Claims

1. A transmitting device for determining radio resources to be used for a data transmission from the transmitting device via a sidelink interface to one or more receiving devices, wherein the transmitting device comprises:

a receiver and processor, which in operation, perform a resource sensing procedure so as to acquire information about radio resources usable for the transmitting device to transmit data at a later point in time,

after data becomes available for transmission, the processor, when in operation, performs an autonomous radio resource allocation to select radio resources within a transmission window to be used for transmitting the data, based on the information acquired by the resource sensing procedure during a sensing window before the data became available for transmission, and

wherein the autonomous radio resource allocation comprises selecting radio resources in primary subframes of the transmission window over radio resources in secondary subframes of the transmission window, and

wherein the secondary subframes in the transmission window correspond to those subframes in the sensing window during which the transmitting device did not perform the resource sensing procedure, and the primary subframes in the transmission window correspond to those subframes in the sensing window during which the transmitting device did perform the resource sensing procedure.

2. The transmitting device according to claim 2, wherein the resource sensing procedure comprises:

- in order to determine radio resources that are reserved by other transmitting devices, the receiver and processor, when in operation, monitor for scheduling information transmitted by other transmitting devices indicating radio resources reserved by the other transmitting devices for a later point in time,

- measures a received signal energy in radio resources so as to identify radio resources that are used by other transmitting devices for transmission.

3. The transmitting device according to claim 1 or 2, wherein the processor, when in operation, determines the secondary subframes as being those subframes of the

transmission window for which the resource sensing procedure did not acquire all possible information during the sensing window,

wherein missing information for a secondary subframe comprises:

- a possible reservation of radio resources by other transmitting devices made during a subframe in the sensing window in which the transmitting device did not perform the resource sensing procedure, wherein the determination of the secondary subframes is based on possible periodicities of the radio resource reservations that can be made by the other transmitting devices, and/or

- information on received signal energy in radio resources of a subframe in the sensing window in which the transmitting device did not perform the resource sensing procedure.

4. The transmitting device according to one of claims 1 to 3, wherein the autonomous radio resource allocation further comprises determining one or more primary transmission radio resource candidates within the primary subframes and determining one or more secondary transmission radio resource candidates within the secondary subframes,

and in case there are more than one primary transmission radio resource candidates, the processor, when in operation, performs candidate ranking of the primary transmission radio resource candidates, and in case there are more than one secondary transmission radio resource candidates, the processor, when in operation, performs candidate ranking of the secondary transmission radio resource candidates, wherein the candidate ranking of the one or more primary transmission radio resource candidates is separate from the ranking of the one or more secondary transmission radio resource candidates,

wherein the candidate ranking considers a time distance of the radio resource candidate from the point in time the data became available for transmission as well as a received signal energy prediction obtained by the resource sensing procedure for the radio resources to be ranked,

wherein the received signal energy prediction for the radio resources to be ranked is based on the measurements of the received signal energy of corresponding radio resources in all subframes of the sensing window or based on the measurements of the received signal energy of corresponding radio resources in subframes of the sensing window related to the subframe which radio resources are to be ranked, wherein the related subframes are those subframes of the sensing window which have a distance

from the radio resources to be ranked of a multiple of possible transmission periodicities by other transmitting devices,

wherein the candidate ranking first considers the time distance and then the received signal energy, or wherein the candidate ranking fist considers the received signal energy and then the time distance, or wherein the candidate ranking is based on a function of the time distance and the received signal energy.

5. The transmitting device according to one of claims 1 to 4, wherein the transmitting device, when performing a data transmission or a scheduling assignment transmission for a data transmission in a subframe, does not perform the resource sensing procedure in that subframe.

6. The transmitting device according to one of claims 1 to 5, wherein in case no radio resources could be selected to be used for the transmission of the data, the processor, when in operation, determines to drop the data in case a priority of the data available for transmission is below a preemption priority threshold, and in case the data is not dropped, the processor, when in operation, performs a resource preemption procedure to select radio resources to be used for the transmission of the data from among the radio resources reserved by one or more of the other transmitting devices,

wherein the processor, when performing the resource preemption procedure, selects the radio resources to be used for the transmission of the data, based on a priority of the reserved radio resources, and/or the priority of the data to be transmitted, and/or received signal energy measured by the resource sensing procedure in radio resources of corresponding subframes in the sensing window, wherein the selection of radio resources in the resource preemption procedure either first considers the priority and then the received signal energy of the reserved radio resources or first considers the received signal energy and then the priority of the reserved radio resources or is based on a function of the priority and the received signal energy of the reserved radio resources.

