

METHOD OF TRANSMITTING A CONVERTED SIGNAL, METHOD OF
RECEIVING A SIGNAL, AND A TRANSCEIVER DEVICE

Cross-Reference To Related Application

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[0001] This application claims the benefit of priority of Singapore patent application No. 201200440-4, filed 19 January 2012, the content of it being hereby incorporated by reference in its entirety for all purposes.

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Technical Field

[0002] Various embodiments relate to a method of transmitting a converted signal, a method of receiving a signal, and a transceiver device.

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Background

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[0003] Wireless broadband services transmit data and information at high speeds using wireless links. Such data and information may include a wide range of content and applications that are accessed over the Internet, including web sites, e-mail, instant messaging, music, games, or data stored on a corporate server. Wireless broadband Internet access services are provided using mobile, fixed, or portable technologies. These technologies transmit data over short, medium, or long ranges, and may use licensed spectrum and/or unlicensed spectrum.

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[0004] For many developed countries, a world without broadband is unimaginable. In fact, broadband Internet access has transformed the way people in developed countries live their lives. However, bringing broadband to everyone has not yet succeeded. For example, for years, large parts of rural area have languished on the sidelines of the digital revolution.

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[0005] Wireless broadband Internet access services offered over fixed networks allow consumers to access the Internet from a fixed point while stationary and often require a direct line-of-sight between the wireless transmitter and receiver. These services have

been offered using both licensed spectrum and unlicensed spectrum. For example, thousands of small Wireless Internet Services Providers (WISPs) provide such wireless broadband at on unlicensed 2.4 GHz or 5.8 GHz ISM (industrial, scientific and medical) bands.

5 [0006] The switchover to digital television freed up a substantially large part of frequency spectrum, i.e., between about 50 MHz and 700 MHz (i.e., frequencies used by analog TV). This is because digital transmissions may be packed into adjacent channels, while analog transmissions are unable to do so. The lower frequency spectrum that television uses can penetrate buildings better, although the EIRP (emitted isotropic
10 radiated power) in white space devices is limited to 100 mW for mobile devices and 4 watt (W) for fixed devices. A white space device (WSD) is a FCC-certified (Federal Communications Commission-certified) wireless device that may be used without an exclusive broadcast license in the RF (radio frequency) spectrum below 700 MHz.

[0007] The frequency band of 2.4 GHz is very crowded because there are three non-
15 overlapping channels supporting a large geographical area. Heavy interference is observed in this band and the Free Space Loss, which is a measure of loss of signal strength resulting from a line-of-sight path through free space (or air) without any obstacles, is higher in this band. Similarly, 5.8 GHz band has more non-overlapping channels but the Free Space Loss is still higher and the range is much shorter.

20 [0008] The electromagnetic spectrum is crowded with a world full of wireless signals bumping up against each other and the sliver of spectrum left open for unlicensed use (meaning it may be used by any gadget, including Wi-Fi routers and cordless phones) is relatively small. The so-called white-space wireless bands use short wavelengths that make them better than a typical Wi-Fi signal at travelling long distances and passing
25 through obstacles such as walls and trees.

[0009] For instance, wireless networks using the technology of white-space wireless bands have been in place at a corporate campus and at a hospital in the US. A “smart grid” system for wirelessly managing electricity consumption has also been in realized in some US communities. Also, the FCC conditionally designated TV bands database
30 administrators.

[0010] While industry groups are working to protect broadcast interests, several parties have submitted a second generation of spectrum-sensing prototype white space devices for testing to the FCC. Incidentally in Software Radio and Dynamic Spectrum Access, a broad view of the issues involved has been reported. For example, it has been reported that the main benefit of dynamic spectrum access would be to improve spectrum utilization, which currently is at best less than 17 percent in urban areas and 5 percent in rural. Spectrum sharing also attributes to the additional benefit that spectrum becomes cheaper to use, which stimulates the development of new services and applications that would otherwise be uneconomical. Applications may include sharing UHF spectrum between terrestrial TV and mobile networks, and allowing UHF spectrum to be used by other technologies including 3G, WiMAX and 4G services and networks. All these wireless technologies may eventually come under a management regime that replaces fixed allocation of radio spectrum with real-time traded spectrum.

[0011] With usable white space spectrum being scarce in bigger markets, the technology may be more suited for rural broadband connectivity. Wireless Internet service providers (ISPs) have been clamouring for white space radio waves to push wireless services into hard-to-reach areas.

[0012] Existing systems are using TCP/IP or other data layer conversion. This incurs higher cost due to more components being used. In addition, with various stages of conversion, latency may become an issue.

[0013] Thus, there is a need to provide a system and method for broadband communication for rural connectivity seeking to address at least the problems above so as to provide range extension and spectrum reuse.

Summary

[0014] According to an embodiment, a transceiver device is provided. This transceiver device includes a receiver configured to wirelessly receive a signal having a master-remote frequency from a communication device; a branch frequency converter configured to convert the master-remote frequency of the received signal to a remote-

terminal frequency; and a transmitter configured to transmit the converted signal having the remote-terminal frequency to a communication terminal.

[0015] According to an embodiment, a transceiver device is provided. The transceiver device includes a receiver configured to receive a signal having a remote-terminal frequency from a communication terminal; a branch frequency converter configured to convert the remote-terminal frequency of the received signal to a master-remote frequency; and a transmitter configured to wirelessly transmit the converted signal having the master-remote frequency to a communication device.

[0016] According to an embodiment, a method of transmitting a converted signal is provided. The method includes wirelessly receiving a signal having a master-remote frequency from a communication device; converting the master-remote frequency of the received signal to a remote-terminal frequency; and transmitting the converted signal having the remote-terminal frequency to a communication terminal.

[0017] According to an embodiment, a method of receiving a signal is provided. The method includes receiving a signal having a remote-terminal frequency from a communication terminal; converting the remote-terminal frequency of the received signal to a master-remote frequency; and wirelessly transmitting the converted signal having the master-remote frequency to a communication device.

Brief Description of the Drawings

[0018] In the drawings, like reference characters generally refer to like parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the invention are described with reference to the following drawings, in which:

[0019] FIG. 1 shows a schematic diagram of a wireless system using a long RF cable.

[0020] FIG. 2 shows a schematic diagram of a wireless system including a device wirelessly communicating with a remote unit, according to various embodiments.

[0021] FIG. 3A shows a schematic block diagram of a transceiver device, according to various embodiments.

[0022] FIG. 3B shows a schematic block diagram of a transceiver device, according to other embodiments.

[0023] FIG. 3C shows a flow chart illustrating a method of transmitting a converted signal, according to various embodiments.

5 [0024] FIG. 3D shows a flow chart illustrating a method of receiving a signal, according to various embodiments.

[0025] FIG. 4 shows a schematic diagram of a system, according to various embodiments.

10 [0026] FIG. 5A shows a block diagram illustrating the functions at an access point device, according to various embodiments.

