Abstract: Methods and apparatus, including computer program products, are provided for using white space frequencies. In one aspect there is provided a method. The method may include receiving, from a base station and a cellular down link, at least one white space frequency available for use by a user equipment including a radio interface; configuring the radio interface to operate on the received at least one white space frequency; and transmitting, by the radio interface at the user equipment, on the at least one white space frequency. Related apparatus, systems, methods, and articles are also described.
CELLULAR BASE STATION WHITE SPACE MASTER

FIELD

[001] The subject matter described herein relates to wireless communications.

BACKGROUND

[002] Some jurisdictions are creating regulations allowing a cognitive radio (CR) configured to operate in certain frequency bands on a licensed-exempt basis (e.g., without requiring a license to broadcast on the frequency bands). For example, the Federal Communications Commission (FCC) has allocated the ultrahigh frequency (UHF) band (commonly used for UHF TV) for licensed-exempt use, and the vacant channels in this band are referred to as white space or TV white space (TVWS). Other jurisdictions around the world, such as Ofcom in the United Kingdom, are also making white space available.

[003] To use the TV white space, regulators typically mandate a lookup into a database containing available frequencies (e.g., also referred to as available channels and/or an available channel list) at a given location before a device can transmit in the given location. This lookup is typically required by regulators to prevent usage on the TV white space to interfere with licensed spectrum usage, such as licensed TV UHF broadcasts. Moreover, a master device is typically used to access the database and obtain the available frequencies and respective maximum permitted transmit powers for those frequencies. The master device knows its location and is authorized to receive from the database available frequencies based on location. The master device may then provide the available frequencies to associated white space devices (also referred to as slaves), so that the white space devices can transmit on the available frequencies.
[004] The white space device is thus a radio that is a so-called "slave" device because it may not know its location (even though it may have a location determination capability, this capability may not function or may be inoperative) or the slave does not have the necessary functionality to communicate to an authorized database configured to provide available frequencies. Instead, the slave relies on the master device to obtain available frequency/channel information obtained from the database. For example, the white space device (or slave) may check for available frequencies by requesting the available frequencies from the master device serving the slave. Next, the master provides to the database a request for available frequencies and location information (representative of the location of the master device). The database returns to the master the available white space frequencies and optionally maximum transmit powers for the given location. Next, the master delivers the available frequencies and optionally maximum transmit powers to the slave. The slave device may then operate on any of the available frequencies provided by the master, so long as the slave remains within range of the master. In the case of the FCC, the slave may use the available frequencies provided by the master, so long as the slave receives a contact verification signal (CVS) transmitted by the master device.

SUMMARY

[005] Methods and apparatus, including computer program products, are provided for using white space frequencies.

[006] In some example embodiments, there may be provided a method. The method may include receiving, from a base station and a cellular down link, at least one white space frequency available for use by a user equipment including a radio interface;
configuring the radio interface to operate on the received at least one white space frequency; and transmitting, by the radio interface at the user equipment, on the at least one white space frequency.

[007] In some variations of some of the embodiments disclosed herein, one or more of the following may be included. The transmitting may stop, when the user equipment does not detect a contact verification signal transmitted by the base station, wherein the user equipment further includes a cellular radio interface. The radio interface may include at least one radio configured to operate on the at least one white space frequency. The at least one white space frequency may be received from a white space database based on information provided by the base station, wherein the information comprises one or more of the following: a first location representative of the user equipment; a second location representative of the base station; a coverage area of the base station; a transmit power of the base station; a contour in a region where the base station is located; a timing advance value; and a base station antenna parameter. The at least one white space frequency may include at least one television white space frequency. The at least one power value representative of a maximum transmit power for transmission on the at least one white space frequency may be received from the base station and the cellular down link. A message may be sent to the base station, wherein the message may comprise at least one of an identifier of the user equipment, a characteristic of the user equipment, and an indication that the user equipment is configured to operate on the at least one white space frequency.

[008] The above-noted aspects and features may be implemented in systems, apparatus, methods, and/or articles depending on the desired configuration. The details of one or more variations of the subject matter described herein are set forth in the
accompanying drawings and the description below. Features and advantages of the subject matter described herein will be apparent from the description and drawings, and from the claims.

