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(54) Title: COMMUNICATIONS NETWORK AND METHODS WITH ENHANCED DUPLEX

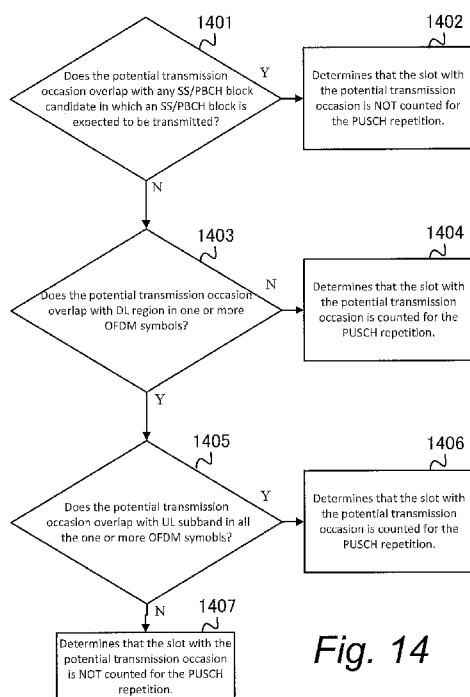


Fig. 14

(57) Abstract: A wireless terminal determines if a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH repetition is eligible for eventual transmission as an actual PUSCH repetition by checking, e.g., whether a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition has a strategic interaction with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a subband grid. In one example method, such strategic interaction comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid in the time domain. In another example, such strategic interaction comprises determining whether the one or more OFDM symbols are confined in any uplink, UL, subband of the grid in the time and frequency domain.

Description

Title of Invention: COMMUNICATIONS NETWORK AND METHODS WITH ENHANCED DUPLEX

Technical Field

[0001] The technology relates to wireless communications, and particularly to wireless terminals and operations thereof including transmission of a Physical Uplink Shared Channel, PUSCH, in duplexed operations thereof.

Background Art

[0002] A radio access network typically resides between wireless devices, such as user equipment (UEs), mobile phones, mobile stations, or any other device having wireless termination, and a core network. Example of radio access network types includes the GERAN, GSM radio access network; the GERAN, which includes EDGE packet radio services; UTRAN, the UMTS radio access network; E-UTRAN, which includes Long-Term Evolution; and g-UTRAN, the New Radio (NR).

[0003] A radio access network may comprise one or more access nodes, such as base station nodes, which facilitate wireless communication or otherwise provides an interface between a wireless terminal and a telecommunications system. A non-limiting example of a base station can include, depending on radio access technology type, a Node B (“NB”), an enhanced Node B (“eNB”), a home eNB (“HeNB”), a gNB (for a New Radio [“NR”] technology system), or some other similar terminology.

[0004] The 3rd Generation Partnership Project (“3GPP”) is a group that, e.g., develops collaboration agreements such as 3GPP standards that aim to define globally applicable technical specifications and technical reports for wireless communication systems. Various 3GPP documents may describe certain aspects of radio access networks. Overall architecture for a fifth-generation system, e.g., the 5G System, also called “NR” or “New Radio”, as well as “NG” or “Next Generation”, is shown in Fig. 24, and is also described in 3GPP TS 38.300. The 5G NR network is comprised of NG-RAN, Next Generation Radio Access Network, and 5GC, 5G Core Network. As shown, NG-RAN is comprised of gNBs, e.g., 5G Base stations, and ng-eNBs, i.e., LTE base stations. An Xn interface exists between gNB-gNB, between (gNB)-(ng-eNB) and between (ng-eNB)-(ng-eNB). The Xn is the network interface between NG-RAN nodes. Xn-U stands for Xn User Plane interface and Xn-C stands for Xn Control Plane interface. A NG interface exists between 5GC and the base stations, i.e., gNB & ng-eNB. A gNB node provides NR user plane and control plane protocol terminations towards the UE and is connected via the NG interface to the 5GC. The 5G NR, New Radio, gNB is connected to Access and Mobility Management Function, AMF, and

User Plane Function, UPF, in the 5G Core Network, 5GC.

[0005] Wireless transmissions from a base station in a direction toward a wireless terminal is referred to as being on the “downlink”, DL, transmissions from the wireless terminal in a direction toward the base station is referred to as being on the “uplink”, UL. As described in more detail herein, the transmissions may occur in a frame or sub-frame structure which may be conceptualized as a two-dimensional grid. The grid may be structured to have time slots in a first dimension and frequencies or sub-carriers in a second dimension. Time division duplex, TDD, operation occurs when information of the frame or sub-frame is split on a time basis between uplink and downlink. In TDD operation there may be a mapping or assignment, referred to as a TDD pattern, of time slots to uplink and downlink transmissions. Frequency division duplex, FDD, operation occurs when information of the frame or sub-frame is split on a frequency or sub-carrier basis between uplink and downlink.

[0006] In dynamic TDD operation, a TDD pattern is configured with flexible regions as shown in Fig. 1. The base station can convert the flexible region to DL region or UL region afterward. Specifically, the base station can indicate usage of the flexible region to the wireless terminal via DCI formats. For example, the base station may indicate usage of the flexible region as downlink by sending a downlink DCI format used to schedule downlink reception on the flexible region. For example, the base station may indicate usage of the flexible region as uplink by sending an uplink DCI format used to schedule uplink transmission on the flexible region.

[0007] On the other hand, the base station may indicate usage of the flexible region as downlink, flexible, or uplink via DCI format, a.k.a. DCI format 2_0, not used to schedule downlink reception or uplink transmission. This information is helpful for semi-static transmission/reception which does not require scheduling DCI format.

[0008] If SubBand Full Duplex, SBFD, operation is introduced, another usage type of “SBFD” where “SBFD” represents simultaneous downlink transmission and uplink reception from the base station perspective.

[0009] RAN1 agrees that semistatic UL subband as baseline. Moreover, at least to control periodic/semi-persistent signals, dynamic activation/deactivation of UL subband should be available.

[0010] What is needed are methods, apparatus, and/or techniques to deal with allocation and/or mapping of radio resources for uplink channels in a duplex operation.

Summary of Invention

[0011] In one example, a wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal includes: processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink

Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both: (1) whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid; and (2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.

[0012] In one example, a method in a wireless terminal which communicates across a radio interface with a radio access network, the method includes: in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both: (1) whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid; and (2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and, transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0013] In one example, a wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal includes: processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.

Brief Description of Drawings

[0014] The foregoing and other objects, features, and advantages of the technology disclosed herein will be apparent from the following more particular description of

preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the technology disclosed herein.

[Fig.1]Fig. 1 is a diagrammatic view of an example of a TDD pattern for dynamic TDD operation.

[Fig.2]Fig. 2 is a conceptual diagram of a wireless communication system according to an aspect of an example embodiment and mode.

[Fig.3]Fig. 3 is a diagrammatic view showing an example of a method of configuring a resource grid according to an aspect of an example embodiment and mode.

[Fig.4]Fig. 4 is a diagram showing a configuration example of a resource grid according to an aspect of an example embodiment and mode.

[Fig.5]Fig. 5 is a schematic block diagram showing a configuration example of the base station device 3 according to an aspect of an example embodiment and mode.

[Fig.6]Fig. 6 is a schematic block diagram showing a configuration example of an example wireless terminal, UE, or terminal device according to an aspect of an example embodiment and mode.

[Fig.7]Fig. 7 is a diagrammatic view showing a configuration example of an SS/PBCH block according to an aspect of an example embodiment and mode.

[Fig.8]Fig. 8 is a diagrammatic view showing an example of the monitoring occasion of search-space-sets according to an aspect of an example embodiment and mode.

[Fig.9]Fig. 9 is a diagrammatic view showing an example configuration of time-frequency subband grid for SBFD operation.

[Fig.10]Fig. 10 is a diagrammatic view showing a first example of a configuration of potential transmission occasions for illustrating a first example embodiment and mode for transmitting PUSCH in an enhanced duplex operation.

[Fig.11]Fig. 11 is a flowchart showing example basic acts or steps involved in the first embodiment and mode for transmitting PUSCH in an enhanced duplex operation.

[Fig.12]Fig. 12 is a diagrammatic view showing a second example of a configuration of potential transmission occasions for illustrating the first example embodiment and mode for transmitting PUSCH in an enhanced duplex operation.

[Fig.13]Fig. 13 is a diagrammatic view showing example potential transmission occasions for illustrating a first variation of the first example embodiment and mode for transmitting PUSCH in an enhanced duplex operation.

