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(71) Applicant (for all designated States except US): **RENE-SAS MOBILE CORPORATION** [JP/JP]; 6-2, Otemachi, 2-chome, Chiyoda-ku, Tokyo 100-0004 (JP).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **ZOU, Wei** [CN/CN]; #57-301, Lane 880, Laiyang Road, Pudong New Area, Shanghai 200129 (CN). **LI, Zhenhong** [FI/CN]; Room 1101, No. 23, Lane 1399, Dingxiang Road, Pudong New Area, Shanghai 200139 (CN). **WANG, Haifeng** [FI/CN];

Room 101, Num 15, Lane 69, Gubei Road, Changning District, Shanghai 200051 (CN).

(74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Centre, No. 1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

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(54) Title: METHOD FOR AVOIDING INTERFERENCE BETWEEN CLUSTERS OF COMMUNICATION DEVICES OFF-LOADED TO UNLICENSED SPECTRUM

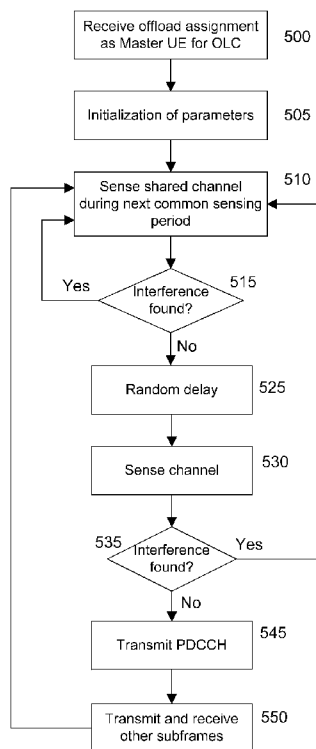


Fig. 5

(57) Abstract: Methods are disclosed for avoiding interference between devices operating in a first (e.g., unlicensed) frequency band under control of a network operating in a second (e.g., licensed) frequency band. Embodiments comprise receiving a first signal comprising assignment as master of a cluster operating in the first band; sensing interference in the first band in a first period; determining a condition related to a second period; if the interference is below a threshold and the condition is positive, transmitting a second control signal in the first band. Conditions include whether interference in the first band during the second period is below a threshold, a random delay value, and/or whether a random bit matches a predetermined value. The method may operate in neighbor discovery and/or collision avoidance modes. The first signal may be received in the second band. Both signals may comprise substantially identical PHY/MAC protocol layers, such as LTE PHY/MAC layers.



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METHOD FOR AVOIDING INTERFERENCE BETWEEN CLUSTERS OF COMMUNICATION DEVICES OFFLOADED TO UNLICENSED SPECTRUM

[0001] The present application is related to international application No. PCT/CN2011/072652, filed on April 12th, 2011, and entitled “Methods and Apparatuses of Spectrum Sharing for Cellular-controlled Offloading Using Unlicensed Band.”

TECHNICAL FIELD

[0002] The disclosure herein relates to the field of wireless communications, and more particularly to methods to avoid interference between clusters of wireless communication devices operating in a frequency band, such as an unlicensed frequency band.

BACKGROUND

[0003] The Third Generation Partnership Project (3GPP) unites six telecommunications standards bodies, known as “Organizational Partners,” and provides their members with a stable environment to produce the highly successful Reports and Specifications that define 3GPP technologies. These technologies are constantly evolving through what have become known as “generations” of commercial cellular/mobile systems. 3GPP also uses a system of parallel “releases” to provide developers with a stable platform for implementation and to allow for the addition of new features required by the market. Each release includes specific functionality and features that are specified in detail by the version of the 3GPP standards associated with that release.

[0004] Universal Mobile Telecommunication System (UMTS) is an umbrella term for the third generation (3G) radio technologies developed within 3GPP and initially standardized in Release 4 and Release 99, which preceded Release 4. UMTS includes specifications for both the UMTS Terrestrial Radio Access Network (UTRAN) as well as the Core Network. UTRAN includes the original Wideband CDMA (W-CDMA) radio access technology that uses paired or unpaired 5-MHz channels, initially within licensed frequency bands near 2 GHz but subsequently expanded into other licensed frequency bands. As used in this disclosure, “licensed frequency band” means that a particular region of the radio frequency spectrum used exclusively by a particular entity (e.g., cellular network operator) under permission from a governmental regulatory agency (e.g., Federal Communications Commission in the U. S.). Similarly, “licensed network” means a network operating in a

licensed frequency band, e.g., a cellular network. Licenses to radio frequency spectrum are usually obtained by competitive bidding process, typically making them very costly.

[0005] Long Term Evolution (LTE) is another umbrella term for so-called fourth-generation (4G) radio access technologies developed within 3GPP and initially standardized in Releases 8 and 9, also known as Evolved UTRAN (E-UTRAN). As with UMTS, LTE is targeted at various licensed frequency bands, including the 700-MHz band in the United States. LTE is accompanied by improvements to non-radio aspects commonly referred to as System Architecture Evolution (SAE), which includes Evolved Packet Core (EPC) network. The overall architecture of a network comprising LTE and SAE is shown in Fig.1A. E-UTRAN 100 comprises one or more evolved Node B's (eNB), such as eNBs 105, 110, and 115, and one or more user equipment (UE), such as UE 120. As used within the 3GPP standards, "user equipment" or "UE" means any wireless communication device (e.g., smartphone or computing device) that is capable of communicating with 3GPP-standard-compliant network equipment, such as UTRAN, E-UTRAN, and/or GERAN, as the second-generation ("2G") 3GPP radio access network is commonly known.

[0006] As specified by 3GPP, E-UTRAN 100 is responsible for all radio-related functions in the network, including radio bearer control, radio admission control, radio mobility control, scheduling, and dynamic allocation of resources to UEs in uplink and downlink, as well as security of the communications with the UE. These functions reside in the eNBs, such as eNBs 105, 110, and 115. The eNBs in the E-UTRAN communicate with each other via the X1 interface, as shown in Fig. 1A. The eNBs also are responsible for the E-UTRAN interface to the EPC, specifically the S1 interface to the Mobility Management Entity (MME) and the Serving Gateway (SGW), shown collectively as MME/S-GWs 134 and 138 in Fig. 1A. Generally speaking, the MME/S-GW handles both the overall control of the UE and data flow between the UE and the rest of the EPC. More specifically, the MME processes the signaling protocols between the UE and the EPC, which are known as the Non Access Stratum (NAS) protocols. The S-GW handles all Internet Protocol (IP) data packets between the UE and the EPC, and serves as the local mobility anchor for the data bearers when the UE moves between eNBs, such as eNBs 105, 110, and 115.

[0007] As mentioned above, wide-area communication technologies such as LTE and UMTS have been developed primarily for use in licensed frequency bands. On the other

hand, unlicensed frequency bands are widely used for wireless local-area communications. As used herein, the term “unlicensed frequency band” means that a particular region of the radio frequency spectrum is available for use by any entity, but often subject to rules, regulations, and/or requirements that attempt to control usage of the spectrum, e.g., to maximize the capacity or number of users. Similarly, “unlicensed network” means a network operating in an unlicensed frequency band.

[0008] For example, Bluetooth and 802.11 (also known as “WiFi”) are two technologies that utilize the unlicensed Industrial Scientific and Medical (“ISM”) frequency band located in the 2.4-2.5 GHz range of the radio spectrum. Other unlicensed frequency bands exist across the radio frequency spectrum, as low as 6 MHz and as high as 245 GHz. Because no spectrum licensing costs are involved, the overall cost per user of a local network operating in an unlicensed frequency band is much lower than a wide-area network (e.g., cellular network) operating in a licensed frequency band. However, the lower cost is offset by the possibility of interference from other users or other local-area networks operating in the same unlicensed frequency band, which may limit availability, capacity, and/or throughput.

[0009] Similarly, networks operating in licensed frequency bands have finite amounts of radio frequency spectrum and also may reach limits on availability, capacity, and/or throughput because. In particular, the increased usage of smartphones running various applications that require sending and receiving vast amounts of data often cause cellular networks to reach or exceed the capacity of their licensed spectrum. This results in lower bandwidth or longer delays for users, which may result in complaints and termination of service (“churn”), which network operators would like to avoid.

[0010] One solution currently in use is for devices, such as smartphones or computing devices, to operate on both licensed and unlicensed networks. For example, many smartphones and computing devices can transmit and receive on both licensed frequency bands using 3GPP-standardized radio technology, such as UMTS and/or LTE, as well as on unlicensed frequency bands using IEEE-standardized technology, such as 802.11 WiFi. Transmitting and receiving data over 802.11 WiFi instead of UMTS and/or LTE is commonly known as “WiFi offloading” and may occur in various ways and under various conditions, including user-initiated, network-initiated, and device-initiated. For example, a

user may turn on the 802.11 WiFi radio in their device, connect to a nearby 802.11 WiFi access point (AP), and communicate exclusively over that connection.

SUMMARY

[0011] Embodiments of the disclosed method for wireless communications comprise receiving a first control signal comprising an assignment as the master device of a cluster of devices operating in a first frequency band; sensing a first interference level in the first frequency band in a first sensing period; determining a transmit condition related to a second sensing period; transmitting a second control signal in the first frequency band to the cluster of devices in response to the first interference level being less than a first interference threshold and the transmit condition being positive. In some embodiments, the first control signal is received in a second frequency band, with the first frequency band being an unlicensed frequency band and the second frequency band being a licensed frequency band. In some embodiments, the first and second control signals comprise Long Term Evolution (LTE) physical (PHY) and medium access control (MAC) protocol layers. Other embodiments comprise wireless communication devices, apparatus, and/or computer-readable media embodying one or more of the disclosed methods.

DESCRIPTION OF THE DRAWINGS

[0012] The detailed description will refer to the following drawings, wherein like numerals refer to like elements, and wherein:

Fig. 1A is a high-level block diagram of the architecture of the Long Term Evolution (LTE) Evolved UTRAN (E-UTRAN) and Evolved Packet Core (EPC) network, as standardized by 3GPP;

Fig. 1B is a high-level block diagram of the architecture of a network that utilizes offloading into unlicensed frequency bands;

Fig. 2 is a high-level block diagram of the architecture of a network with multiple offloaded clusters operating in proximity to each other and to a wireless local-area network, according to one or more embodiments of the present disclosure;

Fig. 3 shows the network of Fig. 2 after certain changes have occurred to the offloaded clusters;

Fig. 4A is a timing diagram of a transmission arrangement for avoiding interference among multiple offloaded clusters and other wireless local-area networks operating in proximity, according to one or more embodiments of the present disclosure;

Fig. 4B is a timing diagram of another transmission arrangement for avoiding interference among multiple offloaded clusters and other wireless local-area networks operating in proximity, according to one or more embodiments of the present disclosure;

Fig. 5 is a flowchart of an exemplary method in a master UE, according to one or more embodiments of the present disclosure;

Fig. 6 is a flowchart of another exemplary method in a master UE, according to one or more embodiments of the present disclosure;

Fig. 7 is a flowchart of another exemplary method in a protocol between a data transmitting device and a data receiving device according to another embodiment of the present disclosure; and

Fig. 8 is a block diagram of an exemplary wireless communication device according to one or more embodiments of the present disclosure.