DESCRIPTION OF DRAWINGS

[009] In the drawings,

[010] FIG. 1 depicts a block diagram of a wireless communication system, in accordance with some example embodiments;

[011] FIG. 2 depicts a process for receiving available white space frequencies from a base station configured as a master device, in accordance with some example embodiments;

[012] FIG. 3 depicts an example of a base station, in accordance with some example embodiments; and

[013] FIG. 4 depicts an example of user equipment, in accordance with some example embodiments.

[014] Like labels are used to refer to same or similar items in the drawings.

DETAILED DESCRIPTION

[015] User equipment, such as a smart phone, and the like may be configured to include a cognitive radio in addition to the cellular, WiFi, and Bluetooth radio interfaces at the user equipment. The cognitive radio may be configured to operate in white space, such as the TV white space band(s). For example, the TV white space band may be used to provide broadband access to the user equipment or to enable the user equipment to operate as a so-called "hot spot."
In some example embodiments, the subject matter disclosed herein relates to configuring a cellular base station to access a database containing frequencies available for use in the white space at a certain location. The cellular base station may then provide any available frequencies (and, in some instances, maximum transmit power values at those frequencies) to the user equipment via the cellular downlinks to the user equipment, rather than via the frequencies of the white space. Moreover, in some example embodiments, the base station may determine the user equipment's location based on timing advance information or cell sector information, although the location of the user equipment or base station may be determined in other ways as well.

Before providing additional details, an exemplary system environment 100 is described in connection with FIG. 1. In some example embodiments, the wireless communication system 100 may include one or more base stations, such as base stations 110A-B, supporting corresponding service or coverage areas, such as coverage areas 112A-B (also referred to as cells). The base stations 110A-B may be capable of communicating with wireless devices, such as user equipment 114A-B, within the coverage areas.

In some example embodiments, each of the base stations 110A-B may be configured to access a database containing frequencies and/or transmit powers values (e.g., maximum allowable transmit powers) available for use in the white space at a certain location. The base stations 110A-B may then provide any available frequencies and/or maximum transmit power(s) to the user equipment via the cellular downlinks to the user equipment. For example, base station 110A may include a master device function for white space 197. In this example, the base station 110A may access link 150A (e.g., the Internet and the like) and couple to white space database 199 containing frequencies.
and/or maximum transmit powers available for use in the white space at a given location. The white space database 199 may provide to base station 110A any available frequencies and/or maximum transmit powers, so that base station 110 can provide the available frequencies and/or maximum transmit powers to user equipment 114A via cellular downlink 116A. The user equipment 114A may then begin transmission (at a power less than or equal to the maximum transmit power provided by database 199) on at least one of the available frequencies in the white space. In some exemplary embodiments, the white space frequencies correspond to TV white space frequencies, although other white space frequencies may be used as well.

[019] In some example embodiments, the base station 110A may transmit a CVS signal. When this is the case, the user equipment 114A may transmit on the white space frequencies, so long as the user equipment can detect the CVS signal. To illustrate by way of another example, user equipment 114A and B may each obtain white space frequencies from base station 110A, and, in this example, the user equipment 114A-B may communicate with each other on an ad hoc basis over the available white space frequencies. Although the previous example described the user equipment 114A-B using the white space frequencies to communication between themselves, each of the user equipment 114A-B may transmit to other devices as well,

[020] The white space database 199 may include frequencies available for use without a license, and these license-exempt frequencies may be referred to as white space and/or white space frequencies. In some example embodiments, the white space includes TV white space, which refers to white space typically associated with the TV licensed portion of the spectrum (e.g., UHF and the like). Because the available frequencies in the white space may be provided to base stations 110A-B (via links 150A-B) in order to avoid
interference with licensed usage of the spectrum, the base stations 110A-B may need to register with the white space database 199 and then provide information to allow allocation of appropriate white space frequencies. This information provided by the base station to obtain an available white space frequency list may include one or more of the following: location information representative of the location of the user equipment; location information representative of the location of the base station; coverage area of the base station; transmitted power of the base station; contour (or topography) in the region where the base station is located; a timing advance value (representing a transmission time (and thus distance) between the user equipment and base station); base station antenna parameters; and any other information which may be relevant to determine whether user equipment in the coverage area of the base station may cause interference to licensed users of the spectrum.