[Fig.14]Fig. 14 a flowchart showing example basic acts or steps involved in the first variation of the first embodiment and mode for transmitting PUSCH in an enhanced duplex operation

[Fig.15]Fig. 15 is a diagrammatic view showing an example of a configuration of

potential transmission occasions for illustrating a second example embodiment and mode for transmitting PUSCH in an enhanced duplex operation.

[Fig.16]Fig. 16 is a diagrammatic view showing example potential transmission occasions for illustrating a first variation of the second example embodiment and mode for transmitting PUSCH in an enhanced duplex operation.

[Fig.17]Fig. 17 is a flowchart showing example basic acts or steps for the of example embodiment and mode of Fig. 16.

[Fig.18]Fig. 18 is a diagrammatic view of an example of a table describing the predetermined rule according to an aspect of example embodiment and mode.

[Fig.19]Fig. 19 is a diagrammatic view of an example of time domain windows according to an aspect of an example embodiment and mode.

[Fig.20]Fig. 20 is a flowchart showing examples acts or steps comprising an example time domain window determination procedure according to an aspect of an example embodiment and mode.

[Fig.21]Fig. 21 is a flowchart showing examples acts or steps performed by a wireless terminal according to the first example embodiment and mode for transmitting PUSCH in an enhanced duplex operation.

[Fig.22]Fig. 22 is a flowchart showing examples acts or steps performed by a wireless terminal according to the second example embodiment and mode for transmitting PUSCH in an enhanced duplex operation.

[Fig.23]Fig. 23 is a diagrammatic view showing example elements comprising electronic machinery which may comprise a wireless terminal, a radio access node, and a core network node according to an example embodiment and mode.

[Fig.24]Fig. 24 is a diagrammatic view of overall architecture for a 5G New Radio system.

Description of Embodiments

[0015] In one of its example aspects the technology disclosed herein concerns a wireless terminal communicates across a radio interface with a radio access network. The wireless terminal comprises processor circuitry which is configured to determine if a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH repetition is eligible for eventual transmission as an actual PUSCH repetition by checking, e.g., whether a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition has a strategic interaction with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a subband grid. In one example method, such strategic interaction comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid in the time domain. In another example, such strategic interaction

comprises determining whether the one or more OFDM symbols are confined in any uplink, UL, subband of the grid in the time and frequency domain. Methods of operating wireless terminals according to example embodiments and modes are also disclosed.

[0016] In another of its example aspects the technology disclosed herein concerns a wireless terminal which communicates across a radio interface with a radio access network. The wireless terminal comprises processor circuitry which is configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion. Making the determination comprises determining both: whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid; and that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted. Transmitter circuitry may also be provided to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network. Methods of operating such wireless terminals are also disclosed.

[0017] In another of its example aspects the technology disclosed herein concerns a wireless terminal which communicates across a radio interface with a radio access network. The wireless terminal comprises processor circuitry which is configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion. Making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted. Transmitter circuitry may also be provided to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network. Methods of operating such wireless terminals are also disclosed.

[0018] In another of its example aspects the technology disclosed herein concerns a wireless terminal which communicates across a radio interface with a radio access network. The wireless terminal comprises processor circuitry which is configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid,

to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both: whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid; and that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted. Transmitter circuitry may also be provided to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network. Methods of operating such wireless terminals are also disclosed.

[0019] In another of its example aspects the technology disclosed herein concerns a wireless terminal which communicates across a radio interface with a radio access network. The wireless terminal comprises processor circuitry which is configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion. Making the determination comprises determining whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted. Transmitter circuitry may also be provided to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network. Methods of operating such wireless terminals are also disclosed.

[0020] In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the technology disclosed herein. However, it will be apparent to those skilled in the art that the technology disclosed herein may be practiced in other embodiments that depart from these specific details. That is, those skilled in the art will be able to devise various arrangements which, although not explicitly described or shown herein, embody the principles of the technology disclosed herein and are included within its spirit and scope. In some instances, detailed descriptions of well-known devices, circuits, and methods are omitted so as not to obscure the description of the technology disclosed herein with unnecessary detail. All statements herein reciting principles, aspects, and embodiments of the technology disclosed herein, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of

structure.

- [0021] Thus, for example, it will be appreciated by those skilled in the art that block diagrams herein can represent conceptual views of illustrative circuitry or other functional units embodying the principles of the technology. Similarly, it will be appreciated that any flow charts, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.
- [0022] As used herein, the term “telecommunication system” or “communications system” can refer to any network of devices used to transmit information. A non-limiting example of a telecommunication system is a cellular network or other wireless communication system. As used herein, the term “cellular network” or “cellular radio access network” can refer to a network distributed over cells, each cell served by at least one fixed-location transceiver, such as a base station. A “cell” may be any communication channel. All or a subset of the cell may be adopted by 3GPP as licensed bands, e.g., frequency band, to be used for communication between a base station, such as a Node B, and a UE terminal. A cellular network using frequency bands can include configured cells. Configured cells can include cells of which a UE terminal is aware and in which it is allowed by a base station to transmit or receive information. Examples of cellular radio access networks include E-UTRAN or New Radio, NR, and any successors thereof, e.g., NUTRAN.
- [0023] A core network, CN, may comprise numerous servers, routers, and other equipment. As used herein, the term “core network” can refer to a device, group of devices, or subsystem in a telecommunication network that provides services to users of the telecommunications network. Examples of services provided by a core network include aggregation, authentication, call switching, service invocation, gateways to other networks, etc. For example, a core network (CN) may comprise one or more management entities, which may be an Access and Mobility Management Function, AMF.
- [0024] As used herein, for a UE in IDLE Mode, a “serving cell” is a cell on which the wireless terminal in idle mode is camped. See, e.g., 3GPP TS 38.304. For a UE in RRC_CONNECTED not configured with carrier aggregation, CA/dual connectivity, DC, there is only one serving cell comprising the primary cell. For a UE in RRC_CONNECTED configured with CA/ DC the term 'serving cells' is used to denote the set of cells comprising of the Special Cell(s) and all secondary cells. See, e.g., 3GPP TS 38.331.
- [0025] Floor (CX) represents a floor function for real number CX. For example, floor (CX) may be a function that provides the largest integer within a range that does not exceed

the real number CX. Ceil (DX) represents a ceiling function to a real number DX. For example, ceil (DX) maybe a function that provides the smallest integer within the range not less than the real number DX. Mod (EX, FX) represents a function that provides the remainder obtained by dividing EX by FX. It is $\exp(GX) = e^{GX}$. Here, e is Napier number. $(HX)^{(IX)}$ indicates IX to the power of HX.

- [0026] In a wireless communication system according to one aspect of an example embodiment and mode, OFDM (Orthogonal Frequency Division Multiplex) is used. An OFDM symbol is a unit of time domain of OFDM. An OFDM symbol is converted to baseband signal in baseband signal generation. In downlink, at least CP-OFDM (Cyclic Prefix-Orthogonal Frequency Division Multiplex) is used. In uplink, either CP-OFDM or DFT-s-OFDM (Discrete Fourier Transform-spread-Orthogonal Frequency Division Multiplex) is used. DFT-s-OFDM is given by applying transform precoding to CP-OFDM. CP-OFDM is OFDM using CP (Cyclic Prefix).
- [0027] Fig. 2 is a conceptual diagram of a wireless communication system according to an aspect of an example embodiment and mode. In Fig. 2, the wireless communication system includes at least terminal devices 1A to 1C and a base station device 3 (BS # 3: Base station # 3). Hereinafter, the terminal devices 1A to 1C are also referred to as a terminal device 1 (UE # 1: User Equipment # 1).
- [0028] The base station device 3 may be configured to include one or more transmission devices, e.g., transmission points, transmission devices, reception devices, transmission points, reception points. When the base station device 3 is configured by a plurality of transmission devices, each of the plurality of transmission devices may be arranged at a different position.
- [0029] The base station device 3 may provide one or more serving cells. A serving cell may be defined as a set of resources used for wireless communication. A serving cell is also referred to as a cell.
- [0030] A serving cell may be configured to include one downlink component carrier (downlink carrier) and/or one uplink component carrier (uplink carrier). A serving cell may be configured to include two or more downlink component carriers and/or two or more uplink component carriers. A downlink component carrier and an uplink component carrier are also referred to as component carriers (carriers).
- [0031] For example, one component carrier may be associated with one or more resource grid. A resource grid includes $N_{\text{grid}, x}^{\text{size}, u} N_{\text{sc}}^{\text{RB}}$ subcarriers. The resource grid starts from a common resource block with index $N_{\text{grid}}^{\text{start}, u}$. The common resource block with the index $N_{\text{grid}}^{\text{start}, u}$ is also referred to as a reference point of the resource grid. The resource grid includes $N_{\text{symb}}^{\text{subframe}, u}$ OFDM symbols. The subscript x indicates the transmission direction and indicates either downlink or uplink. One resource grid is associated with an antenna port p , a subcarrier-spacing configuration u , and a transmission direction x .

