



(51) International Patent Classification:
H04W 48/00 (2009.01)

(21) International Application Number:
PCT/US2016/047919

(22) International Filing Date:
19 August 2016 (19.08.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/297,411 19 February 2016 (19.02.2016) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

[Continued on next page]

(54) Title: PBCH TRANSMISSION INSIDE AND OUTSIDE OF DISCOVERY REFERENCE SIGNAL TRANSMISSION WINDOW TO UES OPERATING IN UNLICENSED FREQUENCY BANDS

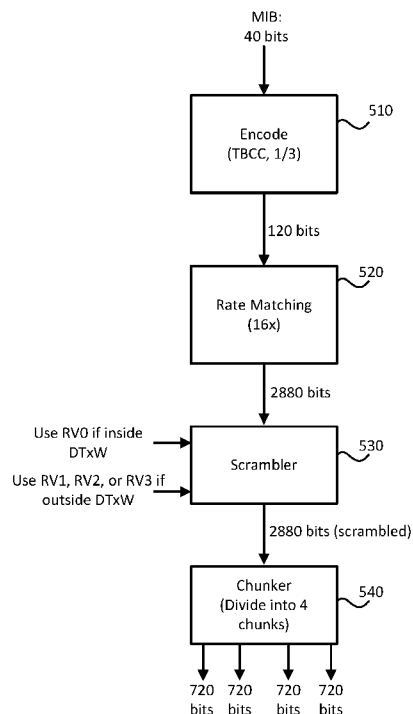


Fig. 5

(57) Abstract: A base station may opportunistically transmit the Physical Broadcast Channel (PBCH) outside and within the Discovery Reference Signal (DRS) transmission window (DTxW). In some implementations, the UE may use the redundancy version (RV) scrambling code of the Master Information Block (MIB), contained in the PBCH, to avoid ambiguity at the UE and to determine whether the PBCH is inside or outside of the DTxW.



(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE,

SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

PBCH TRANSMISSION INSIDE AND OUTSIDE
OF DISCOVERY REFERENCE SIGNAL TRANSMISSION WINDOW TO UES
OPERATING IN UNLICENSED FREQUENCY BANDS

RELATED APPLICATIONS

The present application claims the benefit of also of U.S. Provisional Patent Application No. 62/297,411, which was filed on February 19, 2016, the contents of which is hereby incorporated by reference as though fully set forth herein.

BACKGROUND

Wireless telecommunication networks often include Radio Access Networks (RANs) that enable User Equipment (UE), such as smartphones, tablet computers, laptop computers, etc., to connect to a core network. An example of a wireless telecommunications network may include an Evolved Packet System (EPS) that operates based on 3rd Generation Partnership Project (3GPP) Communication Standards. In a cellular network, UEs typically communicate with base stations using channels corresponding to a licensed spectrum of radio frequencies (e.g., a spectrum of radio frequencies designated for cellular network communications).

Technologies, such as License Assisted Access (LAA), Carrier Aggregation (CA), MulteFire®, etc., may be used to extend the connectivity of the UEs, to the core network, using unlicensed spectrum, and example of which includes the 5 Gigahertz (GHz) Unlicensed Spectrum for Wi-Fi and Other Unlicensed Uses set forth by the Federal Communications Commission (FCC) of the United States of America. Some of these technologies (such as LAA and CA) may require that the UE to maintain a carrier from the licensed spectrum (also referred to as an "anchor") in order to use a carrier in the unlicensed spectrum. By contrast, other technologies, referred to herein as "standalone technologies," such as MulteFire®, may enable UEs to obtain network connectivity without an anchor from the licensed spectrum.

For the standalone technologies, because there is no anchor in the licensed spectrum, system information, including the Master Information Block (MIB), needs to be transmitted in the unlicensed spectrum.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals may designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying

drawings.

Fig. 1 is a diagram of an example environment in which systems and/or methods described herein may be implemented;

Fig. 2 is a diagram illustrating an example of a subframe that includes a Discovery Reference Signal (DRS) transmission window (DTxW);

Figs. 3 and 4 are flowcharts illustrating example processes relating to transmission of the MIB within and outside of the DTxW;

Fig. 5 is a block diagram conceptually illustrating an example implementation of transmit-side components used to transmit the MIB within and outside of the DTxW;

Fig. 6 is a block diagram conceptually illustrating an example implementation of receive-side components used to transmit the MIB within and outside of the DTxW; and

Fig. 7 illustrates, for one embodiment, example components of an electronic device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments are defined by the appended claims and their equivalents.

Techniques are described herein for Physical Broadcast Channel (PBCH) transmission outside of the DTxW in a system operating in the unlicensed spectrum (e.g., a MulteFire® system). In particular, a transmitting node (e.g., a base station) may opportunistically transmit the PBCH outside of the DTxW. In some implementations, the UE may use the redundancy version (RV) scrambling code of the MIB, contained in the PBCH, to avoid ambiguity at the UE and to determine whether the PBCH is inside or outside of the DTxW. Advantageously, the reliability of PBCH transmissions in MulteFire® systems can be increased. Further, the techniques described herein can help to reduce UE acquisition times of the PBCH under different Listen Before Talk (LBT) conditions.

Fig. 1 is a diagram of an example environment 100 in which systems and/or methods described herein may be implemented. Environment 100 may include multiple UEs 110, wireless telecommunications network, and external networks and devices.

The wireless telecommunications network may include an Evolved Packet System (EPS) that includes a Long Term Evolution (LTE) network and/or an evolved packet core (EPC) network that operates based on 3rd Generation Partnership Project (3GPP) wireless

communication standards. The LTE network may be, or may include, RANs that include one or more base stations, such as eNBs 120 and/or Wireless Local Area Network (WLAN) Access Points (APs) 130, via which UEs 110 may communicate with the EPC network. ENBs 120 may be designed to operate using licensed frequency spectrum and WLAN APs 130 may be designed to operate using unlicensed frequency spectrum.

The EPC network may include Serving Gateway (SGW) 140, PDN Gateway (PGW) 150, and Mobility Management Entity (MME) 160. As shown, the EPC network may enable UEs 110 to communicate with an external network (labeled as External Networks and Devices), such as a Public Land Mobile Networks (PLMN), a Public Switched Telephone Network (PSTN), and/or an Internet Protocol (IP) network (e.g., the Internet).

UEs 110 may include portable computing and communication devices, such as a personal digital assistant (PDA), a smart phone, a cellular phone, a laptop computer with connectivity to the wireless telecommunications network. UE 110 may also include a non-portable computing device, such as a desktop computer, a consumer or business appliance, or another device that has the ability to connect to the RANs of the wireless telecommunications network. UE 110 may also include a computing and communication device that may be worn by a user (also referred to as a wearable device) such as a watch, a fitness band, a necklace, glasses, an eyeglass, a ring, a belt, a headset, or another type of wearable device.

UE 110 may be designed to connect to the wireless telecommunications network via licensed frequency bands (e.g., through eNBs 120) and/or unlicensed frequency bands (e.g., through WLAN AP 130). In one implementation, UE 110 may use CA and/or LAA technologies to connect to the wireless telecommunications network using both licensed and unlicensed frequencies. Alternatively, and as particularly described herein, UE 110 may use standalone technologies, such as MulteFire®, to connect to the wireless telecommunications network using only WLAN AP 130 (i.e., without communicating through eNB 120). The use of MulteFire® may be particularly useful when, for example, UE 110 is within wireless communication range of WLAN AP 130 but is not within range of eNB 120.

eNB 120 may include one or more network devices that receive, process, and/or transmit traffic destined for and/or received from UE 110 (e.g., via an air interface). eNB 120 may coordinate with WLAN AP 130 to implement LAA, CA, etc., in order to increase the network resources (e.g., the uplink and/or downlink bandwidth) of the wireless telecommunications network.

WLAN AP 130 may include one or more network device that receive, process, and/or transmit traffic destined for and/or received from UE 110 (e.g., via an air interface). In some

implementations, WLAN AP 130 may implement a standalone (e.g., a non-anchored) version of the 3GPP LTE Communication Standard in the 5 Gigahertz (GHz) Unlicensed Spectrum for Wi-Fi and Other Unlicensed Uses as set forth by the Federal Communications Commission (FCC) of the United States of America. In some implementations, this may include implementing

5 MulteFire® technologies or another type of standalone communication standard. WLAN AP 130 may also coordinate with eNB 120 to implement LAA, CA, etc., in order to increase the network resources (e.g., the uplink and/or downlink bandwidth) of the wireless telecommunications network.

