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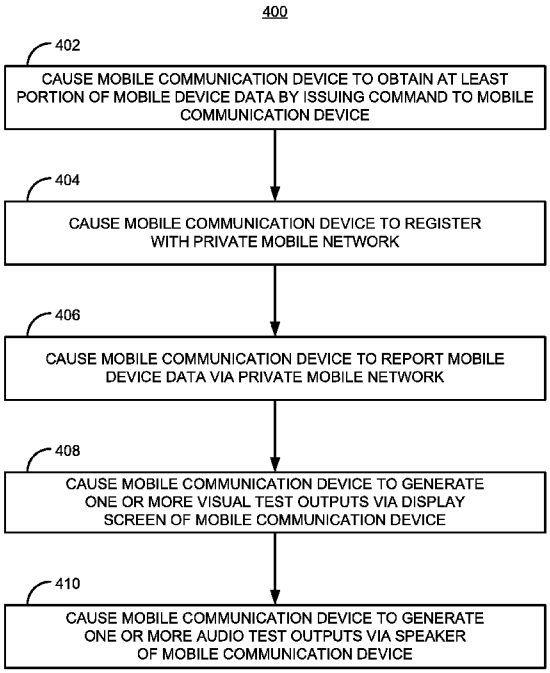

FIG. 4

(57) Abstract: A SIM card for facilitating diagnosis of a mobile device includes a processor and a memory storing a diagnostics application. When executed by the processor, and while the SIM card is electrically coupled to the mobile device, the diagnostics application causes the mobile device to report mobile device data via a private, cellular mobile network. The mobile device data, which is stored in memory of the mobile device, includes data indicative of one or more characteristics or properties of the mobile device. The diagnostics application also causes the mobile device to generate one or more test outputs to be captured by one or more sensors external to the mobile device. The test outputs may include one or more visual test outputs generated via a display screen of the mobile device, and/or one or more audio test outputs generated via a speaker of the mobile device.

[Continued on next page]

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SYSTEM AND METHOD FOR PERFORMING MOBILE COMMUNICATION DEVICE DIAGNOSTICS

TECHNICAL FIELD

[0001] The present disclosure relates generally to mobile communication devices (*e.g.*, mobile phones), and more particularly to systems and methods for diagnosing the condition of a mobile communication device.

BACKGROUND

[0002] Many wireless service providers allow customers to exchange their old mobile devices (*e.g.*, smartphones) for value, such as a credit towards a new, replacement mobile device, or towards a service plan. Typically, the process of receiving or assigning the credit begins with a visual inspection of the current mobile device by personnel (*e.g.*, at a retailer, or a phone recycling entity). The inspecting person may be tasked to perform the visual inspection by determining the make and model, and inspecting physical defects and certain aspects of functionality before deciding on a condition of the phone. This manual inspection process may be very time consuming when there are many devices to assess. Moreover, the process may be subject to human error and/or inconsistency. Worse still, in some rarer cases, exchanged devices may unfairly and purposely be assessed as being in a condition that is worse than the actual condition.

[0003] More recently, techniques and devices have been developed to help address these shortcomings. One such device and technique is described in the international patent publication WO 2017/081527 (Sinha et al.), entitled "Systems and Methods for Assessing a Mobile Device," which is hereby incorporated herein by reference in its entirety. Sinha et al. describes an assessment apparatus (*e.g.*, a kiosk) that enables a customer or other user to place a mobile device in a shielded compartment, such as a sliding drawer that forms a Faraday cage when closed. The apparatus includes a wireless transceiver that is configured to operate as a cellular base station, allowing the mobile device to link to or join a small, localized cell. Thereafter, the apparatus may identify the mobile device via data received over the cellular link. Further, the apparatus may include one or more cameras (*e.g.*, within the Faraday cage) to capture images of the mobile device, which can then be analyzed using image processing techniques to determine the physical condition of the visible exterior of the device (*e.g.*, cracks in the display screen).

Once the condition is assessed, the apparatus may display an appropriate offer (*e.g.*, a specific trade-in value) for the device.

[0004] While an apparatus of this sort potentially overcomes many of the problems associated with manual inspection, there remains a need to evaluate not only the exterior, visible condition of the mobile device, but also certain types of operations or functionality of the device. For example, a device may have a display that has no cracks or other visible imperfections, but nonetheless does not function, or functions in a less than optimal way (*e.g.*, by having certain areas with inoperable pixels, or being unable to accurately depict certain colors, etc.). To evaluate the operational or functional condition of a mobile device, substantial human involvement is still required. For example, personnel may need to attempt certain operations on the device, which may give rise to some of the same drawbacks noted above (*e.g.*, lengthy assessment times, inconsistency, errors, etc.). While some software applications that examine mobile phone functionalities are available, a substantial degree of human involvement is still required. After such an application is downloaded into the phone, personnel must interact with the running application to perform the desired testing.

SUMMARY

[0005] Example systems and methods for performing mobile communication device diagnostics are herein described.

[0006] In one aspect, a Subscriber Identity Module (SIM) card for facilitating diagnosis of a mobile communication device comprises a processor and a memory. The memory stores a diagnostics application that, when executed by the processor while the SIM card is electrically coupled to the mobile communication device, causes the mobile communication device to report mobile device data via a private mobile network. The private mobile network is a cellular network, and the mobile device data (i) includes data indicative of one or more characteristics or properties of the mobile communication device and (ii) is stored in one or more memories of the mobile communication device. The diagnostics application also causes the mobile communication device to generate one or more test outputs to be captured by one or more sensors external to the mobile communication device. The one or more test outputs include one or both of (i) one or more visual test outputs generated via a display screen of the mobile

communication device, and (ii) one or more audio test outputs generated via a speaker of the mobile communication device.

[0007] In another aspect, method, implemented in a SIM card, for facilitating diagnosis of a mobile communication device to which the SIM card is electrically coupled, comprises causing the mobile communication device to report mobile device data via a private mobile network. The private mobile network is a cellular network, and the mobile device data (i) includes data indicative of one or more characteristics or properties of the mobile communication device and (ii) is stored in one or more memories of the mobile communication device. The method also includes causing the mobile communications device to generate one or more test outputs to be captured by one or more sensors external to the mobile communication device. The one or more test outputs include one or both of (i) one or more visual test outputs generated via a display screen of the mobile communication device, and (ii) one or more audio test outputs generated via a speaker of the mobile communication device.

[0008] In another aspect, a method for diagnosing a mobile communication device is implemented in a mobile device diagnostics system. The method comprises establishing a private mobile network, where the private mobile network is a cellular network, and registering a mobile communication device attempting to join the private mobile network. The method also includes receiving mobile device data from the mobile communication device via the private mobile network. The mobile device data includes data indicative of one or more characteristics or properties of the mobile communication device. The method also includes receiving, from the mobile communication device and via the private mobile network, one or more synchronization messages. The one or more synchronization messages indicate when each of one or more test outputs generated by the mobile communication device can be captured by one or more sensors of the mobile device diagnostics system, and the one or more test outputs include one or both of (i) one or more visual test outputs generated by a display screen of the mobile communication device, and (ii) one or more audio test outputs generated by a speaker of the mobile communication device. The method also includes capturing, via the one or more sensors, the one or more test outputs generated by the mobile communication device, and determining a functional condition of the mobile communication device at least by analyzing the captured one or more test outputs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The figures described below depict various aspects of the systems and methods disclosed herein. It should be understood that each figure depicts an embodiment of a particular aspect of the disclosed system and methods, and that each of the figures is intended to accord with a possible embodiment thereof. Further, where possible, the following description refers to the reference numerals included in the following figures, and features depicted in multiple figures are designated with consistent reference numerals.

[0010] Figure 1 is a block diagram of an example environment in which diagnostics may be performed on a mobile communication device.

[0011] Figure 2 depicts a portion of the example self-service apparatus of Figure 1.

[0012] Figure 3 is a timeline view of an example sequence of events that may occur in the example environment of Figure 1.

[0013] Figure 4 is a flow diagram depicting an example method, implemented in a SIM card, for facilitating diagnosis of a mobile communication device to which the SIM card is electrically coupled.

[0014] Figure 5 is a flow diagram depicting an example method, implemented in a mobile device diagnostics system, for diagnosing a mobile communication device.

[0015] Figure 6 is a block diagram of an example computer system in which the described embodiments may be implemented.

DETAILED DESCRIPTION

[0016] In some embodiments of the present invention, the time, costs, and/or errors associated with a manual inspection of a mobile communications device may be reduced by using a Subscriber Identity Module (SIM) card and a mobile device diagnostics system. The mobile communications device (also referred to herein as simply a "mobile device") may be a mobile phone (*e.g.*, smartphone), a tablet device, a wearable device (*e.g.*, a smart watch), a laptop device, or any other device equipped with cellular communication capabilities and the ability to generate audio and/or visual outputs. In embodiments described herein, a diagnostics software application may be installed on the SIM card, which is then manually inserted in the mobile

device. The diagnostics application may then cause the mobile device to automatically interact with the mobile device diagnostics system as discussed further below.

[0017] The mobile device diagnostics system may include, for example, a self-service apparatus for assessing mobile devices. In some embodiments, the mobile device diagnostics system further includes a remote, back-end server in communication with the self-service apparatus. The self-service apparatus may be a kiosk, for example, and may include a shielded drawer or other compartment to physically accept the mobile device. To collect information about the mobile device, the self-service apparatus may also include a base station controller/transceiver, one or more microphones, and/or one or more cameras or other imaging devices. The base station controller/transceiver may enable devices within the shielded compartment to register with a "private mobile network" established by the self-service apparatus, thereby establishing a communications link with the mobile device. The microphone(s) is/are configured to capture sounds emitted by speakers of mobile devices in the shielded compartment, and the imaging device(s) is/are configured to capture images presented on display screens of mobile devices in the shielded compartment.

[0018] Once the SIM card is installed in a mobile device, and the mobile device has been inserted into the drawer or other chamber of the self-service apparatus, the SIM card may cause the mobile device to provide particular characteristics or properties of the mobile device to the self-service apparatus. For example, the SIM card may issue commands that cause the mobile device to send its International Mobile Equipment Identify (IMEI), its serial number, the mobile device manufacturer, and/or other identifying information to the self-service apparatus (*e.g.*, via a General Packet Radio Service (GPRS) link). Also, or instead, the SIM card may cause the mobile device to send information specifying certain capabilities or states of the mobile device to the self-service apparatus.

[0019] Still further, the SIM card may cause the mobile device to generate various kinds of audio and/or visual outputs, to be detected by a microphone and/or imaging device of the self-service apparatus. For example, the SIM card may cause the mobile device to generate a ringtone, cause the mobile device to display a predetermined string of text/characters, and/or cause a web browser of the mobile device to access a Uniform Resource Locator (URL) of a web page that includes a known image. Once the speaker(s) and/or imaging device(s) of the self-

service apparatus have detected the sounds and/or images, the self-service apparatus may analyze the sounds and/or images to determine whether the mobile device is functioning correctly. Alternatively, the self-service apparatus may send the audio and/or image data to the back-end server, and the server may analyze the data to diagnose functionality.

[0020] In some embodiments, once a given mobile device has been assessed based on its identifying information (and/or other properties or characteristics), its audio/speaker operation, and/or its visual/display screen operation, a value is determined for the mobile device. The value may be a discount on a new mobile device, as part of a trade-in process, for example. The value may be displayed to the owner of the old mobile device on a display screen of the self-service apparatus, for example, or may be communicated via other means (*e.g.*, email, text message to the mobile device, etc.).

[0021] Referring now to the figures, Figure 1 depicts an example environment 100 for performing diagnostics on a mobile device 102. The mobile device 102 may be a smartphone, a wearable device (*e.g.*, a smart watch), a tablet device, or any other device capable of communicating via a cellular network and of generating audio and/or visual outputs. In addition to the mobile device 102, the environment 100 includes a self-service apparatus 104, a server 106, and a communications network 110. Self-service apparatus 104 and server 106 may be located remotely from each other, and communicate with each other via network 110. Network 110 may include one or more wired and/or wireless networks, such as the Internet, for example.