A subcarrier-spacing configuration u is also referred to as numerology.

[0032] $N_{\text{grid},x}^{\text{size},u}$ and $N_{\text{grid}}^{\text{start},u}$ are given based on a higher-layer parameter (e.g., referred to as higher-layer parameter CarrierBandwidth). The higher-layer parameter CarrierBandwidth is used to define one or more SCS (SubCarrier-Spacing) specific carriers. Therefore, one resource grid corresponds to one SCS specific carrier. Further, one component carrier may be associated with one or more SCS specific carriers. The higher-layer parameter CarrierBandwidth may be a common parameter or UE-specific parameter. For each SCS specific carrier, a subcarrier-spacing configuration u is associated.

[0033] Table 1A and Table 1B show example relationships between subcarrier-spacing configuration u , the number of OFDM symbols per slot $N_{\text{symb}}^{\text{slot}}$, and the CP configuration according to an aspect of an example embodiment and mode. In Table 1A, for example, when the subcarrier-spacing configuration u is set to 2 and the CP configuration is set to normal CP (normal cyclic prefix), $N_{\text{symb}}^{\text{slot}} = 14$, $N_{\text{slot}}^{\text{frame},u} = 40$, $N_{\text{slot}}^{\text{subframe},u} = 4$.

[0034] Table 1A

u	$N_{\text{symb}}^{\text{slot}}$	$N_{\text{slot}}^{\text{frame},u}$	$N_{\text{slot}}^{\text{subframe},u}$
0	14	10	1
1	14	20	2
2	14	40	4
3	14	80	8
4	14	160	16

[0035] Further, in Table 1B, for example, when the subcarrier-spacing configuration u is set to 2 and the CP configuration is set to an extended CP (extended cyclic prefix), $N_{\text{symb}}^{\text{slot}} = 12$, $N_{\text{slot}}^{\text{frame},u} = 40$, $N_{\text{slot}}^{\text{subframe},u} = 4$.

[0036] Table 1B:

u	$N_{\text{symb}}^{\text{slot}}$	$N_{\text{slot}}^{\text{frame},u}$	$N_{\text{slot}}^{\text{subframe},u}$
2	12	40	4

[0037] In the wireless communication system according to an aspect of an example embodiment and mode, a time unit T_c is used to represent the length of the time domain. The time unit T_c calculated by $1 / (df_{\text{max}} * N_f)$. df_{max} represents 480 kHz. N_f represents 4096. The constant k is $df_{\text{max}} * N_f / (df_{\text{ref}} N_{f,\text{ref}}) = 64$. df_{ref} represents 15 kHz. $N_{f,\text{ref}}$ represents 2048.

[0038] Radio frames (system frames, frames) of length $T_f = (df_{\text{max}} N_f / 100) * T_s = 10$ ms are defined in the time domain. One radio frame is configured to include ten subframes. The subframe length T_{sf} is $(df_{\text{max}} N_f / 1000) T_s = 1$ ms. The number of OFDM symbols

per subframe $N_{\text{subframe}, u}^{\text{symbol}}$ is calculated by $N_{\text{slot}}^{\text{symbol}} N_{\text{subframe}, u}^{\text{slot}}$.

- [0039] Time domain index is provided. For example, slot index n_s^u is provided in ascending order of the time domain in a subframe with an integer value ranging from 0 to $N_{\text{subframe}, u}^{\text{slot}} - 1$. Also, the slot index $n_{s, f}^u$ is provided in ascending order of the time domain in a radio frame with an integer value ranging from 0 to $N_{\text{frame}, u}^{\text{slot}} - 1$.
- [0040] A slot is comprised of consecutive $N_{\text{slot}}^{\text{symbol}}$ OFDM symbols.
- [0041] Fig. 3 is a diagram showing an example of a method of configuring a resource grid according to an aspect of an example embodiment and mode. The horizontal axis in Fig. 3 indicates frequency domain. Fig. 3 shows a configuration example of a resource grid of subcarrier-spacing configuration $u = u_1$ in the component carrier 300 and a configuration example of a resource grid of subcarrier-spacing configuration $u = u_2$ in a component carrier. Although it is assumed in Fig. 3 that $u_1 = u_2 - 1$, various aspects of this embodiment are not limited to the condition of $u_1 = u_2 - 1$.
- [0042] In Fig. 3, the component carrier 300 is a band having a predetermined width in the frequency domain. However, various aspects of this embodiment are not limited to the component carrier 300 being a band. In another example, the component carrier 300 may be a virtual concept associated with Resource grid 3001 and 3002.
- [0043] Point (Point) 3000 is an identifier for identifying a subcarrier. Point 3000 is also referred to as point A. The common resource block (CRB: Common resource block) set 3100 is a set of common resource blocks for the subcarrier-spacing configuration u_1 .
- [0044] Among the common resource block-set 3100, the common resource block including the point 3000 (the block indicated by the upper right diagonal line in Fig. 3) is also referred to as a reference point of the common resource block-set 3100. The reference point of the common resource block-set 3100 may be a common resource block with index 0 in the common resource block-set 3100.
- [0045] The offset 3011 is an offset from the reference point of the common resource block-set 3100 to the reference point of the resource grid 3001. The offset 3011 is indicated by the number of common resource blocks which is relative to the subcarrier-spacing configuration u_1 . Resource grid 3001 includes $N_{\text{grid}, x}^{\text{size}, u}$ common resource blocks starting from the reference point of the resource grid 3001.
- [0046] The offset 3013 is an offset from the reference point of the resource grid 3001 to the reference point ($N_{\text{BWP}, i1}^{\text{start}, u}$) of the BWP (BandWidth Part) 3003 of the index $i1$.
- [0047] Common resource block-set 3200 is a set of common resource blocks with respect to subcarrier-spacing configuration u_2 .
- [0048] A common resource block including the point 3000 (a block indicated by a left-upward hatching in Fig. 3) in the common resource block-set 3200 is also referred to as a reference point of the common resource block-set 3200. The reference point of the

common resource block-set 3200 may be a common resource block with index 0 in the common resource block-set 3200.

- [0049] The offset 3012 is an offset from the reference point of the common resource block-set 3200 to the reference point of the resource grid 3002. The offset 3012 is indicated by the number of common resource blocks for subcarrier-spacing configuration $u = u_2$. Resource grid 3002 includes $N_{\text{grid2},x}^{\text{size},u}$ common resource blocks starting from the reference point of the resource grid 3002.
- [0050] The offset 3014 is an offset from the reference point of the resource grid 3002 to the reference point ($N_{\text{BWP},i2}^{\text{start},u}$) of the BWP 3004 with index i_2 .
- [0051] Fig. 4 is a diagram showing a configuration example of a resource grid 3001 according to an aspect of an example embodiment and mode. In the resource grid of Fig. 4, the horizontal axis indicates OFDM symbol index l_{sym} , and the vertical axis indicates the subcarrier index k_{sc} . The resource grid 3001 includes $N_{\text{grid1},x}^{\text{size},u} N_{\text{sc}}^{\text{RB}}$ subcarriers, and includes $N_{\text{symb}}^{\text{subframes},u}$ OFDM symbols. A resource specified by the subcarrier index k_{sc} and the OFDM symbol index l_{sym} in a resource grid is also referred to as a resource element (RE: Resource Element).
- [0052] A resource block (RB: Resource Block) includes $N_{\text{sc}}^{\text{RB}}$ consecutive subcarriers. A resource block is a generic name of a common resource block (CRB: Common Resource Block), a physical resource block (PRB: Physical Resource Block), and a virtual resource block (VRB: Virtual Resource Block). For example, $N_{\text{sc}}^{\text{RB}}$ may be 12.
- [0053] A resource block unit is a set of resources that corresponds to one OFDM symbol in one resource block. That is, one resource block unit includes 12 resource elements which corresponds to one OFDM symbol in one resource block.
- [0054] Common resource blocks for a subcarrier-spacing configuration u are indexed in ascending order from 0 in the frequency domain in a common resource block-set. The common resource block with index 0 for the subcarrier-spacing configuration u includes (or collides with, matches) the subcarrier corresponding to the point 3000. The index n_{CRB}^u of the common resource block with respect to the subcarrier-spacing configuration u satisfies the relationship of $n_{\text{CRB}}^u = \text{ceil}(k_{\text{sc}} / N_{\text{sc}}^{\text{RB}})$. The subcarrier with $k_{\text{sc}} = 0$ is a subcarrier with the same center frequency as the center frequency of the subcarrier which corresponds to the point 3000.
- [0055] Physical resource blocks for a subcarrier-spacing configuration u are indexed in ascending order from 0 in the frequency domain in a BWP. The index n_{PRB}^u of the physical resource block with respect to the subcarrier-spacing configuration u satisfies the relationship of $n_{\text{CRB}}^u = n_{\text{PRB}}^u + N_{\text{BWP},i}^{\text{start},u}$. The $N_{\text{BWP},i}^{\text{start},u}$ indicates the reference point of BWP with index i .
- [0056] A BWP is defined as a subset of common resource blocks in the resource grid. The BWP includes $N_{\text{BWP},i}^{\text{size},u}$ common resource blocks starting at the reference points $N_{\text{BWP},i}^{\text{start},u}$

BWP_i . A BWP for the downlink component carrier is also referred to as a downlink BWP. A BWP for the uplink component carrier is also referred to as an uplink BWP.

