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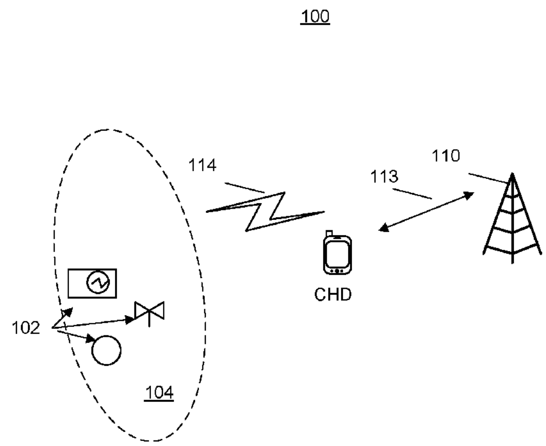

Figure 1a

(57) Abstract: A method at a network element for providing data access to a network. The method comprising establishing a primary communication channel with the network with a first wireless interface of said network element, establishing a complementary communication channel with one or more of a group of delay tolerant devices with a second wireless interface of said network element, receiving data from respective delay tolerant devices in the group, aggregating the received data and transferring said aggregated data on the established primary communication channel to the network. In an embodiment the primary and complementary channels correspond respectively to first and second spectrums, which may in turn be, respective, licensed and unlicensed spectrums.

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SYSTEM AND METHOD FOR MACHINE TYPE COMMUNICATION

[0001] The present application claims benefit of U.S. Non-Provisional Application No. 14/570,445, filed December 15, 2014, entitled "SYSTEM AND METHOD FOR MACHINE TYPE COMMUNICATION," which application is hereby incorporated herein by reference.

FIELD OF THE DISCLOSURE

[0002] The present disclosure relates to mobile communications and in particular relates to machine type communication (MTC).

BACKGROUND

[0003] Wireless data usage has experienced, and continues to experience, significant growth. Some estimates provide for growth in data usage exceeding one thousand times current usage in the near future. Contributing factors to this growth include higher data usage on mobile devices such as smartphones or tablets, as well as the use of data in other emerging areas such as machine-to-machine (M2M), device-to-device (D2D), or other traffic types.

[0004] In particular the explosive growth of MTC will pose unique challenges with regard to access and signaling requirements for network operators. Further these devices are usually energy constrained and designed for low energy consumption thus channel requests for example, which usually use high output power for access bursts also pose a challenge. Further, data transfer from M2M devices is typically bursty with low-rate traffic, resulting in inefficient spectrum usage.

SUMMARY

[0005] An embodiment of the present disclosure provides a method at a network element for providing data access to a network. The method includes establishing a primary communication channel with the network with a first wireless interface of said network element, establishing a complementary communication channel with one or more of a group of delay tolerant devices with a second wireless interface of the network element, receiving data from respective delay tolerant devices in the group, aggregating the received data and transferring the aggregated data on the established primary communication channel to the network.

[0006] Another embodiment of the present disclosure provides a network element for providing data access to a network. The network element includes a processor configured to operate a first wireless interface of the network element to establish a primary communication channel with the network with a first wireless interface of said network element, establish a complementary communication channel with one or more of a group of delay tolerant devices with a second wireless interface of said network element, receive data from respective delay tolerant devices in the group, aggregate the received data and transfer the aggregated data on the established primary communication channel to the network.

[0007] Aspects of the above embodiments provide for the primary and complementary channels to correspond respectively to first and second frequency spectrums, which may be in turn be respectively licensed and unlicensed spectrums.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present disclosure will be better understood with reference to the drawings, in which:

[0009] **Figure 1a** is a block diagram showing network architecture according to an embodiment of the present disclosure;

[0010] **Figure 1b** is a block diagram showing a hierarchical arrangement of the network architecture of Figure 1a, according to an embodiment of the present disclosure;

[0011] **Figure 2a** is a flow diagram of a method for providing data access to a network, in accordance with an embodiment of the present disclosure;

[0012] **Figure 2b** is a dataflow diagram showing signaling between MTC clusters and a network in accordance with an embodiment of the present disclosure;

[0013] **Figure 3** is a resource grid showing resource allocation according one embodiment of the present disclosure;

[0014] **Figure 4** is a block diagram illustrating a computing platform in accordance with an embodiment of the present disclosure; and

[0015] **Figure 5** illustrates a block diagram of an embodiment communications device.

DETAILED DESCRIPTION OF THE DRAWINGS

[0016] Embodiments of the present disclosure provide for methods and systems to exploit a given wireless spectrum (such as an unlicensed spectrum) in order to ease a burden of excessive traffic on another wireless spectrum (such as a licensed spectrum). In one aspect of the present disclosure, the use of the unlicensed (also termed complementary) spectrum in conjunction with multi-hop radio access enables support for massive connectivity of delay tolerant devices without congesting the licensed (also termed primary) spectrum or sacrificing Quality of Service (QoS) for existing users of the primary spectrum.

[0017] As used herein, “licensed spectrum” refers to a portion of radio frequency spectrum exclusively granted to a licensee within a geographic area. For example, various regulatory bodies such as the Federal Communications Commission (FCC) and the National Telecommunications & information Administration (NTIA) in the United States may provide a frequency allocation to a licensee for a portion of the radio frequency spectrum in a given band. Such license typically defines frequency ranges, geographic locations, and maximum power levels, among other provisions.

[0018] “Unlicensed spectrum”, as used herein, refers to a frequency band that has been allocated by regulatory agencies, to be available to unregistered users. That is, the unlicensed spectrum is a portion of the radio frequency spectrum without an exclusive licensee. Regulations may limit transmission power over such unlicensed spectrum.

[0019] Currently, significant data is provided through licensed spectrum. For example, data may be provided over cellular networks, such as those described by the Third Generation Partnership Project (3GPP) standards. Such mobile technologies include, but are not limited to, Second Generation networks such as the Global System for Mobile Communications (GSM) and Code Division Multiple Access (CDMA), Third Generation networks such as the Universal Mobile Telecommunications System (UMTS), and Fourth Generation networks such as Long Term Evolution (LTE). Also, Fifth Generation (5G) networks are starting to be developed. Utilizing the technologies in these standards, network operators provide user equipment (UE) with service over predefined licensed frequencies.

[0020] Wireless data is also provided over unlicensed spectra as for example, described in The Institute of Electrical and Electronic Engineers (IEEE) 802.11 standards for wireless local area networks (WLAN).

[0021] However, licensed spectrum is heavily utilized in many situations and in order to accommodate a significant data increase, various options including the use of unlicensed spectrum for 5G communications may be explored.

[0022] An aspect of the of the present disclosure, for example with M2M traffic, provides for designating a cluster head device (CHD) in a role of an intermediate node in communication between a cluster of machine type devices (MTD) and the network (NW) to thereby provide a two-hop radio access. The CHD may be a dual mode, multi-spectrum device operable on the unlicensed spectrum to aggregate data from MTDs and forward the aggregated data to the NW on the licensed spectrum. The CHD may be designated by the NW, predetermined or discovered by the network. In one embodiment, the CHD may be a user equipment (UE).

