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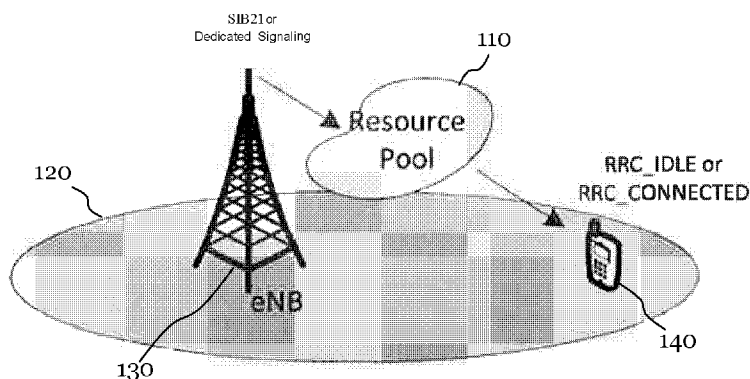


Figure 1

(57) Abstract: A method for resource selection is disclosed. The method includes performing, by a UE, a first sensing operation to determine available resources in a resource pool; transmitting, by the UE, first data using a first set of available resources, the first set of available resources having been selected from the resource pool in accordance with the first sensing operation; performing, by the UE, concurrently with the first sensing operation and resource selection of the first set of available resources and independently from the first sensing operation, a second sensing operation to determine other available resources in the resource pool; and transmitting, by the UE, second data using a second set of available resources, the second set of available resources having been selected from the resource pool in accordance with the second sensing operation, wherein the first set of available resources and the second set of available resources are independently selected.



METHOD FOR RESOURCE SELECTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[1] This application claims the benefit of U.S. Provisional Application No. 62/469,833, filed on March 10, 2017 and U.S. Application No. 15/917,358, filed on March 9, 2018, which are hereby incorporated herein by reference.

TECHNICAL FIELD

[2] The present disclosure relates generally to a system and method for selecting resources and, in particular embodiments, to a system and method for improved transmission reliability between user equipment in V2V/V2X technology.

BACKGROUND

[3] Vehicle-to-Vehicle (V2V) and Vehicle-to-Everything (V2X) technologies have been standardized by the 3rd Generation Partnership Project (3GPP) in Release 14 (Rel-14). V2V/V2X services are supported on the sidelink and reuse much of the Device-to-Device (D2D) work already standardized in Rel-12 and Rel-13. The term “sidelink” refers to communication performed between one user equipment (UE) and one or more other UEs without data being transmitted through an Evolved Node B (eNB) or other centralized controller. In particular, V2V/V2X messages are broadcast by a source without *a priori* knowledge of a receiver.

[4] In Rel-15, the V2V/V2X work is expected to continue for both Long Term Evolution (LTE) and New Radio (NR) Scalable Network. In particular, it is likely that more advanced vehicular services such as platooning, automated merging, and a general move towards autonomous cars will be standardized. The work has already started in the 3GPP Service and System Aspects Group 1 (SA1), where requirements for V2V/V2X services are being drafted.

[5] One of the requirements for advanced V2V/V2X services is the need for higher transmission reliability, for both multicast and unicast transmission. With transmission mode-4 (UE being autonomous without eNB allocating resources), the Rel-14 V2V/V2X solution might not provide adequate reliability. Thus, there is a need for techniques for improved mode-4 reliability.

SUMMARY

[6] In accordance with an embodiment of the present disclosure, a method for resource selection comprises performing, by a UE, a first sensing operation to determine available resources in a resource pool; transmitting, by the UE, first data using a first set of available resources, the first set of available resources having been selected from the resource pool in accordance with the first sensing operation; performing, by the UE, concurrently with the first sensing operation and resource selection of the first set of available resources and independently from the first sensing operation, a second sensing operation to determine other available resources in the resource pool; and transmitting, by the UE, second data using a second set of available resources, the second set of available resources having been selected from the resource pool in accordance with the second sensing operation, wherein the first set of available resources and the second set of available resources are independently selected.

[7] In the previous embodiment, the first data and the second data might be the same data. In any of the previous embodiments, the first data and the second data might be two consecutive data packets. In any of the previous embodiments, the first set of available resources and the second set of available resources might be selected on different subframes. In any of the previous embodiments, the first set of available resources might be used in odd resource intervals and the second set of available resources might be used in even resource intervals. In any of the previous embodiments, the first set of available resources and the second set of available resources might be used in the same resource interval. In any of the previous embodiments, selection of the first set of available resources and selection of the second set of available resources might be performed before a reselection of resources. In any of the previous embodiments, resource reselections for the first set of available resources and the second set of available resources might occur at different times. In any of the previous embodiments, the first set of available resources and the second set of available resources might be in consecutive data blocks. In any of the previous embodiments, the method might further comprise performing, by the UE, concurrently with the first sensing operation and the second sensing operation and independently from the first sensing operation and the second sensing operation, a third sensing operation to determine additional other available resources in the resource pool; and transmitting, by the UE, third data using a third set of available resources, the third set of available resources having been selected from the resource pool in accordance with the third sensing operation. In any of the previous embodiments, the first sensing operation and the second sensing operation might comprise sidelink mode-4 sensing operations.

[8] In accordance with another embodiment of the present disclosure, a UE comprises a transmitter configured to transmit first data using a first set of available resources, the first set of available resources having been selected from the resource pool in accordance with a first sensing operation performed by the UE to determine available resources in a resource pool. The transmitter is further configured to transmit second data using a second set of available resources, the second set of available resources having been selected from the resource pool in accordance with a second sensing operation performed by the UE, concurrently with the first sensing operation and resource selection of the first set of available resources and independently from the first sensing operation, to determine other available resources in the resource pool, wherein the first set of available resources and the second set of available resources are independently selected.

[9] In the previous embodiment, the first data and the second data might be the same data. In any of the previous embodiments, the first data and the second data might be two consecutive data packets. In any of the previous embodiments, the first set of available resources and the second set of available resources might be selected on different subframes. In any of the previous embodiments, the first set of available resources might be used in odd resource intervals and the second set of available resources might be used in even resource intervals. In any of the previous embodiments, the first set of available resources and the second set of available resources might be used in the same resource interval. In any of the previous embodiments, selection of the first set of available resources and selection of the second set of available resources might be performed before a reselection of resources. In any of the previous embodiments, resource reselections for the first set of available resources and the second set of available resources might occur at different times. In any of the previous embodiments, the first set of available resources and the second set of available resources might be in consecutive data blocks. In any of the previous embodiments, the transmitter might be configured to transmit third data using a third set of available resources, the third set of available resources having been selected from the resource pool in accordance with a third sensing operation performed, concurrently with the first sensing operation and the second sensing operation and independently from the first sensing operation and the second sensing operation, to determine additional other available resources in the resource pool. In any of the previous embodiments, the first sensing operation and the second sensing operation might comprise sidelink mode-4 sensing operations.

[10] In accordance with another embodiment of the present disclosure, a device comprises a non-transitory memory storage comprising instructions and one or more processors in communication with the memory storage. The one or more processors execute the instructions to transmit first data using a first set of available resources, the first set of available resources having been selected from the resource pool in accordance with a first sensing operation performed by the device to determine available resources in a resource pool, and transmit second data using a second set of available resources, the second set of available resources having been selected from the resource pool in accordance with a second sensing operation performed by the device, concurrently with the first sensing operation and resource selection of the first set of available resources and independently from the first sensing operation, to determine other available resources in the resource pool, wherein the first set of available resources and the second set of available resources are independently selected.

