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- (54) Title: METHOD AND APPARATUS FOR FACILITATING COMMUNICATIONS IN AN UNLICENSED FREQUENCY BAND

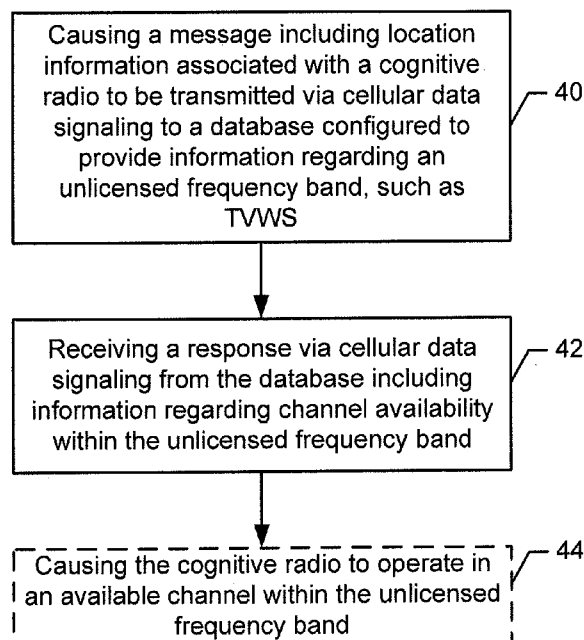


Figure 3

(57) Abstract: A method, apparatus and computer program product are provided for facilitating communications between a cognitive radio and a database that includes information regarding channel availability within an unlicensed frequency band, such as TVWS. In this regard, a message including location information associated with a cognitive radio may be caused to be transmitted to the database. A response may then be received from the database including information regarding channel availability within the unlicensed frequency band. At least one of either causing the message to be transmitted or receiving the response may employ cellular data signaling, such as a Short Message Service (SMS), Dual Tone Multifrequency (DTMF) or Circuit Switched (CS) data signaling. The cognitive radio may then be caused to operate in an available channel within the unlicensed frequency band based upon the response from the database.

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METHOD AND APPARATUS FOR FACILITATING COMMUNICATIONS IN AN UNLICENSED FREQUENCY BAND

TECHNOLOGICAL FIELD

Embodiments of the present invention relate generally to communications technology and, more particularly, to facilitating communications in an unlicensed
5 frequency band.

BACKGROUND

Regulations have been enacted or are being considered in various countries to permit a cognitive radio to operate in certain frequency bands on an unlicensed basis. In a frequency band that is licensed for use by a primary user who can operate within the
10 frequency band at will, a secondary user may be able to operate within specific sections of the same frequency band on an unlicensed basis when the primary user is not operating within those same specific sections of the frequency band. For example, in the United States, the Federal Communications Commission (FCC) has passed such regulations, while the European Conference of Postal and Telecommunications
15 Administrations (CEPT) and the Electronics Communications Committee (ECC) are developing such regulations in Europe.

The initial frequency band for which such unlicensed use is permitted is the ultra-high frequency (UHF) television (TV) band. In the UHF TV band, vacant channels that are not being utilized for television broadcasts are called TV white space (TVWS). The
20 regulations that have been enacted and are being developed that would allow a cognitive radio to utilize TVWS generally require the cognitive radio to obtain information regarding the TVWS from a database associated with the TVWS before the cognitive radio can transmit data via a vacant channel within the TVWS. In this regard, the cognitive radio may obtain information from the database regarding vacant channels within the TVWS so
25 as to protect those channels that are being utilized for television broadcasts or by other primary users, such as a wireless microphone, from interference with data transmitted by cognitive radio by limiting the cognitive radio to transmission on the channels that are vacant within the TVWS.

In one implementation, a cognitive radio provides information, such as one or more of the location of the cognitive radio, the radio transmission power, the device class, etc., to the database. Based upon the information provided by the cognitive radio, the database may evaluate its internal records and provide to the cognitive radio a list of vacant channels, if any, in which the cognitive radio can transmit. The cognitive radio can then commence transmission on a vacant channel within the TVWS.

A cognitive radio cannot utilize broadband wireless access (BWA) over TVWS to initially communicate with the database because the transmitter of the cognitive radio cannot be activated prior to receiving the list of vacant television channels from the database. As such, the device, such as a fixed terminal or a mobile terminal, that includes the cognitive radio may utilize an internet connection that is provided by the device, such as internet connections supported by General Packet Radio Service (GPRS) or a wired Ethernet connection to communicate with the database to learn of the vacant channels within the TVWS at a specific location. In order to provide for security in the communications exchange between the cognitive radio and the database, a Hypertext Transfer Protocol Secure (HTTPS) protocol may be used over GPRS or Ethernet.

While the internet connection that is used to communicate between the cognitive radio and the database associated with the TVWS may be supported by GPRS, the device that includes the cognitive radio is required to have a GPRS subscription prior to utilizing the cognitive radio for transmission via a vacant channel within the TVWS. While effective, the requirement that the device have a GPRS subscription undesirably increases the expense associated with the utilization by the cognitive radio of vacant channels within the TVWS on an unlicensed basis.

BRIEF SUMMARY

A method, apparatus and computer program product are herein provided for facilitating communications between a cognitive radio and a database that includes information regarding channel availability in an unlicensed frequency band, such as within a TVWS. In one embodiment, the method, apparatus and computer program product permit such communication to be conducted without requiring an internet connection supported by GPRS or a wired Ethernet connection. As such, the method, apparatus and computer program product may facilitate such communications between a cognitive radio and a database that includes information regarding channel availability in an unlicensed frequency band, such as within a TVWS, in a more cost effective manner, thereby correspondingly facilitating subsequent use of a vacant channel, e.g., within the TVWS, by the cognitive radio on an unlicensed or secondary basis.

In one example embodiment, a method is provided that includes causing a message including location information associated with a cognitive radio to be transmitted to a database configured to provide information regarding an unlicensed frequency band, such as TVWS. The method of this embodiment may also receive a response from the database including information regarding channel availability within the unlicensed frequency band. At least one of either causing the message to be transmitted or receiving the response may employ cellular data signaling, such as a Short Message Service (SMS), Dual Tone Multifrequency (DTMF) or Circuit Switched (CS) data signaling. The method of one example embodiment may also cause the cognitive radio to operate in an available channel within the unlicensed frequency band, such as the TVWS, based upon the response from the database.

In one embodiment in which the cellular data signaling is SMS messaging, the method may also generate the message that is thereafter transmitted via SMS and that then evokes an SMS response. In this embodiment, the message may include a payload having location information and an encrypted digest of the payload. In a further embodiment, the generation of the message may include encrypting the payload prior to creating the encrypted digest of the payload.

The method of another embodiment in which the cellular data signaling is DTMF signaling may also include generating the message that is thereafter transmitted utilizing DTMF signaling and that then evokes a response that also utilizes DTMF signaling. In this embodiment, the message may be generated by converting the binary data stream including the location information into a stream of octal, decimal or hexadecimal numbers. In a further embodiment, the generation of the message may also include the generation of a message that includes a payload having the location information and an encrypted digest of the payload. Additionally, the generation of the message may include encryption of the payload prior to creating the encrypted digest of the payload.

In another example embodiment, an apparatus is provided that includes at least one processor and at least one memory including computer program code with the at least one memory and the computer program code configured to, with the at least one processor, causing the apparatus at least to cause a message including location information associated with a cognitive radio to be transmitted to a database configured to provide information regarding an unlicensed frequency band, such as TVWS. The apparatus of this embodiment may also be caused to receive a response from the database including information regarding channel availability within the unlicensed frequency band. The apparatus may also be caused to employ cellular data signaling, such as SMS, DTMF or CS data signaling in order to cause the message to be transmitted or to receive the response. In one embodiment, the least one memory and

the computer program code may be further configured to, with the at least one processor, cause the apparatus to cause the cognitive radio to operate in an available channel within the unlicensed frequency band, such as the TVWS, based upon the response from the database.