- [0057] An antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed. For example, the channel may correspond to a physical channel. For example, the symbols may correspond to OFDM symbols. For example, the symbols may correspond to resource block units. For example, the symbols may correspond to resource elements.
- [0058] Two antenna ports are said to be QCL (Quasi Co-Located) if the large-scale properties of the channel over which a symbol on one antenna port is conveyed can be inferred from the channel over which a symbol on the other antenna port is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, average delay, and spatial Rx parameters.
- [0059] Carrier aggregation is a framework for communication using a plurality of aggregated serving cells. In other expression, carrier aggregation may be understood as a framework for communication using a plurality of aggregated component carriers.
- [0060] Fig. 5 is a schematic block diagram showing a configuration example of an access node or base station device 3 according to an aspect of an example embodiment and mode. As shown in Fig. 5, base station device 3 includes a part or all of the wireless transmission / reception unit (physical layer processing unit) 30 and the control unit 34. The wireless transmission / reception unit 30 includes a part or all of the antenna unit 31, the RF unit 32 (Radio Frequency unit 32), and the baseband unit 33. The control unit 34 includes a part or all of the medium access control layer processing unit 35 and the radio resource control (RRC: Radio Resource Control) layer processing unit 36.
- [0061] The wireless transmission / reception unit 30 includes a part of or all of a wireless transmission unit 30a and a wireless reception unit 30b. The configuration of the baseband unit 33 included in the wireless transmission unit 30a and the configuration of the baseband unit 33 included in the wireless reception unit 30b may be the same or different. The configuration of the RF unit 32 included in the wireless transmission unit 30a and the configuration of the RF unit 32 included in the wireless reception unit 30b may be the same or different. The configuration of the antenna unit 31 included in the wireless transmission unit 30a and the configuration of the antenna unit 31 included in the wireless reception unit 30b may be the same or different.
- [0062] The control unit 34 provides downlink data (or transport blocks) to the wireless transmission / reception unit 30 (or the wireless transmission unit 30a). Control unit 34 performs processing of a medium access control (MAC) layer, a packet data convergence protocol layer (PDCP layer), a radio link control layer (RLC layer) and/or an RRC layer.

- [0063] The medium access control layer processing unit 35 included in the control unit 34 performs processing of the MAC layer.
- [0064] The radio resource control layer processing unit 36 included in control unit 34 performs the process of the RRC layer. The radio resource control layer processing unit 36 manages various configuration information / parameters (RRC parameters) of terminal device 1.
- [0065] The control unit 34 may also comprise PUSCH repetition scheduler 37 and time division duplex, TDD, parameter generator 38, which serve to generate information for transmission to wireless terminal 1 as described herein.
- [0066] Various functionalities of base station 3 may be performed by one or more processor(s) 39, also referred to herein as base station or access node processor circuitry. For example, base station processor(s) 39 may comprise or at least partially constitute the control unit 34, base band unit 33, and possibly portions of RF unit 32.
- [0067] The wireless transmission / reception unit 30 (or the wireless transmission unit 30a) performs processing such as encoding and modulation. The wireless transmission / reception unit 30 (or the wireless transmission unit 30a) generates a physical signal by encoding and modulating the downlink data. The wireless transmission / reception unit 30 (or the wireless transmission unit 30a) converts the physical signal to a baseband signal by baseband signal generation. The wireless transmission / reception unit 30 (or the wireless transmission unit 30a) transmits the baseband signal to the terminal device 1 via radio frequency. The wireless transmission / reception unit 30 (or the wireless transmission unit 30a) may arrange the baseband signal on a component carrier and transmit the baseband signal to the terminal device 1.
- [0068] The wireless transmission / reception unit 30 (or the wireless reception unit 30b) performs processing such as demodulation and decoding. The wireless transmission / reception unit 30 (or the wireless reception unit 30b) separates, demodulates and decodes the received physical signal, and provides the decoded information to the control unit 34. The wireless transmission / reception unit 30 (or the wireless reception unit 30b) may perform the channel access procedure prior to the transmission of the physical signal.
- [0069] The RF unit 32 demodulates the physical signal received via the antenna unit 31 into an analog signal, and/or removes extra frequency components. The RF unit 32 provides the processed analog signal to the baseband unit 33.
- [0070] Baseband unit 33 converts the analog signal input from the RF unit 32 into a baseband signal. The baseband unit 33 separates a portion which corresponds to CP (Cyclic Prefix) from the baseband signal. The baseband unit 33 performs Fast Fourier Transformation (FFT) on the baseband signal from which the CP has been removed.
- [0071] The baseband unit 33 performs Inverse Fast Fourier Transformation (IFFT) on

downlink data to generate an OFDM symbol, adds a CP to the generated OFDM symbol, generates a baseband signal, and converts the baseband signal into an analog signal. The baseband unit 33 provides the analog signal to the RF unit 32.

- [0072] The RF unit 32 removes extra frequency components from the analog signal input from the baseband unit 33, up-converts the analog signal to a radio frequency and transmits it via the antenna unit 31. The RF unit 32 may have a function of controlling transmission power. The RF unit 32 is also referred to as a transmission power control unit.
- [0073] One or more serving cells are configured for terminal device 1.
- [0074] There are different types of serving cells. For example, there are PCell (Primary cell), PSCell (Primary SCG cell), and SCell (Secondary Cell).
- [0075] A PCell is a serving cell included in a MCG (Master Cell Group). A PCell is a cell (implemented cell) which performs an initial connection establishment procedure or a connection re-establishment procedure by terminal device 1.
- [0076] A PSCell is a serving cell included in a SCG (Secondary Cell Group). A PSCell is a serving cell in which random-access is performed by the terminal device 1 in a reconfiguration procedure with synchronization (Reconfiguration with synchronization).
- [0077] A SCell may be included in either a MCG or a SCG.
- [0078] The serving cell group (cell group) is a designation including at least MCG and SCG. The serving cell group may include one or more serving cells. Serving cells included in the serving cell group may be operated by carrier aggregation.
- [0079] One or more downlink BWPs may be configured for each serving cell (or each downlink component carrier). One or more uplink BWPs may be configured for each serving cell (or each uplink component carrier).
- [0080] Among the one or more downlink BWPs set for the serving cell (or the downlink component carrier), one downlink BWP may be set as an active downlink BWP (or one downlink BWP may be activated). Among the one or more uplink BWPs set for the serving cell (or the uplink component carrier), one uplink BWP may be set as an active uplink BWP (or one uplink BWP may be activated).
- [0081] A PDSCH, a PDCCH, and a CSI-RS may be received in the active downlink BWP. The terminal device 1 may receive the PDSCH, the PDCCH, and the CSI-RS in the active downlink BWP. A PUCCH and a PUSCH may be sent on the active uplink BWP. terminal device 1 may transmit the PUCCH and the PUSCH in the active uplink BWP. The active downlink BWP and the active uplink BWP are also referred to as active BWP.
- [0082] The PDSCH, the PDCCH, and the CSI-RS may not be received in downlink BWPs other than the active downlink BWP. The terminal device 1 may not receive the PDSCH, the PDCCH, and the CSI-RS in the downlink BWPs other than the active

downlink BWP. The PUCCH and the PUSCH may not be transmitted in uplink BWPs other than the active uplink BWP. The terminal device 1 may not transmit the PUCCH and the PUSCH in the uplink BWPs other than the active uplink BWP.