[11] In the previous embodiment, the first data and the second data might be the same data. In any of the previous embodiments, the first data and the second data might be two consecutive data packets. In any of the previous embodiments, the first set of available resources and the second set of available resources might be selected on different subframes. In any of the previous embodiments, the first set of available resources might be used in odd resource intervals and the second set of available resources might be used in even resource intervals. In any of the previous embodiments, the first set of available resources and the second set of available resources might be used in the same resource interval. In any of the previous embodiments, selection of the first set of available resources and selection of the second set of available resources might be performed before a reselection of resources. In any of the previous embodiments, resource reselections for the first set of available resources and the second set of available resources might occur at different times. In any of the previous embodiments, the first set of available resources and the second set of available resources might be in consecutive data blocks. In any of the previous embodiments, the one or more processors might further execute the instructions to perform, concurrently with the first sensing operation and the second sensing operation and independently from the first sensing operation and the second sensing operation, a third sensing operation to determine additional other available resources in the resource pool; and transmit third data using a third set of available resources, the third set of available resources having been selected from the resource pool in accordance with the third sensing operation. In any of the previous embodiments, the first sensing operation and the second sensing operation might comprise sidelink mode-4 sensing operations.

[12] An advantage of the disclosed embodiments is that the number of consecutive packet losses for V2X mode-4 transmissions might be decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

[13] For a more complete understanding of the present disclosure, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[14] Figure 1 is a diagram illustrating a mode-4 resource pool;

[15] Figure 2 is a diagram illustrating selected resources in resource intervals of a resource pool;

[16] Figure 3 is a diagram illustrating receiving UEs experiencing consecutive packet losses;

[17] Figure 4 is a diagram illustrating selected resources in two different resource intervals of a resource pool according to two embodiment independent resource selection processes;

[18] Figure 5 is a diagram illustrating two different selected resources in the same resource intervals of a resource pool according to two embodiment independent resource selection processes;

[19] Figure 6 is a flowchart illustrating an embodiment method for configuring a UE with a number of resource selection processes and for transmitting data according to the number of resource selection processes;

[20] Figure 7 illustrates the System Information Block 21;

[21] Figure 8 is a flowchart illustrating an embodiment method for sensing and selecting resources and for transmitting data for a single resource selection process;

[22] Figure 9 is a flowchart illustrating an embodiment method for resource selection;

[23] Figure 10 shows an exemplary embodiment of a processing system; and

[24] Figure 11 shows an exemplary embodiment of a transceiver.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[25] Transmission mode-4 provides an autonomous resource selection process, wherein a UE autonomously selects time/frequency transmission resources from a V2X sidelink

transmission resource pool to transmit a V2V or V2X message. While the embodiments disclosed herein are described with respect to LTE-based V2V/V2X transmission systems, the embodiments might also apply to NR-based V2V/V2X systems where UEs autonomously select resources using a resource selection process similar to mode-4, with a sensing phase. The embodiments might also apply when LTE V2V/V2X and NR V2V/V2X (and/or possibly another system) share the same band.

[26] Figure 1 illustrates an embodiment of a resource pool 110 with respect to a cell 120 of a base station, such as an eNB 130, and a UE 140. The resource pool 110 might be available for in-coverage UEs (i.e., UEs covered by the cell 120) and out-of-coverage UEs (i.e., UEs not covered by the cell 120). The resource pool 110 might be provided by the network through the eNB 130 (for in-coverage UEs) or by preconfiguration (for out-of-coverage UEs). The resource pool 110 might be available for idle UEs (RRC_IDLE) or for connected UEs (RRC_CONNECTED). If a mapping between the zones in the cell 120 and the V2X sidelink transmission resource pool 110 is configured, the UE 140 might select from the V2X sidelink resource pool 110 based on the zone where the UE 140 is located.

[27] UEs, such as UEs in V2X vehicles, may be synchronized such that the UEs are able to sense and reserve periodic time/frequency resources in the sidelink transmission resource pool for V2X traffic. That is, a UE might observe data traffic in a cell and determine which resources in the resource pool are occupied and which resources are available. Such a procedure might be referred to as sensing. After performing a sensing operation, the UE might select available resources in the resource pool for its data transmissions.

[28] However, it might happen that two UEs perform a sensing operation at approximately the same time, discover at approximately the same time that the same resources are available, and select those same resources at approximately the same time for their data transmissions. In such a case, the UEs will collide until one of the two UEs reselects the resources or until the distance between the two UEs is sufficiently large. Such processes might take several seconds. If the UEs broadcast data under mode-4 transmission, there is no feedback, and the transmitting UEs are not aware of the collisions. Given that resource reselection is a relatively rare occurrence, a receiving UE might be prevented from receiving data packets from one or more transmitting UEs for a large number of transmissions of consecutive data packets, as illustrated in Figure 2.

[29] In Figure 2, data is semi-persistently transmitted on a resource 210 in a plurality of intervals 220. The length of a resource interval 220 typically is 100 milliseconds (ms) but might

be different. In this example, collisions occur in the first six intervals 220a-220f, and thus transmission failures occur in those intervals 220a-220f. (The failures are marked with exclamation marks in Figure 2.) That is, as described above, if a transmission by a UE on a resource collides with a transmission by another UE, a receiving UE is not able to receive data from the transmitting UEs. The selected resource 210 remains the same until a reselection 230 is triggered and another resource 240 is selected. The reselection 230 is a procedure whereby a UE occasionally chooses a different set of transmission resources to introduce randomness and adaptation to a changing environment. Reselection might be automatically triggered after a defined length of time or after a defined number of transmissions. After the reselection 230, the transmitting UE is able to transmit its data via the reselected resources 240, and the receiving UE might be able to receive the data because no other UE is transmitting data on those resources. (Successful transmission is marked with check marks in Figure 2.)

[30] In an exemplary case, the fraction of receiving UEs experiencing n consecutive packet losses is shown in the diagram 300 of Figure 3. As is apparent, the fraction of receiving UEs experiencing consecutive packet losses is significant. For instance, more than 2% of vehicles experience at least 10 consecutive packet losses. It is noted that, depending on parameters, the proportion of UEs experiencing consecutive packet losses can be much larger (e.g., for shorter interval periodicities, e.g., 20 ms). The number of consecutive packet losses might be too large for the advanced connected vehicle services being considered for 5th Generation (5G) systems. Therefore, there is a need for a solution to lower the number of consecutive packet losses for V2X mode-4.

[31] Embodiments of the present disclosure provide at least one solution to this need. In an embodiment, a UE concurrently performs at least two independent mode-4 resource selection procedures, S_1 and S_2 . The UE might select resources according to a resource selection procedure S_1 on odd subframes, and the UE might select resources according to a resource selection procedure S_2 on even subframes. The resource selection procedures S_1 and S_2 run independently (except for some possible rules to prevent self-collision, such as preventing the resource selection procedures S_1 and S_2 from selecting resources on the same subframe). That is, the resources selected by the S_1 and S_2 procedures are different from one another, and the resource reselection times may be different.

[32] By using two independent sensing and selection procedures or methods, “resource selection diversity” can be achieved. If the probability of two UEs colliding on a given resource

interval is $1/N$, the probability of two UEs colliding for two consecutive transmissions is $1/N^2$ for the same two UEs.

[33] Embodiments of sensing and selection methods are shown in Figures 4 and 5. The embodiment of Figure 4 shows eight resource intervals 411-418. A first transmitting UE selects, according to a first selection procedure S_1 , resources 421, 423 in odd resource intervals 411, 413 and transmits data on those resources 421, 423. In this example, the selected resources 421, 423 are also selected, by coincidence, by a second transmitting UE that also attempts to transmit its data on those resources 421, 423. Because of this collision, a receiving UE will not receive any data from the transmitting UEs. (The failure is marked with exclamation marks in Figure 4.) However, the first transmitting UE has also selected, according to a second selection procedure S_2 , resources 422, 424 in even resource intervals 412, 414 and transmits the same data on those resources 422, 424 that was transmitted in resources 421, 423. In this example, the selected resources 422, 424 are not selected by the second transmitting UE to transmit its data, so the receiving UE receives the data from the first transmitting UE on resources 422, 424. (Successful transmission is marked with check marks in Figure 4.) It should be understood that terms such as “first” and “second” are used herein to differentiate UEs from one another and do not imply any sort of sequence.

