(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 July 2018 (26.07.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/133032 A1

(51) International Patent Classification:
H04W 72/12 (2009.01) *H04L 1/18* (2006.01)

(21) International Application Number:
PCT/CN2017/071925

(22) International Filing Date:
20 January 2017 (20.01.2017)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: METHOD AND APPARATUS FOR DATA TRANSMISSION AND RECEPTION IN A WIRELESS COMMUNICATION SYSTEM

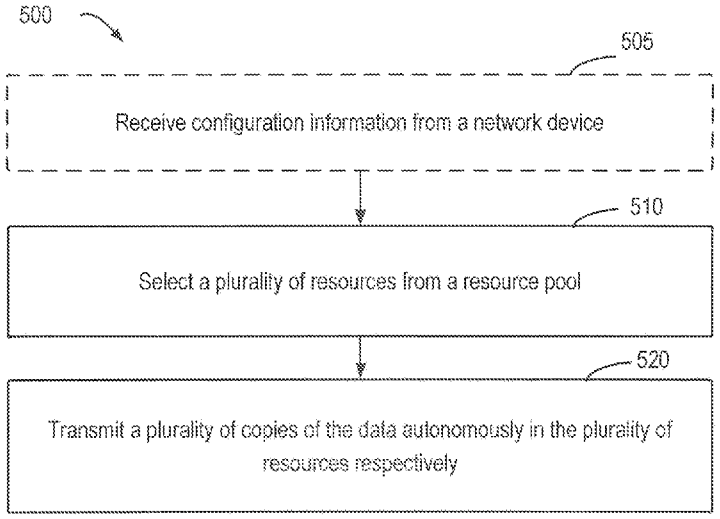

FIG. 5A

(57) Abstract: Embodiments of the present disclosure provide methods, apparatuses and computer program for data transmission and reception in a wireless communication system. A method implemented in a terminal device comprises: selecting a plurality of resources from a resource pool; and transmitting a plurality of copies of the data autonomously in the plurality of resources respectively; wherein transmitting a copy of the plurality of copies of the data comprises: transmitting control information together with the copy of the data, the control information including assistance information for detecting another copy of the plurality of copies. Embodiments of the present disclosure may decrease probability of collision between transmission of different users and increase the reliability of data detection.

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TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

METHOD AND APPARATUS FOR DATA TRANSMISSION AND RECEPTION IN A WIRELESS COMMUNICATION SYSTEM

TECHNICAL FIELD

[0001] The non-limiting and example embodiments of the present disclosure generally relate to a technical field of wireless communication, and specifically to methods, apparatuses and computer programs for data transmission and reception in a wireless communication system.

BACKGROUND

[0002] This section introduces aspects that may facilitate a better understanding of the disclosure. Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

[0003] Currently a new fifth generation (5G) wireless communication technique is being studied in the third generation partnership project (3GPP). According to a standpoint of the International Telecommunication Union (ITU), there are three typical application scenarios in a 5G wireless communication system. The first one is enhanced mobile broadband (eMBB) communication, which requires a peak rate up to 10Gbps for intelligent end users in order to support virtual reality, live video broadcasting and sharing, cloud access at anytime and anywhere, and other applications. The second one is massive machine type communication (mMTC), which supports a high density of human and things in the wireless communication system, for example, human and things connected to a 5G network may reach 1 million per square kilometer. The third scenario is ultra-reliable low-latency communications (URLLC), which requires that latency of a 5G network should be limited to one millisecond at the most so that applications with a low latency requirement, such as intelligent manufacturing, remote mechanical control, assisted driving and automatic driving, can be supported.

[0004] To meet performance requirements of some applications to be supported in a 5G network, schemes for data transmission and reception have to be improved.

SUMMARY

[0005] Some applications to be supported in a 5G network require low latency which may not be ensured by using conventional technologies. For example, uplink transmissions in a legacy Long Term Evolution (LTE) system are grant-based; that is to say, a user equipment (UE) transmits data in uplink in response to a uplink grant received from a serving evolved NodeB (eNB). The uplink grant indicates uplink scheduling information such as physical resource block (PRB) allocation, modulation and coding schemes (MCS), power control for a physical uplink shared channel (PUSCH). The grant-based scheme enables the eNB to fully control uplink transmissions from UEs, and at the same time causes latency in uplink transmissions. In an application scenario requiring low latency, for example, a URLLC scenario in 5G, it is desired to transmit uplink data in a grant-free manner, which means that a UE may transmit uplink data autonomously without requiring a scheduling signaling from the eNB before the uplink transmission. In this way, data may be transmitted immediately in the earliest available time slot once they arrive, without waiting for a scheduling grant from the eNB.

[0006] Though a grant-free autonomous transmission can reduce latency, it may cause collision, because users have to determine resources for their uplink transmissions autonomously and multiple users may choose a same resource for their uplink transmissions. The collision results in performance degradation of uplink transmissions.

[0007] In order to solve at least part of the problems, methods, apparatuses and computer programs are provided in the present disclosure. It will be appreciated that embodiments of the present disclosure are not limited to a 5G system, but could be more widely applied to any wireless communication system where similar problems exist.

[0008] Various embodiments of the present disclosure mainly aim at providing methods, apparatuses and computer programs for data transmission and/or reception. Other features and advantages of embodiments of the present disclosure will be understood from the following description of specific embodiments when read in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of embodiments of the present disclosure.

[0009] In a first aspect of the disclosure, there is provided a method implemented in a terminal device. The method comprises: selecting a plurality of resources from a resource pool; and transmitting a plurality of copies of the data autonomously in the plurality of resources respectively; wherein transmitting a copy of the plurality of copies of the data

comprises: transmitting control information together with the copy of the data, the control information including assistance information for detecting a further copy of the plurality of copies.

[0010] In an embodiment, the assistance information for detecting a further copy of the plurality of copies may indicate a resource for detecting the further copy. In a further embodiment, the assistance information may indicate an offset of the resource for detecting the further copy relative to a resource for transmitting the copy of the plurality of copies.

[0011] In another embodiment, at least two copies of the plurality of copies may be associated with different transmission formats. In still another embodiment, the assistance information for detecting a further copy of the plurality of copies may indicate a transmission format associated with the further copy of the plurality of copies. In some embodiments, the transmission format includes at least one of: a redundant version; and a modulation and coding scheme.

[0012] In an embodiment, the plurality of resources are separated in at least one of: frequency domain, time domain, and code domain.

[0013] In another embodiment, the method may further comprise receiving configuration information from a network device, the configuration information including at least one of: configuration of the resource pool, a maximum number of resources to be selected from the resource pool for the data transmission, a number of resources to be selected from the resource pool for the data transmission, and wherein selecting a plurality of resources from a resource pool may comprise selecting the plurality of resources from the resource pool according to the configuration information.

[0014] In some embodiments, the terminal device may transmit control information together with the copy of the data by: transmitting the control information with a first transmission scheme, and transmitting the copy of the data with a second transmission scheme, wherein the first transmission scheme provides a lower error rate than the second transmission scheme.

[0015] In a second aspect of the disclosure, there is provided a method implemented at a receiving device which may be a network device or a terminal device. The method includes: receiving control information from a terminal device in a first resource of a resource pool, the control information including assistance information for detecting a first copy of data; receiving a second copy of the data transmitted together with the control information in the first resource; receiving the first copy of the data based on the assistance

information, in a second resource of the resource pool; and detecting the data by combining the first copy and the second copy of the data.

[0016] In an embodiment, the assistance information for detecting a first copy of the data may indicate the second resource. In a further embodiment, the assistance information may indicate an offset of the second resource relative to the first resource.

[0017] In another embodiment, the first copy and the second copy of the data may be associated with different transmission formats. In still another embodiment, the assistance information for detecting a first copy of the data may indicate a transmission format associated with the first copy of the data. In some embodiments, the transmission format may include at least one of: a redundant version and a modulation and coding scheme.

[0018] In an embodiment, the first resource and the second resource may be separated in at least one of: frequency domain, time domain, and code domain.

[0019] In some embodiments, the method may further comprise transmitting configuration information to the terminal device, and the configuration information may include at least one of: configuration of the resource pool, a maximum number of resources to be selected from the resource pool for the data transmission, and a number of resources to be selected from the resource pool for the data transmission.

[0020] In an embodiment, the control information may be associated with a first transmission scheme, the second copy of the data may be associated with a second transmission scheme, and the first transmission scheme may provide a lower error rate than the second transmission scheme.

[0021] In a third aspect of the disclosure, there is provided a terminal device. The terminal device may include a selecting unit configured to select a plurality of resources from a resource pool; and a transmitting unit configured to transmit a plurality of copies of the data autonomously in the plurality of resources respectively; wherein transmitting a copy of the plurality of copies of the data comprises: transmitting control information together with the copy of the data, the control information including assistance information for detecting a further copy of the plurality of copies.

[0022] In a fourth aspect of the disclosure, there is provided a receiving device which may be a network device or a terminal device. The receiving device includes a first receiving unit, configured to receive control information from a terminal device in a first resource of a resource pool, the control information including assistance information for detecting a first copy of data; a second receiving unit, configured to receive a second copy

of the data transmitted together with the control information in the first resource; a third receiving unit, configured to receive the first copy of the data based on the assistance information, in a second resource of the resource pool; and a detecting unit, configured to detect the data by combining the first copy and the second copy of the data.

[0023] In a fifth aspect of the disclosure, there is provided an apparatus which may be implemented as/in a terminal device. The apparatus includes a processor and a memory, said memory containing instructions executable by said processor, and said processor being configured to cause the network device to perform a method according the first aspect of the present disclosure.

[0024] In a sixth aspect of the disclosure, there is provided an apparatus which may be implemented as/in a network device or a terminal device. The apparatus includes a processor and a memory, said memory containing instructions executable by said processor and said processor being configured to cause the terminal device to perform a method according the second aspect of the present disclosure.