[0022] A Subscriber Identity Module (SIM) card 112 is configured to mechanically and electrically couple to mobile device 102 (*e.g.*, via a standard SIM card slot, and possibly using a mechanical adapter). SIM card 112 may be a SIM card for a GMS, UMTS, or LTE phone, for example, and may include both hardware and software. As seen in Figure 1, SIM card 112 may include a processor 120, a read-only memory (ROM) 122, a random access memory (RAM) 124, and a diagnostics application 126. ROM 122 may include one or more persistent memories (*e.g.*, ROM, EEPROM, etc.), and RAM 124 may include one or more random-access memories. ROM 122 may store an operating system (not shown in Figure 1) and diagnostics application 126, for example. Diagnostics application 126 includes instructions that can be accessed and executed by processor 120 to facilitate diagnosis of mobile device 102, as discussed in further detail below.

[0023] Self-service apparatus 104 may include a chamber configured to receive and (in some embodiments) electrically isolate mobile devices such as mobile device 102. The hardware construction of self-service apparatus 104, according to some embodiments, is discussed further below in connection with Figure 2. In the embodiment of Figure 1, self-service apparatus 104 also includes a processor 130, a memory 132, a private mobile network (PMN) controller 134 with a short message service center (SMCS) 136, a data collection unit 140, sensors 142, input device 144, output device 146, and a wide area network (WAN) interface 150.

[0024] Processor 130 may include one or more processors of one or more types (*e.g.*, a CPU and a GPU), and memory 132 may include one or more memories of one or more types (*e.g.*, ROM and RAM). Memory 132 stores instructions that are executed by processor 130 to support various functions, such as the functionality of PMN controller 134, data collection unit 140, sensors 142, input device 144, and/or output device 146 as described below.

[0025] PMN controller 134 is associated with one or more wireless transceivers (not shown in Figure 1), and enables self-service apparatus 104 to operate as a base station of a cell in a cellular network, as discussed further below. Data collection unit 140 represents a software module that may be configured to obtain and store (*e.g.*, in a part of memory 132) information, such as one or more identifying properties (*e.g.*, IMEI), that was collected from mobile devices via PMN controller 134 (*i.e.*, via the private mobile network). Data collection unit 140 may also be configured to obtain and store audio and/or image data via sensors 142. Sensors 142 may include one or more microphones and/or one or more imaging devices, for example.

[0026] Input device 144 may include hardware and software for one or more devices that enable a user to enter information, such as a keyboard, mouse, voice-recognition unit, etc. Output device 146 may include hardware and software for one or more devices that are configured to present visual and/or audio information to a user, such as a display screen and/or speaker. In some embodiments, input device 144 and output device 146 are at least partially integrated together (*e.g.*, a touch screen with both input and output capability). WAN interface 150 may include hardware and software configured to communicate with server 106 via network 110.

[0027] Server 106 includes a processor 160, a memory 162, a diagnostics unit 164, and a WAN interface 166. Processor 160 may include one or more processors of one or more types

(*e.g.*, a CPU and a GPU), and memory 162 may include one or more memories of one or more types (*e.g.*, ROM and RAM). Memory 162 stores instructions that are executed by processor 160 to support various functions, such as the functionality of diagnostics unit 164. WAN interface 166 may be similar to WAN interface 150, and enables communication between self-service apparatus 104 and server 106 via network 110. Server 106 may also include (*e.g.*, in a persistent memory of memory 162), or be communicatively coupled to, a mobile device database 170. Server 106 may use mobile device database 170 to obtain various types of information about various mobile device models, such as monetary value, capabilities, and so on. Mobile device database 170 may be stored in a single memory (*e.g.*, memory 162) or distributed across multiple memories in one or more locations.

[0028] Turning now to Figure 2, the mechanical construction of a portion of self-service apparatus 104 is shown in more detail, according to one embodiment. Specifically, Figure 2 depicts an example housing 200 of self-service apparatus 104, which may be used to accept and interact with mobile device 102 and other mobile devices. A top surface/portion of the housing 200 is not shown in Figure 2 in order to provide a clearer view of the internal components. As shown in Figure 2, the housing 200 includes a moveable/sliding drawer 204. At least a portion of each of antennas 206A and 206B is disposed within the housing 200. The antennas 206A, 206B may be patch antennas, or any other suitable type of antenna. In other embodiments, there are more or fewer than two antennas 206A, 206B. Coupled to the antennas 206A, 206B is a wireless transceiver 208, which may be inside or outside the housing 200. Wireless transceiver 208 may be coupled to PMN controller 134 of Figure 1, for example.

[0029] Housing 200 may also include illuminating components 210A and 210B, imaging devices 212A and 212B, and an audio sensor 214. Imaging devices 212A and 212B and audio sensor 214 may be included in sensors 142 of Figure 1, for example. Imaging devices 212A, 212B may be photosensors, photodiodes, photomultipliers, or other image sensor types, including charge-coupled-devices (CCD), complementary metal-oxide semiconductor (CMOS) sensors, etc., or some combination therefore. In some embodiments, housing 200 instead includes a single-camera setup that is capable of capturing video, photo, infrared, etc. Depending on the type of imaging device(s) used, illuminating components 210A, 210B may or may not be needed or included in housing 200. Audio sensor 214 may be any suitable type of microphone. In other embodiments, housing 200 includes more or fewer than two illumination

components 210A, 210B, more or fewer than two imaging devices 212A, 212B, and/or more than one audio sensor 214.

[0030] Illuminating components 210A, 210B (if present) may include light emitting diodes (LEDs), and/or other types of controllable illumination sources. In one example, illuminating components 210A, 210B may include a diffuser configured to spread the light evenly across mobile device 102. In another example, illuminating components 210A, 210B may be configured to provide multiple colors of illumination based on one or more preferred colors of light associated with image processing. For instance, illuminating components 210A, 210B (and possibly one additional illuminating component) may be configured to emit a red light, a blue light, and a green light at different times in order to capture images under each setting of light. In this embodiment, the multiple images may then be combined in order provide a high-resolution, multi-color image. Alternatively, the different colors may be used to better detect a certain color of interest (*e.g.*, by turning off the blue light when attempting to detect a blue color on the display screen of mobile device 102, when generating a visual test output as discussed further below).

[0031] In one embodiment, imaging devices 212A, 212B may be positioned at least 4 cm away from mobile device 102, when mobile device 102 is positioned in drawer 204, in order to obtain more clarity and thereby capture images suitable for analysis. Imaging devices 212A, 212B may be positioned within housing 200 at various angles along one or more surfaces. In one embodiment, imaging devices 212A, 212B may be placed at approximately thirty degree angles relative to a top surface or a bottom surface of the Faraday cage.

[0032] Housing 200 also includes an actuator 216, which may be configured to move drawer 204 to an open position, thereby allowing for placement of mobile device 102 within drawer 204. In some embodiments, actuator 216 is "activated" by placing drawer 204 in an open position. In one example, actuator 216 may be activated based on a received user input (*e.g.*, an input on a display of output device 146 of Figure 1). Alternatively, or additionally, actuator 216 may be automatically activated upon completion of the assessment/diagnosis of mobile device 102, or upon another suitable trigger. Actuator 216 may be an electric linear actuator, for example. In one embodiment, actuator 216 includes a limit switch with a spring actuator.

[0033] Drawer 204 is large enough to receive mobile device 102. In one embodiment, drawer 204 includes a transparent bottom surface (*e.g.*, glass, plastic, etc.) that permits an image to be captured through the transparent surface. In this embodiment, at least one of imaging devices 212A, 212B may be positioned below the transparent surface and configured to capture an image of the down-facing side of mobile device 102. In another embodiment, drawer 204 may include a spring-loaded slot (not shown in Figure 2) that allows mobile device 102 to be held upright while resting on one of its four narrow edges, so that imaging devices 212A, 212B can capture images of both of larger surfaces (*i.e.*, the display side and the reverse side of mobile device 102). In yet another embodiment, drawer 204 may include a mechanism that allows mobile device 102 to be automatically rotated for capturing multiple sides of mobile device 102. Upon closing drawer 204, a Faraday cage may be formed by housing 200. The Faraday cage provides a high level of attenuation for any RF/EMI signals entering or exiting the cage (*e.g.*, at least 65 dB, or at least 50 dB, etc.), at least at certain frequencies or frequency ranges of interest. In other embodiments, no shielding is utilized, and/or mobile device 102 is not placed in an enclosed chamber.

[0034] Processor 130 of Figure 1 may be within or external to housing 200, and may be communicatively coupled to wireless transceiver 208, illuminating components 210A, 210B, imaging devices 212A, 212B, audio sensor 214, and/or actuator 216. By sending appropriate commands (and, in some instances, receiving outputs), processor 130 is configured to control the functions of self-service apparatus 104 that are associated with assessing or diagnosing mobile device 102, as discussed further below.

[0035] In one embodiment, drawer 204 may also include an extraction mechanism (not shown in Figure 2) for automatically placing mobile device 102 into a repository/storage area for later collection and recycling. For example, the drawer 204 may include a "trap door" component, and/or a mechanism for pushing mobile device 102 into a temporary opening formed by the trap door. The extraction mechanism may be subject to manual control (*e.g.*, the user of mobile device 102 pulling a lever), or may be subject to electronic control (*e.g.*, processor 130 sending a command to extract mobile device 102 in response to a user accepting a proposed transaction, as discussed further below). Once stored, mobile device 102 can be retrieved at a later point in time by the appropriate party.

[0036] Operation of the components of the environment 100 will now be described, according to example embodiments, with reference to Figures 1 and 2. First, SIM card 112 is inserted into a SIM card slot of mobile device 102 (*e.g.*, after removing an old SIM card). A user may then utilize a display screen of self-service apparatus 104 (*e.g.*, output device 146) to initiate an assessment/diagnosis of mobile device 102. The user may be the owner of mobile device 102, for example, and may be initiating a process to recycle his or her current phone or other mobile device in exchange for a new, updated model. As another example, the user may be the person (*e.g.*, technician or retail store employee) who inserted SIM card 112 into mobile device 102. At some point in the interaction between self-service apparatus 104 and the user, the user may be presented with a message on output device 146, or on mobile device 102, prompting the user to place mobile device 102 in drawer 204. Processor 130 may automatically cause actuator 216 to open drawer 204 at that time, or the user may need to manually open drawer 204. The user may then close drawer 204, or processor 130 may automatically cause actuator 216 to close drawer 204 (*e.g.*, after a predetermined amount of time, or in response to a weight sensor detecting the presence of mobile device 102, etc.).

[0037] As noted above, antennas 206A, 206B are at least partially disposed within the Faraday cage (if such shielding is present), in order to support communication with mobile device 102 even when drawer 204 is closed. PMN controller 134 and wireless transceiver 208 are configured to operate according to one or more channel access methods (*e.g.*, frequency division multiple access, code division multiple access, time division multiple access, etc.) in order to obtain data from mobile device 102. In particular, PMN controller 134 and wireless transceiver 208 may be configured to operate according to one or more of various worldwide standards for cellular networks and mobile phone usage (*e.g.*, GSM, UMTS, LTE, etc.). In one embodiment, when drawer 204 is in the closed position, mobile device 102 cannot register with any external cells due to the isolation of the Faraday cage, and therefore enters a roaming mode or a handover mode. The attenuation of RF signals provided by the Faraday cage of housing 200 may therefore cause mobile device 102 to register with the cell (*e.g.*, picocell, femtocell, etc.) established by PMN controller 134, wireless transceiver 208, and antennas 206A, 206B, rather an external cell (*e.g.*, a cell provided by a public, telecommunication service base station).

