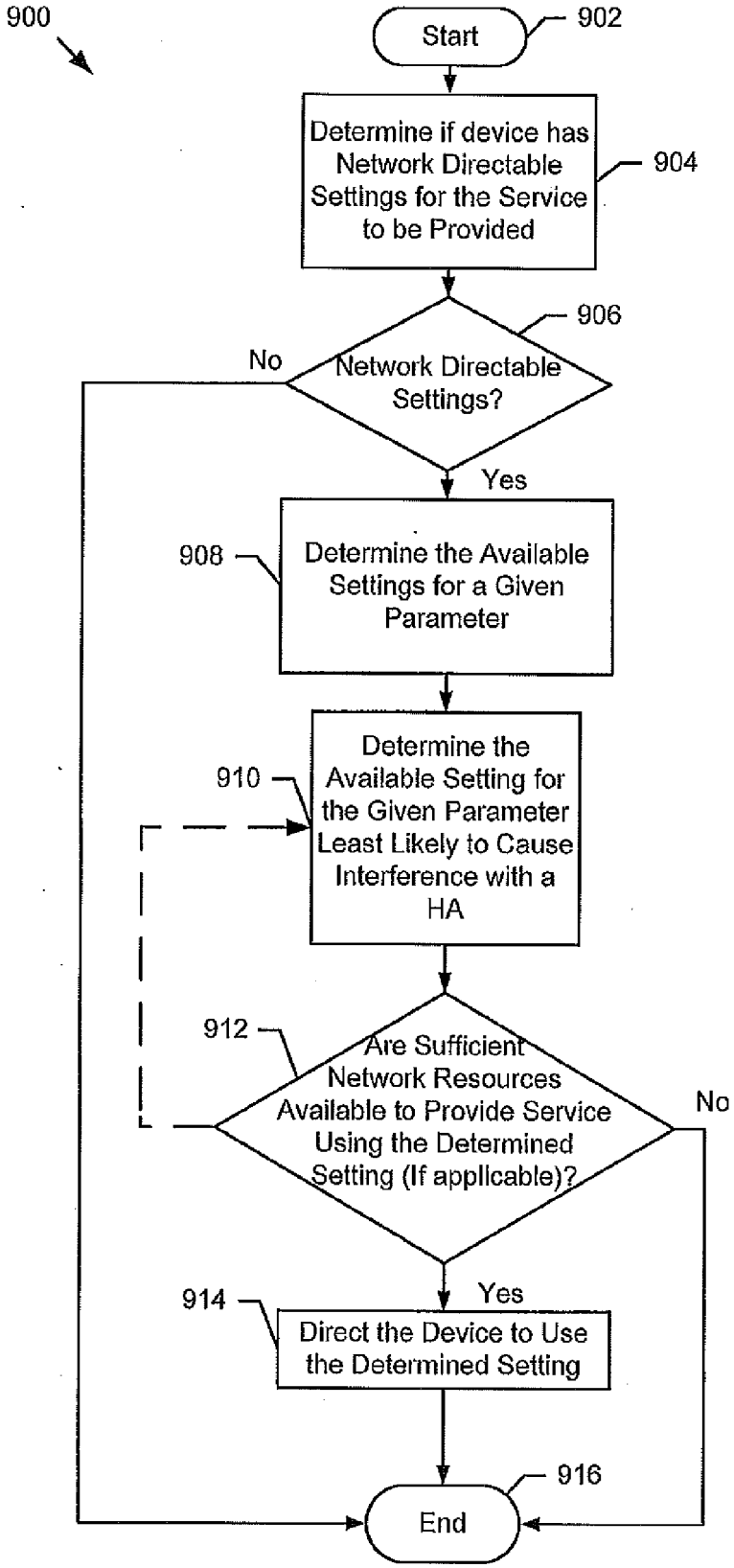

900
Start
902
Determine if device has Network Directable Settings for the Service to be Provided
904
906
Network Directable Settings?
No
Yes
908
Determine the Available Settings for a Given Parameter
910
Determine the Available Setting for the Given Parameter Least Likely to Cause Interference with a HA
912
Are Sufficient Network Resources Available to Provide Service Using the Determined Setting (If applicable)?
No
Yes
914
Direct the Device to Use the Determined Setting
916
End