[021] The base station 110A-B may, in some example embodiments, be implemented as an evolved Node B (eNB) type base station consistent with standards, including the Long Term Evolution (LTE) standards, such as 3GPP TS 36.201, Evolved Universal Terrestrial Radio Access (E-UTRA); Long Term Evolution (LTE) physical layer; General description, 3GPP TS 36.211, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation, 3GPP TS 36.212, Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding, 3GPP TS 36.213, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures, 3GPP TS 36.214, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer - Measurements, and any subsequent additions or revisions to these and other 3GPP series of standards (collectively referred to as LTE standards). The base station may also be
configured as a femtocell base station, home evolved node B base station, and/or a picocell base station as well.

[022] Although FIG. 1 depicts an example of a configuration for base stations 110A-B, the base stations 110A-B may be configured in other ways including, for example, relays, cellular base station transceiver subsystems, gateways, access points, radio frequency (RF) repeaters, frame repeaters, nodes, and include access to other networks as well. For example, base stations 110A-B may have wired and/or wireless backhaul links to other network elements, such as other base stations, a radio network controller, a core network, a serving gateway, a mobility management entity, a serving GPRS (general packet radio service) support node, a network management system, white space database 199, and the like.

[023] In some example embodiments, the user equipment 114A-B may include a plurality of radio interfaces including, for example, one or more of the following: a cellular radio interface (e.g., LTE, LTE-A, and the like), a WiFi radio interface, a Bluetooth radio interface, and a cognitive radio configured to allow operation on a white space frequency, such as the TV white space. In some example embodiments, the white space is the TV UHF band, although other white space frequencies may be used as well.

[024] The user equipment 114A-B may be implemented as a mobile device and/or a stationary device. The user equipment 114A-B are often referred to as, for example, mobile stations, mobile units, subscriber stations, wireless terminals, tablets, smart phones, or the like. A user equipment may be implemented as, for example, a wireless handheld device, a wireless plug-in accessory, or the like. In some cases, user equipment may include a processor, a computer-readable storage medium (e.g., memory, storage, and the like), a radio interface(s), and/or a user interface.
To illustrate by way of an example, user equipment 114A may be in communication with another device, such as user equipment 114B and the like, using the available white space frequencies provided by the base station 110A and white space database 199. This communication may be an ad hoc, peer-to-peer communication and/or the user equipment 114A may serve as an access point hosting other communications (e.g., operating as a so-called hotspot).

In some example embodiments, the wireless communication system 100 may include access links, such as links 122A-B. The access links 122A-B including downlinks 116A-B for transmitting to the user equipment and an uplinks 126A-B for transmitting from user equipment to the base station. The downlinks 116A-B may each comprise a modulated radio frequency carrying information, such as Radio Resource Control (RRC) messages, location information, and the like, to the user equipment, and the uplinks 126A-B may each comprise a modulated radio frequency carrying information, such as RRC messages, assistance information, location information, and the like, from the user equipment to the base station. The downlinks 116A-B and uplinks 126A-B may, in some example embodiments, each represent a radio frequency (RF) signal. The RF signal may, as noted above, include data, such as voice, video, images, Internet Protocol (IP) packets, control information, and any other type of information and/or messages. For example, when LTE is used, the RF signal may use orthogonal frequency division multiple access (OFDMA). OFDMA is a multi-user version of orthogonal frequency division multiplexing (OFDM). In OFDMA, multiple access is achieved by assigning, to individual users, groups of subcarriers (also referred to as subchannels or tones). The subcarriers are modulated using BPSK (binary phase shift keying), QPSK (quadrature phase shift keying), or QAM (quadrature amplitude modulation), and carry symbols (also referred to as...
OFDMA symbols) including data coded using a forward error-correction code. The subject matter described herein is not limited to application to OFDMA systems, LTE, LTE-Advanced, or to the noted standards and specifications.

[027] Although FIG. 1 depicts two base stations 110A-B, two cells 112A-B, and two-user equipment 114A-B, a single white space database 199, the wireless communication system 100 may include other quantities of these devices as well.

[028] FIG. 2 depicts a process 200 for allowing a user equipment to receive white space frequencies and/or transmit powers (e.g., a maximum transmit power allowed for use while transmitting on the white space frequency) from a cellular base station via cellular downlinks, in accordance with some exemplary embodiments. The description of FIG. 2 also refers to FIG. 1.