[0025] In a seventh aspect of the disclosure, there is provided a computer program, comprising instructions which, when executed on one or more processors, cause the one or more processors to carry out a method according to the first aspect of the present disclosure.

[0026] In an eighth aspect of the disclosure, there is provided a computer program, comprising instructions which, when executed on one or more processors, cause the one or more processors to carry out a method according to the second aspect of the present disclosure.

[0027] In a ninth aspect of the disclosure, there is provided an apparatus which may be implemented in/as a terminal device, the apparatus comprising processing means adapted to perform a method according the first aspect of the present disclosure.

[0028] In a tenth aspect of the disclosure, there is provided an apparatus which may be implemented in/as a network device or terminal device, the apparatus comprising processing means adapted to perform a method according the second aspect of the present disclosure.

[0029] According to the various aspects and embodiments as mentioned above, probability of collision between transmissions of different users may be reduced, and/or reliability of data detection may be increased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The above and other aspects, features, and benefits of various embodiments of the present disclosure will become more apparent from the following detailed description provided by way of example with reference to the accompanying drawings, in which like reference numerals or letters are used to designate like or equivalent elements. The drawings are illustrated for facilitating better understanding of the embodiments of the disclosure and not necessarily drawn to scale.

[0031] FIG. 1 illustrates an example wireless communication network in which embodiments of the present disclosure may be implemented;

[0032] FIG. 2 illustrates an example of grant-free transmission from an UE;

[0033] FIG. 3 illustrates an example procedure for grant-free transmission with resource selection;

[0034] FIG. 4 illustrates schematically collision between transmissions from two users;

[0035] FIGs. 5A-5B illustrate flowcharts of a method implemented at a terminal device according to an embodiment of the present disclosure;

[0036] FIG. 6 illustrate example of resource selection for transmitting a plurality of copies of data according to an embodiment of the present disclosure;

[0037] FIG. 7 illustrates a structure for transmitting a copy of data according to an embodiment of the present disclosure;

[0038] FIG. 8 illustrates an example of assistance information according to an embodiment of the present disclosure;

[0039] FIG. 9 illustrates schematically transmission from two users according to an embodiment of the present disclosure;

[0040] FIG. 10 illustrates a flowchart of a method implemented at a receiving device according to embodiments of the present disclosure;

[0041] FIG. 11 illustrates a schematic block diagram of an apparatus implemented as/in a terminal device according to an embodiment of the present disclosure;

[0042] FIG. 12 illustrates a schematic block diagram of an apparatus implemented as/in a receiving device according to an embodiment of the present disclosure; and

[0043] FIG. 13 illustrates a simplified block diagram of an apparatus that may be embodied as/in a network device, and an apparatus that may be embodied as/in a terminal device.

DETAILED DESCRIPTION

[0044] Hereinafter, the principle and spirit of the present disclosure will be described with reference to illustrative embodiments. It should be understood, all these embodiments are given merely for one skilled in the art to better understand and further practice the present disclosure, but not for limiting the scope of the present disclosure. For example, features illustrated or described as part of one embodiment may be used with another embodiment to yield still a further embodiment. In the interest of clarity, not all features of an actual implementation are described in this specification.

[0045] References in the specification to "one embodiment," "an embodiment," "an example embodiment," and the like indicate that the embodiment described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0046] It shall be understood that although the terms "first" and "second" etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed terms.

[0047] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be liming of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0048] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0049] As used herein, the term "wireless communication network" refers to a network following any suitable wireless communication standards, such as New Radio (NR), LTE-Advanced (LTE-A), LTE, Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), and so on. Furthermore, the communications between a network device and a terminal device in the wireless communication network may be performed according to any suitable generation wireless communication protocols, including, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the 5G communication protocols, the NR communication protocols, and/or any other protocols either currently known or to be developed in the future.

[0050] As used herein, the term "network device" refers to a device in a wireless communication network via which a terminal device accesses the network and receives services therefrom. The network device may refer to a base station (BS) or an access point (AP), for example, a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a NR NB (also referred to as a gNB), a Remote Radio Unit (RRU), a radio header (RH), a remote radio head (RRH), a relay, a low power node such as a femto, a pico, and so forth, depending on the applied terminology and technology.

[0051] The term "terminal device" refers to any end device that can access a wireless communication network and receive services therefrom. By way of example and not limitation, a terminal device may be referred to as UE, a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT). The terminal device may include, but not limited to, a mobile phone, a cellular phone, a smart phone, a tablet, a wearable device, a personal digital assistant (PDA), portable computers, image capture terminal devices such as digital cameras, gaming terminal devices, music storage and playback appliances, wearable terminal devices, vehicle-mounted wireless terminal devices and the like. In the following description, the terms "terminal device", "terminal", "user equipment" and "UE" may be used interchangeably.

[0052] FIG. 1 illustrates an example wireless communication network 100 in which embodiments of the disclosure may be implemented. As shown in FIG. 1, the wireless communication network 100 may include one or more network devices, for example

network devices 101, which may be in a form of an eNB or gNB. It will be appreciated that the network device 101 could also be in a form of a Node B, BTS (Base Transceiver Station), and/or BSS (Base Station Subsystem), access point (AP) and the like. The network device 101 may provide radio connectivity to a set of terminal devices, for example UE 102-104 within its coverage. A terminal device (e.g., terminal device 102) may connect to the network device 101 for cellular communication, or communicate with another terminal device (e.g., terminal device 103 or 104) directly via device to device (D2D) or machine to machine (M2M) communication. A downlink (DL) transmission herein refers to a transmission from the network device to a terminal device, and an uplink (UL) transmission refers to a transmission in an opposite direction.

[0053] The uplink transmission from any of UEs 102-104 to the network device 101 is grant-based according to current LTE specification. However, inventor of the present disclosure has realized that for some application scenarios requiring low latency, for example the URLLC scenario in 5G, a grant-free uplink transmission may be desired. A grant-free uplink transmission, or in other words an autonomous uplink transmission, does not require a scheduling signaling from the network device before the uplink transmission, and instead, a terminal device is allowed to transmit data immediately in the earliest available time interval once the data arrives, without waiting for a scheduling grant from the network device. A grant-free autonomous transmission may also be called a transmission in an "arrive-and-go" manner, and an example of which is schematically illustrated in FIG. 2. As shown in FIG. 2, data 210 for UE 220 arrives at time 201, and is transmitted at time 202 to an eNB 221 without a grant from the eNB 221 before the transmission. Likewise, data 211 for the UE 220 arrives at time 203 and is transmitted to the eNB 221 at time 204 autonomously.

[0054] Benefit from such an "arrive-and-go" manner includes reduction in overhead, latency and energy consumption. First, signaling overhead associated with uplink grant transmissions, further potential optimizations in UE states and random access channel (RACH) procedures and messages may be saved. Second, delay needed for sending a grant request and a scheduling grant may be reduced. Third, UE can stay in a discontinuous receiving (DRX) for a longer time duration and is able to transmit quickly when data arrives.

[0055] A resource allocation scheme for the grant-free transmission is proposed in a 3GPP contribution R1-167254, defining a concept of a resource pool which is a set of

time-frequency resource units. One resource pool may contain a certain number of Orthogonal Frequency Division Multiplexing (OFDM) symbols in time domain and a number of subcarriers in frequency domain. The resource pool structure may be different for different use cases, and also may be subject to UE capabilities, e.g., the bandwidth supported by the UE. For example, for eMBB, a resource pool might contain one or multiple PRBs in frequency domain within one subframe, while for mMTC, it might contain one or a few subcarriers in frequency domain, and multiple transmission time intervals (TTIs) in time domain. A resource pool may contain multiple resource units based on configuration from the eNB, and each user can randomly select a certain resource units for its grant-free transmission. An example of an "arrive-and-go" transmission scheme in combination with the resource allocation scheme described above is illustrated schematically in FIG. 3. As shown in FIG. 3, after a RACH procedure 301 performed between an UE 310 and an eNB 320, the eNB 320 configures a resource pool for grant-free uplink transmissions via a signaling 302 to the UE 310. Then the UE 310 selects a resource unit randomly from the preconfigured resource pool at time 303, and transmits uplink data in a grant-free manner (304) using the selected resource unit.

[0056] In a grant-free transmission scheme, users are allowed to select resource unit randomly in the resource pool for uplink data transmission without being scheduled by the eNB, and it is possible that multiple users select a same physical resource for their uplink transmissions. In this case, collision will occur and therefore uplink transmissions from some or even all of the users selecting the same physical resource will fail. An example of transmission collision is illustrated in FIG. 4. In the example shown in FIG. 4, data transmission 410 from UE 401 and data transmission 420 from UE 402 occupy same resource and collide. As a result, one or both of the transmissions 410 and 420 may not be detected correctly by the eNB 403.

[0057] Although some advanced physical layer technologies for enhancing transmission performance in the case of resource collision, e.g., non-orthogonal multiple access (NOMA), have been proposed and are under active discussion, they can only partially solve the problem and may cause an increase in implementation complexity of the physical layer. Therefore, it is meaningful and desirable to seek enhanced upper layer (e.g., Media access control (MAC) layer) solutions, to further improve performance of the grant-free uplink transmission, considering that the transmission reliability for URLLC scenario is supposed to be above 99%.

[0058] The legacy LTE system relies on retransmission mechanisms on multiple protocol layers to recover failed data. In particular, Hybrid Automatic Repeat request (HARQ), as a fast retransmission scheme on MAC layer, can be used to retransmit data with a delay of multiple TTIs which is of the order of ten milliseconds. However, the resultant delay in HARQ retransmission is still too large for low latency application such as URLLC, which requires latency of the order of milliseconds. Therefore, for URLLC applications with much more strict requirements for transmission reliability and delay, it is necessary to adopt a new solution to enhance transmission reliability under reduced transmission delay.