[34] Assuming that the data blocks allocated to the resources 421-424 are consecutive data blocks, the receiving UE at least receives every other data block. Moreover, as can be seen from Figure 4, after reselection 430 in the first selection procedure S_1 , the data blocks are transmitted on the resources 425-427 of the odd and the even resource intervals 415-417. After reselection 440 in the second selection procedure S_2 , the data blocks on the resource 428 of the even interval 418 cannot reach the receiving UE, but the data blocks on the resources 425, 427 of the odd resource intervals 415, 417 can still be received by the receiving UE. It may be noted that the same data is transmitted on different resources, such as on resource 421 and resource 422, before any reselection operation 430 or 440 is performed.

[35] The length of the resource interval may be 100 ms as indicated in Figure 4. Alternatively, the length can be 20 ms, 50 ms, or a multiple of 100 ms, such as 200 ms or 300 ms up to 1 second (s) or 1.5 s. Alternatively, the lengths can be equal to or longer than 20 ms, 50 ms or 100 ms or equal to or shorter than 500 ms, 1 s or 1.5 s.

[36] In various embodiments, the selection procedure S can be extended to k independent sensing and selection procedures S_1 - S_k with each procedure independently sensing and selecting one or more resources in a resource interval and eventually allocating data blocks to the

resources in that resource interval. The periodicity for the k procedures is k . That is, every k resource interval, the same resource is selected, and a data block is allocated until reselection for the resource interval.

[37] In various other embodiments, the different and independent sensing and resource selection procedures S_1 - S_k could be performed during the same resource interval. This is shown in the embodiment of Figure 5. For example, resources 431 are selected according to a first selection procedure, and resources 433 are selected according to a second selection procedure. The transmissions on the two resources in the same resource interval can be the same data packet and can correspond to different Hybrid Automatic Repeat Request (HARQ) transmissions. Alternatively, the transmissions on the two resources can be different data packets, such as consecutive data packets.

[38] In various embodiments, the reselections of the resources of the first and second resource selection procedures S_1 and S_2 may be triggered at different times. In various other embodiments, the reselections may be triggered at the same time. In other embodiments, for more than two independent resource selection procedures, some of the procedures trigger the reselection at different times while others trigger the reselection at the same time.

[39] In yet other embodiments, the sensing and resource selection procedures can be performed as a combination of the embodiments of Figures 4 and 5.

[40] Figure 6 shows an embodiment method 600 for configuring a UE with a number of resource selection processes and for transmitting data according to at least a subset of the number of resource selection processes. At step 610, a resource selection configuration is provided for a transmitting UE. The UE may provide or obtain a resource selection configuration. This can be done in several ways.

[41] In one option, the UE obtains a number of resource selection processes through a broadcast message from the network, e.g., via the base station or eNB. For instance, the number of resource selection processes may be broadcast in the System Information Block 21 (SIB21), as shown in the text box 700 of Figure 7. Alternatively, the number of resource selection processes may be broadcast in an equivalent message, such as in a maximum number of resource selection processes field, *maxNumberResourceProcesses*, or a similar message or field.

[42] In another option, the UE obtains the number of resource selection processes through a dedicated message from the network, base station or eNB, either as a dedicated Radio

Resource Control (RRC) message (with a message format similar to the previous option) or as a physical layer message, such as in Downlink Control Information (DCI).

[43] In another option, the UE is preconfigured with a given number of resource selection processes.

[44] In another option, the UE autonomously selects the number of resource selection processes.

[45] The number of resource selection processes may be service-dependent. For instance, for basic V2X safety features, the number of resource selection processes may be one, whereas for platooning services, the number of resource selection processes might be two, three, five, or more. The number of resource selection processes may depend on quality of service (QoS) requirements, reliability requirements, etc.

[46] In an embodiment, a UE may be initialized or configured with the different resource selection processes before an actual transmission can occur. For example, the UE may perform initial resource sensing (for 1 s in V2X Rel-14) and map resource intervals that need to be excluded. The initializing and configuration can be done any time before data is transmitted.

[47] Returning to Figure 6, at optional step 620, the configuration may be indicated to other network devices. In some cases, an eNB might inform a UE of the selection processes the UE is to use. In some cases, a UE might use control signaling to inform other UEs of the selection processes the UE is using. In various embodiments, there are benefits in having the UE indicate the number of resource selection processes the UE uses and which resource selection is currently used. This can be done in several ways. For example, a new message may be defined to convey this information to other UEs. In other examples, one or more new fields may be added in a Sidelink Control Information (SCI) message. For instance, an index may be associated with each resource selection process. When a transmission occurs for a given resource selection process, the UE may add the corresponding index in the SCI associated with the data transmission.

[48] At step 630, the resource selection procedures are mapped to the resource intervals. The UE may use different resource selection processes for the same or for different consecutive data packet transmissions. Different packet transmissions may be mapped to different resource intervals. For instance, if the transmission periodicity is 100 ms, the UE may use two resource selection processes, S_1 and S_2 , each with a 200 ms periodicity and intertwined as shown in Figure 4. Odd resource intervals may be allocated to the resource selection procedure S_1 , and

even resource intervals may be allocated to the resource selection procedure S_2 . Alternatively, each transmission may be allocated two HARQ transmissions in the same resource interval, the first transmission using resources selected in S_1 and the second transmission using resources selected in S_2 . This alternative is shown in Figure 5.

[49] At step 640, the UE transmits data on the resources that were determined by the resource selection and allocation processes. This step includes transmitting the actual data block on the physical sidelink shared channel (PSSCH) and transmitting the associated Scheduling Assignment (SA), if any, on the physical sidelink control channel (PSCCH). Each sensing and selecting procedure may be performed as described with respect to Figure 8.

[50] Figure 8 shows a method for sensing and selecting resources and for transmitting data in a single resource selection process 800, such as the selection procedures S_1 and S_2 described above. In an embodiment, a UE might perform two or more of these resource sensing and selection processes 800 independently and concurrently. Each process 800 might include sensing available resources in a resource pool, selecting and reserving a resource, and transmitting a data block on the selected resource. Alternatively, the sensing procedure of a UE might include the UE sensing the medium for a given duration (about 1 s in Rel-14), the UE identifying and marking some resources as free, and the UE selecting one resource and using the selected resource until reselection is triggered.

[51] At step 810, the UE decodes other UEs' SA and measures the corresponding PSSCH energy. At step 820, the UE collects sensing information of other UEs' resource occupancy by collecting PSSCH energy measurements. At step 830, the UE excludes high energy resources and forms a candidate resource set comprising low energy resources. At step 840, the UE selects a resource for transmitting a data block from the candidate resource set and transmits data blocks semi-persistently on that resource block. At decision block 850, the UE evaluates whether to trigger resource reselection. If no reselection is necessary or desired, the UE continues to transmit data blocks on the selected resource, and the process moves back to step 840. If resource reselection is necessary or desired, a reselection process is triggered, and the process moves back to step 820 in order to determine a new resource to be selected in the resource pool.

[52] Figure 9 is a flowchart illustrating an embodiment method 900 for sensing and selecting resources and for transmitting data on the selected resources. At block 910, a UE performs a first sensing operation to determine available resources in a resource pool. At block 920, the UE selects a first set of available resources from the resource pool in accordance with

the first sensing operation. At block 930, concurrently with the first sensing operation and resource selection of the first set of available resources and independently from the first sensing operation, the UE performs a second sensing operation to determine other available resources in the resource pool. At block 940, the UE selects a second set of available resources from the resource pool in accordance with the second sensing operation. At block 950, the UE transmits first data using the first set of available resources. At block 960, the UE transmits second data using the second set of available resources. The first data and the second data might be the same data. Alternatively or additionally, the first data and the second data might be two consecutive data packets. The UE might use the first set of available resources and the second set of available resources in alternating time intervals, as in Figure 4. Alternatively, the UE might use the first set of available resources and the second set of available resources in the same time interval, as in Figure 5.

