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(54) Title: SYSTEM AND METHOD FOR RESOURCE ALLOCATION FOR SPARSE CODE MULTIPLE ACCESS TRANSMISSIONS

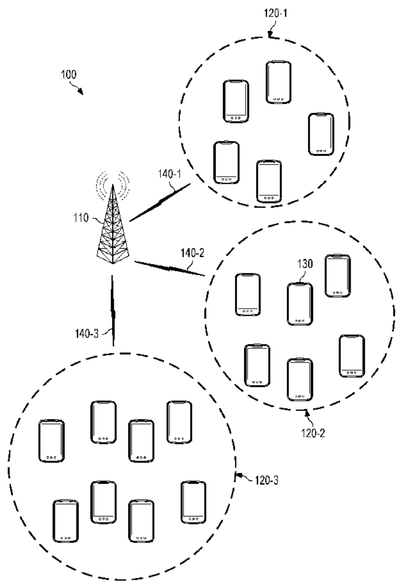

FIG. 1

(57) Abstract: An embodiment method of resource allocation for sparse code multiple access (SCMA) transmissions includes partitioning a resource block into a plurality of resource regions. The method also includes assigning the plurality of resource regions to respective device groups. The resource region assignments are then signaled to devices of the respective device groups. The method also includes receiving SCMA signals from the devices of the respective device groups. The SCMA signals from one group of the respective device groups are asynchronous with respect to the SCMA signals from another group of the respective device groups.

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SYSTEM AND METHOD FOR RESOURCE ALLOCATION FOR SPARSE CODE MULTIPLE ACCESS TRANSMISSIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefits to U.S. Patent Application No. 14/231,217, titled “Method and Apparatus for Asynchronous OFDMA/SC - FDMA,” filed on March 31, 2014, and U.S. Patent Application 14/668,577, entitled “System and Method for Resource Allocation for Sparse Code Multiple Access Transmissions,” filed on March 25, 2015, which applications are hereby incorporated herein by reference.

TECHNICAL FIELD

The present invention relates generally to sparse code multiple access (SCMA), and, in particular embodiments, to a system and method for group-wise asynchronous SCMA transmissions.

BACKGROUND

SCMA is a non-orthogonal multiple access scheme that allows multiple devices, users, or user equipments (UEs) to share channel resources. Potential transmit devices are allocated time and frequency resources, also referred to as resource units. In SCMA, potential transmit devices are also assigned a sparse codebook that allows superposition of device transmissions, which allows SCMA systems to support more connected devices.

In grant-free SCMA systems, there is no signaling from the network to devices for scheduling transmissions. The devices access the shared channel resources in a contention based manner. Contention based access begins to break down when two or more devices attempt to transmit using the same resources, which is referred to as a collision. SCMA can tolerate some amount of signal collision. SCMA systems can control the probability of collision using collision avoidance and collision detection and recovery techniques to mitigate its impact. For additional information regarding SCMA, refer to U.S. Application No. 13/730,355, which is hereby incorporated herein by reference.

Base station receivers generally need arriving signals to be synchronized in time in order to receive them correctly and take advantage of low complexity message passing algorithm (MPA) receivers. That synchronizing is typically achieved through signaling from the base station to the transmitting devices indicating timing adjustments to transmit timing.

SUMMARY

An embodiment method of resource allocation for sparse code multiple access (SCMA) transmissions includes partitioning a resource block into a plurality of resource regions. The method also includes assigning the plurality of resource regions to respective device groups. The resource region assignments are then signaled to devices of the respective device groups. The method also includes receiving SCMA signals from the devices of the respective device groups. The SCMA signals from one group of the respective device groups are asynchronous with respect to the SCMA signals from another group of the respective device groups.

An embodiment method of receiving asynchronous SCMA signals includes partitioning a resource block into a plurality of resource regions. The method also includes receiving a first SCMA signal from a first user equipment (UE). The first SCMA signal uses a first resource region of the plurality of resource regions. The method also includes receiving a second SCMA signal from a second UE. The second SCMA signal uses a second resource region of the plurality of resource regions and is asynchronous with respect to the first SCMA signal.

An embodiment base station for SCMA signals includes a processor, an antenna, a mixer, and a plurality of filters. The processor is configured to respectively assign a plurality of resource regions to a plurality of device groups. The antenna is configured to receive asynchronous SCMA signals from a plurality of devices grouped into the plurality of device groups according to respective locations of the plurality of devices. The mixer is coupled to the antenna and configured to convert the asynchronous SCMA signals from a radio frequency to a baseband frequency. The plurality of filters are coupled to the mixer and respectively correspond to the plurality of resource regions. The plurality of filters are also configured to filter inter-resource region interference for each of the plurality of resource regions.

An embodiment method of transmitting an SCMA signal includes receiving a resource region assignment indicating a resource region allocated to a device group of which the UE is a member. The resource region assignment is received at a UE. The method also includes filtering the SCMA signal using a spectrum shaping filter corresponding to the resource region. The filtering is carried out by the UE. The method also includes transmitting the SCMA signal toward a base station using time and frequency resources of the resource region according to the resource region assignment. The transmitting is carried out synchronously with a local timing reference for the device group.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

Figure 1 is a diagram of one embodiment of a wireless network;

Figure 2 is an illustration of one embodiment of a resource block;

Figure 3 is a block diagram of one embodiment of a base station;

Figure 4 is an illustration of an SCMA encoding scheme;

Figure 5 is a flow diagram of one embodiment of a method of resource allocation for SCMA transmissions;

Figure 6 is a flow diagram of one embodiment of a method of receiving asynchronous SCMA transmissions; and

Figure 7 is a block diagram of one embodiment of a computing system.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The making and using of embodiments are discussed in detail below. It should be appreciated, however, that the present invention provides many applicable inventive concepts that may be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention.

In an embodiment, SCMA encoding encodes binary data streams directly to multi-dimensional codewords rather than using a quadrature amplitude modulation (QAM) symbol, as is done in code division multiple access (CDMA). SCMA encoding provides multiple access by assigning different sparse codewords generated from sparse codebooks for each multiplexed layer, as opposed to using spreading sequences common in CDMA encoding. A multiplexed layer is one that multiple data streams may be communicated over shared resources. For example, the shared resources can be multiple-input multiple-output (MIMO) spatial layers, orthogonal frequency division multiple access (OFDMA) tones, and time division multiple access (TDMA) layers time slots, among others. Sparse codebooks include sparse codewords that allow receivers to use low complexity MPAs to detect respective codewords among the multiplexed codewords, which reduces baseband processing complexity at the receiver.

