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(54) SCANNING AND DECODING METHODS AND APPARATUS FOR MOBILE COMMUNICATION DEVICES

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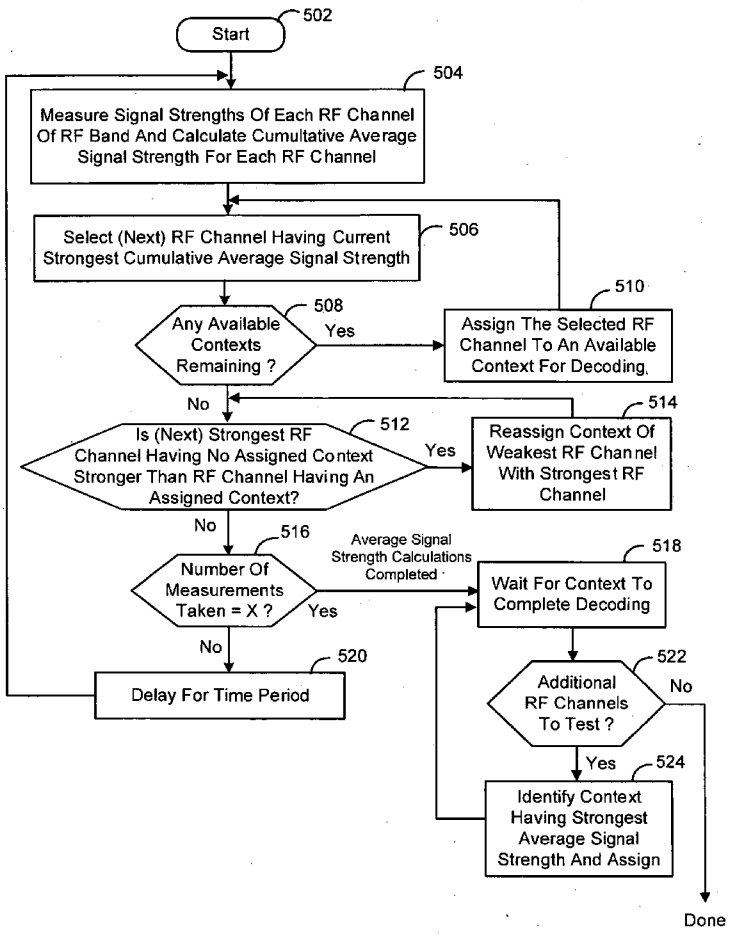
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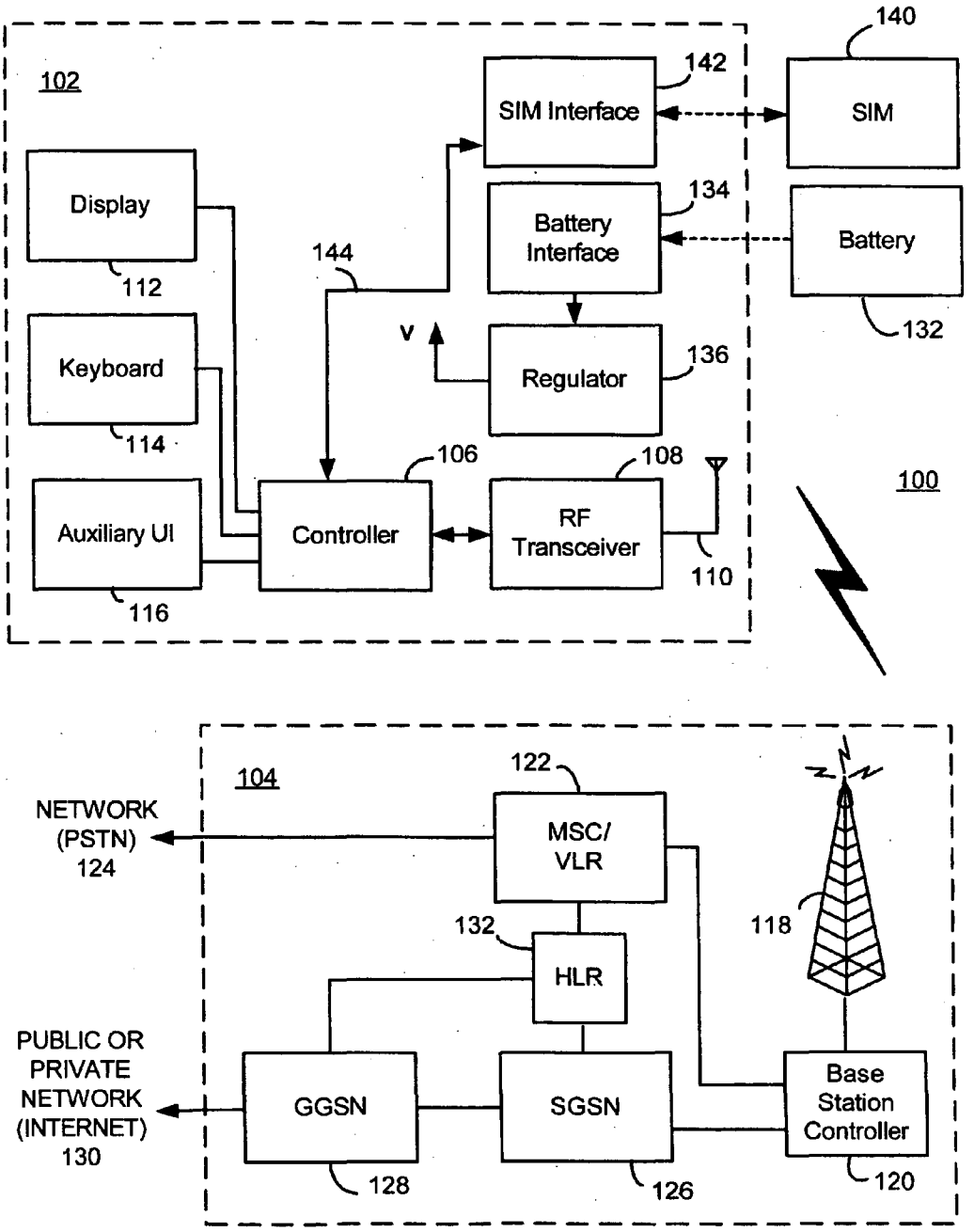
(57) **ABSTRACT**

In one illustrative scanning and decoding method, a signal strength level of an RF signal on an RF channel is measured for a plurality of RF channels of an RF band. The act of measuring a signal strength level is repeated at least one time to obtain at least one other signal strength level of the RF signal. Subsequently, an averaging function is completed with use of the signal strength level and the at least one other signal strength level for identifying an averaged signal strength level of the RF signal. At least one optimal RF signal is then identified based on the averaged signal strength levels of the RF signals on the RF channels. In between the repeated acts of measuring signal strength levels of the RF signals, and prior to identifying the averaged signal strength levels, control information is decoded on at least one of the RF channels and stored in memory. A wireless communication network is selected for communication with use of the control information stored in the memory which corresponds to one of the at least one optimal RF signal. In this manner, the mobile station expeditiously obtains the control information for network selection or other purposes prior to completing the averaging of the signal strength levels.



GOOGLE EXHIBIT 1014

FIG. 1


102
SIM Interface
142
140
SIM
Display
112
144
Battery Interface
134
Battery
132
Keyboard
114
V
Regulator
136
106
108
100
Auxiliary UI
116
Controller
RF Transceiver
110
104
122
NETWORK (PSTN) 124
MSC/ VLR
118
132
HLR
PUBLIC OR PRIVATE NETWORK (INTERNET) 130
GGSN
SGSN
Base Station Controller
128
126
120