[029] At 202, base station 110A including master device 197 may register with a white space database 199, in accordance with some exemplary embodiments. The registration may authorize the base station 110A including master device 197 to obtain available white space frequencies (e.g., TV white space frequencies) from white space database 199.

[030] At 204, the base station 110A including master device 197 may query white space database via link 150A, such as the Internet rather than via the white space frequency bands. This query 204 may allow base station 110A including master device 197 to obtain a list of available white space frequencies and/or maximum transmit powers for those frequencies.

[031] During the query at 204, the base station 110A may provide to white space database 199 information, such as the geo-location of the base station and/or its cellular antenna information of the base station to allow the white space database 199 to identify
white space frequencies for the base station. For example, this information may include one or more of the following: location information representative of the location of the user equipment; location information representative of the location of the base station; a coverage area of the cell served by the base station (including, for example, propagation range, cellular frequency of operation, transmit power, sectorization, antenna height, antenna parameters and the like); a contour map (or topography) in the region where the base station is located; a timing advance value (representing a transmission time (and thus distance) between the user equipment and base station); the base station antenna parameters; and any other information which may be relevant to determine whether the user equipment in the coverage area of the base station may cause interference to licensed users of the spectrum.

[032] In some example embodiments, the base station 110A may provide, at 204, a single point location when requesting available white space frequencies. In this example, movement by the user equipment may prompt a request for additional white space frequencies for the new location. However, in some example embodiments, the base station 110A may provide, at 204, to database 199 an area (e.g., multiple locations) to cover one or more portions (if not all of) the base station's cell-radius. For example, the base station 110A may provide to database 199 information regarding the one or more portions being served. And, this information may comprise points describing a polygon, the interior of which corresponds to the area where the available white space channels may be used. As such, the available frequencies provided in response to this area information (e.g., polygonal location information) may be used throughout the area. For example, user equipment within the area may be authorized to use the available white space frequencies without re-seeking authorization from the database 199. In some
example embodiments, the user equipment may also be permitted to move by a certain
distance (e.g. 100 meters in accordance with FCC rules) before the user equipment
requires additional white space frequencies from database 199.

[033] In some example embodiments, the base station 110A may also provide, at
204, to the white space database 199 an intended maximum transmit power level and the
actual cellular frequency range being used by the base station 110A. This allows a
determination of the region being served by the base station 110A which would include the
location of the user equipment being served by base station 110A and would also allow a
determination of the corresponding available white space channels that can be assigned to
the location. The white space database 199 may compute the area of the coverage area
based on some of the information provided by the base station, as noted above.

[034] Based on the information provided to the white space database at 204, the
white space database responds at 206 to the base station 110A including master device
197 with the available white space frequencies for the coverage area/radius of the base
station 110A (e.g., the area corresponding to cell 112A). The response 206 may also
include one or more maximum transmit power defining a power value which should not be
exceeded when transmitting on one or more corresponding available white space
frequencies. The available frequencies represent white space frequencies that can be
used by the user equipment 114A without interfering with licensed spectrum users. The
white space database 199 may reject the query request made at 204 by, for example,
providing at 206 a rejection response and/or an empty list of available white space
frequencies.

[035] At 208, user equipment 114A may provide to base station 110A including
master device 197 a request message via uplink 126A, in accordance with some
exemplary embodiments. The request may be a request for one or more white space frequencies (or channels), which may be available for use by the user equipment. Alternatively, the request may comprise an indication that the user equipment is configured with a cognitive radio (or white space radio interface) operative on the white space frequencies. For example, the request 208 may be sent as part of the radio resource control signaling between the user equipment and the base station such as the capability exchange, although other types of messages and/or signaling may be used as well.

[036] In some example embodiments, the user equipment 114 including the white space radio (WSR) may provide additional information to the base station 110A in order to improve the available white space frequency allocation process 200. For example, the user equipment 114A including the white space radio may provide at 208 to the base station 110A the user equipment's location (if available) and white space specific capability information (e.g., that the user equipment is configured to operate in white space frequencies), although the user equipment 114A may not need to know its location as the base station 110A can determine the user equipment's location.