[0023] In another aspect of the system and method of the present disclosure, the MTDs are hierarchically clustered into signaling and access groups that communicate with the NW through the CHD. In one embodiment, the MTDs may be preconfigured with a group identification associating them with an access cluster. The group identification may be used in reporting their data (as discussed below). Further, individual MTDs in an access cluster may be preconfigured with an index to aid the CHD in allocating a resource to a particular MTD.

[0024] The system and methods of the present disclosure allow M2M devices to take advantage of mobile networks and future proposed networks based on fifth generation (5G) networks. However, the present disclosure is not limited to 5G networks, and the methods and systems described herein may be equally used with other network technologies. The use of 5G networks in the examples below is merely done for illustration.

[0025] Proposed 5G networks may support a huge number of M2M devices with bursty low-data rate and delay tolerant traffic. Examples of such device traffic may include metering traffic in smart grids, sensor reporting vending machine traffic, to name a few. Further, the systems and methods of the present disclosure make it feasible for M2M traffic to benefit from global coverage and existing mobile infrastructure to achieve ubiquitous connectivity.

[0026] In still a further aspect, delay tolerant MTC traffic may be handled opportunistically using unlicensed spectrum resources. In other words, the network may be able to better time when MTC traffic is communicated on the network.

[0027] Reference is now made to **Figure 1a**, which shows a block diagram of an example wireless network architecture **100** according to an embodiment of the present disclosure. The architecture **100** includes a network element designated as a **CHD**, a base station **110** and a cluster **104** of delay tolerant devices **102** (such as for example **MTDs**). The base station **110** may belong to a particular network operator and provides network access to the **CHD** on a licensed spectrum **113.** While the base station is described in terms of an **eNB**, the base station may be any access point, transmission point, or device, referred to generally as any network element which provides access to the network. The **CHD** may be any UE type device that is a dual-mode device having a first wireless interface operable for establishing a primary communication channel **113** with the network, and a second wireless interface for establishing a complementary communication channel **114** with a one or more of the group **104** of delay tolerant devices **102**. Further, the **CHD** may have a software-configurable air interface. In the illustrated embodiment the primary channel may be in the licensed spectrum and the secondary channel in the unlicensed spectrum. The **CHD** may be configured to receiving data from respective delay tolerant devices **102** in the cluster **104**, aggregate the received data and transfer the aggregated data on the established primary communication channel **113** to the network. The operation of the architecture **100** is described in more detail below.

[0028] Reference is now made to **Figure 1b**, which shows a block diagram **180** of an example hierarchical arrangement of the network architecture **100** according to an aspect of the present disclosure. As seen in **Figure 1b**, various delay tolerant devices, MTDs **102** are organized in groups, termed herein as “access clusters” **104a-d**.

[0029] Each access cluster may be formed based on various criteria. For example, access clusters may be formed by devices sharing a similar physical proximity (e.g. home, warehouse, smart meters, sensors etc). However, in other embodiments clusters may also be formed based on other factors, such as ownership of the various MTDs, communications systems within the MTDs, among other factors.

[0030] The four illustrated access clusters **104a-d**, may be organized into a further group termed a signaling cluster **106**. A signaling cluster **106** may comprise many access clusters in order to increase signaling efficiency. This clustering into signaling and access groups facilitates hierarchical signaling.

[0031] As illustrated in **Figure 1b**, each access cluster **104a-d** uses the unlicensed spectrum to communicate with its dual-mode cluster head device (CHD) **CHDa-d**, respectively. In some of the embodiments described herein, the CHD is a dual-mode 5G device which is operable over both the primary licensed spectrum to communicate with a network (for example via evolved node Bs (eNBs) **110**) and to communicate **114** with the MTDs **102** of its access cluster **104** over the complementary unlicensed spectrum. The CHD may be designated by the network to operate with a large number of MTC devices. The CHD may have a software-configurable air interface. In other embodiments, rather than communicate with an eNB, the CHD may communicate with other access points, transmission points, or devices, referred to generally as any network element.

[0032] The architectures **100** and **180,** as exemplified in **Figures 1a** and **1b** respectively**,** provide a reliable link (due to use of the licensed spectrum) to the existing mobile network infrastructure to ensure random access and control signaling for literally hundreds of the MTC devices attached to it without the excessive overhead incurred if each MTC device attempted to connect directly to the mobile network. If each MTC device attempted to connect to the network, the signaling overhead of the large numbers of MTCs with small data-rate traffic may be overwhelming to the network and the cost for using the licensed spectrum may be exorbitantly high.

[0033] Referring to **Figure 2a** there is shown a flow diagram **200** of a method for providing data access to a network, in accordance with an aspect of the present disclosure. At block **202**, the network element establishes a primary communication channel with the network using a first wireless interface and at block **204** establishes a complementary communication channel with one or more of a group of delay tolerant devices using a second wireless interface. At block **206**, data received form respective delay tolerant devices in the group are aggregated and at block **208**, the received data is transferred on the established primary communication channel to the network.

[0034] Referring now to **Figure 2b** there is shown an example of a signaling diagram **220** for a data access procedure in accordance with an aspect of the present disclosure. In accordance with the embodiment of **Figure 2b**, a pull-based random access is shown for a MTC cluster based random access. However, in other embodiments, push-based random access may be used.

[0035] As described above, the CHD may be a dual-mode CHD **222** capable of operating over the primary licensed spectrum **224** to communicate with an eNB **226**. CHD **222** is further operable over the complementary unlicensed spectrum **228** to communicate with an MTC cluster **230**. Criteria for selecting the cluster-head device may be based on location, channel conditions, multi-spectrum capability, etc.

[0036] In a pull-based embodiment, the network triggers the random access by sending a control signal **232** to the cluster head device **222**. This may be triggered periodically, for example based on knowing when the MTC devices need to send data. For example, if the MTC devices need to report once a day, the network may have a timer to trigger control signal **232** on a daily basis. Other examples are possible. Control signal **232** is meant to start a random access procedure for the entire “cluster”, via the cluster head device **222**.

[0037] The CHD **222** then uses group signaling message **234** to identify itself as the designated CHD to the MTC devices within the MTC cluster **230**.

[0038] The CHD **222** then starts a contention based random access procedure, by sending a RACH (random access channel) preamble **236** to the eNB. As indicated above, preamble **236** is a random access preamble for the MTC cluster, via the CHD **222**.

[0039] The eNB then sends a response message "Random Access Response" **238** to the CHD **222** on the DL-SCH (Downlink shared channel), which includes a timing advance value. The timing advance value is used to inform the CHD **222** on adjusting its uplink timing so it can compensate for the round trip delay caused by CHD distance from the eNB.

[0040] The CHD **222** adjusts its uplink timing and broadcasts a group random access response **240** to the MTC cluster **230** along with the timing advance value so that the MTC devices within the MTC cluster **230** may adjust their uplink timing.