[0038] In some embodiments, when SIM card 112 has been installed in mobile device 102 and mobile device 102 is powered up, diagnostics application 126 may force mobile device 102 to

register to a specific mobile network (*i.e.*, the private mobile network). To accomplish this, the file system of SIM card 112 (*e.g.*, stored in ROM 122) may contain a "blacklist" or list of unwanted mobile network codes (*e.g.*, MNC, MCC) identifying network providers that mobile device 102 can reject immediately (*i.e.*, if those networks are available in the vicinity of mobile device 102). In addition, or alternatively, the file system of SIM card 112 may contain one or more preferred mobile network codes (*e.g.*, MNC, MCC), which diagnostics application 126 may use to accelerate the registration process with the preferred network. For example, if mobile device 102 detects only "blacklist" network, diagnostics application 126 may restart the radio frequency (RF) front-end of mobile device 102, thereby forcing mobile device 102 to start searching for mobile networks until a preferred network (*e.g.*, the private mobile network) is found. If mobile device 102 cannot find a preferred network within a predetermined time period, diagnostics application 126 may repeat the RF restart procedure a number of times and then display an informative message (*e.g.*, "Unable to connect for diagnostic testing") on the display screen of mobile device 102. In some embodiments where diagnostics application 126 forces a preferred network connection, housing 200 may not form a Faraday cage, and/or may be less heavily shielded/isolated.

[0039] After cell registration has occurred, diagnostics application 126 of SIM card 112 may issue one or more commands to cause information about mobile device 102 to be provided to self-service apparatus 104 via the private mobile network/cell. The information may include identifying information/properties (*e.g.*, model, IMEI, serial number, etc.) and/or information specifying one or more other characteristics or properties of mobile device 102 (*e.g.*, phone functions, battery capacity, etc.), for example. To illustrate (though other functions are possible), one, some, or all of the following functions may be performed using SIM card 112, and one, some, or all may be performed without any human intervention required.

[0040] As a first example, diagnostics application 126 may generate a "PRF" command that causes mobile device 102 to report a profile sequence to SIM card 112. Each bit in the sequence (*e.g.*, in a 30-byte sequence) may correspond to a particular function supported by mobile device 102 (*e.g.*, as described in ETSI technical specification TS 102 223). The profile may represent an accurate rendering of the capabilities of mobile device 102. In some embodiments, the capabilities can collectively function as a signature to help distinguish "fake" phones or other devices. SIM card 112 may cause mobile device 102 to transmit the reported profile sequence to

self-service apparatus 104, *e.g.*, as an SMS message to SMSC 136 of PMN controller 134 or, alternatively, as a GPRS data packet via a GPRS connection with PMN controller 134.

[0041] As a second example, diagnostics application 126 may generate an "AT" command that causes mobile device 102 to report a number of different data items, including both identifying data (IMEI, manufacturer, serial number, etc.) and other device properties or characteristics (*e.g.*, signal strength, battery capacity, etc.). The result of the execution of the AT command in mobile device 102 is reported to SIM card 112, after which SIM card 112 may generate an SMS message or GPRS data packet to transmit the AT-related information to PMN controller 134. Self-service apparatus 104 may then transmit the information to server 106 via network 110, for analysis by diagnostics unit 164. The reported data items may include the data items enumerated in the 3GPP technical specification TS 27.007, for example.

[0042] An extended set of AT commands (such as AT+CCAMS) may be used to evaluate cameras and picture quality of mobile device 102. Other commands can force mobile device 102 to launch its web browser and display specific pictures/images utilizing a data channel of GPRS (or possibly another type of data link) with self-service apparatus 104. An Internet connection with an external server, through self-service apparatus 104, may make the system more flexible and dynamic.

[0043] As a third example, diagnostics application 126 may cause mobile device 102 to execute a "USSD" command. The USSD command (*e.g.*, in a packed 7-bit format as specified by ETSI) may cause other profile information relating to mobile device 102 to be extracted. Mobile device 102 may then transmit the reported profile information to self-service apparatus 104, *e.g.*, to PMN controller 134 as a USSD message in a USSD session.

[0044] As a fourth example, diagnostics application 126 may cause various auxiliary functions to be executed, such as an "HLP0" function to check the mobile country code (MCC), mobile network code (MNC), and location area code (LAC) of an active network, and/or an "HLP1" function to check the IMEI of mobile device 102. Mobile device 102 may then transmit the obtained data to self-service apparatus 104 (*e.g.*, as an SMS message to SMSC 136 of PMN controller 134, or as a GPRS data packet via a GPRS link with PMN controller 134).

[0045] Once received by PMN controller 134, the identifying data of mobile device 102 and/or the data indicating characteristics or properties of mobile device 102 (*e.g.*, any

combination of the types of data described above in connection with the example commands/functions) may be passed to data collection unit 140. Data collection unit 140 may store the data locally in memory 132, for example.

[0046] In addition to causing particular types of digital data to be transmitted to self-service apparatus 104, diagnostics application 126 may trigger one or more test routines that involve the generation of images and/or sound by mobile device 102. For example, diagnostics application 126 may cause a speaker of mobile device 102 to generate a particular audio signal for a certain length of time. As another example, diagnostics application 126 may cause a display screen of mobile device 102 to generate a particular image, such as a screen of a particular color, a particular text sequence, a particular picture, and so on. Diagnostics application 126 may also cause mobile device 102 to transmit (*e.g.*, to PMN controller 134, via a wireless transceiver of mobile device 102) one or more synchronization messages indicating when the audio and/or visual outputs were, are, or will be generated. Using the synchronization message(s), data collection unit 140 of self-service apparatus 104 may cause sensors 142 (*e.g.*, imaging devices 212A, 212B and audio sensor 214) to activate at the appropriate times, and/or cause the correct images and/or audio captured by sensors 142 to be tagged for analysis.

[0047] As one example, diagnostics application 126 may send a "TON" command to mobile device 102 that causes a speaker of mobile device 102 to play a ringtone for a certain amount of time (*e.g.*, 7 seconds). Audio sensor 214 of housing 200 may capture the ringtone, and data collection unit 140 may store a digital representation of the ringtone in memory 132.

[0048] As another example, diagnostics application 126 may send a "BRW" command to mobile device 102 to cause mobile device 102 to launch a web browser application to a particular URL (*e.g.*, http://www.mobdevdiagnostics.com). By doing so, the display screen of mobile device 102 may be caused to present whatever known content is associated with the web page at that URL. For example, the web page may include a color picture. Imaging device(s) 212A and/or 212B of housing 200 may capture the contents of the display screen (*e.g.*, after normalizing the image based on the orientation of mobile device 102, if needed), and data collection unit 140 may store a digital representation of the image contents in memory 132.

[0049] As still another example, diagnostics application 126 may send a "DSP" command to mobile device 102 that causes mobile device 102 to display, on its display screen, some

predetermined text for a predetermined amount of time. As with the BRW command, imaging device(s) 212A and/or 212B of housing 200 may capture the contents of the display screen, and data collection unit 140 may store a digital representation of the image contents in memory 132.

[0050] In some embodiments, diagnostics application 126 may also, or instead, trigger other audio and/or visual test outputs, such as causing the display screen of mobile device 102 to generate a series of different colors that each fill the entire screen, or an animation (*e.g.*, at the web page visited with the BRW command) that tests the transient response characteristics of the display screen, and so on.

[0051] In some embodiments, diagnostics application 126 also, or instead, triggers other functions of mobile device 102 that may be used for diagnostic purposes. For example, diagnostics application 126 may send a "CAL" command that causes mobile device 102 to voice call a particular phone number. As another example, diagnostics application 126 may cause mobile device 102 to attempt a network reconnect, including replication of the boot sequence following the PIN check. A voice call to a GSM modem (*e.g.*, within housing 200) may provide an additional diagnostic test relating to the call quality of mobile device 102. A reset/reboot command or "RF restart" of mobile device 102 may be necessary when mobile device 102 takes too long to connect with the private mobile network, or if the software of mobile device 102 and/or the private mobile network is experiencing connectivity problems. In some embodiments, other commands, functions, test outputs, etc., in addition to (or instead of) those noted above, may also be issued, executed, or triggered by the diagnostics application 126.

[0052] Once the device characteristic/property data, the audio data, and/or the image data have been stored in memory 132, the data may be transmitted to server 106 for analysis via network 110 and WAN interfaces 150, 166. The data may be sent piecemeal as the data is collected by data collection unit 140, or may be sent in one or more larger blocks of data (*e.g.*, after all data is collected). At server 106, diagnostics unit 164 may analyze the identifier data (*e.g.*, IMEI) and/or other device characteristic/property data to identify mobile device 102 as precisely as possible.

[0053] Diagnostics unit 164 may also analyze the digital audio and/or image data to determine whether mobile device 102 generated the expected sound(s) and/or image(s), and/or to assess the quality of the sound(s) and/or image(s). If diagnostics application 126 caused mobile device 102

to generate a ringtone, for example, diagnostics unit 164 may analyze the audio signal captured by audio detector 214 to determine whether a ringtone is present, and/or to determine how well the ringtone matches an expected ringtone (*e.g.*, by comparing the detected ringtone to one or more ringtones known to correspond to the model of mobile device 102). As another example, if diagnostics application 126 caused mobile device 102 to access a web page that includes a particular image, diagnostics unit 164 may analyze the image captured by imaging device(s) 212A and/or 212B to determine whether an image is present, and/or to determine whether the displayed image matches an expected image (*e.g.*, as stored in memory 162 or elsewhere). As still another example, if diagnostics application 126 caused mobile device 102 to display a particular text sequence, diagnostics unit 164 may analyze the image captured by imaging device(s) 212A and/or 212B to determine whether text is displayed, and/or to determine whether the displayed text matches expected text (*e.g.*, as stored in memory 162 or elsewhere).

[0054] For images, diagnostics unit 164 may detect certain types of image characteristics in addition to, or instead of, comparing images. For example, diagnostics unit 164 may detect whether any pixels are blacked out or "dead" in the image, whether particular colors are of a certain brightness or tint, and so on. Similarly with audio, diagnostics unit 164 may detect the volume level (*e.g.*, in decibels) and/or other audio characteristics.

[0055] Based on the analyses performed by diagnostics unit 164, diagnostics unit 164 may generate a score or other indicator of the functional/operational condition of mobile device 102. The indicator may be determined based on a particular algorithm. For example, the quality of an image may be given a first weight, the quality of a test ringtone a second weight, and so on, with all weighted scores contributing to a total score. Alternatively, diagnostics unit 164 may output a different score for each analysis, without combining them into a total score.

[0056] In some embodiments, diagnostics unit 164 also generates the overall score or indicator, and/or one or more additional sub-scores/indicators, based on other factors, such as the appearance of mobile device 102 (unrelated to content on the display screen), *e.g.*, whether the display screen or some other part of the mobile device exterior has cracks. For example, the self-service/assessment apparatus 104 may be configured according to any of the embodiments described in the international patent publication WO 2017/081527 (Sinha et al., entitled

"Systems and Methods for Assessing a Mobile Device"), but also having the diagnostic functionality described herein.

[0057] Diagnostics unit 164, or another unit in server 106, may use the score(s) or other indicator(s) to determine a monetary value (in a particular currency or currencies) for mobile device 102 that is appropriate in view of its current condition. To do so, diagnostics unit 164 may access mobile device database 170, using both the type of mobile device 102 (*e.g.*, model, and possibly specific capabilities, learned by self-service apparatus 104 via the private mobile network) and the determined condition of mobile device 102. Mobile device database 170 may include, for example, a relational database that is periodically or continuously updated as monetary values change, and/or as device models and/or capabilities change. In some embodiments, the monetary value is also dependent on other factors unrelated to mobile device 102, such as the device being traded for, or the user's current or selected wireless service plan, etc.

[0058] Server 106 may transmit the monetary value of mobile device 102 (or another value that reflects that value, such as a discounted offer price if the user is exchanging for a new mobile device) to self-service apparatus 104 via network 110 and WAN interfaces 166, 150. Self-service apparatus 104 may then present the value to the user via output device 146, along with an option to accept or reject a transaction having terms based on that value. For example, output device 146 may indicate that the exchange value of mobile device 102 is $120, so long as the user exchanges mobile device 102 for a particular new mobile device and/or service plan. The user may then accept the offer (*e.g.*, by pressing a first button on input device 144) or reject the offer (*e.g.*, by pressing a second button on input device 144). In some embodiments, if the user accepts the offer, an extraction mechanism of the chamber of housing 200 automatically causes mobile device 102 to be moved from the chamber to a repository/storage area for later collection. If there is an exchange, self-service apparatus 104 may automatically place an order for the new mobile device, or may print out a ticket that the user can redeem for the new mobile device. In another embodiment, the user manually removes mobile device 102, and the self-service apparatus 104 prints out a ticket or report showing the monetary value and the date/time of the assessment. The user may then give the ticket or report, and mobile device 102, to an attendant (or mail the ticket/report and mobile device 102 to a particular address, etc.).