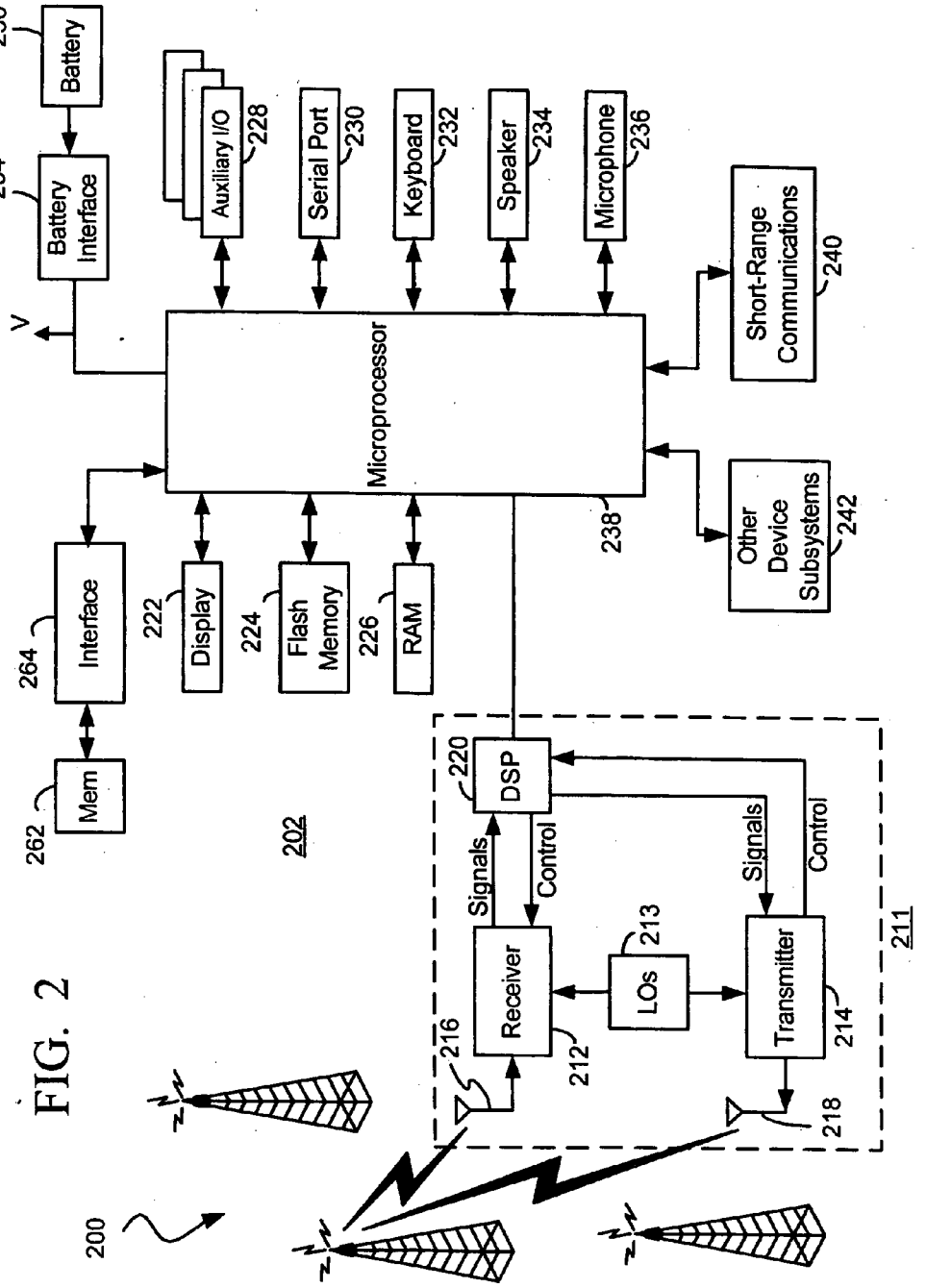

256
Battery
254
Battery Interface
V
Auxiliary I/O
228
Serial Port
230
Keyboard
232
Speaker
234
Microphone
236
Short-Range Communications
240
Microprocessor
238
Other Device Subsystems
242
264
Interface
262
Mem
222
Display
224
Flash Memory
226
RAM
202
220
DSP
Signals
Control
Signals
Control
213
LOs
Receiver
212
Transmitter
214
216
218
211
200

FIG. 2

FIG. 3

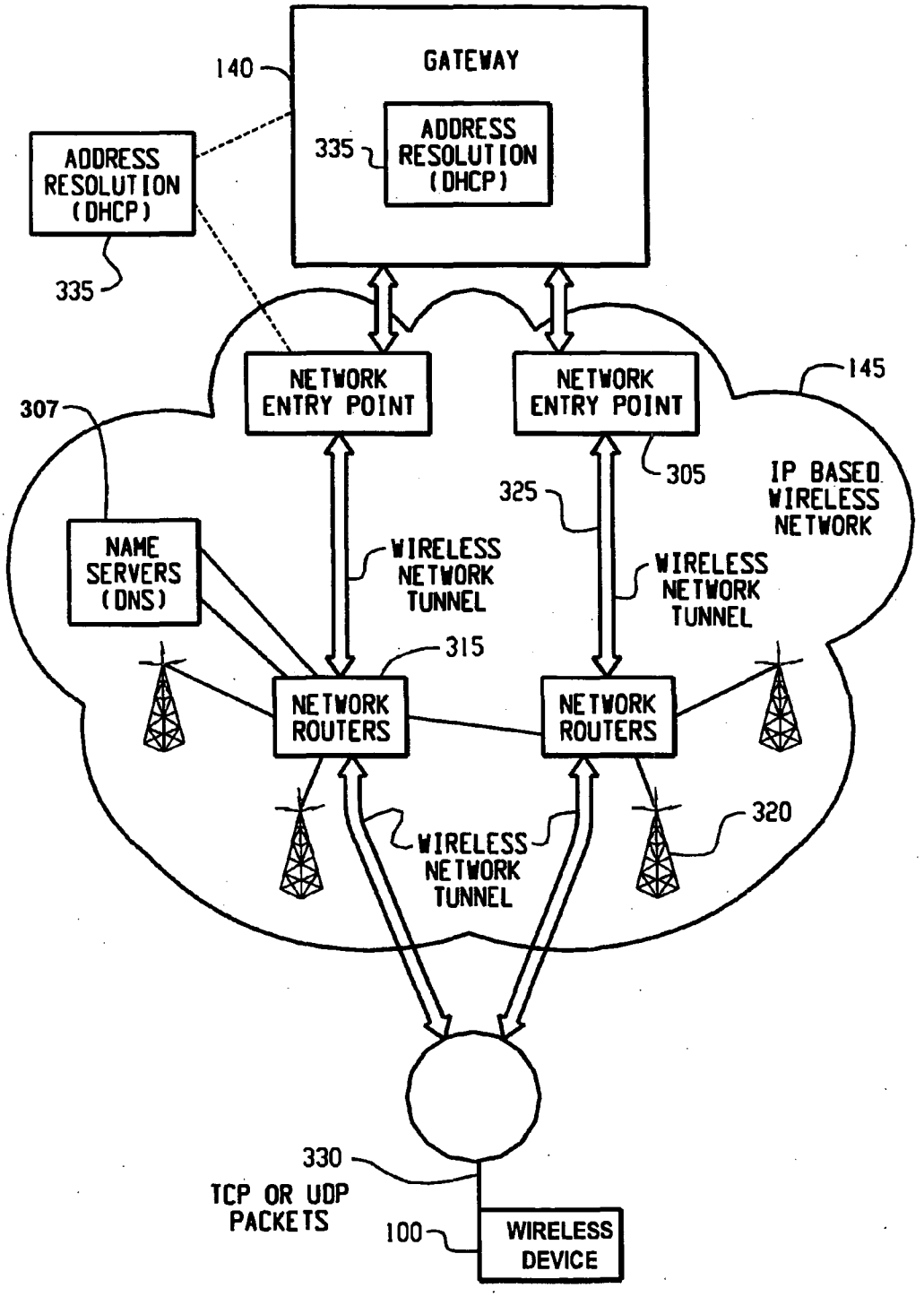

GATEWAY
140
ADDRESS RESOLUTION (DHCP)
335
ADDRESS RESOLUTION (DHCP)
335
NETWORK ENTRY POINT
NETWORK ENTRY POINT
145
307
305
325
IP BASED WIRELESS NETWORK
NAME SERVERS (DNS)
WIRELESS NETWORK TUNNEL
WIRELESS NETWORK TUNNEL
315
NETWORK ROUTERS
NETWORK ROUTERS
320
WIRELESS NETWORK TUNNEL
330
TCP OR UDP PACKETS
100
WIRELESS DEVICE