[0059] In order to solve at least part of the above problems, methods, apparatuses and computer programs have been proposed herein. Some embodiments of the present disclosure provide a method which allows a terminal device to transmit a same data block in multiple resource units, thereby reducing collision probability with other users and increasing reliability of transmission. In some embodiments, redundant versions (RVs) of encoded data transmitted by a terminal device in the multiple resource units may be different, thereby increasing coding gain. In some embodiments, a control region transmitted together with each data block may contain essential information indicating RV of current transmission as well as additional information indicating the positions/indexes of other of the multiple resource units, and/or, RVs for data transmitted in other of the multiple resource units. This enables the receiving side to obtain better performance by combining received multiple data transmissions. For example, once the receiving side (e.g., a base station) successfully decodes a control region in any resource unit, it can obtain the positions/indexes and/or RVs associated with other resource units such that combined decoding across multiple resource units can be enabled to enhance transmission reliability.

[0060] Reference is now made to FIG. 5A which shows a flowchart of a method 500 implemented in a terminal device (e.g., any of UEs 102-104 shown in FIG. 1) according to an embodiment of the present disclosure. For ease of discussions, the method 500 will be described below with reference to terminal device 102 and the environment as described with reference to FIG. 1.

[0061] As illustrated in FIG. 5A, at block 510, the terminal device 102 selects a plurality of resources from a resource pool. In one embodiment, the resource pool may be predefined, or configuration of the resource pool may be obtained by the terminal device 102 implicitly. In another embodiment, the terminal device 102 may receive configuration information from the network device 101 at an optional block 505, and at

block 510 the terminal device 102 may select the plurality of resources from the resource pool according to the received configuration information.

[0062] As an example rather than limitation, the configuration information may include at least one of: configuration of the resource pool, a maximum number of resources to be selected from the resource pool for the data transmission, and a number of resources to be selected from the resource pool for the data transmission. For example, the configuration of the resource pool from the network device 101 may indicate, but is not limited to, one or more of: a starting (frequency/time/code) position of the resource pool, a total number of resources included in the resource pool, and a set of resources included in the resource pool.

[0063] In some embodiments, the resource pool may include a set of resources separated in at least one of frequency domain, time domain, and code domain. Likewise, the plurality of resources selected by the terminal device at block 510 may be separated in at least one of frequency domain, time domain, and code domain. An example for the selected plurality of resources by the terminal device 102 is schematically illustrated in FIG. 6. As shown in FIG. 6, the terminal device 102 selected four resource units 601, 603, 604 and 606 from the resource pool 610. The number of resource units (or the maximum number of resource units) can be selected from the resource pool 610 by a terminal device 102 may be indicated by the control information received at block 505.

[0064] Now referring back to FIG. 5A. In some embodiments, at block 510, the terminal device 102 may select the plurality of resources from the resource pool randomly. Alternatively or additionally, in another embodiment, the terminal device 102 may select/determine the plurality of resources based on its identity (e.g., UE ID). Embodiments of the present disclosure are not limited to any specific way for selecting the plurality of resources from the resource pool.

[0065] As shown in FIG. 5A, at block 520, the terminal device 102 transmits a plurality of copies of data (e.g., a data block) autonomously in the plurality of resources respectively. Though one of the plurality of resources selected by the terminal device 102 may be same as a resource selected by another terminal device (e.g., the terminal device 103 shown in FIG. 1), a probability for all the plurality of resources to be the same as that selected by another terminal device is low. Therefore, with the method 500, transmission of the terminal device 102 may be detected correctly by the network device 101 with an increased probability.

[0066] In an example embodiment, the plurality of copies of data transmitted by the terminal device 102 at block 520 may be associated with a same transmission format. Alternatively, in another embodiment, at least two copies of the plurality of copies transmitted by the terminal device 102 at block 520 may be associated with different transmission formats. For example, two or more (or all) of the plurality of copies of data may be encoded with different RVs and/or MCs. By using the different transmission formats, coding gain achievable at the receiving network device 101 side may be increased.

[0067] In some embodiments, at block 520, the terminal device 102 may transmit a copy of the plurality of copies of the data by transmitting control information together with the copy of the data; that is to say, some or each of the plurality of copies of the data may be transmitted together with a corresponding control region. An example structure 700 for transmitting a copy of the data is schematically illustrated in FIG. 7. Such a transmission structure is also referred to as a "control + data" structure herein.

[0068] Using the structure shown in FIG. 7, at block 520, for transmitting each or some of the plurality of copies of the data, the terminal device 102 may transmit a control region 701 and a data region 702. Embodiments of the present disclosure are not limited to any specific way for multiplexing the control region 701 and the data region 702 of a transmission. Just for example rather than limitation, the two parts may be multiplexed via frequency divisional multiplexing (FDM), time divisional multiplexing (TDM) and/or code divisional multiplexing (CDM).

[0069] In a further embodiment, the control information (e.g., 701 shown in FIG. 7) transmitted together with a copy of the data (e.g., the702 shown in FIG. 7) may include assistance information for detecting another copy of the plurality of copies; that is to say, the control information transmitted together with a copy of the data at block 520 by the terminal device may indicate assistance information for detecting one or some or all of the other copies of the data. As an example, at block 520, the terminal device 102 may transmit 3 copies of data, and each copy of the data is transmitted together with corresponding control information. In this example, the control information transmitted together with the first copy of the data in a first resource unit may indicate information for detecting the second copy and/or the third copy of the data. Likewise, the control information transmitted together with the second copy of the data in a second resource unit may indicate information for detecting the first copy and/or the third copy of the data. The control information transmitted together with the third copy of the data in a third resource

unit may indicate information for detecting the first copy and/or the second copy of the data. Then, once control information transmitted together with one copy of the data is detected correctly, a receiving device (e.g., the network device 101 or a terminal device 104 shown in FIG. 1) can obtain assistance information for detecting another copy of the data or all other copies of the data.

[0070] In one embodiment, the assistance information for detecting another copy of the plurality of copies may indicate a resource for detecting the other copy. As an example, the assistance information may indicate a resource for detecting the other copy by indicating a relative position of the resource. For instance, the assistance information may indicate an offset of the resource for detecting the other copy of the plurality of copies relative to a resource for transmitting current copy of the plurality of copies. In FIG. 8, an example of the assistance information is shown. In this example, the terminal device 102 transmits 4 copies of the data, and as shown in FIG. 8, each of the four transmissions includes a control region. The control region associated with the *i*th transmission indicates resources of other three transmissions relative to the *i*th transmission. For example, control information 813 together with a data copy 803 is transmitted in the resource unit "n", and the control information 813 indicates the position of resource unit "n+2" via a position indication of "1010". The first bit "1" of the position indication indicates that there is a further data copy transmission in a resource unit with an index larger than "n", and the last three bits "010" indicate that difference of index between the resource unit indicated and the resource "n" is two. Likewise, the control information also includes a position indication of "0001"for indicating the position of resource unit "n-1". The first bit "0" position indication "0001" indicates that a further data copy transmission in a resource unit with an index smaller than "n", and the last three bits "001" indicate that difference of index between the resource unit indicated and the resource "n" is one. In the example of FIG. 8, different RVs are used for the data transmission of 801, 803, 804 and 806, however, it should be appreciated that embodiments of the present disclosure are not limited thereto, and in another embodiment, same RV may be used for some or all the transmissions.

[0071] Alternatively or additionally, in another embodiment, the assistance information for detecting another copy of the plurality of copies may indicate a transmission format associated with the other copy of the plurality of copies. For example, the assistance

information may indicate RV and/or MCs associated with one or some or all of the other copies of the data transmitted at block 520.

[0072] Optionally, in still another embodiment, the control information transmitted with a copy of the data the block 520 may include information for detecting the current copy of the data. For example, the control information may indicate RV and/or MCs of current data transmission. In another embodiment, the RV and/MCs for a data transmission may be predefined, or may be derived by the terminal device implicitly based on, for example resource position, and then in this case, the control information for detecting current copy of data may be omitted.

[0073] As described above, the control information transmitted together with a copy of the data facilitates the receiving device (e.g., the network device 101 or UE 104 shown in FIG. 1) to detect other copy (or copies) of the data and/or current data transmission. In some embodiments, the network device 101 may need to extract control information transmitted in the control region in order to obtain the resource locations of other copies of the data before demodulating and combing multiple copies of the data. Therefore, there may be a stricter requirement for the robustness of the control information transmission.

[0074] To meet such a requirement, in some embodiments of the present disclosure, more robust transmission scheme (i.e., a transmission scheme providing a lower error rate) than that used for transmitting the data part are applied to the transmission of the control information. That is, at block 520 of FIG. 5A, the terminal device 102 may transmit the control information and the data with different transmission schemes. An example implementation of the block 520 is shown in FIG. 5B.

[0075] As shown in FIG. 5B, the terminal device 102 may transmit the control information with a first transmission scheme at block 521, and transmit a copy of the data with a second transmission scheme at block 522, and the first transmission scheme provides a lower error rate than the second transmission scheme. As an example rather than a limitation, the first transmission scheme may include a lower modulation order than the second transmission scheme. Alternatively or additionally, in another embodiment, the first transmission scheme may include a lower coding rate than the second transmission scheme.

[0076] FIG.5B is an example for transmitting a copy of the data, and in an embodiment, each of the plurality of copies of the data may be transmitted likewise. In another

embodiment, some copies of the data may be transmitted in a manner different from that shown in FIG. 5B.

[0077] With the example implementation shown in FIG. 5B, control information can be decoded correctly with a higher probability. In some embodiments, once control information associated with one data transmission (i.e., transmitted together with one data transmission) is decoded correctly in a certain resource unit, the resource positions of other resource units carrying other copies of the data (possibly with different RVs) can be obtained by the network device 101, even if decoding of control information in these resource units fails due to collision with other users. This enables the network device 101 to decoding multiple data transmissions in a combined manner.