[0059] In some embodiments, the specific command, functions, etc., of a mobile device that are tested using SIM card 112, self-service apparatus 104, and server 106 may vary depending on the model and/or other properties or characteristics of the mobile device under test. To perform dynamic testing of this sort, SIM card 112, data collection unit 140, and/or diagnostics unit 164 (and possibly other components in the environment 100) may include conditional instructions or functions that vary according to model and/or other properties/characteristics of mobile device 102. For example, SIM card 112 may be capable of executing different sets of commands, and choose one and only one of those sets of commands based on the model of the mobile device.

[0060] In alternative embodiments, the environment 100 may include more, fewer, and/or different components as compared to those shown in Figure 1, and/or the functionality described above may be distributed in a different manner. For example, self-service apparatus 104 may include some or all of the functionality of diagnostics unit 164 as described above, and/or self-service apparatus 104 may access some or all of mobile device database 170. If all of the functionality of diagnostics unit 164 is included in self-service apparatus, server 106 may be omitted from the environment 100. As another example, in some embodiments, a user may use input device 144 of self-service apparatus 104 to enter information that at least partially identifies mobile device 102, in which case self-service apparatus 104 may send that information to server 106 to assist with the diagnosis/analysis. In other embodiments, no such information from the user is input or used during the assessment.

[0061] Figure 3 is a timeline view of an example sequence of events 300 that may occur in an environment similar to the example environment 100 of Figure 1. A first vertical timeline 302 represents processes taking place at, or initiated by, a mobile device (*e.g.*, mobile device 102 of Figure 1). A second vertical timeline 304 represents processes taking place at, or initiated by, a self-service apparatus (*e.g.*, self-service apparatus 104 of Figure 1). A third vertical timeline 306 represents processes taking place at, or initiated by, a server remote from the self-service apparatus (*e.g.*, server 106 of Figure 1). For each of timelines 302, 304, 306, time advances in the direction of the downward arrow.

[0062] Initially, at stage 310, the mobile device physically receives a diagnostic SIM card, such as SIM card 112 of Figure 1, which is inserted by an individual into a SIM card slot of the mobile device. At stage 312, the self-service apparatus physically receives the mobile device,

which an individual places into a drawer or other compartment of the self-service apparatus. At stage 314, the mobile device registers with a private mobile network established by the self-service apparatus. For example, the mobile device may attempt to register in response to detecting a signal broadcast by a base station controller of the self-service apparatus. Correspondingly, the self-service apparatus detects and registers the mobile device at stage 316.

[0063] At stage 318, the mobile device reports mobile device data that specifies identifying information (*e.g.*, model, IMEI, etc.), and/or other properties or characteristics of the mobile device (*e.g.*, capabilities, state, etc.), to the self-service apparatus via the private mobile network. The mobile device data may be obtained from the mobile device by a diagnostics application of the SIM card, which may then generate a message (*e.g.*, an SMS message or a GPRS data packet), containing that data, that is sent to the self-service apparatus, for example. Alternatively, some or all of the data may be obtained by way of the SIM card diagnostics application triggering the mobile device to directly package and send the mobile device data to the self-service apparatus. At stage 320, the self-service apparatus receives the reported mobile device data.

[0064] At stage 322, the mobile device generates one or more test audio and/or visual outputs. For example, the SIM card diagnostics application may cause the speaker of the mobile device to generate a test sound (*e.g.*, a ringtone), and/or cause the display screen of the mobile device to generate a test image (*e.g.*, a picture on a particular web page, or a test text sequence, etc.).

[0065] At stage 324, the self-service apparatus detects the audio and/or visual test outputs, *e.g.*, via one or more microphones and one or more cameras. At stage 326, the self-service apparatus reports the mobile device data, and/or a digital representation of each test output, to the server, which receives the data at a corresponding stage 328.

[0066] At stage 330, the server analyzes the data received at stage 328 to determine the type of the mobile device from the mobile device data, and determine the operational condition of the mobile device from the image and/or audio data. With respect to condition, a diagnosis may be made by comparing characteristics of the test outputs generated at stage 322 to expected characteristics that are stored in a database, or by more simply determining whether the expected type of output exists at all in some form (*e.g.*, a display that is not blank, or a ringtone that is not below some volume threshold), etc.

[0067] At stage 332, the mobile device type and condition are used to determine a monetary value, and the value of the mobile device (or something reflecting the value, such as a discounted price for a new mobile device) is transmitted to the self-service device. The value is received by the self-service apparatus at stage 334, and displayed to a user (*e.g.*, the individual who placed the mobile device in the self-service apparatus) at stage 336.

[0068] In other embodiments, the time arrangement of the stages 310 through 336 differs from what is depicted in Figure 3. For example, stages 318 and 320 may occur after, or simultaneously with, stages 322 and 324. As another example, stages 326 and 328 may be distributed such that a first portion (reporting/receiving mobile device data) occurs before stages 322 and 324, and a second portion (reporting/receiving detected test outputs) occurs after stages 322 and 324. Moreover, in some embodiments, the sequence of events 300 includes more, fewer, and/or different stages. For example, stages 332, 334, and 336 may be omitted, and the server may display the mobile device type and condition (*e.g.*, to an operator of a terminal associated with the server) at a different stage that occurs after stage 330.

[0069] Figure 4 is a flow diagram depicting an example method 400, implemented in a SIM card (*e.g.*, SIM card 112 of Figure 1), for facilitating diagnosis of a mobile communication device to which the SIM card is electrically coupled (*e.g.*, mobile device 102 of Figure 1). The blocks of the method 400 may correspond to functions of a diagnostics application installed on the SIM card, such as diagnostics application 126 of Figure 1, for example.

[0070] At block 402, the SIM card causes the mobile communication device to obtain at least a portion of mobile device data by issuing a command to the mobile communication device. In its entirety, as used herein, "mobile device data" refers to a set of data that is indicative of one or more characteristics or properties of the mobile communication device (*e.g.*, one or more of IMEI, model, serial number, battery capacity, functions/capabilities, and/or other characteristics or properties), and is stored in one or more memories of the mobile communication device. In some embodiments, the issued command is one of those discussed above in connection with Figure 1 (*e.g.*, a "PRF" or "AT" command, etc.). Further, in some embodiments, two or more commands may be issued in order to obtain the mobile device data (or the portion thereof). In an alternative embodiment, block 402 is omitted from the method 400, and all mobile device data is obtained in some other manner.

[0071] At block 404, the SIM card also causes the mobile communication device to register with a private mobile network. The private mobile network may be a cellular network established by a nearby apparatus, such as self-service apparatus 104 of Figure 1, for example, and the mobile communication device may register by engaging in the appropriate handshaking/authentication/etc., as required by the protocol of the private mobile network (*e.g.*, initiated when the mobile communication device detects a broadcast signal associated with the private mobile network). In one embodiment, the SIM card causes the mobile communication device to register with the private mobile network by forcing the mobile communication device to reject any cellular networks that do not have the same identifier(s) as the private mobile network. In such an embodiment, the identifier(s) of the private mobile network are known *a prior* by (*i.e.*, are pre-stored in an EEPROM or other memory of) the SIM card. In an alternative embodiment, block 404 is omitted from the method 400, and the mobile communications device registers without any control and/or influence from the SIM card.

[0072] At block 406, the SIM card causes the mobile communication device to report the mobile device data (including any portion of the data obtained at block 402) via the private mobile network with which the device is registered. For example, the SIM card may generate an SMS message or a GPRS data packet that includes some or all of the data to be reported, and cause the mobile communication device to send the SMS message to an SMSC of a private mobile network controller (*e.g.*, base station controller), or send the GPRS data packet to the private mobile network controller, via a GSM or GPRS connection.

[0073] At block 408, the SIM card causes the mobile communication device to generate one or more visual test outputs via a display screen of the mobile communication device, which are to be captured by one or more sensors (*e.g.*, camera(s) or other imaging devices) external to the mobile communication device (*e.g.*, sensors of an apparatus that includes a controller acting as a base station for the private mobile network, such as sensors of self-service apparatus 104 of Figure 1). In some embodiments, for example, the SIM card causes the mobile communication device to launch a web browser application and visit a web page associated with a particular URL. The visited web page may present a visual test output (*e.g.*, a particular color or black and white picture) via the web browser application and the display screen of the mobile communication device. As another example, the SIM card may cause the mobile communication device to present predetermined text via the display screen of the mobile communication device.

[0074] At block 410, the SIM card causes the mobile communication device to generate one or more audio outputs via a speaker of the mobile communication device, which are to be captured by one or more sensors (*e.g.*, microphone(s)) external to the mobile communication device (*e.g.*, sensors of the same apparatus referred to above in connection with block 408). In some embodiments, for example, the SIM card causes the mobile communication device to play a ringtone via a speaker of the device. In some embodiments, the method 400 includes only one of block 408 and block 410, while in other embodiments both are included.

[0075] In some embodiments, the SIM card issues a set of one or more commands to the mobile communications device to effect blocks 406, 408, and/or 410, with the command set being dynamically determined based upon the type of the mobile communication device (*e.g.*, the model of the device, capabilities of the device, and/or other characteristics or properties of the device). In this manner, the diagnostic testing of a mobile communication device can be automatically tailored to the specific device, without requiring a device-specific diagnostic SIM card. In other embodiments, different SIM cards are used for different device models. In still other embodiments, the command set is dynamic to some extent (*e.g.*, to encompass different models within a particular line of phones), but different SIM cards are used for different manufacturers or product lines.

[0076] In some embodiments, the method 400 includes additional blocks. For example, the method 400 may include an additional block in which the SIM card causes the mobile communication device to send or more synchronization messages via the private mobile network. The synchronization message(s) may indicate when the visual and/or audio test output(s) can be captured by the sensor(s) of another device (*e.g.*, self-service apparatus 104 of Figure 1), to allow the sensors(s) to be activated at the appropriate time, and/or to allow the appropriate captured data to be further analyzed, etc. In one embodiment, the synchronization message(s) indicate that a particular test output or outputs is/are currently being generated. Alternatively, the message(s) may indicate that a particular test output or outputs will be generated at some absolute or relative time in the near future.

[0077] In some embodiments, the blocks of the method 400 occur in the order shown in Figure 4. In other embodiments, the order is different, and/or some blocks occur at least in part simultaneously. For example, block 402 may instead occur after block 404, blocks 402 and 406

may occur after block 408 and/or 410, blocks 402, 406, 408, and/or 410 may occur at least partially in parallel (simultaneously), and so on.

[0078] Figure 5 is a flow diagram depicting an example method 500, implemented in a mobile device diagnostics system (*e.g.*, a system that includes self-service apparatus 104 and/or server 106 of Figure 1), for diagnosing a mobile communication device.

[0079] At block 502, a private mobile network (*e.g.*, a cellular network) is established. The private mobile network may utilize any suitable communications protocol, such as GSM, UMTS, LTE, etc. Block 502 may include configuring a portion of the mobile device diagnostics system as a base station controller, for example.

[0080] At block 504, a mobile communication device attempting to join the private mobile network (*e.g.*, mobile device 102 of Figure 1) is registered. The mobile communication device may join a cell established at block 502, for example. In some embodiments, block 504 only occurs if the mobile communication device is positioned within a specific, shielded compartment (*e.g.*, within housing 200 of Figure 2). In other embodiments, this is not necessary.

[0081] At block 506, mobile device data is received from the registered mobile communication device. The mobile device data includes data indicative of one or more characteristics or properties of the mobile communication device (*e.g.*, one or more of IMEI, model, serial number, battery capacity, functions/capabilities, and/or other characteristics or properties).

