[0009] In accordance with yet another aspect of the present invention, a user equipment (UE) includes a processor, and a computer readable storage medium storing programming for execution by the processor, the programming including instructions to implement a default contention transmission unit (CTU) mapping scheme by determining an appropriate CTU for uplink transmission in accordance with a UE mapping rule and the default CTU mapping scheme, and transmitting, to a base station (BS), an uplink transmission on the appropriate CTU, determine whether a collision has occurred based on an indication by the BS, and re-transmit, to the BS, the uplink transmission using an asynchronous hybrid automatic repeat request (HARQ) mechanism when the UE determines a collision has occurred.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] 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:

[0011] Figure 1 is a block diagram illustrating a network in accordance with various embodiments;

[0012] Figure 2 is a diagram illustrating an example configuration of various contention transmission unit (CTU) access regions in accordance with various embodiments;

[0013] Figure 3 is a diagram illustrating an example mapping of CTUs to CTU access regions in accordance with various embodiments;

[0014] Figure 4 is a diagram illustrating an example CTU index numbering in accordance with various embodiments;

[0015] Figures 5A and 5B are diagrams illustrating an example UE mapping and remapping in accordance with various embodiments;

step 814. In step 814, UE 104 resolves the collision using an asynchronous HARQ method. Alternatively, UE 104 assumes no collision has occurred unless it receives a NACK. If a NACK is received, the UE then continues with the collision resolution procedure.

[0051] In an alternative embodiment illustrated in Figure 8B, if UE 104 determines collision has occurred, UE 104 then determines if the number of collisions exceed a certain threshold in step 816. If not, then UE 104 returns to step 814 and resolves the collision using an asynchronous HARQ method. If the threshold is met, then in step 818, UE 104 may request remapping of CTUs by the BS. UE 104 then returns to step 804 and waits to receive the remapping information from ~~form~~ the BS and proceed with the uplink procedure. In another embodiment, step 818 is optional and UEs do not send a request for remapping. The decision whether to remap UEs is made by the BS based on aggregate information on the collisions of UEs in the CTUs. UE 104 may continue to try to resolve the collision using an asynchronous HARQ method.

[0052] Figure 9 is a block diagram of a processing system 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 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), memory, a mass storage device, a video adapter, and an I/O interface connected to a bus.

[0053] The bus 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 may comprise any type of electronic data processor. The memory may comprise any type of system memory such as static random access memory (SRAM), dynamic random access memory

WHAT IS CLAIMED IS:

1. A method comprising:

implementing, by a base station, BS, a grant-free uplink transmission scheme, wherein the grant-free uplink transmission scheme:

defines a first contention transmission unit, CTU access region in a time-frequency domain;

defines a default CTU mapping scheme by mapping at least some of a plurality of CTUs to the first CTU access region; and

defines a default user equipment, UE mapping scheme by defining rules for mapping a first UE to a first CTU of the plurality of CTUs and a second UE to a second CTU of the plurality of CTUs, the second CTU being different than the first CTU~~;~~

~~receiving, by the BS, a uplink transmission on the first CTU from the first UE; and~~

~~decoding, by the BS, the uplink transmission blindly~~.

2. The method of claim 1, further comprising:

defining, by the BS, at least a portion of the grant-free uplink transmission scheme; and

transmitting the portion of the grant-free uplink transmission scheme defined by the BS using high-level signaling.

3. The method of claim 1, wherein at least a portion of the grant-free uplink transmission scheme is pre-configured on the BS in conformance with a standard.

4. The method of claim 1, wherein implementing the grant-free uplink transmission scheme further comprises~~decoding the uplink transmission blindly comprises blindly identifying a source of the uplink transmission, and wherein implementing the grant-free transmission uplink scheme further comprises~~:

receiving, by the BS, an uplink transmission from the first UE; and

decoding the uplink transmission, wherein decoding the uplink transmission comprises identifying, by the BS, a source of the uplink transmission~~indicating, to the first UE, decoding the uplink transmission blindly was successful~~.

5. The method of claim 4, wherein implementing the grant-free uplink transmission scheme further comprises indicating, to the first UE, whether the decoding the uplink transmission was successful.