[0041] Using the UL-SCH (uplink shared channel), the CHD sends a "RRC connection request message" **242** to the eNB **226** along with a group identification of the MTC cluster to establish an RRC (radio resource control) layer connection between the CHD **222** and the eNB **226**.

[0042] The eNB **226** responds with a contention resolution message **244** to the CHD which contains the new C-RNTI (cell radio network temporary identity) which is used for further communication.

[0043] The CHD **222** in turn establishes a group RRC connection **246** (setup broadcast) with the MTC devices within the MTC clusters **230**.

[0044] In accordance with the embodiments described herein, it is assumed that all MTC devices within the MTC cluster **230** are able to synchronize their downlink timing through either cell search or cluster head device discovery procedures. Further, since the MTC devices within the MTC cluster **230** are co-located, they have similar timing advance which can be estimated through the preamble sent by the CHD **222**.

[0045] Uplink synchronization to the eNB is therefore acquired by the CHD **222** on behalf of the MTC devices in the cluster during the random access response step and forwarded (broadcast) to the MTC devices within the MTC cluster **230**.

[0046] Thus cluster-based random access saves RACH resources (reducing the RACH overload problem) since a separate preamble from every device in the cluster is no longer required. The elimination of the need for a separate preamble from every device also saves power consumption of cluster devices.

[0047] While, the pull-based, i.e. network triggered, cluster-based random access, described above with reference to **Figure 2b**, reduces the RACH overload problem, in some cases push-based approaches to cluster based access may lead to a high variance of RACH intensity. In push-based access, each MTC cluster may individually make the decision on whether to report, and this may make it difficult for the network to estimate the number of MTC devices competing for RACH resources at the same time and allocate the data resources accordingly. However, data aggregation is still possible but it may be less efficient and may lead to some delay since the CHD would wait to receive data from the whole access cluster before aggregating and forwarding it to the network opportunistically. Further the CHD would need adequate storage capacity for the aggregated data.

[0048] From **Figure 2b** above, after the signaling process has completed, the cluster is connected to the eNB and may report data. Reference is now made to **Figure 3**, which shows a resource grid representation **300** for MTC cluster data allocation in accordance with one aspect of the present disclosure. **Figure 3** utilizes a familiar resource grid representation to illustrate an example of how the CHD aggregates the received data from the MTC cluster **304** on the unlicensed spectrum **306** before forwarding the aggregated data to the eNB using the licensed spectrum **308**.

[0049] In accordance with an embodiment of the invention, the radio resource element grid supports multiple radio communication channels that are allocated to certain radio resource elements (locations) in the radio resource element grid. For ease of description, each radio communication channel corresponds to or is allocated a subset of the time-frequency resource element grid. The resource grid shows a repeating sequence of a contention period followed by a data period on the licensed spectrum. This pattern repeats for successive new cluster data transmissions. In the illustrated embodiment **300** it may be assumed that because the MTC devices transmit small amounts of data, each MTC device may be assigned a fixed amount of resource blocks (RBs) for a particular application. For example, in one application (such as smart meter reporting) only 1 RB may be needed per MTC device. However, in other embodiments more resource blocks may be needed, and the present disclosure is not limited to any particular number of resource blocks per MTC device. In still further embodiments the allocation may also account for variable number of RBs per MTC device.

[0050] As shown in **Figure 3**, the CHD during a first phase contention period **311** contends for resources, indicated as contention resources **310**, and secures uplink resources **312** on the licensed spectrum **308** to the eNB. In turn in a second phase 2, the CHD signals the MTC devices using PDCCH (physical downlink control channel) control signaling to allocate uplink resources from the MTC devices on its downlink. As will be appreciated, the CHD only needs to allocate uplink resources for the MTC devices at the cluster level, i.e. the aggregated data. The MTC devices do not need to engage in contention for uplink resources. For example as shown in **Figure 3**, a block of N RBs **314** per CHD can be allocated on the licensed spectrum to convey the aggregated data traffic of a given MTC cluster **304** of size N to the eNB. A block of N RBs **316** per MTC cluster can be allocated on the unlicensed spectrum so that that the MTC devices in the cluster report their data to the CHD.

[0051] Further, MTC devices in the cluster **304** may transmit their data according to a pre-specified indexing order to decrease signaling overhead. In other words each MTC device may be indexed in the cluster to have its data allocated to a specific resource element in the resource grid for transmission to the network. This is illustrated graphically in **Figure 3**, by arrows **320a-c**. For example three MTCs are shown having respective indices **i1**, **i2** and **i3**. The corresponding resource blocks **i1**, **i2** and **i3** are shown allocated in the aggregated data resource blocks 316. The indexing is used by the CHD and the MTC devices to link or allocate specific radio resource to the transmission of the cluster data to the network.

[0052] Signaling overhead may further be decreased by linking the preamble resources (e.g. Zadoff–Chu (*ZC*) sequence) to the actual data resources used by the CHD on the licensed spectrum **308** to convey the aggregated data to the eNB and by the MTC devices on the unlicensed spectrum to report their data to the CHD.

[0053] A benefit of cluster-based control signaling allows spectrum reuse of the unlicensed spectrum because MTC devices use low power to report their data to the CHD.

[0054] The indexing described above may be configured through announcements by the eNB. Further, the indexing, the usage of the indexing by cluster-head devices and MTC devices, may be preconfigured or also announced by the network.

[0055] Thus it may be seen that the random access procedure for a given cluster may be pull-based, i.e. triggered by the network sending of a group signaling message containing the group ID of the access cluster; group rather than individual signaling in this case allows for saving of signaling resources; or push-based, e.g. through access class barring (ACB), separate RACH resources, dynamic allocation of RACH resources, smart meter device specific back off, slotted access etc.

[0056] In another aspect of the disclosure, the network can trigger the reports for a signaling cluster, where the signaling cluster comprises many access clusters as described above.

[0057] In another aspect of the disclosure, the signaling of the resource allocation to the MTC cluster devices can be done directly by the network. In this aspect, the CHD continues to act as the aggregating device and may be informed of the resource allocation.

[0058] The functionality described herein may be implemented on any one or combination of network elements. **Figure 4** is a block diagram of a processing system **400** that may be used for implementing the devices and methods disclosed herein. Specific devices may utilize all of the components shown, or only a subset of the components and levels of integration may vary from device to device. Furthermore, a device may contain multiple instances of a component, such as multiple processing units, processors, memories, transmitters, receivers, etc. The processing system **400** may comprise a processing unit equipped with one or more input/output devices, such as a speaker, microphone, mouse, touchscreen, keypad, keyboard, printer, display, and the like. The processing unit may include a central processing unit (CPU) **410**, memory **420**, a mass storage device **430**, a video adapter **440**, and an I/O interface **450** connected to a bus **460**.

[0059] The bus **460** may be one or more of any type of several bus architectures including a memory bus or memory controller, a peripheral bus, video bus, or the like.

