

will be apparent to one skilled in the art that these specific details are not required. In other instances, well-known electrical structures and circuits are shown in block diagram form in order not to obscure the understanding. For example, specific details are not provided as to whether the embodiments described herein are implemented as a software routine, hardware circuit, firmware, or a combination thereof.

[00126] Embodiments of the disclosure can be represented as a computer program product stored in a machine-readable medium (also referred to as a computer-readable medium, a processor-readable medium, or a computer usable medium having a computer-readable program code embodied therein). The machine-readable medium can be any suitable tangible, non-transitory medium, including magnetic, optical, or electrical storage medium including a diskette, compact disk read only memory (CD-ROM), memory device (volatile or non-volatile), or similar storage mechanism. The machine-readable medium can contain various sets of instructions, code sequences, configuration information, or other data, which, when executed, cause a processor to perform steps in a method according to an embodiment of the disclosure. Those of ordinary skill in the art will appreciate that other instructions and operations necessary to implement the described implementations can also be stored on the machine-readable medium. The instructions stored on the machine-readable medium can be executed by a processor or other suitable processing device, and can interface with circuitry to perform the described tasks.

[00127] One example provides a method comprising: implementing, by a base station (BS), a reliable ultra-low latency (RULL) transmission mechanism in a grant-free uplink transmission scheme, the grant-free uplink transmission scheme having defined therein contention transmission unit (CTU) access regions and a plurality of CTUs; wherein

5 implementing the reliable ultra-low latency transmission mechanism comprises: defining a reliable ultra-low latency user equipment (RULL-UE) mapping scheme by mapping a plurality of RULL-UEs to the plurality of CTUs in an initial pattern for initial transmissions in a first transmission time interval (TTI), and mapping the plurality of RULL-UEs to the plurality of CTUs in a regrouped pattern for redundant transmissions in a second TTI subsequent to the first TTI, wherein the initial pattern is different from the regrouped pattern.

[00128] One option about the above method, wherein implementing the RULL transmission mechanism comprises: defining a reliable ultra-low latency CTU (RULL-CTU) access region from a portion of the CTU access regions of the grant-free transmission scheme; and defining an RULL-CTU mapping scheme by mapping at least a portion of the plurality of CTUs to the RULL-CTU access region to define a plurality of RULL-CTUs.

15 Wherein defining the RULL-UE mapping scheme includes mapping the plurality of the RULL-UEs to the plurality of RULL-CTUs in the initial pattern and the regrouped pattern. Wherein defining the RULL-UE mapping scheme includes mapping the plurality of the RULL-UEs to the plurality of RULL-CTUs in the initial pattern and mapping the plurality of RULL-UEs to the plurality of CTUs in the regrouped pattern.

[00129] One option about the above method, wherein implementing the RULL transmission mechanism further comprises: receiving, by the BS, the initial transmissions in the first TTI and the redundant transmissions in the second TTI, wherein the BS does not transmit acknowledge or negative acknowledgement (ACK/NACK) feedback between receiving the initial and redundant transmissions; resolving collisions utilizing the initial transmissions, the redundant transmissions, and the mapping scheme.

[00130] One option about the above method, wherein implementing the RULL transmission mechanism further comprises: defining a remapping scheme by mapping a plurality of RULL-UEs to the plurality of CTUs in a second initial pattern for initial transmissions in the first TTI, and a second regrouped pattern for redundant transmissions in the second TTI subsequent to the first TTI when the BS determines the number of collisions in at least one of the initial transmissions and redundant transmissions meets a threshold, wherein the second initial pattern is different than the first initial pattern, and the second

regrouped pattern is different than the first regrouped pattern and the second initial pattern; and sending information related to the remapping scheme to the RULL-UEs using high-level signaling.

[00131] One option about the above method, wherein the initial transmissions and the redundant transmissions are based on a sparse code multiple access (SCMA) scheme.

[00132] One option about the above method, further comprising joint detecting and decoding of the initial transmission and the redundant transmission utilizing a message parsing algorithm (MPA).

[00133] One option about the above method, wherein implementing the RULL transmission mechanism further comprises defining a first portion of the plurality of RULL-UEs that transmit redundant transmissions in the second TTI, and a remaining portion of the plurality of RULL-UEs do not transmit redundant transmissions in the second TTI.

[00134] One option about the above method, wherein the first portion of the plurality of RULL-UEs is defined based on RULL-UE identifications of the plurality of RULL-UEs.