DETAILED DESCRIPTION

[0013] While WiFi offloading does reduce the load on the licensed network, it does have some drawbacks. First, the device must support two different sets of medium access control (MAC) and physical (PHY) layer functionality – one for the licensed frequency band (e.g., 3GPP-standardized UMTS and/or LTE), and one for the unlicensed frequency band (e.g., IEEE-standardized 802.11 WiFi). This increases the hardware and software cost and complexity of such devices. Second, in many cases, the unlicensed 802.11 WiFi network (e.g., access point in a home or public place) and the licensed UMTS and/or LTE network operate completely independently. In such cases, the unlicensed frequency band cannot be utilized efficiently for offloading users from overcrowded networks operating in licensed bands.

[0014] Using technologies such as UMTS and/or LTE originally targeted for licensed frequency bands in unlicensed frequency bands has been proposed to as a simplified solution for unlicensed-band offloading. In addition to reducing licensing costs, such solutions also reduce device cost and complexity since devices must support only a single set of MAC and PHY functionality, e.g., 3GPP-standardized UMTS and/or LTE MAC and PHY. Moreover,

placing offloading under control of the licensed network – “cellular-control unlicensed offloading” – increases the usage efficiency and capacity of the unlicensed frequency band for the data traffic of users of the licensed network.

[0015] Fig. 1B is a high-level network diagram that illustrates the use of cellular-controlled offloading of traffic from licensed to unlicensed frequency bands. Although Fig. 1B and other figures are described below using LTE terminology, LTE is used as merely an exemplary or illustrative radio access technology and is not limiting to the scope of the present disclosure. In Fig. 1B, UEs 140 and 152 communicate to eNB 160 via licensed frequency band 130, which may be any frequency band where LTE is allowed for use, such as the 700-MHz band in the U. S. In addition, UE 152 is a “master UE” for offload cluster 150, which also comprises UEs 154 and 156. Within the offload cluster 150, UEs 152, 154, and 156 communicate with each other via unlicensed frequency band 158. The dashed line around offload cluster 150 indicates the geographic range over which master UE 152’s transmissions in unlicensed frequency band 158 can be received by other devices operating in that band, including UEs, and which master UE 152 can receive transmissions of other devices operating in unlicensed frequency band 158. For convenience, this will be referred to herein as the “effective range” of offload cluster 150. The communications within offload cluster 150 may be subject to control by eNB 160, such as assigning UE 152 as master UE, aligning the timing of master UE 152’s transmission in unlicensed frequency band 158 with eNB 160’s transmissions in licensed frequency band 130, etc. The signaling of control information from eNB 160 to master UE 152 may take place in the same licensed band 130 that eNB 160 uses to communicate with UE 140, or in a separate licensed band 130’ (not shown).

[0016] Fig. 2 is a high-level network diagram of an exemplary network, such as an LTE network, having multiple unlicensed band offload clusters under control of a single eNB, according to certain embodiments of the present disclosure. In Fig. 2, UEs 240, 212, and 252 communicate with eNB 260 via licensed frequency band 230, which may be any frequency band where LTE is allowed for use, such as the 700-MHz band in the U. S. In addition, UEs 212 and 252 are assigned by eNB 260 to be master UEs for offload cluster 210 and 250, respectively. Within the offload cluster 210, UEs 212, 214, and 216 communicate with each other via unlicensed frequency band 220. Within the offload cluster 250, UEs 252, 254, and

256 communicate with each other via the same unlicensed frequency band 220. The dashed lines around offload clusters 210 and 250 indicate the respective effective ranges of these offload cluster within unlicensed frequency band 220. The communications within offload clusters 210 and 250 may be subject to control by eNB 260, such as assigning UEs 212 and 252 as master UEs, aligning the transmission timing of master UEs 212 and 252 in unlicensed frequency band 220 with eNB 260's transmissions in licensed frequency band 230, etc. The signaling of control information from eNB 260 to master UEs 212 and 252 may take place in the same licensed band 230 that eNB 260 uses to communicate with UE 240, or in a separate licensed band 230' (not shown).

[0017] Additionally, Fig. 2 shows another unlicensed network 280 operating in the same unlicensed frequency band 220. Network 280 comprises an access point 282 and a user device 284, which communicate with each other wirelessly over unlicensed frequency band 220. For example, unlicensed network 280 may be an 802.11 WiFi network operating in the 2.4 GHZ ISM band, access point 282 may be an 802.11 WiFi access point (also commonly known as a "router"), and an user device 284 may be a computing device with an 802.11 WiFi adapter. Unlicensed network 280 also may be a Bluetooth personal-area network (PAN). In some embodiments of the present disclosure, unlicensed network 280 operates independent (e.g., not under control) of eNB 260. The dashed line around unlicensed network 280 indicates effective range of access point 282 in unlicensed frequency band 220.

[0018] As shown in Fig. 2, the dashed line around unlicensed network 280 intersects with the dashed lines around offload clusters 210 and 250, meaning that offload clusters 210 and 250 can receive the signal transmitted by unlicensed network 280, and vice versa. Since offload clusters 210 and 250 and unlicensed network 280 operate in the same unlicensed frequency band 220, unlicensed network 280 may interfere with the operation of offload clusters 210 and 250. However, since the dashed lines around offload clusters 210 and 250 do not intersect with each other, offload clusters 210 and 250 will not interfere with each other. One or more of UEs 212, 214, 216, 252, 254, and 256 may be portable devices, such as mobile phones. Users may move around these devices, changing the center and/or the size of the effective range of one or more of offload clusters 210 and 250. Fig. 3 shows the network of Fig. 2 (omitting non-master UEs for clarity) after master UE 252 has moved closer in proximity to master UE 212, and the distance between master UE 252 and at least

one of UEs 254 and 256 has increased. In this scenario, the effective ranges of offload clusters 210 and 250 within unlicensed frequency band 220 now overlap, causing these clusters to interfere with each other, in addition to the interference to both caused by unlicensed network 280, as discussed above.

5 [0019] Fig. 4A shows a timing diagram of an exemplary frame structure usable by one or more master UEs operating under control of a single eNB according to exemplary embodiments of the present disclosure. As shown in Fig. 4A, the transmissions on the licensed band are arranged into a frame comprising (D) subframes for downlink (eNB to master UE) transmission, (U) subframes for uplink (master UE to eNB) transmission, and
10 special (S) subframes for downlink-to-uplink switching. Similarly, the offloaded transmissions in the unlicensed band between master UE and other UEs in its offload cluster are arranged into frames comprising beacon (B) subframes for beacon signal transmission and traffic (Tx/Rx) subframes for at least one of transmitting (i.e., from master UE to other UEs) and receiving (i.e., to master UE from other UEs) operations. The licensed band and
15 unlicensed band transmission frames may be aligned on a common timing reference provided by the eNB. As further illustrated in Fig. 4A, the B subframe is the first subframe in the master UE's frame of offloaded, unlicensed band transmission. Optionally, B subframes may be repeated in a period manner (e.g., the sixth subframe in the unlicensed band transmission frame may also be a B subframe), which is effective for reducing the round-trip delay in the
20 unlicensed offloading.

[0020] According to exemplary embodiments of the present disclosure, the first one or more symbols in the B subframe may be utilized commonly by all master UEs under control of an eNB for unlicensed band sensing purposes. This is denoted in Fig. 4A as the "Common Sensing" period. The duration of the Common Sensing period (i.e., number of symbols) may
25 be pre-arranged or configurable by the eNB controlling the master UE's offload cluster. During the Common Sensing period, the master UE of each offload cluster determines if it is possible to use the unlicensed band during the remainder of the current frame. This may be determined by detecting the amount of energy and/or interference present in the bandwidth of the channel used by the master UE, and comparing that amount with predetermined or
30 adaptable threshold that defines the maximum level under which the master UE can use the unlicensed band. Energy and/or interference may be present from transmissions of other

networks operating in the unlicensed band, such as access point 282 operating in unlicensed network 280, as shown in Figs. 2 and 3 and discussed above. However, since all master UEs under control of the same eNB are sensing (i.e., receiving) during the Common Sensing period, they cannot detect interference from each other, such as illustrated in Fig. 3.

5 [0021] If its Common Sensing result is greater than the threshold (i.e., positive), a master UE will not utilize the unlicensed band during the period until the next beacon frame, when it will sense the channel again in the same manner. On the other hand, each master UE under control of the eNB that obtains a Common Sensing result less than or equal to the threshold (i.e., negative) will invoke a carrier-sense multiple-access/collision avoidance (CSMA/CA) technique, referred to herein as either "CSMA mode" or "collision avoidance mode". In CSMA mode, a master UE will wait for a random delay before sensing the channel again. In some embodiments, the random delay may be uniformly distributed over the range of 1 to 16 symbols. Since different offloading clusters have different random delays, the master UE with the shortest random delay will sense that the channel is free (provided that interference from other unlicensed networks is not present) and transmit scheduling information to the other UEs in its offload cluster. Meanwhile, other master UEs with longer random delays will sense the first master UE's transmission and disable their own unlicensed band transmissions to avoid collision until the beginning of the next B subframe, when they can sense the channel again.

15 20 [0022] As shown in Fig. 4A, the master UE may communicate the scheduling information, as well as other control information, to the other UEs using one or more symbols comprising a Packet Data Control Channel (PDCCH). The number of symbols used by the master UE to convey the PDCCH may be configurable, either by the master UE or by the eNB. During the remainder of the B subframe, the master UE that sent the PDCCH may communicate additional information to the other UEs.