It is realized herein the general requirement that SCMA signals received at a base station should be synchronized can be relaxed. Relaxing the synchronization requirement allows a certain amount of signaling overhead to be eliminated, including timing adjustment signaling from the base station to the various transmit devices. The synchronization requirements can be relaxed, it is realized herein, by taking advantage of the simplicity with which local groups of transmit devices can be synchronized. It is further realized herein that transmit devices can be grouped together according to their location and mobility. Device groups can then be allocated, or assigned, regions of the resource block reserved for SCMA transmissions. SCMA transmissions are made over channels defined by time and frequency resources. The resource block can be partitioned into resource regions that can be individually allocated to the device groups, thereby separating asynchronous groups of devices with respect to their time and frequency resources.

It is also realized herein that asynchronous SCMA transmissions in adjacent resource regions can create inter-resource region interference. To mitigate the interference, for a given device group and assigned resource region, digital filters designed for each resource region can be used to filter out side-lobes from SCMA signals originating from other transmit devices in other device groups. It is further realized herein the filtering of the SCMA signals can occur at the transmitter, e.g., UE, mobile device, etc., and at the receiver, e.g., base station, evolved node B (eNB), etc. Certain embodiments can use analog filters for each resource region, however, these embodiments are not as flexible as digital filter embodiments that can adapt to fluctuating bandwidth requirements of various device groups and their corresponding resource regions.

Figure 1 is a diagram of one embodiment of a wireless network 100. Wireless network 100 includes a base station 110 within which the method of resource allocation and method of receiving asynchronous SCMA signals introduced herein may be embodied. Base station 110 serves one or more devices by receiving uplink (UL) communications originating from the devices and forwarding the UL communications to their respective indented destinations, or by receiving communications destined for the devices and forwarding the communications to their respective intended transmit devices. Base station 110 is sometimes referred to as an access point, a Node B, an evolved Node B (eNB), a controller, a transmit device, or a communication controller. Wireless network 100 also includes three device groups 120-1, 120-2, and 120-3. Each of the three device groups contains at least one device. Devices 130 are sometimes referred to as stations, mobile stations, mobiles, mobile devices, terminals, users, UEs, transmit devices, or subscribers.

Devices 130 can be grouped into device groups 120-1, 120-2, and 120-3 according to a variety of parameters, including one or more of the following: respective device locations, respective device mobility predictions, and respective device mobility patterns. In certain embodiments, devices 130 can be grouped by wireless network 100 or, more specifically, by base station 110. In other embodiments, devices 130 can group themselves.

Devices 130 make SCMA transmissions 140-1, 140-2, and 140-3 to base station 110. SCMA transmissions 140-1, 140-2, and 140-3 are typically made using orthogonal frequency division multiple access (OFDMA) waveforms, although other waveforms are possible. SCMA transmissions 140-1 originate from devices 130 within device group 120-1. Likewise, SCMA transmissions 140-2 originate from devices 130 within device group 120-2, and SCMA transmissions 140-3 originate from devices 130 within device group 120-3. SCMA transmissions from different device groups are asynchronous. In the embodiment of Figure 1, SCMA transmissions 140-1 are asynchronous with respect to SCMA transmissions 140-2 and 140-3. SCMA transmissions 140-2 are also asynchronous with respect to SCMA transmissions 140-3. SCMA transmissions 140-1, 140-2, and 140-3 are asynchronous in that respective devices 130 in device groups 120-1, 120-2, and 120-3 have not been synchronized to one another. For example, devices 130 in device group 120-1 are not synchronized with devices 130 in device group 120-2. In certain embodiments, devices 130 within a particular device group are synchronized with each other. For example, a group of sensors located in a single building can be synchronized to a local timing reference or reference device located in the group or in the building, rather than synchronizing to base station 110. In another example, a group of users, i.e., mobile devices, riding in a bus can synchronize to a local timing reference or reference device in the group or in the bus, rather than synchronizing to base station 110. In other embodiments, devices 130 within the particular device group are in close enough proximity that no transmit-timing synchronization is needed for base station 110 to properly receive their SCMA signals.

By not synchronizing devices 130 in one device group with devices 130 in another device group, some overhead signaling from base station 110 can be eliminated. Typically, to globally, i.e., network – wide, synchronize devices 130, base station 110 would signal timing adjustments to each of devices 130, thereby synchronizing each to a common reference. For a small number of devices, the overhead cost associated with this process is manageable. However, as the number of devices grows, the overhead cost becomes significant.

Devices 130 make their respective SCMA transmissions using a resource block defined as a block of time and frequency resources. Devices 130 are allocated at least one time/frequency resource unit and respective sparse codebooks. Figure 2 is an illustration of one embodiment of a resource block 200. Resource block 200 is defined in three dimensions: a frequency dimension 210, a time dimensions 220, and a code dimension 230. In code dimension 230, each time/frequency resource unit is divided into unique codes 240, which are generated from corresponding sparse codebooks.

Resource block 200 is partitioned into three resource regions 250-1, 250-2, and 250-3. The resource regions are depicted as various rectangles in the time/frequency domain. Resource regions can be any shape, although defining a time band and a frequency band naturally defines a rectangle in the time/frequency domain. Resource regions can abut one another, which is to share a boundary, or can be defined with time/frequency gaps between any two resource regions. In certain embodiments, gaps may be needed to achieve sufficiently low levels of inter-group interference. Likewise, the entire resource block 200 need not be partitioned into various resource regions. In such embodiments, various portions of resource block 200 are unassigned. Resource regions are sometimes referred to as SCMA regions or multiple access regions. Partitioning resource block 200 is carried out by the network, such as wireless network 100 from Figure 1. More specifically, the partitioning can be carried out by base station 110. Each of resource regions 250-1, 250-2, and 250-3 are assigned to a respective device group, which is referred to as a resource region assignment. Resource regions are generally contiguously defined in the time/frequency domain. In the case of a non-contiguous resource region, the various pieces of the non-contiguous resource region are treated as independent resource regions assigned to a common device group. In embodiments having spectrum shaping filters, each non-contiguous piece of resource region would have a dedicated filter. In embodiments having resource regions assuming shapes other than rectangles, multiple spectrum shaping filters would be needed. For this reason, rectangular-shaped resource regions are desirable, although alternative implementations with otherwise-shaped resource regions are possible.

