

WHAT IS CLAIMED:

1. A method comprising:

determining, by a user equipment (UE) based on a criterion, whether to indicate, to a gNB, that it is a reduced capability (RedCap) UE during a random access (RA) procedure of the UE or after the RA procedure, the RedCap UE having a quantity of receive branches less than a minimum number of receive branches of a non-RedCap UE, or having a bandwidth less than a minimum bandwidth of the non-RedCap UE, wherein the criterion is associated with a number of receive branches of the UE, a reference signal received power (RSRP) measured by the UE, a reference signal received quality (RSRQ) measured by the UE, a reference signal strength indicator (RSSI) measured by the UE, a combination thereof, or capability of the UE; and indicating, by the UE to the gNB, that it is the RedCap UE according to a determination result.

2. The method of claim 1, wherein the non-RedCap UE is a legacy UE.

3. The method of claim 1 or 2, wherein the RedCap UE has one or two receive branches.

4. The method of any one of claims 1-3, wherein the minimum number of receive branches for the non-RedCap UE is 4 for frequency range 1 (FR1) and is 2 for frequency range 2 (FR2).

5. The method of any one of claims 1-4, wherein the indicating comprises: sending, by the UE to the gNB when determining to indicate during the RA procedure, a first message indicating the UE as the RedCap UE during the RA procedure, the first message comprising a message 1 (Msg1) of the RA procedure, a message 3 (Msg3) of the RA procedure, or a message A (MsgA) of the RA procedure of the RA procedure.

6. The method of claim 5, further comprising:

determining, by the UE before the RA procedure, the first message based on a radio resource control (RRC) configuration that is broadcast by the gNB and received by the UE before the RA procedure.

7. The method of claim 6, wherein the RRC configuration comprises information of the criterion.

8. The method of any one of claims 5-7, wherein the first message is sent by the UE according to a physical random access channel (PRACH) configuration that is broadcast by the gNB and received by the UE before the RA procedure, the PRACH configuration comprising a

RACH preamble, a RACH occasion, or a combination thereof, which is associated with indicating RedCap UEs.

9. The method of any one of claims 5-8, further comprising:
 - 5 receiving, by the UE from the gNB during the RA procedure, a message 2 (Msg2) or a message 4 (Msg4) according to a received coverage recovery technique.
10. The method of any one of claims 5-9, wherein the first message is the Msg1, and the method further comprises:
 - 10 repeating, by the UE, a transmission of the Msg3 to the gNB.
11. The method of claim 10, wherein a number of repetitions of the transmission of the Msg3 is in accordance with a RACH configuration.
- 15 12. The method of claim 10, wherein repeating the transmission of the Msg3 is performed when a reference signal received power (RSRP) measurement of the UE is less than a threshold.
13. The method of any one of claims 1-4, wherein the indicating comprises:
 - 20 sending, by the UE to the gNB when determining to indicate after the RA procedure, information of UE capability indicating the UE as the RedCap UE after the RA procedure is completed.
14. The method of any one of claims 1-13, wherein the determining comprises:
 - 25 when the UE has two receive branches, determining, by the UE, to indicate the UE as the RedCap UE after the RA procedure; or
 - when the UE has one receive branch, determining, by the UE, to indicate the UE as the RedCap UE during the RA procedure.
- 30 15. The method of any one of claims 1-13, wherein the determining comprises:
 - when the UE has two receive branches and is operable in frequency range 1 (FR1) or FR2, determining, by the UE, to indicate the UE as the RedCap UE after the RA procedure;
 - when the UE has one receive branch and is operable in FR1 or FR2, determining, by the UE, to indicate the UE as the RedCap UE during the RA procedure; or
 - 35 when the UE has two receive branches and is operable in FR1, determining, by the UE, to indicate the UE as the RedCap UE during the RA procedure.

16. The method of any one of claims 1-13, wherein the determining comprises:
comparing, by the UE, a RSRP measurement with a threshold configured for RedCap
UEs;

when the RSRP measurement is greater than the threshold, determining, by the UE, to

indicate the UE as the RedCap UE after the RA procedure; or

when the RSRP measurement of the UE is less than or equal to the threshold,
determining, by the UE, to indicate the UE as the RedCap UE during the RA procedure.

17. The method of any one of claims 1-13, wherein the determining comprises:

comparing, by the UE, a RSRP measurement with a threshold configured for RedCap
UEs;

when the UE has two receive branches and the RSRP measurement is greater than the
threshold, determining, by the UE, to indicate the UE as the RedCap UE after the RA procedure;

when the UE has two receive branches and the RSRP measurement of the UE is less than
or equal to the threshold, determining, by the UE, to indicate the UE as the RedCap UE during
the RA procedure; or

when the UE has one receive branch, determining, by the UE, to indicate the UE as the
RedCap UE during the RA procedure.