7. The transmitting device according to one of claims 1 to 6, wherein the receiver and processor, when in operation, determine a channel busy ratio of the sidelink interface indicating a congestion level of the sidelink interface, and wherein the processor, when in operation, performs a data dropping procedure before performing the autonomous radio resource allocation based on the determined channel busy ratio of the sidelink interface so as to determine whether data becoming available for transmission should be dropped

or not, and wherein in case the processor determines to not drop the data, the processor performs the autonomous radio resource allocation,

wherein during the data dropping procedure, the processor drops the data when determining that a priority of the data becoming available for transmission is lower than a channel priority threshold, the channel priority threshold depending on the determined channel busy ratio of the sidelink interface,

wherein the transmitting device is configured by a radio base station controlling the transmitting device to perform or not perform the data dropping procedure, wherein the configuration of the data dropping procedure is separate for each of a plurality of resource pools usable by the transmitting device to select radio resources for transmitting data,

wherein the channel priority threshold further depends on the type of the data becoming available for transmission, wherein a safety-data-related channel priority threshold is lower than a non-safety-data-related channel priority threshold.

8. The transmitting device according to one of claims 1 to 7, wherein the autonomous radio resource allocation comprises excluding the radio resources reserved by the other transmitting devices from the plurality of transmission radio resources, and/or

wherein a radio resource candidate within a subframe comprises one or more resource blocks that are contiguous in the frequency domain.

9. The transmitting device according to one of claims 1 to 8, wherein the sensing window considered for the autonomous radio resource allocation comprises frequency time radio resources starting a predetermined point in time before the data becomes available for transmission and ending at the point in time the data becomes available for transmission, and

the transmission window comprises frequency time radio resources starting at a starting subframe that is immediately after the subframe the data became available for transmission and ending at a subframe that is a predetermined distance away from the starting subframe, wherein the distance depends on delay requirements of the data becoming available for transmission that are to be fulfilled by the transmitting device.

10. A method for a transmitting device for determining radio resources to be used for a data transmission from the transmitting device via a sidelink interface to one or more receiving

devices, wherein the method comprises the following steps performed by the transmitting device:

performing a resource sensing procedure so as to acquire information about radio resources usable for the transmitting device to transmit data at a later point in time,

after data becomes available for transmission, performing an autonomous radio resource allocation to select radio resources within a transmission window to be used for transmitting the data, based on the information acquired by the resource sensing procedure during a sensing window before the data became available for transmission,

wherein the autonomous radio resource allocation comprises selecting radio resources in primary subframes of the transmission window over radio resources in secondary subframes of the transmission window, and

wherein the secondary subframes in the transmission window correspond to those subframes in the sensing window during which the transmitting device did not perform the resource sensing procedure, and the primary subframes in the transmission window correspond to those subframes in the sensing window during which the transmitting device did perform the resource sensing procedure.

11. The method according to claim 10, wherein the resource sensing procedure comprises:

- monitoring for scheduling information transmitted by other transmitting devices indicating radio resources reserved by the other transmitting devices for a later point in time, so as to determine radio resources that are reserved by other transmitting devices,

- measuring a received signal energy in radio resources so as to identify radio resources that are used by other transmitting devices for transmission.

12. The method according to claim 10 or 11, the method further comprising determining the secondary subframes as being those subframes of the transmission window for which the resource sensing procedure did not acquire all possible information during the sensing window,

wherein missing information for a secondary subframe comprises:

- a possible reservation of radio resources by other transmitting devices made during a subframe in the sensing window in which the transmitting device did not perform the resource sensing procedure, wherein the determination of the secondary subframes is based on possible periodicities of the radio resource reservations that can be made by the other transmitting devices, and/or

- information on received signal energy in radio resources of a subframe in the sensing window in which the transmitting device did not perform the resource sensing procedure.