25 30 [0023] Normally, in subsequent subframes, the UEs normally transmit and receive information according to the scheduling received from the master UE via PDCCH. However, to avoid unpredictable interference that may occur in those scheduled subframes, the first one or several symbols in each scheduled subframe may be used by the UE scheduled for transmission to sense the shared unlicensed band channel. The number of symbols to be utilized for sensing purposed may be pre-configured or controlled by the base station of the

relevant offloading cluster. If the sensing result is negative (i.e., interference below a threshold), the UE proceeds with its scheduled transmission. On the other hand, if the sensing result is positive (i.e., interference at or above a threshold), the scheduled UE does not transmit as scheduled. The threshold for this sensing operation may be the same or
5 different from thresholds for other sensing period, and may be fixed or configurable by the master UE and/or the eNB.

[0024] The method described above with reference to the timing diagram of Fig. 4A is further illustrated by the flowchart shown in Fig. 5. Initially, in block 500, the UE receives an assignment from its eNB to be the master UE of an offload cluster (OLC). Next, in block
10 505, the newly assigned master UE receives initialization parameters from the eNB, including frame timing, sensing periods, modes, etc. Based on this initialization, in block 510, the master UE senses the shared unlicensed band channel during the next Common Sensing period that occurs. In block 515, the master UE determines if it found interference during the Common Sensing period, such as by comparing the detected energy or
15 interference with an interference threshold. If so, the master UE branches back to block 510 where it waits until the next Common Sensing period.

[0025] If the master UE determines in block 515 that it found interference during the Common Sensing period, then it proceeds to block 525 where it waits for a random delay period before proceeding to block 530, where it senses the shared unlicensed band channel.
20 In block 535, the master UE determines if it found interference while sensing the channel in block 530. If so, the master UE proceeds to block 510 where it waits until the next Common Sensing period. On the other hand, if the master UE determines at block 535 that it did not detect interference, then it proceeds to block 545 where it transmits the PDCCH to members of its offload cluster and, subsequently, to block 550 where it transmits and receives other
25 information based on the scheduling information contained in the PDCCH.

[0026] Fig. 4B illustrates another timing diagram of an exemplary frame structure usable by one or more master UEs operating under control of a single eNB according to other exemplary embodiments of the present disclosure. In Fig. 4B, the frame structures of the licensed and unlicensed band transmissions by master UEs under control of a single eNB are
30 identical to those shown in Fig. 4A and described above, unless otherwise noted below. Also, as described above with reference to Fig. 4A, the first one or more symbols in the B

subframe of Fig. 4B may be utilized commonly by all master UEs under control of an eNB as a Common Sensing period, whose duration may be pre-arranged or configurable by the eNB. During the Common Sensing period, master UE's may detect energy and/or interference transmitted by other networks operating in the unlicensed band, such as access point 282 operating in unlicensed network 280, as shown in Figs. 2 and 3. However, since all master UEs under control of the same eNB are sensing (i.e., receiving) during the Common Sensing period, they cannot detect interference from each other, such as illustrated in Fig. 3. If a master UE's Common Sensing result is greater than a threshold (i.e., positive), the master UE will not utilize the unlicensed band during the period until the next beacon frame, when it will sense the channel again in the same manner.

[0027] If its Common Sensing result is less than or equal to the threshold (i.e., negative), a master UE will enter behave according to whether it is in neighbor discovery mode ("ND mode") or CSMA mode. In CSMA mode, master UEs behave in a similar manner as described above with reference to Fig. 4A. Operation in ND mode enables master UEs under control of the same eNB to discover and avoid each other's interfering transmissions while avoiding the relatively long random delays used in CSMA mode. In certain embodiments of the present disclosure, all master UEs under control of a single eNB are configured to operate in ND mode when they are initially assigned to be master UEs. Additionally, master UEs may switch between ND and CSMA modes under various conditions. For example, a master UE may switch from ND to CSMA mode upon discovering interference during the Neighbor Discovery period, allowing the master UE to try to avoid this interference during future frames. The duration of the Neighbor Discovery period may be pre-arranged or configurable by the eNB.

[0028] Similarly, a master UE may switch from CSMA to ND mode after "N" consecutive times of not finding interference when sensing the unlicensed band channel following the random delay. The value of N may be configurable and may be chosen such that reaching that value indicates a very low likelihood that a proximate interferer exists. Additionally, a master UE may switch between CSMA and ND modes upon receiving an indication that another master UE under control of the same eNB has switched modes in the same manner.

[0029] Upon finding a negative Common Sensing result, each master UE in ND mode generates a random discovery bit using, for example, a pseudonoise (PN) sequence generator

or other random binary generation methods known to persons of ordinary skill in the art. As shown in Fig. 4B, if a master UE generates a “0” discovery bit, it transmits a PDCCH with scheduling information immediately following the Common Sensing period. On the other hand, if a master UE generates a “1” discovery bit, it delays for a period of time equivalent to the PDCCH duration before transmitting its own PDCCH to other members of its offload cluster. During this period, which is labeled as “Neighbor Discovery” in Fig. 4B, the master UE senses the unlicensed frequency band for interference due to transmissions from other networks operating in this band, including both PDCCH transmissions from other master UEs under control of the same eNB and other unlicensed band transmissions, such as from access point 282 operating in unlicensed network 280, as shown in Figs. 2 and 3. If the master UE finds a positive result during the Neighbor Discovery period (e.g., neighbor offload cluster), it will not utilize the unlicensed band during the period until the next beacon frame, when it will sense the channel again in the manner described above. On the other hand, if the master UE finds a negative result during the Neighbor Discovery period, it will transmit a PDCCH with scheduling information to the other UEs in its offload cluster following the Neighbor Discovery period.

[0030] Fig. 6 is a flowchart describing a method of operation of a master UE according to one or more embodiments of the present disclosure, including embodiments discussed above with reference to Fig. 4B. Initially, in block 600, the UE receives an assignment from its eNB to be the master UE of an offload cluster (OLC). Next, in block 605, the newly assigned master UE receives initialization parameters from the eNB, including frame timing, sensing periods, mode, etc. In some embodiments, the master UE will always be initialized to ND mode at this step. Based on this initialization, in block 610, the master UE senses the shared unlicensed band channel during the next Common Sensing period that occurs. In block 615, the master UE determines if it found interference during the Common Sensing period, such as by comparing the detected energy or interference with an interference threshold, which may be configurable. If so, the master UE branches back to block 610 where it waits until the next Common Sensing period.

[0031] If no interference was found during Common Sensing, the master UE proceeds to block 618 where it checks for and processes any received mode-switch notifications, such as from other master UEs controlled by the same eNB. In block 620, the master UE checks its

mode setting. If the master UE is in ND mode, it proceeds to block 660 where it generates the discovery bit. At block 665, the master UE determines if the discovery bit generated in block 660 was "0" or "1". If the discovery bit was "0", the master UE proceeds to block 680 where it transmits the PDCCH to members of its offload cluster. If the discovery bit was "1",
5 the master UE proceeds to block 670 where it senses the shared unlicensed band channel during the Neighbor Discovery period. In block 675, the master UE determines if it found interference during the Neighbor Discovery period, such as by comparing the detected energy or interference with an interference threshold, which may be configurable and may be the same as or different from the threshold used in blocks 615. If it did not, the master UE
10 proceeds to block 680 where it transmits the PDCCH to members of its offload cluster and, subsequently, to block 685 where it transmits and receives other information based on the scheduling information contained in the PDCCH.

[0032] If in block 675 the master UE determines that it detected interference during the Neighbor Discovery period, it proceeds to block 690 where it switched to CSMA mode and
15 notifies master UEs of any known neighbor offload clusters, including any master UEs that were identified during the Neighbor Discovery period. Subsequently, in block 685, the master UE initializes a channel utilization counter ("ctr") to a value of zero, then proceeds to block 610 where it waits until the next Common Sensing period. On the other hand, if the master UE determines it is in CSMA mode at block 620, it proceeds to block 625 where it
20 waits for a random delay period before proceeding to block 630, where it senses the shared unlicensed band channel.

[0033] In block 635, the master UE determines if it found interference while sensing the channel in 630, such as by comparing the detected energy or interference with an interference threshold, which may be configurable and may be the same as or different from the
25 thresholds used in blocks 615 and/or 675. If so, the master UE proceeds to block 640 where it sets the channel utilization counter ("ctr") to a value of zero, and then proceeds to block 610 where it waits until the next Common Sensing period. On the other hand, if the master UE determines at block 635 that it did not detect interference, then it increments the channel utilization counter ("ctr") in block 645 and determines, in block 650, whether the counter
30 value is greater than a channel utilization threshold, N, which may be a configurable value. If the counter does not exceed that value, then the master UE proceeds to block 680 where it

transmits the PDCCH to members of its offload cluster and, subsequently, to block 685 where it transmits and receives other information based on the scheduling information contained in the PDCCH. If, on the other hand, the master UE determines in block 650 that the channel utilization counter exceeds the maximum value, it proceeds to block 655 where it switches to ND mode and notifies master UEs of any known neighbor offload clusters of this mode switch. Subsequently, the master UE branches back to block 610 where it waits until the next Common Sensing period.

[0034] Fig. 7 is a data flow diagram that further illustrates one or more of the embodiments described above with reference to Figs. 5 and 6. At time t_1 , offload clusters A and B, which are under control of the same eNB, are spaced such that their effective ranges do not overlap. Accordingly, the master UEs of clusters A and B (denoted “master UE A” and “master UE B”, respectively) are operating in ND mode in the manner described above with reference to Figs. 5 and 6. Offload clusters A and/or B subsequently move in proximity to each other such that their effective ranges overlap. At time t_2 , master UEs A and B are still operating in ND mode with discovery bits equal to “1” and “0”, respectively. As such, master UE A discovers the interfering transmission of master UE B during Neighbor Discovery period. This causes master UE A to switch to CSMA mode and notify master UE B of the switch.

[0035] Subsequently, one or both of offload clusters A and B have moved such that their effective ranges no longer overlap. This is reflected at time t_3 , when both master UEs A and B have captured their local unlicensed band channel without sensing any interference during the last N sensing periods. At this point, one – or both – of master UEs A and B switch back to CSMA mode and notify the other of the switch. The sequence of Fig. 7 may be repeated or rearranged in various ways according to the movements of the respective offload clusters. Additionally, a person of ordinary skill in the art would understand that the sequence of Fig. 7 can easily be augmented by the addition of other master UEs, e.g., master UEs C, D, E, etc.

[0036] Fig. 8 is a block diagram of exemplary wireless communication device or apparatus, such as a user equipment (UE), utilizing certain embodiments of the present disclosure, including one or more of the methods described above with reference to Figs. 4 through 7. Device 800 comprises processor 810 which is operably connected to program memory 820 and data memory 830 via bus 870, which may comprise parallel address and data buses, serial ports, or other methods and/or structures known to those of ordinary skill in the art.