FIG. 9

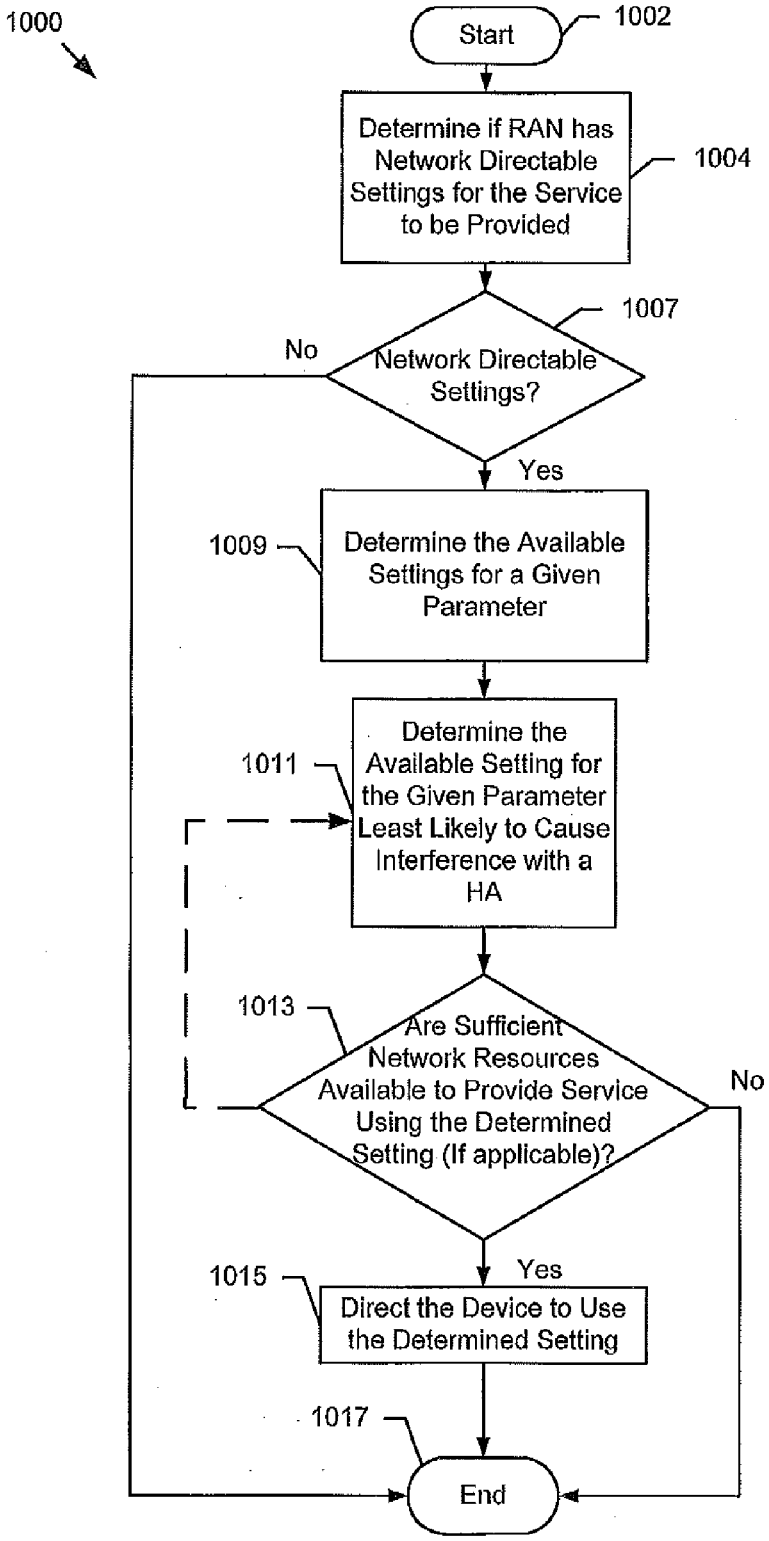

1000
Start
1002
Determine if RAN has Network Directable Settings for the Service to be Provided
1004
1007
Network Directable Settings?
No
Yes
1009
Determine the Available Settings for a Given Parameter
1011
Determine the Available Setting for the Given Parameter Least Likely to Cause Interference with a HA
1013
Are Sufficient Network Resources Available to Provide Service Using the Determined Setting (If applicable)?
No
Yes
1015
Direct the Device to Use the Determined Setting
1017
End

FIG. 10

SYSTEM AND METHOD FOR NETWORK BASED HEARING AID COMPATIBLE MODE SELECTION

TECHNICAL FIELD

[0001] This invention relates generally to mobile network communication device compatibility with hearing assistive devices. More specifically, it relates to the selection of network and handset operating modes that enhance compatibility between mobile communication devices and hearing assistive devices.

BACKGROUND

[0002] Hearing assistive systems are used to assist the hearing impaired to best compensate for a user's hearing loss profile. Hearing assistive systems can include hearing aids, cochlear implants, and related devices. In simple terms a hearing aid is a device worn by a user to pick up and amplify sound and provide it to a user's ear canal. Hearing aid technology has continually improved, resulting in ever smaller devices which are often categorized by how they fit about a user's ear. For example, some common hearing aid styles listed by decreasing size include behind-the-ear (BTE), in-the-ear (ITE), in-the-canal (ITC), mostly-in-the-canal (MIC) and completely-in-the-canal (CIC) hearing aids.

[0003] Hearing aids worn outside the ear and cochlear implant input devices operate in either a microphone mode, in which sound waves incident upon the device are converted to electrical energy, or a telecoil mode, in which magnetic energy is converted to electrical energy. In either mode, the resultant electrical signal is subsequently amplified, processed, and output to the user. When a hearing aid operates in an environment that includes a modulated RF field or a fluctuating magnetic field, undesired interference may be induced in the hearing aid circuitry as the varying fields are detected and processed as electrical signals by the hearing aid.

[0004] Mobile communication devices have now become commonplace, and interference generated by these devices continues to pose challenges for hearing aid designers. Use of a mobile communication device commonly involves placing it close to an ear so that sounds from a speaker can be heard. This placement often leads to a hearing aid of a user being located within a strong, interference-inducing RF field of the communication device. The problem is further exacerbated by the fact that interference generated by the now common digital communication devices such as digital cell phones is generally more obtrusive than that caused by their analog counterparts.

[0005] Digital wireless telephones transmit over a wireless network via radio waves. The radio waves generated by the digital telephone are typically detected and demodulated by the hearing aid circuitry, thereby introducing an interference signal to the hearing assistive device. The interference signal is then amplified, processed, and delivered to the user along with the desired signal. As a result, the audible quality of the desired signal is diminished. Digital wireless devices that employ time division multiplexed modulation schemes often generate interference due to the on/off keying of their modulation envelopes. The pulsing of the transmissions may produce interference at the fundamental frequencies associated with the pulse rates, as well as at the associated harmonic frequencies across the audible spectrum. Interference may also be produced by RF energy picked up by components of hearing assistive devices, such as a telecoil in a hearing aid.

[0006] The digital telephone's electronics, such as the backlighting, the display, the keypad, the battery leads and the circuit board often also generate pulsed magnetic fields. The resultant magnetic field energy typically impacts for example, a hearing aid's wiring and interconnections, to generate interference at the hearing aid. This type of interference, often referred to as baseband magnetic interference, is also converted to an electrical signal that is then processed by the hearing aid, amplified, and delivered to the hearing aid user along with the desired signal, such as the voice of a human speaker. In addition to digital cell phones, digital cordless phones, portable digital radios and other digital devices generate electromagnetic interference which, when processed by the hearing aid, is subsequently output to the user. Analog apparatus such as power transformers, fluorescent lighting, and power lines likewise produce electromagnetic field static that interferes with hearing assistive devices.

[0007] Electronic interference, whether generated by pulsating electric or magnetic fields, combines with the desired signals picked up by a microphone, telecoil, or circuitry to form a composite signal at the hearing assistive device. The composite signal is processed by the hearing assistive device and output to the user. Depending on the source and duration of the interference, the hearing assistive device performance may be noticeably and significantly reduced, to the point where the hearing impaired user is discouraged from either using the hearing assistive device, such as a hearing aid, or discouraged from using the item that generates the interference, such as a cellular telephone.

[0008] Due to the importance of accessible wireless communications for the hearing impaired, the Federal Communications Commission (FCC) has imposed a mandate for hearing aid compatibility (HAC) for wireless communications devices on both device manufacturers and service providers. Many of the solutions proposed for meeting these HAC requirements have focused primarily on handset-based solutions.

SUMMARY

[0009] The various embodiments of the present invention overcome the shortcomings of the prior art by providing a communication system that can offer services by reducing the potential for interference and enabling a hearing aid compatible (HAC) mode of operation. A communication system according to the present invention can comprise a host node, where the host node includes a memory for storing an account identifier in association with a hearing aid user indication. The indication can mark the account as being that of a hearing aid user. Services provided to the account can then be provided in a HAC mode of operation. Alternatively, or in addition, the memory can store an indication that the account is authorized to receive services in a HAC mode of operation if requested. In this case the system can be configured to receive and respond to HAC mode of operation requests from communication devices.

[0010] The communication system can be configured to instruct a communication device to communicate using one or more designated settings when a HAC mode of operation is enabled. The settings to be adjusted can include a codec rate, a burst frame length, error correction coding, operating power level, a frequency band, an antenna configuration, and display backlighting circuitry.

[0011] The communication system can be configured to cause the radio access network of the communication system to communicate with a communication device associated with the account using one or more designated settings when a HAC mode of operation is enabled. The settings to be adjusted can include a codec rate, a burst frame length, error correction coding, operating power level, a frequency band, an interference cancellation technique, and an antenna configuration.