5 In one embodiment in which the cellular data signaling is SMS messaging, the at least one memory and the computer program code may be further configured to, with the at least one processor, cause the apparatus to generate the message that is then caused to be transmitted via SMS and that evokes an SMS response. In this embodiment, the message may include a payload including the location information and an encrypted
10 digest of the payload. The at least one memory and the computer program code of this embodiment may be further configured to, with the at least one processor, cause the apparatus to generate the message by encrypting the payload prior to creating the encrypted digest of the payload.

 The at least one memory and the computer program code may be further
15 configured in another embodiment in which the cellular data signaling is DTMF signaling to, with the at least processor, cause the apparatus to generate the message and to then cause the message to be transmitted utilizing DTMF signaling with the resulting response also being received via DTMF signaling. In this embodiment, the apparatus may be configured to generate the message by converting a binary data stream including the
20 location information to a stream of octal, decimal or hexadecimal numbers. The message may include a payload including the location information and an encrypted digest of the payload. In this embodiment, the at least one memory and the computer program code may be further configured to, with the at least one processor, cause the apparatus to generate the message by encrypting the payload prior to creating the encrypted digest of
25 the payload.

 In a further example embodiment, a computer program product is provided that includes at least one computer-readable storage medium bearing computer program code embodied therein for use with a computer. The computer program code includes code for causing a message including location information associated with a cognitive
30 radio to be transmitted to a database configured to provide information regarding an unlicensed frequency band, such as TVWS. The computer program code may also include code for receiving a response from the database including information regarding channel availability within the unlicensed frequency band. Cellular data signaling, such as Short Message Service (SMS), Dual Tone Multifrequency (DTMF) signaling or CS
35 data signaling, may be employed for causing the message to be transmitted and/or for receiving the response. The computer program code of one example embodiment may also include code for causing the cognitive radio to operate in an available channel within

the unlicensed frequency band, such as the TVWS, based upon the response from the database.

In one embodiment in which the cellular data signaling is SMS messaging, the computer program code may also include code for generating the message that is thereafter transmitted via SMS and that then evokes an SMS response. In this embodiment, the message may include a payload having location information and an encrypted digest of the payload. In a further embodiment, the code for generating the message may include code for encrypting the payload prior to creating the encrypted digest of the payload.

The computer program code of another embodiment in which the cellular data signaling is DTMF signaling may also include code for generating the message that is thereafter transmitted utilizing DTMF signaling and that then evokes a response that also utilizes DTMF signaling. In this embodiment, the code may generate the message by converting the binary data stream including the location information into a stream of octal, decimal or hexadecimal numbers. In a further embodiment, the code for generating the message may also include code for generating a message that includes a payload having the location information and an encrypted digest of the payload. Additionally, the code for generating the message may include code for encrypting the payload prior to creating the encrypted digest of the payload.

In yet another example embodiment, an apparatus is provided that includes means for causing a message including location information associated with a cognitive radio to be transmitted to a database configured to provide information regarding an unlicensed frequency band, such as TVWS. The apparatus of this embodiment may also include means for receiving a response from the database including information regarding channel availability within the unlicensed frequency band. At least one of either the means for causing the message to be transmitted or the means for receiving the response may employ cellular data signaling, such as a Short Message Service (SMS), Dual Tone Multifrequency (DTMF) signaling or CS data signaling. The apparatus of one example embodiment may also include means for causing the cognitive radio to operate in an available channel within the unlicensed frequency band, such as in the TVWS, based upon the response from the database.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described embodiments of the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a schematic representation of a system according to an example embodiment of the present invention;

Figure 2 is a block diagram of an apparatus that may comprise or be embodied in a mobile terminal according to an example embodiment of the present invention;

5 Figure 3 is a block diagram of operations performed in accordance with an example embodiment of the present invention;

Figure 4 is a block diagram of operations performed in accordance with an example embodiment of the present invention that employs SMS; and

10 Figure 5 is a block diagram of operations performed in accordance with an example embodiment of the present invention that employs DTMF signaling.

DETAILED DESCRIPTION

Some embodiments of the present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, various embodiments of the invention
15 may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like reference numerals refer to like elements throughout. As used herein, the terms “data,” “content,” “information” and similar terms may be used interchangeably to refer to data capable of being transmitted,
20 received and/or stored in accordance with embodiments of the present invention. Thus, use of any such terms should not be taken to limit the spirit and scope of embodiments of the present invention.

Additionally, as used herein, the term ‘circuitry’ refers to (a) hardware-only circuit implementations (e.g., implementations in analog circuitry and/or digital circuitry); (b)
25 combinations of circuits and computer program product(s) comprising software and/or firmware instructions stored on one or more computer readable memories that work together to cause an apparatus to perform one or more functions described herein; and (c) circuits, such as, for example, a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation even if the software or firmware is not
30 physically present. This definition of ‘circuitry’ applies to all uses of this term herein, including in any claims. As a further example, as used herein, the term ‘circuitry’ also includes an implementation comprising one or more processors and/or portion(s) thereof and accompanying software and/or firmware. As another example, the term ‘circuitry’ as used herein also includes, for example, a baseband integrated circuit or applications
35 processor integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, other network device, and/or other computing device.

As defined herein a “computer-readable storage medium,” which refers to a non-transitory, physical storage medium (e.g., volatile or non-volatile memory device), can be differentiated from a “computer-readable transmission medium,” which refers to an electromagnetic signal.

5 In accordance with an example embodiment of the present invention, a method, apparatus and computer program product are provided to permit a cognitive radio of a device, such as a mobile terminal, to have the initial communications that are required to subsequently operate in an unlicensed frequency band without requiring Internet connectivity for the initial communications. In this regard, a licensed frequency band is a
10 band of frequencies licensed for use by a primary user who can operate within the frequency band at will. Within specific sections of the same frequency band, a secondary user may be able to operate on an unlicensed basis when the primary user is not operating within those specific sections of the frequency band. As such, the frequency band is a licensed frequency band for the primary user and an unlicensed frequency band
15 for the secondary user. For example, the unlicensed frequency band may be TVWS within the UHS TV band such that the cognitive radio may be configured to communicate with a database that includes information regarding channel availability within the TVWS to ensure that the cognitive radio subsequently operates in the unlicensed frequency band within a vacant channel in the TVWS. However, the method, apparatus and
20 computer program product of example embodiments of the present invention may assist secondary users in making use of other unlicensed frequency bands such that reference herein to the TVWS is by way of example and not of limitation. In order to provide for such initial communications that precede operation in an unlicensed frequency band in a manner that does not require Internet connectivity, the method, apparatus and computer
25 program product of an example embodiment may employ cellular data signaling, such as SMS, DTMF or CS data signaling, such as to communicate with the database that includes information regarding channel availability within the TVWS. Since many devices that include a cognitive radio also support cellular data signaling, the reliance upon cellular data signaling, such as SMS, DTMF or CS data signaling for the initial
30 communications that precede operation within an unlicensed frequency band should facilitate the subsequent establishment of operations within an unlicensed frequency band in a cost effective manner.

The method, apparatus and computer program product of example embodiments of the present invention may be employed in various communication systems that
35 facilitate network communication, such as cellular data signaling, e.g., SMS, DTMF or CS data signaling, between a device, such as a fixed terminal or a mobile terminal, that includes a cognitive radio and a database that includes information regarding channel

availability within the TVWS. In this regard, Figure 1 illustrates a generic diagram of a system 10 in which a device such as a mobile terminal 12, which may benefit from embodiments of the present invention, is shown in an example communication environment. As shown in Figure 1, an embodiment of a system in accordance with an example embodiment of the present invention may include a first communication device (e.g., mobile terminal 10) configured to communicate with other devices, such as other communication devices and/or a database 14 that includes information regarding channel availability within the TVWS, via a network 16.