13. The method according to one of claims 10 to 12, wherein the autonomous radio resource allocation further comprises determining one or more primary transmission radio resource candidates within the primary subframes and determining one or more secondary transmission radio resource candidates within the secondary subframes,

and in case there are more than one primary transmission radio resource candidates, the method comprises performing candidate ranking of the primary transmission radio resource candidates, and in case there are more than one secondary transmission radio resource candidates, the method comprises performing candidate ranking of the secondary transmission radio resource candidates, wherein the candidate ranking of the one or more primary transmission radio resource candidates is separate from the ranking of the one or more secondary transmission radio resource candidates,

wherein the candidate ranking considers a time distance of the radio resource candidate from the point in time the data became available for transmission as well as a received signal energy prediction obtained by the resource sensing procedure for the radio resources to be ranked,

wherein the received signal energy prediction for the radio resources to be ranked is based on the measurements of the received signal energy of corresponding radio resources in all subframes of the sensing window or based on the measurements of the received signal energy of corresponding radio resources in subframes of the sensing window related to the subframe which radio resources are to be ranked, wherein the related subframes are those subframes of the sensing window which have a distance from the radio resources to be ranked of a multiple of possible transmission periodicities by other transmitting devices,

wherein the candidate ranking first considers the time distance and then the received signal energy, or wherein the candidate ranking fist considers the received signal energy

and then the time distance, or wherein the candidate ranking is based on a function of the time distance and the received signal energy.

14. The method according to one of claims 10 to 13, wherein in case no radio resources could be selected to be used for the transmission of the data, the method comprises determining to drop the data in case a priority of the data available for transmission is below a preemption priority threshold, and in case the data is not dropped, the method comprises performing a resource preemption procedure to select radio resources to be used for the transmission of the data from among the radio resources reserved by one or more of the other transmitting devices,

wherein, when performing the resource preemption procedure, the method comprises selecting the radio resources to be used for the transmission of the data, based on a priority of the reserved radio resources, and/or the priority of the data to be transmitted, and/or received signal energy measured by the resource sensing procedure in radio resources of corresponding subframes in the sensing window, wherein the selection of radio resources in the resource preemption procedure either first considers the priority and then the received signal energy of the reserved radio resources or first considers the received signal energy and then the priority of the reserved radio resources or is based on a function of the priority and the received signal energy of the reserved radio resources.

15. The method according to one of claims 10 to 14, wherein the method comprises:

determining a channel busy ratio of the sidelink interface indicating a congestion level of the sidelink interface, and performing a data dropping procedure before performing the autonomous radio resource allocation based on the determined channel busy ratio of the sidelink interface so as to determine whether data becoming available for transmission should be dropped or not, and wherein in case the method determines to not drop the data, the step of performing the autonomous radio resource allocation is performed,

wherein during the data dropping procedure, the method comprises dropping the data when determining that a priority of the data becoming available for transmission is lower than a channel priority threshold, the channel priority threshold depending on the determined channel busy ratio of the sidelink interface,

wherein the transmitting device is configured by a radio base station controlling the transmitting device to perform or not perform the data dropping procedure, wherein the configuration of the data dropping procedure is separate for each of a plurality of

resource pools usable by the transmitting device to select radio resources for transmitting data,

wherein the channel priority threshold further depends on the type of the data becoming available for transmission, wherein a safety-data-related channel priority threshold is lower than a non-safety-data-related channel priority threshold.

16. A transmitting device for transmitting a scheduling assignment and data via a sidelink interface to one or more receiving devices, wherein the transmitting device comprises:

a receiver and processor, which in operation, perform a resource sensing procedure to acquire information about radio resources usable by the transmitting device for transmitting scheduling assignments at a later point in time,

after first data becomes available for transmission, the processor, when in operation, performs an autonomous radio resource allocation procedure to select radio resources within a transmission window for transmitting the first data and to select radio resources within the transmission window for transmitting a first scheduling assignment based on the information acquired by the resource sensing procedure during a sensing window before the first data became available for transmission, wherein the first scheduling assignment comprises information on the selected radio resources in the transmission window for transmitting the first data,