[0027] FIG. 5B shows a block diagram illustrating a geo-location database, according to various embodiments.

[0028] FIG. 6 shows a schematic diagram of an example of an access point device, according to various embodiments.

15 [0029] FIG. 7 shows a schematic diagram of an example of a remote unit, according to various embodiments.

[0030] FIG. 8 shows a schematic diagram of a current system.

Detailed Description

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[0031] The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the invention. The various embodiments are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments.

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[0032] Embodiments described in the context of a method are analogously valid for a device, and vice versa.

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[0033] In the context of various embodiments, the articles “a”, “an” and “the” as used with regard to a feature or element includes a reference to one or more of the features or elements.

[0034] In the context of various embodiments, the phrase “at least substantially” may include “exactly” and a reasonable variance.

[0035] As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0036] In a wireless system 100 such as WiFi, one way to extend the range of a wireless device 102 is to pull a substantially long RF cable 104 and place an antenna 106 at a remote site 108 as depicted in FIG. 1, which reflects an analogy of a wired last mile using a long RF cable (e.g., the RF cable 102). However, such a configuration is not elegant and would not be cost effective for extending the range to the rural areas.

[0037] Various embodiments may provide for use of the TV white space for the broadband communication for rural connectivity in order to achieve range extension and spectrum reuse.

[0038] Various embodiments may provide a wireless system 200 where the cable or wire (e.g., the RF cable 102 of FIG. 1) is replaced with TV white space (TVWS) communication as illustrated conceptually in FIG. 2. In FIG. 2, the wireless system 200 includes a device 202 having an antenna 204 (for example, a UHF antenna or a VHF antenna) that wirelessly communicates with a remote unit 206. The device 202 may be referred to as a master or a master device.

[0039] In one example, the remote unit 206 may include a complementary antenna 208 (for example, a UHF antenna or a VHF antenna) for receiving a signal (for example, a UHF signal or a VHF signal) from the wireless device 202. A converter 210 may convert the frequency of the received signal and the converted signal (for example, a 2.4 GHz signal) may then be transmitted to communication terminals (not shown in FIG. 2) via an antenna 212 (for example, a 2.4 GHz antenna). For example, the converter 210 may up-convert the frequency of the signal.

[0040] Conversely, in another example, the antenna 212 of the remote unit 206 may receive a signal (for example, a 2.4 GHz signal) from a communication terminal (not shown in FIG. 2). The converter 210 may convert the frequency of the signal and the

converted signal (for example, a UHF signal or a VHF signal) may then be transmitted to the wireless device 202 via the antenna 208. For example, the converter 210 may down-convert the frequency of the signal.

[0041] Various embodiments may provide installing a UHF (ultra high frequency) tower with broadband connectivity and spectrum sensing; and receiving a signal on a rural area tower, converting the signal to 2.4 GHz and retransmitting the frequency converted signal.

[0042] Various embodiments may provide a sensing up/down converter for rural Wi-Fi connectivity.

[0043] Various embodiments relate to communicating over a communication network involving a remote unit. The remote unit may include a memory which is for example used in the processing carried out by the remote unit. A memory used in the embodiments may be a volatile memory, for example a DRAM (Dynamic Random Access Memory) or a non-volatile memory, for example a PROM (Programmable Read Only Memory), an EPROM (Erasable PROM), EEPROM (Electrically Erasable PROM), or a flash memory, e.g., a floating gate memory, a charge trapping memory, an MRAM (Magnetoresistive Random Access Memory) or a PCRAM (Phase Change Random Access Memory).

[0044] In order that the invention may be readily understood and put into practical effect, particular embodiments will now be described by way of examples and not limitations, and with reference to the figures.

[0045] FIG. 3A shows a schematic block diagram of a transceiver device 300, according to various embodiments. The transceiver device 300 includes a receiver 302 configured to wirelessly receive a signal having a master-remote frequency from a communication device; a branch frequency converter 304 configured to convert the master-remote frequency of the received signal to a remote-terminal frequency; and a transmitter 306 configured to transmit the converted signal having the remote-terminal frequency to a communication terminal. In FIG. 3A, the line represented as 308 is illustrated to show the relationship between the receiver 302, the branch frequency converter 304, and a transmitter 306, which may include electrical coupling and/or mechanical coupling.

[0046] For example, the communication device may include or may be an access point and the communication terminal may be a mobile device.

[0047] As used herein, the term “wirelessly receive” may be used to describe receiving signals by using electromagnetic radiation through a non-solid medium, for example, air.

[0048] The transceiver device 300 may be a wireless device which generally includes at least one antenna, at least one radio, and at least one processor, where the radio may transmit signals through the antenna and receives signals through the antenna, while the processor may process the signal to be transmitted and the signal that has been received. The processor and the radio may be, for example, the branch frequency converter 304; and the receiver 302 or the transmitter 306, respectively.

[0049] The term “receiver” generally refers to a circuit having receiving capabilities and functions. The term “transmitter” generally refers to a circuit having transmitting (or sending) capabilities and functions.

[0050] In an embodiment, a “circuit” may be understood as any kind of a logic implementing entity, which may be special purpose circuitry or a processor executing software stored in a memory, firmware, or any combination thereof. Thus, in an embodiment, a “circuit” may be a hard-wired logic circuit or a programmable logic circuit such as a programmable processor, e.g., a microprocessor (e.g., a Complex Instruction Set Computer (CISC) processor or a Reduced Instruction Set Computer (RISC) processor). A “circuit” may also be a processor executing software, e.g., any kind of computer program, e.g., a computer program using a virtual machine code such as e.g., Java. Any other kind of implementation of the respective functions which will be described in more detail below may also be understood as a “circuit” in accordance with an alternative embodiment.

[0051] In one example, the transmitter 306 may be a transceiver operating with transmitting (or sending) functions. For example, the transmitter 306 may be a radio.

[0052] In another example, the receiver 302 may be a transceiver operating with receiving functions.

[0053] The term “transceiver” generally refers to a circuit combining a receiver and a transmitter; thereby having both transmitting and receiving capabilities and functions. The transceiver may be a transmitter and a receiver combined in a single package or arranged in separate packages.

[0054] As used herein, the term “communication terminal” may refer to a machine that assists data transmission, that is sending and/or receiving data information. Accordingly, the communication terminal may also be generally referred to as a node. For example, a communication terminal may be but is not limited to, a station (STA), or a substation, or a mobile station (MS), or a port, or a mobile phone, or a computer, or a laptop, or a user equipment (UE), or an advanced MS.

[0055] In one embodiment, the communication terminal may include a mobile device or a station.

[0056] It should be appreciated that the communication terminal is different from any one of a communication device as described herein, a transceiver device (e.g. the transceiver device 300) as defined herein, and a radio.