[0012] The communication system can be configured to monitor the number of HAC mode users at a given cell site and/or sector to prevent the over allocation of network resources. The system can also be configured to increase timers to hold HAC mode calls during periods of high frame rate errors and configured to provide additional network resources to a HAC mode E911 call. An indication that a given account is to be provided a HAC mode of operation can be provided to other communication service providers to facilitate the use of a HAC mode while an audio communication device is roaming on that network.

[0013] A method of providing a hearing aid compatibility mode of operation in a communication network is also described. The method can include performing a lookup operation on a memory of a host node of a communication system to determine if a account should be granted service in a HAC mode of operation. If it is determined that the account should be granted service in a HAC mode of operation, service in a HAC mode of operation is provided.

[0014] An audio communication device according to the present invention comprises a transceiver and a processor where the processor can be configured to accept a user selection indicating that a hearing aid compatibility (HAC) mode of operation is desired. The user's selection can be transmitted by the audio communication device to a communication network in order to request a HAC mode of operation.

[0015] The foregoing has broadly outlined some of the aspects and features of the present invention, which should be construed to be merely illustrative of various potential applications of the invention. Other beneficial results can be obtained by applying the disclosed information in a different manner or by combining various aspects of the disclosed embodiments. Accordingly, other aspects and a more comprehensive understanding of the invention may be obtained by referring to the detailed description of the exemplary embodiments taken in conjunction with the accompanying drawings, in addition to the scope of the invention defined by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIGS. **1***a* and **1***b* are block diagrams illustrating representative environments in which the present invention may be implemented.

[0017] FIG. **2** is a block diagram of a wireless audio communication device according to the present invention.

[0018] FIG. **3** depicts an interface screen for selecting an HAC mode.

[0019] FIG. **4**A depicts an interface screen for answering an incoming call in an HAC mode.

[0020] FIG. **4**B depicts an interface screen for requesting an HAC mode for a call in progress.

[0021] FIG. **5** illustrates a wireless audio communication device having a detector for determining the presence of a hearing aid.

[0022] FIG. **6** is a flowchart of a method for providing an HAC mode of operation according to the present invention.

[0023] FIG. **7** is a flowchart of a method for updating an HAC indication at a communication network according to a selection made by an account user.

[0024] FIG. **8** is a flowchart of a method for providing an HAC mode of operation on a case-by-case basis.

[0025] FIG. **9** is a flowchart of a method for a network to manage communication parameters of wireless UE to provide an HAC mode of operation.

[0026] FIG. **10** is a flowchart of a method for a network to manage communication parameters of a RAN to provide an HAC mode of operation.

DETAILED DESCRIPTION

[0027] As required, detailed embodiments of the present invention are disclosed herein. It will be understood that the disclosed embodiments are merely examples to illustrate aspects of the invention that may be embodied in various and alternative forms. The figures are not necessarily to scale, and some features may be exaggerated or minimized to show details of particular components. In other instances, well-known materials or methods have not been described in detail to avoid obscuring the present invention. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but as a basis for the claims and for teaching one skilled in the art to variously employ the present invention.

[0028] Referring now to the drawings in which like numerals indicate like elements throughout the several views, the drawings illustrate certain of the various aspects of exemplary embodiments of the present invention. FIG. **1***a* illustrates an exemplary UMTS network **100**. The architecture is based on the 3GPP (Third Generation Partnership Project) Release 99 specification. However, it is to be understood that the subject innovation can be applied to any UMTS telecommunications architecture, including by way of example, Release 5 (R5) and Release 6 (R6) 3GPP standards. UMTS offers teleservices (e.g., speech and/or SMS-Short Message Service) and bearer services, which provide the capability for information transfer between access points.

[0029] The UMTS network **100** can consist of three interacting domains; a user equipment (UE) domain **102**, a UMTS Terrestrial Radio Access Network (UTRAN) domain **104**, and a core network (CN) domain **106**. The UTRAN domain **104** is also referred to as the access network domain and the CN **106** is referred to as the core network domain, the both of which comprise an infrastructure domain.

[0030] The UE domain **102** includes a USIM (user services identity module) domain and an ME (mobile equipment) domain. User equipment is the equipment used by the user to access UMTS services. In the UE domain **102**, the UMTS IC card is the USIM **108** which has the same physical characteristics as GSM SIM (subscriber identity module) card. The USIM interfaces to ME **110** via a Cu reference point. Functions of the USIM include: support of one USIM application (and optionally, more than one); support of one or more user profiles on the USIM; update of USIM specific information over the air; security functions; user authentication; optional inclusion of payment methods; and optional secure downloading of new applications.

[0031] UE terminals work as an air interface counterpart for Node-B devices of the access network and have many different types of identities. Following are some of the UMTS

identity types, which are taken directly from GSM specifications: international mobile subscriber identity (IMSI); temporary mobile subscriber identity (TMSI); packet temporary mobile subscriber identity (P-TMSI); temporary logical link identity (TLLI); mobile station ISDN (MSISDN); international mobile station equipment identity (IMEI); and international mobile station equipment identity and software version number (IMEISV).

[0032] A UMTS mobile station (MS) can operate in one of three modes of operation. A PS/CS mode of operation is where the MS is attached to both the PS (packet-switched) domain and CS (circuit-switched) domain, and the MS is capable of simultaneously operating PS services and CS services. A PS mode of operation is where the MS is attached to the PS domain only, and can only operate services of the PS domain. However, this does not prevent CS-like services from being offered over the PS domain (e.g., VoIP). In a third CS mode of operation, the MS is attached to the CS domain only, and can only operate services of the CS domain.

[0033] The UTRAN **104** provides the air interface access method for the UE domain **102**. The reference point between the UE domain and the infrastructure domain is the Uu UMTS radio interface. The access network domain provides the physical entities that manage resources of the access network and facilitates access to the core network domain. In UMTS terminology, a base station of the access network domain is referred as a Node-B device **112**, and control equipment for Node-B devices is called a radio network controller (RNC) **114**. The interface between the Node-B device and the RNC **114** is the lub interface. The interface between two RNCs is called the Iur interface.

[0034] The functions of Node-B devices include: air interface transmission/reception; modulation and demodulation; CDMA (Code Division Multiple Access) physical channel coding; micro diversity; error handing; and closed loop power control. The functions of the RNC include: radio resource control; admission control; channel allocation; power control settings; handover control; macro diversity; ciphering; segmentation and reassembly; broadcast signaling; and open loop power control.

[0035] Wideband CDMA (WCDMA) technology was selected for UTRAN air interface. UMTS WCDMA is a direct sequence CDMA system where user data is multiplied with quasi-random bits derived from WCDMA spreading codes. In UMTS, in addition to channelization, codes are used for synchronization and scrambling. WCDMA has two basic modes of operation: frequency division duplex (FDD) and time division duplex (TDD).