a transmitter, which in operation, transmits the first scheduling assignment using the selected radio resources and transmits the first data using the selected radio resources,

wherein the first scheduling assignment further indicates reserved radio resources usable at a later point in time by the transmitting device to transmit a second scheduling assignment for second data, and

wherein the autonomous radio resource allocation performed to select radio resources within the transmission window to be used for transmitting the first scheduling assignment comprises selecting radio resources in primary subframes of the transmission window preferably over radio resources in secondary subframes of the transmission window, and

wherein the secondary subframes in the transmission window correspond to those subframes in the sensing window during which the transmitting device did not perform the resource sensing procedure, and the primary subframes in the transmission window

correspond to those subframes in the sensing window during which the transmitting device did perform the resource sensing procedure.

17. The transmitting device according to claim 16, wherein the processor, when in operation, determines the secondary subframes as being those subframes of the transmission window for which the resource sensing procedure did not acquire all possible information during the sensing window,

wherein missing information for a secondary subframe comprises:

- a possible reservation of radio resources by other transmitting devices made during a subframe in the sensing window in which the transmitting device did not perform the resource sensing procedure, wherein the determination of the secondary subframes is based on possible periodicities of the radio resource reservations that can be made by the other transmitting devices, and/or

- information on received signal energy in radio resources of a subframe in the sensing window in which the transmitting device did not perform the resource sensing procedure.

18. The transmitting device according to claim 16 or 17, wherein the autonomous radio resource allocation performed to select radio resources within the transmission window to be used for transmitting the first scheduling assignment further comprises determining one or more primary transmission radio resource candidates within the primary subframes and determining one or more secondary transmission radio resource candidates within the secondary subframes,

and in case there are more than one primary transmission radio resource candidates, the processor, when in operation, performs candidate ranking of the primary transmission radio resource candidates, and in case there are more than one secondary transmission radio resource candidates, the processor, when in operation, performs candidate ranking of the secondary transmission radio resource candidates, wherein the candidate ranking of the one or more primary transmission radio resource candidates is separate from the ranking of the one or more secondary transmission radio resource candidates.

19. The transmitting device according to one of claims 16 to 18, wherein the first scheduling assignment indicates radio resources reserved for transmitting the second scheduling assignment at a later point in time:

- in case the first scheduling assignment reserves radio resources usable at a later point in time to transmit the second data by the transmitting device, or
- by comprising information that the first scheduling assignment reserves radio resources for transmitting the second scheduling assignment at a later point in time.

20. The transmitting device according to one of claims 16 to 19, wherein the transmitting device is configured by a radio base station controlling the transmitting device to reserve or not reserve radio resources for transmitting the second scheduling assignment at a later point in time, wherein the configuration is performed by a message broadcast by the radio base station in a cell where the transmitting device is located or by a dedicated message transmitted by the radio base station to the transmitting device,

wherein the configuration as to reserve or not reserve radio resources for the transmission of scheduling assignments is separate for each of a plurality of resource pools usable by the transmitting device to select radio resources for transmitting scheduling assignments.

21. The transmitting device according to one of claims 16 to 20, wherein the transmitter, when in operation, retransmits the first scheduling assignment one or more times within the transmission window, wherein the processor, when in operation, determines the number of retransmissions of the first scheduling assignment based on a priority of the first data and/or a congestion level of the sidelink interface,

wherein the processor, when in operation, performs the autonomous radio resource allocation procedure to select radio resources within the transmission window for the one or more retransmissions of the first scheduling assignment, based on the information acquired by the resource sensing procedure during the sensing window,

wherein the first transmission of the first scheduling assignment and the one or more retransmissions of the first scheduling assignment comprise a common identification so as to allow associating the first and retransmissions of the first scheduling assignment, wherein the common identification identifies the transmitting device and/or a data service of the transmitting device that generates the first data,

wherein the one or more retransmissions of the first scheduling assignment have a predetermined relationship with the first transmission of the first scheduling assignment.