SGW 140 may aggregate traffic received from one or more eNBs 120 and/or WLAN

10 APs 130, and may send the aggregated traffic to an external network or device via PGW 150. Additionally, SGW 140 may aggregate traffic received from one or more PGWs 150 and may send the aggregated traffic to one or more eNBs 120 and/or WLAN APs 130. SGW 140 may operate as an anchor for the user plane during inter-eNB handovers and as an anchor for mobility between different telecommunication networks.

MME 160 may include one or more computation and communication devices that act as

15 a control node for eNB 120 and/or other devices (e.g., WLAN AP 130) that provide the air interface for the wireless telecommunications network. For example, MME 160 may perform operations to register UE 110 with the wireless telecommunications network, to establish bearer channels (e.g., traffic flows) associated with a session with UE 110, to hand off UE 110 to a

20 different eNB, MME, or another network, and/or to perform other operations. MME 160 may perform policing operations on traffic destined for and/or received from UE 110.

PGW 150 may include one or more network devices that may aggregate traffic received from one or more SGWs 140, and may send the aggregated traffic to an external network. PGW

25 150 may also, or alternatively, receive traffic from the external network and may send the traffic toward UE 110 (via eNB 120 and/or WLAN 130).

The quantity of devices and/or networks, illustrated in Fig. 1, is provided for explanatory purposes only. In practice, there may be additional devices and/or networks; fewer devices and/or networks; different devices and/or networks; or differently arranged devices and/or networks than illustrated in Fig. 1. Alternatively, or additionally, one or

30 more of the devices of system 100 may perform one or more functions described as being performed by another one or more of the devices of system 100. Furthermore, while "direct" connections are shown in Fig. 1, these connections should be interpreted as logical communication pathways, and in practice, one or more intervening devices (e.g., routers, gateways, modems, switches, hubs, etc.) may be present.

For MulteFire®, the DTxW is defined as a window in which eNB 120 can transmit the DRS. In LTE systems, DRS is transmitted to enable UEs to facilitate the small cell on/off transitions. For example, the UE may use the DRS to perform cell detection, Radio Resource Management (RRM) measurement, and/or to determine appropriate time and frequency compensation parameters for the channel. The signals that are included in the DRS may include, for example, the Primary Synchronization Signals (PSS), Secondary Synchronization Signals (SSS), the Cell-specific Reference Signals (CRS), and optionally the Channel State Information Reference Signals (CSI-RS). For MulteFire® systems, PBCH carrying MIB may be additionally inserted into the DRS.

In order to increase transmission opportunities, the location of the DRS transmission within the DTxW may be variable (i.e., floating). For example, the DRS may be transmitted within any subframe of the DTxW. In MulteFire®, the particular location of the DRS within the DTxW may be specified using a 3-bit field offset that is transmitted in the MIB. The 3-bit field may be used to communicate an offset value from a particular subframe number, such as with respect to subframe zero or five. The MIB may additionally include system control information, such as system bandwidth information and other control information that may be needed for UEs to communicate with a network communication cell. For example, in addition to the 3-bit offset field, the MIB may include a 3-bit bandwidth information field, a 3-bit Physical Hybrid-ARQ Indicator Channel (PHICH) configuration field, and an 8-bit System Frame Number (SFN) field.

In addition to being able to transmit the MIB (via the PBCH) in the DTxW, WLAN AP 120 may also opportunistically transmit (e.g., subject to LBT and based on eNB implementation) the PBCH outside the DTxW at subframe zero of a frame.

Fig. 2 is a diagram illustrating an example of a subframe that includes a Discovery Reference Signal (DRS) transmission window (DTxW). Fig. 2 may particularly illustrate a channel map relating to the usage of resource elements (REs) in an Orthogonal Frequency-Division Multiplexing (OFDM) transmission scheme. In Fig. 2, the frequency domain is represented on the vertical axes and the time domain on the horizontal axes.

A single subframe 210 is illustrated in Fig. 2. The subframe may be based on a particular carrier bandwidth (e.g., 5 MHz, 10 MHz, or 20 MHz). The total carrier bandwidth may be divided into a number of OFDM sub-carriers. For example, each sub-carrier may have a bandwidth of 15 kHz or 7.5 kHz. In subframe 210, each sub-carrier may be used to transmit a particular number of symbols (illustrated as 14 symbols, labeled as symbols 0 to 13 in Fig. 2). A symbol may represent the smallest discrete part of a

frame/subframe. In various implementations, a symbol may represent 2, 4, or 6 bits of information per symbol.

As mentioned, subframe 210 may be subframe that is designated as including a DTxW, and may thus include DRS information. As shown, in Fig. 2, the DRS may be transmitted in which various resource elements (e.g., OFDM symbols) of subframe 210 are designated as CRS, PSS, the SSS, CSI-RS, and PBCH resource elements. The resource elements corresponding to the PBCH may be particularly used to communicate the MIB. As shown in Fig. 2, the PBCH may be transmitted using symbols 4, 7, 8, 9, 10, and 11. The symbols may be used for the PBCH both inside and outside of the DTxW.

Although the MIB may be transmitted every 10ms, the information content (i.e., the payload) of the MIB may change less frequently (e.g., every 40ms). In this situation, UE 110 may receive four redundant MIBs. Each of the four redundant MIBs may be encoded using one of four predefined redundancy version (RV) scrambling codes. The different RVs may cause the MIBs to be scrambled with different sequences.

As previously mentioned, the MIB may include a 3-bit information field that is used to indicate, to UE 110, the location of the DRS as a subframe offset value. This can potentially cause issues, at UE 110, when the MIB is transmitted outside of the DTxW, because outside of the DTxW the MIB, if transmitted, is always transmitted in subframe zero.

Fig. 3 is a flowchart illustrating an example process 300 relating to transmission of the MIB within and outside of the DTxW. Process 300 may be performed by, for example, UE 110.

Process 300 may include decoding a MIB received in a subframe (block 310). The decoding, by UE 110, may generally include modulation or demodulation, descrambling, and de-rate-matching. In one implementation, the decoding may be performed by a baseband processor(s) of UE 110. When descrambling the MIB, UE 110 may test the MIB to determine whether the MIB is encoded using RV0 (redundancy version zero), RV1 (redundancy version one), RV2 (redundancy version two), or RV3 (redundancy version three). In one implementation, UE 110 may simultaneously descramble the MIB using each of RV0, RV1, RV2, and RV3. UE 110 may thus determine which redundancy version scrambling code (i.e., RV0, RV1, RV2, or RV3) was used, based on which descrambled MIB is valid. In this manner, UE 110 may perform hypothesis testing to identify the RV scrambling code that was used to encode the MIB.

Process 300 may further include determining whether the redundancy version matches a predetermined redundancy version (block 320). In one implementation, the predetermined redundancy version may be RV0.

When the redundancy version matches the predetermined version value (e.g., RV0), this may be a signal, to UE 110, that the DRS was transmitted within the DTxW. In this case, UE 110 may use the MIB offset field (i.e., the 3-bit offset field) to locate the subframe corresponding to the DRS (and hence the PBCH) (block 320 – Yes; block 330).

When the redundancy version does not match the predetermined version value (e.g., the RV value is not RV0), this may be a signal, to UE 110, that the DRS was transmitted outside of the DTxW. In this case, the UE may determine that the PBCH is located at subframe zero (block 320 – No; block 340). The offset field may be effectively ignored by UE 110 (block 340). Thus, outside of the DTxW, the MIB may still contain subframe offset information, but UE 110 may ignore the subframe offset information.

Based on the location of the PBCH/DRS, as determined by the UE based on whether the 3-bit offset field was used (block 330) or ignored (block 340), the UE may continue to process the PBCH/DRS (block 350). In particular, UE 110 may process the PBCH/DRS in the normal manner to obtain control information.

Fig. 4 is a flowchart illustrating an example process 400 relating to transmission of the MIB within and outside of the DTxW. Process 400 may be performed by, for example, WLAN AP 130 (or eNB 120).

Process 400 may include opportunistically determining to transmit PBCH outside of the DTxW (block 410). For example, in order to increase transmission opportunities for the MIB, WLAN AP 130 may determine to transmit the MIB, within the PBCH, outside of the DTxW. In this case, the PBCH may be transmitted at subframe zero of a frame. The PBCH may be transmitted opportunistically, which may refer to the transmission of the PBCH subject to LBT constraints. In LBT, the WLAN AP 130 may "listen" to a particular channel before using the channel, and may only use the channel when the channel is determined to not be in use (e.g., interference for the channel is less than a threshold) by another device (e.g., a WiFi access point).