[0057] For example, the communication terminal may be configured to operate according to an IEEE 802.11 communication standard. It should be appreciated that the communication terminal may also be configured to operate according to any other communication standard.

[0058] In the context of various embodiments, the term “communication device” may refer to a node of a network, which communicates directly with the communication terminal. A communication device may, for example include but not limited to, a base station, or a substation, or an access point, or a modem, a cable, or a port.

[0059] In one embodiment, the communication device may include an access point.

[0060] In one embodiment, the communication device may further include an infrastructural frequency converter configured to convert the frequency of the transmitted signal. The infrastructural frequency converter may be configured to communicate with the access point. The term “infrastructural” is used to denote that the infrastructural frequency converter is located at the infrastructure side of a communication network (for example, at the access point or at a base point). For example, the communication device may be referred to as a master or a master device.

[0061] In various embodiments, the communication device may be configured to operate according to an IEEE 802.11 communication standard. It should be appreciated that the communication device may also be configured to operate according to any other communication standard.

[0062] The communication device, the communication terminal and the transceiver device 300 may be operating in a communication network. The term “communication network” may be a communication network according to an IEEE 802.11 communication standard. For example, the communication network may be a WiFi network. The WiFi network may be a WiFi which may be deployed by service providers (SPs) or a WiFi which may not be deployed by SPs.

[0063] For example, the communication network may be a WiFi network for rural connectivity. In this example, the transceiver device 300 may be referred to as a remote unit or remote device that is remotely located from an associated device (for example, a communication device).

[0064] The associated device may refer to a device that communicates with the transceiver device 300 using the same frequency.

[0065] For example, the transceiver device 300 and the associated device may be separated from each other over any distances that allows for wireless communication with each other. For example, the transceiver device 300 and the associated device may be but are not limited to being located at about 10 m, or about 100 m, or about 1 km, or about 5 km, or about 10 km, or about 20 km, or about 30 km, or about 40 km, or about 50 km, or about 100 km apart from each other.

[0066] The maximum feasible distance, between which the transceiver device 300 and the associated device may be spaced apart from each other, may be dependent on the master-remote frequency used. This maximum feasible distance may also be dependent on the transmitted power and the sensitivity of the receiver.

[0067] The term “signal” refers to an analogue signal or a RF signal. The signal may contain or represent information or data.

[0068] In the context of various embodiments, the term “frequency converter” refers to a circuit that converts or modifies or changes the frequency of the signal. It should be appreciated that the branch frequency converter 304 is not a modulator. In contrast, a modulator generally conveys a message signal, for example, a digital bit stream or an analogue audio signal, inside another signal that may be physically transmitted. The term “branch” used to denote that the branch frequency converter is located at the remote side

of the communication network (for example, distant from the infrastructure side of the communication network).

[0069] In one example, the branch frequency converter 304 may include an oscillator and a frequency mixer configured to frequency mix the received signal with an oscillating source signal from the oscillator. By frequency mixing, the received signal frequency may be mathematically added to or subtracted from the oscillating source signal. The oscillator may provide the oscillating source signal with a desired frequency and the desired frequency may vary.

[0070] In one embodiment, the branch frequency converter 304 may include a voltage controlled oscillator (VCO) and a frequency mixer configured to frequency mix the received signal with an oscillating source signal from the voltage controlled oscillator. The VCO may provide the oscillating source signal with a desired frequency and the desired frequency may vary. The VCO may be controlled by a voltage control signal to provide the oscillating source signal with the desired (or controlled) frequency.

[0071] As used herein, the term “master-remote frequency” refers a frequency at which a signal may travel over a long distance range. The master-remote frequency may also be used to describe the frequency at which a signal is communicated between the transceiver device 300 and the communication device (a master), in accordance to various embodiments.

[0072] In various embodiments, the master-remote frequency may be at least one of an ultra high frequency (UHF) or a very high frequency (VHF).

[0073] UHF designates the International Telecommunication Union (ITU) radio frequency range of electromagnetic waves between about 300 MHz and about 3 GHz. VHF designates the ITU radio frequency range of electromagnetic waves from about 30 MHz to about 300 MHz.

[0074] In various embodiments, the master-remote frequency may be an available frequency for wirelessly receiving the signal from the communication device.

[0075] The term “available” refers to unused or free.

[0076] The master-remote frequency may be selected from a licensed frequency band.

[0077] In various embodiments, the master-remote frequency may be a frequency selected from a range of 50 MHz to 700 MHz.

[0078] For example, the signal having the master-remote frequency is transmitted through existing but unused areas (or parts) of airwaves, such as those reserved for analogue television. The unused areas of airwave may be referred to as white spaces or a part thereof, which refer to frequencies allocated to a broadcasting service but not used locally. Such connectivity may be referred to as white space connectivity which is desirable as low-frequency signals (such as 50-54 MHz VHF) may travel significantly long distances (for example, about 2000 km or more), bend around mountains, and pass through obstacles.

[0079] The signal having the master-remote frequency may refer to the signal being transmitted in a channel using the master-remote frequency. In this context, the term “channel” may refer to a wireless channel for communication between the transceiver device 300 and the communication device.

[0080] The signal having the master-remote frequency may be used for Internet connectivity.

[0081] As used herein, the term “remote-terminal frequency” refers a frequency at which a signal may travel over a short distance range. The remote-terminal frequency may also be used to describe the frequency at which a signal is communicated between the transceiver device 300 and the communication terminal, in accordance to various embodiments.

[0082] In various embodiments, the remote-terminal frequency may be higher than the master-remote frequency.

[0083] The remote-terminal frequency may be selected from an unlicensed frequency band. For example, the remote-terminal frequency may be selected from industrial, scientific and medical (ISM) radio bands, which are radio bands (portions of the radio spectrum) reserved internationally for the use of radio frequency (RF) energy for industrial, scientific and medical purposes other than communications.

[0084] In various embodiments, the remote-terminal frequency may be at least one of 2.4 GHz band or 5.8 GHz band. It should be appreciated that the remote-terminal frequency may be any other higher frequency band other than 2.4 GHz band or 5.8 GHz band.

[0085] In various embodiments, the transceiver device 300 may further include a frequency synchronization control unit configured to associate the receiver 302 with the communication device based on the master-remote frequency.

[0086] In the context of various embodiments, the term “associate” may refer to having a link to or establishing a relationship with. For example, “associate the receiver with the communication device based on the master-remote frequency” may refer to the communication between the receiver 302 and the communication device is carried out using the master-remote frequency.

[0087] For example, the master-remote frequency may not be fixed and may change depending on the availability frequency. The communication device may determine an available frequency by scanning the radio spectrum (i.e., RF spectrum). When an available frequency is determined, the communication device may send a signal at this available frequency or a signal containing information about this available frequency. The transceiver device 300 may receive this signal and obtain information about the available frequency. The frequency synchronization control unit may associate the receiver 302 with the communication device based on the available frequency (i.e., the master-remote frequency). In some examples, the frequency synchronization control unit may also extract information about the available frequency from the received signal.