FIG. 4

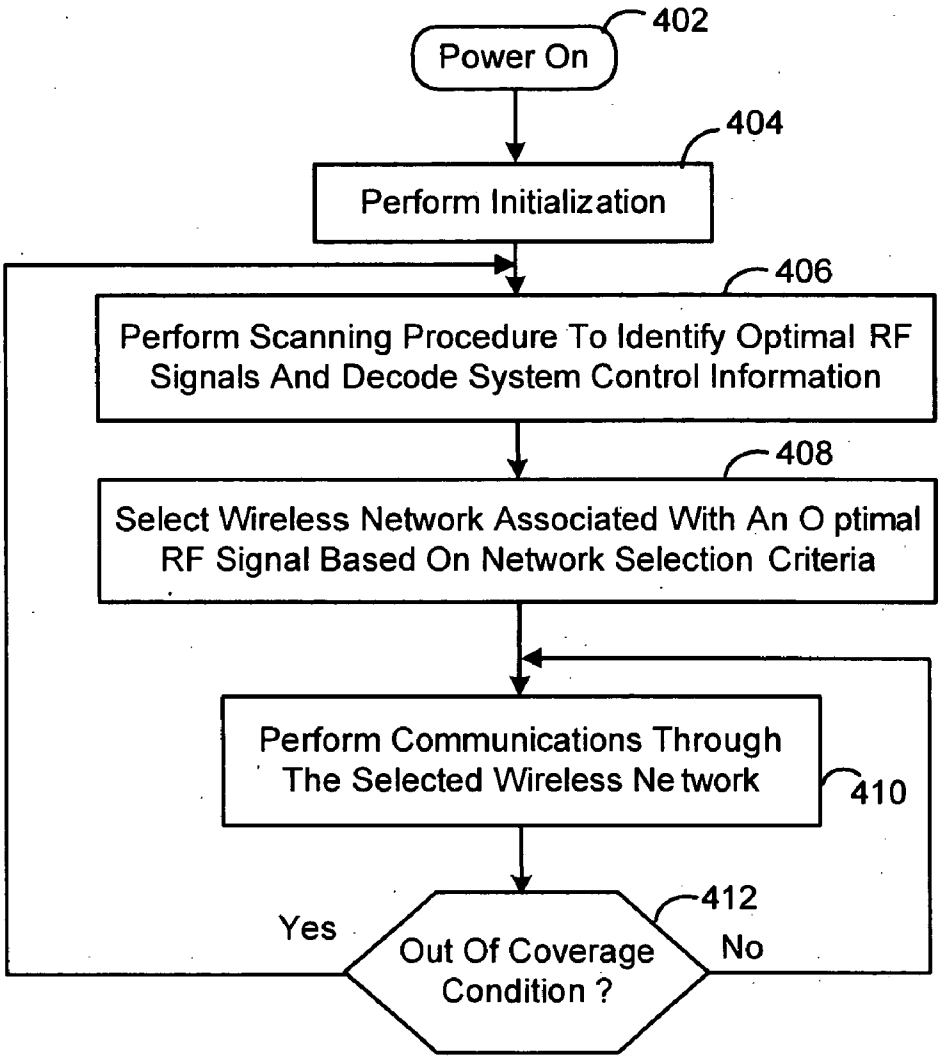

402
Power On
404
Perform Initialization
406
Perform Scanning Procedure To Identify Optimal RF Signals And Decode System Control Information
408
Select Wireless Network Associated With An O ptimal RF Signal Based On Network Selection Criteria
Perform Communications Through The Selected Wireless Ne twork
410
412
Yes
Out Of Coverage Condition ?
No

FIG. 5

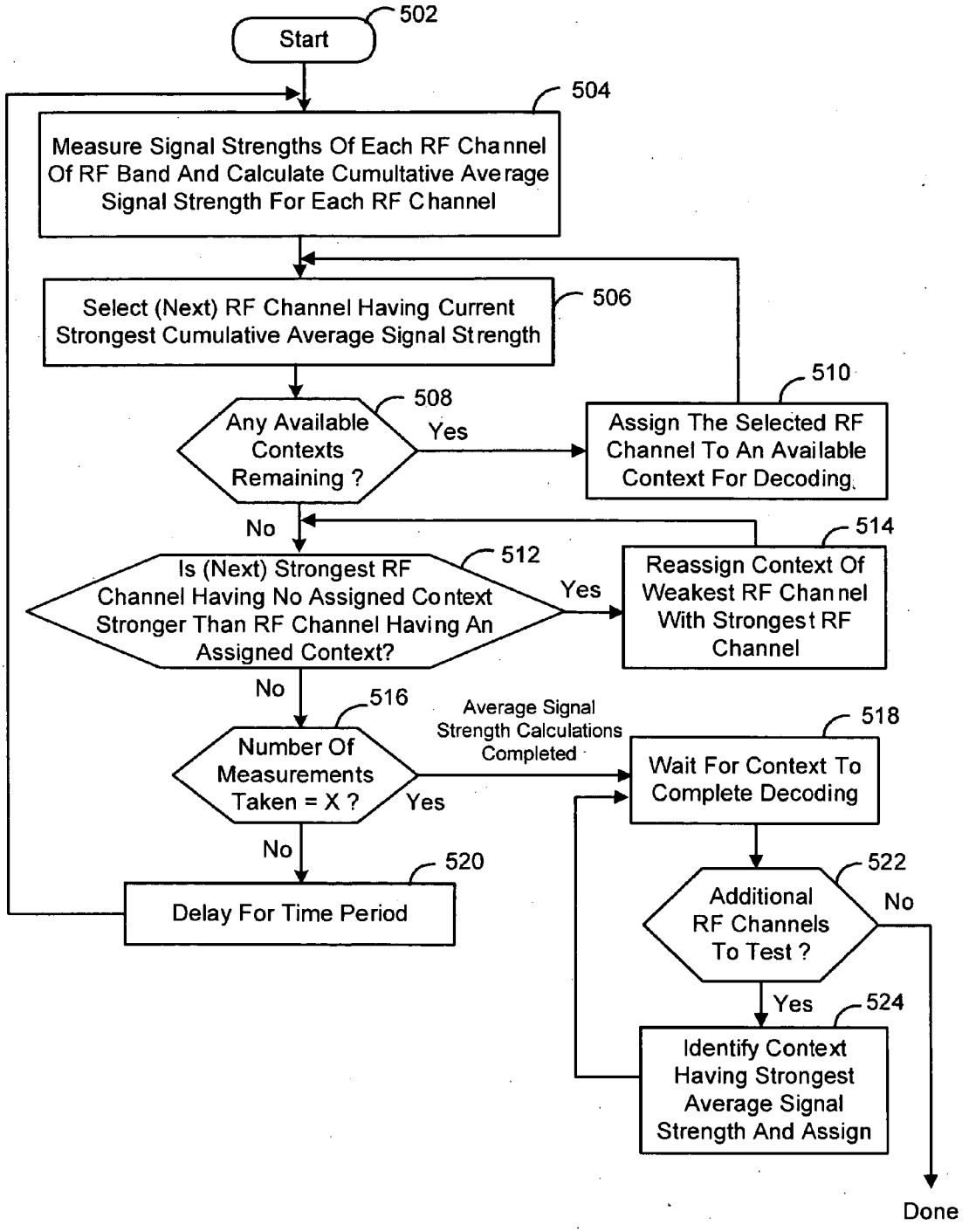
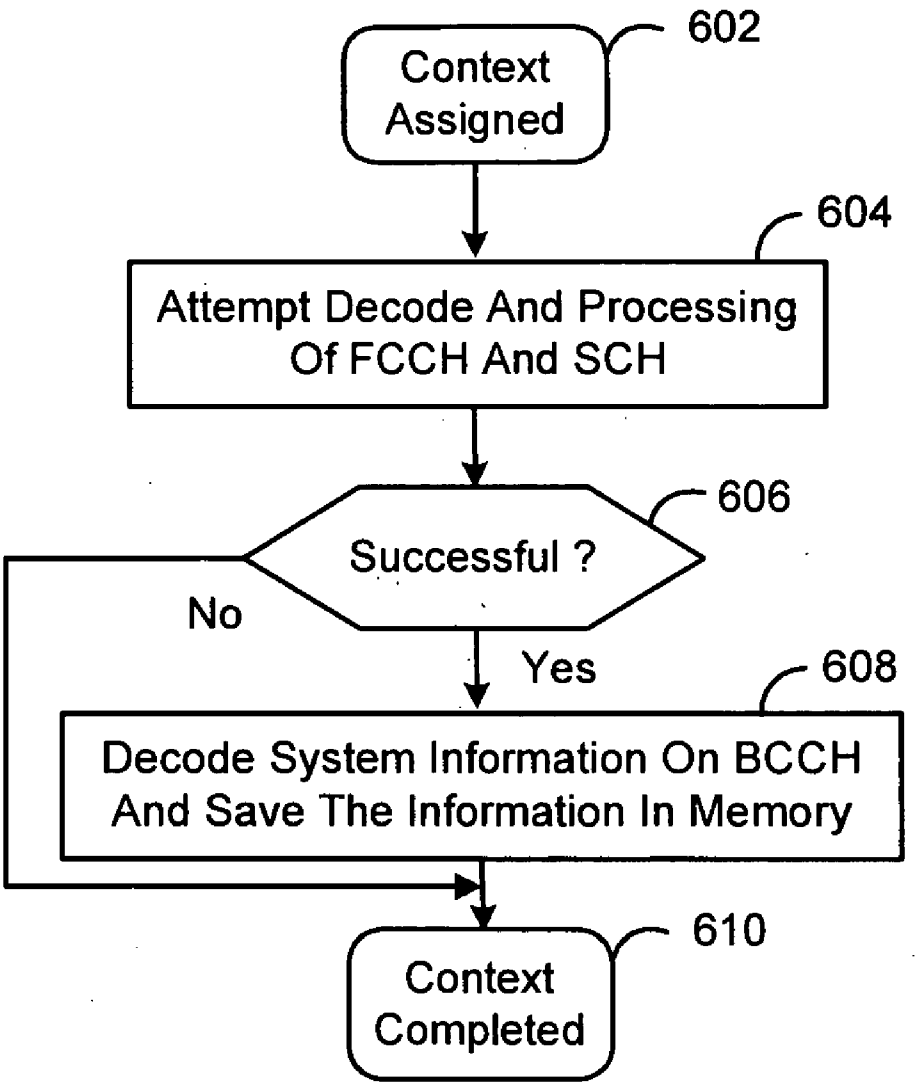