[0078] Though for simplicity, some embodiments are described with reference to terminal device 102 shown in FIG. 1, similar embodiment may be applied to other terminal devices, for example, terminal device 103 shown in FIG. 1. FIG. 9 illustrates an example of uplink data transmission from two terminal devices 910 and 920 (which may be the UE 102 and 103 shown in FIG. 1) according to an embodiment of the present disclosure. In this example, for each terminal device, four different RVs are adopted for transmission of four copies of data over four different resource units. It should be appreciated that the actual number of RVs used for transmission may be configurable by the network device and may be obtained by the terminal devices, for example, at block 505 of FIG. 5A. In the example shown in FIG. 9, data transmissions 911, 913 and 914 from the terminal device 910 over three resource units n+2, n-1 and n-3 collide with the data transmission 921, 923 and 924 from the terminal device 920 over the same resource units. Only one resource unit "n" is solely occupied by the terminal device 910 and only one resource unit "n+1" is solely occupied by the terminal device 920. Therefore, the base station may only successfully decode the control information parts of the transmission 912 from the terminal device 910 over the resource unit "n" where no collision occurs. Note that it does not mean that the base station can correctly decode also the data part carried by the resource unit n without combining data copies transmitted over other resource units, because a more robust transmission scheme than that for the data part may be used for the control information transmission. Based on the decoded control information carried in the resource unit n, the network device can obtain resource unit location information of other data copies, and then can combine all or some of the data copies to improve decoding probability. Likewise, because resource "n+1" is solely occupied by the terminal device

920, the network device may successfully decode the control information part in this resource unit first and then obtain location information of other data copies before combining all or some of the data copies.

[0079] With some embodiments of the present disclosure, probability for successful data transmission/reception may be increased by transmitting a plurality of copies of data in a plurality of resources autonomously. In some embodiments, by transmitting, together with a copy of data, assistance information for detecting one or more other copies of the data, a combined detection (i.e., detecting data by combining a plurality of copies of the data) may be enabled at the receiving device side, and probability for correct decoding may be increased.

[0080] In some embodiments, the plurality of resources selected by the terminal device for data transmission may be in a same time interval, and in this case, at block 520 of FIG. 5A, the terminal device may transmit the plurality of copies of the data simultaneously. Though in this case, energy and/or cost issues may arise, the resulting requirement on additional energy and/or cost may be compensated by performance gain provided by the proposed scheme, and thus it makes sense especially for some URLLC applications which are insensitive to energy/cost issues.

[0081] Further, it should be appreciated that, the methods described above with references FIGs. 5A-5B and 6-9 are not limited to being used for uplink transmission from a terminal device to a network device, but may also be used for other data transmissions, for example but not limited to, D2D or M2M transmission between terminal devices. For example, the terminal device 102 shown in FIG. 1 may transmit data to the terminal device 104 shown in FIG. 1 using an embodiment of the method 500, or vice versa.

[0082] Reference is now made to FIG. 10 which illustrates a schematic flowchart of a method 1000 for data receiving. The method 1000 may be implemented in a network device or a terminal device. For simplicity, the method 1000 will be described below with reference to the network device 101 and the communication environment shown in FIG. 1. However, it would be appreciated that the method 1000 could also be implemented by any other suitable device, for example terminal device 104 shown in FIG. 1.

[0083] As illustrated in FIG. 10, at block 1010, the network device 101 receives control information from a terminal device (for example the terminal device 102 shown in FIG. 1) in a first resource of a resource pool, and the control information includes assistance information for detecting a first copy of data. In one embodiment, the descriptions with

respect to the assistance information and resource pool provided with reference to method 500 also applies here and detailed will not be repeated.

[0084] At block 1020, the network device 101 receives a second copy of the data transmitted together with the control information in the first resource. In some embodiments, the control information received at block 1010 may also include information for detecting the second copy of the data, for example, but not limited to, MCs, RVs. In another embodiment, the network device 101 may receive the second copy of the data blindly, or the information for detecting the second copy may be predefined or implicitly known to the network device 101, and in these cases, it is unnecessary to include information for detecting the second coly of the data in the control information.

[0085] At block 1030, the network device 101 receives the first copy of the data based on the assistance information, in a second resource of the resource pool. Then at block 1040, the network device 101 detects/recovers the data by combining the first copy and the second copy of the data.

[0086] For illustration purpose, an example of the method 1000 will be described below in conjunction with FIG. 8. For instance, at block 1010, the network device 101 may receive the control information 811 in the resource n+2 shown in FIG. 8, and the control information may include assistance information for detecting the data copy transmitted in resource n (and/or resource n-1, and/or resource n-3). At block 1020, the network device 101 may receive the data copy 801 transmitted together with the control information 811 in the resource n+2. At block 1030, the network device 101 may receive the data copy transmitted in the resource n (and/or resource n-1, and/or resource n-3) based on the assistance information indicated in control region 811. At block 1040, the network device 101 may recover the data by combining the data copied transmitted in resource n+2 and n (and/or resource n-1, and/or resource n-3).

[0087] It should be appreciated that the method 1000 also allows the network device 101 to receive more than two copies of the data. For example, in a block not shown in the FIG. 10, the network device 101 may receive a third copy of the data in a similar way as that of block 1020, and at block 1030, the network device 101 may detect the data by combining more than two copies of the data.

[0088] It should be appreciated that embodiments of the present disclosure are not limited to any specific algorithm for combining a plurality of copies of the data at block 1040. For example rather than limitation, a plurality of data copies may be combined via

maximum ratio combining (MRC), or equal gain combining (EGC), or Minimum Mean Square Error (MMSE) combining.

[0089] In some embodiments, the first copy and the second copy of the data received by the network device 101 at block 1030 and 1020 respectively may be transmitted with different transmission formats by the terminal device 102. For example, the two copies of data may be transmitted with different RVs and/or MCs. However, embodiments are not limited thereto. In another embodiment, the first copy of the data and the second copy of the data may be transmitted with a same transmission format.

[0090] In an embodiment, the control information and the second copy of the data received by the network device 101 at block 1010 and 1020 respectively may be transmitted by the terminal device 102 with different transmission schemes. For example, the control information may be associated with more robust transmission scheme which provided lower error rate than that used for the data transmission. Descriptions with respect to control information and data part transmission provided with reference to method 500 also apply here and detailed will not be repeated.

[0091] Optionally, in some embodiments, the method 1000 may further include a block 1005. At block 1005, the network device 101 may transmit configuration information to the terminal device 102 and the configuration information may include at least one of: configuration of the resource pool, a maximum number of resources to be selected from the resource pool for the data transmission, and a number of resources to be selected from the resource pool for the data transmission. Descriptions with respect to the configuration information provided with reference to method 500 also apply here.

[0092] It should be appreciated that the method 1000 may also be implemented in a terminal device, for example the terminal device 104 which may be in D2D communication with the terminal device 102, and in this case, the block 1005 may not be included in the method.

[0093] FIG.11 illustrates a schematic block diagram of an apparatus 1100 in a wireless communication network (e.g., the wireless communication network 100 shown in FIG. 1). The apparatus 1100 may be implemented as/in a terminal device, e.g., any of the terminal devices 102-104 shown in FIG. 1 in communication with the network device 101 or another terminal device. The apparatus 1100 is operable to perform the example method 500, described with reference to FIGs. 5A-5B, 6-9 and possibly any other processes or methods. It is also to be understood that the method 500 is not necessarily performed by the

apparatus 1100. At least some steps of the method 500 can be performed by one or more other entities.

[0094] As illustrated, the apparatus 1100 includes a selecting unit 1101 and a transmitting unit 1102. The selecting unit 1101 is configured to select a plurality of resources from a resource pool; and the transmitting unit 1102 is configured to transmit a plurality of copies of the data autonomously in the plurality of resources respectively. In one embodiment, transmitting a copy of the plurality of copies of the data includes: transmitting control information together with the copy of the data, the control information including assistance information for detecting a further copy of the plurality of copies. That is, in an embodiment, the structure shown in FIG. 7 may be used for transmitting a copy (or each copy) of the data. In another embodiment, the transmitting unit 1102 may include a control transmitting unit 1112 and a data transmitting unit 1122. The control transmitting unit 1112 may be configured to transmit the control information with a first transmission scheme, and the data transmitting unit 1122 may be configured to transmit the copy of the data with a second transmission scheme. In an embodiment, the first transmission scheme may provide a lower error rate than the second transmission scheme.

[0095] In an embodiment, the apparatus 1100 may further include a receiving unit 1103, configured to receiving configuration information from a network device, and the selecting unit 1101 may be configured to select the resource based on the configuration information.

[0096] In some embodiments, the selecting unit 1101, the transmitting unit 1102 and the receiving unit 1103 may be configured to perform functions of blocks 510, 520 and 505 of method 500 respectively, and then descriptions with respect to control information, assistance information, resource pool, configuration information, resource selection, data copy transmission, configuration information reception provided with reference to method 500 also apply here and details will not be repeated.

[0097] FIG. 12 illustrates a schematic block diagram of an apparatus 1200 in a wireless communication network (e.g., the wireless communication network 100 shown in FIG. 1). The apparatus may be implemented as/in a network device or a terminal device, e.g., the network device 101 or any of the terminal devices 102-104 shown in FIG. 1. The apparatus 1200 is operable to carry out the example method 1000 described with reference to FIG. 10 and possibly any other processes or methods. It is also to be understood that

the method 1000 is not necessarily carried out by the apparatus 1200. At least some steps of the method 1000 can be performed by one or more other entities.

