



(51) International Patent Classification:

H04W 72/04 (2009.01)

(21) International Application Number:

PCT/CN2019/123990

(22) International Filing Date:

09 December 2019 (09.12.2019)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1820352.1

13 December 2018 (13.12.2018) GB

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(54) Title: MANAGEMENT OF PRE-ALLOCATED RESOURCES

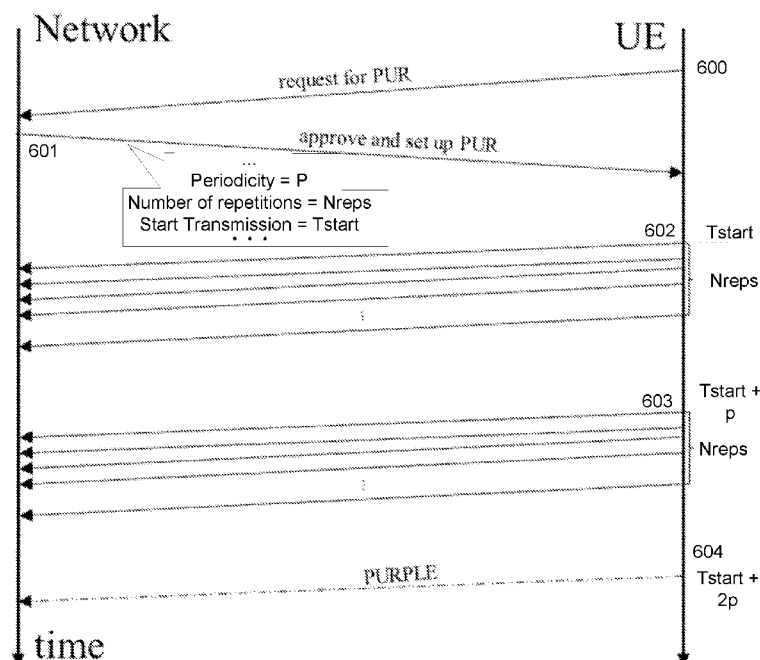


Figure 6

(57) **Abstract:** Methods and systems for the management of pre-allocated uplink resources. Uplink resources are allocated by a cellular network for a UE to utilise. The UE may transmit an indication that the UE intends to, or does not intend, use allocated resources for a transmission. In an example the UE transmits a highly detectable signal to indicate that the resources are not going to be utilised.



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

Published:

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

Management of Pre-Allocated Resources

Technical Field

[1] The following disclosure relates to uplink transmission resources in cellular communications systems, and in particular to the management of pre-allocated resources.

Background

[2] Wireless communication systems, such as the third-generation (3G) of mobile telephone standards and technology are well known. Such 3G standards and technology have been developed by the Third Generation Partnership Project (3GPP). The 3rd generation of wireless communications has generally been developed to support macro-cell mobile phone communications. Communication systems and networks have developed towards a broadband and mobile system.

[3] In cellular wireless communication systems User Equipment (UE) is connected by a wireless link to a Radio Access Network (RAN). The RAN comprises a set of base stations which provide wireless links to the UEs located in cells covered by the base station, and an interface to a Core Network (CN) which provides overall network control. As will be appreciated the RAN and CN each conduct respective functions in relation to the overall network. For convenience the term cellular network will be used to refer to the combined RAN & CN, and it will be understood that the term is used to refer to the respective system for performing the disclosed function.

[4] The 3rd Generation Partnership Project has developed the so-called Long Term Evolution (LTE) system, namely, an Evolved Universal Mobile Telecommunication System Terrestrial Radio Access Network, (E-UTRAN), for a mobile access network where one or more macro-cells are supported by a base station known as an eNodeB or eNB (evolved NodeB). More recently, LTE is evolving further towards the so-called 5G or NR (new radio) systems where one or more cells are supported by a base station known as a gNB. NR is proposed to utilise an Orthogonal Frequency Division Multiplexed (OFDM) physical transmission format.

[5] NB-IoT (Narrow Band Internet of Things) and eMTC (enhanced Machine Type Communications) are 3GPP technologies for supporting machine type communications. NB-IoT is particularly focussed on devices with low complexity and energy consumption which provide a low data throughput. Machine type communications are often characterised by small infrequent data transmissions, but with a requirement to support longer ranges than convention cellular communications. To support longer ranges Coverage Enhancement (CE) modes are provided which enable repetition of transmissions to improve link quality. NB-IoT provides enhanced and extreme coverage modes and eMTC provides CE Modes A & B.

[6] For example, in NB-IoT up to 128 repetitions may be utilised for low SNR channels, as shown in Figure 1.

[7] To reduce the control overhead, and improve latency, a system of Preconfigured Uplink Resources (PUR) may be utilised. In such a system the network allocates uplink resources (in time and frequency) with a specific periodicity which a UE may utilise for its uplink transmissions. This avoids the need for the transmission of a grant request and subsequent control communications. When a UE is in enhanced coverage additional resources in each period may be needed for the repeat transmissions, but other UEs may have nothing to transmit and hence do not require their allocated resources. If allocated resources are not utilised they are wasted as they are preconfigured for a specific UE (or group of UEs).

[8] The minimum time/frequency allocation for UL transmissions in NB-IoT is known as a Resource Unit (RU), as defined in TS 36.211. The size of an RU depends on the Narrow Band Physical Uplink Shared Channel (NB-PUSCH) format and the subcarrier format. Figure 2 shows the available formats. A maximum of 16 slots is used. The slot timing information is dependent on subcarrier spacing. For $\Delta f = 3.75\text{kHz}$ each slot requires 2 ms, and for $\Delta f = 15\text{kHz}$ each slot requires 0.5 ms. NPUSCH format 1 is used for UL data transmission and format 2 for HARQ ACK/NACK messages.

[9] NB-IoT and eMTC services are intended for low-cost devices in which frequency/time synchronisation degradation is likely to occur over long transmission times. It has therefore been proposed that after a transmission of 256 ms a gap of 40 ms is provided to allow for receiver frequency/time resynchronisation. Figure 3 shows the UL transmission and resynchronisation timelines for NB-IoT, at RU-level and for transmission/synchronisation blocks.