18. The method of any one of claims 1-13, wherein the determining comprises:

comparing, by the UE, a RSRP measurement with a threshold configured for RedCap
UEs;

when the UE has one receive branch and the RSRP measurement is greater than the
threshold, determining, by the UE, to indicate the UE as the RedCap UE after the RA procedure;

when the UE has one receive branch and the RSRP measurement is less than or equal to
the threshold, determining, by the UE, to indicate the UE as the RedCap UE during the RA
procedure; or

when the UE has two receive branches, determining, by the UE, to indicate the UE as the
RedCap UE after the RA procedure.

19. A method comprising:

receiving, by a gNB from a user equipment (UE), a first message during a random access
(RA) procedure;

determining, by the gNB, whether the first message indicates that the UE is a reduced
capability (RedCap) UE, the RedCap UE having a quantity of receive branches less than a
minimum number of receive branches of a non-RedCap UE, or having a bandwidth less than a
minimum bandwidth of the non-RedCap UE;

when the first message indicates the UE as the RedCap UE, sending, by the gNB, a

second message to the UE during the RA procedure according to a coverage recovery technique;
when the first message does not indicate the UE as the RedCap UE, determining, by the gNB, whether the UE is the RedCap UE after the RA procedure is completed; and

broadcasting, by the gNB to the UE, information of a criterion enabling the UE to

determine whether to indicate, to the gNB, the UE as the RedCap UE during the RA procedure or after the RA procedure based on the criterion,

wherein the criterion is associated with a number of receive branches of the UE, a reference signal received power (RSRP) measured by the UE, a reference signal received quality (RSRQ) measured by the UE, a reference signal strength indicator (RSSI) measured by the UE, a combination thereof, or capability of the UE.

20. The method of claim 19, wherein the non-RedCap UE is a legacy UE.

21. The method of claim 19 or 20, wherein the RedCap UE has one or two receive branches.

22. The method of any one of claims 19-21, wherein the minimum number of receive branches of the non-RedCap UE is 4 for frequency range 1 (FR1) and is 2 for frequency range 2 (FR2).

23. The method of any one of claims 19-22, wherein the first message comprises a message 1 (Msg1) of the RA procedure, a message 3 (Msg3) of the RA procedure, or a message A (MsgA) of the RA procedure.

24. The method of claim 23, wherein the first message is based on a physical random access channel (PRACH) configuration broadcasted by the gNB, the PRACH configuration comprising a RACH preamble, a RACH occasion, or a combination thereof, which are associated with indicating RedCap UEs.

25. The method of any one of claims 19-24, wherein the second message is a message 2 (Msg2) of the RA procedure, or a message 4 (Msg4) of the RA procedure.

26. The method of any one of claims 19-23, further comprising:
receiving, by the gNB from the UE, information of UE capability indicating the UE as the RedCap UE after the RA procedure is completed.

27. The method of any one of claims 19-26, wherein the criterion comprises:
when the UE has two receive branches, indicating the RedCap UE after the RA
procedure; or
when the UE has one receive branch, indicating the RedCap UE during the RA
5 procedure.

28. The method of any one of claims 19-26, wherein the criterion comprises:
when the UE has two receive branches and is operable in frequency range 1 (FR1) or
FR2, indicating the RedCap UE after the RA procedure;
10 when the UE has one receive branch and is operable in FR1 or FR2, indicating the
RedCap UE during the RA procedure; or
when the UE has two receive branches and is operable in FR1, indicating the RedCap UE
during the RA procedure.

29. The method of any one of claims 19-26, wherein the criterion comprises:
when a RSRP measured by the UE is greater than a threshold, indicating the RedCap UE
after the RA procedure; or
when the RSRP measured by the UE is less than or equal to the threshold, indicating the
RedCap UE during the RA procedure.

30. The method of any one of claims 19-26, wherein the criterion comprises:
when the UE has two receive branches and a RSRP measured by the UE is greater than a
threshold, indicating the RedCap UE after the RA procedure;
when the UE has two receive branches and the RSRP measured by the UE is less than or
25 equal to the threshold, indicating the RedCap UE during the RA procedure; or
when the UE has one receive branch, indicating the RedCap UE during the RA
procedure.

31. The method of any one of claims 19-26, wherein the criterion comprises:
30 when the UE has one receive branch and a RSRP measured by the UE is greater than a
threshold, indicating the RedCap UE after the RA procedure;
when the UE has one receive branch and a RSRP measured by the UE is less than or
equal to the threshold, indicating the RedCap UE during the RA procedure; or
when the UE has two receive branches, indicating the RedCap UE after the RA
35 procedure.

32. The method of any one of claims 19-31, further comprising:
broadcasting, by the gNB, information indicating that the gNB supports RedCap UEs.

33. An apparatus comprising:

a non-transitory memory storage comprising instructions; and

one or more processors in communication with the memory storage, wherein the

instructions, when executed by the one or more processors, cause the apparatus to perform:

determining, based on a criterion, whether to indicate, to a gNB, that the apparatus is a reduced capability (RedCap) UE during a random access (RA) procedure of the apparatus or after the RA procedure, the RedCap UE having a quantity of receive branches less than a minimum number of receive branches of a non-RedCap UE, or having a bandwidth less than a minimum bandwidth of the non-RedCap UE, wherein the criterion is associated with a number of receive branches of the UE, a reference signal received power (RSRP) measured by the UE, a reference signal received quality (RSRQ) measured by the UE, a reference signal strength indicator (RSSI) measured by the UE, a combination thereof, or capability of the UE; and

indicating, to the gNB, that the apparatus is the RedCap UE according to a determination result.