[0098] As illustrated in FIG. 12, the apparatus 1200 includes a first receiving unit 1201, a second receiving unit 1202, a third receiving unit 1203, and a detecting unit 1204. The first receiving unit 1201 is configured to receive control information from a terminal device in a first resource of a resource pool, the control information including assistance information for detecting a first copy of data. The second receiving unit 1202 is configured to receive a second copy of the data transmitted together with the control information in the first resource. The third receiving unit 1203 is configured to receive the first copy of the data based on the assistance information, in a second resource of the resource pool. The detecting unit 1204 is configured to detect the data by combining the first copy and the second copy of the data.

[0099] It should be appreciated that the apparatus 1200 may include a further receiving unit not shown in FIG. 12, for receiving a further copy of the data, and correspondingly the detecting unit 1204 may be configured to detect the data by combining more than two copies of the data.

[00100] In some embodiments, the apparatus 1200 may further include a transmitting unit 1205, configured to transmit configuration information to the terminal device, and the configuration information may include at least one of: configuration of the resource pool, a maximum number of resources to be selected from the resource pool for the data transmission, and a number of resources to be selected from the resource pool for the data transmission.

[00101] In some embodiments, the first receiving unit 1201, the second receiving unit 1202, the third receiving unit 1203, the detecting unit 1204 and the transmitting unit 1205 may be configured to perform the operations of blocks 1010-1040 and 1005 of FIG. 10 respectively, and therefore descriptions provided with reference to FIG. 10 and method 1000 also apply here and details will not be repeated.

[00102] FIG. 13 illustrates a simplified block diagram of an apparatus 1310 that may be embodied in/as a network device or a terminal device, e.g., the network device 101 or any of the terminal 102-104 shown in FIG. 1, and an apparatus 1320 that may be embodied in/as a terminal device, e.g., one of the terminal devices 102 -104 shown in FIG. 1.

[00103] The apparatus 1310 may include one or more processors 1311, such as a data processor (DP) and one or more memories (MEM) 1312 coupled to the processor 1311.

The apparatus 1310 may further include a transmitter TX and receiver RX 1313 coupled to the processor 1311. The MEM 1312 may be non-transitory machine readable storage medium and it may store a program (PROG) 1314. The PROG 1314 may include instructions that, when executed on the associated processor 1311, enable the apparatus 1310 to operate in accordance with the embodiments of the present disclosure, for example to perform the method 1000. A combination of the one or more processors 1311 and the one or more MEMs 1312 may form processing means 1315 adapted to implement various embodiments of the present disclosure.

[00104] The apparatus 1320 includes one or more processors 1321, such as a DP, and one or more MEMs 1322 coupled to the processor 1321. The apparatus 1320 may further include a suitable TX/ RX 1323 coupled to the processor 1321. The MEM 1322 may be non-transitory machine readable storage medium and it may store a PROG 1324. The PROG 1324 may include instructions that, when executed on the associated processor 1321, enable the apparatus 1320 to operate in accordance with the embodiments of the present disclosure, for example to perform the method 500. A combination of the one or more processors 1321 and the one or more MEMs 1322 may form processing means 1325 adapted to implement various embodiments of the present disclosure.

[00105] Various embodiments of the present disclosure may be implemented by computer program executable by one or more of the processors 1311 and 1321, software, firmware, hardware or in a combination thereof.

[00106] The MEMs 1312 and 1322 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory terminal devices, magnetic memory terminal devices and systems, optical memory terminal devices and systems, fixed memory and removable memory, as non-limiting examples.

[00107] The processors 1311 and 1321 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors DSPs and processors based on multicore processor architecture, as non-limiting examples.

[00108] Although some of the above description is made in the context of a cellular wireless communication system, it should not be construed as limiting the spirit and scope of the present disclosure. The principle and concept of the present disclosure may be more generally applicable to other scenarios where similar problem exists.

[00109] In addition, the present disclosure may also provide a memory containing the computer program as mentioned above, which includes machine-readable media and machine-readable transmission media. The machine-readable media may also be called computer-readable media, and may include machine-readable storage media, for example, magnetic disks, magnetic tape, optical disks, phase change memory, or an electronic memory terminal device like a random access memory (RAM), read only memory (ROM), flash memory devices, CD-ROM, DVD, Blue-ray disc and the like. The machine-readable transmission media may also be called a carrier, and may include, for example, electrical, optical, radio, acoustical or other form of propagated signals – such as carrier waves, infrared signals, and the like.

[00110] The techniques described herein may be implemented by various means so that an apparatus implementing one or more functions of a corresponding apparatus described with an embodiment includes not only prior art means, but also means for implementing the one or more functions of the corresponding apparatus described with the embodiment and it may include separate means for each separate function, or means that may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. For a firmware or software, implementation may be made through modules (e.g., procedures, functions, and so on) that perform the functions described herein.

[00111] Example embodiments herein have been described above with reference to block diagrams and flowchart illustrations of methods and apparatuses. It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively, can be implemented by various means including hardware, software, firmware, and a combination thereof. For example, in one embodiment, each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations can be implemented by computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks.

[00112] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the subject matter described herein, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00113] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The above described embodiments are given for describing rather than limiting the disclosure, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the disclosure as those skilled in the art readily understand. Such modifications and variations are considered to be within the scope of the disclosure and the appended claims. The protection scope of the disclosure is defined by the accompanying claims.

WHAT IS CLAIMED IS:

1. A method implemented in a terminal device for data transmission, comprising:

selecting a plurality of resources from a resource pool; and

transmitting a plurality of copies of the data autonomously in the plurality of resources respectively;

wherein transmitting a copy of the plurality of copies of the data comprises:

transmitting control information together with the copy of the data, the control information including assistance information for detecting a further copy of the plurality of copies.

2. The method according to Claim 1, wherein the assistance information for detecting a further copy of the plurality of copies indicates a resource for detecting the further copy.

3. The method according to Claim 2, wherein the assistance information indicates an offset of the resource for detecting the further copy relative to a resource for transmitting the copy of the plurality of copies.

4. The method according to any of Claims 1-3, wherein at least two copies of the plurality of copies are associated with different transmission formats.

5. The method according to any of Claims 1-4, wherein the assistance information for detecting a further copy of the plurality of copies indicates a transmission format associated with the further copy of the plurality of copies.

6. The method according to any of Claims 4 -5, wherein the transmission format includes at least one of:

a redundant version; and

a modulation and coding scheme.

7. The method according to any of Claims 1-6, wherein the plurality of resources are separated in at least one of:

frequency domain;

time domain; and

code domain.

8. The method according to any of Claims 1-7, further comprising:

receiving configuration information from a network device, the configuration information including at least one of:

configuration of the resource pool;

a maximum number of resources to be selected from the resource pool for the data transmission;

a number of resources to be selected from the resource pool for the data transmission; and

wherein selecting a plurality of resources from a resource pool comprises:

selecting the plurality of resources from the resource pool according to the configuration information.

9. The method according to any of Claims 1-8, wherein transmitting control information together with the copy of the data comprises:

transmitting the control information with a first transmission scheme, and

transmitting the copy of the data with a second transmission scheme,

wherein the first transmission scheme provides a lower error rate than the second transmission scheme.

10. A method implemented in a receiving device, comprising:

receiving control information from a terminal device in a first resource of a resource pool, the control information including assistance information for detecting a first copy of data;

receiving a second copy of the data transmitted together with the control information in the first resource;

receiving the first copy of the data based on the assistance information, in a second resource of the resource pool; and

detecting the data by combining the first copy and the second copy of the data.

11. The method according to Claim 10, wherein the assistance information for detecting a first copy of the data indicates the second resource.

12. The method according to Claim 11, wherein the assistance information indicates an offset of the second resource relative to the first resource.

13. The method according to any of Claims 10-12, wherein the first copy and the second copy of the data are associated with different transmission formats.

14. The method according to any of Claims 10-13, wherein the assistance information for detecting a first copy of the data indicates a transmission format associated with the first copy of the data.

15. The method according to any of Claims 13 -14, wherein the transmission format includes at least one of:

a redundant version; and

a modulation and coding scheme.

16. The method according to any of Claims 10-15, wherein the first resource and the second resource are separated in at least one of:

frequency domain;

time domain; and

code domain.

17. The method according to any of Claims 10-16, further comprising:

transmitting configuration information to the terminal device, the configuration information including at least one of:

configuration of the resource pool;

a maximum number of resources to be selected from the resource pool for the data transmission; and

a number of resources to be selected from the resource pool for the data transmission.

18. The method according to any of Claims 10-17, wherein:

the control information is associated with a first transmission scheme,

the second copy of the data is associated with a second transmission scheme, and

the first transmission scheme provides a lower error rate than the second transmission scheme.

19. An apparatus comprising a processor and a memory, said memory containing instructions executable by said processor whereby said apparatus is operative to:

select a plurality of resources from a resource pool;

transmit a plurality of copies of the data autonomously in the plurality of resources respectively; and

wherein transmitting a copy of the plurality of copies of the data comprises:

transmitting control information together with the copy of the data, the control information including assistance information for detecting a further copy of the plurality of copies.

20. The apparatus according to Claim 19, wherein the assistance information for detecting a further copy of the plurality of copies indicates a resource for detecting the further copy.

21. The apparatus according to Claim 20, wherein the assistance information indicates an offset of the resource for detecting the further copy of the plurality of copies relative to a resource for transmitting the copy of the plurality of copies.

22. The apparatus according to any of Claims 19-21, wherein at least two copies of the plurality of copies are associated with different transmission formats.

23. The apparatus according to any of Claims 19-22, wherein the assistance information for detecting a further copy of the plurality of copies indicates a transmission format associated with the further copy of the plurality of copies.

24. The apparatus according to any of Claims 22 -23, wherein the transmission format includes at least one of:

a redundant version; and

a modulation and coding scheme.