[10] For eMTC, uplink transmissions are defined in the same way as legacy LTE with the addition of repetitions. Figure 4 shows the maximum number of repetitions. In eMTC the transmission of a Physical Resource Block (PRB) takes 0.5 ms and the minimum allocation of 2 sequential PRBs in the time domain per transmission, the total transmission time could take up to 2048 ms for 2048 repetitions. For HD-FDD eMTC devices a transmission can take up to 2368ms thanks to the resynchronization time.

[11] In order for a UE to retain its PUR allocation it must utilise the resources at least once after several skips otherwise they may be terminated. However, if there is currently no data to transmit then such transmissions must be dummy transmissions. This increases power consumption and wastes transmission resources, particularly in enhanced coverage where the allocated resources include capacity for all repetitions. In addition, in case the UE skips the transmission, the network has no knowledge of the skip and therefore is unable to utilize these resources.

[12] There is therefore a requirement for more efficient use of resources in a system using PURs.

Summary

[13] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[14] There is provided a method of uplink resource allocation in a cellular communication system, the method comprising the steps of allocating uplink transmission resources for transmissions from a UE to a base station, wherein the uplink transmission resources repeat with a predefined periodicity; transmitting an indication of the allocated resources to the UE; and if an occurrence of the allocated resources is not required transmitting from the UE to the base station, in that occurrence of the allocated resources, an indication that that occurrence of the resources is not required.

[15] The uplink transmission resources may comprise resources for N repetitions of an uplink transmission.

[16] The indication may occupy the resources for up to one of the N repetitions.

[17] The preamble may be selected to have a high detection rate.

- [18] The indication may be a Zadoff-Chu sequence, a DMRS, or a low data rate subframe, or any other high-detectable transmission which may or may not be compromised as a mix of the above.
- [19] The indication may be an indication to suspend the allocated resources for the UE.
- [20] The indication may be an indication to terminate the allocated resources for the UE.
- [21] There is also provided a method of uplink resource allocation in a cellular communication system, the method performed by a UE and comprising the steps of receiving an indication of allocated uplink transmission resources for transmissions from the UE to a base station, wherein the uplink transmission resources repeat with a predefined periodicity; and if an occurrence of the allocated resources is not required transmitting from the UE to the base station, in that occurrence of the allocated resources, an indication that that occurrence of the resources is not required.
- [22] The uplink transmission resources may comprise resources for N repetitions of an uplink transmission.
- [23] The indication may occupy the resources for up to one of the N repetitions.
- [24] The indication may be a Zadoff-Chu sequence, a DMRS, or a low data rate subframe, or any other high-detectable transmission which may or may not be compromised as a mix of the above.
- [25] The indication may be an indication to suspend the allocated resources for the UE.
- [26] The indication may be an indication to terminate the allocated resources for the UE.
- [27] There is also provided a UE configured to perform the methods described herein.
- [28] There is also provided a method of uplink resource allocation in a cellular communication system, the method comprising the steps of allocating uplink transmission resources for transmissions from a UE to a base station, wherein the uplink transmission resources repeat with a predefined periodicity; transmitting an indication of the allocated resources to the UE; and at the start of an occurrence in which the UE intends to make a transmission, transmitting a preamble from the UE to the base station, wherein the preamble indicates there is a transmission from the UE in the resources.
- [29] The uplink transmission resources may comprise resources for N repetitions of an uplink transmission.
- [30] The preamble may be selected to have a high detection rate.
- [31] The preamble may be a Zadoff-Chu sequence, a DMRS, or a low data rate subframe, or any other high-detectable transmission which may or may not be compromised as a mix of the above.
- [32] There is also provided a method of uplink resource allocation in a cellular communication system, the method performed by a UE and comprising the steps of receiving an indication of allocated uplink transmission resources for transmissions from the UE to a base station, wherein the uplink transmission resources repeat with a predefined periodicity; and if an occurrence of the allocated resources is required, transmitting at the start of the occurrence a preamble from the UE to the base station, wherein the preamble indicates there will be a transmission from the UE in the resources.
- [33] The uplink transmission resources may comprise resources for N repetitions of an uplink transmission.

[34] The preamble may be selected to have a high detection rate.

[35] The indication may be a Zadoff-Chu sequence, a DMRS, or a low data rate subframe, or any other high-detectable transmission which may or may not be compromised as a mix of the above.

[36] There is also provided a UE configured to perform the methods described herein.

[37] The non-transitory computer readable medium may comprise at least one from a group consisting of: a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read Only Memory, a Programmable Read Only Memory, an Erasable Programmable Read Only Memory, EPROM, an Electrically Erasable Programmable Read Only Memory and a Flash memory.

Brief description of the drawings

[38] Further details, aspects and embodiments of the invention will be described, by way of example only, with reference to the drawings. Elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. Like reference numerals have been included in the respective drawings to ease understanding.

[39] Figure 1 shows possible repetitions in NB-IoT;

[40] Figure 2 shows NPUSCH formats;

[41] Figure 3 shows uplink transmission and resynchronisation timelines for NB-IoT;

[42] Figure 4 shows maximum numbers of repetitions;

[43] Figure 5 shows a schematic diagram of elements of a cellular communications network;

[44] Figure 6 shows a communication protocol relating to uplink resource management;

[45] Figure 7 shows a processing scheme for uplink physical channels;

[46] Figure 8 shows simulation results for detection probability for different sequences; and

[47] Figure 9 shows relative detection probabilities for different sequences.

Detailed description of the preferred embodiments

[48] Those skilled in the art will recognise and appreciate that the specifics of the examples described are merely illustrative of some embodiments and that the teachings set forth herein are applicable in a variety of alternative settings.

[49] Figure 5 shows a schematic diagram of three base stations (for example, eNB or gNBs depending on the particular cellular standard and terminology) forming a cellular network. Typically, each of the base stations will be deployed by one cellular network operator to provide geographic coverage for UEs in the area. The base stations form a Radio Area Network (RAN). Each base station provides wireless coverage for UEs in its area or cell. The base stations are interconnected via the X2 interface and are connected to the core network via the S1 interface. As will be appreciated only basic details are shown for the purposes of exemplifying the key features of a cellular network.