For the embodiment of Figure 1, device groups 120-1, 120-2, and 120-3 can be respectively assigned, for example, to resource regions 250-1, 250-2, and 250-3. Resource region assignments are then communicated, or signaled, to the individual devices by base station 110. In certain embodiments, the resource region assignments can be communicated to the various device groups using multicast signaling. Again referring to the embodiment of Figure 1, devices 130 then make their respective SCMA transmissions using their respective assigned resource region.

Figure 3 is a block diagram of one embodiment of a base station 300. Base station 300 includes an antenna 310, a mixer 320, couplers 330-1 and 330-2, filters 340-1, 340-2, and 340-3, and processor 350. Base station 300 also includes a transmit stage 360 and another antenna 370. Base station 300 can also include a variety of other components not illustrated in Figure 3, such as amplifiers, analog-to-digital converters, decoders, application specific integrated circuits (ASICS), field programmable gate arrays (FPGAs), dedicated logic circuitry, oscillators, and many other components. These additional components, in various embodiments of base station 300, can appear anywhere in the circuit illustrated in Figure 3, including between any two elements of base station 300.

Antenna 310 is configured to receive SCMA signals from various transmit devices. In certain embodiments, the SCMA transmissions are made using filtered OFDMA waveforms. For further information on filtered OFDMA, refer to U.S. Patent Application No. 14/231,217, which is incorporated herein by reference. The received SCMA signals are radio frequency (RF) transmissions that are down-converted by mixer 320 to baseband signals. The baseband SCMA signals are then passed through filters 340-1, 340-2, and 340-3. The received SCMA signals arrive at base station 300 on channels defined by respective allocations of time and frequency resources. These allocations are made by processor 350 according to a partitioning of a resource block into resource regions, as in, for example, resource block 200 of Figure 2, and assignment of those resource regions to respective device groups, such as device groups 120-1, 120-2, and 120-3 of Figure 1. The respective device groups contain the various transmit devices. Resource region assignments made by processor 350 are communicated to the various transmit devices through transmit stage 360 and antenna 370.

In certain embodiments, the various transmit devices are grouped into device groups by base station 300, particularly processor 350. The base station may transmit, and a UE may receive, a message indicating a plurality of UEs belonging to a device group of which the UE is a member. In other embodiments, the various transmit devices themselves form the device groups. For example, a UE may determine a composition of a device group according to respective locations of a plurality of UEs in the device group. The groupings or compositions of the device groups are communicated by message from the devices or UEs of the respective device groups to base station 300. The UE may communicate by message the devices or UEs belonging to its device group to the base station, or to at least one other UE of the UEs in the device group. The grouping of the various transmit devices can be done according to a variety of parameters, including the respective locations of the various transmit devices and respective mobility predictions and patterns for the various transmit devices. Transmit devices in one device group make SCMA transmissions that are asynchronous to SCMA transmissions made by another device group. In certain embodiments, SCMA transmissions made by two transmit devices in the same device group are synchronous. The synchronous SCMA transmissions can be synchronous as a consequence of their proximity to one another or, in certain embodiments, because transmit devices in that device group are synchronized to a common reference. Asynchronous refers to signals from different device groups arriving at different times.

Filters 340-1, 340-2, and 340-3 are each digital filters designed for a specific resource region to shape the spectrum such that inter-resource region interference is reduced, possibly eliminated. Inter-resource region interference, or inter-SCMA region interference, is caused by asynchronous SCMA transmissions by transmit devices in different device groups over adjacent resource regions. In other words, interference results from two or more asynchronous SCMA transmissions over adjacent time/frequency resources. Filters 340-1, 340-2, and 340-3 are designed to block side-lobes of OFDMA waveforms carrying asynchronous SCMA signals in adjacent resource regions. Doing so allows base station 300 to properly receive the asynchronous SCMA signals. The filtered SCMA signals are then decoded and the payload data ultimately passed to processor 350.

Processor 350 can be implemented in one or more processors, one or more ASICs, one or more FPGAs, dedicated logic circuitry, or any combination thereof, all collectively referred to as a processor. The respective functions for processor can be stored as instructions in non-transitory memory for execution by the processor.

Figure 4 is an illustration of an SCMA encoding scheme 400. SCMA encoding scheme 400 uses multiple sparse codebooks 410, 420, 430, 440, 450, and 460, each of which is assigned to a different multiplexed layer and includes multiple multi-dimensional codewords. More specifically, sparse codebook 410 includes codewords 411-414, sparse codebook 420 includes codewords 421-424, sparse codebook 430 includes codewords 431-434, sparse codebook 440 includes codewords 441-444, sparse codebook 450 includes codewords 451-454, and sparse codebook 460 includes codewords 461-464. Each codeword is mapped to a different binary value. In the embodiment of Figure 4, codewords 411, 421, 431, 441, 451, and 461 are mapped to the binary value '00,' codewords 412, 422, 432, 442, 452, and 462 are mapped to the binary value '01,' codewords 413, 423, 433, 443, 453, and 463 are mapped to the binary value '10,' and codewords 414, 424, 434, 444, 454, and 464 are mapped to the binary value '11.' Although the sparse codebooks of the embodiment of Figure 4 include four codewords apiece, sparse codebooks for SCMA can include any number of codewords. For example, certain embodiment sparse codebooks may have eight codewords mapped to binary values '000' to '111,' while other embodiments may include 16 codewords mapped to binary values '0000' to '1111,' or more.

Different codewords are selected from the various sparse codebooks depending on the binary data to be transmitted over the respective multiplexed layers. In the embodiment of Figure 4, codeword 414 is selected from sparse codebook 410 because the binary value '11' is to be transmitted over the first multiplexed layer. Codeword 422 is selected from sparse codebook 420 because the binary value '01' is being transmitted over the second multiplexed layer. Codeword

433 is selected from sparse codebook 430 because the binary value ‘10’ is to be transmitted over the third multiplexed layer. Codeword 442 is sselected from sparse codebook 440 because the binary value ‘01’ is to be transmitted over the fourth multiplexed layer. Codeword 452 is selected from sparse codebook 450 because the binary value ‘01’ is to be transmitted over the fifth multiplexed layer. Codeword 464 is selected from sparse codebook 460 because the binary value ‘11’ is to be transmitted over the sixth multiplexed layer. Codewords, 414, 422, 433, 442, 452, and 464 are then multiplexted together to form a multiplexed data stream 480, which is transmitted over shared resources. Codewords 414, 422, 433, 442, 452, and 464 are sparse codewords that can be identified upon receipt of multiplexed data stream 480 at the receiver using an MPA.