[0036] The Core Network is divided in circuit-switched and packet-switched domains. Some of the circuit-switched elements are a MSCNLR **116**, and GMSC **118**. Packet-switched elements include a serving GPRS support node (SGSN) **120** and gateway GPRS support node (GGSN) **122**. Some network elements such as an EIR (equipment identity register) (not shown), HLR (home location register) **124**, VLR and AuC (authentication center) (not shown) can be shared by both domains.

[0037] A function of the CN **102** is to provide switching, routing and transit for user traffic. The CN **102** also contains the databases and network management functions. The basic CN architecture for UMTS is based on the GSM network with GPRS (general packet radio service) capability. All equipment is modified for UMTS operation and services. The radio access network has several interfaces which can be configured and dimensioned. The CN **106** interfaces to the radio access domain via an Iu interface. An Iu-CS (circuit-switched) reference point interfaces an RNC of the access network to the MSCNLR entity **116** of the CN **106** for voice from/to the MSCNLR **116**. An Iu-PS (packet-switched) reference point interfaces an RNC of the access network to the SGSN entity **120** of the CN **106** for data from/to the SGSN **120**.

[0038] In the CN **106**, a Gs interface is provided between the MSCNLR **116** and the SGSN. A Gn interface is provided between the SGSN **120** and the GGSN **122**. A D interface is provided between the MSCNLR **116** and the HLR **124**, and the HLR **124** and the GMSC **118**. A Gr interface is provided between the SGSN **120** and the HLR **124**. A Gc interface is provided between the GGSN **122** and the HLR **124**.

[0039] The CN **106** provides the interface from the UE domain **102** to external networks **126** such as the Internet **128** via a Gi interface from the GGSN **122**, and other networks **130** via the GMSC **118**, which can include a PLMN (public land mobile network), PSTN and ISDN (integrated service digital network) networks.

[0040] The disclosed invention finds application to EDGE (Enhanced Data rates for GSM Evolution) technology. EDGE is effectively the final stage in the evolution of the GSM standard, and uses a modulation schema that enables theoretical data speeds of up to 384 Kbps within the existing GSM spectrum. EDGE is an alternative upgrade path towards 3G services for operators, without access to a new spectrum.

[0041] The architecture of the invention also finds application to a hierarchical cell structure (HCS). HCS is the architecture of a multi-layered cellular network where subscribers are handed over from a macrocell to a microcell, and even further, to a picocell, depending on the current network capacity and the needs of the subscriber.

[0042] Prior art solutions to hearing aid compatibility (HAC) issues with wireless communication systems have focused solely or primarily on the UE, its design, and communication parameters under UE control. There are, however, many communication parameters that are not under UE control that can affect the wireless communication system's interference with HA equipment. Other UE settings and parameters are controllable by the UE, but in the context of minimizing HA interference can be better managed by other communication system elements.

[0043] Many of the wireless communication parameters associated with UE communications with a RAN are handled by the RAN or CN, as opposed to the UE. Parameters such as communication mode selection (e.g., GSM vs. UMTS vs. WiFi for UE having multiple modes), operating power levels, codec rates for digitized voice data sent between the UE and the network, burst transmission frame length, error correction coding schemes, frequency selection, antenna selection, quality of service (QoS) provided to a given UE, time windows for holding a call before it is released due to high frame errors, and others are generally controlled by the network or the UE is configured to control these parameters according to a process that does not generally permit user control. User control is generally not permitted for these parameters, as this could be disruptive to the efficient operation of the wireless communication network. For example, if a user is permitted to manually control the transmitter power level of their handset, the communication network could not manage the transmitter power to minimize interference between nearby handsets. Likewise, manual control of codec rates could lead to

inefficient use of the limited bandwidth available. Therefore, the communication network is generally designed to manage many of the communication parameters associated with communication between UEs and the RAN.

[0044] The settings chosen by the network for many of these parameters, individually and in combination, can affect the interference associated with using a audio communication device in concert with a HA. Certain settings can generate relatively high levels of interference, while others tend to minimize interference between a wireless communication network, including its UE, and a HA. The communication network, however, manages these communication parameters without any consideration of how these parameters can affect that interference, in part because the communication network is ignorant of which UE is being used in concert with a HA.

[0045] Where a HA user is properly indicated, the network can attempt, within the limitations imposed by current bandwidth availability, to tailor one or more communication parameters to minimize interference at the HA due to the wireless communication network. Using the disclosed system and methods, the potential for a HA user to successfully place a wireless call or use other communication network service are maximized.

[0046] The CN **106** can store an indication that a subscriber account is one that will be used with a HA. This indication can comprise a record in a database of a server in the CN **106**. For example, the indication can be stored in the host node HLR **124** and/or another database configured to store such data. The indication can comprise an association of an account identifier with an indication that the account will be used with HA equipment. For example, in a GSM or UMTS network, as shown in the examples in Tables 1-3 below, the account identifier can comprise an international mobile subscriber identity (IMSI). The indication that the account will be used with HA equipment can comprise a Boolean value in a column or field of a database table such as a YES, NO, one, zero, check, or no check, for example.

[0047] Table 1 shows an example where the IMSI is used as the account identifier and the hearing aid compatibility account (HAC_account) field holds a Boolean value of 1 to indicate that the account will be used with a hearing aid. Alternatively, the indication can comprise a string placed in a column that can be parsed to determine that the string, such as 'HA' for example, is present in the database field. An example of this format is shown in Table 2 below. Other methods of associating a HA indication with a wireless account and storing this information in the wireless communication network are contemplated. The example records shown in the tables below can include additional fields.

TABLE 1

IMSI	HAC_account
310410123456789	1

TABLE 2

IMSI	Features
310410123456789	xxx,xxx,xxx,HA,xxx,...

[0048] Table 3 below provides an example of a database record which can store an indication that a given subscriber account is authorized to use an HAC mode. Such an indication can be used to permit the subscriber to activate and deactivate an HAC mode for an account. There may be situations where an HAC mode is not desired by a user. For example, the user might not always wear a HA, or the UE might be shared between two or more users all of whom do not wear an HA.

TABLE 3

IMSI	HAC_authorized
310410123456789	1

[0049] Where the communications network stores an indication that the account is authorized to receive a HAC mode of service, the user of the UE can request that the HAC mode be enabled or disabled for services provided by the network to UE used with the account. The user can set the HAC mode via a menu of the UE, UE soft keys, through a web interface, entering a string of digits or characters via a UE keypad, or other methods. The HAC mode can be set by a user on a call by call basis, on a per service basis, and/or the setting can be stored and remain static until the user changes it.

[0050] The wireless communications network operator can require users that desire HAC mode operation of their UE to provide proof that they wear a HA, such as by providing a copy of a HA prescription or other sufficient proof. Because the HAC mode, in some cases, overrides communication parameters normally controlled by the network to manage bandwidth, transmit power (inter UE interference), and quality of service, it is desirable to prevent non-HA users from receiving HAC mode service.