[00135] One option about the above method, wherein the first portion of the plurality of RULL-UEs is defined based on the CTUs that the first portion is mapped to in the regrouped pattern.

[00136] One option about the above method, wherein the first portion of the plurality of RULL-UEs is defined based on the TTI that the redundant transmission is transmitted in.

[00137] One option about the above method, wherein defining the RULL-UE mapping scheme includes mapping the plurality of RULL-UEs to the CTUs in a plurality of unique regrouped patterns, each unique regrouped pattern for a respective one of a plurality of redundant transmissions, each redundant transmission in a respective one of a plurality of TTIs subsequent to the first TTI.

[00138] One option about the above method, , wherein the number of the plurality of redundant transmissions is determined based on one or both of a latency requirement and a reliability requirement of the plurality of RULL-UEs.

[00139] One option about the above method, wherein the plurality of CTUs are frequency resources, or the plurality of CTUs are time resources.

[00140] One option about the above method, wherein defining a RULL-UE mapping scheme comprises mapping a second plurality of RULL-UEs to the plurality of CTUs in a second initial pattern for initial transmissions in second TTI, and mapping the second plurality of RULL-UEs to the plurality of CTUs a second regrouped pattern for redundant

transmissions in a third TTI subsequent to the second TTI, the CTUs mapped to the second plurality of RULL-UEs in the second initial pattern at least partially overlaps the CTUs mapped to the first plurality of RULL-UEs in the regrouped pattern.

[00141] One example provides a base station (BS) comprising: a hardware processor;

5 and a computer readable storage medium having stored thereon computer readable code for execution by the processor to: implement a reliable ultra-low latency (RULL) transmission mechanism in a grant-free uplink transmission scheme, the grant-free uplink transmission scheme having defined therein contention transmission unit (CTU) access regions and a plurality of CTUs, wherein implementing the RULL transmission mechanism comprises:
10 defining a reliable ultra-low latency user equipment (RULL-UE) mapping scheme by mapping a plurality of RULL-UEs to the plurality of CTUs in an initial pattern for initial transmissions in a first transmission time interval (TTI), and mapping the plurality of RULL-UEs to the plurality of CTUs in a regrouped pattern for redundant transmissions in a second TTI subsequent to the first TTI, wherein the initial pattern is different from the regrouped pattern.

15 **[00142]** One option about above BS, wherein implementing the RULL transmission mechanism further comprises: defining a reliable ultra-low latency CTU (RULL-CTU) access region from a portion of the CTU access regions of the grant-free transmission scheme; and defining an RULL-CTU mapping scheme by mapping at least a portion of the plurality of CTUs to the RULL-CTU access region to define a plurality of RULL-CTUs.

20 **[00143]** One option about above BS, wherein defining the RULL-UE mapping scheme includes mapping the plurality of the RULL-UEs to the plurality of RULL-CTUs in the initial pattern and the regrouped pattern.

[00144] One option about above BS, wherein defining the RULL-UE mapping scheme includes mapping the plurality of the RULL-UEs to the plurality of RULL-CTUs in the initial
25 pattern and mapping the plurality of RULL-UEs to the plurality of CTUs in the regrouped pattern.

[00145] One option about above BS, wherein implementing the RULL transmission mechanism further comprises: receiving, by the BS, the initial transmissions in the first TTI and the redundant transmissions in the second TTI; resolving collisions utilizing the initial
30 transmissions, the redundant transmissions, and the mapping scheme.

[00146] One option about above BS, wherein implementing the RULL transmission mechanism further comprises defining a first portion of the plurality of RULL-UEs that

transmit redundant transmissions in the second TTI, and a remaining portion of the plurality of RULL-UEs do not transmit redundant transmissions in the second TTI.

[00147] One option about above BS, wherein defining the RULL-UE mapping scheme includes mapping the plurality of RULL-UEs to the CTUs in a plurality of unique regrouped patterns, each unique regrouped pattern for a respective one of a plurality of redundant transmissions, each redundant transmission in a respective one of a plurality of TTIs subsequent to the first TTI.

