

CLAIMS

WHAT IS CLAIMED IS:

1. A method of wireless communication at a user equipment (UE), comprising:
 - determining to send a transmission to a first base station on a first unlicensed frequency channel of an unlicensed frequency spectrum;
 - determining, for one or more attempts of a listen before talk (LBT) protocol, whether each attempt is a failed attempt or a successful attempt;
 - determining that the first unlicensed frequency channel is one of:
 - unavailable based on the LBT protocol failing due to at least one of a number of failed attempts exceeding a first threshold number of failed attempts or a duration of failed attempts exceeding a first threshold duration, or
 - available based on at least one attempt of the LBT protocol being successful for the transmission; and
 - sending a medium access control (MAC) control element (CE) report from the UE to the first base station indicating whether the first unlicensed frequency channel is unavailable or available ~~through a unicast radio resource control (RRC) message or a medium access control (MAC) control element (CE)~~, wherein the first unlicensed frequency channel is provided by a first secondary cell of the first base station, and wherein the MAC CE is sent through another cell of the first base station, wherein the MAC CE includes an identification of the first secondary cell providing the first unlicensed frequency channel.
2. The method of claim 1, wherein the transmission is one of a scheduling request (SR), a random access channel (RACH) procedure, data on a physical uplink shared channel (PUSCH), or sounding reference signals (SRS) on the first unlicensed frequency channel.
3. The method of claim 1, further comprising:
 - maintaining one or more counters associated with the number of failed attempts or one or more timers associated with the duration of failed attempts based on the LBT protocol to transmit the transmission on the first unlicensed frequency channel; and
 - resetting the one or more counters or the one or more timers upon a determination that the first unlicensed frequency channel is available for the transmission.

4. The method of claim 3, wherein the maintaining the one or more counters or the one or more timers comprises maintaining a first counter or a first timer for a first type of the transmission and a second counter or a second timer for a second type of the transmission, the first type of the transmission being inside a transmission opportunity contended for and provided by the first base station, the second type of the transmission being outside the transmission opportunity contended for and provided by the first base station, the second type of the transmission being transmitted within a transmission opportunity contended for by the UE.

5. The method of claim 3, wherein the maintaining the one or more counters or the one or more timers comprises maintaining separate counters or separate timers for each access priority of a set of access priorities associated with the transmission.

6. The method of claim 5, wherein the maintaining separate counters or separate timers for each access priority of the set of access priorities comprises resetting counters or timers for higher access priorities when a counter or a timer for an access priority is reset.

7. The method of claim 1, wherein the first threshold number of failed attempts is less than a number of failed attempts that triggers a radio link failure (RLF) for a cell corresponding to the first unlicensed frequency channel, and the first threshold duration is less than a duration that triggers an RLF for the cell corresponding to the first unlicensed frequency channel.

8. The method of claim 1, wherein the ~~report~~MAC CE includes at least one of an identification of a cell providing the first unlicensed frequency channel, a type of the transmission, an LBT type, the number of failed attempts, or the duration of failed attempts.

9. The method of claim 8, wherein the ~~report~~MAC CE further includes a weighted sum of the number of failed attempts and the duration of failed attempts.

10. The method of claim 8, wherein the ~~MAC CE~~report further includes at least one of a reference signal received power (RSRP), a reference signal received quality (RSRQ), a signal to interference plus noise ratio (SINR), a signal to noise ratio (SNR), a reference

signal strength indication (RSSI), or a channel occupancy of a set of cells associated with the unlicensed frequency spectrum, the set of cells including a cell providing the first unlicensed frequency channel.

11. The method of claim 10, wherein the set of cells includes cells that were previously deactivated due to failures of previous transmission attempts based on the LBT protocol.

12. The method of claim 1, wherein the first unlicensed frequency channel is provided by a first secondary cell of the first base station, and wherein the MAC CE~~report~~ is sent through a primary cell of the first base station.

13. The method of claim 12, further comprising:

receiving a command from the first base station indicating deactivation of the first secondary cell for communication through the first unlicensed frequency channel and activation of a second secondary cell for communication through a second unlicensed frequency channel of the unlicensed frequency spectrum, the command being received as a result of the MAC CE~~report~~ sent by the UE; and

changing the first secondary cell of the first base station to the second secondary cell of the first base station for communication through the second unlicensed frequency channel upon receiving the command indicating the deactivation of the first secondary cell and the activation of the second secondary cell.