Start
502
Measure Signal Strengths Of Each RF Channel Of RF Band And Calculate Cumultative Average Signal Strength For Each RF Channel
504
Select (Next) RF Channel Having Current Strongest Cumulative Average Signal Strength
506
Any Available Contexts Remaining ?
508
Yes
Assign The Selected RF Channel To An Available Context For Decoding
510
No
Is (Next) Strongest RF Channel Having No Assigned Context Stronger Than RF Channel Having An Assigned Context?
512
Yes
Reassign Context Of Weakest RF Channel With Strongest RF Channel
514
No
Number Of Measurements Taken = X ?
516
Average Signal Strength Calculations Completed
Yes
Wait For Context To Complete Decoding
518
No
Delay For Time Period
520
Additional RF Channels To Test ?
522
No
Yes
Identify Context Having Strongest Average Signal Strength And Assign
524
Done

FIG. 6


602
Context Assigned
604
Attempt Decode And Processing Of FCCH And SCH
606
Successful ?
No
Yes
608
Decode System Information On BCCH And Save The Information In Memory
610
Context Completed

SCANNING AND DECODING METHODS AND APPARATUS FOR MOBILE COMMUNICATION DEVICES

BACKGROUND

[0001] 1. Field of the Technology

[0002] The present application relates generally to mobile stations which utilize scanning techniques in order to identify one or more wireless communication networks within which to communicate.

[0003] 2. Description of the Related Art

[0004] Before wireless communications may take for a mobile station in a Global System for Mobile Communications (GSM) wireless network, the mobile station must identify one or more available wireless networks in its coverage area and select one of them for communication. To do this, the mobile station causes a scanning procedure to be performed to identify one or more radio frequency (RF) signals within its coverage area. Each RF signal is associated with one of the wireless networks within which the mobile station may be able to operate. Optimal RF signals are generally those RF signals which have been identified to have the best RF signal strengths for communication.

[0005] For each optimal RF signal, the mobile station decodes system control information over a broadcast control channel (BCCH). The system control information includes network identification information (e.g. a Mobile Country Code (MCC) and a Mobile Network Code (MNC)) associated with the wireless network and is utilized by the mobile station for selecting the most appropriate wireless network for communication. The mobile station registers and obtains service through the selected wireless network, so that communications through the selected wireless network may proceed.

[0006] The signal strength level which is obtained for each RF signal is actually an averaged signal strength value which is based on a plurality of signal strength measurements of the RF signal taken over a time period. In GSM/GPRS communication systems, for example, it is required to take five measurement samples of the signal strength level of each RF signal over a period of five seconds (generally one sample per second) and complete the averaged signal strength value based on these five measurement samples. After the averaged signal strengths of the RF signals are calculated, the mobile station decodes the control information on each control channel associated with the optimal RF signals which have optimal averaged signal strengths.

[0007] There is a need for improved scanning and decoding methods and apparatus which will result in obtaining control information (e.g. network identification information) of wireless communication networks in a reduced amount of time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Embodiments of present application will now be described by way of example with reference to attached figures, wherein:

[0009] FIG. **1** is a block diagram which illustrates pertinent components of a mobile station and a wireless communication network;

[0010] FIG. **2** is a more detailed diagram of a preferred mobile station of FIG. **1**;

[0011] FIG. **3** is a particular system diagram for the mobile station and wireless network of FIGS. **1** and **2**;

[0012] FIG. **4** is a flowchart which describes a general method of operation for the mobile station; and

[0013] FIGS. **5** and **6** are flowcharts which help describe a scanning and decoding method for the mobile station.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Scanning and decoding methods and apparatus for mobile communication devices are described herein. The nature of the present techniques involves decoding system information over radio frequency (RF) channels in between the successive iterations of obtaining power levels for all of the RF channels under consideration before all sets of signal strength measurements have been obtained. The selection of which RF channels are the strongest for decoding is done speculatively throughout the procedure based on the current subset of measurements performed, rather than waiting until all sets of measurements to have been obtained. Should these speculative guesses as to which RF channels will be the strongest ones prove to be correct by the time all sets of measurements are taken, the mobile station will already have decoded the appropriate system information for processing. Should the speculative guesses prove to be incorrect, the mobile station may discard the measurements and switch to stronger RF channels for measurement and subsequent decoding. In this manner, a mobile station is able to interleave the reading of system information from the strongest RF channels with the actual measurement of signal strength of all channels under consideration throughout the procedure, resulting in a reduced time required to find and identify the strongest wireless networks in a given area.

[0015] FIG. **1** is a block diagram of a communication system **100** which includes a mobile station **102** (one example of a wireless or mobile communication device) which communicates through a wireless communication network **104**. Mobile station **102** preferably includes a visual display **112**, a keyboard **114**, and perhaps one or more auxiliary user interfaces (UI) **116**, each of which are coupled to a controller **106**. Controller **106** is also coupled to radio frequency (RF) transceiver circuitry **108** and an antenna **110**. Typically, controller **106** is embodied as a central processing unit (CPU) which runs operating system software in a memory component (not shown). Controller **106** will normally control overall operation of mobile station **102**, whereas signal processing operations associated with communication functions are typically performed in RF transceiver circuitry **108**. Controller **106** interfaces with device display **112** to display received information, stored information, user inputs, and the like. Keyboard **114**, which may be a telephone type keypad or full alphanumeric keyboard, is normally provided for entering data for storage in mobile station **102**, information for transmission to network **104**, a telephone number to place a telephone call, commands to be executed on mobile station **102**, and possibly other or different user inputs.

[0016] Mobile station **102** sends communication signals to and receives communication signals from network **104** over

a wireless link via antenna **110**. RF transceiver circuitry **108** performs functions similar to those of station **118** and BSC **120**, including for example modulation/demodulation and possibly encoding/decoding and encryption/decryption. It is also contemplated that RF transceiver circuitry **108** may perform certain functions in addition to those performed by BSC **120**. It will be apparent to those skilled in art that RF transceiver circuitry **108** will be adapted to particular wireless network or networks in which mobile station **102** is intended to operate.

[**0017**] Mobile station **102** includes a battery interface **134** for receiving one or more rechargeable batteries **132**. Battery **132** provides electrical power to electrical circuitry in mobile station **102**, and battery interface **132** provides for a mechanical and electrical connection for battery **132**. Battery interface **132** is coupled to a regulator **136** which regulates power to the device. When mobile station **102** is fully operational, an RF transmitter of RF transceiver circuitry **108** is typically keyed or turned on only when it is sending to network, and is otherwise turned off to conserve resources. Similarly, an RF receiver of RF transceiver circuitry **108** is typically periodically turned off to conserve power until it is needed to receive signals or information (if at all) during designated time periods.

[**0018**] Mobile station **102** operates using a Subscriber Identity Module (SIM) **140** which is connected to or inserted in mobile station **102** at a SIM interface **142**. SIM **140** is one type of a conventional "smart card" used to identify an end user (or subscriber) of mobile station **102** and to personalize the device, among other things. Without SIM **140**, the mobile station terminal is not fully operational for communication through wireless network **104**. By inserting SIM **140** into mobile station **102**, an end user can have access to any and all of his/her subscribed services. SIM **140** generally includes a processor and memory for storing information. Since SIM **140** is coupled to SIM interface **142**, it is coupled to controller **106** through communication lines **144**. In order to identify the subscriber, SIM **140** contains some user parameters such as an International Mobile Subscriber Identity (IMSI). An advantage of using SIM **140** is that end users are not necessarily bound by any single physical mobile station. SIM **140** may store additional user information for the mobile station as well, including datebook (or calendar) information and recent call information.

[**0019**] Mobile station **102** may consist of a single unit, such as a data communication device, a cellular telephone, a multiple-function communication device with data and voice communication capabilities, a personal digital assistant (PDA) enabled for wireless communication, or a computer incorporating an internal modem. Alternatively, mobile station **102** may be a multiple-module unit comprising a plurality of separate components, including but in no way limited to a computer or other device connected to a wireless modem. In particular, for example, in the mobile station block diagram of FIG. **1**, RF transceiver circuitry **108** and antenna **110** may be implemented as a radio modem unit that may be inserted into a port on a laptop computer. In this case, the laptop computer would include display **112**, keyboard **114**, one or more auxiliary UIs **116**, and controller **106** embodied as the computer's CPU. It is also contemplated that a computer or other equipment not normally capable of wireless communication may be adapted to connect to and effectively assume control of RF transceiver circuitry **108** and antenna **110** of a single-unit device such as one of those described above. Such a mobile station **102** may have a more particular implementation as described later in relation to mobile station **402** of FIG. **2**.