25. The apparatus according to any of Claims 19-24, wherein the plurality of resources are separated in at least one of:

frequency domain;

time domain; and

code domain.

26. The apparatus according to any of Claims 19-25, wherein said memory contains instructions executable by said processor whereby said apparatus is further operative to:

receive configuration information from a network device, the configuration information including at least one of:

configuration of the resource pool;

a maximum number of resources to be selected from the resource pool for the data transmission;

a number of resources to be selected from the resource pool for the data transmission; and

wherein selecting a plurality of resources from a resource pool comprises:

selecting the plurality of resources from the resource pool according to the configuration information.

27. The apparatus according to any of Claims 19-26, wherein said memory contains instructions executable by said processor whereby said apparatus is further operative to transmit control information together with the copy of the data by:

transmitting the control information with a first transmission scheme, and

transmitting the copy of the data with a second transmission scheme,

wherein the first transmission scheme provides a lower error rate than the second transmission scheme.

28. An apparatus comprising a processor and a memory, said memory containing instructions executable by said processor whereby said apparatus is operative to:

receive control information from a terminal device in a first resource of a resource pool, the control information including assistance information for detecting a first copy of data;

receive a second copy of the data transmitted together with the control information in the first resource;

receive the first copy of the data based on the assistance information, in a second resource of the resource pool; and

detect the data by combining the first copy and the second copy of the data.

29. The apparatus according to Claim 28, wherein the assistance information for detecting a first copy of the data indicates the second resource.

30. The apparatus according to Claim 29, wherein the assistance information indicates the second resource by:

indicating an offset of the second resource relative to the first resource.

31. The apparatus according to any of Claims 28-30, wherein the first copy and the second copy of the data are associated with different transmission formats.

32. The apparatus according to any of Claims 28-30, wherein the assistance information for detecting a first copy of the data indicates a transmission format associated with the first copy of the data.

33. The apparatus according to any of Claims 31 -32, wherein the transmission format includes at least one of:

a redundant version; and

a modulation and coding scheme.

34. The apparatus according to any of Claims 28-33, wherein the first resource and the second resource are separated in at least one of:

frequency domain;

time domain; and

code domain.

35. The apparatus according to any of Claims 28-34, herein said memory contains instructions executable by said processor whereby said apparatus is further operative to:

transmit configuration information to the terminal device, the configuration information including at least one of:

configuration of the resource pool;

a maximum number of resources to be selected from the resource pool for the data transmission; and

a number of resources to be selected from the resource pool for the data transmission.

36. The apparatus according to any of Claims 28-35, wherein:

the control information is associated with a first transmission scheme,

the second copy of the data is associated with a second transmission scheme, and

the first transmission scheme provides a lower error rate than the second transmission scheme.

37. An apparatus comprising processing means adapted to carry out the method according to any of claims 1 to 9.

38. An apparatus comprising processing means adapted to carry out the method according to any of claims 10 to 18.

39. A computer program, comprising instructions which, when executed on at least one processor, cause the at least one processor to carry out the method according to any of claims 1 to 9.

40. A computer program, comprising instructions which, when executed on at least one processor, cause the at least one processor to carry out the method according to any of claims 10 to 18.

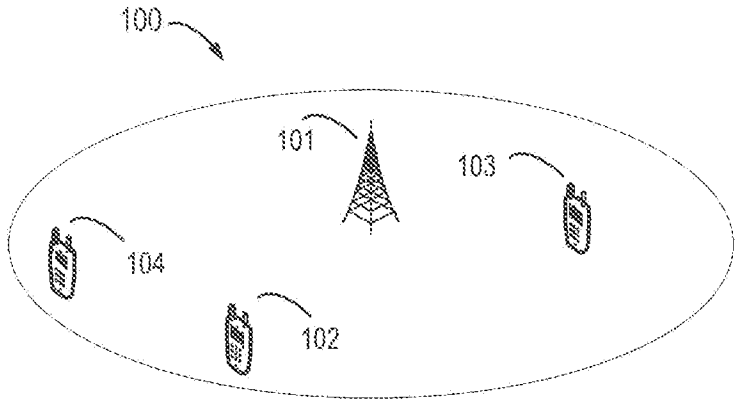

FIG. 1

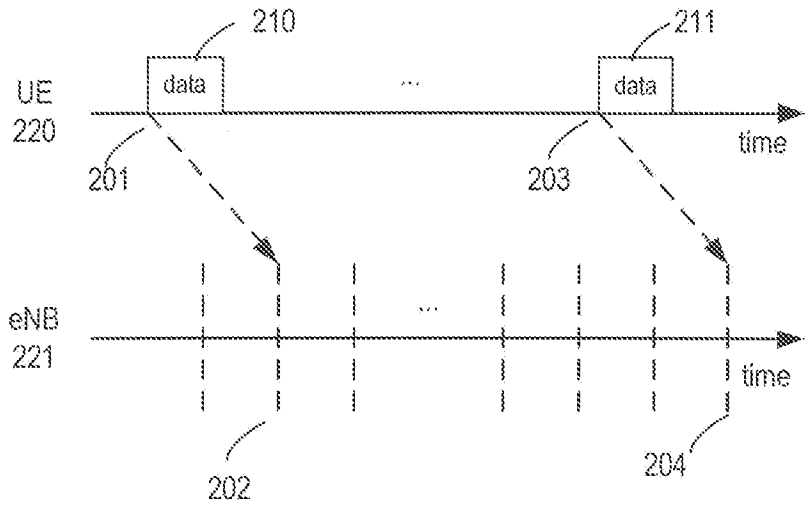

FIG. 2

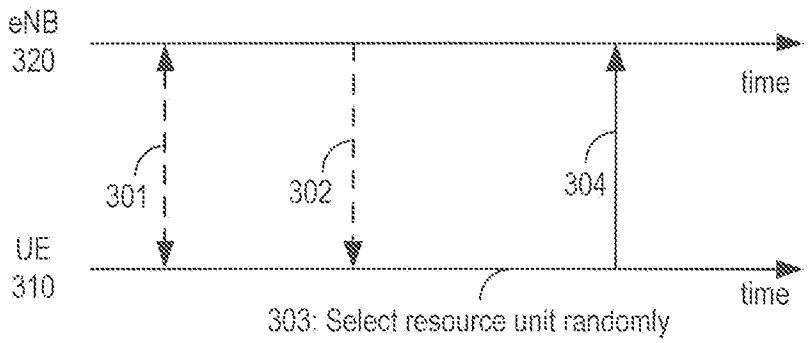

FIG. 3

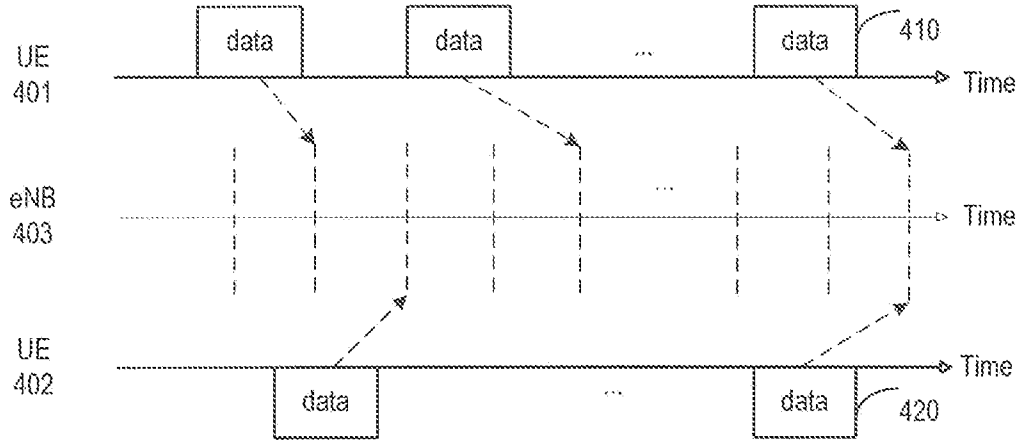
UE
401
data
data
...
data
410
Time
eNB
403
...
Time
UE
402
data
...
data
420
Time

FIG. 4

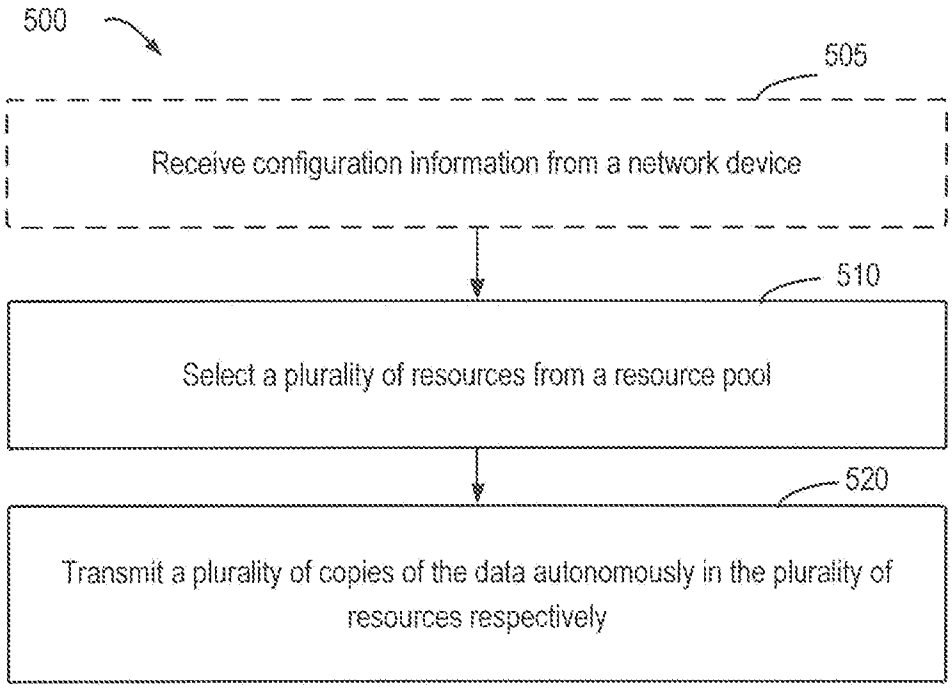
500
505
Receive configuration information from a network device
510
Select a plurality of resources from a resource pool
520
Transmit a plurality of copies of the data autonomously in the plurality of resources respectively