- [0083] Downlink BWP switching deactivates an active downlink BWP and activates one of downlink BWPs other than the active downlink BWP. The downlink BWP switching may be controlled by a BWP field included in a downlink control information. The downlink BWP switching may be controlled based on higher-layer parameters.
- [0084] Uplink BWP switching is used to deactivate an active uplink BWP and activate any uplink BWP other than the active uplink BWP. Uplink BWP switching may be controlled by a BWP field included in a downlink control information. The uplink BWP switching may be controlled based on higher-layer parameters.
- [0085] Among the one or more downlink BWPs set for the serving cell, two or more downlink BWPs may not be set as active downlink BWPs at a time. For the serving cell, at most one downlink BWP may be active at a time.
- [0086] Among the one or more uplink BWPs set for the serving cell, two or more uplink BWPs may not be set as active uplink BWPs at a time. For the serving cell, one uplink BWP may be active at a time.
- [0087] Fig. 6 is a schematic block diagram showing a configuration example of an example wireless terminal, also known as a UE or terminal device 1, according to an aspect of an example embodiment and mode. As shown in Fig. 6, terminal device 1 includes a part or all of the wireless transmission / reception unit (physical layer processing unit) 10 and the control unit 14. The wireless transmission / reception unit 10 includes a part or all of the antenna unit 11, the RF unit 12, and the baseband unit 13. The control unit 14 includes a part or all of the medium access control layer processing unit 15 and the radio resource control layer processing unit 16.
- [0088] The wireless transmission / reception unit 10 includes a part of or all of a wireless transmission unit 10a and a wireless reception unit 10b. The wireless transmission unit 10a may also be referred to as wireless terminal transmitter circuitry and wireless reception unit 10b may also be referred to as wireless terminal receiver circuitry. The configuration of the baseband unit 13 included in the wireless transmission unit 10a and the configuration of the baseband unit 13 included in the wireless reception unit 10b may be the same or different. The configuration of the RF unit 12 included in the wireless transmission unit 10a and the RF unit 12 included in the wireless reception unit 10b may be the same or different. The configuration of antenna unit 11 included in the wireless transmission unit 10a and the configuration of the antenna unit 11 included in the wireless reception unit 10b may be the same or different.
- [0089] The control unit 14 provides uplink data (or transport blocks) to the wireless transmission / reception unit 10 (or the wireless transmission unit 10a). Control unit 14

performs processing of a MAC layer, a packet data integration protocol layer, a radio link control layer, and/or an RRC layer.

[0090] The control unit 14 may also comprise PUSCH generator 17, which in turn may comprise or cooperate with PUSCH repetition transmission occasion controller 18. The PUSCH generator 17 may serve to perform functions and acts including those of Fig. 11; the 18 may perform functions or acts such as act 1102 of Fig. 11 described herein.

[0091] Various functionalities of wireless terminal 1 may be performed by one or more processor(s) 19, also referred to herein as wireless terminal or terminal processor circuitry. For example, wireless terminal processor(s) 19 may comprise or at least partially constitute the control unit 14, base band unit 13, and possibly portions of RF unit 12.

[0092] The medium access control layer processing unit 15 included in the control unit 14 performs processing of the MAC layer.

[0093] The radio resource control layer processing unit 16 included in control unit 14 performs the process of the RRC layer. The radio resource control layer processing unit 16 manages various configuration information / parameters (RRC parameters) of terminal device 1. The radio resource control layer processing unit 16 configures RRC parameters based on the RRC message received from the base station device 3.

[0094] The wireless transmission / reception unit 10 (or the wireless transmission unit 10a) performs processing such as encoding and modulation. The wireless transmission / reception unit 10 (or the wireless transmission unit 10a) generates a physical signal by encoding and modulating the uplink data. The wireless transmission / reception unit 10 (or the wireless transmission unit 10a) converts the physical signal to a baseband signal by baseband signal generation. The wireless transmission / reception unit 10 (or the wireless transmission unit 10a) transmits the baseband signal to the base station device 3 via radio frequency. The wireless transmission / reception unit 10 (or the wireless transmission unit 10a) may arrange the baseband signal on a BWP (active uplink BWP) and transmit the baseband signal to the base station device 3.

[0095] The wireless transmission / reception unit 10 (or the wireless reception unit 10b) performs processing such as demodulation and decoding. The wireless transmission / reception unit 10 (or the wireless reception unit 10b) may receive a physical signal in a BWP (active downlink BWP) of a serving cell. The wireless transmission / reception unit 10 (or the wireless reception unit 10b) separates, demodulates and decodes the received physical signal, and provides the decoded information to the control unit 14. The wireless transmission / reception unit 10 (or the wireless reception unit 10b) may perform the channel access procedure prior to the transmission of the physical signal.

[0096] The RF unit 12 demodulates the physical signal received via the antenna unit 11 into an analog signal, and/or removes extra frequency components. The RF unit 12

provides the processed analog signal to the baseband unit 13.

[0097] The baseband unit 13 converts the analog signal input from the RF unit 12 into a baseband signal. The baseband unit 13 separates a portion which corresponds to CP from the baseband signal, performs fast Fourier transformation on the baseband signal from which the CP has been removed.

[0098] The baseband unit 13 performs inverse fast Fourier transformation on uplink data to generate an OFDM symbol, adds a CP to the generated OFDM symbol, generates a baseband signal, and converts the digital signal into an analog signal. The baseband unit 13 provides the analog signal to the RF unit 12.

[0099] The RF unit 12 removes extra frequency components from the analog signal input from the baseband unit 13, up-converts the analog signal to a radio frequency and transmits it via the antenna unit 11. The RF unit 12 may have a function of controlling transmission power. The RF unit 12 is also referred to as a transmission power control unit.

[0100] Hereinafter, physical signals will be described.

[0101] Physical signal is a generic term for downlink physical channels, downlink physical signals, uplink physical channels, and uplink physical channels. The physical channel is a generic term for downlink physical channels and uplink physical channels.

[0102] An uplink physical channel corresponds to a set of resource elements that carry information originating from the higher-layer and/or uplink control information. The uplink physical channel is transmitted by terminal device 1. The uplink physical channel is received by the base station device 3. In the wireless communication system according to one aspect of an example embodiment and mode, a part or all of PUCCH (Physical Uplink Control CHannel), PUSCH (Physical Uplink Shared CHannel), and PRACH (Physical Random Access CHannel) may be used.

[0103] A PUCCH is sent to deliver (transmission, convey) uplink control information. The terminal device 1 transmits a PUCCH in which uplink control information is arranged. The base station device 3 receives the PUCCH in which the uplink control information is arranged.

[0104] Uplink control information (uplink control information bits, uplink control information sequence, uplink control information type) includes a part or all of channel state information (CSI: Channel State Information), scheduling request (SR: Scheduling Request), and HARQ-ACK (Hybrid Automatic Repeat request ACKnowledgement) information.

[0105] HARQ-ACK information indicates HARQ-ACK status corresponding to a transport block (TB: Transport block, MAC PDU: Medium Access Control Protocol Data Unit, DL-SCH: Downlink-Shared Channel, UL-SCH: Uplink-Shared Channel, PDSCH: Physical Downlink Shared CHannel, PUSCH: Physical Uplink Shared CHannel). The

HARQ-ACK status is either ACK (acknowledgement) or NACK (negative-acknowledgement). The ACK indicates that the transport block has been successfully decoded. The NACK indicates that the transport block has not been successfully decoded. HARQ-ACK information may include a HARQ-ACK codebook that includes one or more HARQ-ACK status (or HARQ-ACK bits).