[0088] For example, the transceiver device 300 may be the remote unit 206 of FIG. 2.

[0089] FIG. 3B shows a schematic block diagram of a transceiver device 310, according to various embodiments. The transceiver device 310 includes a receiver 312 configured to receive a signal having a remote-terminal frequency from a communication terminal; a branch frequency converter 314 configured to convert the remote-terminal frequency of the received signal to a master-remote frequency; and a transmitter 316 configured to wirelessly transmit the converted signal having the master-remote frequency to a communication device. In FIG. 3B, the line represented as 318 is illustrated to show the relationship between the receiver 312, the branch frequency converter 314, and a transmitter 316, which may include electrical coupling and/or mechanical coupling.

[0090] As used herein, the term “wirelessly transmit” may be used to describe sending (or transmitting) signals by using electromagnetic radiation through a non-solid medium, for example, air.

[0091] The transceiver device 310 may be a wireless device which generally includes at least one antenna, at least one radio, and at least one processor, where the radio may transmit signals through the antenna and receives signals through the antenna, while the processor may process the signal to be transmitted and the signal that has been received.

5 The processor and the radio may be, for example, the branch frequency converter 314; and the receiver 312 or the transmitter 316, respectively.

[0092] In one example, the transmitter 316 may be a transceiver operating with transmitting (or sending) functions. For example, the transmitter 316 may be a radio.

[0093] In another example, the receiver 312 may be a transceiver operating with
10 receiving functions.

[0094] The terms “receiver”, “transmitter” and “transceiver” may be defined as above.

[0095] As described above, the communication terminal may include a mobile device or a station.

[0096] For example, the communication terminal may be configured to operate according
15 to an IEEE 802.11 communication standard.

[0097] The term “communication terminal” may be as defined above. It should be appreciated that the communication terminal is different from any one of a communication device as described herein, a transceiver device (e.g. the transceiver device 310) as defined herein, and a radio.

20 [0098] As described above, the communication device may include an access point. In one example, the communication device may further include an infrastructural frequency converter configured to convert the frequency of the signal received by the communication device. The infrastructural frequency converter may be configured to communicate with the access point. The term “infrastructural” is used to denote that the
25 infrastructural frequency converter is located at the infrastructure side of a communication network (for example, at the access point or at a base point). For example, the communication device may be configured to operate according to an IEEE 802.11 communication standard. It should be appreciated that the communication device may be configured to operate according to any other communication standard.

30 [0099] The term “communication device” may be as defined above. The communication device may be referred to as a master or a master device.

[00100] The communication device, the communication terminal and the transceiver device 310 may be operating in a communication network. As described above, the term “communication network” may be a communication network according to an IEEE 802.11 or any other communication standard. For example, the communication network may be a WiFi network. The WiFi network may be a WiFi which may be deployed by service providers (SPs) or a WiFi which may not be deployed by SPs.

[00101] For example, the communication network may be a WiFi network for rural connectivity. In this example, the transceiver device 310 may be referred to as a remote unit or remote device that is remotely located from an associated device (for example, a communication device).

[00102] The term “associated device” may be defined as above.

[00103] For example, the transceiver device 310 and the associated device may be separated from each other over any distances that allows for wireless communication with each other. For example, the transceiver device 310 and the associated device may be but are not limited to being located at about 10 m, or about 100 m, or about 1 km, or about 5 km, or about 10 km, or about 20 km, or about 30 km, or about 40 km, or about 50 km, or about 100 km apart from each other.

[00104] The maximum feasible distance, between which the transceiver device 310 and the associated device may be spaced apart from each other, may be dependent on the master-remote frequency used. This maximum feasible distance may also be dependent on the transmitted power and the sensitivity of the receiver.

[00105] The terms “signal” and “frequency converter” may be defined as above. The term “branch” used to denote that the branch frequency converter is located at the remote side of the communication network (for example, distant from the infrastructure side of the communication network).

[00106] It should be appreciated that the branch frequency converter 314 is not a modulator. In contrast, a modulator generally conveys a message signal, for example, a digital bit stream or an analogue audio signal, inside another signal that may be physically transmitted.

[00107] In one example, the branch frequency converter 314 may include an oscillator and a frequency mixer configured to frequency mix the received signal with an

oscillating source signal from the oscillator. As described above, by frequency mixing, the received signal frequency may be mathematically added to or subtracted from the oscillating source signal. The oscillator may provide the oscillating source signal with a desired frequency and the desired frequency may vary.

5 [00108] In one embodiment, the branch frequency converter 314 may include a voltage controlled oscillator (VCO) and a frequency mixer configured to frequency mix the received signal with an oscillating source signal from the voltage controlled oscillator. The VCO may provide the oscillating source signal with a desired frequency and the desired frequency may vary. The VCO may be controlled by a voltage control signal to
10 provide the oscillating source signal with the desired (or controlled) frequency.

[00109] The term “remote-terminal frequency” may be defined as above. The remote-terminal frequency may also be used to describe the frequency at which a signal is communicated between the transceiver device 310 and the communication terminal, in accordance to various embodiments.

15 [00110] In various embodiments, the remote-terminal frequency may be higher than the master-remote frequency.

[00111] As described above, the remote-terminal frequency may be selected from an unlicensed frequency band. For example, the remote-terminal frequency may be selected from industrial, scientific and medical (ISM) radio bands, which are radio bands
20 (portions of the radio spectrum) reserved internationally for the use of radio frequency (RF) energy for industrial, scientific and medical purposes other than communications.

[00112] In various embodiments, the remote-terminal frequency may be at least one of 2.4 GHz band or 5.8 GHz band. It should be appreciated that the remote-terminal frequency may be any other higher frequency band other than 2.4 GHz band or 5.8 GHz
25 band.

[00113] The term “master-remote frequency” may be defined as above. The master-remote frequency may also be used to describe the frequency at which a signal (in this embodiment, the converted signal) is communicated between the transceiver device 310 and the communication device (e.g. the master), in accordance to various
30 embodiments.

[00114] In various embodiments, the master-remote frequency may be at least one of an ultra high frequency (UHF) or a very high frequency (VHF).

[00115] In various embodiments, the master-remote frequency may be an available frequency for wirelessly sending the converted signal to the communication device.

5 [00116] The term “available”, “UHF” and “VHF” may be defined as above.

[00117] As described above, the master-remote frequency may be selected from a licensed frequency band. The master-remote frequency may be a frequency selected from a range of 50 MHz to 700 MHz.

[00118] The converted signal having the master-remote frequency may refer to the
10 converted signal being transmitted in a channel using the master-remote frequency. In this context, the term “channel” may refer to a wireless channel for communication between the transceiver device 310 and the communication device.

[00119] The converted signal having the master-remote frequency may be used for Internet connectivity.