FIG. 5A

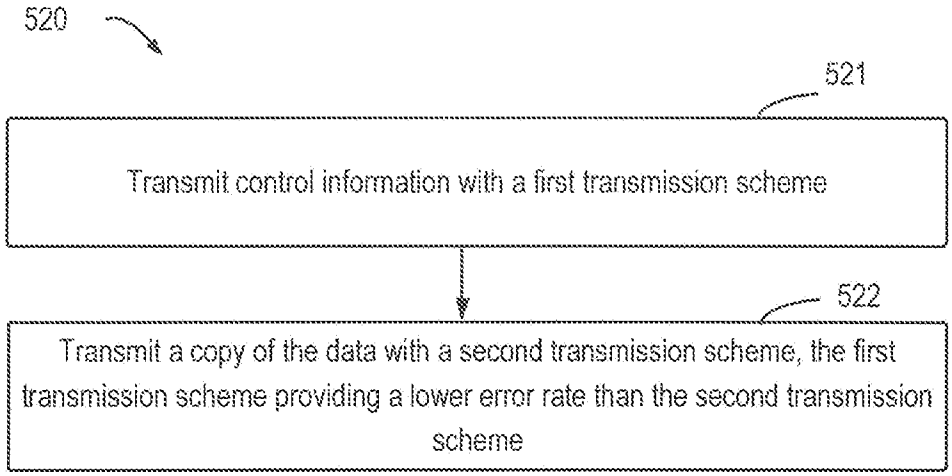

FIG. 5B

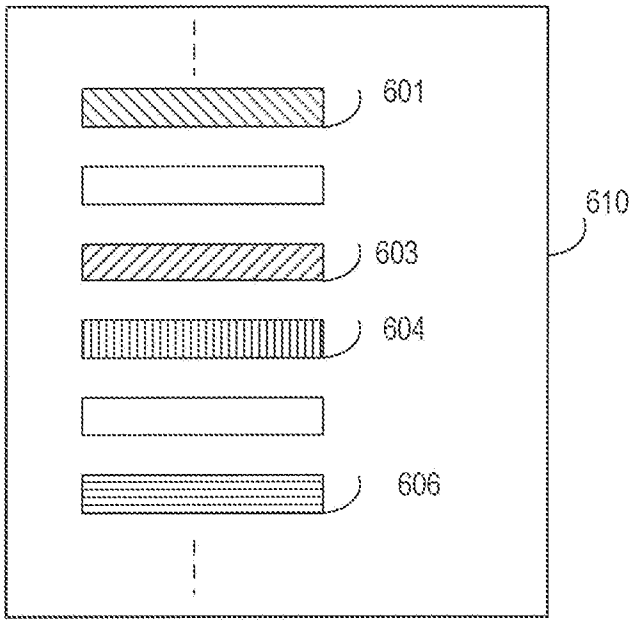

FIG. 6

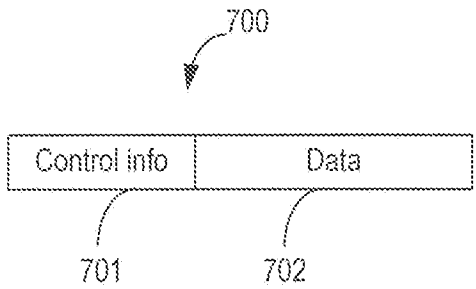

FIG. 7

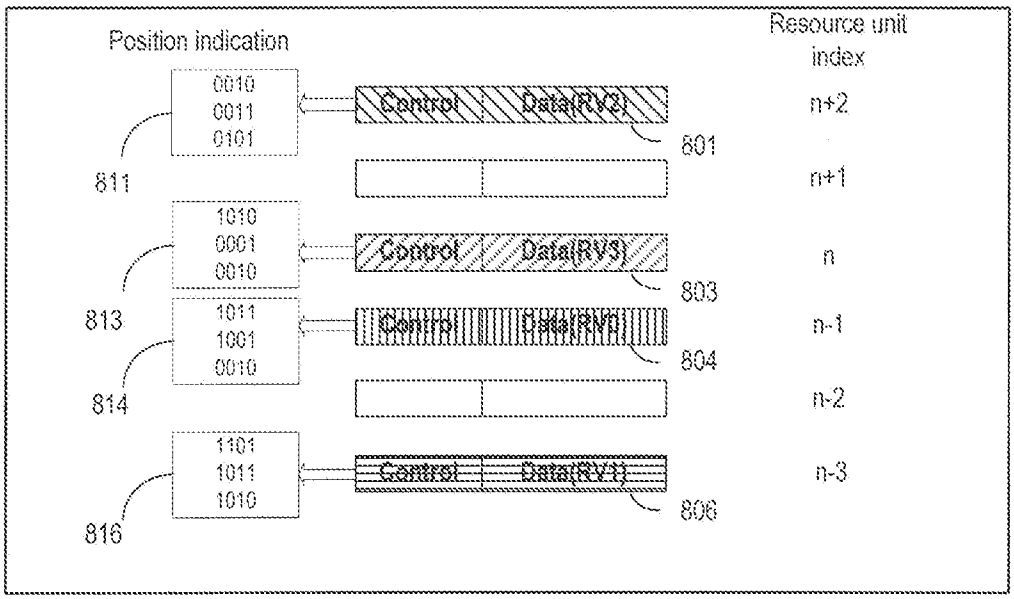
Position indication
Resource unit index
0010
0011
0101
811
Control
Data(RV2)
801
n+2
n+1
1010
0001
0010
813
Control
Data(RV3)
803
n
1011
1001
0010
814
Control
Data(RV0)
804
n-1
n-2
1101
1011
1010
816
Control
Data(RV1)
806
n-3

FIG. 8

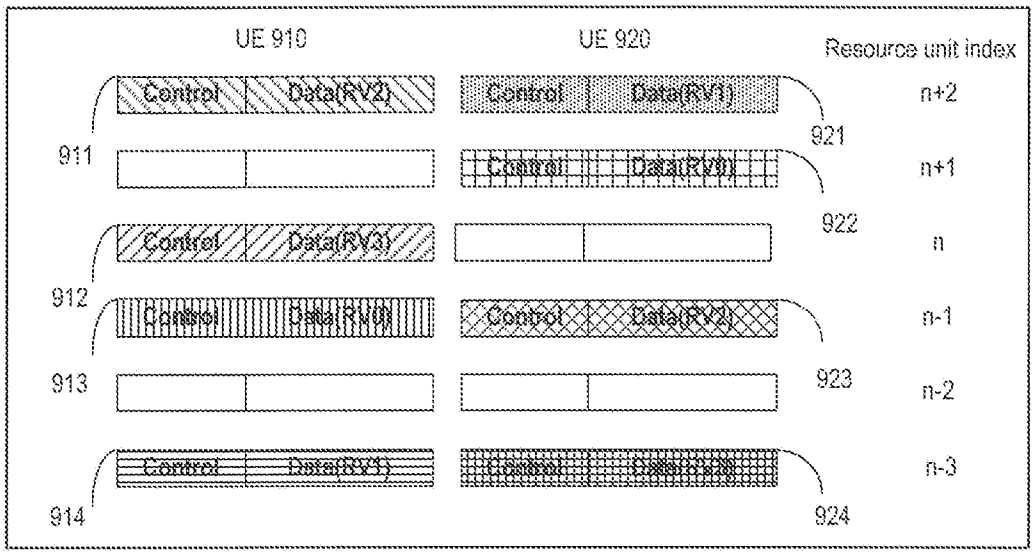
UE 910
UE 920
Resource unit index
Control
Data(RV2)
Control
Data(RV1)
911
921
n+2
Control
Data(RV0)
n+1
922
Control
Data(RV3)
n
912
Control
Data(RV0)
Control
Data(RV2)
n-1
913
923
n-2
Control
Data(RV1)
914
924
n-3