[53] Figure 10 is a block diagram illustrating an embodiment processing system 1000 for performing methods described herein, which may be installed in a host device. As shown, the processing system 1000 includes a processor 1004, a memory 1006, and interfaces 1010-1014, which may (or may not) be arranged as shown in the figure. The processor 1004 may be any component or collection of components adapted to perform computations and/or other processing related tasks, and the memory 1006 may be any component or collection of components adapted to store programming and/or instructions for execution by the processor 1004. In an embodiment, the memory 1006 includes a non-transitory computer readable medium. The interfaces 1010, 1012, 1014 may be any component or collection of components that allow the processing system 1000 to communicate with other devices/components and/or a user. For example, one or more of the interfaces 1010, 1012, 1014 may be adapted to communicate data, control, or management messages from the processor 1004 to applications installed on the host device and/or a remote device. As another example, one or more of the interfaces 1010, 1012, 1014 may be adapted to allow a user or user device (e.g., personal computer (PC), etc.) to interact/communicate with the processing system 1000. The processing system 1000 may include additional components not depicted in the figure, such as long term storage (e.g., non-volatile memory, etc.).

[54] In some embodiments, the processing system 1000 is included in a network device that is accessing, or part otherwise of, a telecommunications network. In one example, the processing system 1000 is in a network-side device in a wireless or wireline telecommunications network, such as a base station, a relay station, a scheduler, a controller, a gateway, a router, an

applications server, or any other device in the telecommunications network. In other embodiments, the processing system 1000 is in a user-side device accessing a wireless or wireline telecommunications network, such as a mobile station, a user equipment (UE), a personal computer (PC), a tablet, a wearable communications device (e.g., a smartwatch, etc.), or any other device adapted to access a telecommunications network.

[55] In some embodiments, one or more of the interfaces 1010, 1012, 1014 connects the processing system 1000 to a transceiver adapted to transmit and receive signaling over the telecommunications network. Figure 11 is a block diagram illustrating a transceiver 1100 adapted to transmit and receive signaling over a telecommunications network. The transceiver 1100 may be installed in a host device. As shown, the transceiver 1100 comprises a network-side interface 1102, a coupler 1104, a transmitter 1106, a receiver 1108, a signal processor 1110, and a device-side interface 1112. The network-side interface 1102 may include any component or collection of components adapted to transmit or receive signaling over a wireless or wireline telecommunications network. The coupler 1104 may include any component or collection of components adapted to facilitate bi-directional communication over the network-side interface 1102. The transmitter 1106 may include any component or collection of components (e.g., up-converter, power amplifier, etc.) adapted to convert a baseband signal into a modulated carrier signal suitable for transmission over the network-side interface 1102. The receiver 1108 may include any component or collection of components (e.g., down-converter, low noise amplifier, etc.) adapted to convert a carrier signal received over the network-side interface 1102 into a baseband signal. The signal processor 1110 may include any component or collection of components adapted to convert a baseband signal into a data signal suitable for communication over the device-side interface(s) 1112, or vice-versa. The device-side interface(s) 1112 may include any component or collection of components adapted to communicate data-signals between the signal processor 1110 and components within the host device (e.g., the processing system 1000, local area network (LAN) ports, etc.).

[56] The transceiver 1100 may transmit and receive signaling over any type of communications medium. In some embodiments, the transceiver 1100 transmits and receives signaling over a wireless medium. For example, the transceiver 1100 may be a wireless transceiver adapted to communicate in accordance with a wireless telecommunications protocol, such as a cellular protocol (e.g., long-term evolution (LTE), etc.), a wireless local area network (WLAN) protocol (e.g., Wi-Fi, etc.), or any other type of wireless protocol (e.g., Bluetooth, near field communication (NFC), etc.). In such embodiments, the network-side interface 1102 comprises one or more antenna/radiating elements. For example, the network-side interface

1102 may include a single antenna, multiple separate antennas, or a multi-antenna array configured for multi-layer communication, e.g., single input multiple output (SIMO), multiple input single output (MISO), multiple input multiple output (MIMO), etc. In other embodiments, the transceiver 1100 transmits and receives signaling over a wireline medium, e.g., twisted-pair cable, coaxial cable, optical fiber, etc. Specific processing systems and/or transceivers may utilize all of the components shown, or only a subset of the components, and levels of integration may vary from device to device.

[57] At the receiving end, the receiving UE may operate as currently known. In an embodiment, the UE may receive the resource selection process index in the SCI as described above. This may need a new SCI format. Alternatively, some of the currently reserved bits of SCI format 1 may be used to indicate the resource selection process index, and/or the maximum number of resource selection processes. A receiving UE may benefit from decoding this information.

[58] At the network, base station or eNB, depending on the embodiment, some changes may be needed. In an embodiment, if the number or maximum number of resource selection processes is broadcast by the network, base station or eNB, a new field may be needed in SIB21 or a similar message. If dedicated RRC signaling is used, a new information element, or a new field in an information element may be needed. Alternatively, if the resource selection process management is fully under the control of the transmitting UE, no change at the network, base station or eNB is needed.

[59] While this disclosure has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of the disclosure, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

[60] For example, in one embodiment a user equipment (UE) is disclosed that includes a transmitter means configured to transmit first data using a first set of available resources, the first set of available resources having been selected from a resource pool in accordance with a first sensing operation performed by the UE to determine available resources in the resource pool, the transmitter further configured to transmit second data using a second set of available resources, the second set of available resources having been selected from the resource pool in accordance with a second sensing operation performed by the UE, concurrently with the first sensing operation and resource selection of the first set of available resources and independently

from the first sensing operation, to determine other available resources in the resource pool, wherein the first set of available resources and the second set of available resources are independently selected.

WHAT IS CLAIMED IS:

1. A method for resource selection, the method comprising:
 - performing, by a user equipment (UE), a first sensing operation to determine available resources in a resource pool;
 - transmitting, by the UE, first data using a first set of available resources, the first set of available resources having been selected from the resource pool in accordance with the first sensing operation;
 - performing, by the UE, concurrently with the first sensing operation and resource selection of the first set of available resources and independently from the first sensing operation, a second sensing operation to determine other available resources in the resource pool; and
 - transmitting, by the UE, second data using a second set of available resources, the second set of available resources having been selected from the resource pool in accordance with the second sensing operation, wherein the first set of available resources and the second set of available resources are independently selected.
2. The method according to claim 1, wherein the first data and the second data are the same data.
3. The method according to claim 1 or claim 2, wherein the first data and the second data are two consecutive data packets.
4. The method according to any of claims 1-3, wherein the first set of available resources and the second set of available resources are selected on different subframes.
5. The method according to any of claims 1-4, wherein the first set of available resources are used in odd resource intervals and the second set of available resources are used in even resource intervals.
6. The method according to any of claims 1-5, wherein the first set of available resources and the second set of available resources are used in the same resource interval.
7. The method according to any of claims 1-6, wherein selection of the first set of available resources and selection of the second set of available resources are performed before a reselection of resources.

8. The method according to claim 7, wherein resource reselections for the first set of available resources and the second set of available resources occur at different times.
9. The method according to claim 1, wherein the first set of available resources and the second set of available resources are in consecutive data blocks.
10. The method according to claim 1, further comprising:
 - performing, by the UE, concurrently with the first sensing operation and the second sensing operation and independently from the first sensing operation and the second sensing operation, a third sensing operation to determine additional other available resources in the resource pool; and
 - transmitting, by the UE, third data using a third set of available resources, the third set of available resources having been selected from the resource pool in accordance with the third sensing operation.
11. The method according to claim 1, wherein the first sensing operation and the second sensing operation comprise sidelink mode-4 sensing operations.
12. A user equipment (UE) comprising:
 - a transmitter configured to transmit first data using a first set of available resources, the first set of available resources having been selected from a resource pool in accordance with a first sensing operation performed by the UE to determine available resources in the resource pool, the transmitter further configured to transmit second data using a second set of available resources, the second set of available resources having been selected from the resource pool in accordance with a second sensing operation performed by the UE, concurrently with the first sensing operation and resource selection of the first set of available resources and independently from the first sensing operation, to determine other available resources in the resource pool, wherein the first set of available resources and the second set of available resources are independently selected.
13. The UE according to claim 12, wherein the first data and the second data are the same data.
14. The UE according to claim 12 or claim 13, wherein the first data and the second data are two consecutive data packets.