15 [00120] In various embodiments, the transceiver device 310 may further include a frequency synchronization control unit configured to associate the transmitter 316 with the communication device based on the master-remote frequency.

[00121] In the context of various embodiments, the term “associate” may refer to having a link to or establishing a relationship with. For example, “associate the
20 transmitter with the communication device based on the master-remote frequency” may refer to the communication between the transmitter 316 and the communication device is carried out using the master-remote frequency.

[00122] As described above, for example, the master-remote frequency may not be fixed and may change depending on the availability frequency. The communication
25 device may determine an available frequency by scanning the radio spectrum (i.e., RF spectrum). When an available frequency is determined, the communication device may send a signal at this available frequency or a signal containing information about this available frequency. The transceiver device 310 may receive this signal and obtain information about the available frequency. The frequency synchronization control unit
30 may associate the transmitter 316 with the communication device based on the available frequency (i.e., the master-remote frequency). In some examples, the frequency

synchronization control unit may also extract information about the available frequency from the received signal.

[00123] For example, the transceiver device 310 may be the remote unit 206 of FIG. 2 or the transceiver device 300 of FIG. 3A.

5 [00124] FIG. 3C shows a flow chart 320 illustrating a method of transmitting a converted signal, according to various embodiments.

[00125] At 322, a signal having a master-remote frequency may be wirelessly received from a communication device. At 324, the master-remote frequency of the received signal may be converted to a remote-terminal frequency. At 326, the converted
10 signal having the remote-terminal frequency may be transmitted to a communication terminal.

[00126] The method 320 may be performed using the transceiver device 300 of FIG. 3A.

[00127] The terms “signal”, “wirelessly received”, “communication device”,
15 “converted”, and “communication terminal” may be defined as above.

[00128] For example, the communication terminal may be configured to operate according to an IEEE 802.11 communication standard. In another example, the communication terminal may be configured to operate according to any other communication standard.

20 [00129] For example, the communication device may be configured to operate according to an IEEE 802.11 communication standard. In another example, the communication device may be configured to operate according to any other communication standard.

[00130] The method 320 may be performed in a communication network. The term
25 “communication network” may be a communication network according to an IEEE 802.11 or any other communication standard. For example, the communication network may be a WiFi network. The WiFi network may be a WiFi which may be deployed by service providers (SPs) or a WiFi which may not be deployed by SPs.

[00131] For example, the communication network may be a WiFi network for rural
30 connectivity. In this example, the method 320 may be performed by a device (e.g., the

transceiver device 300) that is remotely located from an associated device (for example, a communication device).

[00132] The term “associated device” may be as defined above.

[00133] The maximum feasible distance, between which the device (e.g., the transceiver device 300) and the associated device may be spaced apart from each other, may be dependent on the master-remote frequency used. The term “maximum feasible distance” may be defined as above.

[00134] As described above, the term “signal” refers to an analogue signal or a RF signal. The signal may contain or represent information or data.

[00135] The term “converting” refers to converts or modifies or changes the frequency of the signal. It should be appreciated that the “converting” is different from “modulating”. In contrast, modulating generally refers to conveying a message signal, for example, a digital bit stream or an analogue audio signal, inside another signal that may be physically transmitted.

[00136] In one example, converting the master-remote frequency of the received signal to a remote-terminal frequency at 324 may include frequency mixing the received signal with an oscillating source signal from an oscillator. By frequency mixing, the received signal frequency may be mathematically added to or subtracted from the oscillating source signal. The oscillator may provide the oscillating source signal with a desired frequency and the desired frequency may vary.

[00137] In various embodiments, converting the master-remote frequency of the received signal to a remote-terminal frequency at 324 may include frequency mixing the received signal with an oscillating source signal from a voltage controlled oscillator (VCO).

[00138] The VCO may be controlled by a microcontroller and a network control configured to provide the appropriate oscillating source signal for conversion of the frequency of the received signal.

[00139] In various embodiments, the method 320 may further include determining an available frequency to be the master-remote frequency for wirelessly receiving the signal from the communication device.

[00140] The terms “available” may be defined as above.

[00141] In one embodiment, the master-remote frequency may be at least one of an ultra high frequency (UHF) or a very high frequency (VHF). The terms “master-remote frequency”, “UHF” and “VHF” may be defined as above.

[00142] As described above, for example, the master-remote frequency may be selected from a licensed frequency band. The master-remote frequency may be a frequency selected from a range of 50 MHz to 700 MHz. The signal having the master-remote frequency may refer to the signal being transmitted in a channel using the master-remote frequency. In this context, the term “channel” may refer to a wireless channel for wirelessly receiving the signal having the master-remote frequency from the communication device at 324. The signal having the master-remote frequency may be used for Internet connectivity.

[00143] In one embodiment, the remote-terminal frequency may be higher than the master-remote frequency.

[00144] In one embodiment, the remote-terminal frequency may be selected from an unlicensed frequency band. The term “remote-terminal frequency” may be defined as above.

[00145] In one embodiment, the remote-terminal frequency may be at least one of 2.4 GHz band or 5.8 GHz band. It should be appreciated that the remote-terminal frequency may be any other higher frequency band other than 2.4 GHz band or 5.8 GHz band.

[00146] FIG. 3D shows a flow chart 330 illustrating a method of receiving a signal, according to various embodiments.

[00147] At 332, a signal having a remote-terminal frequency may be wirelessly received from a communication terminal. At 334, the remote-terminal frequency of the received signal may be converted to a master-remote frequency. At 336, the converted signal having the master-remote frequency may be wirelessly transmitted to a communication device.

[00148] The method 330 may be performed using the transceiver device 310 of FIG. 3B.

[00149] The terms “signal”, “wirelessly transmitted”, “communication device”, “converted”, and “communication terminal” may be defined as above.

[00150] As described above, for example, the communication terminal may be configured to operate according to an IEEE 802.11 communication standard. For example, the communication device may be configured to operate according to an IEEE 802.11 or any other communication standard.

5 [00151] The method 330 may be performed in a communication network. The term “communication network” may be a communication network according to an IEEE 802.11 communication standard. As described above, for example, the communication network may be a WiFi network. The WiFi network may be a WiFi which may be deployed by service providers (SPs) or a WiFi which may not be deployed by SPs.

10 [00152] For example, the communication network may be a WiFi network for rural connectivity. In this example, the method 330 may be performed by a device (e.g., the transceiver device 310) that is remotely located from an associated device (for example, a communication device). The term “associated device” may be as defined above. The maximum feasible distance, between which the device (e.g., the transceiver device 310) and the associated device may be spaced apart from each other, may be dependent on the master-remote frequency used. The term “maximum feasible distance” may be defined as above.

[00153] As described above, the term “signal” refers to an analogue signal or a RF signal. The signal may contain or represent information or data.

20 [00154] The term “converting” may be defined as above.