FIG. 9

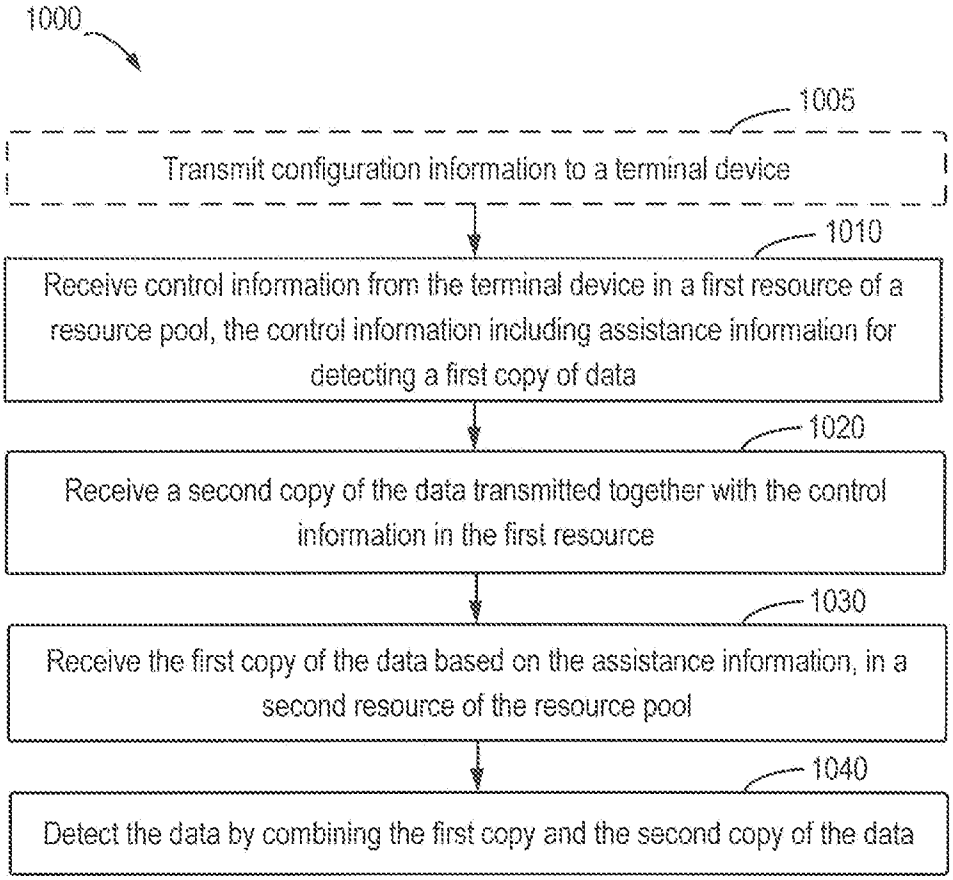
1000
1005
Transmit configuration information to a terminal device
1010
Receive control information from the terminal device in a first resource of a resource pool, the control information including assistance information for detecting a first copy of data
1020
Receive a second copy of the data transmitted together with the control information in the first resource
1030
Receive the first copy of the data based on the assistance information, in a second resource of the resource pool
1040
Detect the data by combining the first copy and the second copy of the data

FIG. 10

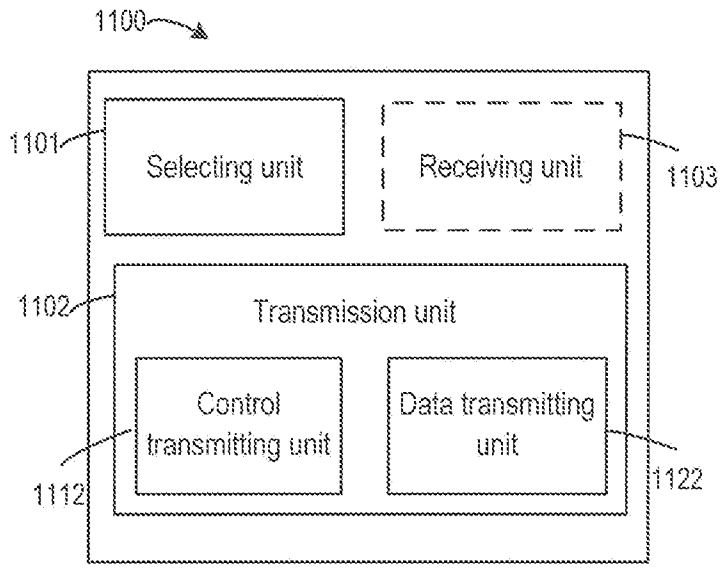
1100
1101
Selecting unit
Receiving unit
1103
1102
Transmission unit
Control transmitting unit
Data transmitting unit
1112
1122

FIG. 11

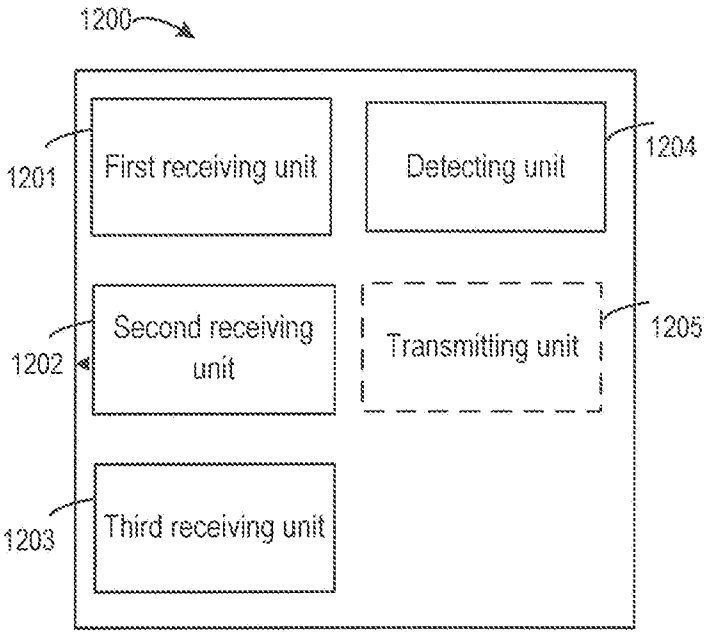
1200
First receiving unit
1201
Detecting unit
1204
Second receiving unit
1202
Transmitting unit
1205
Third receiving unit
1203

FIG. 12

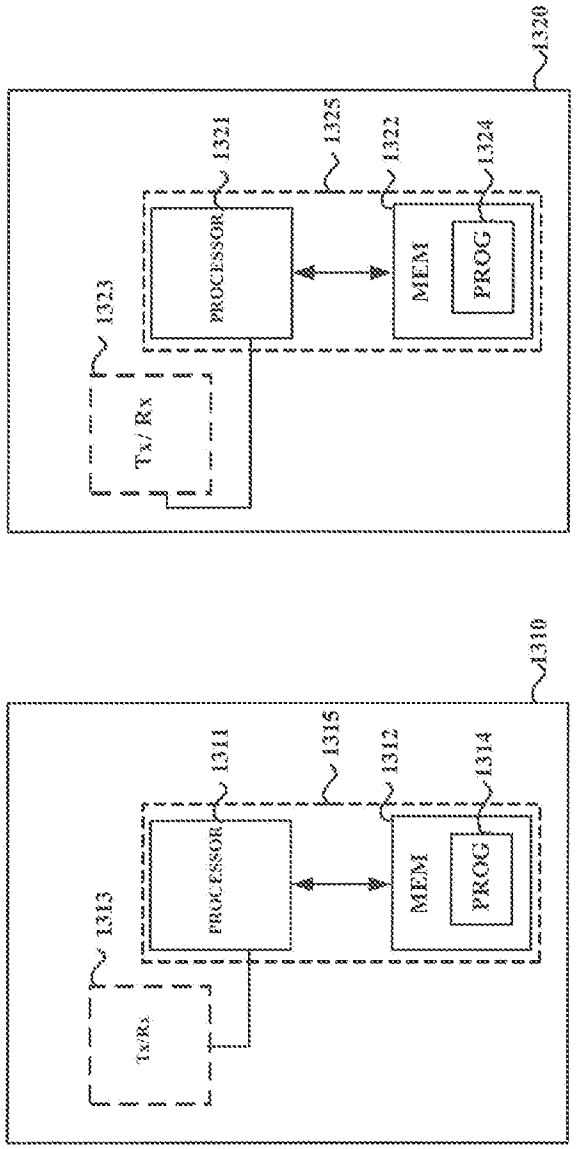
1320
1321
1325
1322
1324
1323
PROCESSOR
MEM
PROG
Tx/ Rx
1310
1311
1315
1312
1314
1313
PROCESSOR
MEM
PROG
Tx/Rx

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/071925

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/12(2009.01)i; H04L 1/18(2006.01)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 H04L 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)

CNPAT, CNKI, WPI, EPODOC: copy, resource pool, data, control information, index, LTE, latency, delay, collision, uplink, grant free, 5G

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 105517168 A (DONGGUAN COOLPAD SOFTWARE TECHNOLOGY CO., LTD.) 20 April 2016 (2016-04-20) abstract, description, paragraphs [0006]-[0189]	1-40
Y	WO 2009068499 A1 (NOKIA SIEMENS NETWORKS OY) 04 June 2009 (2009-06-04) abstract, description, paragraphs [0014]-[0028]	1-40
A	CN 1997013 A (HUAZHONG UNIVERSITY OF SCIENCE & TECHNOLOGY) 11 July 2007 (2007-07-11) the whole document	1-40
A	CN 106162910 A (ZTE CORPORATION) 23 November 2016 (2016-11-23) the whole document	1-40
A	US 2016323911 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 03 November 2016 (2016-11-03) the whole document	1-40

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

"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

Date of the actual completion of the international search	Date of mailing of the international search report
16 September 2017	**28 September 2017**

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**	**YAN,Hongbo**
Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)61648511**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/071925

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 105517168 A	20 April 2016	WO 2017101207 A1	22 June 2017
WO 2009068499 A1	04 June 2009	EP 2218204 A1	18 August 2010
		CN 101878612 A	03 November 2010
		RU 2010126339 A	10 January 2012
		US 2010275082 A1	28 October 2010
		US 2013290804 A1	31 October 2013
		EP 2066063 A1	03 June 2009
		CN 103312478 A	18 September 2013
		ZA 201003470 A	29 September 2010
		RU 2469482 C2	10 December 2012
CN 1997013 A	11 July 2007	None	
CN 106162910 A	23 November 2016	None	
US 2016323911 A1	03 November 2016	WO 2014135126 A1	12 September 2014
		EP 2946624 A1	25 November 2015
		IN 201502810 P2	24 June 2016
		SG 10201702411 A1	30 May 2017
		JP 2016514416 A	19 May 2016
		KR 20170081766 A	12 July 2017
		KR 20150119355 A	23 October 2015
		VN 45518 A	25 January 2016
		JP 2017147758 A	24 August 2017
		BR 112015021803 A2	18 July 2017
		US 2014254544 A1	11 September 2014
		SG 11201506590 A1	29 September 2015
		RU 2621909 C2	08 June 2017
		CN 105284172 A	27 January 2016