[50] The base stations each comprise hardware and software to implement the RAN's functionality, including communications with the core network and other base stations, carriage of control and data signals between the core network and UEs, and maintaining wireless communications with UEs associated with each base station. The core network comprises hardware and software to implement the network functionality, such as overall network

management and control, and routing of calls and data. UEs (not shown) for connecting to the cellular network comprise hardware and software to provide the functionality described herein and to provide the normal operating capabilities associated with a UE.

[51] Figure 6 shows a transmission diagram between a cellular network and a UE connected to a base station of that network. At step 600 the UE transmits a request to the network for uplink resources to be preconfigured for use by the UE. At step 601 the network allocates appropriate resources and transmits (from the relevant base station) an indication to the UE of the allocated resources. The details may include time and frequency allocations, periodicity (P), the number of repetitions per transmission in each period (N_{reps}), and the starting transmission time (T_{start}). Each of these may be explicitly or implicitly signalled, or in some circumstances may not be required.

[52] The UE then has the resources available for transmission and at steps 602 and 603 the UE utilises the allocated resources to transmit data to the cellular network. However, at the next available occurrence of the resources, 604, the UE does not have data to transmit and hence does not require the resources. In the prior art systems discussed above the UE had the possibility of transmitting nothing, and losing the resources, or making a dummy transmission and hence consuming power despite having not data to transmit.

[53] According to the method of Figure 6, in place of a regular transmission (or no transmission) the UE transmits an indication, which may be known as a preamble, in the first resources of the next repetition at 604. The preamble is received by the network and decoded as an indication that the UE does not have any data to transmit but does not wish to terminate the resource allocation. The cellular network thus knows not to expect any further transmission in this occurrence of the resources but does not cancel the allocation. The cellular network can re-allocate the resources that will not be used to other UEs.

[54] The effect of transmitting the preamble when the resources are not required is to reduce the UE power consumption compared to transmitting dummy data. Without the disclosed technique to preserve the resources using dummy data the UE would have to transmit N_{reps} . Assuming the transmission power of the preamble is the same as one data transmission, then the saved power ($P_{\text{conserved}}$) is given by :-

$$P_{\text{conserved}} = (N_{\text{reps}} - 1) * P_{\text{Tx}}$$

[55] Where P_{Tx} is the power of one repetition. As the number configured repetitions increases the power saving also increases. Where $N_{\text{reps}} = 1$ there is no power saving as the preamble takes the place of the only dummy transmission that would be required. The method may therefore only be applied when $N_{\text{reps}} > 1$, and if $N_{\text{reps}} = 1$ a dummy transmission can be made.

[56] The preamble may be any signal that the cellular network can receive and recognise as an indication that the resources allocated to the UE should be suspended. The signal must thus convey the identity of the UE (implicitly or explicitly), but no other data may be required. However, it is also possible to use the preamble to transmit control data or user data if required. The preamble may be selected to have a high detection rate.

[57] In an example the preamble may be a Zadoff-Chu sequence (ZC-sequence). Such sequences have a high detection rate and enable the signal to be transmitted at a high power due to good PAPR properties. A fixed root, defined length, $12 \cdot n_{\text{RB}}$ sequence may be used. n_{RB} is defined as the bandwidth in resource blocks for the predefined UL transmission. The sequence is repeated over all 14 OFDM symbols in the transmission subframe. A potential drawback of such a sequence is that such sequences are not conventionally used in uplink transmissions and accordingly may lead to additional complexity for the UE and cellular network.

[58] In a further example a UL-DMRS (Demodulation Reference Signal) may be utilised as the preamble. Such signals also have good detection probability and PAPR properties and have the benefit that they are already utilised for uplink transmissions so additional complexity should be minimised. The same DMRS may be used for each transmission in all 14 OFDM symbols in the subframe, or alternatively different DMRSs may be utilised in each or some of the OFDM symbols. In further examples a longer DMRS may be selected which can fill all or some of the OFDM symbols and thus avoid repetition of the sequence.

[59] In a further example known sequence may be utilised as the preamble which is transmitted in the same way as a conventional transmission on NPUSCH. The sequence may be transmitted as a low data rate subframe. Figure 7, derived from Figure 5.3-1 of TS 36-211, shows the uplink physical channel processing process. In an example the sequence may be [0 1 0 1 0 1 0 1]. Compared to the earlier-described examples such sequences may have a lower detection probability and a varying PAPR, although the latter may be reduced by selection of a sequence having a low PAPR. There is a risk, if the normal transmission chain is utilised, that the decoded sequence is a real data string leading to erroneous decoding. With the assumption that the data string is evenly distributed, the chance of such a data string naturally arriving at the transmitter is 1 in 2 in the power of the sequence length.

[60] An important factor in the selection of the preamble is the detection probability as the signal affects uplink transmission for a number of subsequent subframes. Figure 8 shows simulation results of detection failure against SNR for different preambles. An SNR of -19dB is equivalent to MCL of -164dBm which is extreme coverage. In the simulation, each transmission takes 1 subframe in the time domain and 1 or 2 RBs of bandwidth (as shown in the key).

[61] Figure 8 shows an advantage for **Error! Reference source not found.** the Zadoff-Chu sequences, followed by DMRS, while lower bitrate sequences have the worst detection probability. A preamble could be repeated several times to improve detection probability, but power savings would be reduced.

[62] Figure 9 shows the effect of the different types of preamble on various factors that are relevant to the choice of preamble.

[63] In the foregoing description a preamble has been transmitted to indicate that allocated resources are not required and can be suspended. In an alternative arrangement the preamble may indicate that the resources can be terminated.

[64] In a further alternative, the preamble is an indication that data is being transmitted in the allocated resources. That is the preamble is transmitted prior to each UL transmission and used by the cellular network as an indication that data is expected. If the UE doesn't have anything to transmit the allocated resources can be skipped. Such a system increases the overhead for each transmission, but conserves the power used by the UE when there is no data to send as the device can stay in IDLE without having to make dummy transmission. Since there is no positive indication that the UE is not making a transmission the network cannot know whether a missed reception is due to a lost connection or a deliberate non-transmission. A longer reservation for a PUR may thus be needed.