Figure 5 is flow diagram of one embodiment of a method of resource allocation for SCMA signals. The method begins at a start step 510. At a partitioning step 520, a base station partitions a resource block into a plurality of resource regions. The resource block is defined as a block of time, frequency, and codebook resources. At an assigning step 530, the resource regions are assigned to respective device groups. Transmit devices are grouped into the device groups according to their respective locations. In certain embodiments, the transmit devices are grouped into the device groups according to respective mobility predictions and patterns for the transmit devices.

The resource region assignments are signaled to the transmit devices at a communicating step 540. The resource region assignments need not be communicated to the transmit devices for every data transmission. The transmit devices make their respective SCMA transmissions using their respective assigned resource regions. The SCMA signals are received at by the base station at a receiving step 550. The SCMA transmissions are asynchronous from device group to device group. In certain embodiments, the method also includes filtering the SCMA signals using, e.g., spectrum shaping filters corresponding to the respective resource regions, in order to filter out inter-resource region interference caused by the asynchronous transmissions. The filtering allows the base station receivers to properly receive, decode, and detect the SCMA signals. The method ends at an end step 560.

Figure 6 is a flow diagram of one embodiment of a method of receiving asynchronous SCMA signals. The method begins at a start step 610. At a base station, at a partitioning step 620, a resource block is partitioned into a plurality of resource regions. The resource regions are assigned to respective device groups. The device groups each contain at least one transmit device, i.e., UE. In certain embodiments, the UEs are grouped into the device groups according to their respective locations. In some embodiments the UEs are grouped according to respective mobility predictions and patterns for the UEs. The grouping can be carried out, in certain embodiments, by the base station while, in other embodiments, the grouping is carried out by the UEs themselves.

The device groups of UEs are assigned to the resource regions and the assignments are communicated to the UEs. The device groups can contain any number of UEs. UEs within a given device group transmit using resource region assigned to the device group. At a first receiving step 630, a first SCMA signal is received at the base station from a first UE. The first UE makes the first SCMA transmission using a first resource region of the plurality of resource regions. In certain embodiments, multiple sparse codewords, or layers, can be superposed on the first resource region. At a second receiving step 640, a second SCMA signal is received at the base station from a second UE. The second UE makes the second SCMA transmission using a second resource region of the plurality of resource regions. Because the first UE and the second UE are in different device groups and assigned different resource regions, the first SCMA transmission and the second SCMA transmission are asynchronous. The first UE and second UE have not been synchronized to a common reference. In certain embodiments, for the base station to properly receive the SCMA signals, the first SCMA signal and the second SCMA signal are passed through filters designed for their respective resource regions. Each filter, designed for a specific resource region, is configured to filter out the interference caused by asynchronous SCMA transmissions from neighboring resource regions. The method ends at an end step 650.

Figure 7 is a block diagram of a computing system 700 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 computing system 700 may comprise a processing unit 702 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) 714, memory 708, a mass storage device 704, a video adapter 710, and an I/O interface 712 connected to a bus 720.

The bus 720 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 714 may comprise any type of electronic data processor. The memory 708 may comprise any type of non-transitory 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 708 may include ROM for use at boot-up, and DRAM for program and data storage for use while executing programs.

The mass storage 704 may comprise any type of non-transitory storage device configured to store data, programs, and other information and to make the data, programs, and other information accessible via the bus 720. The mass storage 704 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.

The video adapter 710 and the I/O interface 712 provide interfaces to couple external input and output devices to the processing unit 702. As illustrated, examples of input and output devices include a display 718 coupled to the video adapter 710 and a mouse/keyboard/printer 716 coupled to the I/O interface 712. Other devices may be coupled to the processing unit 702, 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.

The processing unit 702 also includes one or more network interfaces 706, 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 interfaces 706 allow the processing unit 702 to communicate with remote units via the networks. For example, the network interfaces 706 may provide wireless communication via one or more transmitters/transmit antennas and one or more receivers/receive antennas. In an embodiment, the processing unit 702 is coupled to a local-area network 722 or a wide-area network for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

In accordance with one embodiment of the invention, a base station is also disclosed. The base station includes a processor, a transmitter, and a receiver. The processor is configured to partition a resource block into a plurality of resource regions and assign the plurality of resource regions to respective device groups. The transmitter is operatively coupled to the processor and is configured to signal resource region assignments to devices of the respective device groups. The receiver is operatively coupled to the processor and is configured to receive sparse code multiple access (SCMA) signals from the devices of the respective device groups. In the embodiment, the SCMA signals from one group of the respective device groups are asynchronous with respect to the SCMA signals from another group of the respective device groups.

In accordance with another embodiment of the invention, a UE is disclosed. The UE includes a receiver to configured to receive a resource region assignment indicating a resource region allocated to a device group of which the UE is a member; filter a sparse code multiple access

(SCMA) signal using a spectrum shaping filter corresponding to the resource region; and transmit the filtered SCMA signal toward a base station using time and frequency resources of the resource region according to the resource region assignment. In the embodiment, the transmitting is carried out synchronously with a local timing reference for the device group.

While this invention has 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 the invention, 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.

WHAT IS CLAIMED IS:

1. A method of resource allocation for sparse code multiple access (SCMA) signals, comprising:

partitioning a resource block into a plurality of resource regions;

assigning the plurality of resource regions to respective device groups;

signaling resource region assignments to devices of the respective device groups; and

receiving the SCMA signals from the devices of the respective device groups, wherein the SCMA signals from one group of the respective device groups are asynchronous with respect to the SCMA signals from another group of the respective device groups.

2. The method of Claim 1 further comprising filtering received SCMA signals, wherein the filtering is carried out by respective spectrum shaping filters for the plurality of resource regions.

3. The method of Claim 1 further comprising grouping the devices into the respective device groups according to respective locations of the devices.

4. The method of Claim 3 wherein the grouping is carried out by a base station or the devices of the respective device groups.

5. The method of Claim 4 further comprising receiving a message from the devices of the respective device groups indicating the grouping.

6. The method of Claim 1 further comprising grouping the devices into the respective device groups according to respective mobility predictions for the devices.