The mobile terminal 12 may be any of multiple types of mobile communication and/or computing devices such as, for example, portable digital assistants (PDAs), pagers, mobile televisions, mobile telephones, gaming devices, laptop computers, cameras, camera phones, video recorders, audio/video players, radios, global positioning system (GPS) devices, or any combination of the aforementioned, and other types of voice and text communications devices.

The network 16 may include a collection of various different nodes, devices or functions that may be in communication with each other via corresponding wired and/or wireless interfaces. As such, the illustration of Figure 1 should be understood to be an example of a broad view of the system 10 and not an all inclusive or detailed view of the system or the network. Although not necessary, in some embodiments, the network may be capable of supporting communication in accordance with any one or more of a number of first-generation (1G), second-generation (2G), 2.5G, third-generation (3G), 3.5G, 3.9G, fourth-generation (4G) mobile communication protocols, Long Term Evolution (LTE), and/or the like.

One or more communication terminals such as the mobile terminal 10 may be in communication with the network 16 and/or with the database 14 via the network. Thus, each communication terminal may include an antenna or antennas for transmitting signals to and for receiving signals from a base site, which could be, for example a base station that is a part of one or more cellular or mobile networks or an access point that may be coupled to a data network, such as a local area network (LAN), a metropolitan area network (MAN), and/or a wide area network (WAN), such as the Internet.

Alternatively, such devices may include communication interfaces supporting landline based or wired communication with the network. In turn, other devices such as processing elements (e.g., personal computers, server computers or the like) may be coupled to the mobile terminal via the network. By directly or indirectly connecting the mobile terminal and other devices to the network, the mobile terminal may be enabled to communicate with the other devices or each other, for example, according to numerous

communication protocols including Hypertext Transfer Protocol (HTTP) and/or the like, to thereby carry out various communication or other functions of the mobile terminal.

Furthermore, although not shown in Figure 1, the mobile terminal 10 may communicate in accordance with, for example, radio frequency (RF), Bluetooth (BT), Infrared (IR) or any of a number of different wireline or wireless communication techniques, including LAN, wireless LAN (WLAN), Worldwide Interoperability for Microwave Access (WiMAX), WiFi, ultra-wide band (UWB), Wibree techniques and/or the like. As such, the mobile terminal may be enabled to communicate with the network 16 and other devices by any of numerous different access mechanisms. For example, mobile access mechanisms such as wideband code division multiple access (W-CDMA), CDMA2000, global system for mobile communications (GSM), general packet radio service (GPRS) and/or the like may be supported as well as wireless access mechanisms such as WLAN, WiMAX, and/or the like and fixed access mechanisms such as digital subscriber line (DSL), cable modems, Ethernet and/or the like.

Referring now to Figure 2, a schematic block diagram of an apparatus 20 that includes a cognitive radio 32 and that is configured to conduct initial communications with the database 14 that includes information regarding channel availability in the TVWS is illustrated in accordance with an example embodiment of the present invention. The apparatus of Figure 2 may be employed, for example, on a communication device, such as a fixed terminal or a mobile terminal 12.

As shown, the apparatus 20 may include or otherwise be in communication with a processor 22 and a memory device 24 that may collectively comprise processing circuitry 26. The apparatus may also include or otherwise be in communication with a user interface 28, a communication interface 30 and the cognitive radio 32. In some embodiments, the processor (and/or co-processors or any other processing circuitry assisting or otherwise associated with the processor) may be in communication with the memory device via a bus for passing information among components of the apparatus. The memory device may include, for example, one or more volatile and/or non-volatile memories. In other words, for example, the memory device may be an electronic storage device (e.g., a computer readable storage medium) comprising gates configured to store data (e.g., bits) that may be retrievable by a machine (e.g., a computing device like the processor). The memory device may be configured to store information, data, applications, instructions or the like for enabling the apparatus to carry out various functions in accordance with an example embodiment of the present invention. For example, the memory device could be configured to buffer input data for processing by the processor. Additionally or alternatively, the memory device could be configured to store instructions for execution by the processor. In some embodiments, the memory

device may also or alternatively store content items (e.g., media content, documents, chat content, message data, videos, music, pictures and/or the like).

The apparatus 20 may, in some embodiments, be the mobile terminal 12 or other computing device configured to employ an example embodiment of the present invention.

5 However, in some embodiments, the apparatus or at least the processing circuitry 26 may be embodied as a chip or chip set. In other words, the apparatus or at least the processing circuitry may comprise one or more physical packages (e.g., chips) including materials, components and/or wires on a structural assembly (e.g., a baseboard). The structural assembly may provide physical strength, conservation of size, and/or limitation
10 of electrical interaction for component circuitry included thereon. The apparatus or at least the processing circuitry may therefore, in some cases, be configured to implement an embodiment of the present invention on a single chip or as a single "system on a chip." As such, in some cases, a chip or chipset may constitute means for performing one or more operations for providing the functionalities described herein.

15 The processor 22 may be embodied in a number of different ways. For example, the processor may be embodied in hardware as one or more of various processing means such as a coprocessor, a microprocessor, a controller, a digital signal processor (DSP), a processing element with or without an accompanying DSP, or various other processing circuitry including integrated circuits such as, for example, an ASIC
20 (application specific integrated circuit), an FPGA (field programmable gate array), a microcontroller unit (MCU), central processing unit (CPU), a hardware accelerator, a vector processor, a graphics processing unit (GPU), a special-purpose computer chip, or the like. As such, in some embodiments, the processor may include one or more processing cores configured to perform independently. A multi-core processor may
25 enable multiprocessing within a single physical package. Additionally or alternatively, the processor may include one or more processors, such as one or more processors configured in tandem via the bus to enable independent execution of instructions, pipelining and/or multithreading.

In an example embodiment, the processor 22 may be configured to execute
30 instructions stored in the memory device 24 or otherwise accessible to the processor. Alternatively or additionally, the processor may be configured to execute hard coded functionality. As such, whether configured by hardware or software methods, or by a combination thereof, the processor may represent an entity (e.g., physically embodied in circuitry) capable of performing operations according to an embodiment of the present
35 invention while configured accordingly. Thus, for example, when the processor is embodied as an ASIC, FPGA or the like, the processor may be specifically configured hardware for conducting the operations described herein. Alternatively, as another

example, when the processor is embodied as an executor of software instructions, the instructions may specifically configure the processor to perform the algorithms and/or operations described herein when the instructions are executed. However, in some cases, the processor may be a processor of a specific device (e.g., a mobile terminal 12) adapted for employing an embodiment of the present invention by further configuration of the processor by instructions for performing the algorithms and/or operations described herein. The processor may include, among other things, a clock, an arithmetic logic unit (ALU) and logic gates configured to support operation of the processor.

The user interface 28 (if employed) may be in communication with the processor 22 to receive an indication of a user input at the user interface and/or to provide an audible, visual, mechanical or other output to the user. As such, the user interface may include, for example, a keyboard, a mouse, a joystick, a display, a touch screen, soft keys, a microphone, a speaker, or other input/output mechanisms. In an example embodiment in which the apparatus is embodied as a communication device (e.g., the mobile terminal 12), the user interface may include, among other devices or elements, any or all of a speaker, a microphone, a display, and a keyboard or the like. In this regard, for example, the processor may comprise user interface circuitry configured to control at least some functions of one or more elements of the user interface, such as, for example, a speaker, ringer, microphone, display, and/or the like. The processor and/or user interface circuitry comprising the processor may be configured to control one or more functions of one or more elements of the user interface through computer program instructions (e.g., software and/or firmware) stored on a memory accessible to the processor (e.g., memory device 24, and/or the like).