Program memory 820 comprises software code executed by processor 810 that enables device 800 to communicate with one or more other devices using protocols according to various embodiments of the present disclosure, including the 3GPP LTE PHY and MAC protocols, and improvements thereto. Program memory 820 also comprises software code
5 executed by processor 810 that enables device 800 to communicate with one or more other devices using other protocols or protocol layers, such as one or more of the 3GPP LTE higher-layer protocols; UMTS, HSPA, GSM, GPRS, EDGE, and/or CDMA2000 protocols; or any other protocols utilized in conjunction with radio transceiver 840, user interface 850, and/or host interface 860. Program memory 820 further comprises software code executed
10 by processor 810 to control the functions of device 800, including configuring and controlling various components such as radio transceiver 840, user interface 850, and/or host interface 860. Such software code may be specified or written using any known or future developed programming language, such as e.g. Java, C++, C, and Assembler, as long as the desired functionality, e.g., as defined by the implemented method steps, is preserved.

15 **[0037]** Data memory 830 may comprise memory area for processor 810 to store variables used in protocols, configuration, control, and other functions of device 800. As such, program memory 820 and data memory 830 may comprise non-volatile memory (e.g., flash memory), volatile memory (e.g., static or dynamic RAM), or a combination thereof. Persons of ordinary skill in the art will recognize that processor 810 may comprise multiple
20 individual processors (not shown), each of which implements a portion of the functionality described above. In such case, multiple individual processors may be commonly connected to program memory 820 and data memory 830 or individually connected to multiple individual program memories and or data memories. More generally, persons of ordinary skill in the art will recognize that various protocols and other functions of device 800 may be
25 implemented in many different combinations of hardware and software including, but not limited to, application processors, signal processors, general-purpose processors, multi-core processors, ASICs, fixed digital circuitry, programmable digital circuitry, analog baseband circuitry, radio-frequency circuitry, software, firmware, and middleware.

[0038] Radio transceiver 840 may comprise radio-frequency transmitter and/or receiver
30 functionality that enables device 800 to communicate with other equipment supporting like wireless communication standards. In an exemplary embodiment, radio transceiver 940

includes an LTE transmitter and receiver that enable device 800 to communicate with various E-UTRANs according to standards promulgated by 3GPP. In other embodiments, radio transceiver 840 includes circuitry, firmware, etc. necessary for device 800 to support LTE offloading to unlicensed frequency bands, at least to the extent that this functionality is implemented by other circuitry in device 800, such as processor 810 executing protocol program code stored in program memory 820. In some embodiments, radio transceiver 840 implements the LTE PHY and MAC layers, including circuitry, firmware, etc. necessary to support LTE. In some embodiments, radio transceiver 840 is capable of communicating on a plurality of LTE frequency-division-duplex (FDD) frequency bands 1 through 25, as specified in 3GPP standards. In some embodiments, radio transceiver 840 is capable of communicating on a plurality of LTE time-division-duplex (TDD) frequency bands 33 through 43, as specified in 3GPP standards. In some embodiments, radio transceiver 840 is capable of communicating on a combination of these LTE FDD and TDD bands, as well as other bands that are specified in the 3GPP standards. In some embodiments, radio transceiver 840 is capable of communicating on one or more unlicensed frequency bands, such as the ISM band in the region of 2.4 GHz.

[0039] User interface 850 may take various forms depending on the particular embodiment of device 800. In some embodiments, device 800 is a mobile phone, in which case user interface 850 may comprise a microphone, a loudspeaker, slidable buttons, depressable buttons, a keypad, a keyboard, a display, a touchscreen display, and/or any other user-interface features commonly found on mobile phones. In other embodiments, device 800 is a data modem capable of being utilized with a host computing device, such as a PCMCIA data card or a modem capable of being plugged into a USB port of the host computing device. In these embodiments, user interface 850 may be very simple or may utilize features of the host computing device, such as the host device's display and/or keyboard.

[0040] Host interface 860 of device 800 also may take various forms depending on the particular embodiment of device 800. In embodiments where device 800 is a mobile phone, host interface 860 may comprise a USB interface, an HDMI interface, or the like. In the embodiments where device 800 is a data modem capable of being utilized with a host computing device, host interface may be a USB or PCMCIA interface.

[0041] In some embodiments, device 800 may comprise more functionality than is shown in Fig. 9. In some embodiments, device 800 may also comprise functionality such as a video and/or still-image camera, media player, etc., and radio transceiver 840 may include circuitry necessary to communicate using multiple radio-frequency communication standards including GSM, GPRS, EDGE, UMTS, HSPA, CDMA2000, LTE, WiFi, Bluetooth, GPS, and/or others. Persons of ordinary skill in the art will recognize the above list of features and radio-frequency communication standards is merely exemplary and not limiting to the scope of the present disclosure. Accordingly, processor 810 may execute software code stored in program memory 820 to control such additional functionality.

[0042] As described herein, a device or apparatus may be represented by a semiconductor chip, a chipset, or a (hardware) module comprising such chip or chipset; this, however, does not exclude the possibility that a functionality of a device or apparatus, instead of being hardware implemented, be implemented as a software module such as a computer program or a computer program product comprising executable software code portions for execution or being run on a processor. A device or apparatus may be regarded as a device or apparatus, or as an assembly of multiple devices and/or apparatuses, whether functionally in cooperation with or independently of each other. Moreover, devices and apparatuses may be implemented in a distributed fashion throughout a system, so long as the functionality of the device or apparatus is preserved. Such and similar principles are considered as known to a skilled person.

[0043] Furthermore, even though embodiments described herein utilize LTE for cellular-controlled offloading of traffic from licensed to unlicensed frequency bands, a person of ordinary skill in the art would understand that other PHY/MAC protocol layers commonly used in cellular networks may be employed for this purpose and achieve the same advantages as LTE compared to WiFi offloading. For example, PHY/MAC protocol layers for cellular standards including GSM, GPRS, EDGE, UMTS, HSPA, and CDMA20000 may be used for cellular-controlled offloading within the spirit and scope of the present disclosure.

[0044] More generally, even though the present disclosure and exemplary embodiments are described above with reference to the examples according to the accompanying drawings, it is to be understood that they are not restricted thereto. Rather, it is apparent to those skilled in the art that the disclosed embodiments can be modified in many ways without departing

from the scope of the disclosure herein. Moreover, the terms and descriptions used herein are set forth by way of illustration only and are not meant as limitations. Those skilled in the art will recognize that many variations are possible within the spirit and scope of the disclosure as defined in the following claims, and their equivalents, in which all terms are to

5 be understood in their broadest possible sense unless otherwise indicated.

What is claimed is:

1. A method for wireless communications, comprising the steps of:
receiving a first control signal comprising an assignment as the master device of a cluster of devices operating in a first frequency band;
5 sensing a first interference level in the first frequency band in a first sensing period;
determining a transmit condition related to a second sensing period;
transmitting a second control signal in the first frequency band to the cluster of devices in response to the first interference level being less than a first interference threshold and the transmit condition being positive.
- 10 2. The method of claim 1, wherein:
receiving the first control signal comprises receiving it in a second frequency band;
and
receiving the assignment comprises receiving an initialization value for at least one of a duration of the first sensing period, a duration of the second sensing period, the first
15 interference threshold, a second interference threshold, a third interference threshold, a sensing mode, a channel utilization threshold, a minimum delay, a maximum delay, and a frame timing.
3. The method of claim 1, wherein determining a transmit condition comprises:
determining a sensing mode;
20 generating a discovery bit in response to the sensing mode being a neighbor discovery mode;
sensing the second interference level in the first frequency band during the second sensing period in response to the discovery bit being a first value; and
determining the transmit condition is positive in response to the discovery bit being a
25 second value or the second interference level being less than a second interference threshold.
4. The method of claim 3, in response to the second interference level not being less than the second interference threshold, further comprising:
switching to collision avoidance mode; and
notifying one or more other master devices of respective one or more other clusters of
30 devices of the switching to collision avoidance mode.

5. The method of claim 1, wherein determining a transmit condition based on a second sensing period comprises:

determining a sensing mode;

generating a random delay value in response to the sensing mode being a collision
5 avoidance mode;

delaying the second sensing period for a duration equal to the random delay value;

sensing the second interference level in the first frequency band during the second
sensing period; and

determining the transmit condition is positive in response to the second interference
10 level being less than a third interference threshold.

6. The method of claim 5, wherein transmitting a second control signal further
comprises:

incrementing a channel utilization counter;

comparing the channel utilization counter to a channel utilization threshold;

15 transmitting the second control signal in the first frequency band to the cluster of
devices in response to the channel utilization counter being less than or equal to the channel
utilization threshold.

7. The method of claim 6, further comprising if the channel utilization counter is
greater than the channel utilization threshold:

20 switching to neighbor discovery mode; and

notifying one or more other master devices of respective one or more other clusters of
devices about the switching to neighbor discovery mode.

8. The method of claim 1, wherein the first frequency band is an unlicensed
frequency band and the second frequency band is a licensed frequency band.

25 9. The method of claim 1, wherein both the first and second control signals
comprise substantially the same physical (PHY) and medium access control (MAC) protocol
layers.

10. The method of claim 1, wherein the first and second control signals comprise
Long Term Evolution (LTE) physical (PHY) and medium access control (MAC) protocol
30 layers.

11. A wireless communication device, comprising:

a transmitter;

a receiver;

a processor; and

at least one memory including program code that, when executed by the processor,
5 causes the wireless communication device to:

receive a first control signal comprising an assignment as the master device of
a cluster of devices operating in a first frequency band;

sense a first interference level in the first frequency band in a first sensing
period;

10 determine a transmit condition related to a second sensing period;

transmit a second control signal in the first frequency band to the cluster of
devices in response to the first interference level being less than a first interference
threshold and the transmit condition being positive.

12. The wireless communication device of claim 11, wherein the at least one
15 memory includes program code that, when executed by the processor, further causes the
wireless communication device to:

receive the first control signal in a second frequency band; and

process the assignment comprising an initialization value for at least one of a duration
of the first sensing period, a duration of the second sensing period, the first interference
20 threshold, a second interference threshold, a third interference threshold, a sensing mode, a
channel utilization threshold, a minimum delay, a maximum delay, and a frame timing.

13. The wireless communication device of claim 11, wherein the program code
that, when executed by the processor, causes the wireless communication device to determine
a transmit condition further causes the wireless communication device to:

25 determine a sensing mode;

generate a discovery bit in response to the sensing mode being a neighbor discovery
mode;

sense the second interference level in the first frequency band during the second
sensing period in response to the discovery bit being a first value; and

30 determine the transmit condition is positive in response to the discovery bit being a
second value or the second interference level being less than a second interference threshold.