[**0020**] Mobile station **102** communicates in and through wireless communication network **104**. Wireless communication network **104** may be a cellular telecommunications network. In the embodiment of FIG. **1**, wireless network **104** is configured in accordance with General Packet Radio Service (GPRS) and a Global Systems for Mobile (GSM) technologies. Wireless network **104** includes a base station controller (BSC) **120** with an associated tower station **118**, a Mobile Switching Center (MSC) **122**, a Home Location Register (HLR) **132**, a Serving General Packet Radio Service (GPRS) Support Node (SGSN) **126**, and a Gateway GPRS Support Node (GGSN) **128**. MSC **122** is coupled to BSC **120** and to a landline network, such as a Public Switched Telephone Network (PSTN) **124**. SGSN **126** is coupled to BSC **120** and to GGSN **128**, which is in turn coupled to a public or private data network **130** (such as the Internet). HLR **132** is coupled to MSC **122**, SGSN **126**, and GGSN **128**.

[**0021**] Station **118** is a fixed transceiver station, and station **118** and BSC **120** may be referred to as transceiver equipment. The transceiver equipment provides wireless network coverage for a particular coverage area commonly referred to as a "cell". The transceiver equipment transmits communication signals to and receives communication signals from mobile stations within its cell via station **118**. The transceiver equipment normally performs such functions as modulation and possibly encoding and/or encryption of signals to be transmitted to the mobile station in accordance with particular, usually predetermined, communication protocols and parameters, under control of its controller. The transceiver equipment similarly demodulates and possibly decodes and decrypts, if necessary, any communication signals received from mobile station **102** within its cell. Communication protocols and parameters may vary between different networks. For example, one network may employ a different modulation scheme and operate at different frequencies than other networks.

[**0022**] The wireless link shown in communication system **100** of FIG. **1** represents one or more different channels, typically different radio frequency (RF) channels, and associated protocols used between wireless network **104** and mobile station **102**. An RF channel is a limited resource that must be conserved, typically due to limits in overall bandwidth and a limited battery power of mobile station **102**. Those skilled in art will appreciate that a wireless network in actual practice may include hundreds of cells, each served by a station **118** (i.e. or station sector), depending upon desired overall expanse of network coverage. All pertinent components may be connected by multiple switches and routers (not shown), controlled by multiple network controllers.

[**0023**] For all mobile station's **102** registered with a network operator, permanent data (such as mobile station **102** user's profile) as well as temporary data (such as mobile station's **102** current location) are stored in HLR **132**. In case of a voice call to mobile station **102**, HLR **132** is queried to determine the current location of mobile station **102**. A Visitor Location Register (VLR) of MSC **122** is

responsible for a group of location areas and stores the data of those mobile stations that are currently in its area of responsibility. This includes parts of the permanent mobile station data that have been transmitted from HLR **132** to the VLR for faster access. However, the VLR of MSC **122** may also assign and store local data, such as temporary identifications. Optionally, the VLR of MSC **122** can be enhanced for more efficient co-ordination of GPRS and non-GPRS services and functionality (e.g. paging for circuit-switched calls which can be performed more efficiently via SGSN **126**, and combined GPRS and non-GPRS location updates).

[**0024**] Serving GPRS Support Node (SGSN) **126** is at the same hierarchical level as MSC **122** and keeps track of the individual locations of mobile stations. SGSN **126** also performs security functions and access control. Gateway GPRS Support Node (GGSN) **128** provides interworking with external packet-switched networks and is connected: with SGSNs (such as SGSN **126**) via an IP-based GPRS backbone network. SGSN **126** performs authentication and cipher setting procedures based on the same algorithms, keys, and criteria as in existing GSM. In conventional operation, cell selection may be performed autonomously by mobile station **102** or by the transceiver equipment instructing mobile station **102** to select a particular cell. Mobile station **102** informs wireless network **104** when it reselects another cell or group of cells, known as a routing area.

[**0025**] In order to access GPRS services, mobile station **102** first makes its presence known to wireless network **104** by performing what is known as a GPRS "attach". This operation establishes a logical link between mobile station **102** and SGSN **126** and makes mobile station **102** available to receive, for example, pages via SGSN, notifications of incoming GPRS data, or SMS messages over GPRS. In order to send and receive GPRS data, mobile station **102** assists in activating the packet data address that it wants to use. This operation makes mobile station **102** known to GGSN **128**; interworking with external data networks can thereafter commence. User data may be transferred transparently between mobile station **102** and the external data networks using, for example, encapsulation and tunneling. Data packets are equipped with GPRS-specific protocol information and transferred between mobile station **102** and GGSN **128**.

[**0026**] Those skilled in art will appreciate that a wireless network may be connected to other systems, possibly including other networks, not explicitly shown in FIG. **1**. A network will normally be transmitting at very least some sort of paging and system information on an ongoing basis, even if there is no actual packet data exchanged. Although the network consists of many parts, these parts all work together to result in certain behaviours at the wireless link.

[**0027**] FIG. **2** is a detailed block diagram of a preferred mobile station **202** of the present application. Mobile station **202** is preferably a two-way communication device having at least voice and advanced data communication capabilities, including the capability to communicate with other computer systems. Depending on the functionality provided by mobile station **202**, it may be referred to as a data messaging device, a two-way pager, a cellular telephone with data messaging capabilities, a wireless Internet appliance, or a data communication device (with or without telephony capabilities). Mobile station **202** may communicate with any one of a plurality of fixed transceiver stations **200** within its geographic coverage area.

[**0028**] Mobile station **202** will normally incorporate a communication subsystem **211**, which includes a receiver **212**, a transmitter **214**, and associated components, such as one or more (preferably embedded or internal) antenna elements **216** and **218**, local oscillators (LOs) **213**, and a processing module such as a digital signal processor (DSP) **220**. Communication subsystem **211** is analogous to RF transceiver circuitry **108** and antenna **110** shown in FIG. **1**. As will be apparent to those skilled in field of communications, particular design of communication subsystem **211** depends on the communication network in which mobile station **202** is intended to operate.

[**0029**] Mobile station **202** may send and receive communication signals over the network after required network registration or activation procedures have been completed. Signals received by antenna **216** through the network are input to receiver **212**, which may perform such common receiver functions as signal amplification, frequency down conversion, filtering, channel selection, and like, and in example shown in FIG. **2**, analog-to-digital (A/D) conversion. A/D conversion of a received signal allows more complex communication functions such as demodulation and decoding to be performed in DSP **220**. In a similar manner, signals to be transmitted are processed, including modulation and encoding, for example, by DSP **220**. These DSP-processed signals are input to transmitter **214** for digital-to-analog (D/A) conversion, frequency up conversion, filtering, amplification and transmission over communication network via antenna **218**. DSP **220** not only processes communication signals, but also provides for receiver and transmitter control. For example, the gains applied to communication signals in receiver **212** and transmitter **214** may be adaptively controlled through automatic gain control algorithms implemented in DSP **220**.

[**0030**] Network access is associated with a subscriber or user of mobile station **202**, and therefore mobile station **202** requires a Subscriber Identity Module or "SIM" card **262** to be inserted in a SIM interface **264** in order to operate in the network. SIM **262** includes those features described in relation to FIG. **1**. Mobile station **202** is a battery-powered device so it also includes a battery interface **254** for receiving one or more rechargeable batteries **256**. Such a battery **256** provides electrical power to most if not all electrical circuitry in mobile station **202**, and battery interface **254** provides for a mechanical and electrical connection for it. The battery interface **254** is coupled to a regulator (not shown) which provides power V+ to all of the circuitry.

[**0031**] Mobile station **202** includes a microprocessor **238** (which is one implementation of controller **106** of FIG. **1**) which controls overall operation of mobile station **202**. Communication functions, including at least data and voice communications, are performed through communication subsystem **211**. The scanning technique of the present application is generally controlled by microprocessor **238** in connection with DSP **220**. Microprocessor **238** also interacts with additional device subsystems such as a display **222**, a flash memory **224**, a random access memory (RAM) **226**, auxiliary input/output (I/O) subsystems **228**, a serial port **230**, a keyboard **232**, a speaker **234**, a microphone **236**, a short-range communications subsystem **240**, and any other

device subsystems generally designated at **242**. Some of the subsystems shown in FIG. **2** perform communication-related functions, whereas other subsystems may provide "resident" or on-device functions. Notably, some subsystems, such as keyboard **232** and display **222**, for example, may be used for both communication-related functions, such as entering a text message for transmission over a communication network, and device-resident functions such as a calculator or task list. Operating system software used by microprocessor **238** is preferably stored in a persistent store such as flash memory **224**, which may alternatively be a read-only memory (ROM) or similar storage element (not shown). Those skilled in the art will appreciate that the operating system, specific device applications, or parts thereof, may be temporarily loaded into a volatile store such as RAM **226**.