[037] The base station 110A may use the location of the user equipment to determine which available white space frequencies to provide to the user equipment. In some example embodiments, the user equipment provides its location expressly (e.g., providing its latitude and longitude), although the location of the user equipment may be determined in other ways, such as based on the timing advance associated with the use equipment. In any case, the base station 110A including master device 197 may provide at 210 the available white space frequencies. The available white space frequencies may be identified by the base station by initiating another query at 204 (e.g., a request) to the
In some example embodiments, base station may request via a query at 204 from the database a list of white space frequencies/channels which are available for use over some, and/or all of the area of the cell/sector being served by the base station. In response, the database may provide available white space frequencies and/or a maximum transmit power for each of the white space frequencies. When this is the case, the base station may respond at 210 with one of those white space frequencies to a user equipment being served by the base station. In some example embodiments, the base station may request available white space frequencies/channels for a specific user equipment at a specific location. In this example, database 199 may return an available white space frequency/channel list for the specific user equipment, and this user equipment-specific list may include available white space frequencies/channels and maximum transmit power for each white space frequency at the given location. When this is the case, the base station may respond at 210 with the specific user equipment with the available white space frequencies/channels and maximum transmit power for each white space frequency at the given location.

Before sending the response at 210 to the user equipment 114A, the base station 110A may exchange additional information with the white space database 199 as may be required. For example, the base station 110A may provide the identity of the user equipment 114A to the white space database 199 to validate the user equipment (e.g., to confirm that the user equipment is certified to operate on unlicensed portions of the spectrum and the like).
At 210, the base station 110A including master device 197 responds to the user equipment 114A with the available white space frequencies/channels and/or maximum transmit power values, in accordance with some exemplary embodiments. For example, the base station 110A may provide the available white space frequencies to user equipment 114A via downlink 116A. Moreover, the base station 110A may provide the available white space frequencies in a control message, such as via the RRC signaling between the user equipment and the base station, although other mechanisms may be used to convey the available white space frequencies to user equipment 114A. Moreover, the base station 110A may provide the available white space frequencies as a list of actual frequencies, a list of actual channels, or using a value that can be used to look-up the available white space frequencies.

At 212, the user equipment 114A may configure itself (e.g., by switching, tuning, and/or the like) to transmit (and/or receive) using the available white space frequencies received at 210, in accordance with some exemplary embodiments. However, the user equipment 114A may be configured to only transmit on the available white space frequencies while the user equipment 114A can detect a contact verification signal (CVS) transmitted, at 214, by the base station 110A. For example, the base station 110A may transmit the CVS periodically by embedding the CVS signal in a control channel. The correct reception of this CVS signal may be verified by each of the user equipment that transmits using the cognitive radio/slave white space radio device (WSD) to determine that the user equipment is still within a region authorized to use the available TV white space frequencies. For example, if the user equipment 114A detects the CVS signal, the user equipment 114A is still likely to be within cell 112A and thus still authorized to use the available white space frequencies provided at 210. However, if the user equipment 114A
cannot detect the CVS signal, the user equipment 114A is likely to have roamed into another cell (or is not sufficiently close the base station 110A), and thus the available white space frequencies provided at 210 cannot be used, without possibly causing interference in the licensed portion of the spectrum. Moreover, the user equipment 114A may be configured to request another set of white space frequencies, when the user equipment moves (e.g., into another cell, a specified distance, and the like).