The CPU **410** may comprise any type of electronic data processor. The memory **420** may comprise any type of system memory such as static random access memory (SRAM), dynamic random access memory (DRAM), synchronous DRAM (SDRAM), read-only memory (ROM), a combination thereof, or the like. In an embodiment, the memory may include ROM for use at boot-up, and DRAM for program and data storage for use while executing programs.

[0060] The mass storage device **430** may comprise any type of storage device configured to store data, programs, and other information and to make the data, programs, and other information accessible via the bus. The mass storage device **430** may comprise, for example, one or more of a solid state drive, hard disk drive, a magnetic disk drive, an optical disk drive, or the like.

[0061] The video adapter **440** and the I/O interface **450** provide interfaces to couple external input and output devices to the processing unit. As illustrated, examples of input and output devices include the display **442** coupled to the video adapter and the mouse/keyboard/printer **452** coupled to the I/O interface. Other devices may be coupled to the processing unit, and additional or fewer interface cards may be utilized. For example, a serial interface such as Universal Serial Bus (USB) (not shown) may be used to provide an interface for a printer.

[0062] The processing unit **400** also includes one or more network interfaces **470**, which may comprise wired links, such as an Ethernet cable or the like, and/or wireless links to access nodes or different networks. The network interface **470** allows the processing unit to communicate with remote units via the networks. For example, the network interface **470** may provide wireless communication via one or more transmitters/transmit antennas and one or more receivers/receive antennas. In an embodiment, the processing unit **400** is coupled to a local-area network or a wide-area network, shown as network **472**, for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

[0063] **Figure 5** illustrates a block diagram of an embodiment of a communications device **500**, which may be equivalent to one or more devices (e.g., UEs, NBs, MTD's etc.) discussed above. The communications device **500** may include a processor **504**, a memory **506**, a cellular interface **510**, a supplemental wireless interface **512**, and a supplemental interface **514**, which may (or may not) be arranged as shown in **Figure 5**. The processor **504** may be any component capable of performing computations and/or other processing related tasks, and the memory **506** may be any component capable of storing programming and/or instructions for the processor **504**. The cellular interface **510** may be any component or collection of components that allows the communications device **500** to communicate using a cellular signal, and may be used to receive and/or transmit information over a cellular connection of a cellular network on either a licensed and or unlicensed spectrum. The supplemental wireless interface **512** may be any component or collection of components that allows the communications device **500** to communicate via a non-cellular wireless protocol, such as a Wi-Fi or Bluetooth protocol, or a control protocol. The device **500** may use the cellular interface **510** and/or the supplemental wireless interface **512** to communicate with any wirelessly enabled component, e.g., a base station, relay, mobile device, machine type device etc. The supplemental interface **514** may be any component or collection of components that allows the communications device **500** to communicate via a supplemental protocol, including wire-line protocols. In embodiments, the supplemental interface **514** may allow the device **500** to communicate with another component, such as a backhaul network component.

[0064] The device **500** may be configured according to any aspect of the present disclosure. For example the controller/processor **504** may control the various components and executes any software or firmware in memory **506** that is used to operate the functionality and features of device **500**. For example the device **500** may have a software-configurable air interface featuring dual-mode (licensed-unlicensed) multi-spectrum relaying and data-aggregation capabilities. Further, the device **500** may receive information from a serving base station with regard to a MTC cluster-based data access. Such signals may be received by device **500** over antennas **508,** served by cellular interface **510** or supplemental wireless interface **512**. Under control of controller/processor **504**, the signals are decoded to receive the information for the communication.

[0065] The device **500** may also include MTC cluster-based access logic **506a** for aggregating data on the unlicensed spectrum from MTDs and forward the aggregated data to the NW on the licensed spectrum. Accordingly, the device **500** under control of controller/processor **504** may execute MTC cluster-based access logic **506a** stored in memory **506**, in order to participate in the role of intermediate node in communications between a cluster of machine type devices (MTD) and the NW. The logic **506a** may implement the signaling and resource allocation as for example described with reference to **Figures 2** and **3** respectively.

[0066] The device **500** may in another aspect be configured as a MTD and include in memory **506**, information **506b** for participating in cluster based access. Such information may include group (cluster) identification, indexing, information on geographically co-located MTC devices and such like.

[0067] As described above, the use of the unlicensed spectrum is particularly relevant to MTC devices. Specifically, MTC devices are typically characterized by small packet size (each MTC device typically sends or receives a small amount of data), mostly delay tolerant thereby allowing for opportunistic usage of unlicensed spectrum, and mostly energy constrained. These characteristics make MTC a suitable application scenario for using unlicensed spectrum due to the unreliable but rich nature of such spectrum, i.e. even when subject to high interference levels, the unlicensed spectrum will suffice for such applications.

[0068] Further, M2M communication may also benefit from unlicensed spectrum usage with lower frequency and longer-range characteristics in order to facilitate long-distance data transfers and meter reports while consuming less energy.

[0069] For large file transfers (such as surveillance video), opportunistic usage of non-congested unlicensed spectrum may be implemented. For example if data is not needed instantly, then M2M applications can wait for available unlicensed spectrum chunks to opportunistically deliver low data rate delay tolerant M2M traffic from groups of geographically co-located MTC devices. These application scenarios include collecting measurement data from MTC devices in smart grid networks or navigation signals from positioning sensors in navigation networks.

[0070] While embodiments of this disclosure have been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of this disclosure, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

CLAIMS

1. A method at a network element for providing data access to a network, said method comprising:

establishing a primary communication channel with said network with a first wireless interface of said network element;

establishing a complementary communication channel with one or more of a group of delay tolerant devices with a second wireless interface of said network element;

receiving data from respective delay tolerant devices in said group;

aggregating said received data; and

transferring said aggregated data on said established primary communication channel to said network.

2. The method of claim 1, wherein said primary channel uses a first spectrum and said complementary communication channel uses a second spectrum.

3. The method of claim 2, wherein said first spectrum is a licensed spectrum and said second spectrum is an unlicensed spectrum.

4. The method of claim 2, further comprising receiving a signal indicating an allocation of resource blocks (RBs) on said second spectrum for said aggregated data.

5. The method of claim 2, further comprising transmitting a signal for an allocation of uplink data resources on said first spectrum, said allocation comprising an allocation for said aggregated data.

6. The method of claim 5, comprising conveying said aggregated data on said allocated uplink data resources.

7. The method of claim 5, further comprising linking a preamble resource to said allocated uplink data resource for conveying said aggregated data to said network.

8. The method of claim 2, further comprising allocating resource blocks (RBs) on said second spectrum for said data received from said respective delay tolerant devices.

9. The method of claim 8, further comprising linking a preamble resource to an allocated downlink resource on said second spectrum.

10. The method of claim 8, wherein said allocating of RBs includes indexing individual resource blocks with corresponding indices on respective delay tolerant devices.

11 The method of claim 1, further comprising receiving a signal from said network to trigger said data transfer.

12. The method of claim 1, wherein said wireless interfaces are software-configurable.

13. The method of claim 1, further comprising acquiring uplink synchronization information from said network in a random access channel procedure (RACH) during said establishing said primary communication channel with said network.