15. The UE according to any of claims 12-14, wherein the first set of available resources and the second set of available resources are selected on different subframes.
16. The UE according to any of claims 12-15, wherein the first set of available resources are used in odd resource intervals and the second set of available resources are used in even resource intervals.
17. The UE according to any of claims 12-16, wherein the first set of available resources and the second set of available resources are used in the same resource interval.
18. The UE according to any of claims 12-17, wherein selection of the first set of available resources and selection of the second set of available resources are performed before a reselection of resources.
19. The UE according to any of claims 12-18, wherein resource reselections for the first set of available resources and the second set of available resources occur at different times.
20. The UE according to any of claims 12-19, wherein the first set of available resources and the second set of available resources are in consecutive data blocks.
21. The UE according to claim 12, wherein the transmitter is configured to transmit third data using a third set of available resources, the third set of available resources having been selected from the resource pool in accordance with a third sensing operation performed, concurrently with the first sensing operation and the second sensing operation and independently from the first sensing operation and the second sensing operation, to determine additional other available resources in the resource pool.
22. The UE according to claim 12, wherein the first sensing operation and the second sensing operation comprise sidelink mode-4 sensing operations.

23. A device comprising:
a non-transitory memory storage comprising instructions; and
one or more processors in communication with the memory storage, wherein the one or more processors execute the instructions to:
transmit first data using a first set of available resources, the first set of available resources having been selected from a resource pool in accordance with a first sensing operation performed by the device to determine available resources in the resource pool; and
transmit second data using a second set of available resources, the second set of available resources having been selected from the resource pool in accordance with a second sensing operation performed by the device, concurrently with the first sensing operation and resource selection of the first set of available resources and independently from the first sensing operation, to determine other available resources in the resource pool, wherein the first set of available resources and the second set of available resources are independently selected.
24. The device according to claim 23, wherein the first data and the second data are the same data.
25. The device according to claim 23 of claim 24, wherein the first data and the second data are two consecutive data packets.
26. The device according to any of claims 23-25, wherein the first set of available resources and the second set of available resources are selected on different subframes.
27. The device according to any of claims 23-26, wherein the first set of available resources are used in odd resource intervals and the second set of available resources are used in even resource intervals.
28. The device according to any of claims 23-27, wherein the first set of available resources and the second set of available resources are used in the same resource interval.
29. The device according to any of claims 23-28, wherein selection of the first set of available resources and selection of the second set of available resources are performed before a reselection of resources.
30. The device according to claim 29, wherein resource reselections for the first set of available resources and the second set of available resources occur at different times.

31. The device according to claim 23, wherein the first set of available resources and the second set of available resources are in consecutive data blocks.
32. The device according to claim 23, wherein the one or more processors further execute the instructions to:
- perform, concurrently with the first sensing operation and the second sensing operation and independently from the first sensing operation and the second sensing operation, a third sensing operation to determine additional other available resources in the resource pool; and
 - transmit third data using a third set of available resources, the third set of available resources having been selected from the resource pool in accordance with the third sensing operation.
33. The device according to claim 23, wherein the first sensing operation and the second sensing operation comprise sidelink mode-4 sensing operations.