[0051] FIG. **1***b* illustrates an exemplary GSM network that may be used to implement the various aspects of the present invention. The GSM system, designed as a **2**G cellular communications system, utilizes time division multiple access (TDMA) technology. Digitally-encoded speech can also be ciphered to retain call privacy. Voice calls are the primary function of the GSM system. To achieve this, a vocoder is used. A vocoder is a voice coder device that usually consists of a speech analyzer and a speech synthesizer. The speech analyzer converts analogue speech waveforms into narrowband digital signals during an encoding process. The speech synthesizer converts or decodes the digital signals into artificial speech sounds.

[0052] GSM also supports a variety of other data services, although the performance for such data services (e.g., facsimile videotext and teletext) is relatively slow. One data service includes SMS that allows bi-directional messaging, store-and-forward delivery, and alphanumeric messages. The overall system definition for GSM describes not only the air interface, but also the network. GSM uses 200 KHz RF channels, and are typically multiplexed to, for example, enable eight users to access each carrier.

[0053] The GSM network **132** includes a base station subsystem (BSS) **134**, a network subsystem (NSS) **136** and a GPRS core network **138**. The BSS **134** can include one or more base transceiver stations (BTS) **140** and a base station controller (BSC) **142** connected together on an A-bis interface. The BTS and accompanying base stations (not shown) connect a cell phone to a cellular network. Base stations are

all interconnected to facilitate roaming from one cell to another via a process called handover, without losing the cell connection.

[0054] A packet control unit (PCU) **144** is shown connected to the BTS **140** although the exact position of this can depend on the vendor architecture. The BSS **134** is connected by the air interface Urn to a mobile terminal **146**. The BTS **140** are the actual transmitters and receivers of radio signals. Typically, a BTS for anything other than a picocell will have several different transceivers (TRXs) which allow it to serve several different frequencies or even several different cells (in the case of sectorized base stations).

[0055] By using directional antennae on a base station, each pointing in different directions, it is possible to sectorize the base station so that several different cells are served from the same location. This increases the traffic capacity of the base station (each frequency can carry eight voice channels) while not greatly increasing the interference caused to neighboring cells (in any given direction, only a small number of frequencies are being broadcast).

[0056] The BSC **142** provides the intelligence behind the BTS **140**. Typically, a BSC can have tens or even hundreds of BTSs **140** under its control. The BSC **142** handles allocation of radio channels, receives measurements from the mobile phones, and controls handovers from BTS to BTS (except in the case of an inter-MSC handover in which case control is in part the responsibility of the an MSC). One function of the BSC **142** is to act as a concentrator such that many different low capacity connections to the BTS **140** can become reduced to a smaller number of connections towards the MSC. Generally, this means that networks are often structured to have many BSCs **142** distributed into regions near the BTS **140** which are then connected to large centralized MSC sites.

[0057] The PCU **144** can perform some of the equivalent tasks of the BSC **142**. The allocation of channels between voice and data can be controlled by the base station, but once a channel is allocated to the PCU **144**, the PCU **144** takes full control over that channel. The PCU **144** can be built into the base station, built into the BSC, or even in some architecture, it can be at an SGSN site.

[0058] The BSS **134** connects to the NSS **136** by an A interface. The NSS **136** is shown containing an MSC **148** connected via an SS7 network **150** to an HLR **152**. The AuC and the EIR, although technically separate functions from the HLR **152**, are shown together since combining them can be performed in the network.

[0059] The NSS **136** has a direct connection to the PSTN (public switched telephone network) **154** from the MSC **148**. There is also a connection to/from the NSS **136** to the GPRS core network **138** via a Gr/Gs interface although this is optional and not always implemented. The illustrated GPRS Core Network **138** is simplified to include a SGSN **156** (connected to the BSS **134** by the Gb interface) and a GGSN **158**. The SGSN **156** and the GGSN **158** are connected together by a private IP network **160** called a GPRS backbone shown as the Gn reference point. A computer **162** is depicted as connecting to the core network **138** via an Internet or corporate network **164**.

[0060] FIG. **2** illustrates a device (e.g., UE **102**) according to the present invention. The UE **102** includes a microphone **214**, a speaker **202**, battery **212**, and a display **204**. The UE can further comprise a transceiver **206**, a codec **208**, and a processor **210**. It should be understood that a standalone codec is not required and that, in some embodiments, codec functions can be performed by the processor. The UE **102** can also include one or more antennas **216**, **218** for transmitting and receiving signals from the wireless communication network.

[0061] FIG. **3** depicts a user interface screen on display **204** of a UE **102**. In the embodiment illustrated, the UE **102** is capable of accepting a HAC mode selection. The interface screen can be reached by navigating a menu **300** of the UE **102** using the directional keys **306**, the soft keys **302**, **304**, and/or the keypad **308**. The UE **102** can provide the selection to the communication network upon a change, and/or the selection can be provided to the network upon requesting a network service including not only originating a voice call, but also receiving an incoming call.

[0062] FIGS. **4**A and **4**B depict interface screens that can be used on UE **102** to permit a user to select a HAC mode of operation upon receiving an incoming call or originating a voice call. FIG. **4**A shows that an incoming call has been placed to the UE **102** from the number 123-456-7890. An indication is provided above the soft key **302** to accept input from a user of the UE to request that the network and UE connect the call in HAC mode upon the user pressing the soft key **302**. FIG. **4**B depicts an interface screen **204** of the UE **102**, where a call is currently in progress (or has been dialed and is ringing) and where an indication is provided above the soft key **302** to accept input from a user of the UE to request that service for the call be provided to the UE **102** in a HAC mode. Though not illustrated, a similar feature can be provided whereby a user can request HAC mode before initiating a call.

[0063] As an alternative to the illustrated embodiment, a dedicated button can be designed on the UE for a "push to HAC" feature implementation. That is, the HAC feature could be enabled by a user by pressing the dedicated button. Such an embodiment is described in more detail in published U.S. Patent Application No. 2007/0009125 to the same assignee.

[0064] FIG. **5** shows a system that can be used to provide an indication to the UE and on to the communication network, on a call-by-call basis, that the UE is being used with a HA. The UE **102** is shown having a detector **500**, which can detect the presence of a tag **506** of the HA **504** of an ear **502** that is brought into proximity to the UE **102**. The detector can comprise an RFID reader and the tag **506** can comprise an RFID tag. Although an ITE HA is illustrated, similar systems can be implemented with other HA types.

[0065] In the examples of FIGS. **3**-**5**, settings of the UE, selections by the user, and/or the detection of a HA can be provided to the communications network via an air interface of the communications network. In response the communications network can determine if a HAC mode of operation should be provided to the UE and, if so, can set one or more communication parameters of the network, or instruct the UE to set such parameters in a way so as to minimize the potential for interference of the communications network and/or the UE **102** with a HA of the user.