7. The method of Claim 1 furthering comprising synchronizing the devices of the one group of the respective device groups with other devices of the one group.

8. The method of Claim 1 wherein the resource block is defined by a block of time and frequency resources.

9. A method of receiving asynchronous sparse code multiple access (SCMA) signals, comprising:

partitioning a resource block into a plurality of resource regions;

receiving a first SCMA signal from a first user equipment (UE), wherein the first SCMA signal uses a first resource region of the plurality of resource regions; and

receiving a second SCMA signal from a second UE, wherein the second SCMA signal uses a second resource region of the plurality of resource regions and is asynchronous with respect to the first SCMA signal.

10. The method of Claim 9 further comprising:

assigning the first resource region to a first group of devices containing the first UE; and

assigning the second resource region to a second group of devices containing the second UE.

11. The method of Claim 10 further comprising signaling resource region assignments to the first group of devices and the second group of devices.

12. The method of Claim 10 further comprising assigning the first UE to the first group of devices according to a proximity of the first UE to the first group of devices.

13. The method of Claim 9 further comprising:

passing the first SCMA signal through a first filter having a first pass band corresponding to the first resource region; and

passing the second SCMA signal through a second filter having a second pass band corresponding to the second resource region.

14. A base station comprising:

a processor configured to respectively assign a plurality of resource regions to a plurality of device groups;

an antenna configured to receive asynchronous sparse code multiple access (SCMA) signals from a plurality of devices grouped into the plurality of device groups according to respective locations of the plurality of devices;

a mixer coupled to the antenna and configured to convert the asynchronous SCMA signals from a radio frequency to a baseband frequency; and

a plurality of filters respectively corresponding to the plurality of resource regions, and configured to filter inter-resource region interference from the asynchronous SCMA signals for each of the plurality of resource regions.

15. The base station of Claim 14 further comprising a transmit stage coupled to the processor and configured to communicate assignments of the plurality of resource regions to the plurality of devices.

16. The base station of Claim 15 wherein the transmit stage is further configured to multicast the assignments to the plurality of plurality of devices.

17. The base station of Claim 14 wherein the plurality of devices are grouped according to respective mobility predictions for the plurality of devices.

18. The base station of Claim 14 wherein the processor is further configured to group the plurality of devices into the plurality of device groups.

19. The base station of Claim 14 wherein the asynchronous SCMA signals comprise orthogonal frequency division multiple access (OFDMA) waveforms.

20. The base station of Claim 14 wherein the processor is further configured to partition a time/frequency resource block into the plurality of resource regions.

21. A method of transmitting a multiple access signal, comprising:

receiving, at an user equipment (UE), a resource region assignment indicating a resource region allocated to a device group of which the UE is a member;

filtering, at the UE, a sparse code multiple access (SCMA) signal using a spectrum shaping filter corresponding to the resource region; and

transmitting the filtered SCMA signal toward a base station using time and frequency resources of the resource region according to the resource region assignment, wherein the transmitting is carried out synchronously with a local timing reference for the device group.

22. The method of Claim 21 further comprising:

determining, by the UE, a composition of the device group according to respective locations of a plurality of UEs in the device group; and

communicating the composition of the device group to the base station.

23. The method of Claim 22 further comprising communicating the composition of the device group to at least one UE of the plurality of UEs in the device group.

24. The method of Claim 21 further comprising receiving a message indicating a plurality of UEs belonging to the device group.

25. The method of Claim 24 wherein the receiving the message comprises receiving the message from the base station.

26. A base station comprising means configured to implement steps in a method in accordance with any one of claims 1 to 8.

27. A user equipment (UE) comprising means configured to implement steps in a method in accordance with any one of claims 21 to 25.