[**0032**] Microprocessor **238**, in addition to its operating system functions, preferably enables execution of software applications on mobile station **202**. A predetermined set of applications which control basic device operations, including at least data and voice communication applications, will normally be installed on mobile station **202** during its manufacture. A preferred application that may be loaded onto mobile station **202** may be a personal information manager (PIM) application having the ability to organize and manage data items relating to user such as, but not limited to, e-mail, calendar events, voice mails, appointments, and task items. Naturally, one or more memory stores are available on mobile station **202** and SIM **256** to facilitate storage of PIM data items and other information. The PIM application preferably has the ability to send and receive data items via the wireless network. In a preferred embodiment, PIM data items are seamlessly integrated, synchronized, and updated via the wireless network, with the mobile station user's corresponding data items stored and/or associated with a host computer system thereby creating a mirrored host computer on mobile station **202** with respect to such items. This is especially advantageous where the host computer system is the mobile station user's office computer system. Additional applications may also be loaded onto mobile station **202** through network, an auxiliary I/O subsystem **228**, serial port **230**, short-range communications subsystem **240**, or any other suitable subsystem **242**, and installed by a user in RAM **226** or preferably a non-volatile store (not shown) for execution by microprocessor **238**. Such flexibility in application installation increases the functionality of mobile station **202** and may provide enhanced on-device functions, communication-related functions, or both. For example, secure communication applications may enable electronic commerce functions and other such financial transactions to be performed using mobile station **202**.

[**0033**] In a data communication mode, a received signal such as a text message, an e-mail message, or web page download will be processed by communication subsystem **211** and input to microprocessor **238**. Microprocessor **238** will preferably further process the signal for output to display **222** or alternatively to auxiliary I/O device **228**. A user of mobile station **202** may also compose data items, such as e-mail messages, for example, using keyboard **232** in conjunction with display **222** and possibly auxiliary I/O device **228**. Keyboard **232** is preferably a complete alphanumeric keyboard and/or telephone-type keypad. These composed items may be transmitted over a communication network through communication subsystem **211**. For voice communications, the overall operation of mobile station **202** is substantially similar, except that the received signals would be output to speaker **234** and signals for transmission would be generated by microphone **236**. Alternative voice or audio I/O subsystems, such as a voice message recording subsystem, may also be implemented on mobile station **202**. Although voice or audio signal output is preferably accomplished primarily through speaker **234**, display **222** may also be used to provide an indication of the identity of a calling party, duration of a voice call, or other voice call related information, as some examples.

[**0034**] Serial port **230** in FIG. **2** is normally implemented in a personal digital assistant (PDA)-type communication device for which synchronization with a user's desktop computer is a desirable, albeit optional, component. Serial port **230** enables a user to set preferences through an external device or software application and extends the capabilities of mobile station **202** by providing for information or software downloads to mobile station **202** other than through a wireless communication network. The alternate download path may, for example, be used to load an encryption key onto mobile station **202** through a direct and thus reliable and trusted connection to thereby provide secure device communication. Short-range communications subsystem **240** of FIG. **2** is an additional optional component which provides for communication between mobile station **202** and different systems or devices, which need not necessarily be similar devices.

[**0035**] FIG. **3** shows a particular system structure for communicating with a mobile station. In particular, FIG. **3** shows basic components of an IP-based wireless data network which may be utilized. A mobile station **100** communicates with a wireless packet data network **145**, and may also be capable of communicating with a wireless voice network (not shown). As shown in FIG. **3**, a gateway **140** may be coupled to an internal or external address resolution component **335** and one or more network entry points **305**. Data packets are transmitted from gateway **140**, which is source of information to be transmitted to mobile station **100**, through network **145** by setting up a wireless network tunnel **325** from gateway **140** to mobile station **100**. In order to create this wireless tunnel **325**, a unique network address is associated with mobile station **100**. In an IP-based wireless network, however, network addresses are typically not permanently assigned to a particular mobile station **100** but instead are dynamically allocated on an as-needed basis. It is thus preferable for mobile station **100** to acquire a network address and for gateway **140** to determine this address so as to establish wireless tunnel **325**.

[**0036**] Network entry point **305** is generally used to multiplex and demultiplex amongst many gateways, corporate servers, and bulk connections such as the Internet, for example. There are normally very few of these network entry points **305**, since they are also intended to centralize externally available wireless network services. Network entry points **305** often use some form of an address resolution component **335** that assists in address assignment and lookup between gateways and mobile stations. In this example, address resolution component **335**, is shown as a dynamic host configuration protocol (DHCP) as one method for providing an address resolution mechanism.

[**0037**] A central internal component of wireless data network **345** is a network router **315**. Normally, network routers

315 are proprietary to the particular network, but they could alternatively be constructed from standard commercially available hardware. The purpose of network routers **315** is to centralize thousands of fixed transceiver stations **320** normally implemented in a relatively large network into a central location for a long-haul connection back to network entry point **305**. In some networks there may be multiple tiers of network routers **315** and cases where there are master and slave network routers **315**, but in all such cases the functions are similar. Often network router **315** will access a name server **307**, in this case shown as a dynamic name server (DNS) **307** as used in the Internet, to look up destinations for routing data messages. Fixed transceiver stations **320**, as described above, provide wireless links to mobile stations such as mobile station **100**.

[0038] Wireless network tunnels such as a wireless tunnel **325** are opened across wireless network **345** in order to allocate necessary memory, routing, and address resources to deliver IP packets. Such tunnels **325** are established as part of what are referred to as Packet Data Protocol or "PDP contexts" (i.e. data sessions). To open wireless tunnel **325**, mobile station **100** must use a specific technique associated with wireless network **345**. The step of opening such a wireless tunnel **325** may require mobile station **100** to indicate the domain, or network entry point **305** with which it wishes to open wireless tunnel **325**. In this example, the tunnel first reaches network router **315** which uses name server **307** to determine which network entry point **305** matches the domain provided. Multiple wireless tunnels can be opened from one mobile station **100** for redundancy, or to access different gateways and services on the network. Once the domain name is found, the tunnel is then extended to network entry point **305** and necessary resources are allocated at each of the nodes along the way. Network entry point **305** then uses the address resolution (or DHCP **335**) component to allocate an IP address for mobile station **100**. When an IP address has been allocated to mobile station **100** and communicated to gateway **140**, information can then be forwarded from gateway **140** to mobile station **100**.

[0039] FIG. **4** is a flowchart which describes a general method of operation for the mobile station for network selection. The mobile station is powered-on at a start block **402** of FIG. **4**. After power-on, the processor of the mobile station causes initialization procedures to be performed (step **404** of FIG. **4**). After initialization procedures are completed, the processor causes a scanning procedure to be performed to identify one or more optimal radio frequency (RF) signals within a coverage area of the mobile station (step **406** of FIG. **4**). Also in step **406**, system control information is decoded on control channels associated with these optimal RF signals and saved in memory. Optimal RF signals are generally those RF signals which have been identified by the mobile station to have the best RF signal strengths for communication. Each optimal RF signal is associated with one of a plurality of wireless communication networks within which the mobile station may be able to operate. Each of these wireless networks is identifiable by network identification information, which is part of the system control information broadcasted by the wireless network on its control channel.

[0040] After the optimal RF signals are identified and the system control information is decoded by the mobile station, the processor selects one of the wireless networks associated with an optimal RF signal for communication based on predetermined network selection criteria (step **408** of FIG. **4**). The predetermined network selection criteria may general indicate, for example, that the "home" communication network be selected or, if the home network is unavailable, a preferred communication network be selected (e.g. where the preferred networks are indicated in a prestored network list (e.g. in SIM) or based on predetermined available services offered for the mobile station). The mobile station then registers and obtains service through this selected wireless network, and communications through the wireless network may then proceed (step **410** of FIG. **4**). Note that the mobile station may reperform the procedure beginning again at step **406** in response to particular conditions, such as an out-of-coverage condition where RF coverage between the mobile station and the wireless network is lost (step **412** of FIG. **4**).

[0041] FIG. **5** is a flowchart which describes a scanning and decoding method for the mobile station for use in the present application, which is closely associated with the technique utilized in step **406** of FIG. **4**. The mobile station which performs this method includes at least an RF transceiver, an antenna means coupled to the RF transceiver, and one or more processors coupled to the RF transceiver which executes the steps of the method. A computer program product of the present application includes a storage medium (e.g. memory) and computer program instructions stored in the storage medium which are executable by the one or more processors of the mobile station to perform the steps of the method.