[0082] At block 508, one or more synchronization messages are received from the mobile communication device via the private mobile network. The synchronization messages may indicate when each of one or more test outputs generated by the mobile communication device (*e.g.*, one or more visual test outputs generated by a display screen of the mobile communication device, and/or one or more audio test outputs generated by a speaker of the mobile communication device) can be captured by one or more sensors (*e.g.*, imaging devices and/or microphones) of the mobile device diagnostics system. For example, a given message may indicate that a particular test output is currently being generated by the mobile communications device, or is about to be generated by the mobile communication device.

[0083] At block 510, the one or more test outputs generated by the mobile communications device are captured via the sensor(s) of the mobile device diagnostics system. The test output(s)

may be captured by using the synchronization message(s) to identify the appropriate time(s) to activate the sensor(s), for example.

[0084] At block 512, the functional condition of the mobile communication device is determined, at least by analyzing the test output(s) captured at block 510. For example, each of the one or more captured test outputs may be compared to a corresponding expected test output. If the mobile device diagnostics system knows *a priori* that a certain text sequence, color, picture, etc., should be displayed, for example, it may determine the functional condition by analyzing ways in which the test output differs from that expected output (*e.g.*, differences in colors/brightness/tint, missing pixels, etc.).

[0100] In some embodiments, the method 500 includes additional blocks not shown in Figure 5. For example, a first block may include determining the value of the mobile communication device based on the functional condition determined at block 512, and a second additional block may include causing that value to be presented to a user via a display screen of the mobile device diagnostics system (*e.g.*, a self-service kiosk or other apparatus included in the system). In such an embodiment, the value may be determined not only based upon the functional condition, but also based upon some or all of the mobile device data received at block 506. For example, an IMEI, model, and/or other identifying information in the mobile device data may be used in conjunction with the functional condition to determine the value. Other factors may also be used to determine value, such as the visual appearance of the exterior of the mobile communication device (*e.g.*, cracks or scuff marks). The blocks of the method 500 may occur in the order shown in Figure 5, or in a different order, and/or with some blocks occurring at least in part simultaneously. For example, block 506 may instead occur after block 508 and/or 510.

[0101] Figure 6 is a block diagram of an example system 600 that may operate in accordance with the described embodiments. The system 600 of Figure 6 includes a computing device in the form of a computer 610. Computer 610 may be a part of the self-service apparatus 104 of Figure 1, for example. Components of the computer 610 may include, and are not limited to, a processing unit 620, a system memory 630, and a system bus 621 that couples various system components including the system memory to the processing unit 620. The system bus 621 may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. By way of example,

and not limitation, such architectures include the Industry Standard Architecture (ISA) bus, Micro Channel Architecture (MCA) bus, Enhanced ISA (EISA) bus, Video Electronics Standards Association (VESA) local bus, and Peripheral Component Interconnect (PCI) bus (also known as Mezzanine bus).

[0102] The computer 610 typically includes a variety of computer readable media. Computer readable media can be any available media that can be accessed by computer 610 and includes both volatile and nonvolatile media, and both removable and non-removable media. By way of example, and not limitation, computer readable media may comprise computer storage media and communication media. Computer storage media includes volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules or other data. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, FLASH memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by computer 610. Communication media typically embodies computer readable instructions, data structures, program modules or other data in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, radio frequency (RF), infrared and other wireless media. Combinations of any of the above are also included within the scope of computer readable media.

[0103] The system memory 630 includes computer storage media in the form of volatile and/or nonvolatile memory such as read only memory (ROM) 631 and random access memory (RAM) 632. A basic input/output system 633 (BIOS), containing the basic routines that help to transfer information between elements within computer 610, such as during start-up, is typically stored in ROM 631. RAM 632 typically contains data and/or program modules or routines, *e.g.*, analyzing, calculating, indicating, etc., that are immediately accessible to and/or presently being operated on by processing unit 620. By way of example, and not limitation, Figure 6 illustrates

operating system 634, application programs 635, other program modules 636, and program data 637.

[0104] The computer 610 may also include other removable/non-removable, volatile/nonvolatile computer storage media. By way of example only, Figure 6 illustrates a hard disk drive 641 that reads from or writes to non-removable, nonvolatile magnetic media, a magnetic disk drive 651 that reads from or writes to a removable, nonvolatile magnetic disk 652, and an optical disk drive 655 that reads from or writes to a removable, nonvolatile optical disk 656 such as a CD ROM or other optical media. Other removable/non-removable, volatile/nonvolatile computer storage media that can be used in the exemplary operating environment include, but are not limited to, magnetic tape cassettes, flash memory cards, digital versatile disks, digital video tape, solid state RAM, solid state ROM, and the like. The hard disk drive 641 is typically connected to the system bus 621 through a non-removable memory interface such as interface 640, and magnetic disk drive 651 and optical disk drive 655 are typically connected to the system bus 621 by a removable memory interface, such as interface 650.

[0105] The drives and their associated computer storage media discussed above and illustrated in Figure 6 provide storage of computer readable instructions, data structures, program modules and other data for the computer 610. In Figure 6, for example, hard disk drive 641 is illustrated as storing operating system 644, application programs 645, other program modules 646, and program data 647. Note that these components can either be the same as or different from operating system 634, application programs 635, other program modules 636, and program data 637. Operating system 644, application programs 645, other program modules 646, and program data 647 are given different numbers here to illustrate that, at a minimum, they are different copies. A user may enter commands and information into the computer 610 through input devices such as a keyboard 662 and cursor control device 661, commonly referred to as a mouse, trackball or touch pad. A screen 691 or other type of display device is also connected to the system bus 621 via an interface, such as a graphics controller 690. In addition to the screen 691, computers may also include other peripheral output devices such as printer 696, which may be connected through an output peripheral interface 695.

[0106] The computer 610 may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer 680. The remote computer 680 may be server 106 of Figure 1, for example. The logical connections depicted in Figure 6 include a local area network (LAN) 671 and a wide area network (WAN) 673, but may also include other networks. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets, and the Internet.

[0107] When used in a LAN networking environment, the computer 610 is connected to the LAN 671 through a network interface or adapter 670. When used in a WAN networking environment, the computer 610 typically includes a modem 672 or other means for establishing communications over the WAN 673, such as the Internet. The modem 672, which may be internal or external, may be connected to the system bus 621 via the input interface 660, or other appropriate mechanism. In a networked environment, program modules depicted relative to the computer 610, or portions thereof, may be stored in the remote memory storage device 681. By way of example, and not limitation, Figure 6 illustrates remote application programs 685 as residing on memory device 681.

[0108] The communications connections 670, 672 allow the device to communicate with other devices. The communications connections 670, 672 are an example of communication media. The communication media typically embodies computer readable instructions, data structures, program modules or other data in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. A "modulated data signal" may be a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media. Computer readable media may include both storage media and communication media.

[0109] The embodiments for the methods for performing diagnostics on a mobile communication device as described above may be implemented in part or in their entirety using one or more computer systems such as the computer system 600 illustrated in Figure 6. The PMN controller 134 and/or data collection unit 140 of self-service apparatus 104 (in Figure 1) may be included in application programs 645, for example. As another example, the diagnostics

unit 164 of Figure 1 may be included in remote application programs 685 of remote computer 680, and/or the above-described data sent between self-service apparatus 104 and server 106 may be communicated via WAN 673, etc.

[0110] Aspects of the present invention include:

[0111] 1. A Subscriber Identity Module (SIM) card for facilitating diagnosis of a mobile communication device, the SIM card comprising: a processor; and a memory storing a diagnostics application that, when executed by the processor while the SIM card is electrically coupled to the mobile communication device, causes the mobile communication device to (A) report mobile device data via a private mobile network, wherein the private mobile network is a cellular network, and wherein the mobile device data (i) includes data indicative of one or more characteristics or properties of the mobile communication device and (ii) is stored in one or more memories of the mobile communication device, and (B) generate one or more test outputs to be captured by one or more sensors external to the mobile communication device, wherein the one or more test outputs include one or both of (i) one or more visual test outputs generated via a display screen of the mobile communication device, and (ii) one or more audio test outputs generated via a speaker of the mobile communication device.

[0112] 2. The SIM card of aspect 1, wherein, prior to causing the mobile communication device to report the mobile device data, the diagnostics application obtains at least a portion of the mobile device data by issuing a command to the mobile communication device.

[0113] 3. The SIM card of aspect 1 or 2, wherein the mobile device data includes an identifier of the mobile communication device.

[0114] 4. The SIM card of aspect 3, wherein the identifier of the mobile communication device is an International Mobile Equipment Identifier (IMEI) of the mobile communication device.

[0115] 5. The SIM card of aspect 1 or 2, wherein the mobile device data includes a model of the mobile communication device.

[0116] 6. The SIM card of any one of aspects 1 through 5, wherein the diagnostics application causes the mobile communication device to generate a visual test output, at least by causing the mobile communication device to (i) launch a web browser application and (ii) visit a

web page associated with a particular Uniform Resource Locator (URL), and wherein the web page presents the visual test output via the web browser application and the display screen of the mobile communication device.

[0117] 7. The SIM card of any one of aspects 1 through 5, wherein the diagnostics application causes the mobile communication device to generate a visual test output, at least by causing the mobile communication device to present predetermined text via the display screen of the mobile communication device.

[0118] 8. The SIM card of any one of aspects 1 through 7, wherein the diagnostics application causes the mobile communication device to generate an audio test output, at least by causing the mobile communication device to play a ringtone via the speaker of the mobile communication device.

[0119] 9. The SIM card any one of aspects 1 through 8, wherein the diagnostics application: determines a type of the mobile communication device; and one or both of (i) causes the mobile communication device to report the mobile device data, and (ii) causes the mobile communication device to generate the one or more test outputs, by issuing one or more commands that are specific to the determined type of the mobile communication device.

[0120] 10. The SIM card of any one of aspects 1 through 9, wherein the diagnostics application further causes the mobile communication device to, prior to reporting the mobile device data and prior to generating the one or more test outputs: register with the private mobile network.

[0121] 11. The SIM card of aspect 10, wherein the diagnostics application causes the mobile communication device to register with the private mobile network at least by causing the mobile communication device to reject any cellular networks other than the private mobile network.

[0122] 12. The SIM card of any one of aspects 1 through 11, wherein the diagnostics application causes the mobile communication device to report the mobile device data via the private mobile network using General Packet Radio Service (GPRS).

[0123] 13. The SIM card of any one of aspects 1 through 11, wherein the diagnostics application causes the mobile communication device to report the mobile device data via the private mobile network at least by generating a Short Message Service (SMS) message.

[0124] 14. The SIM card of any one of aspects 1 through 13, wherein the diagnostics application further causes the mobile communication device to: send one or more synchronization messages via the private mobile network, wherein the one or more synchronization messages indicate when the one or more test outputs can be captured by the one or more sensors.

[0125] 15. A method, implemented in a Subscriber Identity Module (SIM) card, for facilitating diagnosis of a mobile communication device to which the SIM card is electrically coupled, the method comprising: causing the mobile communication device to report mobile device data via a private mobile network, wherein the private mobile network is a cellular network, and wherein the mobile device data (i) includes data indicative of one or more characteristics or properties of the mobile communication device and (ii) is stored in one or more memories of the mobile communication device; and causing the mobile communications device to generate one or more test outputs to be captured by one or more sensors external to the mobile communication device, wherein the one or more test outputs include one or both of (i) one or more visual test outputs generated via a display screen of the mobile communication device, and (ii) one or more audio test outputs generated via a speaker of the mobile communication device.

[0126] 16. The method of aspect 15, further comprising: prior to reporting the mobile device data, obtaining at least a portion of the mobile device data by issuing a command to the mobile communication device.

[0127] 17. The method of aspect 15 or 16, further comprising: causing the mobile communication device to, prior to reporting the mobile device data and prior to generating the one or more test outputs, register with the private mobile network.