Meanwhile, the communication interface 30 may be any means such as a device or circuitry embodied in either hardware, or a combination of hardware and software, that is configured to receive and/or transmit data from/to the network 16 and/or any other device in communication with the apparatus. In this regard, the communication interface may include, for example, an antenna (or multiple antennas) and supporting hardware and/or software for enabling communications with one or more wireless communication networks. In some environments, the communication interface may alternatively or also support wired communication. As such, for example, the communication interface may include a communication modem and/or other hardware/software for supporting communication via cable, digital subscriber line (DSL), universal serial bus (USB) or other mechanisms. Regardless of the type of communication, the communication interface of one embodiment may be configured to support cellular data signaling, such as SMS messaging, DTMF signaling or CS data signaling, between the apparatus 20 and the database 14.

The cognitive radio 32 may also be any means such as a device or circuitry embodied in either hardware, or a combination of hardware and software, such as a software defined radio platform, that is configured to receive and/or transmit data from/to the network 16 and/or any other device in communication with the network in a manner that permits, for example, changes in the transmission or reception parameters to allow for efficient communication while avoiding interference with licensed or unlicensed users.

In one embodiment, the operations performed by the apparatus 20 that includes a cognitive radio 32 in order to establish operations in an unlicensed frequency band, such as within a TVWS of a UHF TV band are illustrated in Figure 3. As shown in block 40, the apparatus may include means, such as the processing circuitry 26, the processor 22, the communications interface 30 or the like, for causing a message to be transmitted to the database 14 that is configured to provide information regarding the TVWS. This message may be transmitted as a preparatory operation to subsequently establishing communications within an unlicensed frequency band. The message may include location information, such as the latitude and longitude, of the cognitive radio. The message may also include one or more other parameters associated with the cognitive radio and its operation. For example, the message may include the transmission power of the cognitive radio, the device class of the cognitive radio, information regarding the antenna(s) employed by the cognitive radio, etc.

As shown in block 42 of Figure 3, the apparatus 20 may also include means, such as the processing circuitry 26, the processor 22, the communication interface 30 or the like, for receiving a response from the database 14, including information regarding channel availability within the TVWS. This response from the database that includes information regarding channel availability within the TVWS is in response to the message that was caused to be transmitted by the apparatus and, in some embodiments, is dependent upon the location information and any other information relating to the cognitive radio 32 that is provided within the initial message. The response that is received from the database may include a variety of information and be formatted in a number of different ways. In one embodiment, however, the response from the database includes a listing of channels within the UHF TV band and an indication of the channels that are vacant and available for use by the apparatus. For example, the apparatus may be configured to receive a bit stream with each bit representing the availability or unavailability of a respective channel, and with the ordering of the bit stream being in accordance with a predefined ordering of the channels. For example, the first bit may represent the availability of channel 0, the second bit may represent the availability of channel 1, the third bit may represent the availability of channel 2, and so on. The bits may designate channel availability in various manners, but, in one embodiment, a bit may

be set to 0 if the channel is unavailable, but may be set to 1 if the channel is available. In one embodiment, the response from the database may also include additional parameters relating to at least the available channels within the TVWS. For example, the response from the database may also include channel parameters, such as optimum
5 channel parameters, for at least the available channels, including, for example, the maximum transmission power supported by a respective channel or the like.

In accordance with an example embodiment, the message may be caused to be transmitted from the apparatus 20 to the database 14 and/or the response from the database may be received by the apparatus via cellular data signaling, such as SMS,
10 DTMF or CS data signaling. In this regard, the network 16 may be configured to support SMS messaging, DTMF signaling and/or CS data signaling which, in turn, serves to interconnect the apparatus and the database prior to establishment of communications in an unlicensed frequency band. While either the transmission of the message from the apparatus to the database or the receipt of the response from the database by the
15 apparatus may be supported by cellular data signaling, the method, apparatus and computer program product of one example embodiment employs cellular data signaling, such as one of SMS, DTMF or CS data signaling, for both the transmission of the message from the apparatus to the database and the reception of the response from the database by the apparatus. Indeed, in one embodiment, SMS is employed for both
20 transmitting the message from the apparatus to the database and receiving the response from the database by the apparatus, while in another embodiment, DTMF signaling is employed for both transmitting the message from the apparatus to the database and receiving the response from the database by the apparatus. By relying upon cellular data signaling for the exchange of messages between the apparatus and the database that
25 are required to establish operation within an unlicensed frequency band, such as via a vacant channel within the TVWF, the exchange of initial messages can be accomplished without requiring Internet connectivity and by, instead, utilizing cellular data signaling, such as SMS, DTMF or CS data signaling, that is commonly supported by a device, such as a mobile terminal 12, that includes a cognitive radio 32 that is capable of operating
30 within an unlicensed frequency band.

As shown in block 44 of Figure 3, the apparatus 20 may also include means, such as the processing circuitry 26, the processor 22, the cognitive radio 32 or the like, for causing the cognitive radio to operate in an unlicensed frequency band, such as in an available channel within the TVWS based upon the response from the database 14. In
35 this regard, the apparatus, such as the processing circuitry, the processor, the cognitive radio or the like, may evaluate the information regarding channel availability within the TVWS that is provided by the database and may select an available channel for

subsequent operation within the unlicensed frequency band. In an embodiment in which the response from the database also includes one or more channel parameters, such as the maximum transmission power or the like, the apparatus, such as the processing circuitry, the processor, the cognitive radio or the like, may also select an available
5 channel based upon the channel parameters associated with the various channels such that the available channel that is selected by the apparatus can subsequently support operation over the channel in accordance with the respective channel parameters.

Although the operations performed in accordance with an example embodiment of the present invention are illustrated in Figure 3 and have been described above, the
10 operations of a method, apparatus and computer program product of another embodiment of the present invention that is configured to utilize SMS for the initial exchange of messages prior to establishing operation within the unlicensed frequency band is shown in Figure 4 and will be described hereinafter. In this embodiment, the apparatus 20 may include means, such as the processing circuitry 26, the processor 22,
15 the communication interface 30 or the like, for causing a message, including location information and, in some embodiments, other cognitive radio parameters, such as radio transmission power, device type, antenna information or the like, to be transmitted to the database 14 via SMS. See block 56 of Figure 4. In order to facilitate transmission of the message as an SMS message, the apparatus, such as the processing circuitry, the
20 processor or the like, may assemble and format the information, including the location information and any other cognitive radio parameters, as ASCII information. The apparatus of this embodiment may also include means, such as the processing circuitry, the processor, the communication interface or the like, for receiving an SMS response from the database, including information regarding channel availability within the TVWS
25 and, in some embodiments, channel parameters for at least the available channels. See block 58 of Figure 4. As a response is received in this embodiment as an SMS message, the response may also have an ASCII format. As shown in block 60 of Figure 4 and as described above in conjunction with the embodiment of Figure 3, the apparatus may also include means, such as the processing circuitry, the processor, the cognitive radio or the
30 like, for causing the cognitive radio to operate in an unlicensed frequency band, such as in an available channel within the TVWS based upon the response from the database. In this embodiment, authenticity of the initial SMS messages may be provided by the source address of the SMS message, while, in one embodiment in which the SMS messages are transmitted via a cellular system, confidentiality of the message and the response may be
35 provided by the cellular system.

In order to provide improved authenticity, the apparatus 20 of one embodiment may include means, such as the processing circuitry 26, the processor 22 or the like, for

generating the initial message that is transmitted to the database 14 so that the message has a payload including the location information associated with the cognitive radio 32 and any additional operational parameters associated with cognitive radio. See block 50 of Figure 4. The message may have any of various formats, such as an ASCII or binary format. In this embodiment, the apparatus may also include means, such as the processing circuitry, the processor or the like, for creating a digest of the payload that is then encrypted by the private key of the apparatus in accordance, for example, with the public key infrastructure (PKI) model. See block 54 of Figure 4. A digest may be created in various manners, including, for example, by the Message-Digest Algorithm 5 (MD5).