34. An apparatus comprising:

a non-transitory memory storage comprising instructions; and

one or more processors in communication with the memory storage, wherein the instructions, when executed by the one or more processors, cause the apparatus to perform:

receiving, from a user equipment (UE), a first message during a random access (RA) procedure;

determining whether the first message indicates that the UE is a reduced capability (RedCap) UE, the RedCap UE having a quantity of receive branches less than a minimum number of receive branches of a non-RedCap UE, or having a bandwidth less than a minimum bandwidth of the non-RedCap UE;

when the first message indicates the UE as the RedCap UE, sending a second message to the UE during the RA procedure according to a coverage recovery technique;

when the first message does not indicate the UE as the RedCap UE, determining whether the UE is the RedCap UE after the RA procedure is completed; and

broadcasting, by the gNB to the UE, information of a criterion enabling the UE to determine whether to indicate, to the gNB, the UE as the RedCap UE during the RA procedure or after the RA procedure based on the criterion,

wherein the criterion is associated with a number of receive branches of the UE, a reference signal received power (RSRP) measured by the UE, a reference signal received quality (RSRQ) measured by the UE, a reference signal strength indicator (RSSI) measured by the UE, a combination thereof, or capability of the UE.

35. A non-transitory computer-readable media storing computer instructions, that when executed by one or more processors of an apparatus, cause the apparatus to perform:

determining, based on a criterion, whether to indicate, to a gNB, that the apparatus is a reduced capability (RedCap) UE during a random access (RA) procedure of the apparatus or
5 after the RA procedure, the RedCap UE having a quantity of receive branches less than a minimum number of receive branches of a non-RedCap UE, or having a bandwidth less than a minimum bandwidth of the non-RedCap UE, wherein the criterion is associated with a number of receive branches of the UE, a reference signal received power (RSRP) measured by the UE, a reference signal received quality (RSRQ) measured by the UE, a reference signal strength
10 indicator (RSSI) measured by the UE, a combination thereof, or capability of the UE; and
indicating, to the gNB, that the apparatus is the RedCap UE according to a determination result.

36. A non-transitory computer-readable media storing computer instructions, that when
15 executed by one or more processors of an apparatus, cause the apparatus to perform:

receiving, from a user equipment (UE), a first message during a random access (RA) procedure;

determining whether the first message indicates that the UE is a reduced capability (RedCap) UE, the RedCap UE having a quantity of receive branches less than a minimum
20 number of receive branches of a non-RedCap UE, or having a bandwidth less than a minimum bandwidth of the non-RedCap UE;

when the first message indicates the UE as the RedCap UE, sending a second message to the UE during the RA procedure according to a coverage recovery technique;

when the first message does not indicate the UE as the RedCap UE, determining whether
25 the UE is the RedCap UE after the RA procedure is completed; and

broadcasting, by the gNB to the UE, information of a criterion enabling the UE to determine whether to indicate, to the gNB, the UE as the RedCap UE during the RA procedure or after the RA procedure based on the criterion,

wherein the criterion is associated with a number of receive branches of the UE, a
30 reference signal received power (RSRP) measured by the UE, a reference signal received quality (RSRQ) measured by the UE, a reference signal strength indicator (RSSI) measured by the UE, a combination thereof, or capability of the UE.

37. A system comprising a user equipment (UE) and a gNB;

35 wherein the UE is configured to perform:

determining, based on a criterion, whether to indicate, to the gNB, that the UE is a reduced capability (RedCap) UE during a random access (RA) procedure of the UE or after the RA procedure, the RedCap UE having a quantity of receive branches less than a minimum

number of receive branches of a non-RedCap UE, or having a bandwidth less than a minimum bandwidth of the non-RedCap UE; and

indicating, to the gNB, that the UE is the RedCap UE according to a determination result; and

5 wherein the gNB is configured to perform:

 receiving, from the UE, a first message during a random access (RA) procedure;

 determining whether the first message indicates that the UE is the RedCap UE;

 when the first message indicates the UE as the RedCap UE, sending a second message to the UE during the RA procedure according to a coverage recovery technique;

10 when the first message does not indicate the UE as the RedCap UE, determining whether the UE is the RedCap UE after the RA procedure is completed; and

 broadcasting, to the UE, information of a criterion enabling the UE to determine whether to indicate, to the gNB, the UE as the RedCap UE during the RA procedure or after the RA procedure based on the criterion,

15 wherein the criterion is associated with a number of receive branches of the UE, a reference signal received power (RSRP) measured by the UE, a reference signal received quality (RSRQ) measured by the UE, a reference signal strength indicator (RSSI) measured by the UE, a combination thereof, or capability of the UE.