[0128] 18. The method of any one of aspects 15 through 17, wherein causing the mobile communication device to report the mobile device data includes causing the mobile communication device to report the mobile device data via the private mobile network using General Packet Radio Service (GPRS).

[0129] 19. The method of any one of aspects 15 through 18, further comprising: determining a type of the mobile communication device; wherein one or both of (i) causing the mobile communication device to report the mobile device data, and (ii) causing the mobile

communication device to generate the one or more test outputs, includes issuing one or more commands that are specific to the determined type of the mobile communication device.

[0130] 20. A method, implemented in a mobile device diagnostics system, for diagnosing a mobile communication device, the method comprising: establishing a private mobile network, wherein the private mobile network is a cellular network; registering a mobile communication device attempting to join the private mobile network; receiving mobile device data from the mobile communication device via the private mobile network, wherein the mobile device data includes data indicative of one or more characteristics or properties of the mobile communication device; receiving, from the mobile communication device and via the private mobile network, one or more synchronization messages, wherein the one or more synchronization messages indicate when each of one or more test outputs generated by the mobile communication device can be captured by one or more sensors of the mobile device diagnostics system, and wherein the one or more test outputs include one or both of (i) one or more visual test outputs generated by a display screen of the mobile communication device, and (ii) one or more audio test outputs generated by a speaker of the mobile communication device; capturing, via the one or more sensors, the one or more test outputs generated by the mobile communication device; and determining a functional condition of the mobile communication device at least by analyzing the captured one or more test outputs.

[0131] 21. The method of aspect 20, wherein the mobile device data includes data indicative of one or both of (i) an identifier of the mobile communication device, and (ii) a model of the mobile communication device.

[0132] 22. The method of aspect 20 or 21, wherein capturing the one or more test outputs includes capturing a visual test output generated by the display screen of the mobile communication device using one or more imaging devices of the mobile device diagnostics system.

[0133] 23. The method of any one of aspects 20 through 22, wherein capturing the one or more test outputs includes capturing an audio test output generated by the speaker of the mobile communication device using one or more microphones of the mobile device diagnostics system.

[0134] 24. The method of any one of aspects 20 through 23, wherein determining a functional condition of the mobile communication device includes comparing the one or more test outputs to one or more expected test outputs.

[0135] 25. The method of any one of aspects 20 through 24, wherein the mobile device diagnostics system includes a kiosk.

[0136] 26. The method of aspect 25, wherein the mobile device diagnostics system further includes a server communicatively coupled to the kiosk via a wide area network.

[0137] 27. The method of aspect 26, further comprising:

[0138] determining a value of the mobile communication device at the server based on the determined functional condition; and causing the value to be presented to a user via a display screen of the kiosk.

[0139] The patent claims at the end of this patent application are not intended to be construed under 35 U.S.C. § 112(f) unless traditional means-plus-function language is expressly recited, such as "means for" or "step for" language being explicitly recited in the claim(s).

[0140] Moreover, although the foregoing text sets forth a detailed description of numerous different embodiments, it should be understood that the scope of the patent is defined by the words of the claims set forth at the end of this patent. The detailed description is to be construed as exemplary only and does not describe every possible embodiment because describing every possible embodiment would be impractical, if not impossible. Numerous alternative embodiments could be implemented, using either current technology or technology developed after the filing date of this patent, which would still fall within the scope of the claims.

WHAT IS CLAIMED:

1. A Subscriber Identity Module (SIM) card for facilitating diagnosis of a mobile communication device, the SIM card comprising:

a processor; and

a memory storing a diagnostics application that, when executed by the processor while the SIM card is electrically coupled to the mobile communication device, causes the mobile communication device to

report mobile device data via a private mobile network, wherein the private mobile network is a cellular network, and wherein the mobile device data (i) includes data indicative of one or more characteristics or properties of the mobile communication device and (ii) is stored in one or more memories of the mobile communication device, and

generate one or more test outputs to be captured by one or more sensors external to the mobile communication device, wherein the one or more test outputs include one or both of (i) one or more visual test outputs generated via a display screen of the mobile communication device, and (ii) one or more audio test outputs generated via a speaker of the mobile communication device.

2. The SIM card of claim 1, wherein, prior to causing the mobile communication device to report the mobile device data, the diagnostics application obtains at least a portion of the mobile device data by issuing a command to the mobile communication device.

3. The SIM card of claim 1 or 2, wherein the mobile device data includes an identifier of the mobile communication device.

4. The SIM card of claim 3, wherein the identifier of the mobile communication device is an International Mobile Equipment Identifier (IMEI) of the mobile communication device.

5. The SIM card of claim 1 or 2, wherein the mobile device data includes a model of the mobile communication device.

6. The SIM card of any one of claims 1 through 5, wherein the diagnostics application causes the mobile communication device to generate a visual test output, at least by causing the mobile communication device to (i) launch a web browser application and (ii) visit a web page associated with a particular Uniform Resource Locator (URL), and wherein the web page presents the visual test output via the web browser application and the display screen of the mobile communication device.

7. The SIM card of any one of claims 1 through 5, wherein the diagnostics application causes the mobile communication device to generate a visual test output, at least by causing the mobile communication device to present predetermined text via the display screen of the mobile communication device.

8. The SIM card of any one of claims 1 through 7, wherein the diagnostics application causes the mobile communication device to generate an audio test output, at least by causing the mobile communication device to play a ringtone via the speaker of the mobile communication device.

9. The SIM card any one of claims 1 through 8, wherein the diagnostics application:

determines a type of the mobile communication device; and

one or both of (i) causes the mobile communication device to report the mobile device data, and (ii) causes the mobile communication device to generate the one or more test outputs, by issuing one or more commands that are specific to the determined type of the mobile communication device.

10. The SIM card of any one of claims 1 through 9, wherein the diagnostics application further causes the mobile communication device to, prior to reporting the mobile device data and prior to generating the one or more test outputs:

register with the private mobile network.

11. The SIM card of claim 10, wherein the diagnostics application causes the mobile communication device to register with the private mobile network at least by causing the mobile communication device to reject any cellular networks other than the private mobile network.

12. The SIM card of any one of claims 1 through 11, wherein the diagnostics application further causes the mobile communication device to:

send one or more synchronization messages via the private mobile network, wherein the one or more synchronization messages indicate when the one or more test outputs can be captured by the one or more sensors.

13. A method, implemented in a Subscriber Identity Module (SIM) card, for facilitating diagnosis of a mobile communication device to which the SIM card is electrically coupled, the method comprising:

causing the mobile communication device to report mobile device data via a private mobile network, wherein the private mobile network is a cellular network, and wherein the mobile device data (i) includes data indicative of one or more characteristics or properties of the mobile communication device and (ii) is stored in one or more memories of the mobile communication device; and

causing the mobile communications device to generate one or more test outputs to be captured by one or more sensors external to the mobile communication device, wherein the one or more test outputs include one or both of (i) one or more visual test outputs generated via a display screen of the mobile communication device, and (ii) one or more audio test outputs generated via a speaker of the mobile communication device.

14. The method of claim 13, further comprising:

prior to reporting the mobile device data, obtaining at least a portion of the mobile device data by issuing a command to the mobile communication device.

15. The method of claim 13 or 14, further comprising:

causing the mobile communication device to, prior to reporting the mobile device data and prior to generating the one or more test outputs, register with the private mobile network.

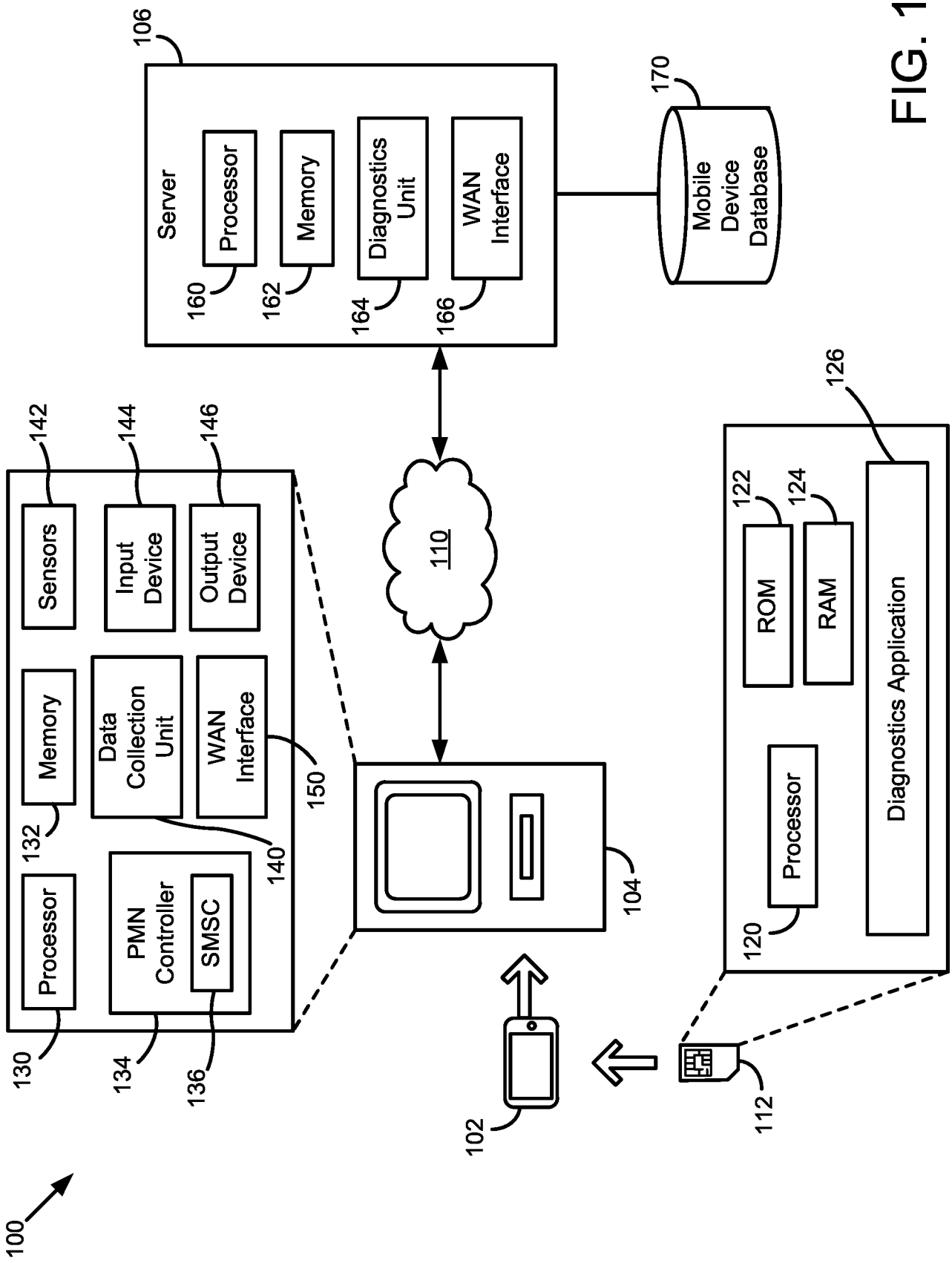
100
106
Server
Processor
Memory
Diagnostics Unit
WAN Interface
160
162
164
166
170
Mobile Device Database
110
142
144
146
Sensors
Input Device
Output Device
Memory
Data Collection Unit
WAN Interface
150
132
140
Processor
PMN Controller
SMSC
130
134
136
104
102
112
126
122
124
ROM
RAM
Diagnostics Application
Processor
120