[0066] The system and methods described can be used in providing both circuit switched and packet switched (such as voice over IP (VoIP)) wireless communication services such as voice calls. The coupling mode between a HA and the UE can be microphone, telecoil (magnetic) or both. The disclosed systems and methods are applicable to any of a number of wireless communication standards, including but not limited to GSM, TDMA, iDEN, WiFi, IEEE 802.xx, 802.16, 802.20,

UMTS, HSDPA/HSUPA or HSPA, CDMA, EV-DO, UMB, and LTE. The UE can have multiple modes such as a UMTS mode and a WiFi mode. A HAC mode can be configured to select between the multiple modes and may be further configured to prioritize the modes. The invention can also be implemented in a cordless phone network such as a household cordless phone system; in such a system a HAC mode could be indicated by a user through the methods described above or through a physical switch on a handset or a base unit.

[0067] With the communication network having knowledge that a wireless account is associated with a hearing aid user and that a HAC mode of operation is to be provided, a number of communication parameters can be manipulated and network resources allocated to attempt to minimize interference with a HA. Where a communication network is experiencing a heavy load, certain parameters or resources might not be available.

[0068] FIG. **6** shows a flowchart depicting a method **600** for providing an HAC mode of operation according to the present invention. The method begins at block **602** and proceeds to block **604** where a request is received at a communication network for wireless communication service for a given subscriber account. At block **606** the account identifier of the request is retrieved. At block **608** a lookup operation is performed to determine if the account should receive an HAC mode of operation for the service to be provided. At decision block **610** if an HAC mode of operation is indicated service can be provided in an HAC mode of operation **612** and the method ends at block **616**. If an HAC mode of operation is not indicated for the account, service can be provided in a standard mode of operation at block **614**. The method **600** can be used generally where the HAC mode of operation is set for the account and used for services provided to the account until the HAC mode of operation indicator is changed, in contrast to the method **800** of FIG. **8** where the request for HAC service is received on a case by case basis.

[0069] FIG. **7** is a flowchart depicting a method **700** for updating an HAC indication at a communication network according to a selection made by an account user. The method starts at block **702** and proceeds to block **704** where a user selection for an HAC preference is received from a communication device at the communication network. At block **706** the account identifier is retrieved for the subject account. At block **708** a lookup operation is performed to retrieve an HAC authorization indication corresponding to the account. At decision block **710**, if the account is HAC authorized the HAC indication stored on the network is updated according to the user selection **712**. If the account is not HAC authorized a message is transmitted to the user's audio communication device indicating that the account is not HAC authorized **714**. The method ends at block **716**.

[0070] FIG. **8** is a flowchart depicting a method **800** where an HAC authorization indication is stored at the network and requests for a HAC mode of operation are received by the network before or as services are being provided. The method begins at block **802** and proceeds to block **804** where a request is received for wireless communication service in an HAC mode of operation at a communication network. This request can be received, for example, upon an audio communication device initiating a telephone call where a setting has been made in the audio communication device indicating that the user desires an HAC mode of operation. The request can also be received where an audio communication device initiates a telephone call upon pressing a soft key to place the call in an HAC mode. In addition, the method can be used where a user answers an incoming call by pressing a soft key indicating that the user wishes to answer the call in an HAC mode of operation, and/or used where a detector such as the detector **500** of FIG. **5** is used to detect the presence of an HA near the acoustic output of the UE. The method continues to block **806** where the account identifier for the account is retrieved from the request. At block **808** a lookup operation is performed to retrieve the HAC authorization indication for the account. At decision block **810**, if the account is HAC authorized, service is provided in an HAC mode at block **812**. If the account is not HAC authorized, service is provided in a normal/standard mode at block **814**. The method ends at block **816**.

[0071] FIG. **9** depicts a method **900** for a network to manage communication parameters of wireless UE to provide a HAC mode of operation. The method begins at block **902** and proceeds to block **904** where it is determined whether the UE associated with the account to which service is being provided has network directable settings for the service to be provided. For example, the method can determine if the subject device has multiple codec settings the selection of which can be controlled by the network. The existence of such settings can be presumed in the case of some communication technologies where their existence is part of the communication standard. Where multiple settings for a given parameter are optional in communication devices, the communication network can query the device and/or the network to determine the capabilities of the device. For example, if the device is a GSM/UMTS device an IMEI can be obtained from the device by the network, the network can then query a network memory to determine the capabilities of the device where the memory queried includes IMEIs stored with device capabilities—in a database table, for example. Alternatively, the audio communication device can report its capabilities to the network through the RAN.

[0072] If it is determined that the device has no network directable settings for the given communication parameter at decision block **906**, the method ends at block **916**. If it is determined that the device has network directable settings for the given parameter, the set of available settings can be determined at block **908**. The available settings can be determined in a similar way as described above for determining if any directable settings exist. At block **910**, the network determines which of the available settings is least likely to cause interference with a HA of the device user. At decision block **912**, a check is performed to determine if sufficient network resources exist to provide the service using the determined setting. If such resources exist, the device is directed to use the determined setting at block **914**. If sufficient resources do not exist, the method ends at **916**. If two or more alternatives exist for the setting as determined at block **908**, the method can loop back to block **910** from decision block **912** to determine if a less resource intensive setting can be used to minimize HA interference. This loop back operation is only available if two or more alternatives exist for the setting as determined at block **908** and as such, a dashed loop is illustrated for this case.

[0073] If only one setting is available, flow proceeds through each block ultimately directing the device to use the sole setting. If two settings exist, that is a first setting and one alternative setting, then a decision is made at block **910** to determine the available setting for the given parameter least likely to cause interference with a HA. The setting least likely to cause interference with the HA is then used by the device.

In some instances, as determined at block **912**, network resources are not sufficient to provide service using the selected setting. Accordingly, the method proceeds to block **916** and the method ends. A first setting and one alternative setting can cause the method to default to the remaining setting if the first selected setting does not meet the requirements of block **912**.

[0074] If three or more setting exist, that is a first setting and at least two alternative settings, then a decision is made at block **910** to determine the available setting for the given parameter least likely to cause interference with the HA. It is then determined, at block **912**, if network resources are sufficient to provide service using the selected setting. If network resources are not sufficient, flow proceeds through the dashed loop back to block **910** wherein the remaining settings are analyzed to determine the given parameter least likely to cause interference with the HA. The method repeats until a setting is determined, at block **912**, to be sufficient to provide service using the selected setting.

[0075] FIG. **10** depicts a method **1000** for a network to manage communication parameters of a RAN to provide an HAC mode of operation. The method begins at block **1002** and proceeds to block **1004** where it is determined whether the RAN associated with the account to which service is being provided has network directable settings for the service to be provided. For example, the method can determine if the RAN has any steerable antennas which can be used directed toward the location of the UE communicating with the RAN.

[0076] If it is determined that the RAN has no network directable settings for the given communication parameter at decision block **1007**, the method ends at block **1017**. If it is determined that the RAN has network directable settings for the given parameter, the set of available settings can be determined at block **1009**. At block **1011**, the network determines which of the available settings is least likely to cause interference with a HA of the device user. At decision block **1013** a check is performed to determine if sufficient network resources exist to provide the service using the determined setting. If such resources exist, the RAN is directed to use the determined setting at block **1015**. If sufficient resources do not exist, the method ends at **1017**. If two or more alternatives exist for the setting as determined at block **1009**, the method can loop back to block **1011** from decision block **1013** to determine if a less resource intensive setting can be used to minimize HA interference. This loop back operation is only available if two or more alternatives exist for the setting as determined at block **1009** and, as such, a dashed loop is illustrated for this case.