Process 400 may further include encoding the MIB using a redundancy version other than the predetermined redundancy version (block 420). As discussed with respect to Fig. 3, in one implementation, the predetermined redundancy value may be zero (RV0). Thus, WLAN AP 130 may use RV1, RV2, or RV3 to encode the MIB. Process 400 may further include transmitting the PBCH (including the MIB) (block 430). By encoding the

MIB using a redundancy version that is not the predetermined RV version, WLAN AP 130 may signal, to UE 110, that the PBCH is being transmitted outside of the DTxW. Within the DTxW, the predetermined redundancy version (e.g., RV0), may always be used. In this manner, the MIB can be opportunistically transmitted every 10ms outside of the DTxW; however, the predetermined RV version (e.g., RV0) is only transmitted within the DTxW.

Fig. 5 is a block diagram conceptually illustrating an example implementation of transmit-side components used to transmit the MIB within and outside of the DTxW. The components of Fig. 5 may be implemented, for example, by baseband processing logic in WLAN AP 130 (or eNB 120). The components of Fig. 5 may be used to implement the process of Fig. 4.

As mentioned, the MIB may include system control information, needed by UEs, in order to be able to access and operate properly within the wireless telecommunications network. The MIB may be a 40-bit block that may include a number of fields.

A tail-bit convolutional code (TBCC) 510 may initially encode the 40 bit MIB with a 1/3-rate tail-bit convolutional code to obtain 120 bits of encoded information. The encoded 120 bits may be repeated 16 times by rate-matcher 520, which may result in 2880 output bits. Scrambler 530 may operate to scramble the 2880 output bits. The scrambling may be performed pursuant to one of four 3GPP standardized scrambling techniques (i.e., RV0, RV1, RV2, or RV3). In one implementation, and as discussed with respect to Fig. 4, the scrambling may be performed, by WLAN AP 130, such that RV0 is used when the MIB is within the DTxW. Outside of the DTxW, one of RV1, RV2, or RV3 may instead be used. The output of scrambler 530 may include 2880 scrambled bits. In some implementations, the bit sequence may be zero padded either before or after scrambling by scrambler 530.

The scrambled bits may then be divided into 4 sections (chunks) by chunker 540. Each chunk may be 720 bits and the 720 bit chunks may be successively transmitted, every 10 ms. A new MIB may be generated, by WLAN AP 130, every 40 ms.

Fig. 6 is a block diagram conceptually illustrating an example implementation of receive-side components used to transmit the MIB within and outside of the DTxW. The components of Fig. 6 may be implemented, for example, by baseband processing logic in UE 110. The components of Fig. 6 may be used to implement the process of Fig. 3.

Data received by UE 110, via the radio link with WLAN AP 130, may be processed to perform, for example, demodulation, OFDM processing, and resource element (RE) demapping (block 610) (illustrated as being performed by demodulation, OFDM

processing, and RE demapping component 610). For the MIB, a 720 bit sequence (i.e., the outputs of the processing shown in Fig. 5), may be received (e.g., every 10 ms).

Descrambler 620 may descramble the 720 bit sequence based on the correct redundancy version scrambling code. In one implementation, descrambler 620 may do hypothesis testing, for the redundancy version, by performing the descrambling using all of the possible redundancy version scrambling codes until a valid descrambled bit sequence is obtained. In some implementations, all four redundancy version scrambling codes may be applied, in parallel, to obtain the correctly descrambled bit sequence (e.g., 720 bits). Descrambler 620 may additionally output the indication (RV) of the detected redundancy version scrambling code.

The output of descrambler 620 may be input to derate matcher 630, which may derate-match the sequence with a rate of 1/6. The output of derate matcher 630 may include a 120 bit sequence, which may be input to decoder 640. Decoder 640 may perform TBCC decoding, using 1/3-rate tail-bit convolutional code to, to obtain the 40 bits of payload data for the MIB.

Although the description above generally discussed a MIB having a length of 40 bits, in different implementations, MIB lengths other than 40 bits may be used. For example, different rate matching values and encoding redundancy values may be used to modify the MIB length. In some implementations, instead of 40 bits, the MIB length may be particularly set to be 30 or 32 bits. More particularly, in one implementation, the MIB payload may have a length of X-bits (e.g., X equals 30, 32, or 40 bits). The MIB payload may be TBCC encoded at a rate of 1/3, and the resulting 3X-bit sequence may be repeated $4n$ times through a rate matcher, with an output of $12*n*X$ bits, where n is an integer (e.g., 6 or 7). The rate-matched bits may then be scrambled. The scrambled bits may be divided into 4 chunks and each chunk may be QPSK modulated to obtain $(3nX - Y)/2$ OFDM symbols and mapped to $(3nX-Y)/2$ REs for transmission every 10 ms (where Y depends on X, n, and the available REs).

As used herein, the term "circuitry" or "processing circuitry" may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Fig. 7 illustrates, for one embodiment, example components of an electronic device 700. In embodiments, the electronic device 700 may be a UE, an eNB, a WLAN AP, or some other appropriate electronic device. In some embodiments, the electronic device 700 may include application circuitry 702, baseband circuitry 704, Radio Frequency (RF) circuitry 706, front-end module (FEM) circuitry 708 and one or more antennas 760, coupled together at least as shown. In other embodiments, any of said circuitries can be included in different devices.

The application circuitry 702 may include one or more application processors. For example, the application circuitry 702 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage, and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system. In some implementations, storage medium 703 may include a non-transitory computer-readable medium. The memory/storage may include, for example, computer-readable medium 703, which may be a non-transitory computer-readable medium. Application circuitry 702 may, in some embodiments, connect to or include one or more sensors, such as environmental sensors, cameras, etc.

Baseband circuitry 704 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 704 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 706 and to generate baseband signals for a transmit signal path of the RF circuitry 706. Baseband processing circuitry 704 may interface with the application circuitry 702 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 706. For example, in some embodiments, the baseband circuitry 704 may include a second generation (2G) baseband processor 704a, third generation (3G) baseband processor 704b, fourth generation (4G) baseband processor 704c, and/or other baseband processor(s) 704d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 704 (e.g., one or more of baseband processors 704a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 706. The radio control functions may include, but are not limited to, signal modulation/demodulation,

encoding/decoding, radio frequency shifting, etc. In some implementations, baseband circuitry 704 may be associated with storage medium 703 or with another storage medium.

In some embodiments, modulation/demodulation circuitry of the baseband circuitry 704 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 704 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments. In some embodiments, the baseband circuitry 704 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (E-UTRAN) protocol including, for example, physical (PHY), MAC, radio link control (RLC), PDCP, and/or radio resource control (RRC) elements. A central processing unit (CPU) 704e of the baseband circuitry 704 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 704f. The audio DSP(s) 704f may include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

The baseband circuitry 704 may further include memory/storage 704g. The memory/storage 704g may be used to load and store data and/or instructions for operations performed by the processors of the baseband circuitry 704. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 704g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 704g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 704 and the application circuitry 702 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 704 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the

baseband circuitry 704 may support communication with an E-UTRAN and/or other wireless metropolitan area networks (WMAN), a WLAN, a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 704 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 706 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 706 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 706 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 708 and provide baseband signals to the baseband circuitry 704. RF circuitry 706 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 704 and provide RF output signals to the FEM circuitry 708 for transmission.

In some embodiments, the RF circuitry 706 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 706 may include mixer circuitry 706a, amplifier circuitry 706b and filter circuitry 706c. The transmit signal path of the RF circuitry 706 may include filter circuitry 706c and mixer circuitry 706a. RF circuitry 706 may also include synthesizer circuitry 706d for synthesizing a frequency for use by the mixer circuitry 706a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 706a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 708 based on the synthesized frequency provided by synthesizer circuitry 706d. The amplifier circuitry 706b may be configured to amplify the down-converted signals and the filter circuitry 706c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals.

Output baseband signals may be provided to the baseband circuitry 704 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 706a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 706a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 706d to generate RF output signals for the FEM circuitry 708. The baseband signals may be provided by the baseband circuitry 704 and may be filtered by filter

circuitry 706c. The filter circuitry 706c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 706a of the receive signal path and the mixer circuitry 706a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 706a of the receive signal path and the mixer circuitry 706a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 706a of the receive signal path and the mixer circuitry 706a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 706a of the receive signal path and the mixer circuitry 706a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 706 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 704 may include a digital baseband interface to communicate with the RF circuitry 706.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 706d may be a fractional-N synthesizer or a fractional N/N+6 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 706d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 706d may be configured to synthesize an output frequency for use by the mixer circuitry 706a of the RF circuitry 706 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 706d may be a fractional N/N+6 synthesizer.