[0042] Beginning at a start block **502** of FIG. **5**, the mobile station initiates a scanning procedure for scanning a plurality of RF channels of at least one RF band associated with the system. A plurality of signal strength levels for a plurality of RF channels of the RF band are measured and identified (step **504** of FIG. **5**). In step **504**, a cumulative average signal strength level for each of these RF channels is also calculated using an averaging function and these values stored in memory in a list. The processor then identifies and selects the RF channel having the current strongest cumulative average signal strength (step **506** of FIG. **5**). If there are available software "contexts" for use (step **508** of FIG. **5**), then the processor causes a context to be assigned and activated for the RF channel that is associated with the current strongest cumulative average signal strength (step **510** of FIG. **5**). Each new context operates independently and asynchronously with respect to the steps of the flowchart of FIG. **5**. The operation of a context is described later in relation to FIG. **6**. In general, such a context is used for decoding control information over the RF channel. General processing associated with a context for decoding will be described later below in relation to FIG. **6**.

[0043] After a context is assigned in step **510**, steps **506**, **508**, and **510** are repeated such that the next RF channel having the (next) current strongest cumulative average signal strength is selected and assigned to an available context. These steps **506**, **508**, and **510** are repeated until all of the available contexts are utilized as identified in step **508**. When there are no more available contexts as identified in step **508**, the processor identifies whether the RF channel associated with the (next) strongest cumulative average signal strength and having no assigned context is stronger than any RF channels having an assigned context (step **512**

of FIG. **5**). If true, then the assigned context associated with the weakest RF channel is reassigned to this RF channel associated with this strongest cumulative average signal strength identified in step **512** (step **514** of FIG. **5**). The context is discarded irrespective of its state in the flowchart of FIG. **6**.

[**0044**] If any context is reassigned in step **514**, steps **512** and **514** are repeated so that any assigned contexts may be reassigned to any RF channels having stronger cumulative average signal strengths. As apparent from the steps above, a plurality of contexts will be assigned and initiated for decoding a plurality of different RF channels of the RF band substantially at the same time.

[**0045**] It is required that a plurality of signal strength measurements be taken over a time period in order to complete the calculation of a final averaged signal strength level for the RF signal over the time period. Therefore, the processor identifies whether the number of signal strength measurements taken in step **504** are equal to a predetermined number (step **516** of FIG. **5**). For this purpose, the processor may increment/decrement a scanning loop counter each time the scanning loop or operation is performed. If additional measurements are needed as identified in step **516**, the processor causes a delay to occur for the time period (step **520** of FIG. **5**) before repeating the operation or loop for taking additional measurements beginning again at step **504**. Otherwise, if all of the required number of signal strength measurements have been taken as identified in step **516**, processing continues to step **518** of FIG. **5**.

[**0046**] In GSM/GPRS, the predetermined number of times that the scanning operation or loop is performed is five (5) (i.e. there are 5 signal strength measurements taken). Each scanning operation takes about one (1) second for a total time period of about five (5) seconds for the entire scanning procedure to be completed (i.e. so as to reach step **518**). When step **518** of FIG. **5** is reached, the averaging function on all of the signal strength measurements for each RF channel is completed so that the final averaged signal strength level for each RF channel is known.

[**0047**] In step **518**, the processor waits for decoding of any context to be completed (step **518** of FIG. **5**). When there are additional RF channels having active contexts to test as identified in step **522** of FIG. **5**, the process identifies the RF channel associated with the strongest final averaged signal strength level and assigns it as the optimal RF channel (step **524** of FIG. **5**). Steps **518**, **522**, and **524** are then repeated until all contexts are completed, when the RF channel associated with the strongest RF channel is identified and assigned. When there are no additional RF channels having active contexts to test, the flowchart ends as shown.

[**0048**] FIG. **6** is a flowchart which describes the general functionality associated with each context assigned for an RF channel which may be activated in the flowchart of FIG. **5**. In the flowchart, each context operates independently from other contexts and independently from the steps of the flowchart of FIG. **5** except through steps **510**-**514**.

[**0049**] Beginning at a start block **602** of FIG. **6** where a context is assigned and activated, the processor attempts to decode and process signals on a frequency correction channel (FCCH) and a synchronization channel (SCH) (step **604** of FIG. **6**) associated with the RF channel. This is done generally in order to correctly synchronize in frequency and in time with the system. If decoding and processing on the FCCH and SCH is successful as identified in step **606** of FIG. **6**, the processor decodes and processes signals on a broadcast control channel (BCCH) associated with the RF channel in order to obtain system control information (step **608** of FIG. **6**). The control information includes network identification information such as Mobile Country Code (MCC) and Mobile Network Code (MNC) pairs which uniquely identify each wireless network. After being decoded, the control information is stored in memory of the mobile station in association with an identification of the RF channel. The decoding and saving steps are preferably performed with use of DSP **220**, microprocessor **238**, and Flash memory **224** of FIG. **2**.

[**0050**] Note that the decoding of the control information in step **520** occurs prior to any completion of the final averaged signal strength levels of the RF channels. When the decoding is completed in step **608**, or decoding of the FCCH and SCH is unsuccessful in step **606**, the context processing is completed (step **610** of FIG. **6**). The context is then deassigned, which makes it available for reassignment for subsequent use.

[**0051**] Thus, prior to identifying the optimal RF channel based on the final averaged signal strengths, the control information from the wireless networks is already stored in memory from the previous steps of decoding and saving/storing (i.e. step **608** of FIG. **6**). Using and reading this control information stored in the memory (e.g. the network identification information such as MCCs and MNCs), the processor selects one of the wireless communication networks associated with the adequate RF signals based on a predetermined network selection criteria or technique as described earlier in relation to step **408** of FIG. **4**. The mobile station then registers and obtains service through this selected wireless network, and communications through the selected wireless network may then proceed as previously described.

[**0052**] As indicated earlier above, the network selection technique of step **408** of FIG. **4** may be based on any suitable technique, such as those conventional or traditional techniques outlined in well-known communication standard documents (e.g. GSM/GPRS standard documents). Using such techniques, the mobile station typically selects a wireless communication network which is identified as its "home" communication network (e.g. HPLMN) if it is available. If the home communication network is unavailable, then the mobile station may select a wireless communication network based on network identification information in a preferred/prioritized network list (e.g. Preferred PLMN list) stored in memory. The preferred network list may be stored in a memory card such as a Subscriber Identity Module (SIM) of the mobile station. If this type of list is utilized, the mobile station typically operates to select the "best" available network as prioritized in the preferred network list. Alternatively, or additionally, the mobile station may have a network selection technique that is based on other criteria, such as the availability of particular communication services (e.g. data services) offered by the wireless network.

[**0053**] As apparent, it is not necessary for the mobile station to decode the control information for each optimal

RF signal just after completion of the final averaged signal strength level. The control information for each RF signal having an optimal RF signal strength has already been decoded and stored in memory by at least one of the multiple running contexts (see FIG. **6**) which were assigned in steps **510** and **514** of FIG. **5** for each scanning loop. Since the control information is already saved/stored in memory, the processor of the mobile station may refrain from causing any control information to be subsequently decoded again over the RF channel in response to optimal RF signals being identified based on the final averaged signal strengths. Network selection of step **408** and communications in step **410** may then be achieved more expeditiously. As an option, the mobile station may decode at least some of control information for optimal RF signals as a follow-up to confirm the adequacy or freshness of the control information.

[**0054**] Note further that the technique allows the mobile station to cause control information to be decoded for more than one wireless network during each scanning loop operation. That is, control information may be obtained from two of more wireless communication networks during each scanning loop operation if their cumulative average signal strength levels (identified in step **504** of FIG. **5**) are deemed sufficient during the scanning loop time period. Note even further that control information need not be decoded again for RF channels over which control information has already been obtained from a previous scanning loop operation. In fact, it may be preferred that the processor refrains from assigning a context and decoding control information over an RF channel if the control information has already been previously decoded and stored in memory from a previous scanning operation/loop. Also note that the signal strength levels of the RF signals may vary over each of the plurality of scanning loop operations, such that different RF channels may be deemed to be stronger or weaker during different points in time during the time period of the entire scanning procedure. Since different RF signals/RF channels may be deemed to be stronger or weaker over the entire scanning procedure, different sets of control information associated with the different RF signals/RF channels may be obtained. In this case, all control information associated with all RF signals/RF channels may be kept stored in memory at least until the entire scanning procedure is completed, even if any one of the RF signals/RF channels fails to meet the optimal signal strength level criteria for any single scanning loop operation.

[**0055**] Thus, scanning and decoding methods and apparatus for mobile communication devices have been described. In one illustrative method, a signal strength level of an RF signal on an RF channel is measured for a plurality of RF channels of an RF band. The act of measuring a signal strength level is repeated at least one time to obtain at least one other signal strength level of the RF signal. Subsequently, an averaging function is completed with use of the signal strength level and the at least one other signal strength level for identifying an averaged signal strength level of the RF signal. At least one optimal RF signal is then identified based on the averaged signal strength levels of the RF signals on the RF channels. In between the repeated acts of measuring signal strength levels of the RF signals, and prior to identifying the averaged signal strength levels, control information is decoded on at least one of the RF channels and stored in memory. A wireless communication network is selected for communication with use of the control information stored in the memory which corresponds to one of the at least one optimal RF signal. In this manner, the mobile station expeditiously obtains the control information for network selection or other purposes prior to completing the averaging of the signal strength levels. A computer program product of the present application includes a storage medium and computer program instructions stored in the storage medium which are executable by one or more processors for performing the method described above.