FIG. 1

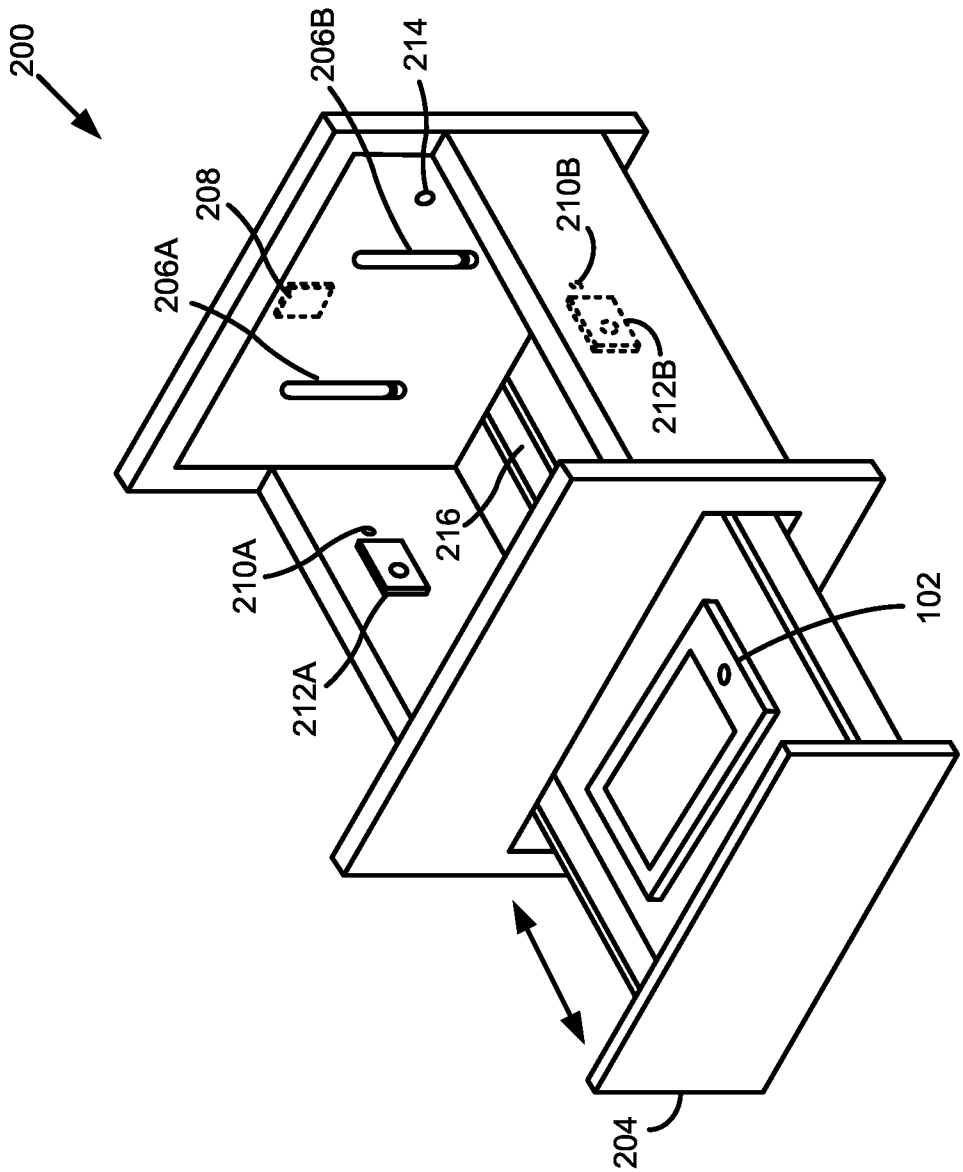

FIG. 2

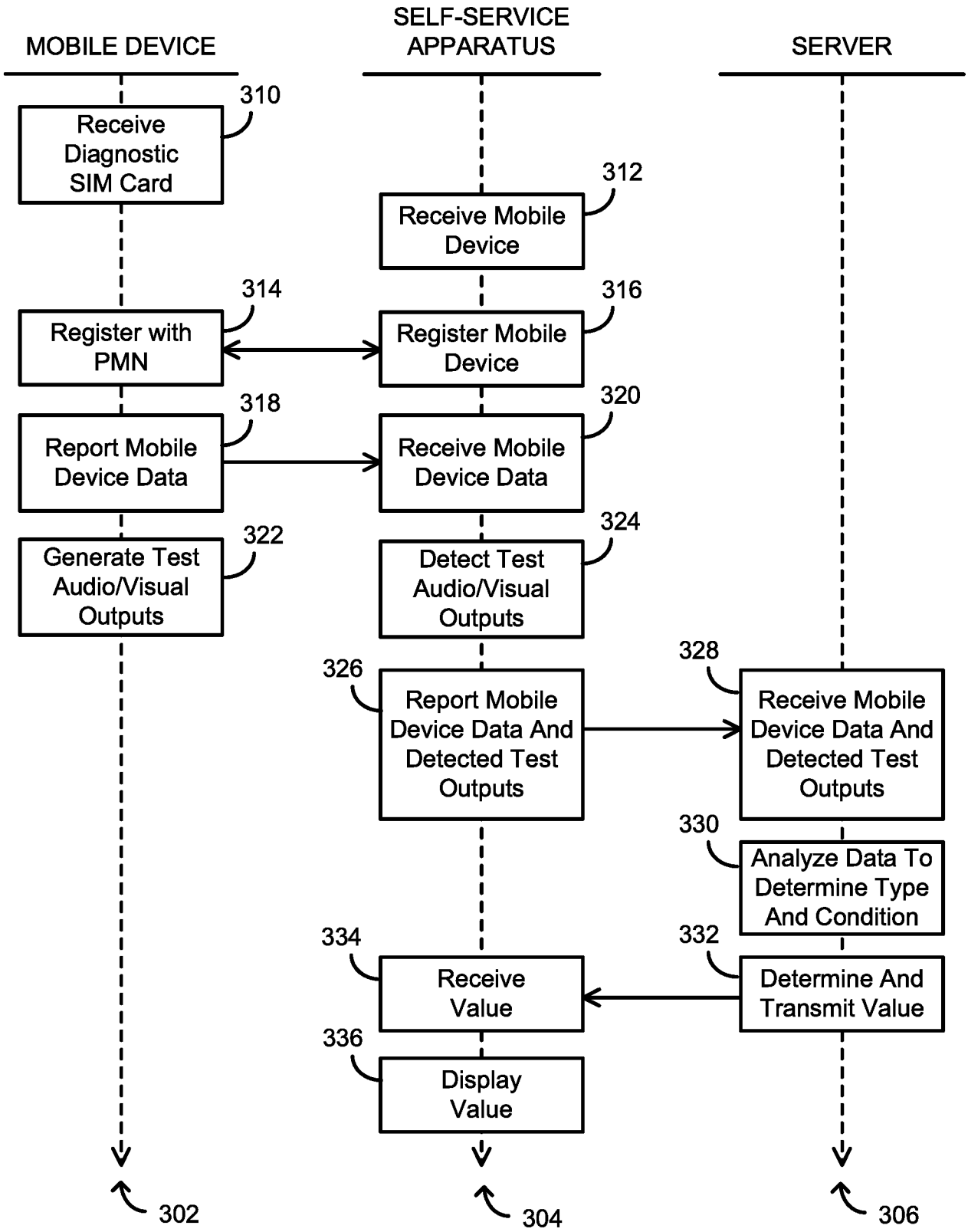
MOBILE DEVICE
SELF-SERVICE APPARATUS
SERVER
310
Receive Diagnostic SIM Card
312
Receive Mobile Device
314
Register with PMN
316
Register Mobile Device
318
Report Mobile Device Data
320
Receive Mobile Device Data
322
Generate Test Audio/Visual Outputs
324
Detect Test Audio/Visual Outputs
326
Report Mobile Device Data And Detected Test Outputs
328
Receive Mobile Device Data And Detected Test Outputs
330
Analyze Data To Determine Type And Condition
332
Determine And Transmit Value
334
Receive Value
336
Display Value
302
304
306

FIG. 3

300

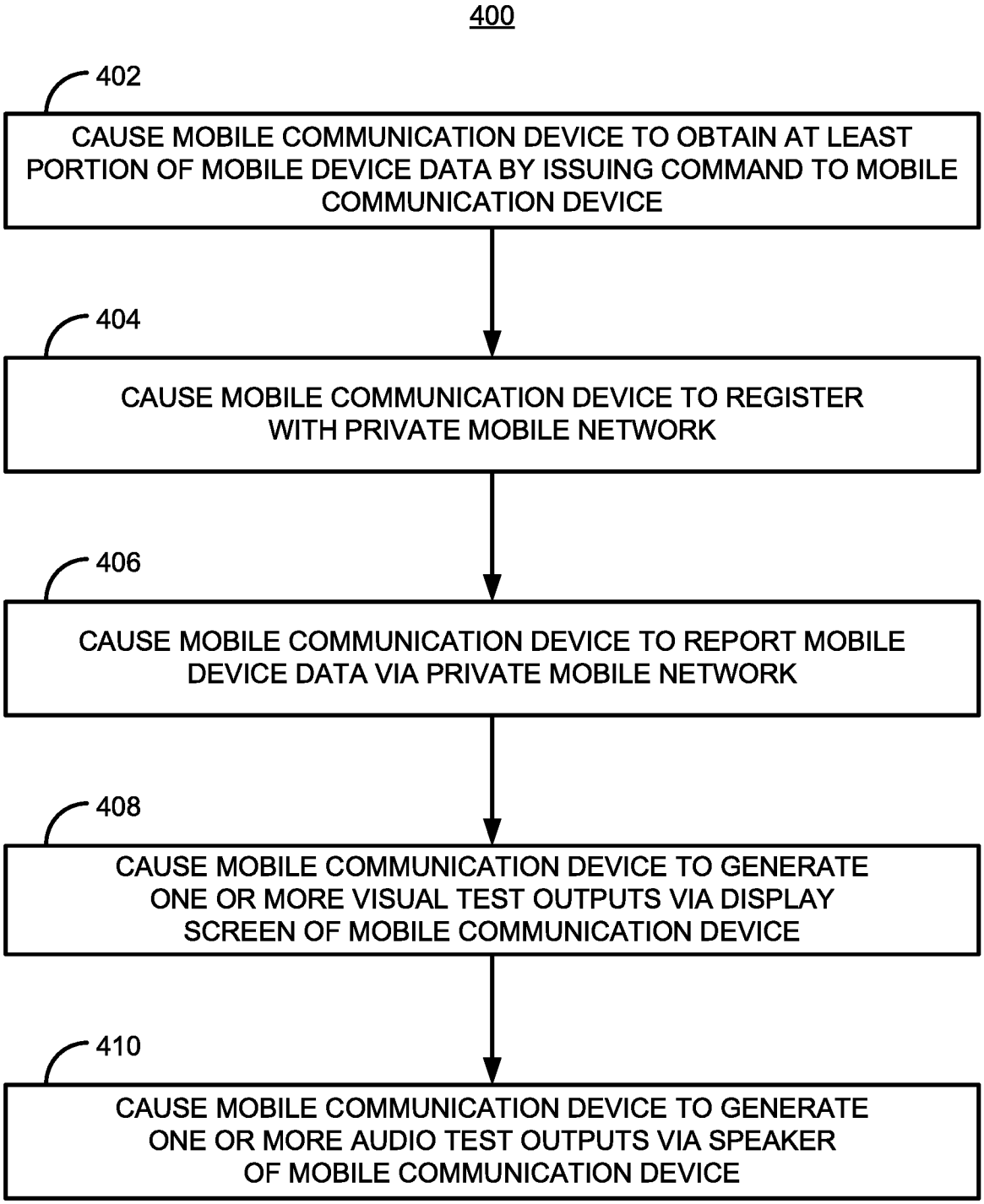
400
402
CAUSE MOBILE COMMUNICATION DEVICE TO OBTAIN AT LEAST PORTION OF MOBILE DEVICE DATA BY ISSUING COMMAND TO MOBILE COMMUNICATION DEVICE
404
CAUSE MOBILE COMMUNICATION DEVICE TO REGISTER WITH PRIVATE MOBILE NETWORK
406
CAUSE MOBILE COMMUNICATION DEVICE TO REPORT MOBILE DEVICE DATA VIA PRIVATE MOBILE NETWORK
408
CAUSE MOBILE COMMUNICATION DEVICE TO GENERATE ONE OR MORE VISUAL TEST OUTPUTS VIA DISPLAY SCREEN OF MOBILE COMMUNICATION DEVICE
410
CAUSE MOBILE COMMUNICATION DEVICE TO GENERATE ONE OR MORE AUDIO TEST OUTPUTS VIA SPEAKER OF MOBILE COMMUNICATION DEVICE