- [0106] HARQ-ACK status may indicate ACK or NACK which correspond to one CBG (Code Block Group) included in the transport block.
- [0107] The scheduling request is used to request UL-SCH resources for initial transmission. The scheduling request is used to indicate either a positive SR or a negative SR. The fact that the scheduling request indicates a positive SR is also referred to as "a positive SR is sent". The positive SR indicates that the UL-SCH resource for initial transmission is requested by terminal device 1. The fact that the scheduling request bit indicates a negative SR is also referred to as "a negative SR is sent". A negative SR indicates that the UL-SCH resource for initial transmission is not requested by terminal device 1.
- [0108] The channel state information may include at least part or all of a channel quality indicator (CQI), a precoder matrix indicator (PMI), and a rank indicator (RI). CQI is an indicator related to channel quality (e.g., propagation quality) or physical channel quality, and PMI is an indicator related to a precoder. RI is an indicator related to transmission rank (or the number of transmission layers).
- [0109] Channel state information is provided based on receiving one or more physical signals (e.g., one or more CSI-RSs). The channel state information is determined by the terminal device 1 based on receiving one or more physical signals.
A PUSCH is used to convey uplink data (a transport block) and/or uplink control information. The terminal device 1 transmits a PUSCH in which uplink data (a transport block) and/or uplink control information is arranged. The base station device 3 receives a PUSCH in which uplink data (a transport block) and/or uplink control information is arranged.
- [0110] A PRACH is used to transmit a random-access preamble. The sequence $x_{u,v}(n)$ of the PRACH is defined by $x_{u,v}(n) = x_u \pmod{(n + C_v, L_{RA})}$. The x_u may be a ZC sequence (Zadoff-Chu sequence). The x_u may be defined by $x_u = \exp(-jpu(i + 1) / L_{RA})$. The j is an imaginary unit. The p is the circle ratio. The C_v corresponds to cyclic shift of the PRACH. L_{RA} corresponds to the length of the PRACH. The L_{RA} may be 839 or 139 or another value. The i is an integer in the range of 0 to $L_{RA}-1$. The u is a sequence index for the PRACH. The terminal device 1 transmits the PRACH. The base station device 3 receives the PRACH.
- [0111] For a given PRACH occasion, 64 random-access preambles are defined. The random-access preamble is specified (determined, given) based on the cyclic shift C_v

of the PRACH and the sequence index u for the PRACH.

- [0112] An uplink physical signal corresponds to a set of resource elements. The uplink physical signal may not carry information generated in the higher-layer. The terminal device 1 transmits an uplink physical signal. The base station device 3 receives the uplink physical signal. In the radio communication system according to one aspect of an example embodiment and mode, at least a part or all of UL DMRS (UpLink Demodulation Reference Signal), SRS (Sounding Reference Signal), UL PTRS (UpLink Phase Tracking Reference Signal) may be used.
- [0113] UL DMRS is a generic name of a DMRS for a PUSCH and a DMRS for a PUCCH.
- [0114] A set of antenna ports of a DMRS for a PUSCH (a DMRS associated with a PUSCH, a DMRS included in a PUSCH, a DMRS which corresponds to a PUSCH) may be given based on a set of antenna ports for the PUSCH. For example, the set of DMRS antenna ports for the PUSCH may be the same as the set of antenna ports for the PUSCH.
- [0115] Transmission of a PUSCH and transmission of a DMRS for the PUSCH may be indicated (or scheduled) by one DCI format. The PUSCH and the DMRS for the PUSCH is collectively referred to as a PUSCH.
- [0116] A set of antenna ports of a DMRS for a PUCCH (a DMRS associated with a PUCCH, a DMRS included in a PUCCH, a DMRS which corresponds to a PUCCH) may be identical to a set of antenna ports for the PUCCH.
- [0117] Transmission of a PUCCH and transmission of a DMRS for the PUCCH may be indicated (or triggered) by one DCI format. The arrangement of the PUCCH in resource elements (resource element mapping) and/or the arrangement of the DMRS in resource elements for the PUCCH may be provided by one PUCCH format. The PUCCH and the DMRS for the PUCCH is collectively referred to as PUCCH.
- [0118] A downlink physical channel corresponds to a set of resource elements that carry information originating from the higher-layer and/or downlink control information. The base station device 3 transmits the downlink physical channel. The terminal device 1 receives the downlink physical channel. In the wireless communication system according to one aspect of an example embodiment and mode, a part or all of PBCH (Physical Broadcast Channel), PDCCH (Physical Downlink Control Channel), and PDSCH (Physical Downlink Shared Channel) may be used.
- [0119] The PBCH is used to transmit a MIB (Master Information Block) and/or physical layer control information. The physical layer control information is a kind of downlink control information. The terminal device 1 receives the PBCH. The base station device 3 transmits the PBCH. The physical layer control information is also referred to as a PBCH payload

Physical layer control information comprises of 8 bits. The physical layer control in-

formation comprises of a part or all of 0A to 0D. The 0A is radio frame information. The 0B is half radio frame information (half system frame information). The 0C is SS/PBCH block index information. The 0D is subcarrier offset information.

- [0120] The radio frame information is used to indicate a radio frame in which the PBCH is transmitted.
- [0121] The half radio frame information is used to indicate whether the PBCH is transmitted in first five subframes or in second five subframes among radio frames in which the PBCH is transmitted.
- [0122] The SS/PBCH block index information is used to indicate an SS/PBCH block index.
- [0123] The subcarrier offset information is used to indicate subcarrier offset. The subcarrier offset information is used to indicate the difference between the first subcarrier in which the PBCH is arranged and the first subcarrier in which the control resource set with index 0 is arranged.
- [0124] A PDCCH is used to transmit downlink control information (DCI). The terminal device 1 receives a PDCCH in which downlink control information is arranged. The base station device 3 transmits the PDCCH in which the downlink control information is arranged.
- [0125] Downlink control information is formatted by a DCI format. There may be several DCI format types, such as DCI format 0_0, DCI format 0_1, DCI format 1_0, DCI format 1_1, DCI format 2_0, discussed herein as non-limiting examples.
- [0126] DCI format is a generic name for DCI format 0_0, DCI format 0_1, DCI format 1_0, and DCI format 1_1. Uplink DCI format is a generic name of the DCI format 0_0 and the DCI format 0_1. Downlink DCI format is a generic name of the DCI format 1_0 and the DCI format 1_1.
- [0127] The DCI format 0_0 is used for scheduling a PUSCH for a cell (or a PUSCH arranged on a cell). The DCI format 0_0 includes a part or all of fields 1A to 1E. The 1A is a DCI format identification field (Identifier field for DCI formats). The 1B is a frequency domain resource assignment field (FDRA field). The 1C is a time domain resource assignment field (TDRA field). The 1D is a frequency-hopping flag field. The 1E is an MCS field (Modulation-and-Coding-Scheme field).
- [0128] The DCI format identification field in the DCI format 0_0 indicates whether the DCI format including the DCI format identification field is an uplink DCI format or a downlink DCI format. The DCI format identification field included in the DCI format 0_0 indicates 0 (or indicates that the DCI format 0_0 is an uplink DCI format).
- [0129] The frequency domain resource assignment field included in the DCI format 0_0 is used to indicate the assignment of frequency resources for a PUSCH scheduled by the DCI format 0_0.
- [0130] The time domain resource assignment field included in the DCI format 0_0 is used to

indicate the assignment of time resources for a PUSCH scheduled by the DCI format 0_0.

- [0131] The frequency-hopping flag field in the DCI format 0_0 is used to indicate whether frequency-hopping is applied to a PUSCH scheduled by the DCI format 0_0.
- [0132] The MCS field included in the DCI format 0_0 is used to indicate a modulation scheme for a PUSCH scheduled by the DCI format 0_0 and/or a part or all of a target coding rate for the PUSCH. A size of a transport block (TBS: Transport Block Size) of the PUSCH is determined based on a target coding rate and a part or all of a modulation scheme for the PUSCH.
- [0133] The DCI format 0_0 does not include fields used for requesting CSI.
- [0134] The DCI format 0_0 does not include a carrier indicator field. An uplink component carrier on which a PUSCH scheduled by the DCI format 0_0 is arranged is the same as an uplink component carrier on which a PDCCH including the DCI format 0_0 is arranged.
- [0135] The DCI format 0_0 does not include a BWP field. Active uplink BWP does not change by the DCI format 0_0.
- [0136] The DCI format 0_1 is used for scheduling of a PUSCH for a cell (or arranged on a cell). The DCI format 0_1 includes a part or all of fields 2A to 2H. The 2A is a DCI format identification field. The 2B is a frequency domain resource assignment field. The 2C is a time domain resource assignment field. The 2D is a frequency-hopping flag field. The 2E is an MCS field. The 2F is a CSI request field. The 2G is a BWP field. The 2H is a carrier indicator field.
- [0137] The DCI format identification field included in the DCI format 0_1 indicates 0 (or indicates that the DCI format 0_1 is an uplink DCI format).
- [0138] The frequency domain resource assignment field included in the DCI format 0_1 is used to indicate the assignment of frequency resources for a PUSCH scheduled by the DCI format.
- [0139] The time domain resource assignment field included in the DCI format 0_1 is used to indicate the assignment of time resources for a PUSCH scheduled by the DCI format.
- [0140] The frequency-hopping flag field in the DCI format 0_1 is used to indicate whether frequency-hopping is applied to a PUSCH scheduled by the DCI format 0_1.
- [0141] The MCS field included in the DCI format 0_1 is used to indicate a modulation scheme for a PUSCH scheduled by the DCI format and/or a part or all of a target coding rate for the PUSCH.
- [0142] When the DCI format 0_1 includes the BWP field, the BWP field may be used to indicate an uplink BWP on which a PUSCH scheduled by the DCI format 0_1 is arranged, depending on capability of the terminal device 1. When the DCI format 0_1 does not include the BWP field, active uplink BWP does not change by the DCI format

0_1.