[65] The proposed preambles are selected to be easy to detect and hence improves the chances of the receiving base station detecting the transmission, including in bad channel conditions. Failure to detect the preamble at the start of the resources is therefore an early indication that the UE does not intend to use the resources. The base station is thus aware, before the actual data transmission starts, that the UE is not going to use the resources.

[66] The cellular network can thus reallocate the resources as soon as the preamble period ends without receipt.

[67] The selected preamble may be utilised to transmit additional information from the UE. For example, several roots for the ZC-sequence, or several sequences, can form a set of possible preambles. A selected root or sequence can then be selected corresponding to the information required. For example, one sequence may indicate a request to suspend resources and another sequence may indicate a request to terminate the allocation. The same principles may be applied to the use of DMRS but may be more difficult due to the risk of interference with neighbouring cells. In an example, the data carried could be an indication of how long the UE intends to suspend transmission for. Predefined periods may be defined and each period indicated by a selected preamble. Such a system may provide further savings as the UE only needs to transmit one preamble per suspension, rather than one per occurrence of the resources.

[68] Such a system, however, increases the complexity of the receive chain as blind decoding must be performed over multiple sequences.

[69] Although not shown in detail any of the devices or apparatus that form part of the network may include at least a processor, a storage unit and a communications interface, wherein the processor unit, storage unit, and communications interface are configured to perform the method of any aspect of the present invention. Further options and choices are described below.

[70] The signal processing functionality of the embodiments of the invention especially the gNB and the UE may be achieved using computing systems or architectures known to those who are skilled in the relevant art. Computing systems such as, a desktop, laptop or notebook computer, hand-held computing device (PDA, cell phone, palmtop, etc.), mainframe, server, client, or any other type of special or general purpose computing device as may be desirable or appropriate for a given application or environment can be used. The computing system can include one or more processors which can be implemented using a general or special-purpose processing engine such as, for example, a microprocessor, microcontroller or other control module.

[71] The computing system can also include a main memory, such as random access memory (RAM) or other dynamic memory, for storing information and instructions to be executed by a processor. Such a main memory also may be used for storing temporary variables or other intermediate information during execution of instructions to be executed by the processor. The computing system may likewise include a read only memory (ROM) or other static storage device for storing static information and instructions for a processor.

[72] The computing system may also include an information storage system which may include, for example, a media drive and a removable storage interface. The media drive may include a drive or other mechanism to support fixed or removable storage media, such as a hard disk drive, a floppy disk drive, a magnetic tape drive, an optical disk drive, a compact disc (CD) or digital video drive (DVD) read or write drive (R or RW), or other removable or fixed media drive. Storage media may include, for example, a hard disk, floppy disk, magnetic tape, optical disk, CD or DVD, or other fixed or removable medium that is read by and written to by media drive. The storage media may include a computer-readable storage medium having particular computer software or data stored therein.

[73] In alternative embodiments, an information storage system may include other similar components for allowing computer programs or other instructions or data to be loaded into the computing system. Such components may include, for example, a removable storage unit and an interface, such as a program cartridge and cartridge interface, a removable memory (for example, a flash memory or other removable memory module) and memory slot, and other

removable storage units and interfaces that allow software and data to be transferred from the removable storage unit to computing system.

[74] The computing system can also include a communications interface. Such a communications interface can be used to allow software and data to be transferred between a computing system and external devices. Examples of communications interfaces can include a modem, a network interface (such as an Ethernet or other NIC card), a communications port (such as for example, a universal serial bus (USB) port), a PCMCIA slot and card, etc. Software and data transferred via a communications interface are in the form of signals which can be electronic, electromagnetic, and optical or other signals capable of being received by a communications interface medium.

[75] In this document, the terms 'computer program product', 'computer-readable medium' and the like may be used generally to refer to tangible media such as, for example, a memory, storage device, or storage unit. These and other forms of computer-readable media may store one or more instructions for use by the processor comprising the computer system to cause the processor to perform specified operations. Such instructions, generally referred to as 'computer program code' (which may be grouped in the form of computer programs or other groupings), when executed, enable the computing system to perform functions of embodiments of the present invention. Note that the code may directly cause a processor to perform specified operations, be compiled to do so, and/or be combined with other software, hardware, and/or firmware elements (e.g., libraries for performing standard functions) to do so.

[76] The non-transitory computer readable medium may comprise at least one from a group consisting of: a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a Read Only Memory, a Programmable Read Only Memory, an Erasable Programmable Read Only Memory, EPROM, an Electrically Erasable Programmable Read Only Memory and a Flash memory. In an embodiment where the elements are implemented using software, the software may be stored in a computer-readable medium and loaded into computing system using, for example, removable storage drive. A control module (in this example, software instructions or executable computer program code), when executed by the processor in the computer system, causes a processor to perform the functions of the invention as described herein.

[77] Furthermore, the inventive concept can be applied to any circuit for performing signal processing functionality within a network element. It is further envisaged that, for example, a semiconductor manufacturer may employ the inventive concept in a design of a stand-alone device, such as a microcontroller of a digital signal processor (DSP), or application-specific integrated circuit (ASIC) and/or any other sub-system element.

[78] It will be appreciated that, for clarity purposes, the above description has described embodiments of the invention with reference to a single processing logic. However, the inventive concept may equally be implemented by way of a plurality of different functional units and processors to provide the signal processing functionality. Thus, references to specific functional units are only to be seen as references to suitable means for providing the described functionality, rather than indicative of a strict logical or physical structure or organisation.

[79] Aspects of the invention may be implemented in any suitable form including hardware, software, firmware or any combination of these. The invention may optionally be implemented, at least partly, as computer software running on one or more data processors and/or digital signal processors or configurable module components such as FPGA devices.