The encrypted digest may be known as a signature. The apparatus, such as the processing circuitry, the processor or the like, may then assemble the message, including the payload and the encrypted digest, such as by appending the encrypted digest to the payload. In an embodiment in which the payload and/or the encrypted digest are not in an ASCII format, such as by being, instead, in a binary format, the apparatus, such as the processing circuitry, the processor or the like, may convert the payload and/or the digital signal to ASCII format. For example, in an embodiment in which the payload and the encrypted digest are in a binary format, the payload and the encrypted digest may be converted to ASCII format by uuencode or the like. Thereafter, the apparatus, such as the processing circuitry, the processor, the communication interface 30 or the like, may cause the resulting message to be transmitted to the database as an SMS message. See block 56 of Figure 4.

In return, an SMS response may be received from the database 14. See block 58 of Figure 4. In one embodiment, the response may include a payload and an encrypted digest. In this embodiment, the apparatus 20 may include means, such as the processing circuitry 26, the processor 22 or the like, for confirming the authenticity of the response based upon the signature, e.g., the encrypted digest, provided by the database. Thereafter, the apparatus may cause the cognitive radio 32 to operate in an available channel within the TVWS based upon the response from the database. See block 60. In this embodiment, authenticity is provided by the encryption of the digest with the private key of the sender in accordance, for example, with the PKI model, while, in one embodiment in which the SMS messages are transmitted via a cellular system, confidentiality of the message and the response may continue to be provided by the cellular system.

In a further embodiment, the confidentiality of the SMS messages may be increased by encrypting the payload prior to creation of the encrypted digest. In this regard, the payload may be generated so as to include the location information and any other operational parameters associated with the cognitive radio, as described above, for

example, in conjunction with block 50 of Figure 4. The payload may be, for example, in an ASCII format. The apparatus 20 of this embodiment may also include means, such as the processing circuitry 26, processor 22 or the like, for encrypting the payload, such as by encrypting the payload with the private key of the apparatus. See block 52 of Figure 4.

5 The apparatus, such as the processing circuitry, the processor or the like, may then create a digest of the encrypted payload and then encrypt the digest with the private key of the apparatus. See block 54 of Figure 4. As described above, the apparatus, such as the processing circuitry, the processor or the like, may then combine the encrypted digest of the encrypted payload with the encrypted payload, such as by appending the
10 encrypted digest to the encrypted payload, and the resulting message may be converted to ASCII prior to being caused to be transmitted to the database, as described above in conjunction with block 56 of Figure 4. The resulting response from the database may also include an encrypted digest and may be evaluated by the apparatus, such as the processing circuitry, the processor or the like, such as in accordance with the public key
15 of the database, to confirm the authenticity of the response. The payload of the response may also be encrypted in this embodiment and, as such, the apparatus, such as the processing circuitry the processor or the like, may decrypt the payload, such as in accordance with the public key of the database, prior to evaluating the response and, if appropriate, causing the cognitive radio 32 to commence operations in an available
20 channel within the TVWS based upon the response from the database. See block 60 of Figure 4. As a result of the encryption of the payload, the confidentiality and authenticity are provided by this embodiment may be improved, such as to the limits of the PKI model.

As another example, the operations of a method, apparatus and computer
25 program product of another embodiment of the present invention that is configured to utilize DTMF signaling for the initial exchange of messages prior to establishing operation within the unlicensed frequency band is shown in Figure 5 and will be described hereinafter. In this embodiment, the apparatus 20 may include means, such as the processing circuitry 26, the processor 22, the communication interface 30 or the like, for
30 causing a message, including location information and, in some embodiments, other cognitive radio parameters, such as radio transmission power, device type, antenna information or the like, to be transmitted to the database 14 via DTMF signaling. See block 78 of Figure 5. In order to facilitate transmission of the message via DTMF signaling, the apparatus, such as the processing circuitry, the processor or the like, may
35 assemble and format the information, including the location information and any other cognitive radio parameters, as a binary data stream. The apparatus of this embodiment may also include means, such as the processing circuitry, the processor or the like, for

converting the binary data stream into, for example, octal, decimal or hexadecimal numbers. See block 76.

The apparatus 20 of this embodiment may also include means, such as the processing circuitry 26, the processor 22, the communication interface 30 or the like, for receiving an DTMF response from the database 14, including information regarding channel availability within the TVWS and, in some embodiments, channel parameters for at least the available channels. See block 80 of Figure 5. As a response is received in this embodiment via DTMF signaling, the apparatus may include means, such as the processing circuitry, the processor or the like, for converting the octal, decimal or hexadecimal numbers into a binary data stream that includes the information regarding channel availability within the TVWS. As shown in block 82 of Figure 5 and as described above in conjunction with the embodiment of Figure 3, the apparatus may also include means, such as the processing circuitry, the processor, the cognitive radio 32 or the like, for causing the cognitive radio to operate in an unlicensed frequency band, such as in an available channel within the TVWS, based upon the response from the database. In this embodiment, authenticity of the initial DTMF messages may be provided by the source address of the DTMF message, while, in one embodiment in which the DTMF messages are transmitted via a cellular system, confidentiality of the message and the response may be provided by the cellular system.

In order to provide improved authenticity, the apparatus 20 of one embodiment may include means, such as the processing circuitry 26, the processor 22 or the like, for generating the initial message that is transmitted to the database 14 so that the message has a payload including the location information associated with the cognitive radio 32 and any additional operational parameters associated with cognitive radio. See block 70 of Figure 5. The message may have any of various formats, such as an ASCII or binary format. In this embodiment, the apparatus may also include means, such as the processing circuitry, the processor or the like, for creating a digest of the payload that is then encrypted by the private key of the apparatus in accordance, for example, with the public key infrastructure (PKI) model. See block 74 of Figure 5. As noted above, the encrypted digest may be known as a signature. The apparatus, such as the processing circuitry, the processor or the like, may then assemble the message, including the payload and the encrypted digest into a binary data stream, such as by appending the encrypted digest to the payload. To facilitate DTMF signaling, the apparatus, such as the processing circuitry, the processor or the like, may convert the binary data stream into octal, decimal or hexadecimal numbers. See block 76. Thereafter, the apparatus, such as the processing circuitry, the processor, the communication interface 30 or the like, may

cause the resulting message to be transmitted to the database via DTMF signaling. See block 78 of Figure 5.

In return, a response may be received from the database 14 via DTMF signaling. See block 80 of Figure 5. As a result of the DTMF signaling, the apparatus 20, such as the processing circuitry 26, the processor 22 or the like, may convert the octal, decimal or hexadecimal numbers that comprise the response to a binary data stream that includes, for example, a payload and an encrypted digest. In this embodiment, the apparatus may include means, such as the processing circuitry, the processor or the like, for confirming the authenticity of the response based upon the signature provided by the encryption of the digest by the database. Thereafter, the apparatus may cause the cognitive radio 32 to operate in an available channel within the TVWS based upon the response from the database. See block 82. In this embodiment, authenticity is provided by the encryption of the digest with the private key of the sender in accordance, for example, with the PKI model, while, in one embodiment in which the DTMF messages are transmitted via a cellular system, confidentiality of the message and the response may continue to be provided by the cellular system.

