Thus, existing systems and methods for handling transmission failures in a wireless communication are not entirely satisfactory.

SUMMARY

The exemplary embodiments disclosed herein are directed to solving the issues relating to one or more of the problems presented in the prior art, as well as providing additional features that will become readily apparent by reference to the following detailed description when taken in conjunction with the accompany drawings. In accordance with various embodiments, exemplary systems, methods, devices and computer program products are disclosed herein. It is understood, however, that these embodiments are presented by way of example and not limitation, and it will be apparent to those of ordinary skill in the art who read the present disclosure that various modifications to the disclosed embodiments can be made while remaining within the scope of the present disclosure.

In a first aspect, a method performed by a wireless communication device is disclosed. The method comprises: obtaining, by a media access control (MAC) layer of the wireless communication device, an indication from a physical layer of the wireless communication device. The indication indicates a transmission failure of the wireless communication device at the physical layer, the transmission failure being due to a listen-before-talk (LBT) failure in unlicensed spectrum; starting, in response to the indication, a timer at the MAC layer; incrementing, in response to the indication, a counter at the MAC layer by one; determining that the counter has reached a predetermined threshold; and indicating, after the timer is started, a MAC layer transmission failure to a radio resource control (RRC) layer of the wireless communication device; the method further comprising: restarting, in response to another indication indicating a transmission failure of the wireless communication device at the physical layer due to an LBT failure in unlicensed spectrum, the timer at the MAC layer; and resetting the counter at the MAC layer in response to an expiration of the timer.

In a second aspect, a user equipment configured to carry out the method according to the first aspect is disclosed.

In a third aspect, a wireless communication device is disclosed. The wireless communication device comprises: a physical layer, configured to provide an indication, which

indicates a transmission failure of the wireless communication device at the physical layer, the transmission failure being due to a listen-before-talk (LBT) failure in unlicensed spectrum; a media access control (MAC) layer, configured to obtain the indication and comprising: a timer, configured to be started in response to the indication and further configured to be restarted in response to another indication indicating a transmission failure of the wireless communication device at the physical layer due to an LBT failure in unlicensed spectrum; and a counter, configured to be incremented by one in response to the indication and further configured to be reset in response to an expiration of the timer; and the MAC layer is further configured to: determine whether the counter has reached a predetermined threshold; and in response to determining the counter has reached the predetermined threshold, indicate, after the timer is started, a MAC layer transmission failure to a radio resource control (RRC) layer of the wireless communication device.

In a third aspect, a non-transitory computer-readable medium is disclosed. The non-transitory computer-readable medium having stored thereon computer executable instructions, the computer executable instructions, when being executed, configured to cause a wireless communication device to perform steps comprising: obtaining, by a media access control (MAC) layer of the wireless communication device, an indication from a physical layer of the wireless communication device, wherein the indication indicates a transmission failure of the wireless communication device at the physical layer, the transmission failure being due to a listen-before-talk (LBT) failure in unlicensed spectrum; starting, in response to the indication, a timer at the MAC layer; incrementing, in response to the indication, a counter at the MAC layer by one; determining that the counter has reached a predetermined threshold; and indicating, after the timer is started, a MAC layer transmission failure to a radio resource control (RRC) layer of the wireless communication device; wherein the computer executable instructions, when being executed, is further configured to cause the wireless communication device to perform steps comprising: restarting, in response to another indication indicating a transmission failure of the wireless communication device at the physical layer due to an LBT failure in unlicensed spectrum, the timer at the MAC layer; and resetting the counter at the MAC layer in response to an expiration of the timer.

In another embodiment, a method performed by a wireless communication device is disclosed. The method comprises: performing, by a first layer module of the wireless

communication device, a wireless transmission of a message at a first layer; and sending, by the first layer module, an indication to a second layer module of the wireless communication device. The first layer module is configured for performing a process at the first layer. The second layer module is configured for performing a process at a second layer that is different from the first layer. The indication indicates whether there is a transmission failure of transmitting the message at the first layer.

In yet another embodiment, a method performed by a wireless communication device is disclosed. The method comprises: obtaining, by a first layer module of the wireless

CLAIMS

1. A method performed by a wireless communication device, the method comprising:

obtaining, by a media access control (MAC) layer of the wireless communication device, an indication from a physical layer of the wireless communication device, wherein

the indication indicates a transmission failure of the wireless communication device at the physical layer, the transmission failure being due to a listen-before-talk (LBT) failure in unlicensed spectrum;

starting, in response to the indication, a timer at the MAC layer;

incrementing, in response to the indication, a counter at the MAC layer by one;

determining that the counter has reached a predetermined threshold; and

indicating, after the timer is started, a MAC layer transmission failure to a radio resource control (RRC) layer of the wireless communication device; the method further comprising:

restarting, in response to another indication indicating a transmission failure of the wireless communication device at the physical layer due to an LBT failure in unlicensed spectrum, the timer at the MAC layer; and

resetting the counter at the MAC layer in response to an expiration of the timer.

2. The method of claim 1, further comprising:

determining a radio link failure (RLF) at the RRC layer based on the indicated MAC layer transmission failure.

3. A user equipment configured to carry out the method of claim 1.

4. The user equipment of claim 3, further configured to determine a radio link failure (RLF) at the RRC layer based on the indicated MAC layer transmission failure.

5. A wireless communication device, comprising:

a physical layer, configured to provide an indication, which indicates a transmission failure of the wireless communication device at the physical layer, the transmission failure being due to a listen-before-talk (LBT) failure in unlicensed spectrum;

a media access control (MAC) layer, configured to obtain the indication and comprising:

a timer, configured to be started in response to the indication and further configured to be restarted in response to another indication indicating a transmission failure of the wireless communication device at the physical layer due to an LBT failure in unlicensed spectrum; and

a counter, configured to be incremented by one in response to the indication and further configured to be reset in response to an expiration of the timer; and

the MAC layer is further configured to:

determine whether the counter has reached a predetermined threshold; and

in response to determining the counter has reached the predetermined threshold, indicate, after the timer is started, a MAC layer transmission failure to a radio resource control (RRC) layer of the wireless communication device.

6. The wireless communication device of claim 5, wherein the RRC layer is further configured to determine a radio link failure (RLF) based on the indication of the MAC layer transmission failure.

7. A non-transitory computer-readable medium having stored thereon computer executable instructions, the computer executable instructions, when being executed, configured to cause a wireless communication device to perform steps comprising:

obtaining, by a media access control (MAC) layer of the wireless communication device, an indication from a physical layer of the wireless communication device, wherein the indication indicates a transmission failure of the wireless communication device at the physical layer, the transmission failure being due to a listen-before-talk (LBT) failure in unlicensed spectrum;

starting, in response to the indication, a timer at the MAC layer;

incrementing, in response to the indication, a counter at the MAC layer by one;

determining that the counter has reached a predetermined threshold; and

indicating, after the timer is started, a MAC layer transmission failure to a radio resource control (RRC) layer of the wireless communication device; wherein the computer executable instructions, when being executed, is further configured to cause the wireless communication device to perform steps comprising:

restarting, in response to another indication indicating a transmission failure of the wireless communication device at the physical layer due to an LBT failure in unlicensed spectrum, the timer at the MAC layer; and

resetting the counter at the MAC layer in response to an expiration of the timer.

8. The non-transitory computer-readable medium of claim 13, wherein the computer executable instructions, when being executed, is further configured to cause the wireless communication device to determine a radio link failure (RLF) at the RRC layer based on the indicated MAC layer transmission failure.