In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 704 or the applications processor 702 depending on the desired

output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 702.

Synthesizer circuitry 706d of the RF circuitry 706 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or N+6 (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into N_d equal packets of phase, where N_d is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 706d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (fLO). In some embodiments, the RF circuitry 706 may include an IQ/polar converter.

FEM circuitry 708 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 760, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 706 for further processing. FEM circuitry 708 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 706 for transmission by one or more of the one or more antennas 760.

In some embodiments, the FEM circuitry 708 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 706). The transmit signal path of the FEM circuitry 708 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 706), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 760).

In some embodiments, the electronic device 700 may include additional elements such as, for example, memory/storage, display, camera, sensors, and/or input/output (I/O) interface. In some embodiments, the electronic device of Fig. 7 may be configured to perform one or more methods, processes, and/or techniques such as those described herein.

5 A number of examples, relating to embodiments of the techniques described above, will next be given.

In a first example, a baseband apparatus for User Equipment (UE) for a cellular network, may comprise one or more processors to process, for radio subframes that are within a Discovery Reference Signal (DRS) Transmission Window (DTxW) and that are received
10 via an unlicensed frequency band, a Physical Broadcast Channel (PBCH) that contains control information for connecting with the cellular network, the PBCH being located, within the DTxW, at a particular subframe of a plurality of subframes within the DTxW, wherein the PBCH within the DTxW is received using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven of the
15 particular subframe; and process the PBCH from a radio subframe that is not within the DTxW and that is received, via the unlicensed band, at radio subframe zero, wherein the processing of the radio subframes, both within and outside of the DTxW, includes identifying Master Information Block (MIB) structures from the PBCH, both within and not within the DTxW.

20 In example 2, the subject matter of claim 1, or any of the examples herein, wherein the particular subframe is indicated as an offset value, offset with respect to subframe zero or five, that is included in the MIB or an earlier MIB.

In example 3, the subject matter of claim 1, or any of the examples herein, wherein the one or more processors are further to: descramble the MIB using a plurality of
25 Redundancy Version (RV) scrambling codes; determine which of the plurality of RV scrambling codes resulted in a valid descrambling of the MIB; and ignore the offset value when the determined RV scrambling code does not match a predetermined RV scrambling code.

30 In example 4, the subject matter of claim 3, or any of the examples herein, wherein the RV scrambling codes are each of length 720 bits.

In example 5, the subject matter of claims 1 or 2, or any of the examples herein, wherein the MIB, within the DTxW, is scrambled using Redundancy Version (RV) zero.

In example 6, the subject matter of claims 1 or 2, or any of the examples herein, wherein the one or more processors are further to: descramble the MIB using a plurality of

redundancy version scrambling codes; derate match, by one-sixth, the descrambled version of the MIB; and perform tail-bit convolutional decoding (TBCC) on an output of the derate matching.

In example 7, the subject matter of claim 1, or any of the examples herein, wherein
5 the MIB structure is periodically identified at 10 milli-second intervals.

In an eighth example, a UE comprising logic to: process, for subframes that are within a Discovery Reference Signal (DRS) Transmission Window (DTxW) and that are received via an unlicensed frequency band, a Physical Broadcast Channel (PBCH) that contains control information for connecting with the cellular network, the PBCH being
10 located, within the DTxW, at a particular subframe of the plurality of subframes within the DTxW, the processing including descrambling the PBCH using Redundancy Version (RV) zero scrambling code; process, the PBCH from a subframe that is not within the DTxW and that is received, via the unlicensed band, at subframe zero, the processing of subframe zero including descrambling the PBCH using an RV scrambling code other than RV zero;
15 wherein the processing of the subframes of the DTxW includes identifying Master Information Block (MIB) structures from the PBCH within and not within the DTxW.

In example 9, the subject matter of claim 8, or any of the examples herein, wherein the PBCH within the DTxW is received using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven of the particular
20 subframe.

In example 10, the subject matter of claims 8 or 9, or any of the examples herein, wherein the particular subframe is indicated as an offset value, offset with respect to subframe zero or five, that is included in the MIB or an earlier MIB.

In example 11, the subject matter of claim 10, or any of the examples herein,
25 further comprising logic to: descramble the MIB using a plurality of Redundancy Version (RV) scrambling codes; determine which of the plurality of RV scrambling codes resulted in a correct code that resulted in a valid descrambling of the MIB; and ignore the offset value when the determined RV scrambling code does not match a predetermined RV scrambling code that is defined for MIB transmission within the DTxW.

In example 12, the subject matter of claim 11, or any of the examples herein,
30 wherein the RV scrambling codes are each of length 720 bits.

In example 13, the subject matter of claims 8 or 9, or any of the examples herein, wherein the MIB, within the DTxW, is scrambled using Redundancy Version (RV) zero.

In example 14, the subject matter of claims 8 or 9, or any of the examples herein, further comprising logic to: descramble the MIB using a plurality of redundancy version scrambling codes; derate match, by one-sixth, the descrambled version of the MIB; and perform tail-bit convolutional decoding (TBCC) on an output of the derate matching.

5 In example 15, the subject matter of claim 8, or any of the examples herein, wherein the MIB structure is periodically identified at 10 milli-second intervals.

In a sixteenth example, a base station may comprise circuitry to: transmit, via an unlicensed frequency band and for subframes of a frame corresponding to Discovery Reference Signal (DRS) Transmission Window (DTxW) subframes, a Physical Broadcast Channel (PBCH) that contains control information for enabling User Equipment (UE) to
10 connect with a cellular network, the PBCH being included at a particular subframe within the DTxW, wherein the PBCH within the DTxW is encoded using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven of the particular subframe within the DTxW; and opportunistically transmit, subject
15 to Listen Before Talk (LBT) constraints, the Physical Broadcast Channel (PBCH), outside of the DTxW, using the unlicensed frequency band and at subframe zero of a frame.

In example 17, the subject matter of claim 16, or any of the examples herein, wherein the PBCH, both within and outside of the DTxW, includes a Master Information Block (MIB) structure.

20 In example 18, the subject matter of claim 17, or any of the examples herein, wherein the selectable subframe is indicated as an offset value that is included in the MIB or an earlier MIB.

In example 19, the subject matter of claim 17, or any of the examples herein, wherein the circuitry is further to: scramble the MIB using Redundancy Version (RV) zero
25 scrambling code when the MIB is transmitted within the DTxW; and scramble the MIB using a RV other than zero when the MIB is transmitted outside of the DTxW.

In example 20, the subject matter of claim 17, or any of the examples herein, wherein the RV scrambling codes are each of length 720 bits.

In example 21, the subject matter of claim 17, or any of the examples herein,
30 wherein the MIB structure is 30, 32, or 40 bits in length.

In a twenty-second, a base station may comprising logic to: generate, for subframes of a frame corresponding to Discovery Reference Signal (DRS) Transmission Window (DTxW) subframes, first Physical Broadcast Channel (PBCH) data that contains control information for enabling User Equipment (UE) to connect with the cellular network, the

first PBCH data being located, within the DTxW, at a particular subframe of a plurality of subframes within the DTxW, where generation of the first PBCH data includes scrambling the first PBCH data using Redundancy Version (RV) zero scrambling code; generate second PBCH data, at a subframe outside of the DTxW, the generation of the second
5 PBCH data including scrambling the second PBCH using a RV scrambling code other than RV zero; and transmit the first and second PBCH using an unlicensed frequency band.

In example 23, the subject matter of claim 22, or any of the examples herein, wherein the second PBCH data is opportunistically included, subject to Listen Before Talk (LBT) constraints, within subframe zero of a frame.

10 In example 24, the subject matter of claim 22, or any of the examples herein, wherein the first and second PBCH data is transmitted using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven.

In example 25, the subject matter of claim 22, or any of the examples herein,
15 wherein the selectable subframe is indicated as an offset value that is included in a Master Information Block (MIB).

In a twenty-sixth, a method, implemented by User Equipment (UE), comprising: processing, for radio subframes of a frame corresponding to Discovery Reference Signal (DRS) Transmission Window (DTxW) subframes that are received via an unlicensed
20 frequency band, a Physical Broadcast Channel (PBCH) that contains control information for connecting with a cellular network, the PBCH being located, within the DTxW, at a particular subframe of a plurality of subframes within the DTxW, wherein the PBCH within the DTxW is received using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven of the particular subframe; and
25 processing, the PBCH from a radio subframe that is not within the DTxW and that is received, via the unlicensed band, at radio subframe zero, wherein the processing of the radio subframes, both within and outside of the DTxW, includes identifying Master Information Block (MIB) structures from the PBCH within and not within the DTxW.