[0143] The CSI request field is used to request CSI.

[0144] If the DCI format 0_1 includes the carrier indicator field, the carrier indicator field is used to indicate an uplink component carrier (or a serving cell) on which a PUSCH is arranged. When the DCI format 0_1 does not include the carrier indicator field, a serving cell on which a PUSCH is arranged is the same as the serving cell on which a PDCCH including the DCI format 0_1 used for scheduling of the PUSCH is arranged.

[0145] The DCI format 1_0 is used for scheduling of a PDSCH for a cell (arranged on a cell). The DCI format 1_0 includes a part or all of fields 3A to 3F. The 3A is a DCI format identification field. The 3B is a frequency domain resource assignment field. The 3C is a time domain resource assignment field. The 3D is an MCS field. The 3E is a PDSCH-to-HARQ-feedback indicator field. The 3F is a PUCCH resource indicator field.

[0146] The DCI format identification field included in the DCI format 1_0 indicates 1 (or indicates that the DCI format 1_0 is a downlink DCI format).

[0147] The frequency domain resource assignment field included in the DCI format 1_0 is used to indicate the assignment of frequency resources for a PDSCH scheduled by the DCI format 1_0.

[0148] The time domain resource assignment field included in the DCI format 1_0 is used to indicate the assignment of time resources for a PDSCH scheduled by the DCI format 1_0.

[0149] The MCS field included in the DCI format 1_0 is used to indicate a modulation scheme for a PDSCH scheduled by the DCI format 1_0 and/or a part or all of a target coding rate for the PDSCH. A size of a transport block (TBS: Transport Block Size) of a PDSCH is determined based on a target coding rate and a part or all of a modulation scheme for the PDSCH.

[0150] The PDSCH-to-HARQ-feedback timing indicator field is used to indicate the offset (K1) from a slot in which the last OFDM symbol of a PDSCH scheduled by the DCI format 1_0 is included to another slot in which the first OFDM symbol of a PUCCH triggered by the DCI format 1_0 is included.

[0151] The PUCCH resource indicator field is a field indicating an index of any one or more PUCCH resources included in the PUCCH resource set for a PUCCH transmission. The PUCCH resource set comprises of one or more PUCCH resources.

[0152] The DCI format 1_0 does not include the carrier indicator field. A downlink component carrier on which a PDSCH scheduled by the DCI format 1_0 is arranged is the same as a downlink component carrier on which a PDCCH including the DCI format 1_0 is arranged.

[0153] The DCI format 1_0 does not include the BWP field. A downlink BWP on which a

PDSCH scheduled by a DCI format 1_0 is arranged is the same as a downlink BWP on which a PDCCH including the DCI format 1_0 is arranged.

- [0154] The DCI format 1_1 is used for scheduling of a PDSCH for a cell (or arranged on a cell). The DCI format 1_1 includes a part or all of fields 4A to 4H. The 4A is a DCI format identification field. The 4B is a frequency domain resource assignment field. The 4C is a time domain resource assignment field. The 4D is an MCS field. The 4E is a PDSCH-to-HARQ-feedback indicator field. The 4F is a PUCCH resource indicator field. The 4G is a BWP field. The 4H is a carrier indicator field.
- [0155] The DCI format identification field included in the DCI format 1_1 indicates 1 (or indicates that the DCI format 1_1 is a downlink DCI format).
- [0156] The frequency domain resource assignment field included in the DCI format 1_1 is used to indicate the assignment of frequency resources for a PDSCH scheduled by the DCI format 1_1.
- [0157] The time domain resource assignment field included in the DCI format 1_1 is used to indicate the assignment of time resources for a PDSCH scheduled by the DCI format 1_1.
- [0158] The MCS field included in DCI format 1_1 is used to indicate a modulation scheme for a PDSCH scheduled by the DCI format 1_1 and/or a part or all of a target coding rate for the PDSCH.
- [0159] When the DCI format 1_1 includes a PDSCH-to-HARQ-feedback timing indicator field, the PDSCH-to-HARQ-feedback timing indicator field indicates an offset (K1) from a slot including the last OFDM symbol of a PDSCH scheduled by the DCI format 1_1 to another slot including the first OFDM symbol of a PUCCH triggered by the DCI format 1_1.
- [0160] When the DCI format 1_1 includes the BWP field, the BWP is used to indicate a downlink BWP on which a PDSCH scheduled by the DCI format 1_1 is arranged. When the DCI format 1_1 does not include the BWP field, a downlink BWP on which a PDSCH scheduled by a DCI format 1_1 is arranged is the same as a downlink BWP on which a PDCCH including the DCI format 1_1 is arranged.
- [0161] If the DCI format 1_1 includes the carrier indicator field, the carrier indicator field is used to indicate a downlink component carrier (or a serving cell) on which a PDSCH is arranged. When the DCI format 1_1 does not include the carrier indicator field, a downlink component carrier (or a serving cell) on which a PDSCH is arranged is the same as a downlink component carrier (or a serving cell) on which a PDCCH including the DCI format 1_1 used for scheduling of the PDSCH is arranged.
- [0162] A PDSCH is used to transmit one or more transport blocks. The base station device 3 transmits a PDSCH. The terminal device 1 receives the PDSCH.
- [0163] Downlink physical signals corresponds to a set of resource elements. The downlink

physical signals may not carry the information generated in the higher-layer. A downlink physical signal is transmitted by the base station device 3. The downlink physical signal is received by the terminal device 1. In the wireless communication system according to one aspect of an example embodiment and mode, a part or all of an SS (Synchronization signal), DL DMRS (DownLink DeModulation Reference Signal), CSI-RS (Channel State Information-Reference Signal), and DL PTRS (DownLink Phase Tracking Reference Signal) may be used.

- [0164] The synchronization signal is used for terminal device 1 to synchronize in the frequency domain and/or time domain for downlink. The synchronization signal is a generic name of PSS (Primary Synchronization Signal) and SSS (Secondary Synchronization Signal).
- [0165] Fig. 7 is a diagram showing a configuration example of an SS/PBCH block according to an aspect of an example embodiment and mode. In Fig. 7, the horizontal axis indicates time domain (OFDM symbol index l_{sym}), and the vertical axis indicates frequency domain. The shaded blocks indicate a set of resource elements for a PSS. The blocks of grid lines indicate a set of resource elements for an SSS. Also, the blocks in the horizontal line indicate a set of resource elements for a PBCH and a set of resource elements for a DMRS for the PBCH (DMRS related to the PBCH, DMRS included in the PBCH, DMRS which corresponds to the PBCH).
- [0166] As shown in Fig. 7, the SS/PBCH block includes a PSS, an SSS, and a PBCH. The SS/PBCH block includes 4 consecutive OFDM symbols. The SS/PBCH block includes 240 subcarriers. The PSS is allocated to the 57th to 183rd subcarriers in the first OFDM symbol. The SSS is allocated to the 57th to 183rd subcarriers in the third OFDM symbol. The first to 56th subcarriers of the first OFDM symbol may be set to zero. The 184th to 240th subcarriers of the first OFDM symbol may be set to zero. The 49th to 56th subcarriers of the third OFDM symbol may be set to zero. The 184th to 192nd subcarriers of the third OFDM symbol may be set to zero. In the first to 240th subcarriers of the second OFDM symbol, the PBCH is allocated to subcarriers in which the DMRS for the PBCH is not allocated. In the first to 48th subcarriers of the third OFDM symbol, the PBCH is allocated to subcarriers in which the DMRS for the PBCH is not allocated. In the 193rd to 240th subcarriers of the third OFDM symbol, the PBCH is allocated to subcarriers in which the DMRS for the PBCH is not allocated. In the first to 240th subcarriers of the 4th OFDM symbol, the PBCH is allocated to subcarriers in which the DMRS for the PBCH is not allocated.
- [0167] The antenna ports of a PSS, an SSS, a PBCH, and a DMRS for the PBCH in an SS/PBCH block is identical.
- [0168] For the DM-RS for the PBCH, the channel over which a symbol for the PBCH on an antenna port is conveyed can be inferred from the channel over which another symbol

for the DM-RS on the antenna port is conveyed only if the two symbols are within a SS/PBCH block transmitted within the same slot, and with the same SS/PBCH block index.