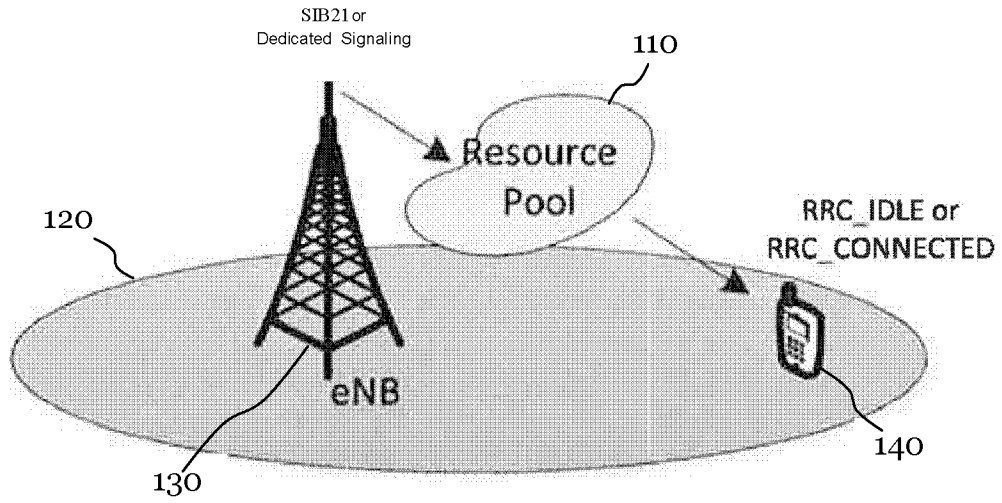


Figure 1

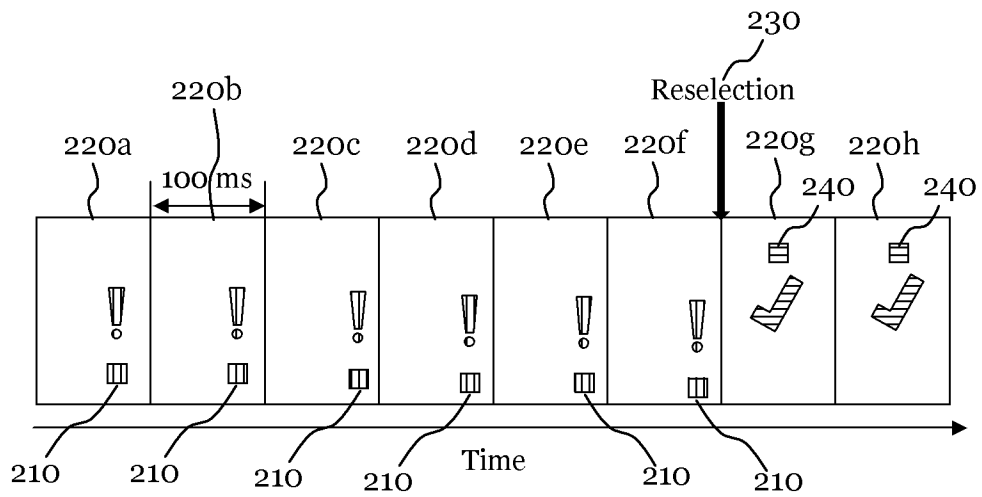


Figure 2

300

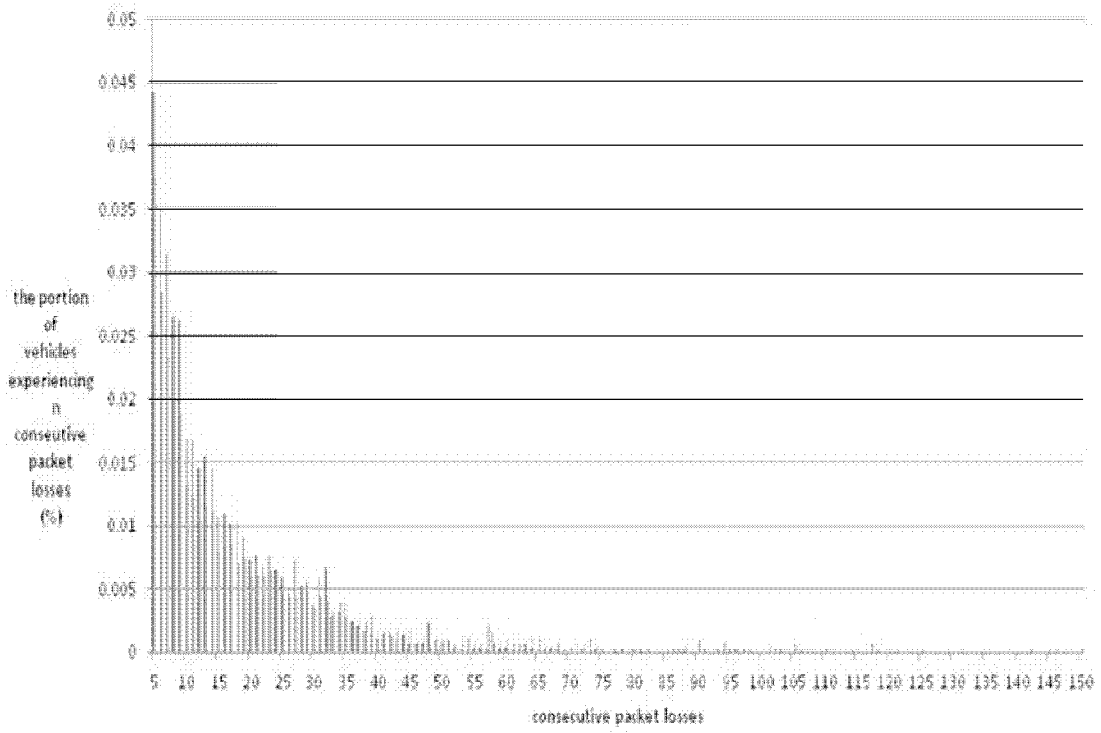


Figure 3

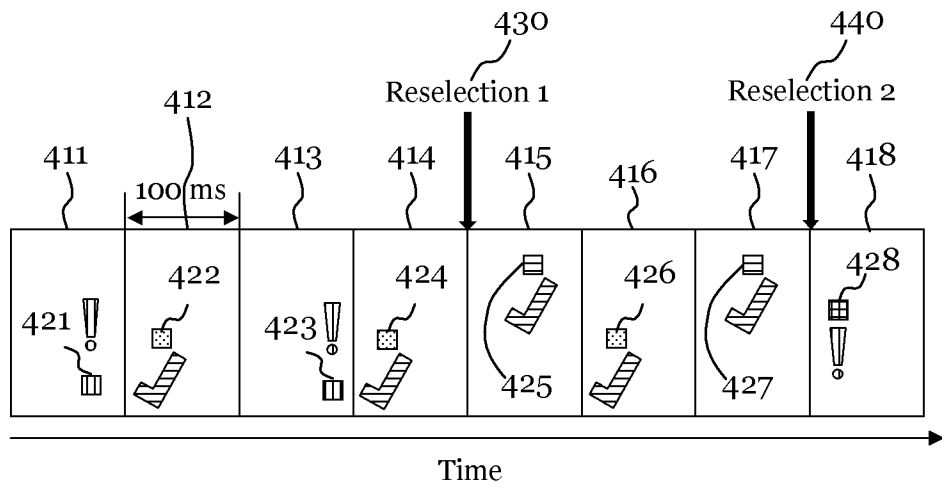


Figure 4

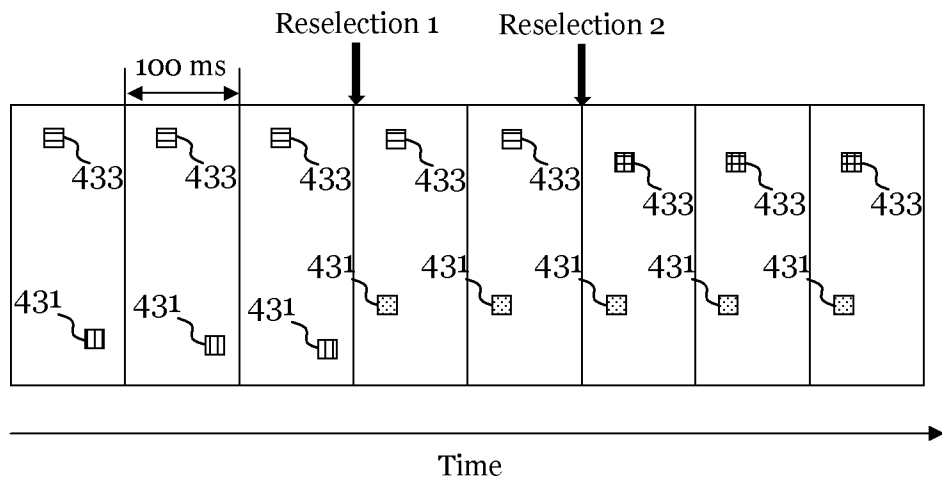


Figure 5

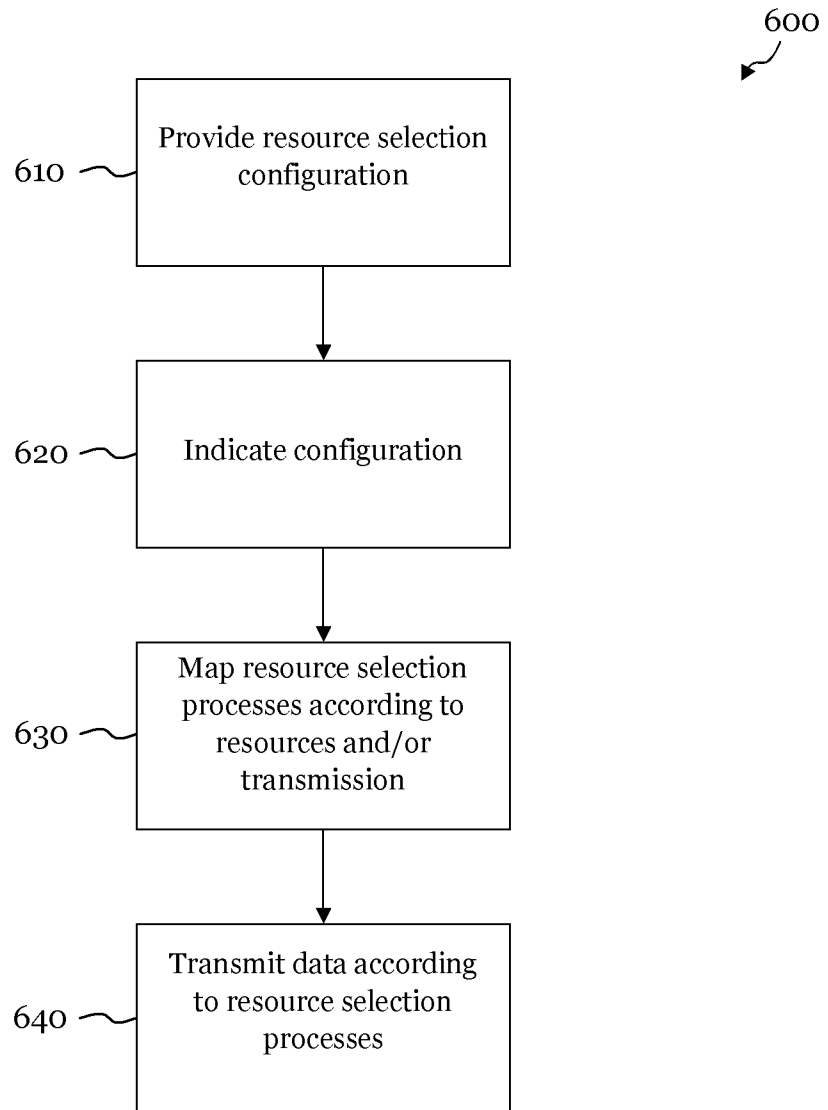


Figure 6

```

-- ASN1START
SystemInformationBlockType21-r14 ::= SEQUENCE {
    sl-V2X-ConfigCommon-r14          SL-V2X-ConfigCommon-r14          OPTIONAL,  -- Need OR
    lateNonCriticalExtension         OCTET STRING                OPTIONAL,
    ...
}

SL-V2X-ConfigCommon-r14 ::= SEQUENCE {
    v2x-CommRxPool-r14              SL-CommRxPoolListV2X-r14          OPTIONAL,  --
Need OR
    v2x-CommTxPoolNormalCommon-r14  SL-CommTxPoolListV2X-r14          OPTIONAL,  --
Need OR
    v2x-CommTxPoolExceptional-r14   SL-CommResourcePoolV2X-r14       OPTIONAL,  --
Need OR
    v2x-SyncConfig-r14              SL-SyncConfigListV2X-r14         OPTIONAL,  --
Need OR
    v2x-InterFreqInfoList-r14       SL-InterFreqInfoListV2X-r14     OPTIONAL,  --
Need OR
    v2x-ResourceSelectionConfig-r14  SL-CommTxPoolSensingConfig-r14   OPTIONAL,
    -- Need OR
    zoneConfig-r14                  SL-ZoneConfig-r14                OPTIONAL,  --
Need OR
}

SL-CommTxPoolSensingConfig-r14 ::= SEQUENCE {
    pssch-TxConfigList-r14          SL-PSSCH-TxConfigList-r14,
    thresPSSCH-RSRP-List-r14       SL-ThresPSSCH-RSRP-List-r14,
    restrictResourceReservationPeriod-r14  BIT STRING (SIZE (10)),
    probResourceKeep-r14            ENUMERATED {v0, v0dot2, v0dot4, v0dot6, v0dot8,
                                                spare3, spare2, spare1}
}

S1-XXXXX-R15
-- ASN1STOP