In example 27, the subject matter of claim 26, or any of the examples herein,
30 wherein the particular subframe is indicated as an offset value that is included in the MIB or an earlier MIB.

In example 28, the subject matter of claim 27, or any of the examples herein, further comprising: descrambling the MIB using a plurality of Redundancy Version (RV) scrambling codes; determining which of the plurality of RV scrambling codes resulted in a

valid descrambling of the MIB; and ignoring the offset value when the determined correct code does not match a predetermined RV scrambling code.

In example 29, the subject matter of claim 28, or any of the examples herein, wherein the RV scrambling codes are each of length 720 bits.

5 In a 30th example UE may comprise: means for processing, for radio subframes of a frame corresponding to Discovery Reference Signal (DRS) Transmission Window (DTxW) subframes that are received via an unlicensed frequency band, a Physical Broadcast Channel (PBCH) that contains control information for connecting with a cellular network, the PBCH being located, within the DTxW, at a particular subframe of a plurality of
10 subframes within the DTxW, wherein the PBCH within the DTxW is received using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven of the particular subframe; and means for processing the PBCH from a radio subframe that is not within the DTxW and that is received, via the unlicensed band, at radio subframe zero, wherein the processing of the radio subframes, both within and
15 outside of the DTxW, includes identifying Master Information Block (MIB) structures from the PBCH within and not within the DTxW.

In example 31, the subject matter of claim 30, or any of the examples herein, wherein the particular subframe is indicated as an offset value, offset with respect to subframe zero or five, that is included in the MIB or an earlier MIB.

20 In example 32, the subject matter of claim 32, or any of the examples herein, further comprising: means for descrambling the MIB using a plurality of Redundancy Version (RV) scrambling codes; means for determining which of the plurality of RV scrambling codes resulted in a valid descrambling of the MIB; and means for ignoring the offset value when the determined correct code does not match a predetermined RV
25 scrambling code.

In example 33, the subject matter of claim 32, or any of the examples herein, wherein the RV scrambling codes are each of length 720 bits.

In the preceding specification, various embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and
30 changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

For example, while series of signals and/or operations have been described with regard to one or more figures, the order of the signals may be modified in other embodiments. Further, non-dependent signals/operations may be performed in parallel.

It will be apparent that example aspects, as described above, may be implemented in many different forms of software, firmware, and hardware in the embodiments illustrated in the figures. The actual software code or specialized control hardware used to implement these aspects should not be construed as limiting. Thus, the operation and behavior of the aspects were described without reference to the specific software code--it being understood that software and control hardware could be designed to implement the aspects based on the description herein.

Further, certain portions may be implemented as "logic" that performs one or more functions. This logic may include hardware, such as an application-specific integrated circuit ("ASIC") or a field programmable gate array ("FPGA"), or a combination of hardware and software.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to be limiting. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

No element, act, or instruction used in the present application should be construed as critical or essential unless explicitly described as such. An instance of the use of the term "and," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Similarly, an instance of the use of the term "or," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Also, as used herein, the article "a" is intended to include one or more items, and may be used interchangeably with the phrase "one or more." Where only one item is intended, the terms "one," "single," "only," or similar language is used.

WHAT IS CLAIMED IS:

1. A baseband apparatus for User Equipment (UE) for a cellular network, comprising one or more processors to:

process, for radio subframes that are within a Discovery Reference Signal (DRS) Transmission Window (DTxW) and that are received via an unlicensed frequency band, a Physical Broadcast Channel (PBCH) that contains control information for connecting with the cellular network, the PBCH being located, within the DTxW, at a particular subframe of a plurality of subframes within the DTxW, wherein the PBCH within the DTxW is received using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven of the particular subframe; and

process the PBCH from a radio subframe that is not within the DTxW and that is received, via the unlicensed band, at radio subframe zero,

wherein the processing of the radio subframes, both within and outside of the DTxW, includes identifying Master Information Block (MIB) structures from the PBCH, both within and not within the DTxW.

2. The baseband apparatus of claim 1, wherein the particular subframe is indicated as an offset value, offset with respect to subframe zero or five, that is included in a MIB of the MIB structures.

3. The baseband apparatus of claim 2, wherein the one or more processors are further to:

descramble the MIB using a plurality of Redundancy Version (RV) scrambling codes;

determine which of the plurality of RV scrambling codes resulted in a valid descrambling of the MIB; and

ignore the offset value when the determined RV scrambling code does not match a predetermined RV scrambling code.

4. The baseband apparatus of claim 3, wherein the RV scrambling codes are each of length 720 bits.

5. The baseband apparatus of claim 1 or 2, wherein the MIB, within the DTxW, is scrambled using Redundancy Version (RV) zero.

6. The baseband apparatus of claim 1 or 2, wherein the one or more processors are further to:

descramble the MIB using a plurality of redundancy version scrambling codes;
5 derate match, by one-sixth, the descrambled version of the MIB; and
perform tail-bit convolutional decoding (TBCC) on an output of the derate matching.

7. The baseband apparatus of claim 1, wherein the MIB structure is periodically identified at 10 milli-second intervals.

8. User Equipment (UE) comprising logic to:

process, for subframes that are within a Discovery Reference Signal (DRS) Transmission Window (DTxW) and that are received via an unlicensed frequency band, a Physical Broadcast Channel (PBCH) that contains control information for connecting with
15 the cellular network, the PBCH being located, within the DTxW, at a particular subframe of the plurality of subframes within the DTxW, the processing including

descrambling the PBCH using Redundancy Version (RV) zero scrambling code;

process, the PBCH from a subframe that is not within the DTxW and that is
20 received, via the unlicensed band, at subframe zero, the processing of subframe zero including

descrambling the PBCH using an RV scrambling code other than RV zero;
wherein the processing of the subframes of the DTxW includes identifying Master Information Block (MIB) structures from the PBCH within and not within the DTxW.

9. The UE of claim 8, wherein the PBCH within the DTxW is received using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven of the particular subframe.

10. The UE of claim 8 or 9, wherein the particular subframe is indicated as an offset value, offset with respect to subframe zero or five, that is included in a MIB of the MIBs.

11. The UE of claim 10, further comprising logic to:

descramble the MIB using a plurality of Redundancy Version (RV) scrambling codes;

determine which of the plurality of RV scrambling codes resulted in a correct code that resulted in a valid descrambling of the MIB; and

5 ignore the offset value when the determined RV scrambling code does not match a predetermined RV scrambling code that is defined for MIB transmission within the DTxW.

12. The UE of claim 11, wherein the RV scrambling codes are each of length 720 bits.

10

13. The UE of claim 8 or 9, wherein the MIB, within the DTxW, is scrambled using Redundancy Version (RV) zero.

14. The UE of claim 8 or 9, further comprising logic to:
15 descramble the MIB using a plurality of redundancy version scrambling codes;
derate match, by one-sixth, the descrambled version of the MIB; and
perform tail-bit convolutional decoding (TBCC) on an output of the derate matching.

15. The UE of claim 8, wherein the MIB structure is periodically identified at 10
20 milli-second intervals.

16. A base station comprising circuitry to:
transmit, via an unlicensed frequency band and for subframes of a frame
corresponding to Discovery Reference Signal (DRS) Transmission Window (DTxW)
25 subframes, a Physical Broadcast Channel (PBCH) that contains control information for
enabling User Equipment (UE) to connect with a cellular network, the PBCH being
included at a particular subframe within the DTxW, wherein the PBCH within the DTxW
is encoded using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols
four, seven, eight, nine, ten, and eleven of the particular subframe within the DTxW; and
30 opportunistically transmit, subject to Listen Before Talk (LBT) constraints, the
Physical Broadcast Channel (PBCH), outside of the DTxW, using the unlicensed frequency
band and at subframe zero of a frame.

17. The base station of claim 16, wherein the PBCH, both within and outside of

the DTxW, includes Master Information Block (MIB) structures.

18. The base station of claim 17, wherein the particular subframe is indicated as an offset value that is included in the MIB or an earlier MIB.

5

19. The base station of claim 17, wherein the circuitry is further to:
scramble the MIB using Redundancy Version (RV) zero scrambling code when the MIB is transmitted within the DTxW; and

10 scramble the MIB using a RV other than zero when the MIB is transmitted outside of the DTxW.