14. The wireless communication device of claim 13, wherein the at least one memory further includes program code that, when executed by the processor, causes the wireless communication device to switch to collision avoidance mode and notify one or more other master devices of respective one or more other clusters of devices of the switch to collision avoidance mode, in response to the second interference level not being less than the second interference threshold.

15. The wireless communication device of claim 11, wherein the program code that, when executed by the processor, causes the wireless communication device to determine a transmit condition further causes the wireless communication device to:

- 10 determine a sensing mode;
- generate a random delay value in response to the sensing mode being a collision avoidance mode;
- delay the second sensing period for a duration equal to the random delay value;
- sense the second interference level in the first frequency band during the second
- 15 sensing period; and
- determine the transmit condition is positive in response to the second interference level being less than a third interference threshold.

16. The wireless communication device of claim 11, wherein the program code that, when executed by the processor, causes the wireless communication device to transmit a second control signal further causes the wireless communication device to:

- 20 increment a channel utilization counter;
- compare the channel utilization counter to a channel utilization threshold; and
- transmit the second control signal in the first frequency band to the cluster of devices in response to the channel utilization counter being less than or equal to the channel
- 25 utilization threshold.

17. The wireless communication device of claim 16, wherein the at least one memory further includes program code that, when executed by the processor, causes the wireless communication device to switch to neighbor discovery mode and notify one or more other master devices of respective one or more other clusters of devices about the switch to neighbor discovery mode, in response to the channel utilization counter being greater than the channel utilization threshold.

18. The wireless communication device of claim 11, wherein the first frequency band is an unlicensed frequency band and the second frequency band is a licensed frequency band.

19. The wireless communication device of claim 11, wherein both the first and second control signals comprise substantially the same physical (PHY) and medium access control (MAC) protocol layers.

20. The wireless communication device of claim 11, wherein the first and second control signals comprise Long Term Evolution (LTE) physical (PHY) and medium access control (MAC) protocol layers.

21. A computer readable medium comprising a set of instructions that, when executed on a wireless communication device, causes the wireless communication device to:

- receive a first control signal comprising an assignment as the master device of a cluster of devices operating in a first frequency band;
- sense a first interference level in the first frequency band in a first sensing period;
- determine a transmit condition related to a second sensing period;
- transmit a second control signal in the first frequency band to the cluster of devices in response to the first interference level being less than a first interference threshold and the transmit condition being positive.

22. The computer readable medium of claim 21 further comprising instructions that, when executed on the wireless communication device, cause the wireless communication device to:

- receive the first control signal in a second frequency band; and
- process the assignment comprising an initialization value for at least one of a duration of the first sensing period, a duration of the second sensing period, the first interference threshold, a second interference threshold, a third interference threshold, a sensing mode, a channel utilization threshold, a minimum delay, a maximum delay, and a frame timing.

23. The computer readable medium of claim 21, wherein the instructions that, when executed by the processor, cause the wireless communication device to determine a transmit condition further causes the wireless communication device to:

- determine a sensing mode;

generate a discovery bit in response to the sensing mode being a neighbor discovery mode;

sense the second interference level in the first frequency band during the second sensing period in response to the discovery bit being a first value; and

5 determine the transmit condition is positive in response to the discovery bit being a second value or the second interference level being less than a second interference threshold.

24. The computer readable medium of claim 23, further comprising instructions that, when executed on the wireless communication device, cause the wireless communication device to switch to collision avoidance mode and notify one or more other
10 master devices of respective one or more other clusters of devices of the switch to collision avoidance mode, in response to the second interference level not being less than the second interference threshold.

25. The computer readable medium of claim 21, wherein the instructions that, when executed by the wireless communication device, cause the wireless communication
15 device to determine a transmit condition further cause the wireless communication device to:

 determine a sensing mode;

 generate a random delay value in response to the sensing mode being a collision avoidance mode;

 delay the second sensing period for a duration equal to the random delay value;

20 sense the second interference level in the first frequency band during the second sensing period; and

 determine the transmit condition is positive in response to the second interference level being less than a third interference threshold.

26. The computer readable medium of claim 21, wherein the instructions that, when executed by the wireless communication device, cause the wireless communication
25 device to transmit a second control signal further cause the wireless communication device to:

 increment a channel utilization counter;

 compare the channel utilization counter to a channel utilization threshold; and

 transmit the second control signal in the first frequency band to the cluster of devices
30 in response to the channel utilization counter being less than or equal to the channel utilization threshold.

27. The computer readable medium of claim 26, further including instructions that, when executed by the wireless communication device, cause the wireless communication device to switch to neighbor discovery mode and notify one or more other master devices of respective one or more other clusters of devices about the switch to neighbor discovery mode, in response to the channel utilization counter being greater than the channel utilization threshold.

28. The computer readable medium of claim 21, wherein the first frequency band is an unlicensed frequency band and the second frequency band is a licensed frequency band.

29. The computer readable medium of claim 21, wherein both the first and second control signals comprise substantially the same physical (PHY) and medium access control (MAC) protocol layers.

30. The computer readable medium of claim 21, wherein the first and second control signals comprise Long Term Evolution (LTE) physical (PHY) and medium access control (MAC) protocol layers.

31. An apparatus for wireless communications, comprising:

transmitter means;

receiver means;

processor means; and

at least one memory means including program code that, when executed by the processor means, causes the apparatus to:

receive a first control signal comprising an assignment as the master device of a cluster of devices operating in a first frequency band;

sense a first interference level in the first frequency band in a first sensing period;

determine a transmit condition related to a second sensing period;

transmit a second control signal in the first frequency band to the cluster of devices in response to the first interference level being less than a first interference threshold and the transmit condition being positive.

32. The apparatus of claim 31, wherein the at least one memory means includes program code that, when executed by the processor means, further causes the apparatus to:

receive the first control signal in a second frequency band; and

process the assignment comprising an initialization value for at least one of a duration of the first sensing period, a duration of the second sensing period, the first interference threshold, a second interference threshold, a third interference threshold, a sensing mode, a channel utilization threshold, a minimum delay, a maximum delay, and a frame timing.

5 33. The apparatus of claim 31, wherein the program code that, when executed by the processor means, causes the apparatus to determine a transmit condition further causes the apparatus to:

 determine a sensing mode;

 generate a discovery bit in response to the sensing mode being a neighbor discovery
10 mode;

 sense the second interference level in the first frequency band during the second sensing period in response to the discovery bit being a first value; and

 determine the transmit condition is positive in response to the discovery bit being a second value or the second interference level being less than a second interference threshold.

15 34. The apparatus of claim 33, wherein the at least one memory means further includes program code that, when executed by the processor means, causes the apparatus to switch to collision avoidance mode and notify one or more other master devices of respective one or more other clusters of devices of the switch to collision avoidance mode, in response to the second interference level not being less than the second interference threshold.

20 35. The apparatus of claim 31, wherein the program code that, when executed by the processor means, causes the apparatus to determine a transmit condition further causes the apparatus to:

 determine a sensing mode;

 generate a random delay value in response to the sensing mode being a collision
25 avoidance mode;

 delay the second sensing period for a duration equal to the random delay value;

 sense the second interference level in the first frequency band during the second sensing period; and

 determine the transmit condition is positive in response to the second interference
30 level being less than a third interference threshold.

36. The apparatus of claim 31, wherein the program code that, when executed by the processor means, causes the apparatus to transmit a second control signal further causes the apparatus to:

- increment a channel utilization counter;
- 5 compare the channel utilization counter to a channel utilization threshold; and
- transmit the second control signal in the first frequency band to the cluster of devices in response to the channel utilization counter being less than or equal to the channel utilization threshold.

37. The apparatus of claim 36, wherein the at least one memory means further
10 includes program code that, when executed by the processor means, causes the apparatus to switch to neighbor discovery mode and notify one or more other master devices of respective one or more other clusters of devices about the switch to neighbor discovery mode, in response to the channel utilization counter being greater than the channel utilization threshold.

38. The apparatus of claim 31, wherein the first frequency band is an unlicensed
15 frequency band and the second frequency band is a licensed frequency band.

39. The apparatus of claim 31, wherein both the first and second control signals comprise substantially the same physical (PHY) and medium access control (MAC) protocol layers.

40. The apparatus of claim 11, wherein the first and second control signals
20 comprise Long Term Evolution (LTE) physical (PHY) and medium access control (MAC) protocol layers.