[00148] One example provides a method comprising: implementing, by a reliable ultra-low latency user equipment (RULL-UE), a reliable ultra-low latency (RULL) mechanism in a default reliable ultra-low latency contention transmission unit (RULL-CTU) mapping scheme by: determining a first contention transmission unit (CTU) for an initial transmission in a first transmission time interval (TTI) in accordance with an initial RULL-UE mapping rule and the default RULL-CTU mapping scheme; transmitting, to a base station (BS), the initial transmission on the first CTU during the first TTI; determining a second CTU for a redundant transmission in a second TTI subsequent to the first TTI in accordance with a redundant RULL-UE mapping rule and the default RULL-CTU mapping scheme; transmitting, to the BS, the redundant transmission on the second CTU during the second TTI without receiving, at the RULL-UE, acknowledgement/negative acknowledgement (ACK/NACK) feedback from the BS.

[00149] One option about above method, wherein determining a second CTU includes determining a plurality of redundant CTUs, each of the redundant CTUs for one of a plurality of redundant transmissions, each redundant transmission in one of a plurality of TTIs subsequent to the first TTI; and wherein transmitting the redundant transmission on the second CTU includes transmitting each of the redundant transmissions on a respective one of the plurality of CTUs during a respective one of the plurality of TTIs.

[00150] One option about above method, wherein transmitting the redundant transmission on the second CTU comprises automatically transmitting a first portion of the plurality of redundant transmissions, and not transmitting a remaining portion of the redundant transmissions.

[00151] One option about above method, wherein the first portion is determined based on the respective CTU that each of the plurality of redundant transmissions transmits on.

[00152] One option about above method, wherein the first portion is determined based on the respective TTI that each of the plurality of redundant transmissions transmit during.

[00153] One option about above method, the first CTU determined by the RULL-UE for the initial transmission in the first TTI is mapped to a first CTU access region; and the second CTU determined by the RULL-UE for the redundant transmission in the second TTI is mapped to a second CTU access region different from the first CTU access region.

5 **[00154]** One example provides a reliable ultra-low latency user equipment (RULL-UE) comprising: a hardware processor; and a computer readable storage medium having stored thereon computer readable code for execution by the processor to: implement a reliable ultra-low latency (RULL) transmission mechanism in a default reliable ultra-low latency contention transmission unit (RULL-CTU) mapping scheme, wherein implementing the RULL
10 transmission mechanism comprises: determining a first contention transmission unit (CTU) for an initial transmission in a first transmission time interval (TTI) in accordance with an initial RULL-UE mapping rule and the default RULL-CTU mapping scheme; transmitting, to a base station (BS), the initial transmission on the first CTU during the first TTI; determining a second CTU for a redundant transmission in a second TTI subsequent to the first TTI in
15 accordance with a redundant RULL-UE mapping rule and the default RULL-CTU mapping scheme; transmitting, to the BS, the redundant transmission on the second CTU during the second TTI without receiving, at the RULL-UE, acknowledgement/negative acknowledgement (ACK/NACK) feedback from the BS.

[00155] One option about above UE, wherein determining a second CTU includes
20 determining a plurality of redundant CTUs, each of the redundant CTUs for one of a plurality of redundant transmissions, each redundant transmission in one of a plurality of TTIs subsequent to the first TTI; and wherein transmitting the redundant transmission on the second CTU includes automatically transmitting each of the redundant transmissions on a respective one of the plurality of CTUs during a respective one of the plurality of TTIs.

25 **[00156]** One option about above UE, wherein transmitting the redundant transmission on the second CTU comprises automatically transmitting a first portion of the plurality of redundant transmissions, and not transmitting a remaining portion of the redundant transmissions.

[00157] One option about above UE, wherein the first portion is determined based on
30 the respective CTU that each of the plurality of redundant transmissions transmits on.

[00158] One option about above UE, wherein the first portion is determined based on the respective TTI that each of the plurality of redundant transmissions transmit during.

[00159] One option about above UE, wherein: the first CTU determined by the RULL-UE for the initial transmission in the first TTI is mapped to a first CTU access region; and the second CTU determined by the RULL-UE for the redundant transmission in the second TTI is mapped to a second CTU access region different from the first CTU access region.

- 5 **[00160]** The above-described embodiments are intended to be examples only. Alterations, modifications and variations can be effected to the particular embodiments by those of skill in the art. The scope of the claims should not be limited by the particular embodiments set forth herein, but should be construed in a manner consistent with the specification as a whole.