14. The method of claim 13, further comprising broadcasting said uplink synchronization information to said group of delay tolerant devices.

15. The method of claim 1, further comprising transmitting a preamble signal to said group for use by said delay tolerant devices in estimating a timing advance.

16. The method of claim 1, wherein said network element is user equipment (UE).

17. The method of claim 1, wherein said network element is a transmission point.

18. A network element for providing data access to a network, said network element comprising a processor configured to:

establish a primary communication channel with said network with a first wireless interface of said network element;

establish a complementary communication channel with one or more of a group of delay tolerant devices with a second wireless interface of said network element;

receive data from respective delay tolerant devices in said group;

aggregate said received data; and

transfer said aggregated data on said established primary communication channel to said network.

19. The network element of claim 18, wherein said primary channel uses a first spectrum and said complementary communication channel uses a second spectrum.

20. The network element of claim 19, wherein said first spectrum is a licensed spectrum and said second spectrum is an unlicensed spectrum.

21. The network element of claim 19, wherein the processor is further configured to transmit a signal for an allocation of uplink data resources on said first spectrum, said allocation comprising an allocation for said aggregated data.

22. The network element of claim 21, wherein the processor is further configured to convey said aggregated data on said allocated uplink resources.

23. The network element of claim 21, wherein the processor is further configured to link a preamble resource to said allocated uplink data resource for conveying said aggregated data to said network.

24. The network element of claim 19, wherein the processor is further configured to allocate resource blocks (RBs) on said second spectrum for said data received from said respective delay tolerant devices.

25. The network element of claim 24, wherein the processor is further configured to link a preamble resource to an allocated downlink resource on said second spectrum.

26. The network element of claim 24, wherein the allocated RBs includes indexing of individual resource blocks with corresponding indices on respective delay tolerant devices.

27. The network element of claim 19, wherein the processor is further configured to receive a signal indicating an allocation of resource blocks (RBs) on said second spectrum for said aggregated data.

28. The network element of claim 18, wherein the processor is further configured to receive a signal from said network to trigger said data transfer.

29. The network element of claim 18, wherein said wireless interfaces are software-configurable.

30. The network element of claim 18, wherein the processor is further configured to acquire uplink synchronization information from said network in a random access channel procedure (RACH), during said establishing said primary communication channel with said network.

31. The network element of claim 30, wherein the processor is further configure to broadcast said uplink synchronization information to said group of delay tolerant devices.

32. The network element of claim 18, wherein the processor is further configured to transmit a preamble signal to said group for use by said delay tolerant devices in estimating a timing advance.

33. The network element of claim 18, wherein said network element is user equipment (UE).

34. The network element of claim 18, wherein said network element is a transmission point.

35. The network element of claim 18, wherein said complementary communication channel is established with a respective one of a plurality of groups of delay tolerant devices.

36. The network element of claim 35, wherein each said group of delay tolerant devices is identified by a group identification index.

37. The network element of claim 18, wherein said group of delay tolerant devices is identified by a group identification index.

100

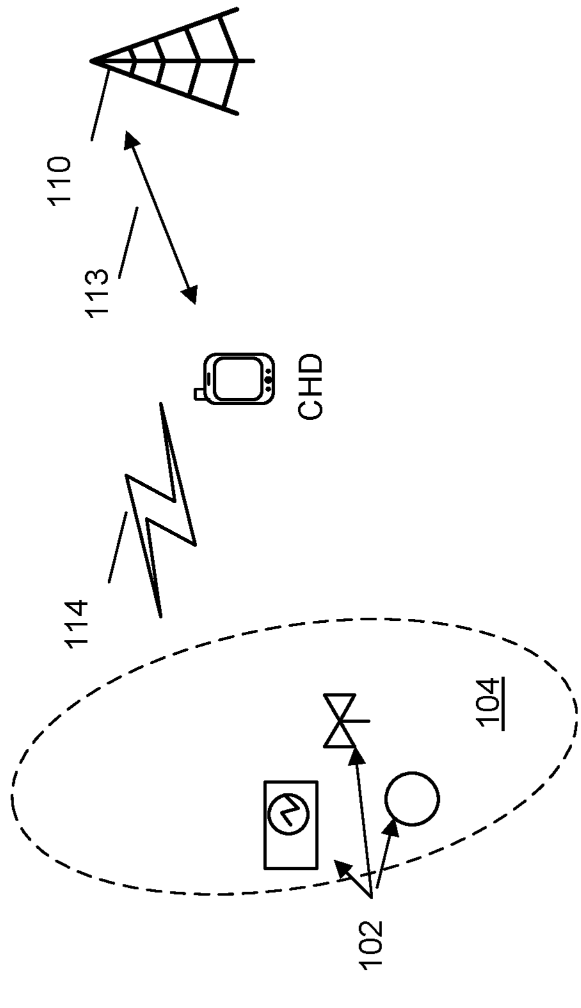

Figure 1a

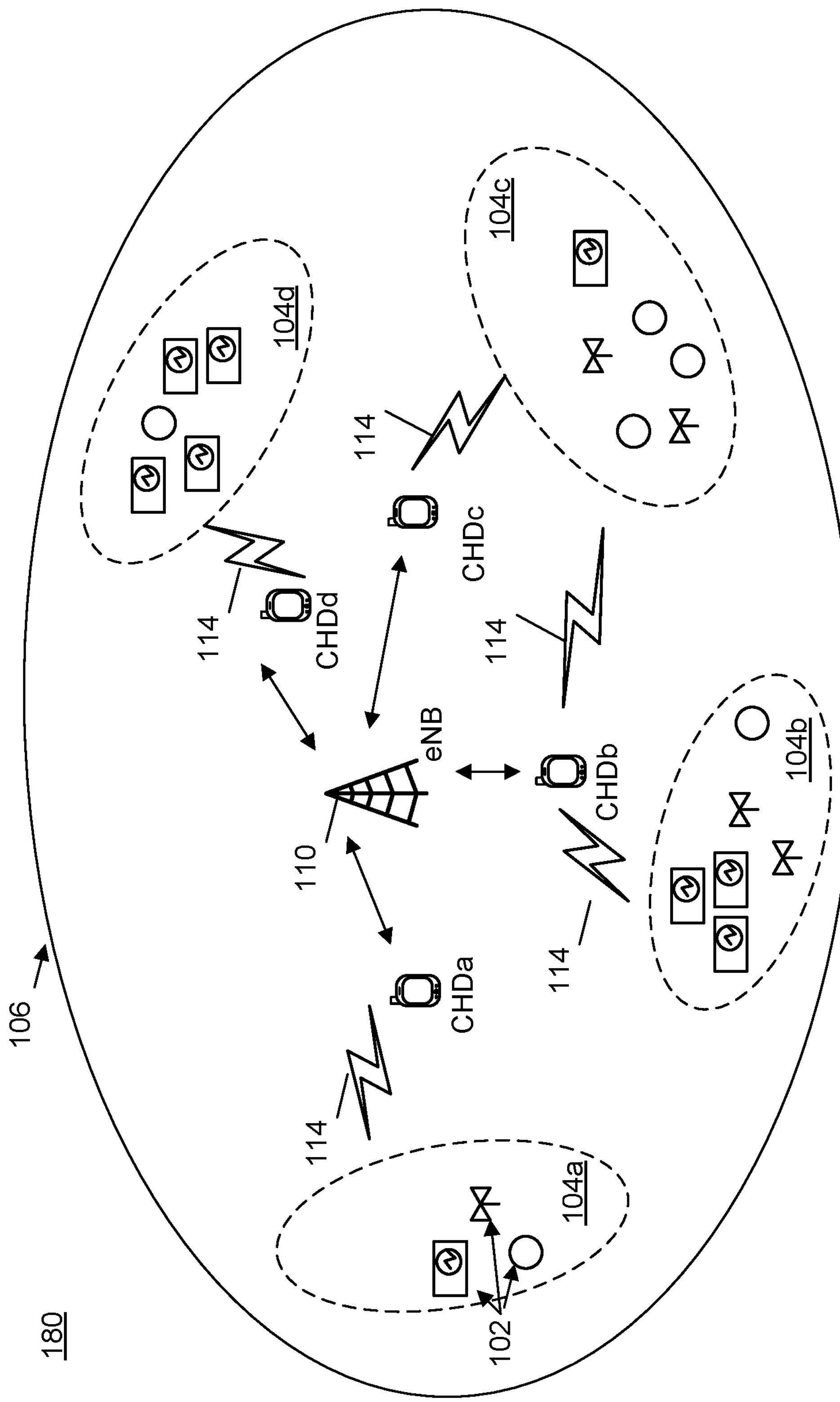
180
106
102
104a
104b
104c
104d
110
eNB
CHDa
CHDb
CHDc
CHDd
114
114
114
114
114