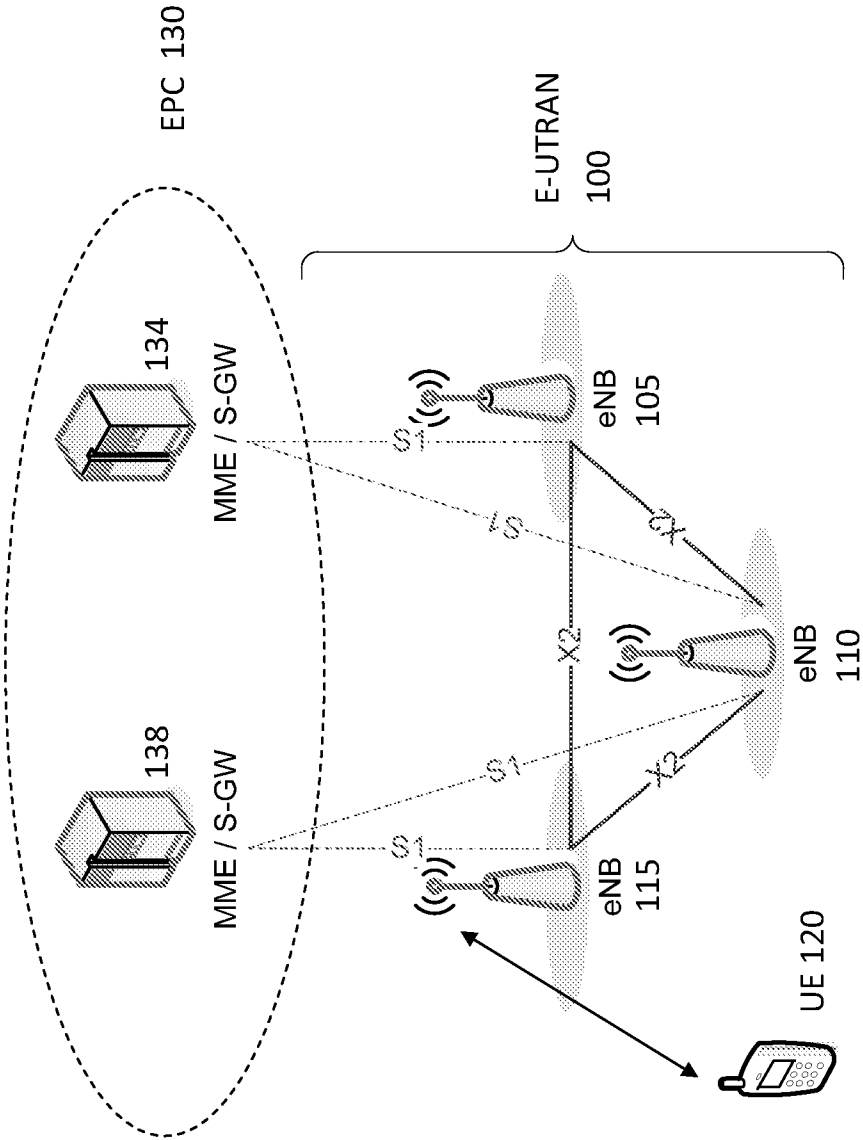


Fig. 1A

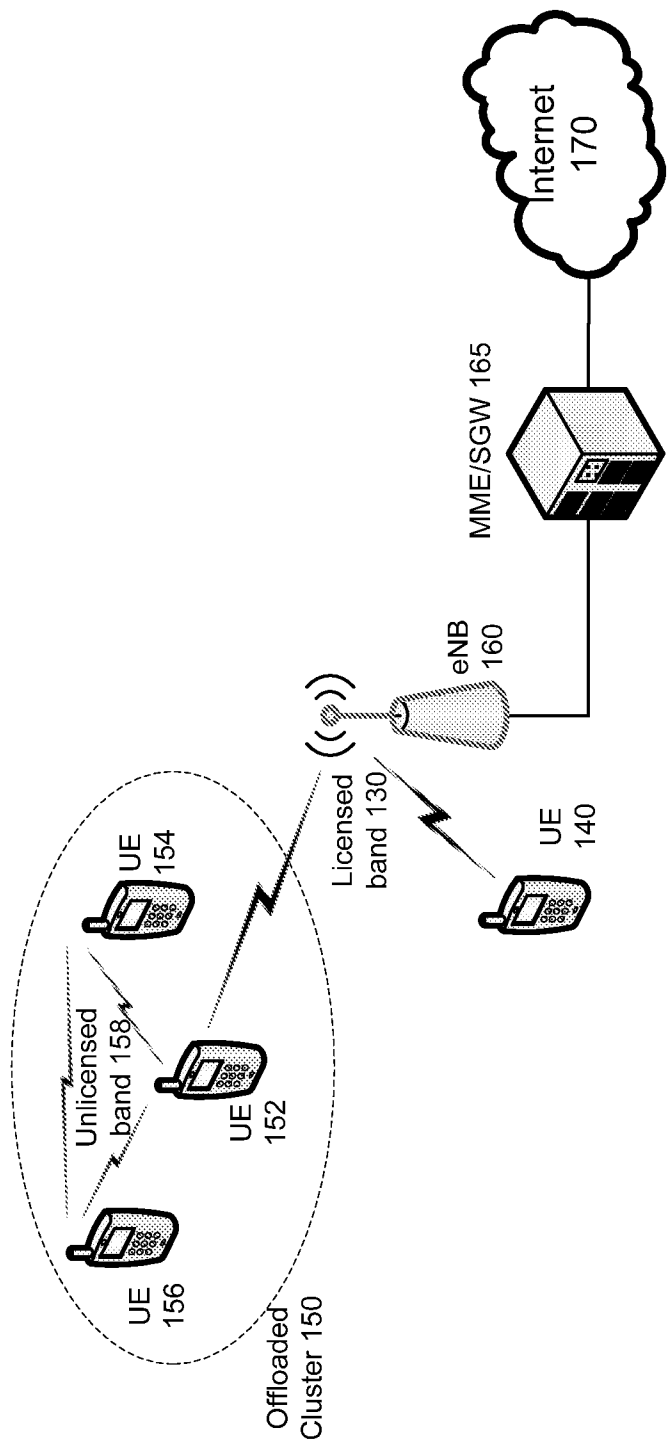


Fig. 1B

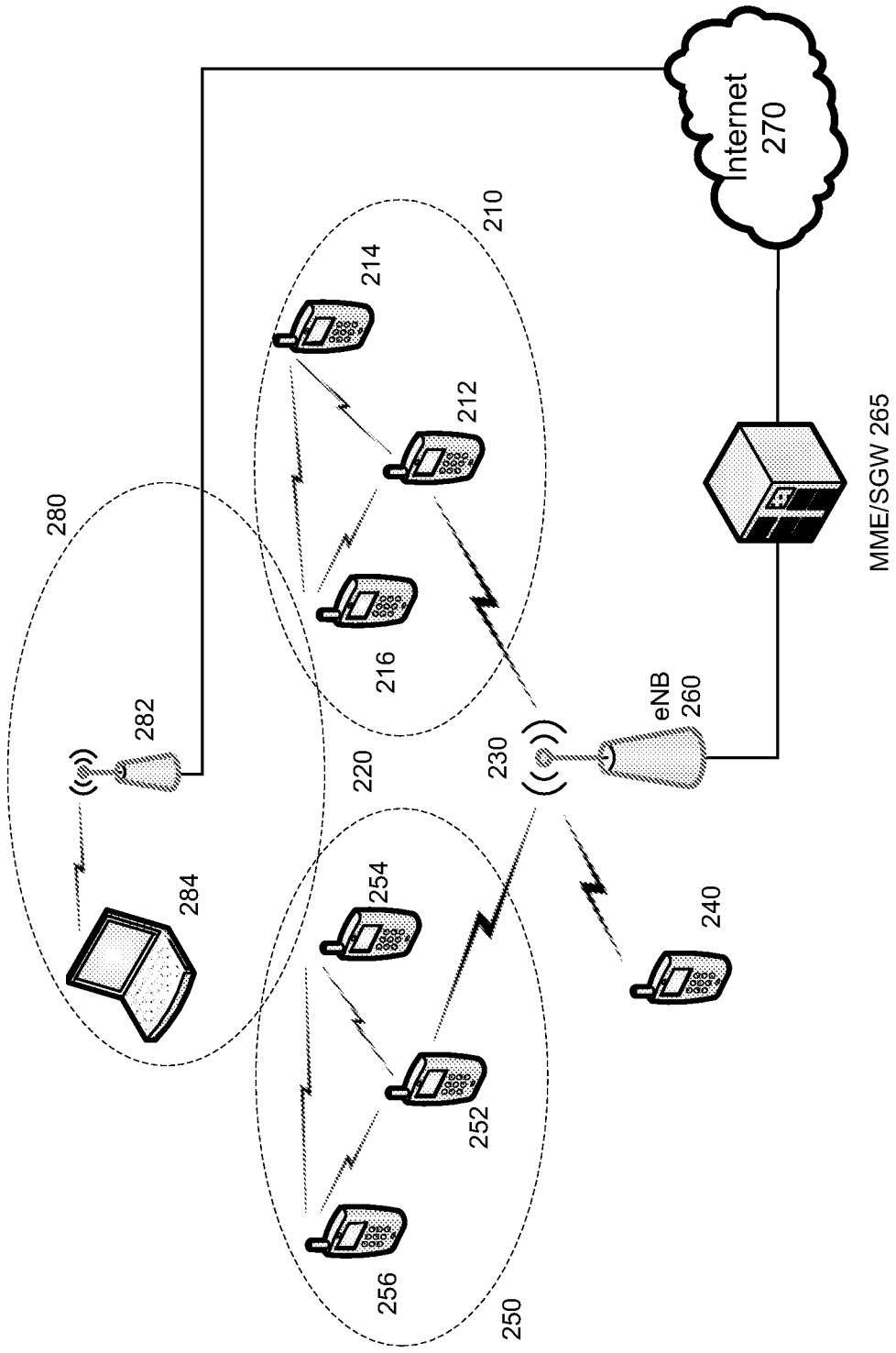


Fig. 2