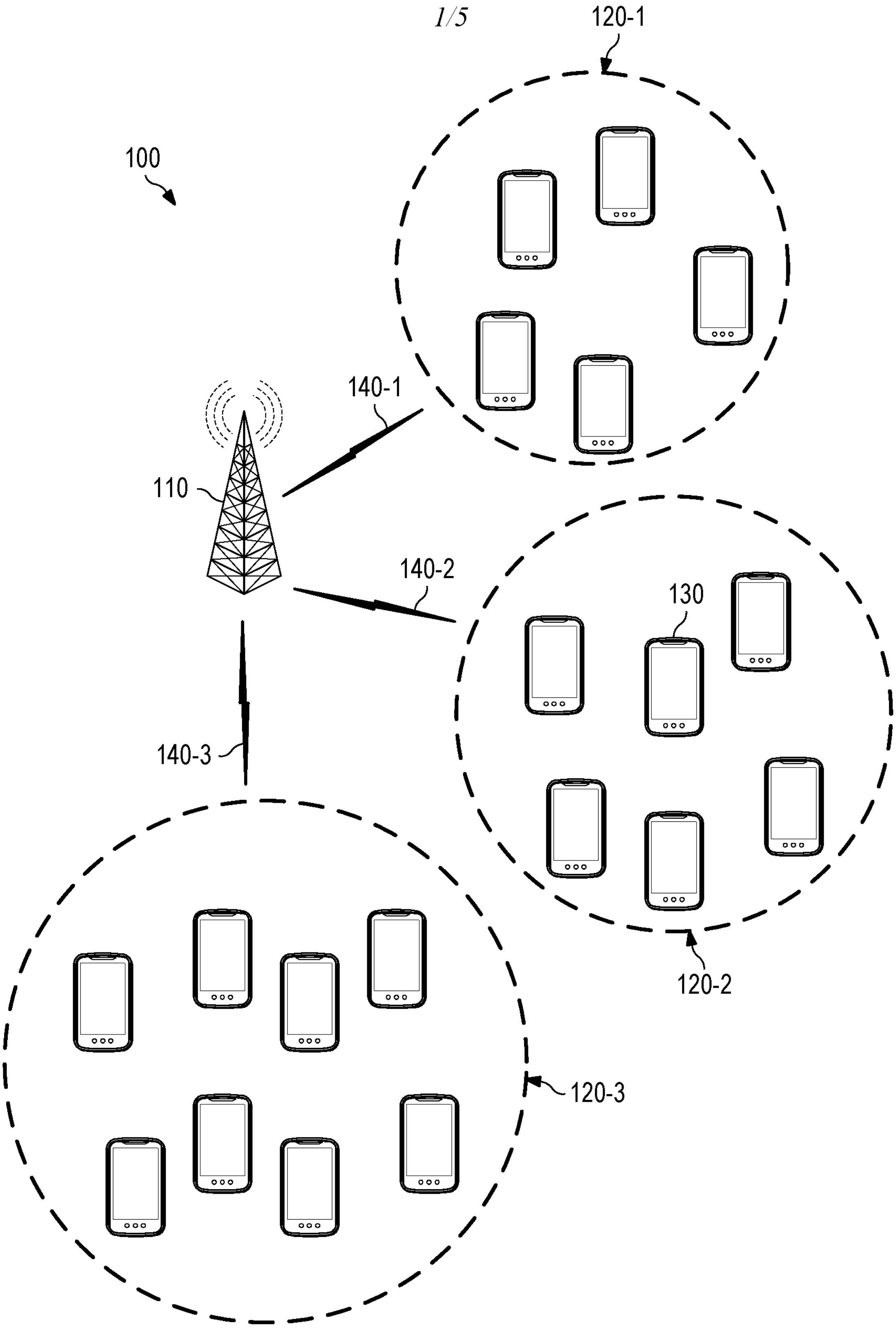


FIG. 1

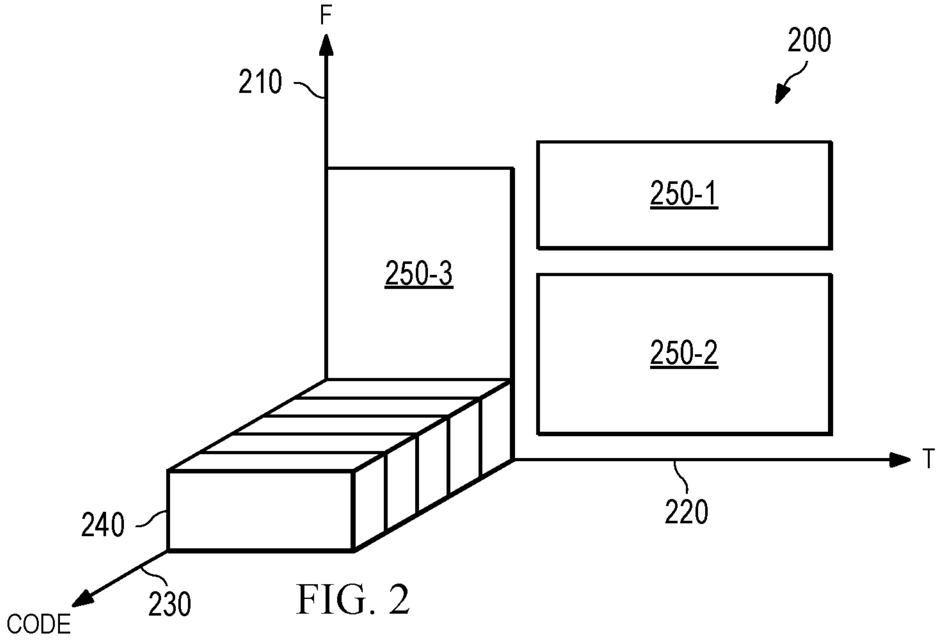
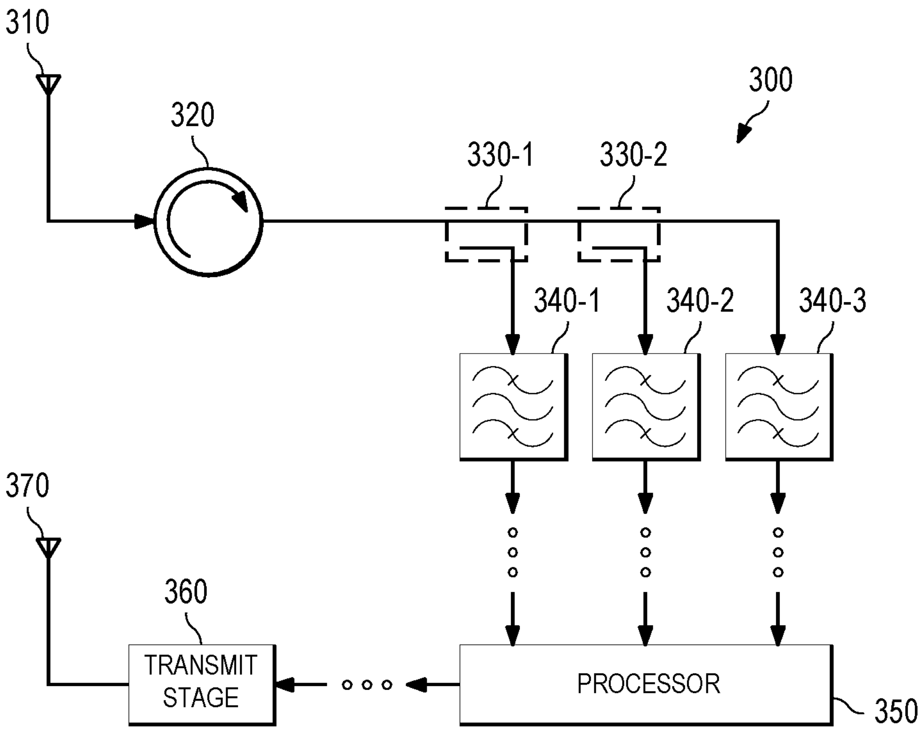