6. The method of claim 4 or 5, wherein the decoding uplink transmission comprises decoding uplink transmission blindly.

~~5.~~7.The method of claim 4, wherein the grant-free uplink transmission scheme further defines a second CTU access region in the time-frequency domain and further defines the default CTU mapping scheme by mapping the plurality of CTUs to the first and second CTU access regions, and wherein the implementing the grant-free uplink transmission~~transmission uplink~~ scheme further comprises:

defining, by the BS, a CTU remapping scheme by remapping a portion of the plurality of CTUs to the first and second CTU access regions when the BS determines a number of collisions is too frequent, wherein the BS determines the number of collisions is too frequent when:

the BS determines a number times decoding ~~attempting to decode~~ the uplink transmission ~~blindly~~ was unsuccessful and the number of times is over a threshold; or

the BS receives a remapping request signal from the first UE; and

sending information related to the CTU remapping scheme using high-level signaling.

~~6.~~8.The method of claim 4, wherein implementing the grant-free uplink transmission~~transmission uplink~~ scheme further comprises:

defining, by the BS, a UE remapping scheme by mapping the first UE to a third CTU, the third CTU being one of the plurality of CTUs other than the first CTU, when the BS determines a number of collisions is too frequent, wherein the BS determines the number of collisions is too frequent when:

the BS determines a number times ~~attempting to~~ decodinge the uplink transmission ~~blindly~~ was unsuccessful and the number of times is over a threshold; or

the BS receives a remapping request signal from the first UE; and

sending information related to the UE remapping scheme using high-level signaling.

~~7.~~9. The method of claim ~~4~~1, wherein decoding the uplink transmission ~~blindly~~ comprises using a joint signature and data detection using a message passing algorithm (JMPA) method in combination with an active UE detector method, wherein the active UE detector method comprises:

receiving a list of all potential UEs;

receiving a plurality of signals transmitted over the time-frequency domain;

receiving an output, from the JMPA method, comprising an updated list of potential UEs, wherein the updated list includes fewer potential UEs than the list of all potential UEs; and

creating an active potential UE list in accordance with the plurality of signals and the updated list of potential UEs.

~~8.~~10. The method of claim 1, wherein the grant-free uplink transmission scheme defines a number of unique pilots for grant-free uplink transmissions.

~~9.~~11. A base station, BS, comprising:

a processor; and

a computer readable storage medium storing programming for execution by the processor, the programming including instructions to:

implement a grant-free uplink transmission scheme, wherein the grant-free uplink transmission scheme:

defines one or more contention transmission unit, CTU, access regions in a time-frequency domain;

defines a default CTU mapping scheme by mapping a plurality of ~~contention transmission units,~~ CTUs to the one or more CTU access regions ~~in a time-frequency domain~~; and

defines a default user equipment, UE, mapping scheme by defining rules for mapping a first UE to a first CTU of the plurality of CTUs and a second UE to a second CTU of the plurality of CTUs, the second CTU being different than the first CTU~~;~~

~~receive an uplink transmission from the first UE on the first CTU;~~

~~decode the uplink transmission blindly; and~~

~~indicate to the first UE, whether decoding the uplink transmission blindly was successful~~.

12. The BS of claim 11, wherein the programming further includes instructions to:

receive an uplink transmission from the first UE on the first CTU; and

decode the uplink transmission.

13. The BS of claim 12, wherein the programming further includes instructions to indicate to the first UE whether the decoding the uplink transmission was successful.

14. The BS of claim 12 or claim 13, wherein the instructions to decode the uplink transmission comprise instructions to decode the uplink transmission blindly.

~~10.~~15. The BS of claim ~~9~~11, wherein the plurality of CTUs comprises individual CTUs each defined as a time, frequency, signature, pilot, or a combination thereof element.

~~11.~~16. The BS of claim-15~~10~~, wherein each CTU is defined as a combination of time, frequency, signature, and pilot elements, and the grant-free uplink transmission scheme maps multiple pilot elements to each signature element.

~~12.~~17. The BS of claim ~~9~~11, wherein the grant-free uplink transmission scheme defines a plurality of CTU access regions, wherein the plurality of CTU access regions each provide a type of service to the first UE based on quality of service, QoS, level of the first UE, configuration, subscribed level of service, geometry, or a combination thereof.