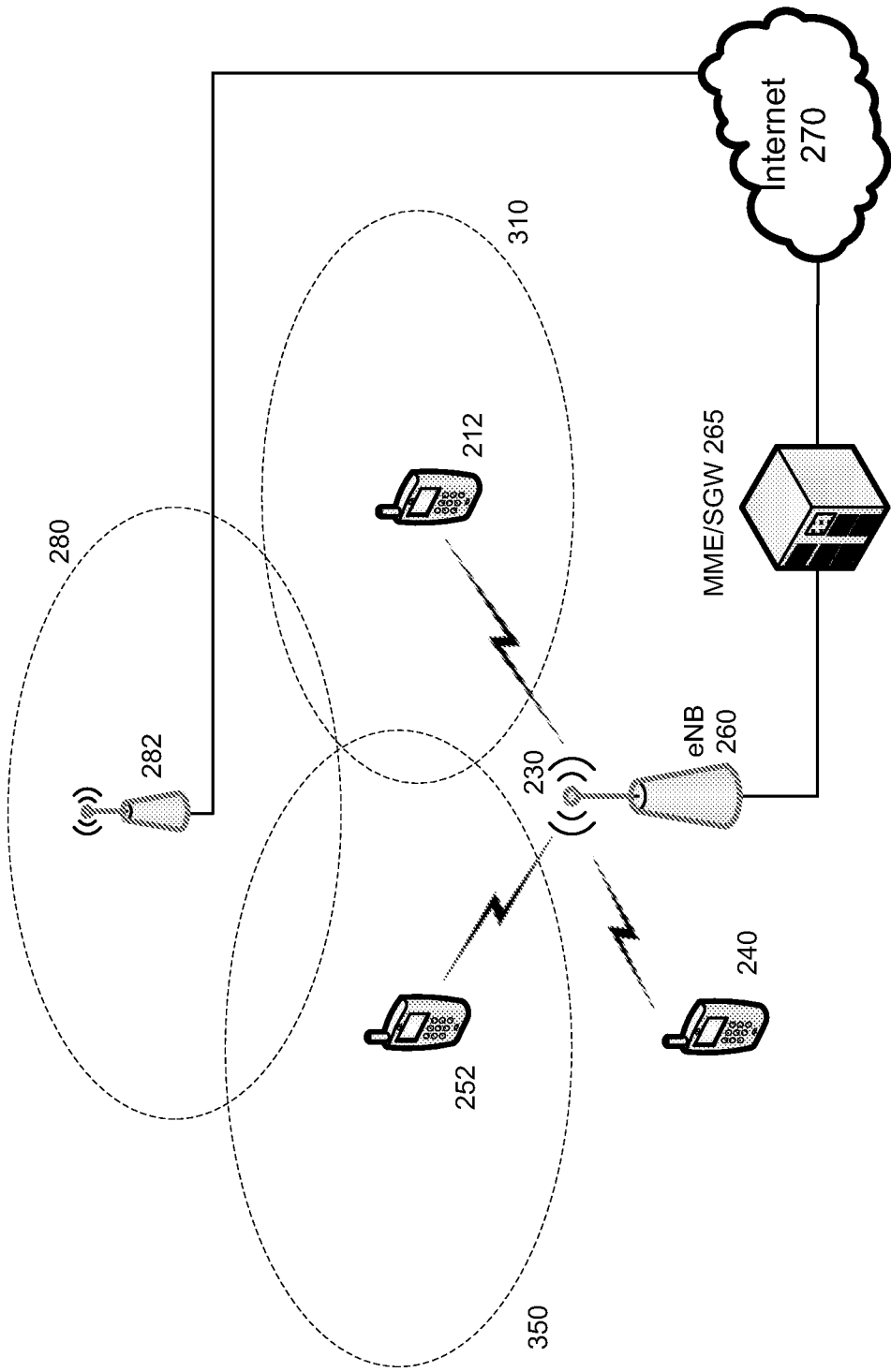


Fig. 3

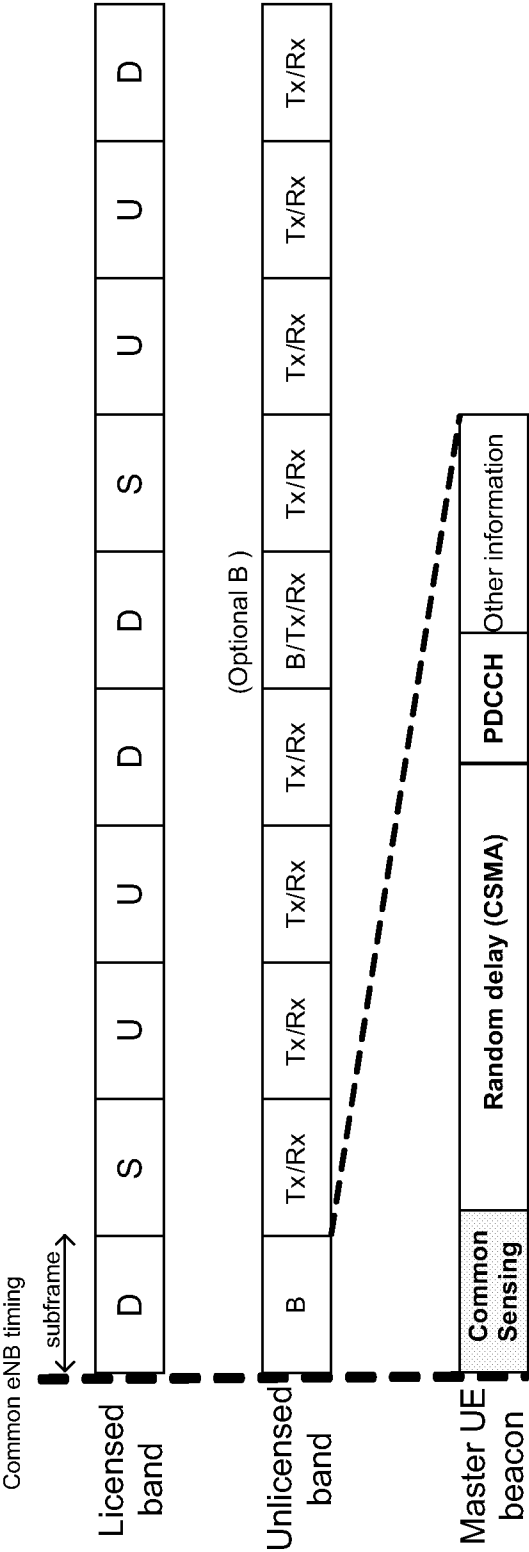


Fig. 4A

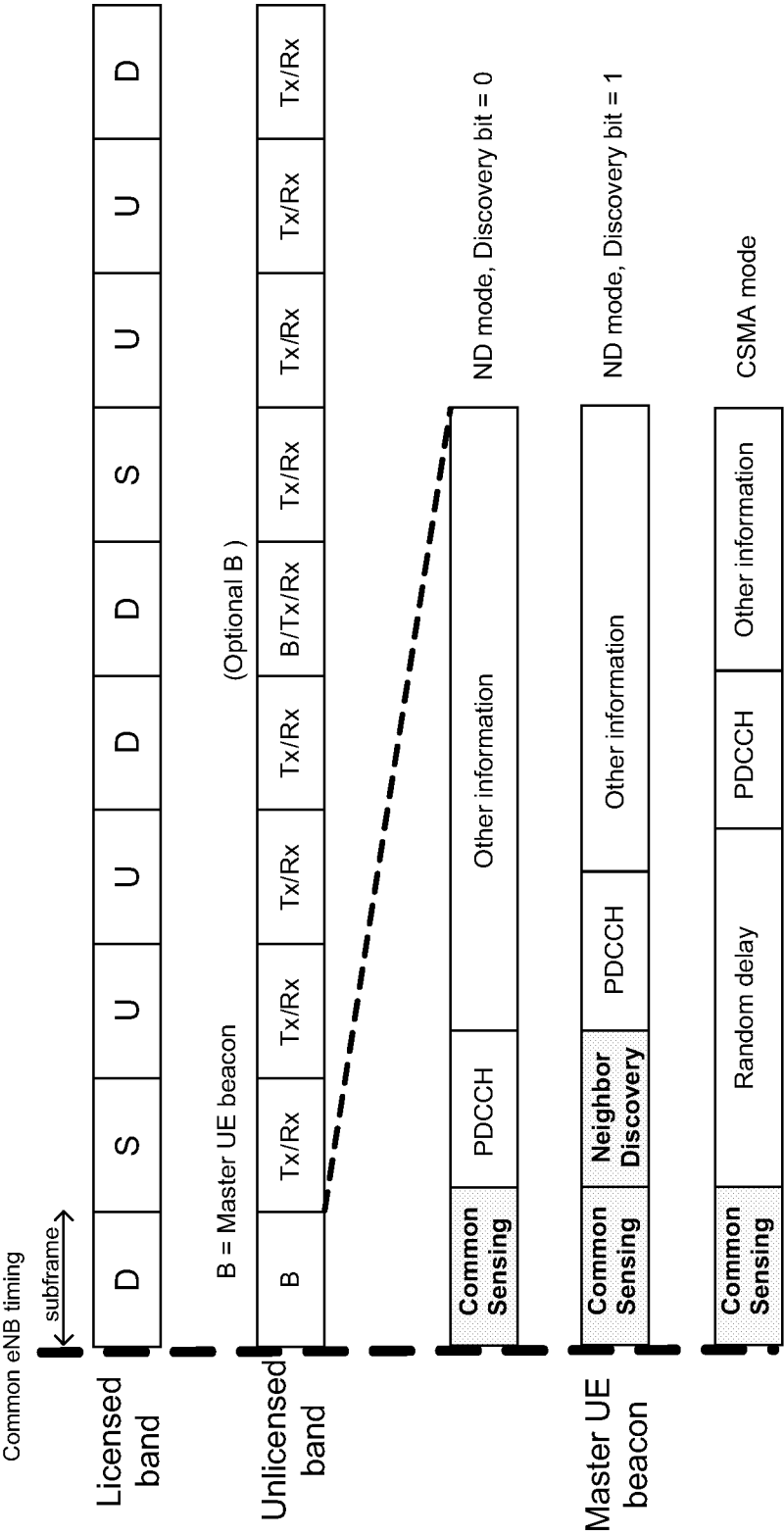
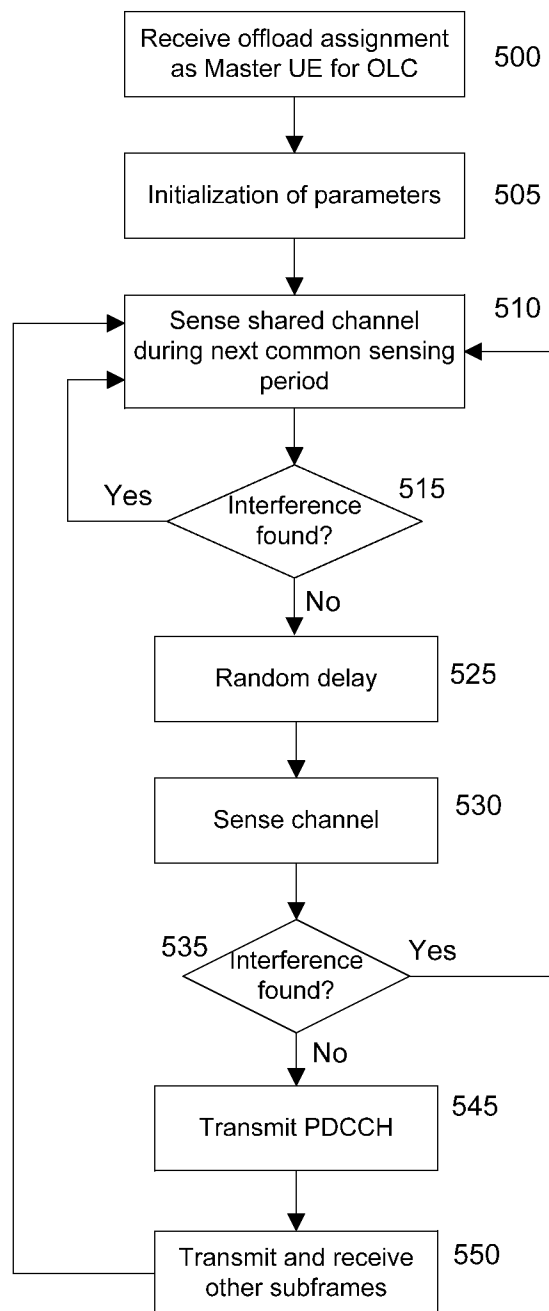