F
210
200
250-1
250-3
250-2
T
220
240
230
CODE

FIG. 2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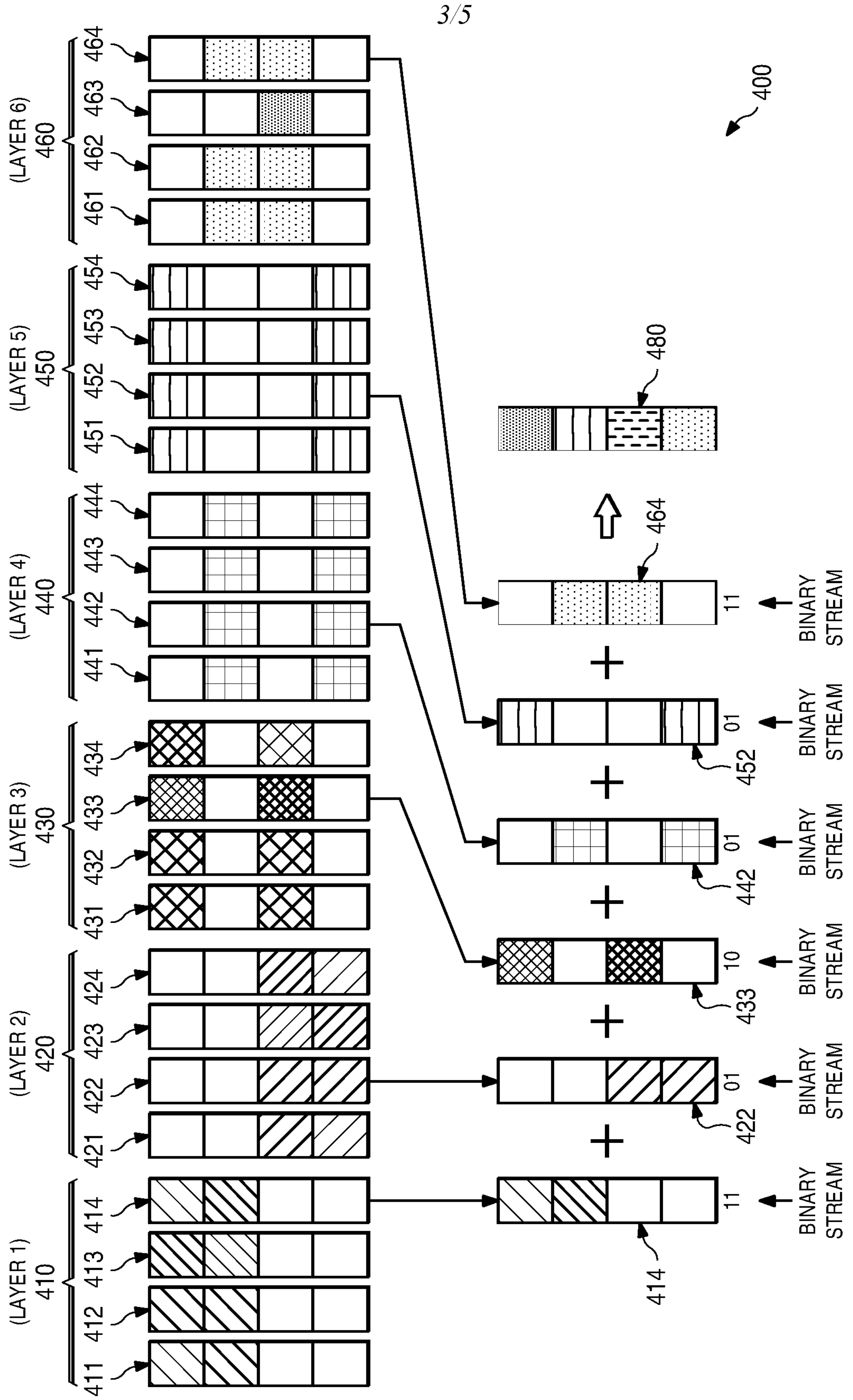
300
330-1
330-2
340-1
340-2
340-3
370
360
TRANSMIT STAGE
PROCESSOR
350

FIG. 3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(LAYER 1)
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411
412
413
414
(LAYER 2)
420
421
422
423
424
(LAYER 3)
430
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433
434
(LAYER 4)
440
441
442
443
444
(LAYER 5)
450
451
452
453
454
(LAYER 6)
460
461
462
463
464
BINARY STREAM
11
414
BINARY STREAM
01
422
BINARY STREAM
10
433
BINARY STREAM
01
442
BINARY STREAM
01
452
BINARY STREAM
11
464
480

FIG. 4

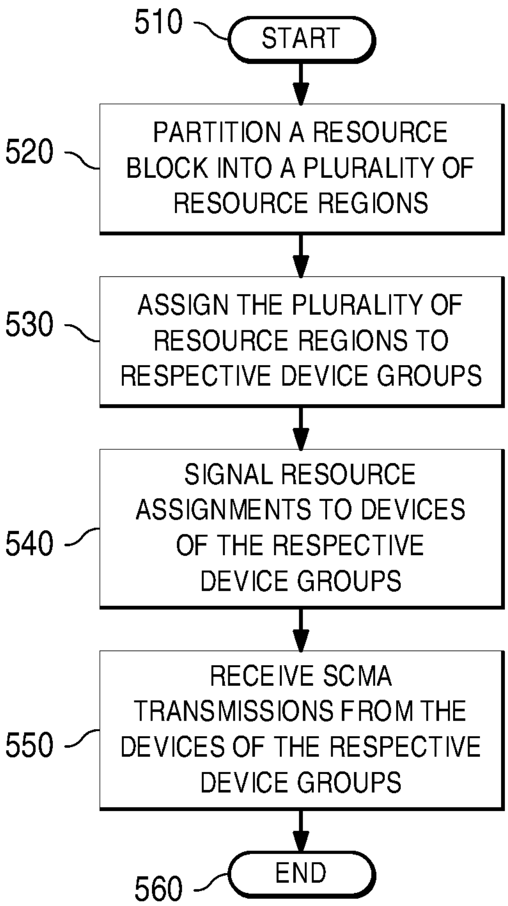
510
START
520
PARTITION A RESOURCE BLOCK INTO A PLURALITY OF RESOURCE REGIONS
530
ASSIGN THE PLURALITY OF RESOURCE REGIONS TO RESPECTIVE DEVICE GROUPS
540
SIGNAL RESOURCE ASSIGNMENTS TO DEVICES OF THE RESPECTIVE DEVICE GROUPS
550
RECEIVE SCMA TRANSMISSIONS FROM THE DEVICES OF THE RESPECTIVE DEVICE GROUPS
560
END