[80] Thus, the elements and components of an embodiment of the invention may be physically, functionally and logically implemented in any suitable way. Indeed, the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. Although

the present invention has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the accompanying claims. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognise that various features of the described embodiments may be combined in accordance with the invention. In the claims, the term 'comprising' does not exclude the presence of other elements or steps.

[81] Furthermore, although individually listed, a plurality of means, elements or method steps may be implemented by, for example, a single unit or processor. Additionally, although individual features may be included in different claims, these may possibly be advantageously combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. Also, the inclusion of a feature in one category of claims does not imply a limitation to this category, but rather indicates that the feature is equally applicable to other claim categories, as appropriate.

[82] Furthermore, the order of features in the claims does not imply any specific order in which the features must be performed and in particular the order of individual steps in a method claim does not imply that the steps must be performed in this order. Rather, the steps may be performed in any suitable order. In addition, singular references do not exclude a plurality. Thus, references to 'a', 'an', 'first', 'second', etc. do not preclude a plurality.

[83] Although the present invention has been described in connection with some embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the accompanying claims. Additionally, although a feature may appear to be described in connection with particular embodiments, one skilled in the art would recognise that various features of the described embodiments may be combined in accordance with the invention. In the claims, the term 'comprising' or "including" does not exclude the presence of other elements.

Claims

1. A method of uplink resource allocation in a cellular communication system, the method comprising the steps of
allocating uplink transmission resources for transmissions from a UE to a base station, wherein the uplink transmission resources repeat with a predefined periodicity;
transmitting an indication of the allocated resources to the UE; and
if an occurrence of the allocated resources is not required transmitting from the UE to the base station, in that occurrence of the allocated resources, an indication that that occurrence of the resources is not required.
2. A method according to claim 1, wherein the uplink transmission resources comprise resources for N repetitions of an uplink transmission.
3. A method according to claim 2, wherein the indication occupies the resources for up to one of the N repetitions.
4. A method according to claim 1 or claim 2, wherein the preamble is selected to have a high detection rate.
5. A method according to any preceding claim, wherein the indication is a Zadoff-Chu sequence, a DMRS, or a low data rate subframe, or a combination thereof.
6. A method according to any preceding claim, wherein the indication is an indication to suspend the allocated resources for the UE.
7. A method according to any of claims 1 to 5, wherein the indication is an indication to terminate the allocated resources for the UE.
8. A method of uplink resource allocation in a cellular communication system, the method performed by a UE and comprising the steps of
receiving an indication of allocated uplink transmission resources for transmissions from the UE to a base station, wherein the uplink transmission resources repeat with a predefined periodicity; and
if an occurrence of the allocated resources is not required transmitting from the UE to the base station, in that occurrence of the allocated resources, an indication that that occurrence of the resources is not required.
9. A method according to claim 8, wherein the uplink transmission resources comprise resources for N repetitions of an uplink transmission.
10. A method according to claim 8, wherein the indication occupies the resources for up to one of the N repetitions.
11. A method according to any of claims 8 to 10, wherein the indication is a Zadoff-Chu sequence, a DMRS, or a low data rate subframe, or a combination thereof.
12. A method according to any of claims 8 to 11, wherein the indication is an indication to suspend the allocated resources for the UE.

13. A method according to any of claims 8 to 11, wherein the indication is an indication to terminate the allocated resources for the UE.
14. A UE configured to perform the method of any of claims 8 to 13.
15. A method of uplink resource allocation in a cellular communication system, the method comprising the steps of
 - allocating uplink transmission resources for transmissions from a UE to a base station, wherein the uplink transmission resources repeat with a predefined periodicity;
 - transmitting an indication of the allocated resources to the UE; and
 - at the start of an occurrence in which the UE intends to make a transmission, transmitting a preamble from the UE to the base station, wherein the preamble indicates there is a transmission from the UE in the resources.
16. A method according to claim 15, wherein the uplink transmission resources comprise resources for N repetitions of an uplink transmission.
17. A method according to claim 14 or 15, wherein the preamble is selected to have a high detection rate.
18. A method according to any of claims 15 to 17, wherein the preamble is a Zadoff-Chu sequence, a DMRS, or a low data rate subframe, or a combination thereof.
19. A method of uplink resource allocation in a cellular communication system, the method performed by a UE and comprising the steps of
 - receiving an indication of allocated uplink transmission resources for transmissions from the UE to a base station, wherein the uplink transmission resources repeat with a predefined periodicity; and
 - if an occurrence of the allocated resources is required, transmitting at the start of the occurrence a preamble from the UE to the base station, wherein the preamble indicates there will be a transmission from the UE in the resources.
20. A method according to claim 19, wherein the uplink transmission resources comprise resources for N repetitions of an uplink transmission.
21. A method according to claim 19 or 20, wherein the preamble is selected to have a high detection rate.
22. A method according to any of claims 19 to 21, wherein the indication is a Zadoff-Chu sequence, a DMRS, or a low data rate subframe, or a combination thereof.
23. A UE configured to perform the method of any of claims 21 to 24.

I_{Rep}	N_{Rep}
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128

Figure 1

NPUSCH format	Δf	$??_{sc}^{RU}$	$??_{slots}^{UL}$	$??_{symb}^{UL}$
1	3.75 kHz	1	16	7
	15 kHz	1	16	
		3	8	
		6	4	
		12	2	
2	3.75 kHz	1	4	
	15 kHz	1	4	

Figure 2

[illegible]

Figure 3

Time [ms]=	552- 592	848- 888	1144- 1184	1184- 1440	1440-1480	1736- 1776	1776- 2022	2022- 2062	2062- 2318	2318- 2358	2358- 2614	2614- 2654
$\Delta f=15\text{KHz}$	Synch	Tx Sync	Synch Tx	EOT								
$\Delta f=3.75\text{KHz}$	Synch	Synch Tx	Synch Tx	Synch Tx	Synch Tx	Synch Tx	Synch Tx	Synch Tx	Synch Tx	Synch Tx	Synch Tx	Synch
Time [ms]=	2654- 2910	2950- 3206	3246- 3502	3502- 3542	3542+3798 3838	3838- 4094	4096- 4134	4134- 4390	4390- 4430	4430- 4686	4686- 4726	
$\Delta f=15\text{KHz}$												
$\Delta f=3.75\text{KHz}$	Tx Synch	Tx Synch	Tx Tx	Synch Tx	Synch Tx	Tx Tx	Synch Tx	Tx Tx	Synch Tx	EOT		