```

700 

Figure 7

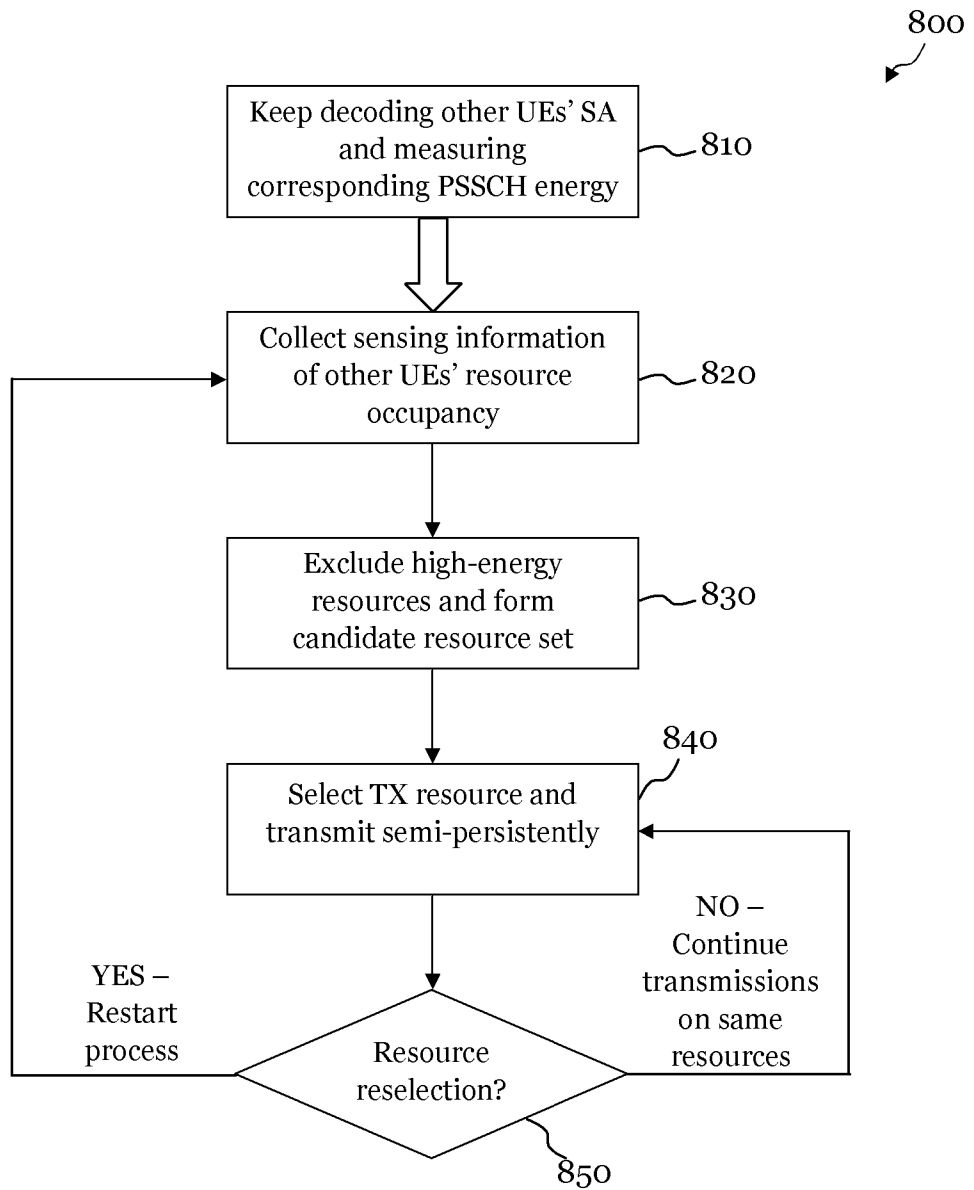


Figure 8

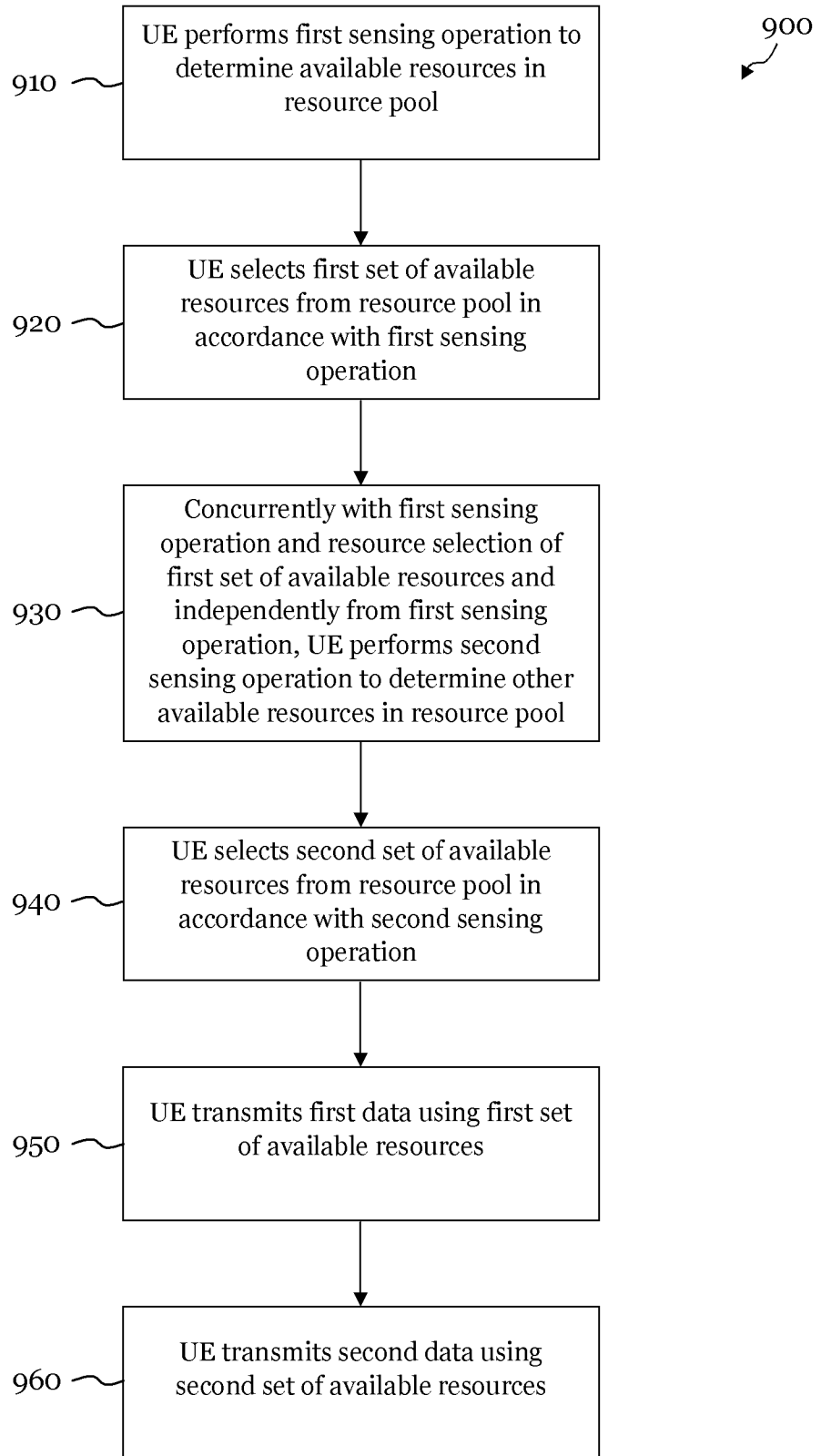


Figure 9

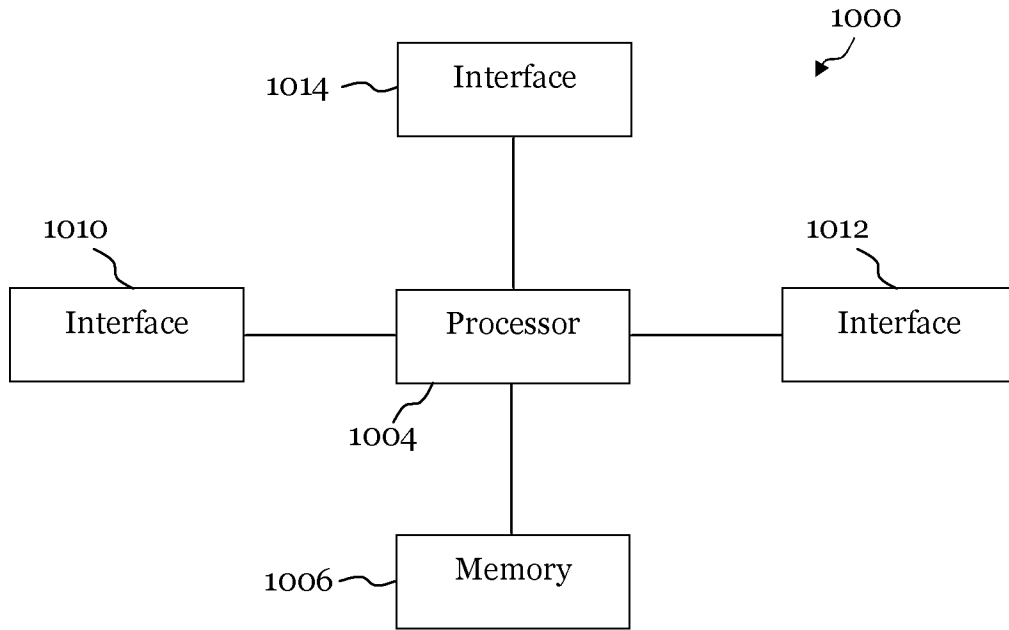


Figure 10

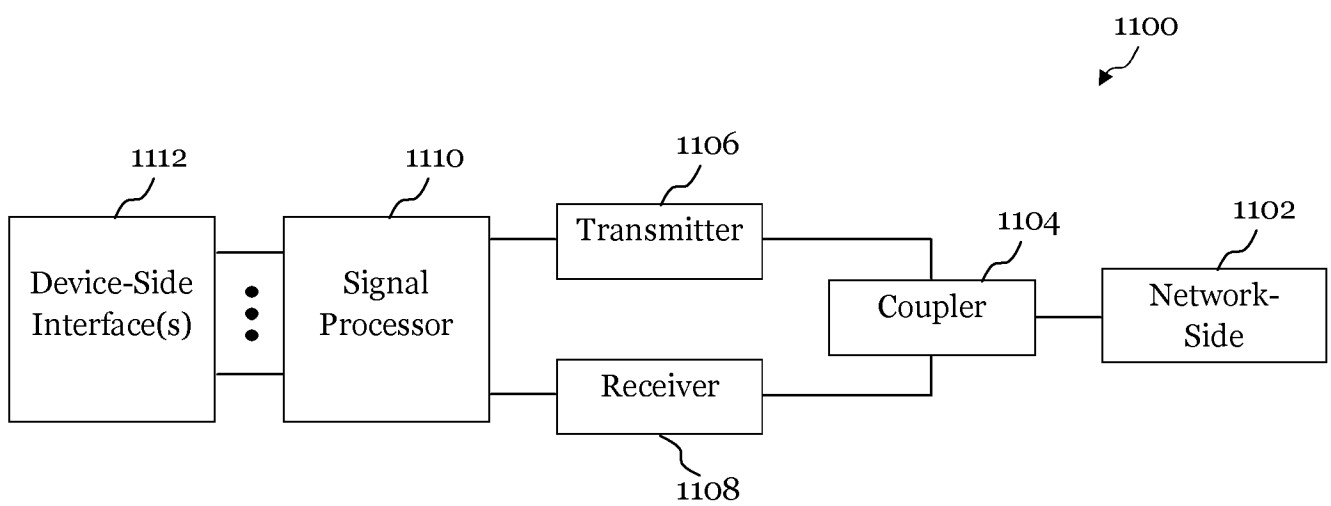


Figure 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2018/078725

A. CLASSIFICATION OF SUBJECT MATTER		
H04W 72/04(2009.01)i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
H04W; H04B; H04Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
WPI; EPODOC; CNKI; CNPAT: vehicle, resource, allocat+, select, request, determine, pool, sense, available, set, independent, transmit, data, packet, consecutive		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 105657842 A (YULONG COMPUTER TELECOMMUNICATION SCIENTIFIC SHENZHEN CO., LTD.) 08 June 2016 (2016-06-08) description, paragraphs [0050]-[0064]	1-33
A	CN 104080176 A (PEKING UNIVERSITY) 01 October 2014 (2014-10-01) the whole document	1-33
A	CN 106028386 A (YULONG COMPUTER TELECOMMUNICATION SCIENTIFIC SHENZHEN CO., LTD.) 12 October 2016 (2016-10-12) the whole document	1-33
A	CN 106257958 A (BEIJING ZHIGU RUITUO TECHNOLOGY SERVICES CO., LTD.) 28 December 2016 (2016-12-28) the whole document	1-33
A	WO 2017008227 A1 (NOKIA SOLUTIONS & NETWORKS OY) 19 January 2017 (2017-01-19) the whole document	1-33
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
"A" document defining the general state of the art which is not considered to be of particular relevance		
"E" earlier application or patent but published on or after the international filing date		
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"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search	Date of mailing of the international search report	
16 May 2018	30 May 2018	
Name and mailing address of the ISA/CN	Authorized officer	
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088 China	XU,Quan	
Facsimile No. (86-10)62019451	Telephone No. 86-(010)-53961794	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2018/078725

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	105657842	A	08 June 2016	WO	2017121123	A1	20 July 2017
CN	104080176	A	01 October 2014	None			
CN	106028386	A	12 October 2016	WO	2017193552	A1	16 November 2017
CN	106257958	A	28 December 2016	US	2017006594	A1	05 January 2017
WO	2017008227	A1	19 January 2017	CN	107852232	A	27 March 2018