20. The base station of claim 17, wherein the RV scrambling codes are each of length 720 bits.

15 21. The base station of claim 17, wherein the MIB structure is 30, 32, or 40 bits in length.

22. A base station comprising logic to:

20 generate, for subframes of a frame corresponding to Discovery Reference Signal (DRS) Transmission Window (DTxW) subframes, first Physical Broadcast Channel (PBCH) data that contains control information for enabling User Equipment (UE) to connect with the cellular network, the first PBCH data being located, within the DTxW, at a particular subframe of a plurality of subframes within the DTxW, where generation of the first PBCH data includes scrambling the first PBCH data using Redundancy Version
25 (RV) zero scrambling code;

generate second PBCH data, at a subframe outside of the DTxW, the generation of the second PBCH data including scrambling the second PBCH using a RV scrambling code other than RV zero; and

transmit the first and second PBCH using an unlicensed frequency band.

30

23. The base station of claim 22, wherein the second PBCH data is opportunistically included, subject to Listen Before Talk (LBT) constraints, within subframe zero of a frame.

24. The base station of claim 22, wherein the first and second PBCH data is transmitted using at least Orthogonal Frequency-Division Multiplexing (OFDM) symbols four, seven, eight, nine, ten, and eleven.

- 5 25. The base station of claim 22, wherein the particular subframe is indicated as an offset value that is included in a Master Information Block (MIB).