In a further embodiment, the confidentiality of the DTMF messages may be increased by encrypting the payload prior to creation of the encrypted digest. In this regard, the payload may be generated so as to include the location information and any other operational parameters associated with the cognitive radio, as described above, for example, in conjunction with block 70 of Figure 5. The payload may be, for example, in an ASCII format. The apparatus 20 of this embodiment may also include means, such as the processing circuitry 26, processor 22 or the like, for encrypting the payload, such as by encrypting the payload with the private key of the apparatus. See block 72 of Figure 5. The apparatus, such as the processing circuitry, the processor or the like, may then create a digest of the encrypted payload and then sign the digest by encrypting the digest with the private key of the apparatus. See block 74 of Figure 5. As described above, the apparatus, such as the processing circuitry, the processor or the like, may then combine the encrypted digest of the encrypted payload with the encrypted payload, such as by appending the encrypted digest to the encrypted payload, to form a binary data stream and may then convert the binary data stream into octal, decimal or hexadecimal numbers to facilitate DTMF signaling. See block 76 of Figure 5. Thereafter, the apparatus, such as the processing circuitry, the processor, the communication interface 30 or the like, may cause the resulting message to be transmitted to the database via DTMF signaling. See block 78 of Figure 5.

In return, a response may be received from the database 14 via DTMF signaling. See block 80 of Figure 5. As a result of the DTMF signaling, the apparatus 20, such as

the processing circuitry 26, the processor 22 or the like, may convert the octal, decimal or hexadecimal numbers that comprise the response to a binary data stream that includes, for example, a payload and an encrypted digest. In this embodiment, the apparatus may include means, such as the processing circuitry, the processor or the like, for confirming the authenticity of the response based upon the signature provided by the encryption of the digest by the database. The payload of the response may also be encrypted in this embodiment and, as such, the apparatus, such as the processing circuitry the processor or the like, may decrypt the payload, such as in accordance with the public key of the database, prior to evaluating the response and, if appropriate, causing the cognitive radio 32 to commence operations in an available channel within the TVWS based upon the response from the database. See block 82 of Figure 5. As a result of the encryption of the payload, the confidentiality and authenticity are provided by this embodiment may be improved, such as to the limits of the PKI model.

Figures 3-5 are flowcharts of a method and program product according to example embodiments of the invention. It will be understood that each block of the flowcharts, and combinations of blocks in the flowcharts, may be implemented by various means, such as hardware, firmware, processor, circuitry and/or other device associated with execution of software including one or more computer program instructions. For example, one or more of the procedures described above may be embodied by computer program instructions. In this regard, the computer program instructions which embody the procedures described above may be stored by a memory device of the mobile terminal and executed by a processor in the mobile terminal. As will be appreciated, any such computer program instructions may be loaded onto a computer or other programmable apparatus (e.g., hardware) to produce a machine, such that the instructions which execute on the computer or other programmable apparatus create means for implementing the functions specified in the flowcharts block(s). These computer program instructions may also be stored in a non-transitory computer-readable storage memory that may direct a computer or other programmable apparatus to function in a particular manner, such that the instructions stored in the computer-readable storage memory produce an article of manufacture including means which implement the function specified in the flowcharts block(s). The computer program instructions may also be loaded onto a computer or other programmable apparatus to cause a series of operations to be performed on the computer or other programmable apparatus to produce a computer-implemented process such that the instructions which execute on the computer or other programmable apparatus implement the functions specified in the flowcharts block(s).

Accordingly, blocks of the flowcharts support combinations of means for performing the specified functions, combinations of operations for performing the specified functions and program instructions for performing the specified functions. It will also be understood that one or more blocks of the flowcharts, and combinations of blocks
5 in the flowcharts, can be implemented by special purpose hardware-based computer systems which perform the specified functions, or combinations of special purpose hardware and computer instructions.

In some embodiments, certain ones of the operations of Figures 3-5 may be modified or further amplified as described below. Moreover, in some situations, the
10 operations described above may be augmented with additional optional operations, as shown by the dashed blocks in Figures 3-5. It should be appreciated that each of the modifications, augmentations or amplifications may be included with the operations above either alone or in combination with any others among the features described herein.

Many modifications and other embodiments of the inventions set forth herein will
15 come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Moreover, although the foregoing
20 descriptions and the associated drawings describe example embodiments in the context of certain example combinations of elements and/or functions, it should be appreciated that different combinations of elements and/or functions may be provided by alternative embodiments without departing from the scope of the appended claims. In this regard, for example, different combinations of elements and/or functions than those explicitly
25 described above are also contemplated as may be set forth in some of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

That Which is Claimed:

1. A method comprising:
causing a message including location information associated with a cognitive
5 radio to be transmitted to a database configured to provide information regarding an
unlicensed frequency band; and
receiving a response from the database including information regarding channel
availability within the unlicensed frequency band,
wherein at least one of causing the message to be transmitted or receiving the
10 response employs cellular data signaling.
2. A method according to Claim 1 further comprising generating the message
comprising a payload including the location information and an encrypted digest of the
payload, wherein causing the message to be transmitted and receiving the response
15 employ short message service (SMS).
3. A method according to Claim 2 wherein generating the message further
comprises encrypting the payload prior to creating the encrypted digest of the payload.
- 20 4. A method according to Claim 1 further comprising generating the message by
converting a binary data stream including the location information into a stream of octal,
decimal or hexadecimal numbers, wherein causing the message to be transmitted and
receiving the response employ dual tone multifrequency (DTMF) signaling.
- 25 5. A method according to Claim 4 wherein generating the message comprises
generating the message including a payload including the location information and an
encrypted digest of the payload.
- 30 6. A method according to Claim 5 wherein generating the message further
comprises encrypting the payload prior to creating the encrypted digest of the payload.
7. A method according to Claim 1 wherein causing the message to be transmitted
and receiving the response employ Circuit Switched (CS) data signaling.
- 35 8. A method according to any one of Claims 1-7 wherein the unlicensed frequency
band comprises television white space (TVWS), and wherein the method further

comprises causing the cognitive radio to operate in an available channel within the TVWS based upon the response from the database.

9. An apparatus comprising at least one processor and at least one memory
5 including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

cause a message including location information associated with a cognitive radio to be transmitted to a database configured to provide information regarding an unlicensed frequency band; and

10 receive a response from the database including information regarding channel availability within the unlicensed frequency band,

wherein the apparatus is also caused to employ cellular data signaling in order to cause the message to be transmitted or to receive the response.

15 10. An apparatus according to Claim 9 wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to generate the message comprising a payload including the location information and an encrypted digest of the payload, and wherein the apparatus is also
20 caused to employ short message service (SMS) in order to cause the message to be transmitted and to receive the response.

11. An apparatus according to Claim 10 wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to generate the message by encrypting the payload prior to creating the
25 encrypted digest of the payload.

12. An apparatus according to Claim 9 wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to generate the message by converting a binary data stream including the
30 location information into a stream of octal, decimal or hexadecimal numbers, wherein the apparatus is also caused to employ dual tone multifrequency (DTMF) signaling to cause the message to be transmitted and to receive the response.

13. An apparatus according to Claim 12 wherein the at least one memory and the
35 computer program code are further configured to, with the at least one processor, cause the apparatus to generate the message by including a payload including the location information and an encrypted digest of the payload.

14. An apparatus according to Claim 13 wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to generate the message by encrypting the payload prior to creating the encrypted digest of the payload.

15. An apparatus according to Claim 9 wherein the apparatus is caused to employ Circuit Switched (CS) data signaling to cause the message to be transmitted and to receive the response.

16. An apparatus according to any one of Claims 9-15 wherein the unlicensed frequency band comprises television white space (TVWS), and wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to cause the cognitive radio to operate in an available channel within the TVWS based upon the response from the database.

17. A computer program product comprising at least one computer-readable storage medium bearing computer program code embodied therein for use with a computer, the computer program code comprising code for:

causing a message including location information associated with a cognitive radio to be transmitted to a database configured to provide information regarding an unlicensed frequency band; and

receiving a response from the database including information regarding channel availability within the unlicensed frequency band,

wherein the code for at least one of causing the message to be transmitted or receiving the response includes code for employing cellular data signaling.

18. A computer program product according to Claim 17 further comprising code for generating the message comprising a payload including the location information and an encrypted digest of the payload, wherein the code for causing the message to be transmitted and receiving the response comprises code for employing short message service (SMS).