Figure 1b

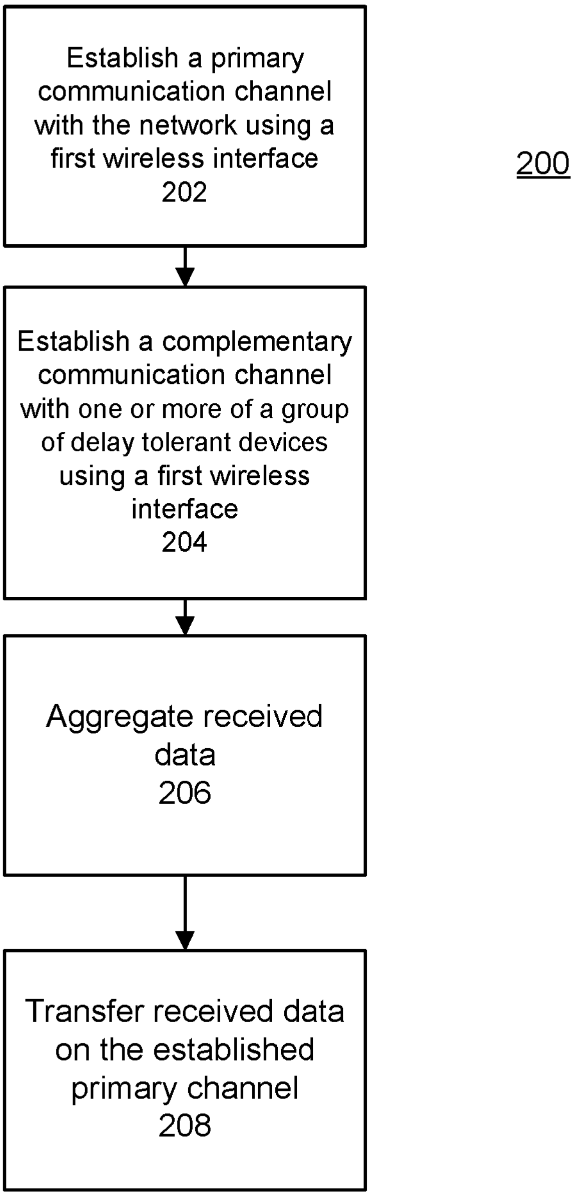
Establish a primary communication channel with the network using a first wireless interface
202
Establish a complementary communication channel with one or more of a group of delay tolerant devices using a first wireless interface
204
Aggregate received data
206
Transfer received data on the established primary channel
208
200

Figure 2a

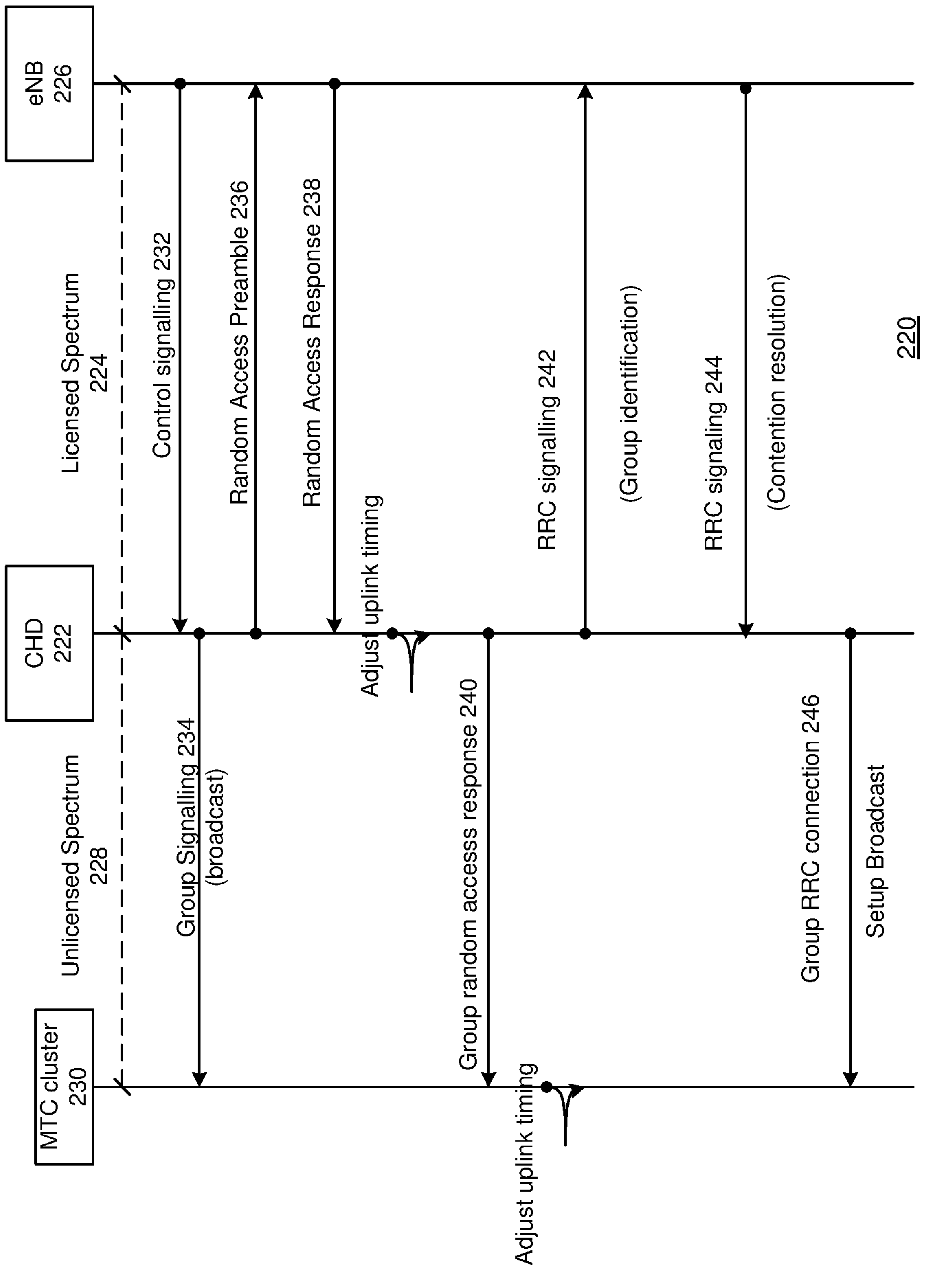
eNB
226
CHD
222
MTC cluster
230
Licensed Spectrum
224
Unlicensed Spectrum
228
Control signalling 232
Group Signalling 234
(broadcast)
Random Access Preamble 236
Random Access Response 238
Adjust uplink timing
Group random accesss response 240
Adjust uplink timing
RRC signalling 242
(Group identification)
RRC signaling 244
(Contention resolution)
Group RRC connection 246
Setup Broadcast
220