CLAIMS:

1. A method comprising:
 - receiving, by a user equipment (UE), a high-level signaling information regarding a first contention transmission unit (CTU) access region for an initial transmission in a first transmission time interval (TTI) and a second CTU access region for a redundant transmission in a second TTI;
 - transmitting, by the UE, to a base station (BS), the initial transmission using at least one CTU in the first CTU access region during the first TTI without scheduling signaling from the BS; and
 - transmitting, by the UE, to the BS, the redundant transmission using at least one CTU in the second CTU access region during the second TTI without waiting for acknowledgement/negative acknowledgement (ACK/NACK) feedback.
2. The method of claim 1, wherein the first CTU and the second CTU comprises at least time, frequency and pilot.
3. The method of claim 1, wherein the first CTU and the second CTU comprises at least time, frequency, pilot and signature.
4. The method of claim 1, further comprising: transmitting, by the UE, to the BS, a second redundant transmission on a third CTU during a third TTI without waiting for ACK/NACK feedback.
5. The method of claim 1, further comprising: transmitting, to the BS, a connection setup signaling after the UE initially accesses the BS.
6. A method comprising:
 - transmitting, by a base station (BS), to a user equipment (UE), a high-level signaling information regarding a first contention transmission unit (CTU) access region for an initial transmission in a first transmission time interval (TTI) and a second CTU access region for a redundant transmission in a second TTI;
 - receiving, by the BS, from the UE, the initial transmission on at least one CTU in the first CTU access region during the first TTI without transmitting scheduling signaling by the BS to the UE; and
 - receiving, by the BS, from the UE, the redundant transmission on at least one CTU in the second CTU access region during the second TTI without transmitting acknowledgement/negative acknowledgement (ACK/NACK) feedback by the BS to the UE.
7. The method of claim 6, wherein the first CTU and the second CTU comprises at least time, frequency and pilot.

8. The method of claim 6, wherein the first CTU and the second CTU comprises at least time, frequency, pilot and signature.
9. The method of claim 6, further comprising: receiving, by the BS, from the UE, a second redundant transmission on a third CTU during a third TTI without transmitting ACK/NACK feedback by the BS to the UE.
10. The method of claim 6, further comprising: receiving, by the BS, a connection setup signaling after the UE initially accesses the BS.
11. A user equipment (UE) comprising:
a hardware processor; and
a computer readable storage medium having stored thereon computer readable code for execution by the processor to cause the UE to:
receive a high-level signaling information regarding a first contention transmission unit (CTU) access region for an initial transmission in a first transmission time interval (TTI) and a second CTU access region for a redundant transmission in a second TTI;
transmit, to a base station (BS), the initial transmission using at least one CTU in the first CTU access region during the first TTI without scheduling signaling from the BS; and
transmit, to the BS, the redundant transmission using at least one CTU in the second CTU access region during the second TTI without waiting for acknowledgement/negative acknowledgement (ACK/NACK) feedback.
12. The UE of claim 11, wherein the first CTU and the second CTU comprises at least time, frequency and pilot.
13. The UE of claim 11, wherein the first CTU and the second CTU comprises at least time, frequency, pilot and signature.
14. The UE of claim 11, wherein the computer readable code further causes the UE to: transmit, to the BS, a second redundant transmission on a third CTU during a third TTI without waiting for ACK/NACK feedback.
15. The UE of claim 11, wherein the computer readable code further causes the UE to: transmit, to the BS, a connection setup signaling after the UE initially accesses the BS.

16. A base station (BS) comprising:
a hardware processor; and
a computer readable storage medium having stored thereon computer readable code for execution by the processor to cause the BS to:
transmit, to a user equipment (UE), a high-level signaling information regarding a first contention transmission unit (CTU) access region for an initial transmission in a first transmission time interval (TTI) and a second CTU access region for a redundant transmission in a second TTI;
receive, from the UE, the initial transmission on at least one CTU in the first CTU access region during the first TTI without transmitting scheduling signaling by the BS to the UE; and
receive, from the UE, the redundant transmission on at least one CTU in the second CTU access region during the second TTI without transmitting acknowledgement/negative acknowledgement (ACK/NACK) feedback by the BS to the UE.
17. The BS of claim 16, wherein the first CTU and the second CTU comprises at least time, frequency and pilot.
18. The BS of claim 16, wherein the first CTU and the second CTU comprises at least time, frequency, pilot and signature.
19. The BS of claim 16, wherein the computer readable code further causes the BS to: receive, from the UE, a second redundant transmission on a third CTU during a third TTI without transmitting ACK/NACK feedback by the BS to the UE.
20. The BS of claim 16, wherein the computer readable code further causes the BS to: receive, a connection setup signaling after the UE initially accesses the BS.