[00155] In one example, converting the remote-terminal frequency of the received signal to a master-remote frequency at 334 may include frequency mixing the received signal with an oscillating source signal from an oscillator. The term “frequency mixing” may be defined as above.

25 [00156] In various embodiments, converting the remote-terminal frequency of the received signal to a master-remote frequency at 334 may include frequency mixing the received signal with an oscillating source signal from a voltage controlled oscillator (VCO).

[00157] As described above, the VCO may be controlled by a microcontroller and a network control configured to provide the appropriate oscillating source signal for conversion of the frequency of the received signal.

[00158] In one example, the method 330 may further include determining an available frequency to be the master-remote frequency for wirelessly sending the converted signal to the communication device.

[00159] The terms “available” may be defined as above.

5 [00160] In one embodiment, the remote-terminal frequency may be selected from an unlicensed frequency band. The term “remote-terminal frequency” may be defined as above.

[00161] In one embodiment, the remote-terminal frequency may be at least one of 2.4 GHz band or 5.8 GHz band. It should be appreciated that the remote-terminal frequency may be any other higher frequency band other than 2.4 GHz band or 5.8 GHz band.

[00162] In one embodiment, the remote-terminal frequency may be higher than the master-remote frequency.

15 [00163] In one embodiment, the master-remote frequency may be at least one of an ultra high frequency (UHF) or a very high frequency (VHF). The terms “master-remote frequency”, “UHF” and “VHF” may be defined as above.

[00164] As described above, for example, the master-remote frequency may be selected from a licensed frequency band. The master-remote frequency may be a frequency selected from a range of 50 MHz to 700 MHz. The signal having the master-remote frequency may refer to the signal being transmitted in a channel using the master-remote frequency. In this context, the term “channel” may refer to a wireless channel for wirelessly sending the converted signal having the master-remote frequency to the communication device at 334. The converted signal having the master-remote frequency may be used for Internet connectivity.

25 [00165] The transceiver device 300 and the method of transmitting a converted signal 320 in accordance with various embodiments may adopt white space technology as the “middle-wire” for communication between the transceiver device 300 and the communication device in order to extend the range or provide better transmission/reception quality while keeping the cost and latency low. Signals may be converted directly at the RF level to reduce the component count as well as reducing the

latency in conversion as there would be no need for TCP/IP or other data layer conversion.

[00166] Correspondingly, the transceiver device 310 and the method of receiving a signal 330 in accordance with various embodiments may adopt white space technology as the “middle-wire” for communication between the transceiver device 310 and the communication device in order to extend the range or provide better transmission/reception quality while keeping the cost and latency low. Similarly, signals may be converted directly at the RF level to reduce the component count as well as reducing the latency in conversion as there would be no need for TCP/IP or other data layer conversion.

[00167] Various embodiments may provide a system 400 including an access point (AP) 402 at a terminal (or infrastructure) side as shown in FIG. 4. The AP 402 includes a UHF WiFi radio 404 for receiving or transmitting WiFi signals. The UHF WiFi Radio 404 may be a 2.4 GHz WiFi or a wireless device that may be connected to the Internet cloud 410 via a 2.4 GHz antenna port to receive WiFi signals. A frequency conversion circuit to perform ISM to UHF conversion 406 is provided. Frequency identification 408 is provided to the frequency conversion circuit. For example, the AP 402 may be referred to as a master; and the ISM to UHF conversion 406 may be provided by the infrastructural frequency converter as described above.

[00168] The system 400 further includes a remote unit 412 located in a remote site including a UHF receiver 414. The UHF receiver 414 is programmed to establish connections (associations) with the AP 402 and/or re-establish connections (associations) with the AP 402 whenever the selected UHF channel is changed. The remote unit 412 also provides UHF to ISM conversion. The remote unit 412 communicates with a plurality of communication terminals 416 via ISM bands (e.g., 2.4 GHz band). In one example, the remote unit 412 may be the transceiver device 300 (FIG. 3A) or the remote unit 206 (FIG. 2) for downlink connectivity. In another example, the remote unit 412 may be the transceiver device 310 (FIG. 3B) or the remote unit 206 (FIG. 2) for uplink connectivity.

[00169] FIG. 5A shows a block diagram 500 illustrating the functions of the system 400 of FIG. 4 at the terminal side. In FIG. 5A, a UHF receiver 502 at the terminal

side (i) performs TV white space sensing 504 or uses geo-location database 506 to scan through a priority list of available channels, (ii) detects for available channel 508 by measuring the RSSI (received signal strength indicator) or other quality metrics, and (iii) makes a decision for the selection of channel 510 to determine whether to establish association with the AP (e.g., the AP 402 of FIG. 4) if a quality metric is met. Generally, the AP is pre-programmed and the terminal modules (or interchangeably referred to as terminal devices) scan through the frequencies and lock to the desired channel to be associated with the AP. In order to speed up on the scanning, both the AP and the terminal modules are pre-programmed with the same priority list.

[00170] The UHF receiver 502 at the terminal side may be the UHF WiFi radio 404 of FIG. 4.

[00171] For downlink connectivity, the WiFi/2G/3G/LTE or any other signal 512 is converted by the frequency up/down converter 514 to a UHF signal based on the decision for selection of channel 510 for TV white space channel transmission 516. The UHF signal may be transmitted using a highly directional antenna or an omni-directional antenna depending on a given application and/or a given scenario.

[00172] For uplink connectivity, the UHF signal is converted by the frequency up/down converter 514 to a WiFi/2G/3G/LTE or any other signal based on the decision for selection of channel 510 for TV white space channel transmission 516. The UHF signal may be received using a highly directional antenna or an omni-directional antenna depending on a given application and/or a given scenario.

[00173] For example, the frequency up/down converter 514 may provide the ISM to UHF conversion 406.

[00174] FIG. 6 shows a schematic diagram of the access point (AP) device 600, in accordance to various embodiments illustrating an example of the frequency up/down converter 514 (FIG. 5A) in detail. The AP device 600 may refer to the communication device at the infrastructure side of a communication network as described hereinabove. The frequency up/down converter 514 may refer to the infrastructural frequency converter as described above.

[00175] In FIG. 6, a network control 602 is used to control a spectrum sensing device or a geo-location database device 604. For example, the spectrum sensing device

604 (which may be provided by the TV white space sensing 504 and the detection for available channel 508 of FIG. 5A) detects the available channel for guiding UHF radio at the AP device 600 to transmit in that channel. In the spectrum sensing device 604, the available frequency is determined and is adopted to identify a suitable frequency for transmission at the transmitter.

[00176] In another example, a geo-location database device 604 (which may be provided by the geo-location database 506 and the detection for available channel 508 of FIG. 5A) may also be used to detect the available channel for guiding UHF radio at the access point to transmit in that channel. In using the geo-location database 604, the available frequency is adopted to identify a suitable frequency for transmission at the transmitter.