Figure. 2b

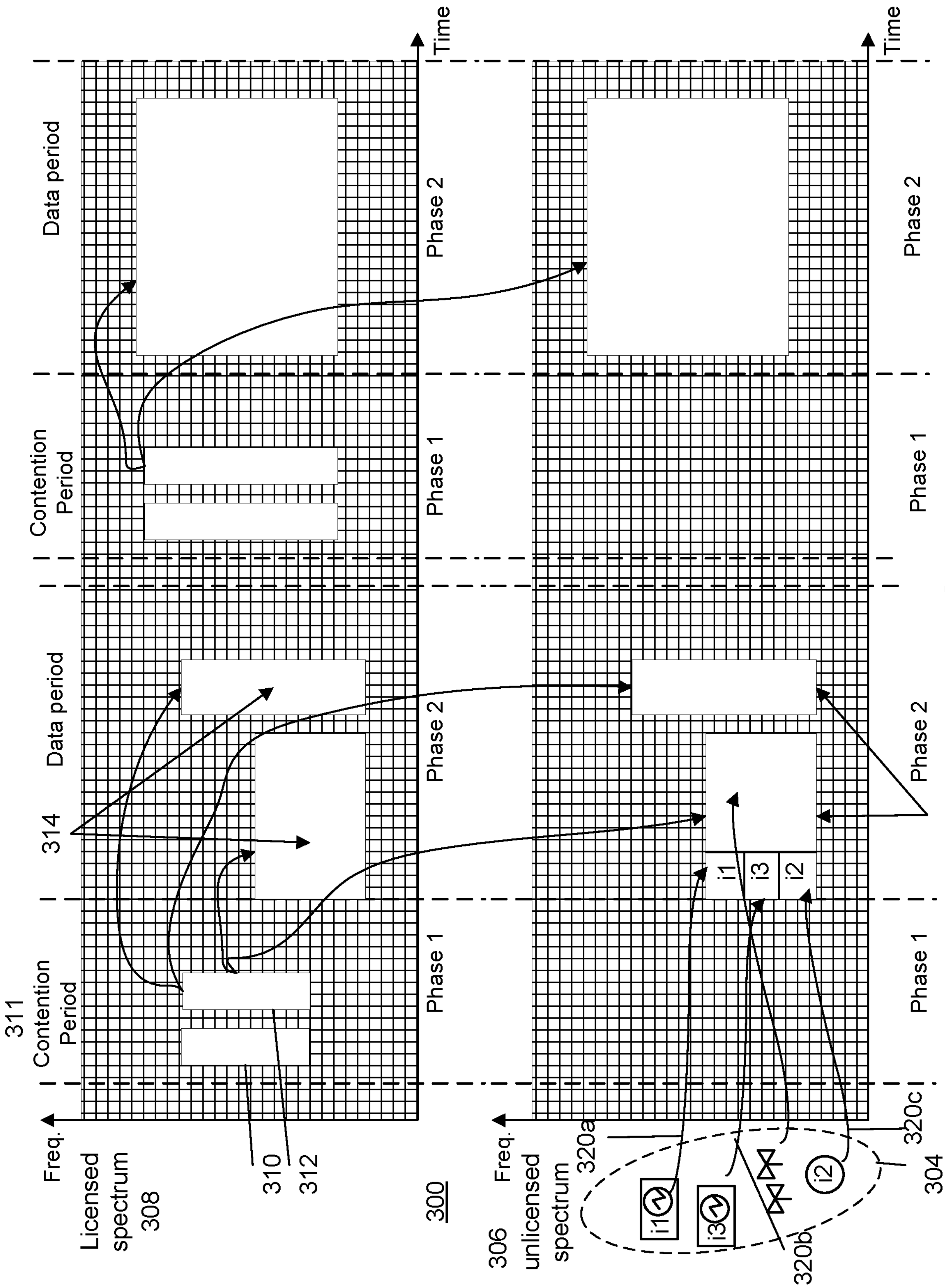
Licensed spectrum 308
Freq.
Time
311
Contention Period
Data period
Contention Period
Data period
Phase 1
Phase 2
Phase 1
Phase 2
310
312
314
300
306 unlicensed spectrum
Freq.
Time
320a
320b
320c
304
i1
i3
i2
316
Phase 1
Phase 2
Phase 1
Phase 2