[0077] If only one setting is available, flow proceeds through each block ultimately directing the device to use the sole setting. If two settings exist, that is a first setting and one alternative setting, then a decision is made at block **1011** to determine the available setting for the given parameter least likely to cause interference with a HA. The setting least likely to cause interference with the HA is then used by the device. In some instances, as determined at block **1013**, network resources are not sufficient to provide service using the selected setting. Accordingly, the method proceeds to block **1017** and the method ends. A first setting and one alternative setting can cause the method to default to the remaining setting if the first selected setting does not meet the requirements of block **1013**.

[0078] If three or more setting exist, that is a first setting and at least two alternative settings, then a decision is made at block **1011** to determine the available setting for the given parameter least likely to cause interference with the HA. It is then determined, at block **1013**, if network resources are sufficient to provide service using the selected setting. If network resources are not sufficient, flow proceeds through the dashed loop back to block **1011** wherein the remaining settings are analyzed to determine the given parameter least likely to cause interference with the HA. The method repeats until a setting is determined, at block **1013**, to be sufficient to provide service using the selected setting.

[0079] In many cases the methods **900** and **1000** will be used in combination. That is, a setting directed to the UE will also be directed to the RAN. Where this is the case, the available settings for a given parameter can be corroborated between the two methods to limit the selected setting to one that is shared between the RAN and the UE.

[0080] Various communication parameters that can be directed for either or both a UE and a RAN are discussed below. This list is not exhaustive, and the methods of the present invention can be used to manage other parameters not listed in order to provide a HAC mode of operation.

[0081] Codec Rate

[0082] As a part of a HAC mode provided by a network which is aware of an account being associated with a HA user, the network can instruct the UE and the RAN to operate using an adaptive multi-rate (AMR) speech codec. By way of example, the applicable codec rates 12.2 kbits/s, 10.2 kbits/s, 7.95 kbits/s, 7.4 kbits/s, 6.7 kbits/s, 5.9 kbits/s, 5.15 kbits/s, 4.75 kbits/s, or 1.8 kbits/s as described in 3rd Generation Partnership Project (3GPP) 26.071 may be used. Alternatively, other codec rates may be used as required for a specific implementation. In a HAC mode, the network can instruct the UE to maintain higher level codec rates such as 12.2 and 10.2 kbits/s to maintain speech quality and intelligibility.

[0083] Burst Frame Length

[0084] In a HAC mode, the network can instruct the UE and the RAN to prefer and communicate using longer burst frame lengths for transmissions from the UE to the RAN. For example, a burst frame length of 10 ms can be used instead of a shorter frame length such as 2 ms. The use of the longer frame can reduce potential RF interference into the HA which produces noise in the audible range for human hearing (100 kHz to 4000 kHz).

[0085] Error Correction Coding

[0086] Mobile networks employ error detection and error correction methods to maintain quality of the speech transmitted during poor RF Signal to Noise connection. Speech information is assembled by the network in speech frames. The quality of the voice channel is typically based on the number of speech frames received and those that are rejected based on the pass/fail of the error detection. The mobile network classifies the quality of the voice call by the number of speech frames rejected and may drop the voice call because of high speech frame error rates. In a HAC mode, the speech quality for a HA user may need to be maintained and in poor RF signal conditions the network may see high speech frame rejections and should not drop the call until the HA user ends the call.

[0087] Power Levels

[0088] While a HAC mode is being used, the network can instruct the UE to prefer the use of lower power levels between bursts. The reduction of the power level can reduce the RF induced interference into the HA. The power levels can be any as defined by the GSM/UMTS specifications such

as provided in 3GPP 34.121. Alternatively, other power levels may be used as required for a specific implementation. In a HAC mode, the network can instruct the UE to limit the RF power to certain power class steps.

[0089] Frequency Selection

[0090] Where a HAC mode is enabled and the UE being used is capable of operating on various frequency bands, the network can instruct the UE and RAN to prefer one or more of the bands over the others in order to reduce the RF induced interference into the HA.

[0091] RAN Antenna Preference

[0092] When a HAC mode is enabled, the network can instruct the RAN to prefer steerable antennas or the use of interference cancellation techniques to permit the UE to operate using a lower power output level while still maintaining an acceptable signal to noise ratio for uplink communications.

[0093] UE Antenna Preference

[0094] Where the UE being used has multiple antennas and a HAC mode is enabled, the network can instruct the UE to transmit from an antenna or multiple antennas where transmitting out of such antennas serves to reduce the electromagnetic field strengths in or near the UE acoustic output (e.g. speaker). For example, the network can direct the UE **102** to transmit from antenna **218** (shown in FIG. **2**) instead of antenna **216**.

[0095] UE Display Settings

[0096] The circuitry used to power the backlights of many UE displays can cause interference with a HA. In a HAC enabled mode, the network of the present invention can instruct the UE (a UE according to the present invention which supports this feature) to turn off the backlight and/or disable other display options and processes.

[0097] Quality of Service

[0098] Where a HAC mode is indicated, the network can allocate resources to the UE according to QoS levels available on the network to reduce the interference into the HA.

[0099] Increasing Call Timers

[0100] In a HAC mode, the HA user's speech frames may be rejected due to the selection of a higher speech codec rate and error correction in a poor RF signal condition. Where a HAC mode of operation is indicated, the network can increase the timer windows to hold a call longer during periods of high speech frame errors and thus not dropping the call.

[0101] Packet Scheduler

[0102] Mobile communication networks have been based on Circuit Switched (CS) voice calling. The next generation of mobile communications such as LTE and UWB are planning on introduction of Packet Switched (PS) voice calling such as voice over Internet protocol (VoIP). Unlike circuit switched voice calls the packetized transport of VoIP introduces variable delay due to scheduling of the voice packets through the network. In a HAC mode, the network can prioritize the voice packet to enable a higher Quality of Service (QoS) for the HAC call to limit the amount of delay introduced to maintain a higher speech quality voice call.

[0103] Communication Standard

[0104] Many newer UE devices include support for multiple communication standards. For example, a UE may include support for both a GSM standard and a WiFi standard allowing the UE connect to wireless access points and place VoIP calls. The methods of the present invention can be used to direct a UE to prefer a WiFi mode of operation where one is available even if a GSM mode of operation would normally be used by the UE in the given circumstances. This can enable to phone to communicate using lower power levels to avoid interference with a HA.

[0105] E911 Calls

[0106] Where a HAC mode of operation is indicated, the network can further adjust any of the parameters and/or allocate additional resources as discussed herein to give priority to a HA user placing an emergency call.