14. The method of claim 1, further comprising moving in a handover from the first base station to a second base station and sending the MAC CE~~report~~ to the second base station.

15. The method of claim 1, further comprising:

determining that the transmission based on the LBT protocol has failed for at least one of a second threshold number of failed attempts or a second threshold duration, the second threshold number of failed attempts being greater than the first threshold number of failed attempts, the second threshold duration being greater than the first threshold duration; and

declaring a radio link failure (RLF) upon the determination that the transmission based on the LBT protocol has failed for at least one of the second threshold number of failed attempts or the second threshold duration.

16. The method of claim 1, wherein the MAC CE~~report~~ is sent as part of a set of MAC CE~~reports~~, each report in the set of MAC CE~~reports~~ being sent periodically to the first base station to inform the first base station of an availability of the first unlicensed frequency channel.

17. The method of claim 1, wherein the determining, for one or more attempts of the LBT protocol, whether each attempt is a failed attempt or a successful attempt comprises periodically performing the LBT protocol when no transmission is available to send.

18. The method of claim 17, wherein periodically performing the LBT protocol is based on a first periodicity for a LBT protocol attempt during a transmission opportunity contended for and provided by the first base station and a second periodicity for a LBT protocol attempt outside the transmission opportunity.

19. An apparatus for wireless communication, comprising:

means for determining to send a transmission to a first base station on a first unlicensed frequency channel of an unlicensed frequency spectrum;

means for determining, for one or more attempts of a listen before talk (LBT) protocol, whether each attempt is a failed attempt or a successful attempt;

means for determining that the first unlicensed frequency channel is one of:

unavailable based on the LBT protocol failing due to at least one of a number of failed attempts exceeding a first threshold number of failed attempts or a duration of failed attempts exceeding a first threshold duration, or

available based on the LBT protocol being successful for the transmission;

and

means for sending a medium access control (MAC) control element (CE)~~report~~from the UE– to the first base station indicating whether the first unlicensed frequency channel is unavailable or available ~~through a unicast radio resource control (RRC) message or a medium access control (MAC) control element (CE)~~, wherein the first unlicensed frequency channel is provided by a first secondary cell of the first base station, and wherein the MAC CE is sent through another cell of the first base station, wherein the MAC CE includes an identification of the first secondary cell providing the first unlicensed frequency channel.

20. The apparatus of claim 19, further comprising:

means for maintaining one or more counters associated with the number of failed attempts or one or more timers associated with the duration of failed attempts based on the LBT protocol to transmit the transmission on the first unlicensed frequency channel; and

means for resetting the one or more counters or the one or more timers a determination that the first unlicensed frequency channel is available for the transmission.

21. The apparatus of claim 19, wherein the first unlicensed frequency channel is provided by a first secondary cell of the first base station, and wherein the ~~report~~ MAC CE is sent through a primary cell of the first base station, further comprising:

means for receiving a command from the first base station indicating deactivation of the first secondary cell for communication through the first unlicensed frequency channel and activation of a second secondary cell for communication through a second unlicensed frequency channel of the unlicensed frequency spectrum, the command being received as a result of the ~~report~~ MAC CE sent by the apparatus; and

means for changing the first secondary cell of the first base station to the second secondary cell of the first base station for communication through the second unlicensed frequency channel upon receiving the command indicating the deactivation of the first secondary cell and the activation of the second secondary cell.

22. The apparatus of claim 19, further comprising means for moving in a handover from the first base station to a second base station, wherein the means for sending the ~~report~~ MAC CE to the first base station is further configured to send the ~~report~~ MAC CE to the second base station.

23. The apparatus of claim 19, further comprising:

means for determining that the transmission based on the LBT protocol has failed for at least one of a second threshold number of failed attempts or a second threshold duration, the second threshold number of failed attempts being greater than the first threshold number of failed attempts, the second threshold duration being greater than the first threshold duration; and

means for declaring a radio link failure (RLF) upon the determination that the transmission based on the LBT protocol has failed for at least one of the second threshold number of failed attempts or the second threshold duration.