Fig. 4B

**Fig. 5**

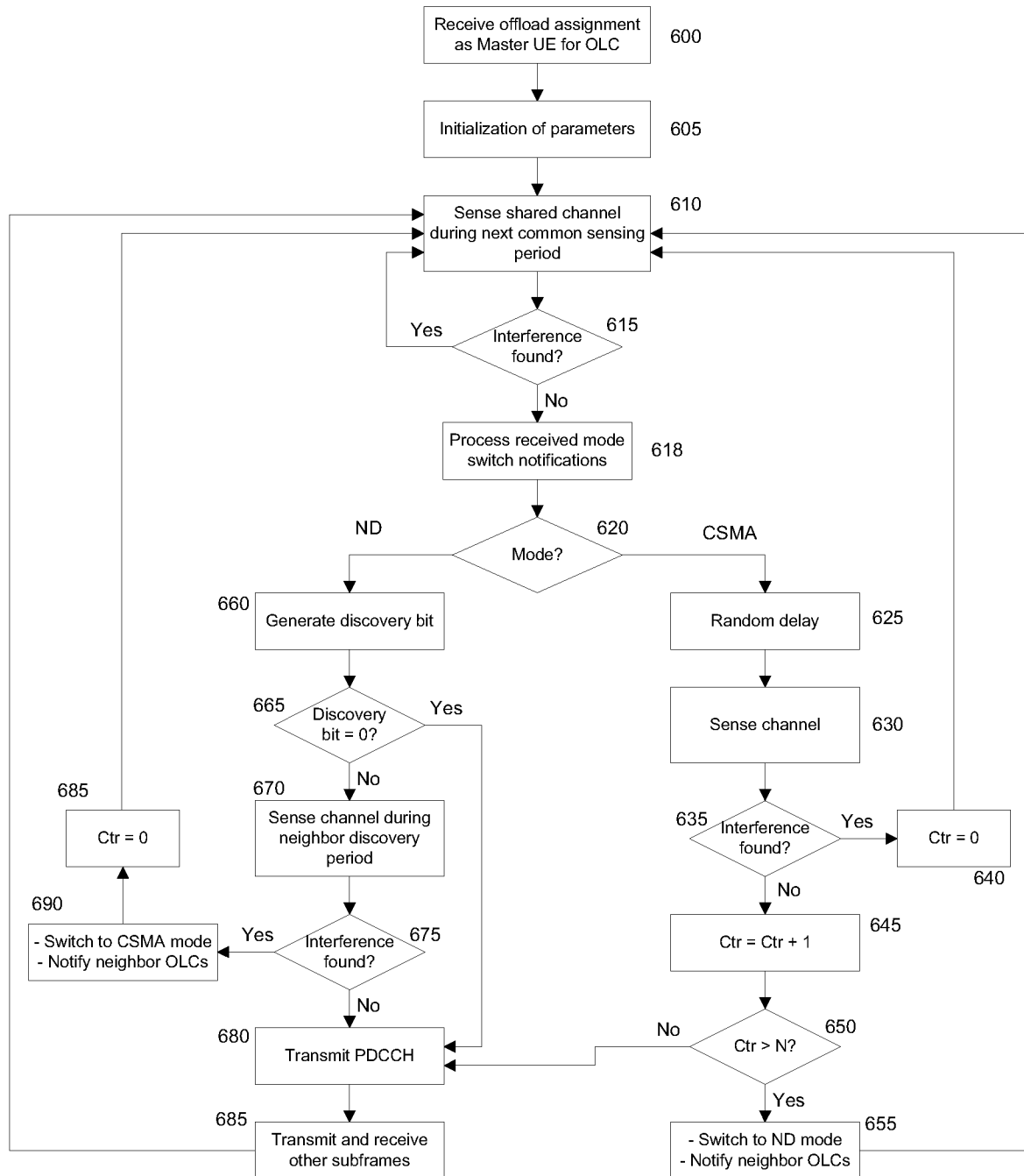


Fig. 6

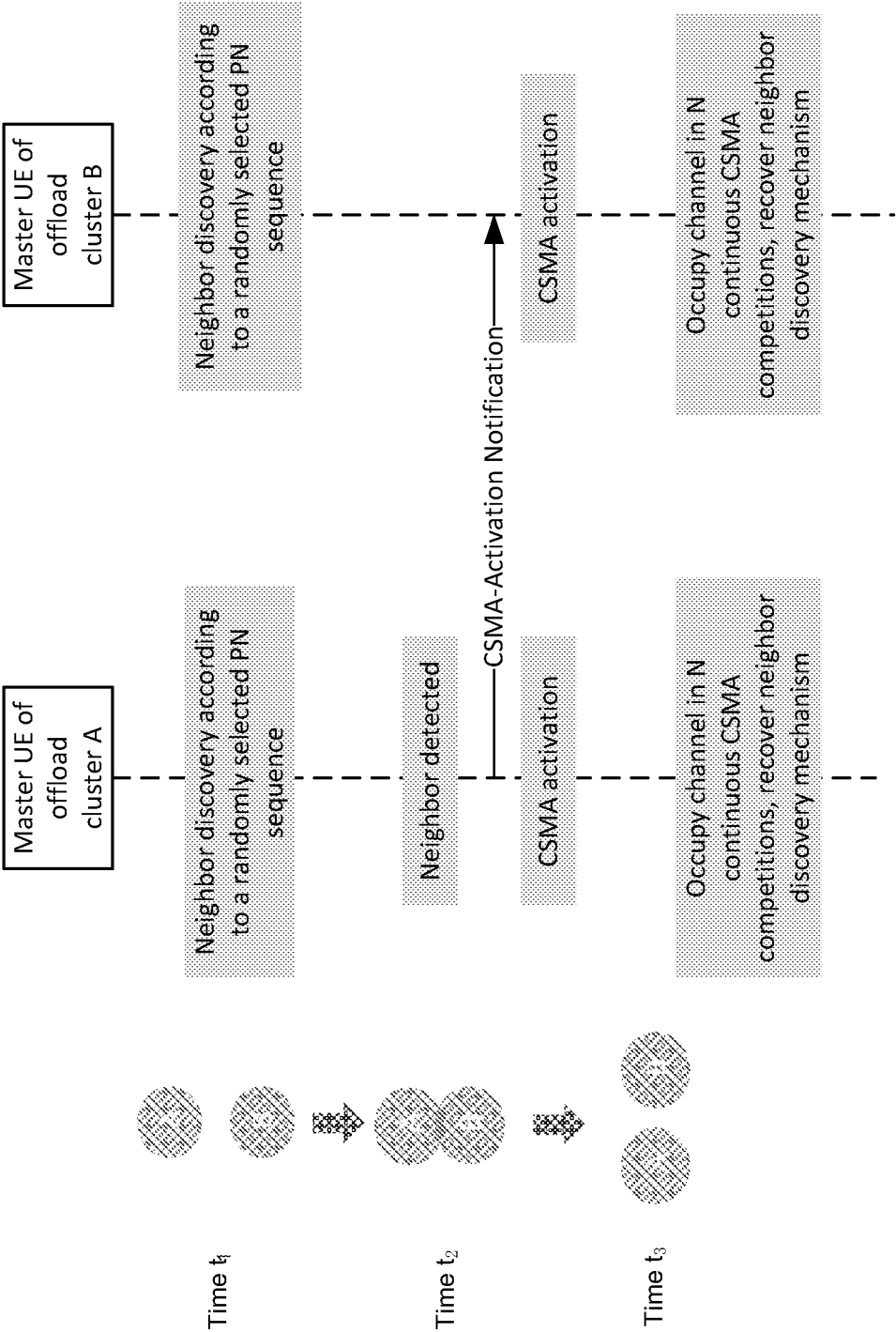
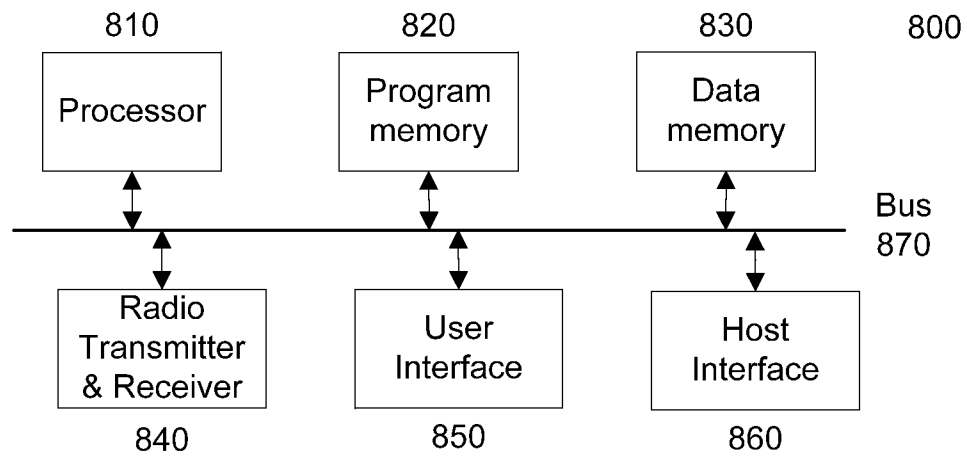


Fig. 7

**Fig. 8**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/074188

A. CLASSIFICATION OF SUBJECT MATTER

see the extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W; H04B; H04Q; 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)

CNABS; CNTXT; CNKI; VEN: unlicensed, frequency, WIFI, bluetooth, Wimax, offload+, master, interference, threshold, cluster?, second

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN1839587A (KEIO UNIVERSITY et al.) 27 Sep. 2006 (27.09.2006) the abstract, claim 1, embodiment 1 and figures 1A-6	1-40
A	CN102340876A (NOKIA CORP.) 01 Feb. 2012 (01.02.2012) the whole document	1-40
A	WO2009127690A1 (TELEFONAKTIEBOLAGET L MERICSSON(PUBL)) 22 Oct. 2009 (22.10.2009) the whole document	1-40

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“A” document defining the general state of the art which is not considered to be of particular relevance	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“E” earlier application or patent but published on or after the international filing date	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	“&” document member of the same patent family
“O” document referring to an oral disclosure, use, exhibition or other means	
“P” document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 08 Jan. 2013 (08.01.2013)	Date of mailing of the international search report 24 Jan. 2013 (24.01.2013)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer HU, Shaoqin Telephone No. (86-10) 62412000

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/074188

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN1839587A	27.09.2006	JP2005341290A	08.12.2005
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		JP2005065102A	10.03.2005
		US2007109989A1	17.05.2007
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		US2009262785A1	22.10.2009
		JP2011523521A	11.08.2011

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/074188

A. CLASSIFICATION OF SUBJECT MATTER

H04W 84/18(2009.01) i

H04W 88/08(2009.01) i