~~13.~~18. The BS of claim ~~9~~11, wherein a size of each of the one or more CTU access regions is defined based on an estimated probability of collisions, a number of total collisions over a period of time, a number of UEs supported by the BS, or a combination thereof.

~~14.~~19. The BS of claim ~~9~~11, wherein a size of each of the plurality of CTUs is defined based on an expected transmission threshold, a ~~desired~~ specified padding level, a modulation coding scheme (MCS) level, or a combination thereof.

~~15.~~20. The BS of claim ~~9~~11, wherein the grant-free uplink transmission~~s~~ scheme ~~creates~~ defines the~~a~~ default CTU mapping scheme in accordance with goals of distributing potential UEs uniformly over the one or more CTU access regions and reducing a probability of pilot collision.

~~16.~~21. A method for a grant-free transmission scheme comprising:

implementing, by a first user equipment ,UE, a default contention transmission unit, CTU mapping scheme by:

selecting a~~determining an appropriate~~ CTU for uplink transmission in accordance with a UE mapping rule and the default CTU mapping scheme, wherein the UE mapping rule maps a

second UE to a second CTU in the default CTU mapping scheme, the second CTU being different than the selected CTU; and

transmitting an uplink transmission, to a base station, BS, on the selected~~a first~~ CTU~~;~~

~~determining, by the UE, that the uplink transmission was not successfully decoded; and the UE randomly selecting a second CTU for retransmitting the uplink transmission, the retransmitting the uplink transmission using an asynchronous hybrid automatic repeat request (HARQ) method~~.

~~17.~~22. The method of claim ~~21~~16, further comprising, after sending an uplink transmission:~~,~~ ~~wherein:~~

determining, by the first UE, whether a collision has occurred based on an indication by the BS; and

resolving the collision using an asynchronous hybrid automatic repeat request (HARQ) method when the first UE determines a collision has occurred~~, that the uplink transmission was not successfully decoded comprises receiving an indication from the BS that a collision has occurred~~.

~~18. The method of claim 17, wherein the indication is a negative acknowledgement (NACK).~~

~~19.~~23. The method of claim ~~22~~17, further comprising transmitting, by the first UE, a remapping request to the BS using high-level signaling when the first UE determines a number of collisions have occurred and the number of collisions is above a threshold.

~~20.~~24. A user equipment (UE) comprising:

a processor; and

a computer readable storage medium storing programming for execution by the processor, the programming including instructions to:

implement a default contention transmission unit (CTU) mapping scheme by:

~~determining an~~selecting a ~~appropriate~~ CTU for uplink transmission in accordance with a UE mapping rule and the default CTU mapping scheme, wherein the UE mapping rule maps a second UE to a second CTU in the default CTU mapping scheme, the second CTU being different than the selected CTU; and

transmitting, to a base station (BS), an uplink transmission on ~~a first~~the selected CTU~~;~~

~~determining, by the UE, that the uplink transmission was not successfully decoded; and~~

~~the UE randomly selecting a second CTU for retransmitting the uplink transmission, the retransmitting the uplink transmission using an asynchronous hybrid automatic repeat request (HARQ) method~~.

25. The UE of claim 24, wherein the programming further includes instructions to:

determine whether a collision has occurred based on an indication by the BS; and

re-transmit, to the BS, the uplink transmission using an asynchronous hybrid automatic repeat request (HARQ) mechanism when the UE determines that a collision has occurred.

~~21.~~26. The UE of claim 24~~0~~, wherein the UE mapping rule includes information for ~~determining the first~~selecting a CTU in accordance with a dedicated connection signature (DCS) of the UE, a DCS index, a total number of CTUs in the default CTU mapping scheme, a subframe number, or a combination thereof.

~~22.~~27. The UE of claim 242~~0~~, wherein the UE mapping rule includes information for ~~determining a first~~selecting a CTU index corresponding to an index in the default CTU mapping scheme in accordance with:

$$I_{CTU} = DSC_i \bmod N_{CTU},$$

wherein I_{CTU} is a CTU index, DSC_i is a DCS index assigned to the UE by the BS, and N_{CTU} is a total number of CTUs in the default CTU mapping scheme.

~~23.~~28. The UE of claim 24~~20~~, wherein the UE mapping rule is pre-configured on the UE

~~24.~~29. The UE of claim 24~~20~~, wherein the UE is configured to receive the UE mapping rule from the BS.