FIG. 3

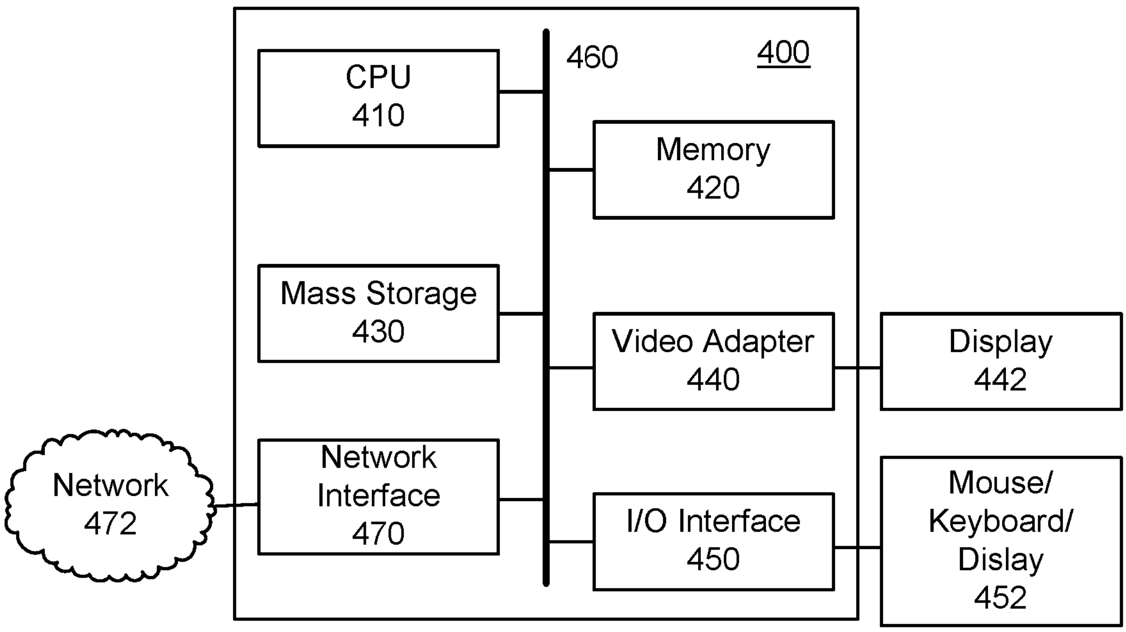
CPU
410
460
400
Memory
420
Mass Storage
430
Video Adapter
440
Display
442
Network
472
Network
Interface
470
I/O Interface
450
Mouse/
Keyboard/
Dislay
452

FIG. 4

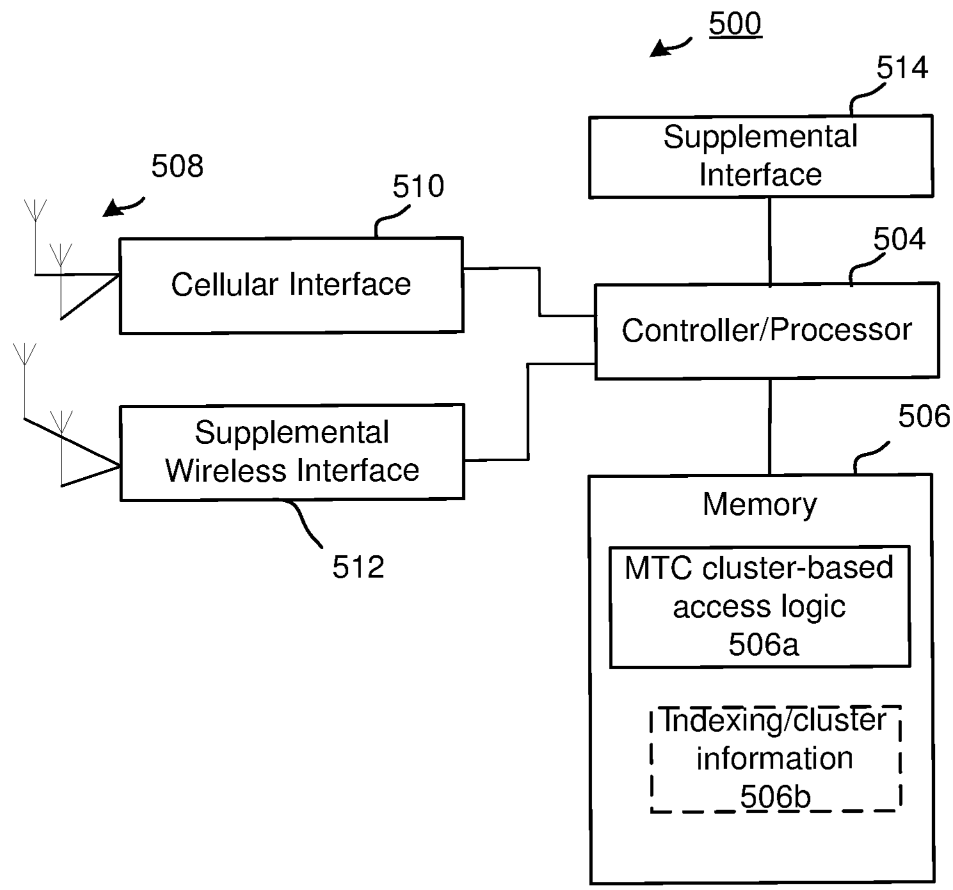
500
514
Supplemental Interface
508
510
Cellular Interface
504
Controller/Processor
Supplemental Wireless Interface
506
Memory
512
MTC cluster-based access logic 506a
Indexing/cluster information 506b

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/097178

A. CLASSIFICATION OF SUBJECT MATTER

H04W 4/00(2009.01)i

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; H04Q

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)

CNPAT, CNKI, WPI, EPODOC:M2M, MTC, machine, connect, interface, network, access, gateway, AP, GW, primary, complementary, channel, dual, multi, second, mode, aggregate, delay, tolerant, unlicensed, licensed, spectrum, allocation, preamble

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013215755 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 22 August 2013 (2013-08-22) the abstract, description, paragraphs [0003], [0090] to [0094]	1-37
Y	WO 2011109424 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 09 September 2011 (2011-09-09) the abstract, description, paragraphs [0073], [0101] to [0103], figure 3	1-37
A	WO 2012109531 A2 (INTERDIGITAL PATENT HOLDINGS, INC.) 16 August 2012 (2012-08-16) the whole document	1-37
A	CN 102130839 A (DATANG MOBILE COMMUNICATION EQUIP CO., LTD.) 20 July 2011 (2011-07-20) the whole document	1-37

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

* Special categories of cited documents:

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

"E" earlier application or patent but published on or after the international filing date

"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)

"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

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 February 2016	**11 March 2016**

Name and mailing address of the ISA/CN	Authorized officer
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Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)62413456**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/097178

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2013215755	A1	22 August 2013	WO	2011137801	A1	10 November 2011
				CN	102421140	A	18 April 2012
				EP	2624625	A1	07 August 2013
WO	2011109424	A1	09 September 2011	US	2011213871	A1	01 September 2011
				TW	201206132	A	01 February 2012
				CN	102804738	A	28 November 2012
				EP	2543175	A1	09 January 2013
				KR	20130037199	A	15 April 2013
				JP	2013521709	A	10 June 2013
				RU	2012141560	A	27 May 2014
				JP	2014112843	A	19 June 2014
				HK	1177997	A0	30 August 2013
WO	2012109531	A2	16 August 2012	TW	201249154	A	01 December 2012
				EP	2673965	A2	18 December 2013
				KR	20140008373	A	21 January 2014
				CN	103621113	A	05 March 2014
				JP	2014506764	A	17 March 2014
				US	2014126581	A1	08 May 2014
				EP	2854423	A1	01 April 2015
				HK	1192677	A1	19 June 2015
CN	102130839	A	20 July 2011	None			