24. An apparatus for wireless communication, comprising:

a memory; and

at least one processor coupled to the memory and configured to:

determine to send a transmission to a first base station on a first unlicensed frequency channel of an unlicensed frequency spectrum;

determine, for one or more attempts of a listen before talk (LBT) protocol, whether each attempt is a failed attempt or a successful attempt;

determine that the first unlicensed frequency channel is one of:

unavailable based on the LBT protocol failing due to at least one of a number of failed attempts exceeding a first threshold number of failed attempts or a duration of failed attempts exceeding a first threshold duration, or

available based on at least one attempt of the LBT protocol being successful for the transmission; and

send a medium access control (MAC) control element (CE) report from the UE- to the first base station indicating whether the first unlicensed frequency channel is unavailable or available ~~through a unicast radio resource control (RRC) message or a medium access control (MAC) control element (CE), wherein the~~ first unlicensed frequency channel is provided by a first secondary cell of the first base station, and wherein the MAC CE is sent through another cell of the first base station, wherein the MAC CE includes an identification of the first secondary cell providing the first unlicensed frequency channel.

25. The apparatus of claim 24, wherein the at least one processor coupled to the memory is further configured to:

maintain one or more counters associated with the number of failed attempts or one or more timers associated with the duration of failed attempts based on the LBT protocol to transmit the transmission on the first unlicensed frequency channel; and

reset the one or more counters or the one or more timers upon a determination that the first unlicensed frequency channel is available for the transmission.

26. The apparatus of claim 25, wherein the ~~report~~-MAC CE includes at least one of a type of the transmission, an LBT type, a number of failed attempts, or a duration of failed attempts.

27. The apparatus of claim 26, wherein the ~~report~~-MAC CE further includes at least one of a reference signal received power (RSRP), a reference signal received quality (RSRQ), a signal to interference plus noise ratio (SINR), a signal to noise ratio (SNR), a reference signal strength indication (RSSI), or a channel occupancy of a set of cells associated with the unlicensed frequency spectrum, the set of cells including a cell providing the first unlicensed frequency channel, wherein the set of cells include cells that were previously deactivated due to failures of previous transmission attempts based on the LBT protocol.

28. The apparatus of claim 25, wherein the first unlicensed frequency channel is provided by a first secondary cell of the first base station, and wherein the ~~report~~-MAC CE is sent through a primary cell of the first base station, wherein the at least one processor coupled to the memory is further configured to:

receive information from the first base station indicating deactivation of the first secondary cell for communication through the first unlicensed frequency channel and activation of a second secondary cell for communication through a second unlicensed frequency channel of the unlicensed frequency spectrum, the information being received as a result of the report sent by the apparatus; and

change the first secondary cell of the first base station to the second secondary cell of the first base station for communication through the second unlicensed frequency channel upon receiving the information indicating the deactivation of the first secondary cell and the activation of the second secondary cell.

29. The apparatus of claim 25, wherein the at least one processor coupled to the memory is further configured to:

move in a handover from the first base station to a second base station; and
send the ~~report~~-MAC CE to the second base station.

30. A method of wireless communication of a wireless device at a first base station, comprising:

determining a failure of a listen before talk (LBT) protocol for a transmission from a user equipment (UE) to the first base station through an unlicensed frequency spectrum, wherein the determining the failure of the LBT protocol for the transmission from the UE comprises:

receiving a medium access control (MAC) control element (CE) report from the UE indicating the failure of the LBT protocol for the transmission from the UE ~~through the unlicensed frequency spectrum, wherein the unlicensed frequency spectrum is served by a first secondary cell of the first base station, and wherein the MAC CE is received through another cell of the first base station;~~ and

determining the failure of the LBT protocol for the transmission from the UE based on the received report; and

performing, based on the determination of the failure of the LBT protocol for the transmission from the UE, one of changing a secondary cell at the first base station for the UE for communication through the unlicensed frequency spectrum or handing over the UE to a primary cell at a second base station for communication through the unlicensed frequency spectrum, wherein the MAC CE includes an identification of the first secondary cell providing the first unlicensed frequency channel.

31. The method of claim 11, wherein the deactivated cells are kept in a dormant-type state and are monitored by the UE.