[00177] The objective of the geo-location database is such that in order for certain incumbent users to be protected, TV white space devices communicate with an Internet database to obtain a current list of available white space channels. Available channels may vary, depending on TV-band device (TVBD) type and location. These white space devices can only transmit on the channels issued to them by the database.

[00178] A database manager stores information needed to execute its geo-location purposes. FIG. 5B shows a block diagram 520 illustrating an exemplary database manager and its interfaces. For example, three database tables to be stored may be:

A. Incumbent Database-Consolidated Database System (CDBS) 522

- Contains information on all the television transmitters including TV tower location, channel, height, transmit power, antenna directionality, mechanical beam tilt.
- Facilities are limited to digital television (DTV) stations, digital and analog Class A television stations, low power television (LPTV) stations, television translator and booster stations, broadcast auxiliary service (BAS) stations (including receive only sites) other than low power auxiliary stations, private land mobile radio service (PLMRS) stations.
- Commercial mobile radio service (CMRS) stations and offshore radiotelephone service (ORS) stations.

- It is to be synchronized on a daily basis with other databases.

B. White Space Devices Database (WSD) 524

- Contains all the information on the all the white space devices that are services by the database including the location, ID, channel, height, transmit power, antenna information, time of the last report from the WSD, etc.

C. Wireless Microphone Registration Database (WMRD) 526

- Contains the wireless microphone registration data including location of the wireless microphone, channel and time of the last report.

[00179] There are two interfaces to the databases, namely, the synchronization of the database manager with other external databases 528; and the on-demand query for available channels 530 (via the Internet 532) from either administration application 534, web application 536 or embedded application with the white space devices 538.

[00180] There are two schemes to determine the white space availability at a given location. The first scheme is to use the spectrum measurements for that location. However this needs extensive measurements at low sensitivity thresholds. In additional, this is dependable on the user's transmission characteristics such as transmit power and antenna height. The second scheme is to use a model-driven approach for computing the available white spaces. The model-driven approach is adopted for the examples described hereinabove.

[00181] The Longley-Rice (L-R) model is the default model that is used for predicting signal attenuation. It may be used to predict the propagation loss of the transmissions over TV bands. For example, the locations higher than the surroundings and with unblocked views of the TV transmission towers, a terrain irregularity equivalent to a flat terrain ($\Delta h < 30$ m) may be used while for locations with high building around and blocked views of the transmission towers, a larger terrain irregularity ($30 \text{ m} < \Delta h < 200 \text{ m}$) may better predict the path loss.

[00182] In various example, the software used may be AMP software bundle which includes Apache HTTP Server, MySQL and PHP (a hypertext preprocessor).

Apache HTTP Server is an open source web server to host the PHP-based web application. MySQL is SQL database system to host the database.

[00183] Since the white space devices (WSD) are not allowed to transmit until they have successfully determined the available channels from the database. This requires
5 the initial access to the database to be carried out via other means rather than using white space frequencies. For the gateway which acts as a master, there are no problems since Internet access is allowed.

[00184] One possible implementation is to transmit a single geo-location query for its entire service area (covering the positions of all attached slave WSDs). The master
10 dynamically performs channel and power allocation for its slave white space devices. The master then performs interference calculations to ensure the total aggregated interference of all the slaves.

[00185] In FIG. 6, the frequency conversion circuit then converts the transmission to the desired frequency. The frequency conversion circuit may include a microcontroller
15 606 that controls a VCO 608 which in turn provides an oscillating source signal to a mixer 610.

[00186] In one example, for downlink connectivity, the mixer 610 may receive a WiFi/2G/3G/LTE or any other signal which may be conditioned by a 2 GHz bandpass filter 614, a bi-directional amplifier 616, and a further bandpass filter 618. The further
20 bandpass filter 618 may be a 2 GHz bandpass filter. The mixer 610 outputs a signal at the TVWS band 620, which may be conditioned by a bandpass filter 622, a bi-directional amplifier 624, and a 700 MHz bandpass filter 626. The bandpass filter 622 may be a 700 MHz bandpass filter.

[00187] In another example, for uplink connectivity, the mixer 610 may receive a
25 signal at the TVWS band 620, which may be conditioned by the bandpass filter 622, the bi-directional amplifier 624, and the 700 MHz bandpass filter 626. The mixer 610 outputs a WiFi/2G/3G/LTE or any other signal which may be conditioned by the bandpass filter 618, the bi-directional amplifier 616, and the 2 GHz bandpass filter 614.

[00188] FIG. 7 shows a schematic diagram of a remote unit 700, in accordance to
30 various embodiments illustrating a frequency converter for performing UHF to ISM conversion (e.g., similar to the remote unit 412 of FIG. 4) in detail.

[00189] At the receiver of the remote unit 700, a frequency synchronization control (not shown in FIG. 7) is used to associate the receiver (e.g., the receiver 302 of FIG. 3A) or the transmitter (e.g., the transmitter 316 of FIG. 3B) to the communication device (e.g., the AP device 600 of FIG. 6 or the AP 402 of FIG. 4), and the receiver receives signals at the frequency identified by the communication device or the transmitter transmits signals at the frequency identified by the communication device. For example, the remote unit 700 may be the transceiver device 300 of FIG. 3A or the transceiver device 310 of FIG. 3B.

[00190] In one example, for downlink connectivity, a UHF signal at the TVWS band 702 may be received from the communication device (e.g., the AP 402 of FIG. 4) by another highly directional or omni-directional antenna mounted in a rural area. An up/down converter is used to convert the signal from UHF to 2.4 GHz; thereby providing a 2.4 GHz WiFi signal. A booster for boosting the WiFi signal may be used. The boosted WiFi signal is fed to the omni-directional antenna installed in the center of the rural area. The 2.4 GHz WiFi signal is received by the various client devices (e.g., the plurality of communication terminals 416 of FIG. 4) in the vicinity of the omni-directional antenna.

[00191] In another example, for uplink connectivity, a WiFi signal 718 may be received from the communication terminal by the omni-directional antenna installed in the center of the rural area. The up/down converter is used to convert the signal from 2.4 GHz to UHF; thereby providing a UHF signal. A booster for boosting the UHF signal may be used. The boosted UHF signal is fed to the highly directional or omni-directional antenna. The UHF signal is received by the communication device.

[00192] More specifically in FIG. 7, a network control 704 is used to control a microcontroller 706 that controls a VCO 708 which in turn provides an oscillating source signal to a mixer 710.

[00193] In one example, for downlink connectivity, the mixer 710 may receive the signal at the TVWS band 702, which may be conditioned by a 700 MHz bandpass filter 712, a bi-directional amplifier 714, and a bandpass filter 716. The bandpass filter 716 may be a 700 MHz bandpass filter. The mixer 710 outputs a WiFi/2G/3G/LTE or any other signal 718 (e.g.,) which may be conditioned by a bandpass filter 720, a bi-

directional amplifier 722, and a 2 GHz bandpass filter 724. The bandpass filter 720 may be a 2 GHz bandpass filter.