19. A computer program product according to Claim 17 further comprising code for generating the message by converting a binary data stream including the location information into a stream of octal, decimal or hexadecimal numbers, wherein the code for causing the message to be transmitted and receiving the response comprises code for

employing dual tone multifrequency (DTMF) signaling, and wherein the code for generating the message comprises code for generating the message including a payload including the location information and an encrypted digest of the payload.

- 5 20. A computer program product according to Claim 17 wherein the code for causing the message to be transmitted and receiving the response comprises code for employing Circuit Switched (CS) data signaling.

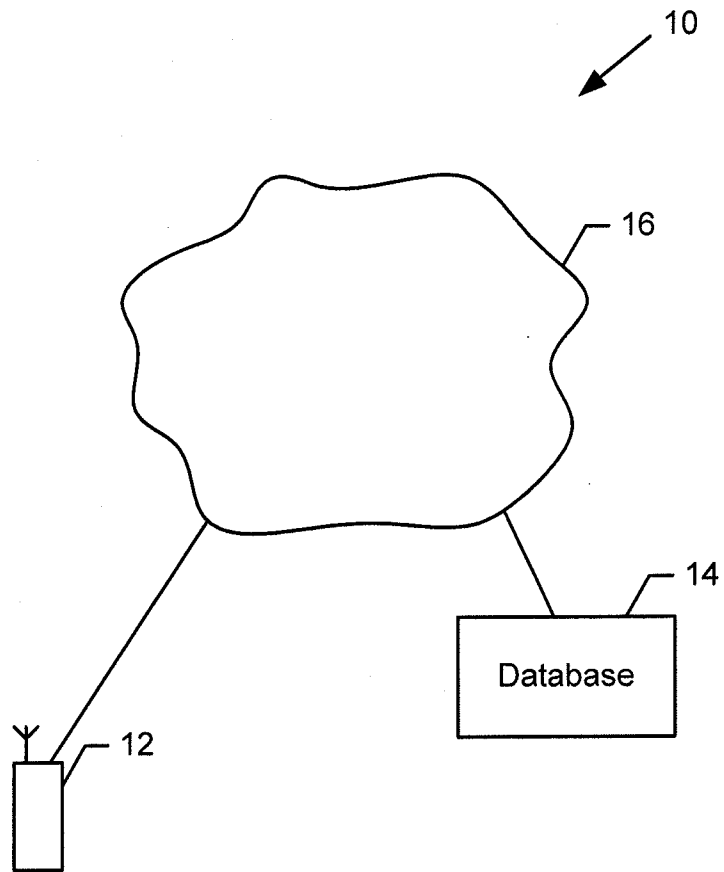


Figure 1

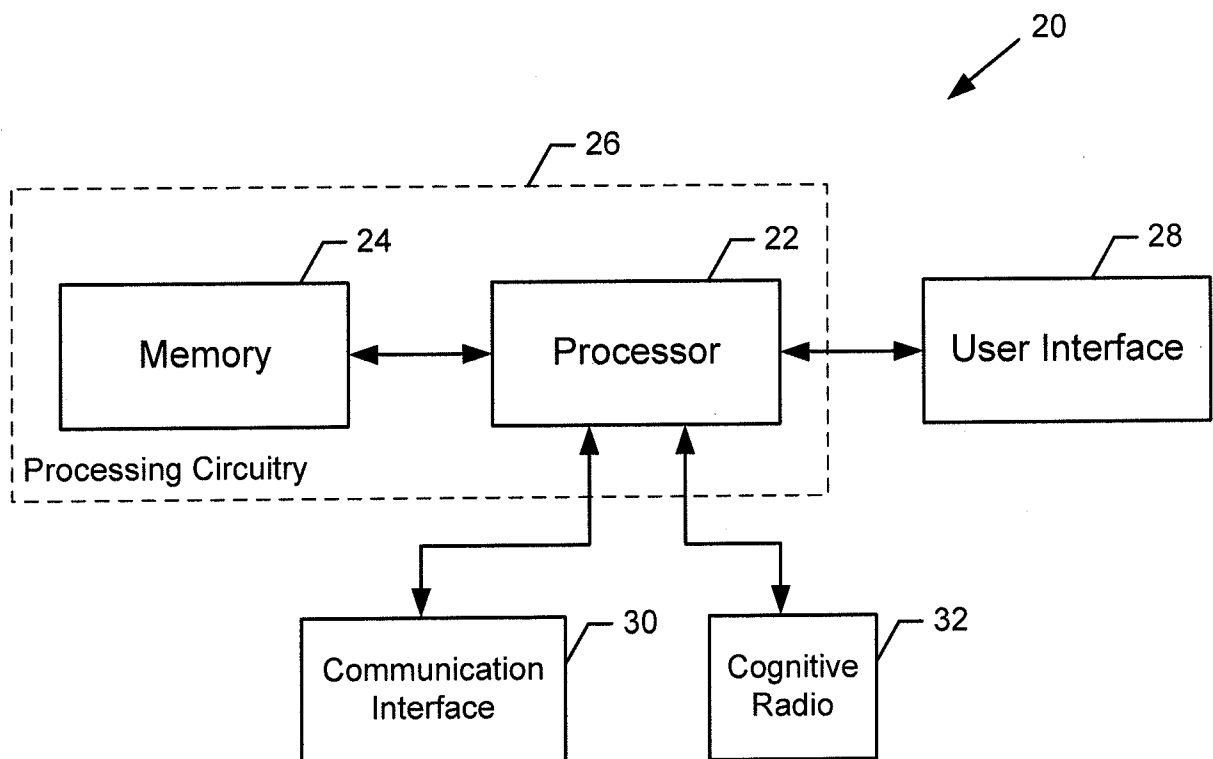


Figure 2

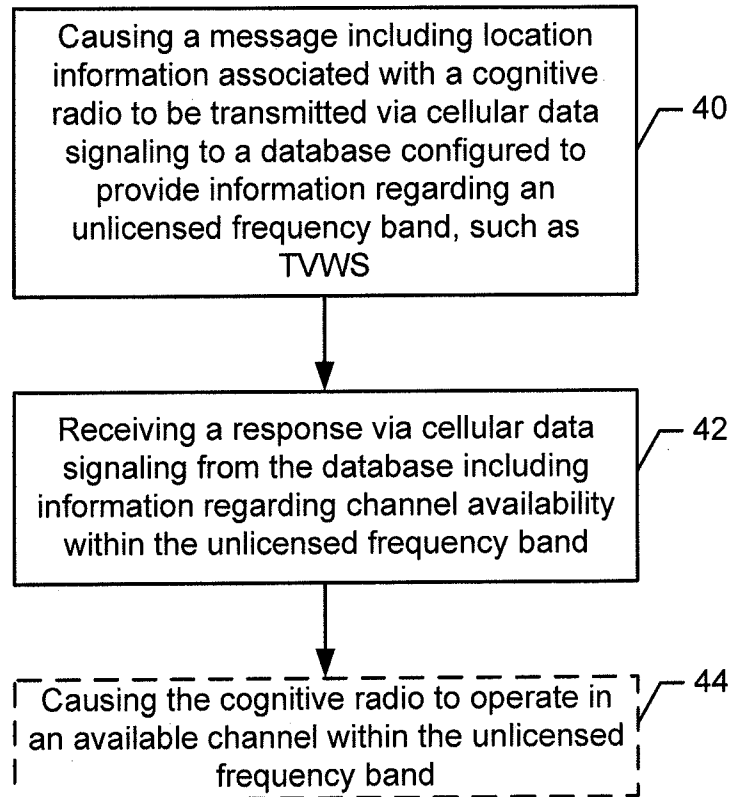


Figure 3

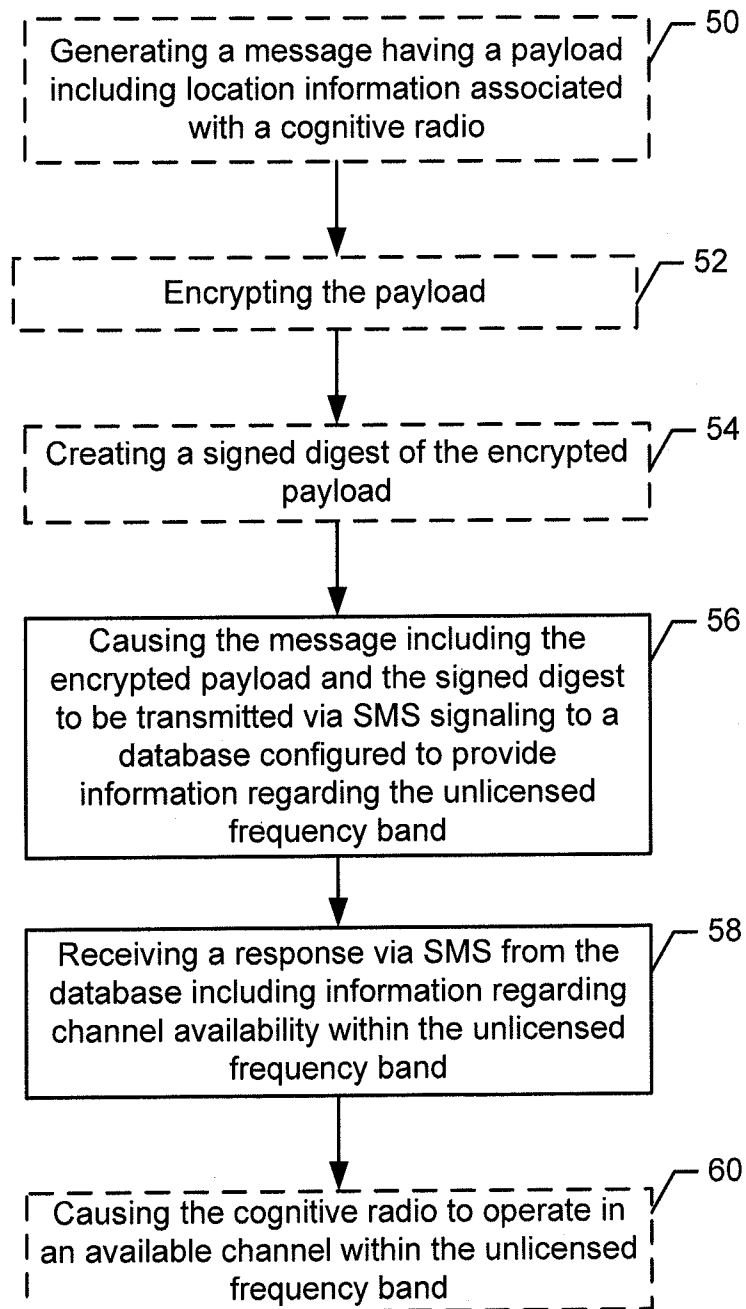
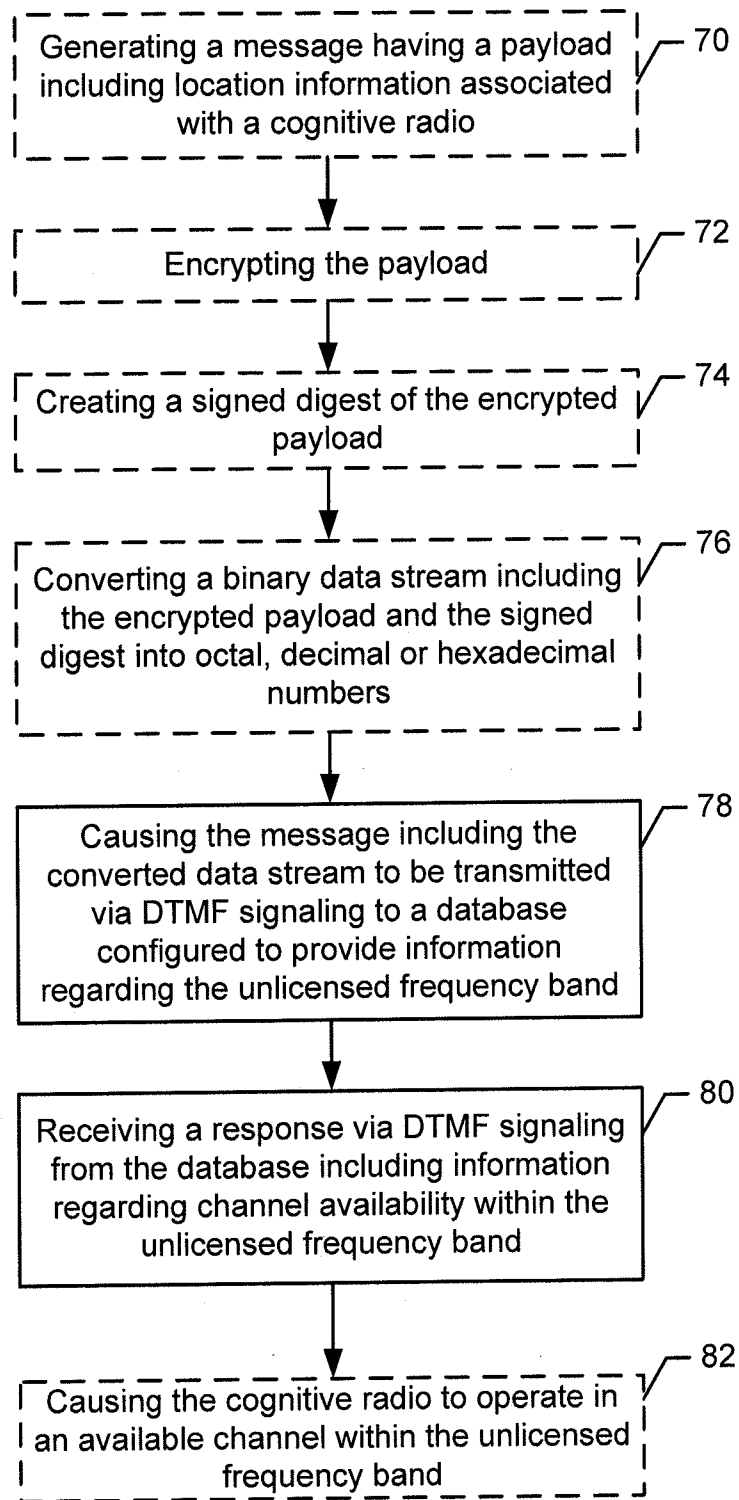


Figure 4

**Figure 5**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/026672

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04B 15/00 (2011.01)

USPC - 455/62

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)

IPC(8) - H04B 15/00; H04K 1/00 (2011.01)

USPC - 455/62; 380/247

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)

MicroPatent, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7,424,268 B2 (DIENER et al) 09 September 2008 (09.09.2008) entire document	1-20
Y	US 5,822,324 A (KOSTRESTI et al) 13 October 1998 (13.10.1998) entire document	1-20
Y	US 2006/0182280 A1 (LAITINEN et al) 17 August 2006 (17.08.2006) entire document	2-3, 5-8, 10-11, 13-16, 18-20
Y	US 2002/0186781 A1 (USUI) 12 December 2002 (12.12.2002) entire document	4-6, 8, 12-14, 16, 19
Y	US 2008/0130519 A1 (BAHL et al) 05 June 2008 (05.06.2008) entire document	8, 16

☐ Further documents are listed in the continuation of Box C.


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"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

15 April 2011

Date of mailing of the international search report

28 APR 2011

Name and mailing address of the ISA/US

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