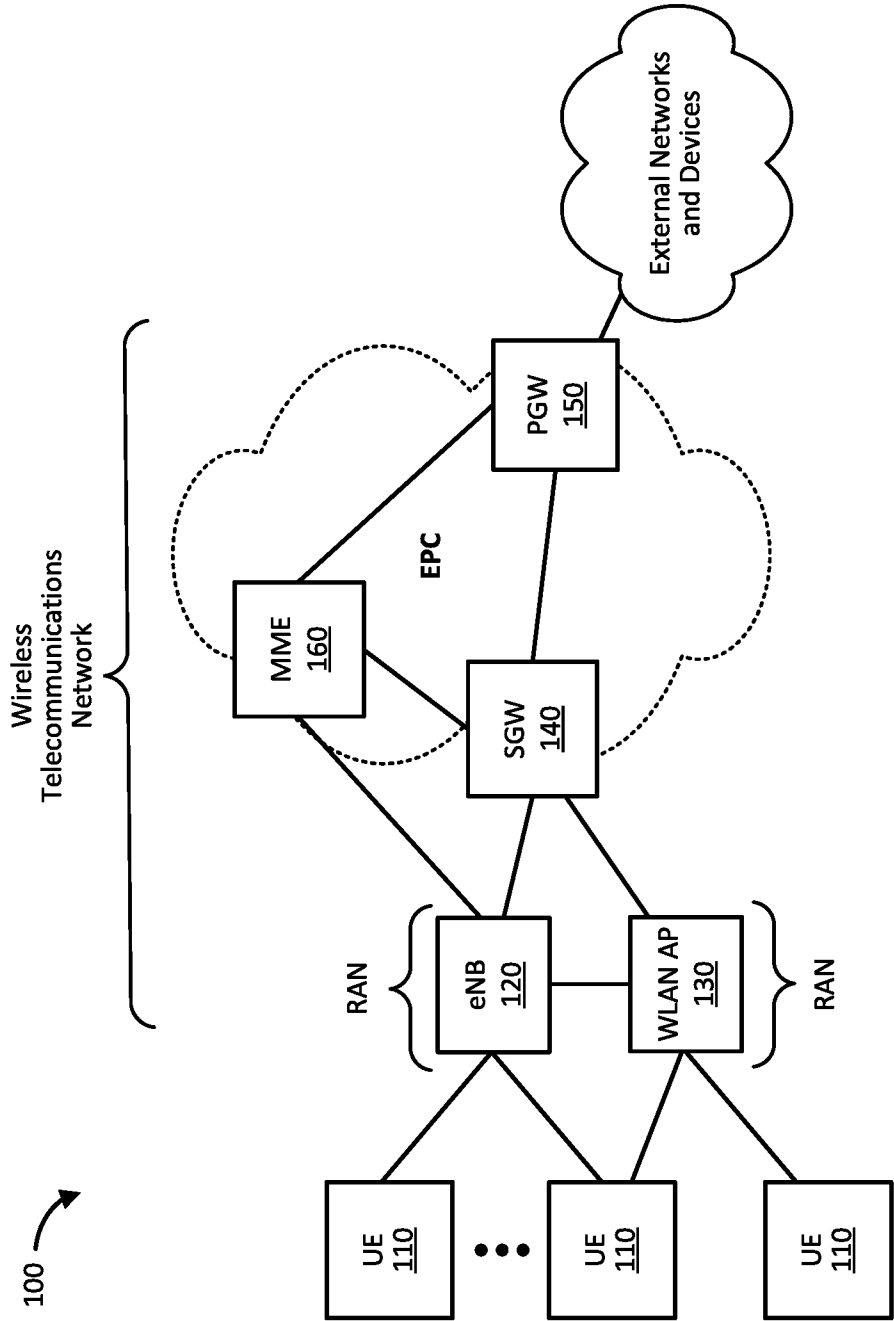


Fig. 1

2/7

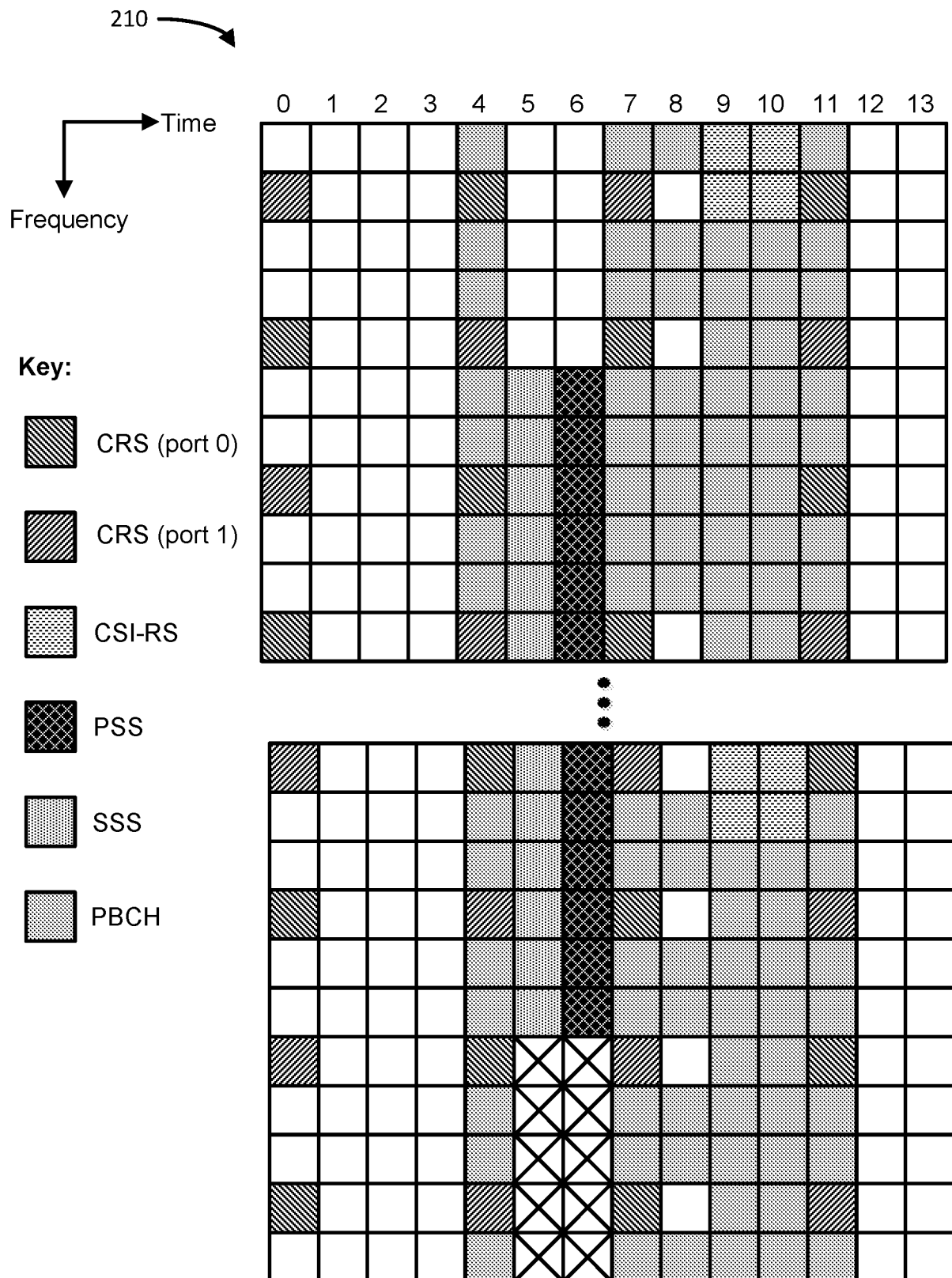
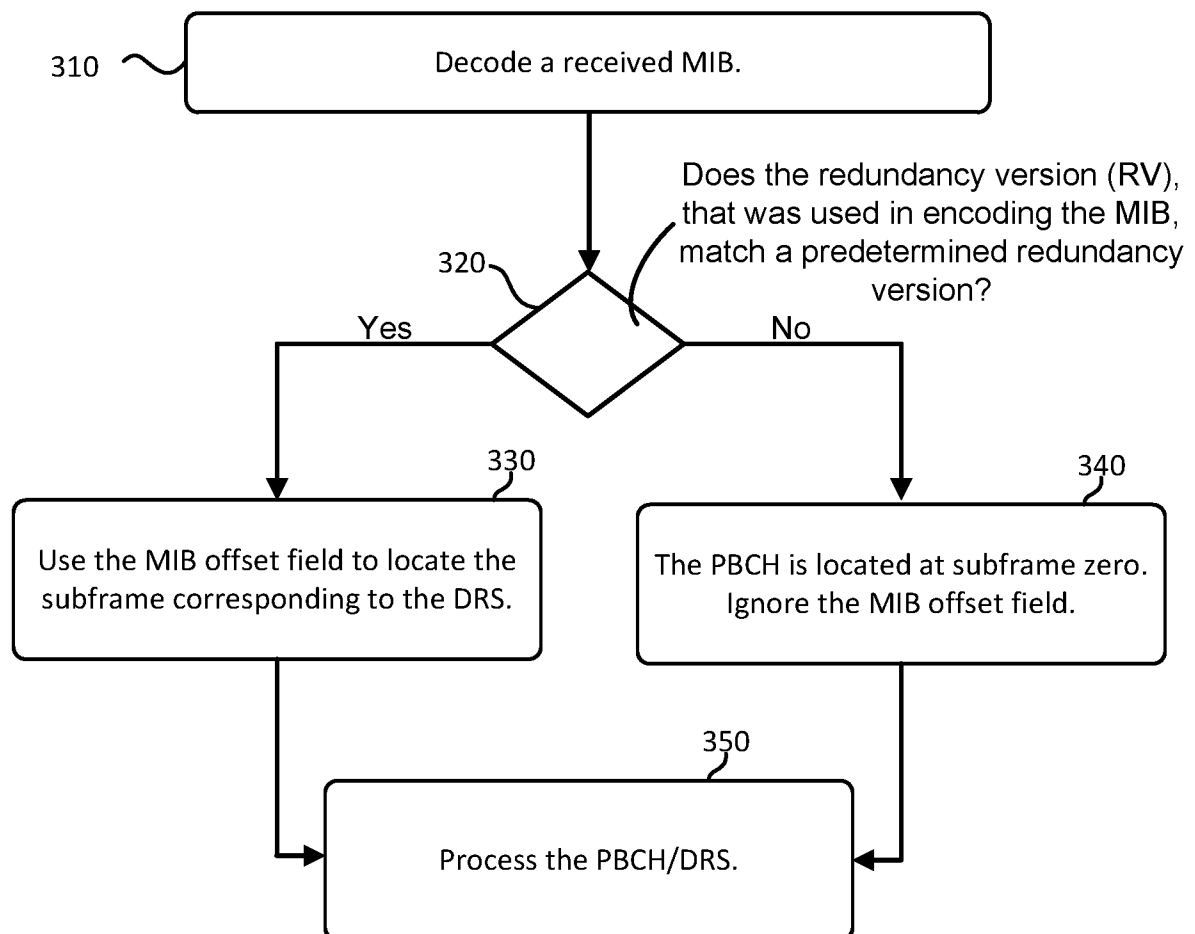


Fig. 2

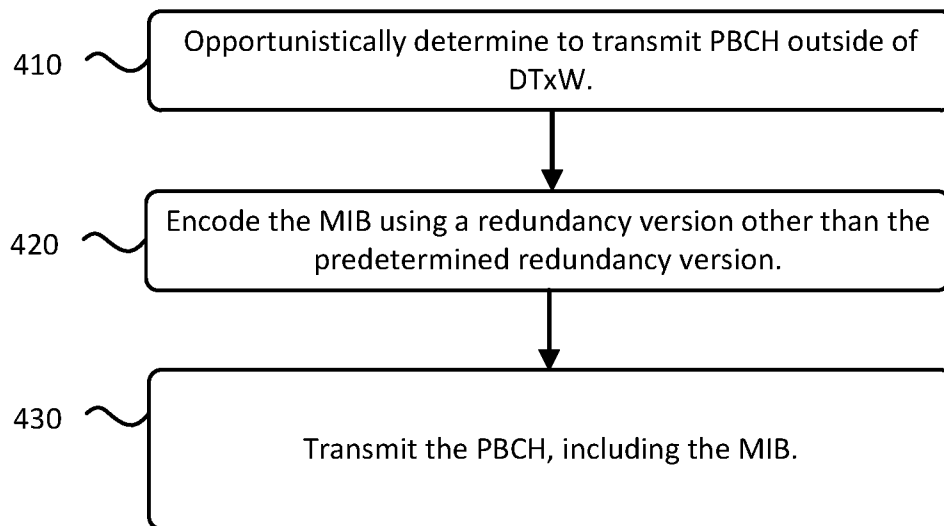
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300 →