FIG. 4

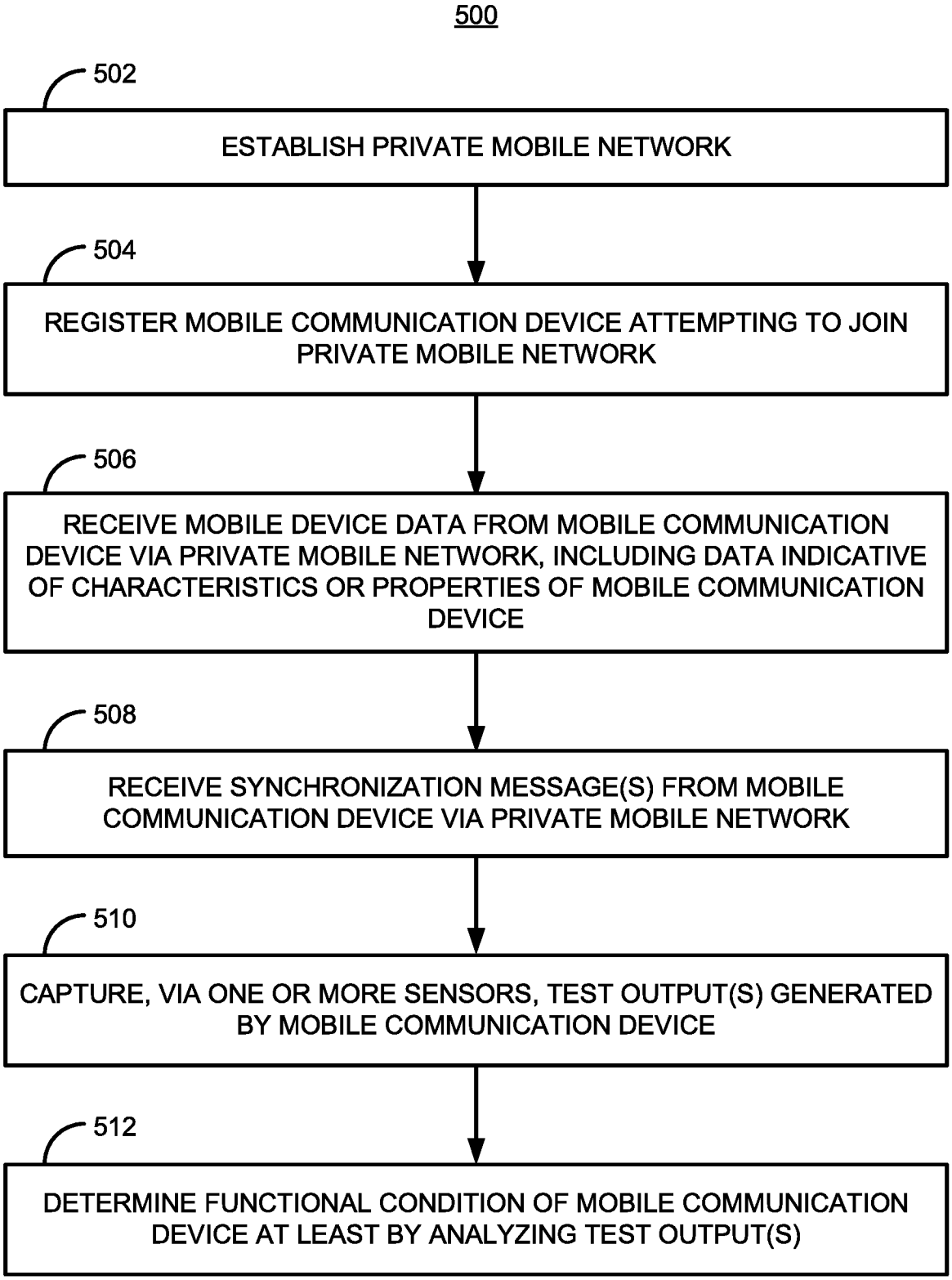
500
502
ESTABLISH PRIVATE MOBILE NETWORK
504
REGISTER MOBILE COMMUNICATION DEVICE ATTEMPTING TO JOIN PRIVATE MOBILE NETWORK
506
RECEIVE MOBILE DEVICE DATA FROM MOBILE COMMUNICATION DEVICE VIA PRIVATE MOBILE NETWORK, INCLUDING DATA INDICATIVE OF CHARACTERISTICS OR PROPERTIES OF MOBILE COMMUNICATION DEVICE
508
RECEIVE SYNCHRONIZATION MESSAGE(S) FROM MOBILE COMMUNICATION DEVICE VIA PRIVATE MOBILE NETWORK
510
CAPTURE, VIA ONE OR MORE SENSORS, TEST OUTPUT(S) GENERATED BY MOBILE COMMUNICATION DEVICE
512
DETERMINE FUNCTIONAL CONDITION OF MOBILE COMMUNICATION DEVICE AT LEAST BY ANALYZING TEST OUTPUT(S)

FIG. 5

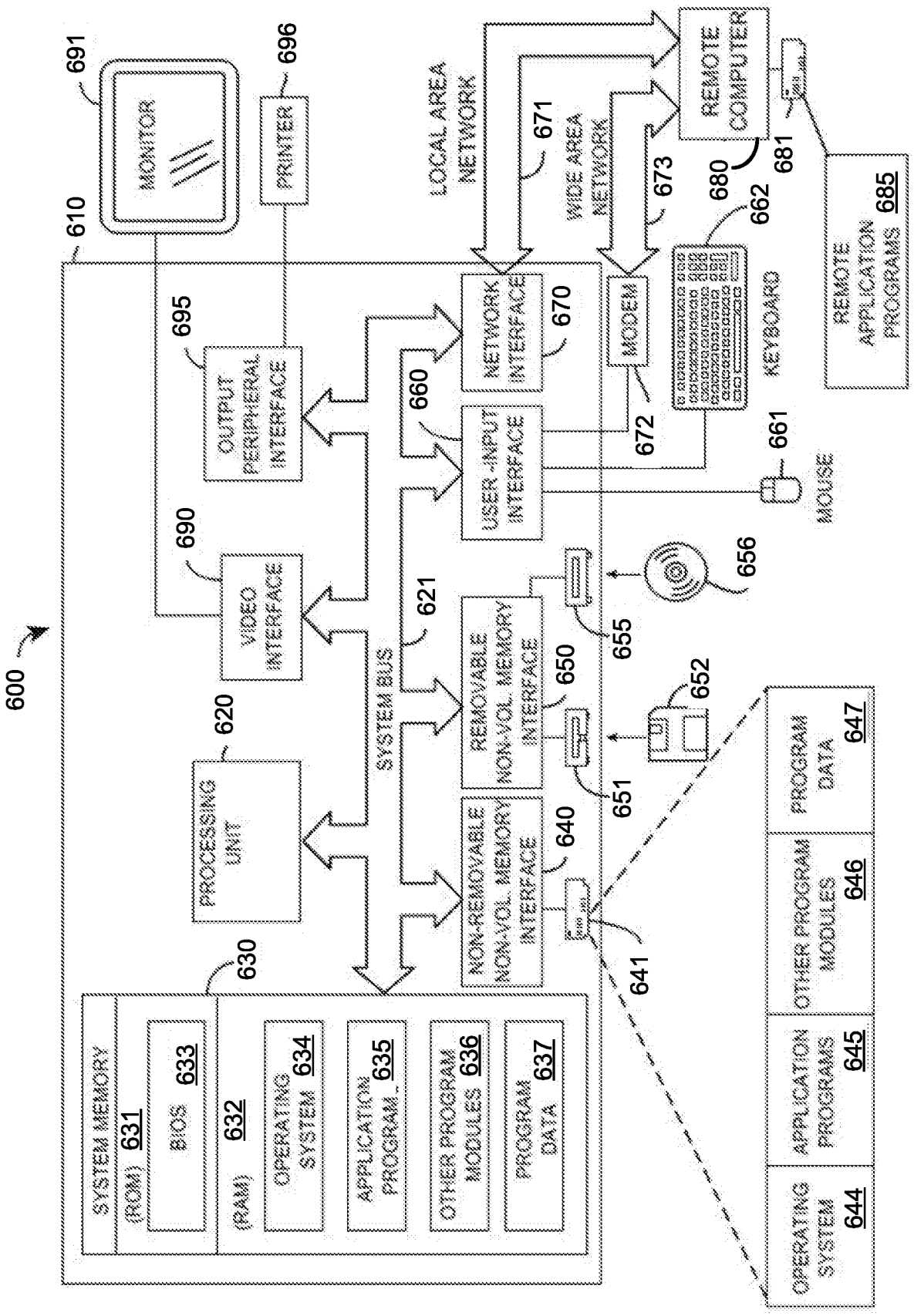
600
610
691
MONITOR
696
PRINTER
LOCAL AREA NETWORK
671
WIDE AREA NETWORK
673
REMOTE COMPUTER
680
681
662
KEYBOARD
661
MOUSE
REMOTE APPLICATION PROGRAMS 685
695
OUTPUT PERIPHERAL INTERFACE
NETWORK INTERFACE 670
660
MODEM
672
USER -INPUT INTERFACE
690
VIDEO INTERFACE
621
SYSTEM BUS
656
655
652
620
PROCESSING UNIT
REMOVABLE NON-VOL MEMORY INTERFACE 650
651
NON-REMOVABLE NON-VOL MEMORY INTERFACE 640
641
630
SYSTEM MEMORY (ROM) 631
BIOS 633
(RAM) 632
OPERATING SYSTEM 634
APPLICATION PROGRAM 635
OTHER PROGRAM MODULES 636
PROGRAM DATA 637
OPERATING SYSTEM 644
APPLICATION PROGRAMS 645
OTHER PROGRAM MODULES 646
PROGRAM DATA 647

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/001675

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04M1/24 G06Q10/00 G06Q30/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04M G06Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/055302 A1 (SEEKER WIRELESS PTY LTD [AU]; MACNAUGHTAN MALCOLM DAVID [AU]; SCOTT CR) 15 May 2008 (2008-05-15) page 24, line 7 - page 25, line 5 page 31, line 17 - page 34, line 11 claims 1,11 figures 1-4,7,9,10,13-15 -----	1-11, 13-15
A	WO 2017/081527 A1 (SMARTBOX LTD [GB]) 18 May 2017 (2017-05-18) cited in the application paragraph [0022] paragraphs [0034] - [0045] paragraphs [0206] - [0208], [0216] -----	1-15
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 March 2018	21/03/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	de Biolley, Luc

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/001675

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015/046343 A1 (MARTINI PAUL MICHAEL [US]) 12 February 2015 (2015-02-12) claims 1,31 paragraphs [0055] - [0057], [0061] paragraph [0071] paragraphs [0092] - [0094] figures 1-4	6,8

A	WO 2007/098890 A2 (ERICSSON TELEFON AB L M [SE]; TOPPHEM GUNILLA MARGARETA [SE]; TOPPHEM) 7 September 2007 (2007-09-07) abstract page 5	6

A	US 7 024 161 B1 (LAMEDICA JR LOUIS [US]) 4 April 2006 (2006-04-04) column 4, line 1 - column 5, line 15 column 11, lines 30-40 claim 1 figures 1,4,5	7,8,12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2017/001675

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2008055302 A1	15-05-2008	NONE	
WO 2017081527 A1	18-05-2017	US 2017318140 A1	02-11-2017
		WO 2017081527 A1	18-05-2017
US 2015046343 A1	12-02-2015	NONE	
WO 2007098890 A2	07-09-2007	EP 2014118 A2	14-01-2009
		JP 5112340 B2	09-01-2013
		JP 2009528734 A	06-08-2009
		TW 200805057 A	16-01-2008
		US 2007207798 A1	06-09-2007
		WO 2007098890 A2	07-09-2007
US 7024161 B1	04-04-2006	NONE	