[0107] Network Monitoring of HAC Mode Users at Given Cell

[0108] Even where network directable settings exist, the network might not be able to direct that such settings be used due to there consuming extra network resources. In some cases, such additional network resources might not be available. In order to manage these resources, the present invention can monitor a given cell site and its sectors to determine the number of HAC mode users connected to the cell. The methods of the present invention can be used to direct one or more HAC mode users to prefer a connection to another cell or sector where one is available if the number of HAC mode users connected to a given cell is high or the resources available at the cell are low.

[0109] As described above, the present invention provides network-oriented methods and systems for addressing the HAC issues. It should be understood that some communication parameters can be interdependent and that, in such cases, some parameters make take priority over others in the network's direction of those parameters.

[0110] In addition, the methods and systems are operated on computers and/or computer readable memory or medium, as understood by one skilled in the art.

[0111] The law does not require and it is economically prohibitive to and teach every possible embodiment of the present claims. Hence, the above-described embodiments are merely exemplary illustrations of implementations set forth for a clear understanding of the principles of the invention. Variations, modifications, and combinations may be made to the above-described embodiments without departing from the scope of the claims. All such variations, modifications, and combinations are included herein by the scope of this disclosure and the following claims.

What is claimed is:

1. A communication system, comprising:

a processor; and

a computer-readable medium comprising instructions that, when executed by the processor, cause the processor to perform operations comprising:

determining which of multiple available user-device settings is least likely to cause interference with a hearing aid being used with an audio communication device, yielding a lowest-interference user-device setting, wherein the audio communication device is associated with a user account;

determining, in response to determining the lowest-interference user-device setting, whether sufficient network resources exist to provide a service using the lowest-interference user-device setting; and

directing, in response to determining that sufficient network resources exist to provide the service using the lowest-interference user-device setting, the audio communication device to operate according to the lowest-interference user-device setting determined.

2. The communication system of claim **1**, wherein the operations further comprise:

receiving, from the audio communication device, being associated with the user account, a request for a hearing-aid-compatibility mode of operation in connection with the service being or to be provided to the audio communication device;

determining, in response to receiving the request, whether the account is authorized for the hearing-aid-compatibility mode of operation;

enabling, in response to determining that the account is authorized for the hearing-aid-compatibility mode, the hearing-aid-compatibility mode of operation for the account in connection with the service;

3. The communication system of claim **1**, wherein the operations further comprise:

determining whether the audio communication device has one or more adjustable, network-directable settings;

identifying, in response to determining that the audio communication device has one or more network-directable settings, the multiple available user-device settings of the audio communications device;

4. The communication system of claim **1**, wherein the operations further comprise increasing a timer to hold hearing-aid compatibility mode calls to the audio communication device during periods of high frame rate errors.

5. The communication system of claim **1**, wherein the operations further comprise providing, to a communication service provider, an indication that the account is using the hearing-aid-compatibility mode to facilitate use of the mode or the audio communication device while the audio communication device is roaming on a network served by the communication provider.

6. The communication system of claim **1**, wherein determining whether sufficient network resources exist to provide the service using the lowest-interference user-device setting includes determining whether currently-available network bandwidth is sufficient to provide the service to the audio communication device with lowest-interference user-device setting.

7. The communication system of claim **1**, wherein the operations further comprise determining whether the network has network-directable settings related to provision of the service to the audio communications device.

8. The communication system of claim **1**, wherein the lowest-interference user-device setting includes a frequency-band setting.

9. The communication system of claim **3**, wherein identifying the available user-device settings of the audio communications device comprises querying the device to determine device capabilities.

10. The communication system of claim **3**, wherein determining whether the audio communication device has the network-directable settings comprises querying the device to determine device capabilities.

11. The communication system of claim **1**, wherein the lowest-interference user-device setting includes at least one feature selected from group consisting of:

a user-device operating power level optimized for reduced hearing-aid interference;

an antenna configuration of the device selected to reduce the electromagnetic field inference induced on an acoustic output of the audio communication device;

a display setting, including a display backlighting circuitry optimizable for reduced hearing-aid interference; and

a frequency-band setting.

12. The communication system of claim **1**, wherein the operations further comprise monitoring a number of hearing-aid-compatibility mode users operating at a given location at a given time to prevent over allocation of resources.

13. The communication system of claim **1**, wherein the operations further comprise:

identifying network-directable settings related to provision of the service to the audio communications device;

determining which of the network-directable settings is least likely to cause interference with a hearing aid being used with the audio communication device, yielding a lowest-interference network-device setting;

determining, in response to determining the lowest-interference user-device setting, whether sufficient network resources exist to provide the service using the lowest-interference network-device setting.

14. The communication system of claim **13**, wherein the lowest-interference network-device setting includes at least one characteristic selected from a group consisting of: a codec rate; a burst frame length; an error correction coding; an operating power level; a frequency band; an antenna configuration; an interference cancellation technique; a quality of service, a call timer setting, packet prioritization.

15. A computer-readable storage device comprising instructions that, when executed by a processor, cause the processor to perform operations comprising:

determining which of multiple available user-device settings is least likely to cause interference with a hearing aid being used with an audio communication device, yielding a lowest-interference user-device setting, wherein the audio communication device is associated with a user account;

determining, in response to determining the lowest-interference user-device setting, whether sufficient network resources exist to provide a service using the lowest-interference user-device setting; and

directing, in response to determining that sufficient network resources exist to provide the service using the lowest-interference user-device setting, the audio communication device to operate according to the lowest-interference user-device setting determined.

16. The computer-readable storage device of claim **1**, wherein the operations further comprise:

receiving, from the audio communication device, being associated with the user account, a request for a hearing-aid-compatibility mode of operation in connection with the service being or to be provided to the audio communication device;

determining, in response to receiving the request, whether the account is authorized for the hearing-aid-compatibility mode of operation;

enabling, in response to determining that the account is authorized for the hearing-aid-compatibility mode, the hearing-aid-compatibility mode of operation for the account in connection with the service;

17. The computer-readable storage device of claim **15**, wherein the operations further comprise:

determining whether the audio communication device has one or more adjustable, network-directable settings;

identifying, in response to determining that the audio communication device has one or more network-directable settings, the multiple available user-device settings of the audio communications device;

18. The computer-readable storage device of claim **15**, wherein the operations further comprise increasing a timer to hold hearing-aid compatibility mode calls to the audio communication device during periods of high frame rate errors.

19. The computer-readable storage device of claim **15**, wherein the operations further comprise providing, to a communication service provider, an indication that the account is using the hearing-aid-compatibility mode to facilitate use of the mode or the audio communication device while the audio communication device is roaming on a network served by the communication provider.

20. A method, comprising:

determining, by a system using a processor, which of multiple available user-device settings is least likely to cause interference with a hearing aid being used with an audio communication device, yielding a lowest-interference user-device setting, wherein the audio communication device is associated with a user account;

determining, by the system, in response to determining the lowest-interference user-device setting, whether sufficient network resources exist to provide a service using the lowest-interference user-device setting; and

directing, by the system, in response to determining that sufficient network resources exist to provide the service using the lowest-interference user-device setting, the audio communication device to operate according to the lowest-interference user-device setting determined.

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