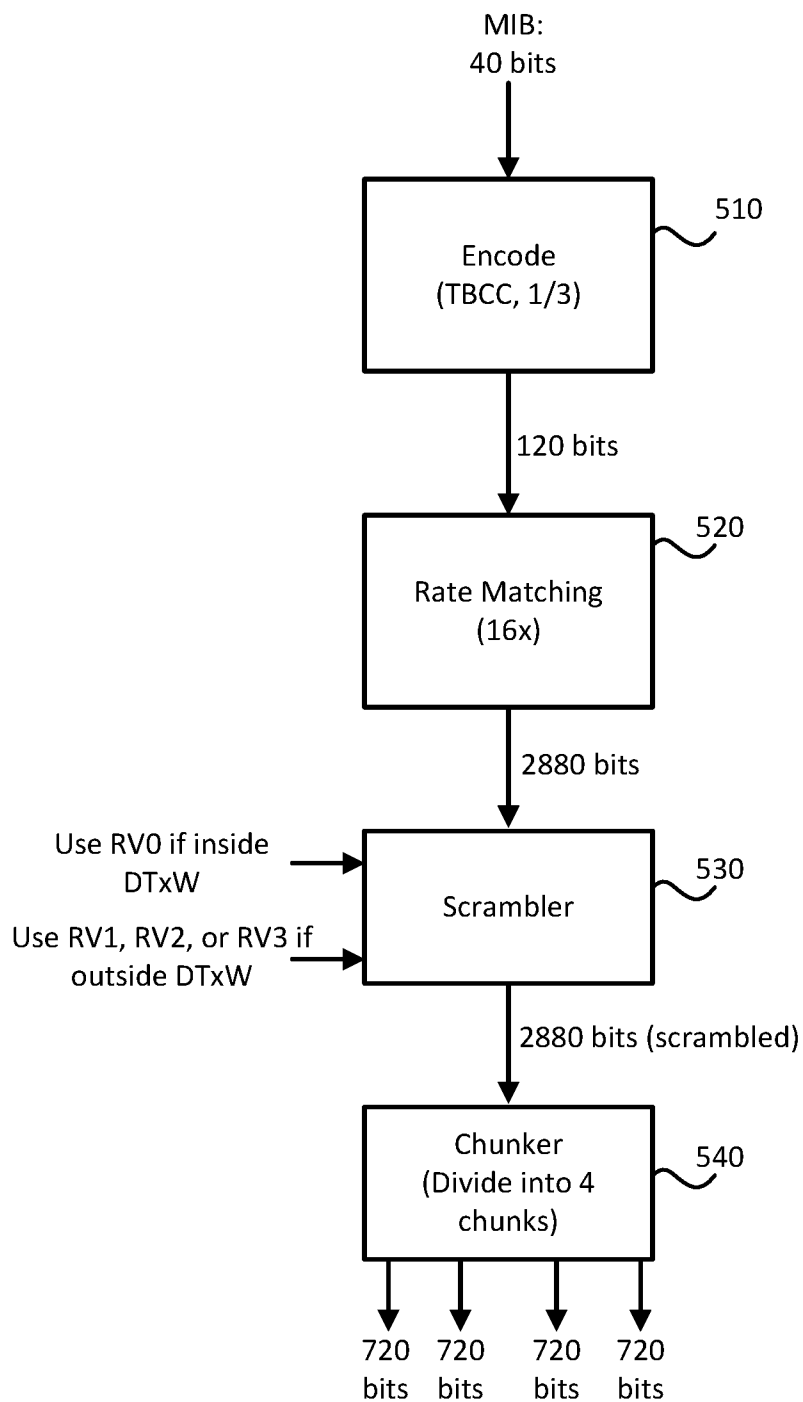
**Fig. 3**

4/7

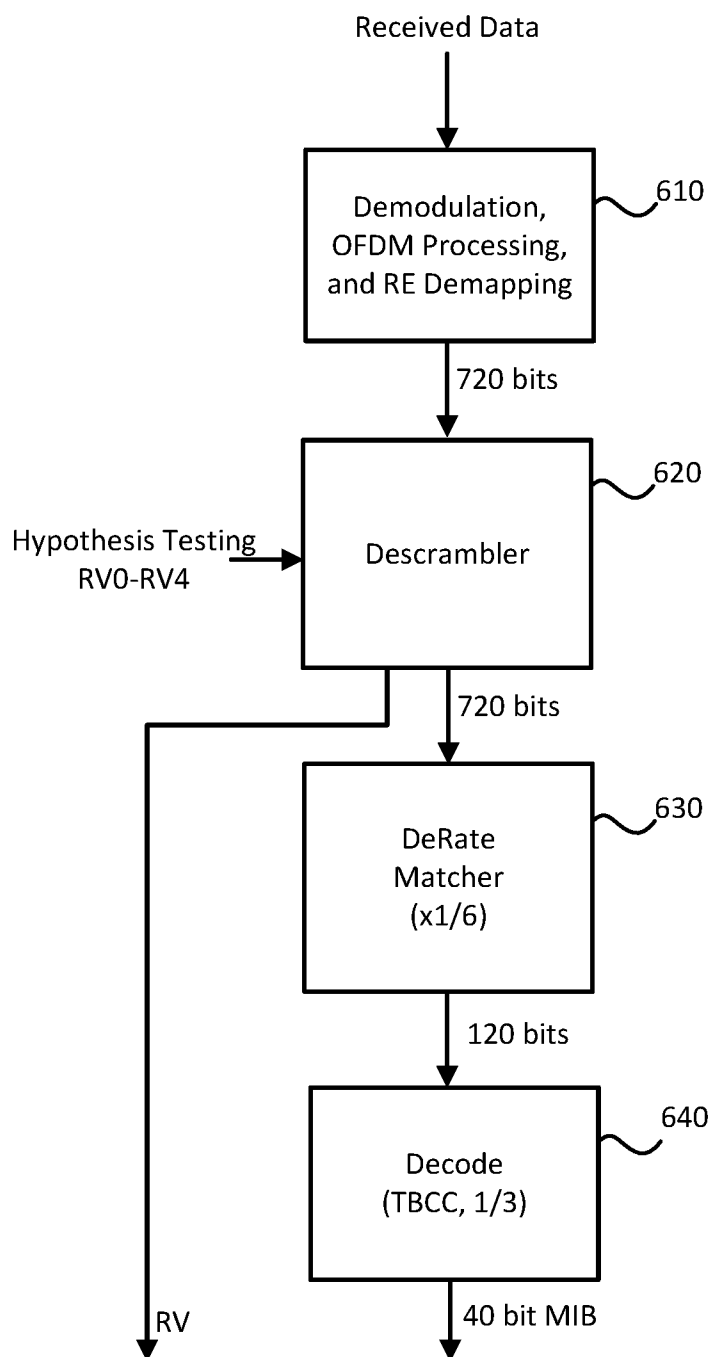
400 →

**Fig. 4**

5/7

**Fig. 5**

6/7

**Fig. 6**

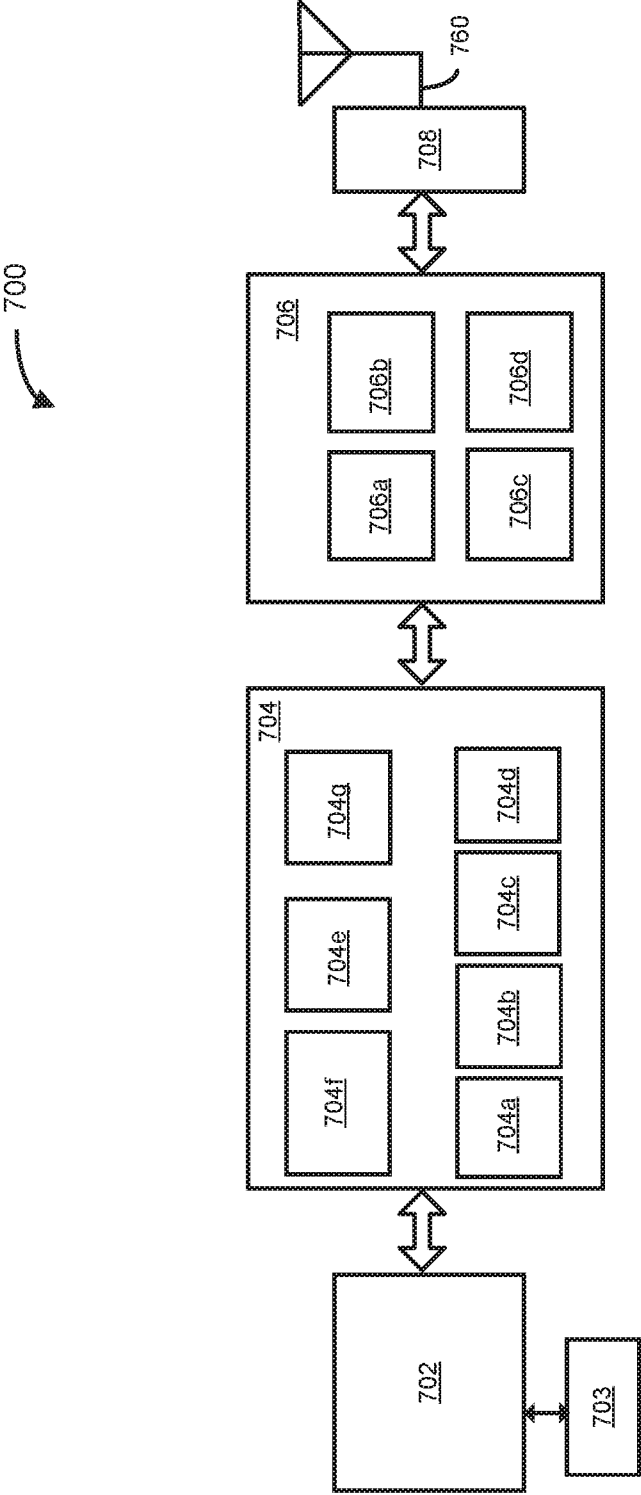


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/047919

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W48/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HARTUNG LANCE ET AL: "Policy driven multi-band spectrum aggregation for ultra-broadband wireless networks", 2015 IEEE INTERNATIONAL SYMPOSIUM ON DYNAMIC SPECTRUM ACCESS NETWORKS (DYSPAN), IEEE, 29 September 2015 (2015-09-29), pages 82-93, XP032822637, DOI: 10.1109/DYSPAN.2015.7343852 [retrieved on 2015-12-02] the whole document	1-25
A	US 2012/122440 A1 (KRISHNAMURTHY SANDEEP H [US] ET AL) 17 May 2012 (2012-05-17) abstract paragraph [0045] - paragraph [0088]	1-25



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

26 October 2016

Date of mailing of the international search report

07/11/2016

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	MCC SUPPORT: "Draft Report of 3GPP TSG RAN WG1 #83 v0.1.0 (Anaheim, USA, 15th - 22nd November 2015)", 3GPP DRAFT; DRAFT MINUTES REPORT RAN1#83 V010, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. St Julian's, Malta; 20160215 - 20160219 27 November 2015 (2015-11-27), XP051042281, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_83/Report/ [retrieved on 2015-11-27] paragraphs [6.2.1.4] - [6.2.4.1] -----	1-25
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