FIG. 5

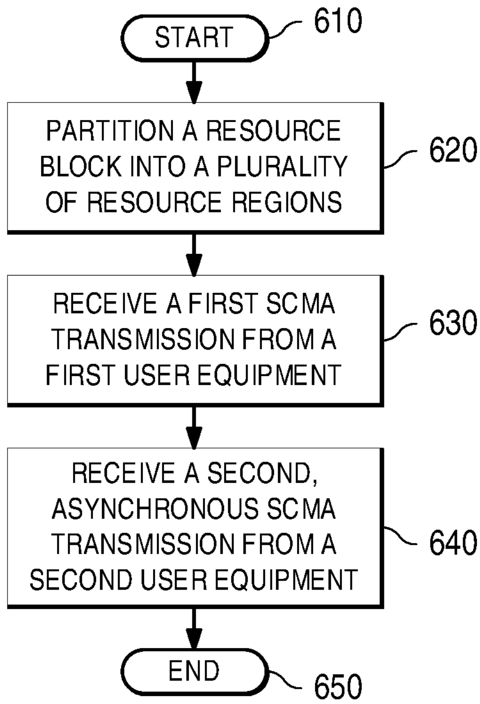
610
START
620
PARTITION A RESOURCE BLOCK INTO A PLURALITY OF RESOURCE REGIONS
630
RECEIVE A FIRST SCMA TRANSMISSION FROM A FIRST USER EQUIPMENT
640
RECEIVE A SECOND, ASYNCHRONOUS SCMA TRANSMISSION FROM A SECOND USER EQUIPMENT
650
END

FIG. 6

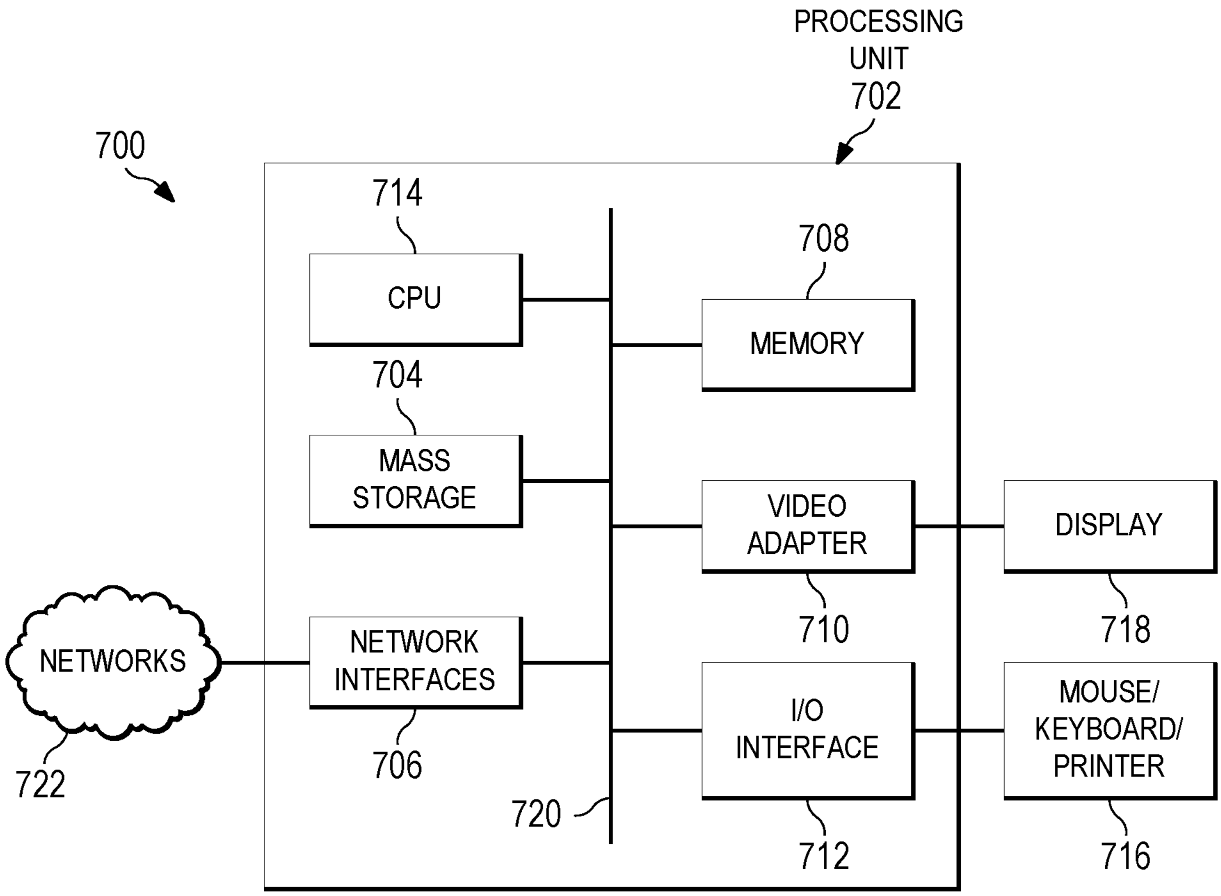
PROCESSING
UNIT
702
700
714
CPU
708
MEMORY
704
MASS
STORAGE
VIDEO
ADAPTER
DISPLAY
NETWORKS
NETWORK
INTERFACES
710
718
I/O
INTERFACE
MOUSE/
KEYBOARD/
PRINTER
722
706
720
712
716

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/075434

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/02(2006.01)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)

H04B; H04L; H04W

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

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

CNPAT, CNKI, WPI, VEN: sparse code, SCMA, 5G, region, group, asynchronous, synchronize, block, base station, UE, time

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 102439866 A (HUAWEI TECHNOLOGIES CO., LTD.) 02 May 2012 (2012-05-02) the whole document	1-27
A	CN 103262453 A (RESEARCH IN MOTION LIMITED) 21 August 2013 (2013-08-21) the whole document	1-27
A	CN 102232319 A (HUAWEI TECHNOLOGIES CO., LTD.) 02 November 2011 (2011-11-02) the whole document	1-27

☐ 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
29 June 2015	**03 July 2015**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/075434

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 102439866 A	02 May 2012	WO 2011082589 A1	14 July 2011
		US 2011170625 A1	14 July 2011
		US 2011249590 A1	13 October 2011
		US 8059752 B2	15 November 2011
		EP 2460285 A1	06 June 2012
		KR 20120061890 A	13 June 2012
		KR 101183942 B1	18 September 2012
		JP 2013509053 A	07 March 2013
		ZA 201205129 A	27 March 2013
		INCHENP 201202042 E	26 April 2013
		RU 2012116338 A	20 February 2014
		RU 2516484 C2	20 May 2014
		CN 102439866 B	30 April 2014
CN 103262453 A	21 August 2013	WO 2012048218 A1	12 April 2012
		CA 2813769 A1	12 April 2012
		US 2013182791 A1	18 July 2013
		EP 2625807 A1	14 August 2013
CN 102232319 A	02 November 2011	WO 2010102435 A1	16 September 2010
		CN 102232319 B	14 August 2013