[042] FIG. 3 depicts an example implementation of a base station 300, which may be implemented at base station 110A-B. The base station includes one or more antennas 320 configured to transmit via a downlink and configured to receive uplinks via the antenna(s) 320. The base station further includes one or more radio interfaces 340 coupled to the antenna(s) 320, a processor 330 for controlling the base station 300 and for accessing and executing program code stored in memory 335. The radio interfaces 340 further include other components, such as filters, converters (e.g., digital-to-analog converters and the like), mappers, a Fast Fourier Transform (FFT) module, and the like, to generate symbols for a transmission via one or more downlinks and to receive symbols (e.g., via an uplink). Base station may also include a network interface to couple to backhaul links including database 199. In some implementations, the base station is also compatible with IEEE 802.16, LTE, LTE-Advanced, and the like, and the RF signals of downlinks and uplinks are configured as an OFDMA signal. The processor 330 may access code in memory, which causes base station 300 to provide one or more of the operations described herein with respect to a base station, such as access a database containing frequencies available for use in the white space at a certain location, to provide any available frequencies to the user equipment via the cellular downlinks to the user equipment, and the like.
[043] FIG. 4 depicts a block diagram of a radio, such as a user equipment 400. The user equipment 400 may include one or more antennas 420 for receiving a downlink and transmitting via an uplink. The user equipment 400 may also include radio interfaces 440 compatible with a cognitive radio interface for operating on the white space frequency band, WiFi, Bluetooth, GERAN, UTRAN, E-UTRAN, and/or other standards and specifications as well. The radio interfaces 440 may include other components, such as filters, converters (e.g., digital-to-analog converters and the like), symbol demappers, signal shaping components, an Inverse Fast Fourier Transform (IFFT) module, and the like, to process symbols, such as OFDMA symbols, carried by a downlink or an uplink. The user equipment 400 may further include at least one processor, such as processor 430, for controlling user equipment 400 and for accessing and executing program code stored in memory 435. The processor 430 may access code in memory, which causes user equipment 400 to provide one or more of the operations described herein with respect to the user equipment, such as request and receive available white space frequencies from the base station via the cellular downlinks, configure the user equipment to operate in the white space frequency bands, and the like.

[044] The subject matter described herein may be embodied in systems, apparatus, methods, and/or articles depending on the desired configuration. For example, the base stations and user equipment (or one or more components therein) and/or the processes described herein can be implemented using one or more of the following: a processor executing program code, an application-specific integrated circuit (ASIC), a digital signal processor (DSP), an embedded processor, a field programmable gate array (FPGA), and/or combinations thereof. These various implementations may include implementation in one or more computer programs that are executable and/or interpretable.
on a programmable system including at least one programmable processor, which may be special or general purpose, coupled to receive data and instructions from, and to transmit data and instructions to, a storage system, at least one input device, and at least one output device. These computer programs (also known as programs, software, software applications, applications, components, program code, or code) include machine instructions for a programmable processor, and may be implemented in a high-level procedural and/or object-oriented programming language, and/or in assembly/machine language. As used herein, the term "machine-readable medium" refers to any computer program product, computer-readable medium, computer-readable storage medium, apparatus and/or device (e.g., magnetic discs, optical disks, memory, Programmable Logic Devices (PLDs)) used to provide machine instructions and/or data to a programmable processor, including a machine-readable medium that receives machine instructions. Similarly, systems are also described herein that may include a processor and a memory coupled to the processor. The memory may include one or more programs that cause the processor to perform one or more of the operations described herein.

[045] Although a few variations have been described in detail above, other modifications or additions are possible. In particular, further features and/or variations may be provided in addition to those set forth herein. Moreover, the implementations described above may be directed to various combinations and subcombinations of the disclosed features and/or combinations and subcombinations of several further features disclosed above. In addition, the logic flow depicted in the accompanying figures and/or described herein does not require the particular order shown, or sequential order, to achieve desirable results. Other embodiments may be within the scope of the following claims.
WHAT IS CLAIMED:

1. A method comprising:
   receiving, from a base station and a cellular down link, at least one white space frequency available for use by a user equipment including a radio interface;
   configuring the radio interface to operate on the received at least one white space frequency; and
   transmitting, by the radio interface at the user equipment, on the at least one white space frequency.

2. The method of claim 1 further comprising:
   stopping the transmitting, when the user equipment does not detect a contact verification signal transmitted by the base station, wherein the user equipment further comprises a cellular radio interface.

3. A method as in claims 1-2, wherein the radio interface comprises at least one radio configured to operate on the at least one white space frequency.

4. A method as in claims 1-3, wherein the receiving further comprises:
   receiving the at least one white space frequency from a white space database based on information provided by the base station, wherein the information comprises one or more of the following: a first location representative of the user equipment; a second location representative of the base station; a coverage area of the base station; a transmit power of the base station; a contour in a region where the base station is located; a timing advance value; and a base station antenna parameter.

5. A method as in claims 1-4, wherein the at least one white space frequency comprises at least one television white space frequency.

6. A method as in claims 1-5, wherein the receiving further comprises:
receiving, from the base station and the cellular down link, at least one power value representative of a maximum transmit power for transmission on the at least one white space frequency.