[**0056**] A mobile communication device of the present application includes a radio frequency (RF) transceiver, an antenna means coupled to the RF transceiver, and one or more processors coupled to the RF transceiver. The one or more processors are adapted to, for at least some of a plurality of RF channels of an RF band: identify a signal strength level of an RF signal of a wireless communication network on an RF channel; repeat the act of identifying at least one time so that at least one other signal strength level of the RF signal is identified; complete an averaging function with the signal strength level and the at least one other signal strength level for identifying an averaged signal strength level for the RF signal on the RF channel; and in between at least some of the acts of identifying signal strength levels of the RF signal, decode control information on at least one of the RF channels of the RF band and storing the control information in memory.

[**0057**] The above-described embodiments of the present application are intended to be examples only. For example, although the present application describes a technique applicable to a GSM/GPRS network, the technique is also applicable to other networks such as a CDMA or other suitable network. Those of skill in the art may effect alterations, modifications and variations to the particular embodiments without departing from the scope of the application. The invention described herein in the recited claims intends to cover and embrace all suitable changes in technology.

What is claimed is:

1. A method for use in scanning a radio frequency (RF) band having a plurality of RF channels in a scanning procedure, the method comprising the acts of:

for at least some of the plurality of RF channels of the RF band:

measuring a signal strength level of an RF signal of a wireless communication network on an RF channel;

repeating the act of measuring at least one time so that at least one other signal strength level of the RF signal is identified;

completing an averaging function with the signal strength level and the at least one other signal strength level for identifying an averaged signal strength level for the RF signal on the RF channel; and

in between at least some of the acts of measuring signal strength levels of the RF signal, decoding control information on at least one of the RF channels of the RF band and storing the control information in memory.

2. The method of claim 1, further comprising:

identifying at least one optimal RF signal based on the averaged signal strength levels of the RF signals on the at least some RF channels; and

selecting a wireless communication network for communication with use of the control information stored in the memory which corresponds to one of the at least one optimal RF signal.

3. The method of claim 1, further comprising:

after identifying the averaged signal strength level for the RF signal on the RF channel, reading the control information associated with the RF channel from memory for use in selecting a wireless communication network for communication.

4. The method of claim 1, further comprising:

identifying at least one optimal RF signal based on the signal strength level of the RF signal on the RF channel; and

wherein the act of decoding comprises the further act of decoding the control information in response to identifying that the RF signal comprises one of the at least one optimal RF signal.

5. The method of claim 1, wherein the act of decoding comprises decoding control information on two or more of the RF channels of the RF band simultaneously and storing the control information in memory.

6. The method of claim 1, further comprising:

wherein in a first repetition of signal strength measurements taken for the RF channels of the RF band, the method further comprises:

identifying a first signal strength level of a first RF signal on a first RF channel;

identifying that the first RF signal is an optimal RF signal based at least on the first signal strength level;

decoding first control information on the first RF channel and storing the first control information in memory based on identifying that the first RF signal is an optimal RF signal;

wherein in a subsequent repetition of signal strength measurements taken for the RF channels of the RF band, the method further comprises:

identifying a second signal strength level of a second RF signal on a second RF channel which is different from the first RF channel;

identifying that the second RF signal is an optimal RF signal based at least on the second signal strength level; and

decoding second control information on the second RF channel and storing the second control information in memory based on identifying that the second RF signal is an optimal RF signal.

7. The method of claim 1, wherein the control information comprises a network identification associated with the wireless communication network.

8. The method of claim 1, wherein the method is performed by a mobile station, the wireless communication network comprises a Global Systems for Mobile communications (GSM) network, and the act of identifying is performed five times for each RF signal on each RF channel over a time period of about five seconds.

9. A communication device, comprising;

a radio frequency (RF) transceiver;

an antenna means coupled to the RF transceiver;

one or more processors coupled to the RF transceiver;

the one or more processors being adapted to, for at least some of a plurality of RF channels of an RF band:

measuring a signal strength level of an RF signal of a wireless communication network on an RF channel;

repeat the act of measuring at least one time so that at least one other signal strength level of the RF signal is identified;

complete an averaging function with the signal strength level and the at least one other signal strength level for identifying an averaged signal strength level for the RF signal on the RF channel; and

in between at least some of the acts of measuring signal strength levels of the RF signal, decode control information on at least one of the RF channels of the RF band and storing the control information in memory.

10. The communication device of claim 9, wherein the one or more processors are further adapted to:

identify at least one optimal RF signal based on the averaged signal strength levels of the RF signals on the at least some RF channels; and

select a wireless communication network for communication with use of the control information stored in the memory which corresponds to one of the at least one optimal RF signal.

11. The communication device of claim 9, wherein the one or more processors are further adapted to:

after identifying the averaged signal strength level for the RF signal on the RF channel, read the control information associated with the RF channel from the memory for use in selecting a wireless communication network for communication.

12. The communication device of claim 9, wherein the one or more processors are further adapted to identify at least one optimal RF signal based on the signal strength level of the RF signal on the RF channel, and wherein the one or more processors are further adapted to decode the control information by decoding the control information in response to identifying that the RF signal comprises one of the at least one optimal RF signal.

13. The communication device of claim 9, wherein the one or more processors are further operative to decode the control information by decoding control information on two or more of the RF channels of the RF band simultaneously and storing the control information in memory.

14. The communication device of claim 9, wherein the one or more processors are further adapted to decode by assigning two or more contexts for decoding control information on two or more of the RF channels of the RF band simultaneously.

15. The communication device of claim 9, further comprising:

wherein the one or more processors are further adapted to, in a first repetition of signal strength measurements taken for the RF channels of the RF band:

identify a first signal strength level of a first RF signal on a first RF channel;

identify that the first RF signal is an optimal RF signal based at least on the first signal strength level;

decode first control information on the first RF channel and storing the first control information in memory based on identifying that the first RF signal is an optimal RF signal;

wherein the one or more processors are further adapted to, in a subsequent repetition of signal strength measurements taken for the RF channels of the RF band:

identify a second signal strength level of a second RF signal on a second RF channel which is different from the first RF channel;

identify that the second RF signal is an optimal RF signal based at least on the second signal strength level; and

decode second control information on the second RF channel and storing the second control information in memory based on identifying that the second RF signal is an optimal RF signal.

16. A computer program product, comprising:

a storage medium;

computer program instructions stored in the storage medium;

the computer program instructions being executable by one or more processors for scanning a radio frequency (RF) band having a plurality of RF channels by:

for at least some of the plurality of RF channels of the RF band:

identifying a signal strength level of an RF signal of a wireless communication network on an RF channel;

repeating the act of identifying at least one time so that at least one other signal strength level of the RF signal is identified;

completing an averaging function with the signal strength level and the at least one other signal strength level for identifying an averaged signal strength level for the RF signal on the RF channel; and

in between at least some of the acts of identifying signal strength levels of the RF signal: decoding control information on at least one of the RF channels of the RF band and storing the control information in memory.

17. The computer program product of claim 16, wherein the computer program instructions are further executable for:

identifying at least one optimal RF signal based on the averaged signal strength levels of the RF signals on the at least some RF channels; and

selecting a wireless communication network for communication with use of the control information stored in the memory which corresponds to one of the at least one optimal RF signal.

18. The computer program product of claim 16, wherein the computer program instructions are further executable for:

after identifying the averaged signal strength level for the RF signal on the RF channel, reading the control information associated with the RF channel from the memory for selecting a wireless communication network for communication.

19. The computer program product of claim 16, wherein the computer program instructions are further executable for:

identifying at least one optimal RF signal based on the signal strength level of the RF signal on the RF channel; and

decoding the control information in response to identifying that the RF signal comprises one of the at least one optimal RF signal.

20. The computer program product of claim 16, wherein the computer program instructions are further executable for decoding by decoding control information on two or more of the RF channels of the RF band simultaneously and storing the control information in memory.

21. The computer program product of claim 16, further comprising:

wherein the computer instructions are further executable for, in a first repetition of signal strength measurements taken for the RF channels of the RF band:

identifying a first signal strength level of a first RF signal on a first RF channel;

identifying that the first RF signal is an optimal RF signal based at least on the first signal strength level;

decoding first control information on the first RF channel and storing the first control information in memory based on identifying that the first RF signal is an optimal RF signal;

wherein the computer instructions are further executable for, in a subsequent repetition of signal strength measurements taken for the RF channels of the RF band:

identifying a second signal strength level of a second RF signal on a second RF channel which is different from the first RF channel;

identifying that the second RF signal is an optimal RF signal based at least on the second signal strength level; and

decoding second control information on the second RF channel and storing the second control information in memory based on identifying that the second RF signal is an optimal RF signal.

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