Higher layer parameter	$\{n1, n2, n3, n4\}$
Not configured	{1,2,4,8}
16	{1,4,8,16}
32	{1,4,16,32 }

Higher layer parameter	$\{n1, n2, \dots, n8\}$
Not configured	{4,8,16,32,64,128,256,512}
192	{1,4,8,16,32,64,128,192}
256	{4,8,16,32,64,128,192,256}
384	{4,16,32,64,128,192,256,384}
512	{4,16,64,128,192,256,384,512}
768	{8,32,128,192,256,384,512,768}
1024	{4,8,16,64,128,256,512,1024}
1536	{4,16,64,256,512,768,1024,1536}
2048	{4,16,64,128,256,512,1024,2048}

Figure 4

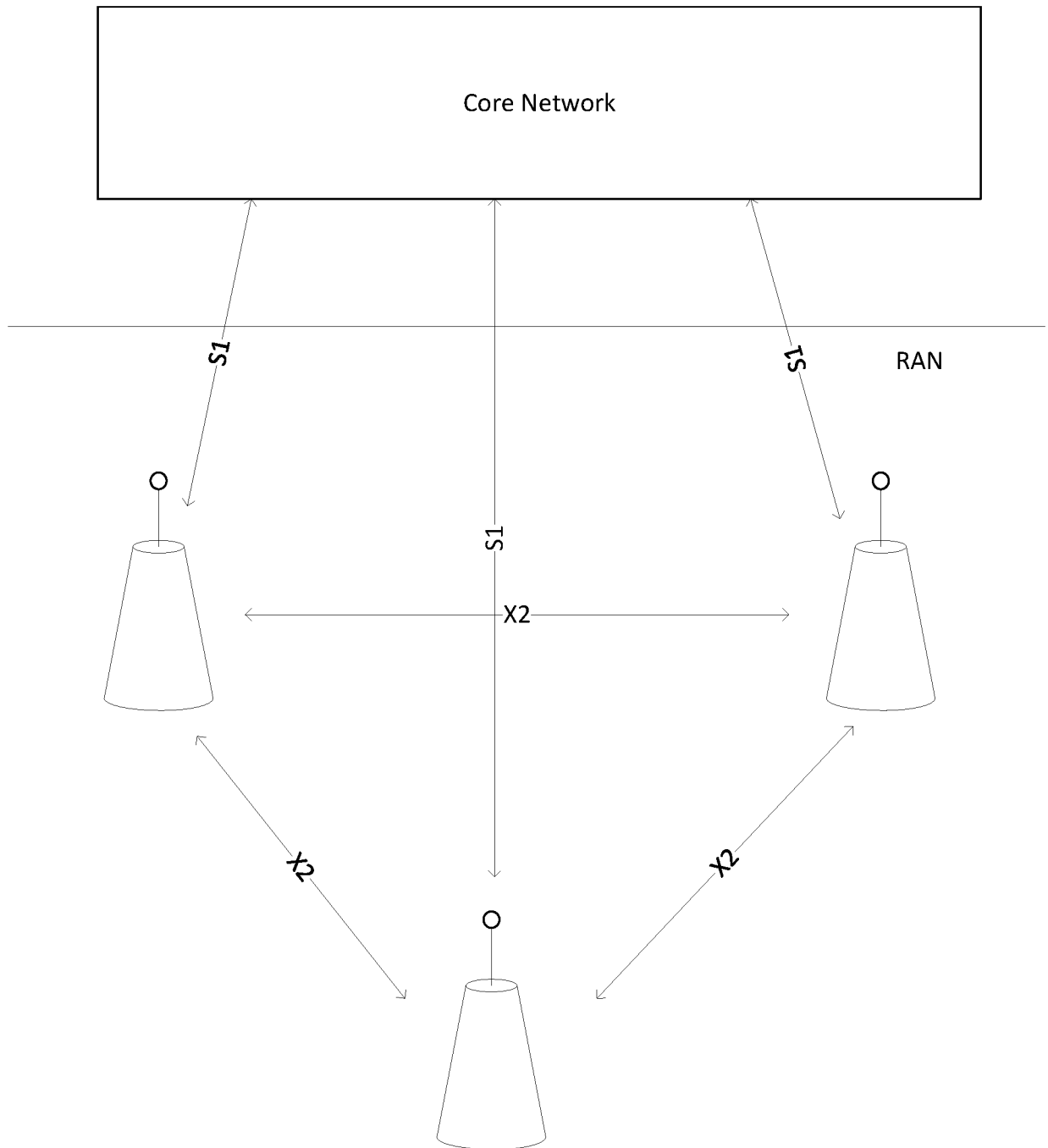


Figure 5

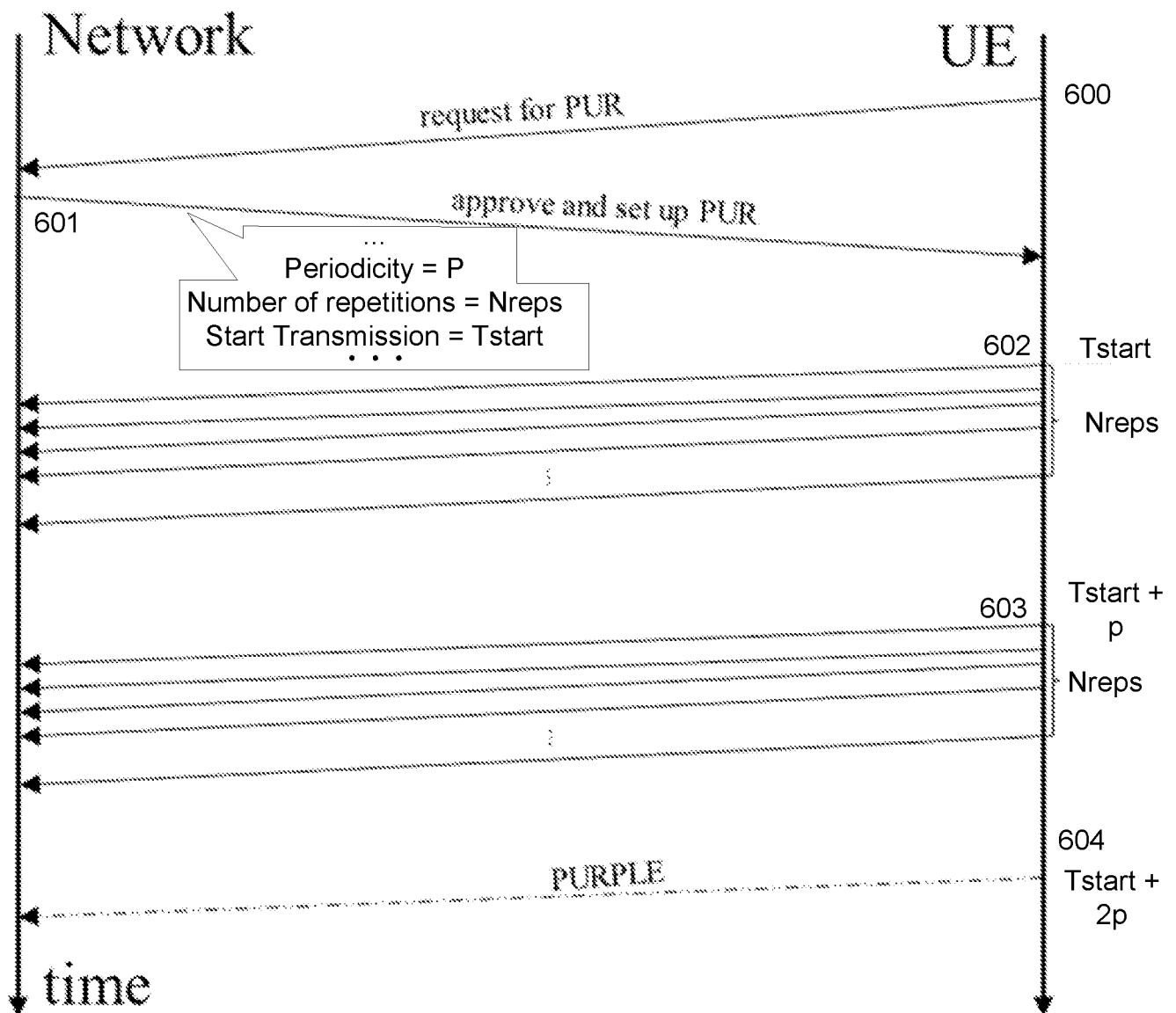


Figure 6

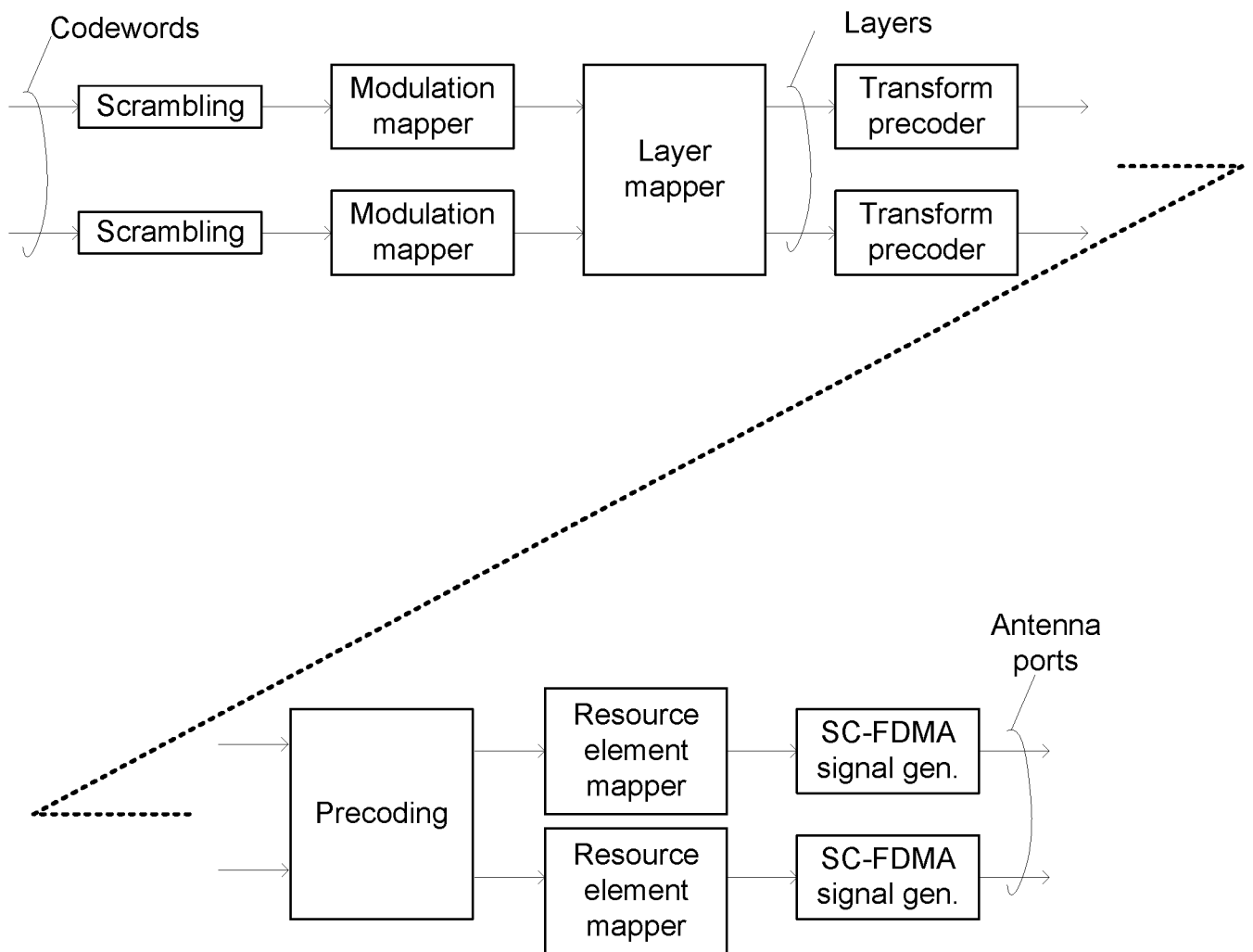


Figure 7

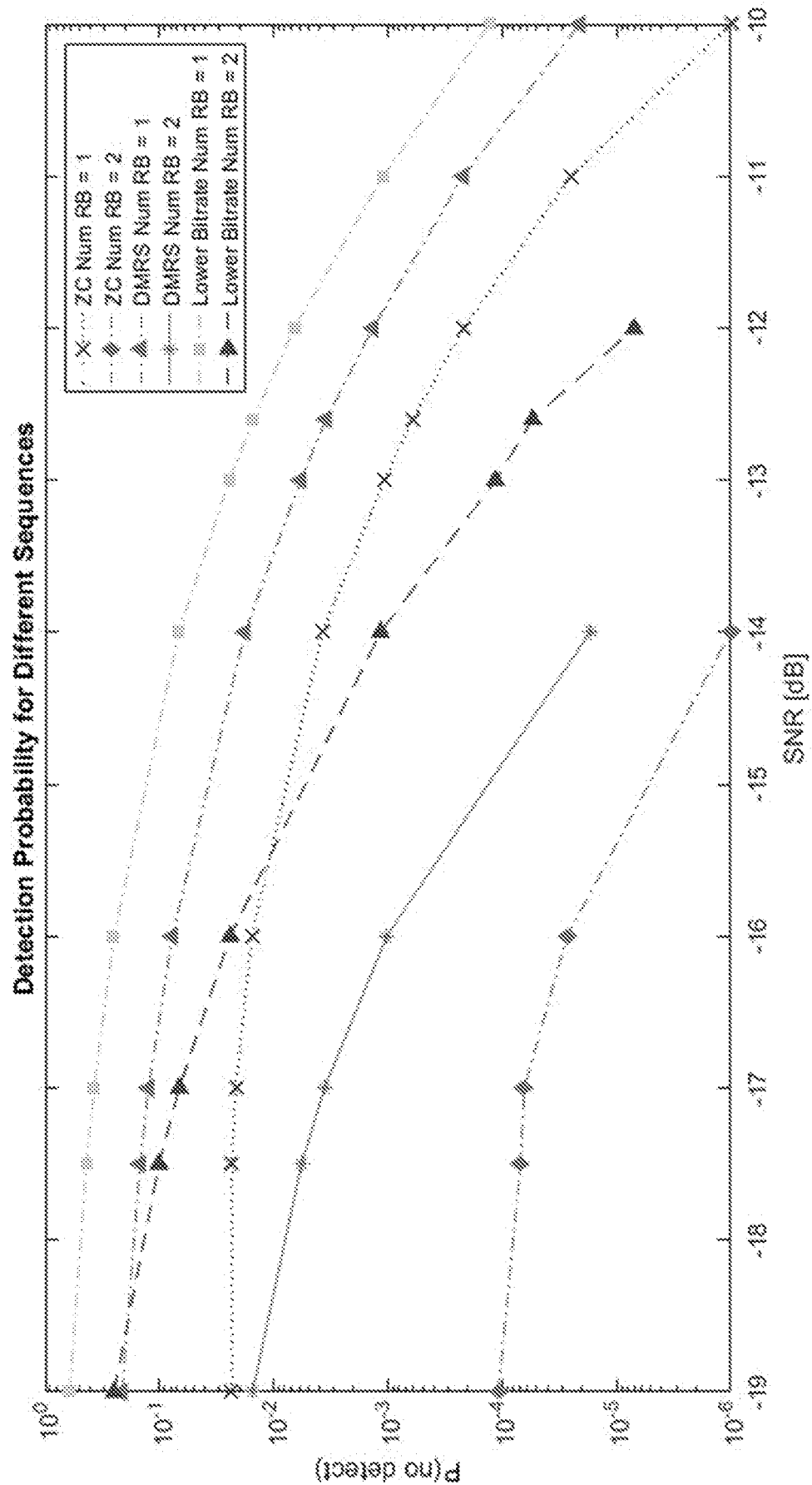


Figure 8

	Zadoff-Chu sequence	Dense DMRS sequence	Low bit rate sequence
UE complexity	High	Medium	Low
eNB complexity	Medium High	Medium	Low
