

System and Method for Uplink Grant-Free Transmission Scheme

[0001] ~~The present application claims benefit of US Non-provisional Application No. 13/790,673, filed on March 8, 2013, entitled “System and Method for Uplink Grant-Free Transmission Scheme,” which application is hereby incorporated herein by reference.~~

5 TECHNICAL FIELD

[0002] The present invention relates to a system and method for wireless communications, and, in particular embodiments, to a system and method for uplink grant-free transmission scheme.

BACKGROUND

10 [0003] In a typical wireless network such as long-term evolution (LTE) network, the selection of shared data channels for uplink (UL) is scheduling/grant based, and the scheduling and grant mechanisms are controlled by a base station (BS) in a network. A user equipment (UE) sends an UL scheduling request to the base station. When the BS receives the scheduling request, the BS sends an UL grant to the UE indicating its UL resource allocation. The UE then
15 transmits data on the granted resource.

[0004] An issue with this approach is that the signaling resource overhead for the scheduling/grant mechanism can be quite large, especially in cases where the data transmitted is small. For example, for small packet transmissions of around 20 bytes each, the resources used by the scheduling/grant mechanism could be around 30%, or even 50%, of the packet's size.

20 Another issue with this approach is the scheduling/grant procedure causes an initial delay in data transmission. Even when the resources are available, there is a minimum 7-8ms delay in a typical wireless network between a scheduling request being sent and the first uplink data transmission.

SUMMARY OF THE INVENTION

[0005] These and other problems are generally solved or circumvented, and technical advantages are generally achieved, by preferred embodiments of the present invention which provide a system and method for uplink grant-free transmission scheme.

[0006] In accordance with an ~~embodiment~~aspect of the present invention, a method includes implementing, by a BS, a grant-free uplink transmission scheme. The grant-free uplink transmission scheme defines a first contention transmission unit (CTU) access region in a time-frequency domain, defines a plurality of CTUs, defines a default CTU mapping scheme by mapping at least some of the plurality of CTUs to the first CTU access region, and defines a default user equipment (UE) mapping scheme by defining rules for mapping a plurality of UEs to the plurality of CTUs.

[0007] In accordance with another ~~embodiment~~aspect of the present invention, a base station (BS) includes 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, receive an uplink transmission from a user equipment (UE), attempt to decode the uplink transmission blindly, and indicate to the UE whether the attempt to decode the uplink transmission blindly was successful. The grant-free uplink transmission scheme defines a plurality of contention transmission units (CTUs), defines one or more CTU access regions in a time-frequency domain, creates a default CTU mapping scheme by mapping the plurality of CTUs to the one or more CTU access regions, and creates a default UE mapping scheme by defining rules for mapping a plurality of UEs to the plurality of CTUs.

[0008] In accordance with another ~~embodiment~~aspect of the present invention, a method for a grant-free transmission scheme includes implementing, by a user equipment (UE), 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 an uplink transmission, to a base station (BS), on the appropriate CTU.

[0009] In accordance with yet another embodiment 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.

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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 drawing, in which:

15 [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 (CTU) access regions in accordance with various embodiments;

20 [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;

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 plurality of CTUs;

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

defines a default user equipment (UE) mapping scheme by defining rules for mapping a plurality of UEs to the plurality of CTUs.

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 transmission uplink scheme further comprising:

receiving, by the BS, an uplink transmission from a user equipment (UE);

attempting to decode the uplink transmission blindly; and

indicating, to the UE, whether the attempting to decode the uplink transmission blindly was successful.

5. 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 mapping scheme by mapping the multitude of CTUs to the first and second CTU access regions, and wherein the implementing the grant-free 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 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 UE; and
sending information related to the remapping scheme using high-level signaling.

6. The method of claim 4, wherein the default UE mapping scheme maps the UE to a first CTU, the first CTU being one of the plurality of CTUs, and wherein implementing the grant-free transmission uplink scheme further comprises:

defining, by the BS, a UE remapping scheme by mapping the UE to a second CTU, the second 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 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 UE; and
sending information related to the UE remapping scheme using high-level signaling.

7. The method of claim 4, wherein attempting to decode 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 multitude 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 multitude of signals and the updated list of potential UEs.

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

9. 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 a plurality of contention transmission units (CTUs);
 - defines one or more CTU access regions in a time-frequency domain;
 - creates a default CTU mapping scheme by mapping the plurality of CTUs to the one or more CTU access regions; and
 - creates a default UE mapping scheme by defining rules for mapping a plurality of UEs to the plurality of CTUs;
 - receive an uplink transmission from a user equipment (UE);
 - attempt to decode the uplink transmission blindly; and

indicate to the UE whether the attempt to decode the uplink transmission blindly was successful.

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

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

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

15. The BS of claim 9, wherein the grant-free uplink transmissions scheme creates a default CTU mapping 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. A method for a grant-free transmission scheme comprising:

implementing, by a user equipment (UE), 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 an uplink transmission, to a base station (BS), on the appropriate CTU.

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

determining, by the 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 UE determines a collision has occurred.

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

19. 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 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.

20. The UE of claim 19, wherein the UE mapping rule includes information for determining an appropriate 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.

21. The UE of claim 19, wherein the UE mapping rule includes information for determining an appropriate 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 CTU mapping scheme.

22. The UE of claim 19, wherein the UE mapping rule is pre-configured on the UE.

23. The UE of claim 19, wherein the UE is configured to receive the UE mapping rule from the BS.

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 plurality of CTUs;

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

defines a default user equipment, UE mapping scheme by defining rules for 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.

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 transmission uplink scheme further comprising:

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

attempting to decode the uplink transmission blindly, wherein attempting to decode the uplink transmission blindly comprises attempting, by the BS, to blindly identify a source of the uplink transmission; and

indicating, to the first UE, whether the attempting to decode the uplink transmission blindly was successful.

5. 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 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 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. The method of claim 4, wherein implementing the grant-free 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 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 UE remapping scheme using high-level signaling.

7. The method of claim 4, wherein attempting to decode 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. The method of claim 1, wherein the grant-free uplink transmission scheme defines a number of unique pilots for grant-free uplink transmissions.

9. 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 a plurality of contention transmission units, CTUs;

defines one or more CTU access regions in a time-frequency domain;

creates a default CTU mapping scheme by mapping the plurality of CTUs to the one or more CTU access regions; and

creates 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;
attempt to decode the uplink transmission blindly; and
indicate to the first UE whether the attempt to decode the uplink transmission
blindly was successful.

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

11. The BS of claim 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. The BS of claim 9, wherein the grant-free uplink transmission scheme defines a plurality of CTU access regions, 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. The BS of claim 9, 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. The BS of claim 9, wherein a size of each of the plurality of CTUs is defined based on an expected transmission threshold, a desired padding level, a modulation coding scheme (MCS) level, or a combination thereof.

15. The BS of claim 9, wherein the grant-free uplink transmissions scheme creates a default CTU mapping 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. 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:

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 appropriate CTU; and

transmitting an uplink transmission, to a base station, BS, on the appropriate CTU.

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

determining, by the 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 UE determines a collision has occurred.

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

19. 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 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 appropriate CTU; 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.

20. The UE of claim 19, wherein the UE mapping rule includes information for determining an appropriate 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.

21. The UE of claim 19, wherein the UE mapping rule includes information for determining an appropriate 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 CTU mapping scheme.

22. The UE of claim 19, wherein the UE mapping rule is pre-configured on the UE.

23. The UE of claim 19, wherein the UE is configured to receive the UE mapping rule from the BS.