[00194] In another example, for uplink connectivity, the mixer 710 may receive a WiFi/2G/3G/LTE or any other signal 718 which may be conditioned by the 2 GHz bandpass filter 724, the bi-directional amplifier 722, and the bandpass filter 720. The mixer 710 outputs a signal at the TVWS band 702, which may be conditioned by the bandpass filter 716, the bi-directional amplifier 714, and the 700 MHz bandpass filter 712.

[00195] The system 400 is different from a current system 800 as shown in FIG. 8 for comparison purpose only. In FIG. 8, the current system 800 includes an access point (AP) 802 at a terminal side. The AP 802 includes a UHF WiFi radio 804 for receiving WiFi signals. At the AP 802, ISM to UHF conversion 806 and frequency identification or determination 808 are provided. The AP 802 is connected to the Internet or Internet cloud 810. The system 800 further includes a remote unit 812 located in a remote site including a UHF modem 814 and a wireless router (or a radio) 816. The remote unit 812 is programmed to establish connections (associations) with the AP 802 and/or re-establish connections (associations) with the AP 802 whenever the selected UHF channel is changed. The frequency identification or determination 808 is based on the use of a lookup table. The ISM to UHF conversion 806 converts the frequency depending on the frequency identification or determination 808 such that communication can be carried out between the AP 802 and the remote unit 812 on the desired UHF channel. The remote unit 812 further communicates with a plurality of communication terminals 818.

[00196] It is clear from FIG. 4 that the interface at the remote unit 412 is performed at the RF level as opposed to the interface at the remote unit 812 being carried out at the data layer of the current system (FIG. 8). With the direct conversion of the system 400 in accordance with various embodiments, both the latency and component costs are lowered.

[00197] Various embodiments described herein may provide the following advantages:

- Use of UHF bands extend the range for WiFi;

- No need for two radios on each AP side and remote side as compared to the current system, for example, in FIG. 8 where two radios 804, 816 are required at the remote side;
- No extra latency due to TCP/IP level data passing as present in current systems;
- Transparent to wireless access protocols;
- Short development / deployment time; and
- Reduced components thereby resulting in ease of maintenance.

[00198] While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

CLAIMS

1. A transceiver device comprising:
 - 5 a receiver configured to wirelessly receive a signal having a master-remote frequency from a communication device;
 - a branch frequency converter configured to convert the master-remote frequency of the received signal to a remote-terminal frequency; and
 - a transmitter configured to transmit the converted signal having the remote-
 - 10 terminal frequency to a communication terminal.
2. The transceiver device of claim 1, wherein the master-remote frequency is at least one of an ultra high frequency or a very high frequency.
- 15 3. The transceiver device of claim 1 or 2, wherein the master-remote frequency is an available frequency for wirelessly receiving the signal from the communication device.
4. The transceiver device of claim 1, wherein the master-remote frequency is a frequency selected from a range of 50 MHz to 700 MHz.
- 20 5. The transceiver device of any one of claims 1 to 4, wherein the remote-terminal frequency is higher than the master-remote frequency.
6. The transceiver device of any one of claims 1 to 5, wherein the remote-terminal
- 25 frequency is selected from an unlicensed frequency band.
7. The transceiver device of any one of claims 1 to 6, wherein the remote-terminal frequency is at least one of 2.4 GHz band or 5.8 GHz band.
- 30 8. The transceiver device of any one of claims 1 to 7, wherein the branch frequency converter comprises a voltage controlled oscillator and a frequency mixer configured to

frequency mix the received signal with an oscillating source signal from the voltage controlled oscillator.

9. The transceiver device of any one of claims 1 to 8, further comprising a frequency
5 synchronization control unit configured to associate the receiver with the communication device based on the master-remote frequency.

10. The transceiver device of any one of claims 1 to 9, wherein the communication device comprises an access point.

10 11. The transceiver device of any one of claims 1 to 10, wherein the communication device further comprises an infrastructural frequency converter configured to convert the frequency of the transmitted signal.

15 12. The transceiver device of claim 11, wherein the infrastructural frequency converter is configured to communicate with the access point.

13. The transceiver device of any one of claims 1 to 12, wherein the communication device is configured to operate according to an IEEE 802.11 communication standard.

20 14. A transceiver device comprising:

a receiver configured to receive a signal having a remote-terminal frequency from a communication terminal;

a branch frequency converter configured to convert the remote-terminal frequency
25 of the received signal to a master-remote frequency; and

a transmitter configured to wirelessly transmit the converted signal having the master-remote frequency to a communication device.

15. The transceiver device of claim 14, wherein the remote-terminal frequency is
30 selected from an unlicensed frequency band.

16. The transceiver device of claim 14 or 15 wherein the remote-terminal frequency is at least one of 2.4 GHz band or 5.8 GHz band.

17. The transceiver device of any one of claims 14 to 16, wherein the master-remote
5 frequency is at least one of an ultra high frequency or a very high frequency.

18. The transceiver device of any one of claims 14 to 17, wherein the branch
frequency converter comprises a voltage controlled oscillator and a frequency mixer
configured to frequency mix the received signal with an oscillating source signal from the
10 voltage controlled oscillator.

19. The transceiver device of any one of claims 14 to 18, further comprising a
frequency synchronization control unit configured to associate the transmitter with the
communication device based on the master-remote frequency.

20. A method of transmitting a converted signal, the method comprising:
wirelessly receiving a signal having a master-remote frequency from a
communication device;
converting the master-remote frequency of the received signal to a remote-
20 terminal frequency; and
transmitting the converted signal having the remote-terminal frequency to a
communication terminal.

21. The method of claim 20, wherein the master-remote frequency is at least one of an
25 ultra high frequency or a very high frequency.

22. The method of claim 20 or 21, wherein the master-remote frequency is a
frequency selected from a range of 50 MHz to 700 MHz.

23. The method of any one of claims 20 to 22, wherein the remote-terminal frequency
30 is at least one of 2.4 GHz band or 5.8 GHz band.

24. The method of any one of claims 20 to 23, wherein converting the master-remote frequency of the received signal to a remote-terminal frequency comprises frequency mixing the received signal with an oscillating source signal from a voltage controlled oscillator.

25. The method of any one of claims 20 to 24, further comprising determining an available frequency to be the master-remote frequency for wirelessly receiving the signal from the communication device.

26. A method of receiving a signal, the method comprising:
receiving a signal having a remote-terminal frequency from a communication terminal;
converting the remote-terminal frequency of the received signal to a master-remote frequency; and
wirelessly transmitting the converted signal having the master-remote frequency to a communication device.

27. The method of claim 26, wherein the remote-terminal frequency is at least one of 2.4 GHz band or 5.8 GHz band.

28. The method of claim 26 or 27, wherein the master-remote frequency is at least one of an ultra high frequency or a very high frequency.