Detection probability	High	Medium	Low
PAPR	Low	Low	Sequence dependent

Figure 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/123990

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; H04Q; H04L

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)

CNKI;CNPAT;WPI;EPODOC;3GPP;IEEE:uplink, resource?, allocat+, waste, indicaton, sequence

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011009333 A1 (ZTE CORPORATION) 27 January 2011 (2011-01-27) description, pages 10-13	1-23
A	US 2014204835 A1 (SCA IPLA HOLDINGS INC.) 24 July 2014 (2014-07-24) the whole document	1-23
A	CN 101137182 A (HUAWEI TECHNOLOGIES CO., LTD.) 05 March 2008 (2008-03-05) the whole document	1-23

☐ 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

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“O” document referring to an oral disclosure, use, exhibition or other means

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“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

02 March 2020

Date of mailing of the international search report

09 March 2020

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2019/123990

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WO	2011009333	A1	27 January 2011	CN	101965059	A	02 February 2011
US	2014204835	A1	24 July 2014	GB	201114348	D0	05 October 2011
				GB	2493785	B	20 April 2016
				WO	2013027025	A1	28 February 2013
				KR	20140056345	A	09 May 2014
				US	2017041063	A1	09 February 2017
				JP	2014527763	A	16 October 2014
				EP	2745612	A1	25 June 2014
				CN	103733720	A	16 April 2014
CN	101137182	A	05 March 2008	None			