22. A method for a transmitting device for transmitting a scheduling assignment and data via a sidelink interface to one or more receiving devices, wherein the method comprises the following steps performed by the transmitting device:

performing a resource sensing procedure to acquire information about radio resources usable by the transmitting device for transmitting scheduling assignments at a later point in time,

after first data becomes available for transmission, performing an autonomous radio resource allocation procedure to select radio resources within a transmission window for transmitting the first data and selecting radio resources within the transmission window for transmitting a first scheduling assignment based on the information acquired by the resource sensing procedure during a sensing window before the first data became available for transmission, wherein the first scheduling assignment comprises information on the selected radio resources in the transmission window for transmitting the first data,

transmitting the first scheduling assignment using the selected radio resources and transmits the first data using the selected radio resources,

wherein the first scheduling assignment further indicates reserved radio resources usable at a later point in time by the transmitting device to transmit a second scheduling assignment for second data, and

wherein the autonomous radio resource allocation performed to select radio resources within the transmission window to be used for transmitting the first scheduling assignment comprises selecting radio resources in primary subframes of the transmission window over radio resources in secondary subframes of the transmission window, and

wherein the secondary subframes in the transmission window correspond to those subframes in the sensing window during which the transmitting device did not perform the resource sensing procedure, and the primary subframes in the transmission window correspond to those subframes in the sensing window during which the transmitting device did perform the resource sensing procedure.

23. The method according to claim 22, wherein the method comprises determining the secondary subframes as being those subframes of the transmission window for which the

resource sensing procedure did not acquire all possible information during the sensing window,

wherein missing information for a secondary subframe comprises:

- a possible reservation of radio resources by other transmitting devices made during a subframe in the sensing window in which the transmitting device did not perform the resource sensing procedure, wherein the determination of the secondary subframes is based on possible periodicities of the radio resource reservations that can be made by the other transmitting devices, and/or

- information on received signal energy in radio resources of a subframe in the sensing window in which the transmitting device did not perform the resource sensing procedure.

24. The method according to claim 22 or 23, wherein the autonomous radio resource allocation performed to select radio resources within the transmission window to be used for transmitting the first scheduling assignment further comprises determining one or more primary transmission radio resource candidates within the primary subframes and determining one or more secondary transmission radio resource candidates within the secondary subframes,

and in case there are more than one primary transmission radio resource candidates, the method comprises performing candidate ranking of the primary transmission radio resource candidates, and in case there are more than one secondary transmission radio resource candidates, the method comprises performing candidate ranking of the secondary transmission radio resource candidates, wherein the candidate ranking of the one or more primary transmission radio resource candidates is separate from the ranking of the one or more secondary transmission radio resource candidates.

25. The method according to one of claims 22 to 24, wherein the first scheduling assignment indicates radio resources reserved for transmitting the second scheduling assignment at a later point in time:

- in case the first scheduling assignment reserves radio resources usable at a later point in time to transmit the second data by the transmitting device, or

- by comprising information that the first scheduling assignment reserves radio resources for transmitting the second scheduling assignment at a later point in time.

26. The method according to one of claims 22 to 25, wherein the transmitting device is configured by a radio base station controlling the transmitting device to reserve or not reserve radio resources for transmitting the second scheduling assignment at a later point in time, wherein the configuration is performed by a message broadcast by the radio base station in a cell where the transmitting device is located or by a dedicated message transmitted by the radio base station to the transmitting device,

wherein the configuration as to reserve or not reserve radio resources for the transmission of scheduling assignments is separate for each of a plurality of resource pools usable by the transmitting device to select radio resources for transmitting scheduling assignments.

27. The method according to one of claims 22 to 26, further comprising retransmitting the first scheduling assignment one or more times within the transmission window, and wherein the method further comprises determining the number of retransmissions of the first scheduling assignment based on a priority of the first data and/or a congestion level of the sidelink interface,

wherein the method comprises performing the autonomous radio resource allocation procedure to select radio resources within the transmission window for the one or more retransmissions of the first scheduling assignment, based on the information acquired by the resource sensing procedure during the sensing window,

wherein the first transmission of the first scheduling assignment and the one or more retransmissions of the first scheduling assignment comprise a common identification so as to allow associating the first and retransmissions of the first scheduling assignment, wherein the common identification identifies the transmitting device and/or a data service of the transmitting device that generates the first data,

wherein the one or more retransmissions of the first scheduling assignment have a predetermined relationship with the first transmission of the first scheduling assignment.