7. A method as in claims 1-6 further comprising:

sending a message to the base station, wherein the message comprises at least one of an identifier of the user equipment, a characteristic of the user equipment, and an indication that the user equipment is configured to operate on the at least one white space frequency, wherein the configuring further comprises configuring by at least switching the first radio interface to the at least one white space frequency.

8. An apparatus comprising:

at least one processor; and

at least one memory including code, which when executed by the at least one processor provides operations comprising:

receiving, from a base station and a cellular down link, at least one white space frequency available for use by a user equipment including a radio interface;

configuring the radio interface to operate on the received at least one white space frequency; and

transmitting, by the radio interface at the user equipment, on the at least one white space frequency.

9. The apparatus of claim 8 further comprising:

stopping the transmitting, when the user equipment does not detect a contact verification signal transmitted by the base station, wherein the user equipment further comprises a cellular radio interface.
10. An apparatus as in claims 8-9, wherein the radio interface comprises at least one radio configured to operate on the at least one white space frequency.

11. An apparatus as in claims 8-10, wherein the receiving further comprises:
receiving the at least one white space frequency from a white space database based on information provided by the base station, wherein the information comprises one or more of the following: a first location representative of the user equipment; a second location representative of the base station; a coverage area of the base station; a transmit power of the base station; a contour in a region where the base station is located; a timing advance value; and a base station antenna parameter.

12. An apparatus as in claims 8-11, wherein the at least one white space frequency comprises at least one television white space frequency.

13. An apparatus as in claims 8-12, wherein the receiving further comprises:
receiving, from the base station and the cellular down link, at least one power value representative of a maximum transmit power for transmission on the at least one white space frequency.

14. An apparatus as in claims 8-13 further comprising:
sending a message to the base station, wherein the message comprises at least one of an identifier of the user equipment, a characteristic of the user equipment, and an indication that the user equipment is configured to operate on the at least one white space frequency.

15. A non-transitory computer-readable medium including code, which when executed by at least one processor provides operations comprising:
receiving, from a base station and a cellular down link, at least one white space frequency available for use by a user equipment including a radio interface;
configuring the radio interface to operate on the received at least one white space frequency; and

transmitting, by the radio interface at the user equipment, on the at least one white space frequency.

16. The non-transitory computer-readable medium of claim 15 further comprising:

   stopping the transmitting, when the user equipment does not detect a contact verification signal transmitted by the base station, wherein the user equipment further comprises a cellular radio interface.

17. A non-transitory computer-readable medium as in claims 15-16, wherein the radio interface comprises at least one radio configured to operate on the at least one white space frequency.

18. A non-transitory computer-readable medium as in claims 15-17, wherein the receiving further comprises:

   receiving the at least one white space frequency from a white space database based on information provided by the base station, wherein the information comprises one or more of the following: a first location representative of the user equipment; a second location representative of the base station; a coverage area of the base station; a transmit power of the base station; a contour in a region where the base station is located; a timing advance value; and a base station antenna parameter.

19. A non-transitory computer-readable medium as in claims 15-18, wherein the at least one white space frequency comprises at least one television white space frequency.
20. A non-transitory computer-readable medium as in claims 15-19, wherein the receiving further comprises:

    receiving, from the base station and the cellular down link, at least one power value representative of a maximum transmit power for transmission on the at least one white space frequency.
200

UE 114A

Base Station 110A
(including master device 197)

White Space Database 199

202 Registration
Query (including information re: UE and/or BS)

204

206 Response including white space channel list

208 Request

210 White Space Channel List via downlink

Transmit via White Space Radio Channel 212

214 Contact Verification Signal

FIG. 2
Radio Interfaces
(e.g., cellular, cognitive/white space, and the like)
A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W72/04

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)

H04W

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<tr>
<td></td>
<td>paragraphs [0109], [0114], [0126]; figures 5,6,10</td>
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<td>paragraphs [0017], [0022]; figures la, lb</td>
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* Special categories of cited documents:

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

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Date of the actual completion of the international search: 19 March 2013

Date of mailing of the international search report: 02/04/2013

Authorized officer: Dioni si, M
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<td></td>
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<tr>
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<td>WO 2011133771 A1</td>
<td>27-10-2011</td>
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