- [0169] DL DMRS is a generic name of DMRS for a PBCH, DMRS for a PDSCH, and DMRS for a PDCCH.
- [0170] A set of antenna ports for a DMRS for a PDSCH (a DMRS associated with a PDSCH, a DMRS included in a PDSCH, a DMRS which corresponds to a PDSCH) is given based on the set of antenna ports for the PDSCH. For example, the set of antenna ports for the DMRS for the PDSCH may be the same as the set of antenna ports for the PDSCH.
- [0171] Transmission of a PDSCH and transmission of a DMRS for the PDSCH is indicated by one DCI format. The PDSCH and the DMRS for the PDSCH is collectively referred to as PDSCH.
- [0172] For a DM-RS associated with a PDSCH, the channel over which a symbol for the PDSCH on one antenna port is conveyed can be inferred from the channel over which another symbol for the DM-RS on the antenna port is conveyed only if the two symbols are within the same resource as the scheduled PDSCH, in the same slot, and in the same PRG (Precoding Resource Group).
- [0173] Antenna ports for a DMRS for a PDCCH (a DMRS associated with a PDCCH, a DMRS included in a PDCCH, a DMRS which corresponds to a PDCCH) is the same as an antenna port for the PDCCH.
- [0174] For a DM-RS associated with a PDCCH, the channel over which a symbol for the PDCCH on one antenna port is conveyed can be inferred from the channel over which another symbol for the DM-RS on the same antenna port is conveyed only if the two symbols are within resources for which the UE may assume the same precoding being used (i.e., within resources in a REG bundle).
- [0175] A BCH (Broadcast CHannel), a UL-SCH (Uplink-Shared CHannel) and a DL-SCH (Downlink-Shared CHannel) are transport channels. A channel used in the MAC layer is called a transport channel. A unit of transport channel used in the MAC layer is also called transport block (TB) or MAC PDU (Protocol Data Unit). In the MAC layer, control of HARQ (Hybrid Automatic Repeat request) is performed for each transport block. The transport block is a unit of data delivered by the MAC layer to the physical layer. In the physical layer, transport blocks are mapped to codewords, and modulation processing is performed for each codeword.
- [0176] A BCCH (Broadcast Control CHannel), a CCCH (Common Control CHannel), and a DCCH (Dedicated Control CHannel) are logical channels. The BCCH is a channel of the RRC layer used to deliver MIB or system information. The CCCH is used to transmit a common RRC message in a plurality of terminal devices 1. The CCCH is

used for terminal device 1 that is not in RRC-connected mode. The DCCH is used to transmit a dedicated RRC message to the terminal device 1. The DCCH is used for the terminal device 1 that is in RRC-connected mode.

- [0177] The RRC message includes one or more RRC parameters. For example, the RRC message may include a MIB. For example, the RRC message may include system information (SIB: System Information Block, MIB). SIB is a generic name for various type of SIBs (e.g., SIB1, SIB2). For example, the RRC message may include a message which corresponds to a CCCH. For example, the RRC message may include a message which corresponds to a DCCH. RRC message is a general term for common RRC message and dedicated RRC message.
- [0178] The BCCH in the logical channel is mapped to the BCH or the DL-SCH in the transport channel. The CCCH in the logical channel is mapped to the DL-SCH or the UL-SCH in the transport channel. The DCCH in the logical channel is mapped to the DL-SCH or the UL-SCH in the transport channel.
- [0179] The UL-SCH in the transport channel is mapped to a PUSCH in the physical channel. The DL-SCH in the transport channel is mapped to a PDSCH in the physical channel. The BCH in the transport channel is mapped to a PBCH in the physical channel.
- [0180] A higher-layer parameter is a parameter included in an RRC message or a MAC CE (Medium Access Control Control Element). The higher-layer parameter is a generic name of information included in a MIB, system information, a message which corresponds to CCCH, a message which corresponds to DCCH, an RRC parameter, and a MAC CE.
- [0181] A higher-layer parameter may be a cell-specific parameter or a UE-specific parameter. A cell-specific parameter is a parameter including a common configuration in a cell. A UE-specific parameter is a parameter including a configuration that may be configured differently for each UE.
- [0182] The base station device 3 may indicate change of cell-specific parameters by reconfiguration with random-access. The UE may change cell-specific parameters before triggering random-access. The base station device may indicate change of UE-specific parameters by reconfiguration with or without random-access. The UE may change UE-specific parameters before or after random-access.
- [0183] The procedure performed by terminal device 1 includes a part or all of the following 5A to 5C. The 5A is cell search. The 5B is random-access. The 5C is data communication.
- [0184] The cell search is a procedure used by the terminal device 1 to synchronize with a cell in the time domain and/or the frequency domain and to detect a physical cell identity. Terminal device 1 tries to detect the physical cell ID by performing synchro-

nization of time domain and/or frequency domain with a cell by the cell search.

- [0185] A sequence of a PSS is given based on a physical cell ID. A sequence of an SSS is given based on the physical cell ID.
- [0186] An SS/PBCH block candidate indicates a resource for which transmission of the SS/PBCH block may exist. An SS/PBCH block is transmitted at a resource indicated as the SS/PBCH block candidate. The base station device 3 transmits an SS/PBCH block at an SS/PBCH block candidate. The terminal device 1 receives the SS/PBCH block at the SS/PBCH block candidate.
- [0187] The base station device 3 transmits SS/PBCH blocks of one or more indexes at a pre-determined cycle. The terminal device 1 tries to decode the PBCH included in the SS/PBCH block.
- [0188] The random-access is a procedure including a part or all of message 1, message 2, message 3, and message 4.
- [0189] The message 1 is a procedure in which the terminal device 1 transmits a PRACH. The terminal device 1 transmits the PRACH in one PRACH occasion selected from among one or more PRACH occasions based on the index of the SS/PBCH block candidate detected based on the cell search.
- [0190] The message 2 is a procedure in which the terminal device 1 attempts to detect a DCI format 1_0 with CRC (Cyclic Redundancy Check) scrambled by an RA-RNTI (Random Access-Radio Network Temporary Identifier).
- [0191] The message 3 is a procedure for transmitting a PUSCH scheduled by a random-access response grant included in a random access response scheduled by the DCI format 1_0 detected in the message 2 procedure.
- [0192] The PUSCH scheduled based on the random-access response grant is either a message 3 PUSCH or a PUSCH. The message 3 PUSCH contains a contention resolution identifier MAC CE. The contention resolution ID MAC CE includes a contention resolution ID.
- [0193] Retransmission of the message 3 PUSCH is scheduled by DCI format 0_0 with CRC scrambled by a TC-RNTI (Temporary Cell-Radio Network Temporary Identifier).
- [0194] The message 4 is a procedure that attempts to detect a DCI format 1_0 with CRC scrambled by either a C-RNTI (Cell-Radio Network Temporary Identifier) or a TC-RNTI. The terminal device 1 receives a PDSCH scheduled based on the DCI format 1_0. The PDSCH may include a collision resolution ID.
- [0195] Data communication is a generic term for downlink communication and uplink communication.
- [0196] In data communication, the terminal device 1 attempts to detect a PDCCH (attempts to monitor a PDCCH, monitors a PDCCH, detect a DCI format, attempts to monitor a DCI format, monitors a DCI format) in a resource identified based on a control

resource set and a search-space-set. It's also called as "the terminal device 1 attempts to detect a PDCCH in a control resource set", "the terminal device 1 attempts to detect a PDCCH in a search-space-set", "the terminal device 1 attempts to detect a PDCCH candidate in a control resource set", "the terminal device 1 attempts to detect a PDCCH candidate in a search-space-set", "the terminal device 1 attempts to detect a DCI format in a control resource set", or "the terminal device 1 attempts to detect a DCI format in a search-space-set". Monitoring a PDCCH may be equivalent as monitoring a DCI format in the PDCCH.

- [0197] The control resource set is a set of resources identified by a set of resource blocks and a set of OFDM symbols in a slot.
- [0198] The set of resources for the control resource set may be indicated by higher-layer parameters. The number of OFDM symbols included in the control resource set may be indicated by higher-layer parameters.
- [0199] A PDCCH may be also called as a PDCCH candidate.
- [0200] A search-space-set is defined as a set of PDCCH candidates. A search-space-set may be a Common Search Space (CSS) set or a UE-specific Search Space (USS) set.
- [0201] The CSS set is a generic name of a type-0 PDCCH common search-space-set, a type-0a PDCCH common search-space-set, a type-1 PDCCH common search-space-set, a type-2 PDCCH common search-space-set, and a type-3 PDCCH common search-space-set. The USS set may be also called as UE-specific PDCCH search-space-set.
- [0202] The type-0 PDCCH common search-space-set may be used as a common search-space-set with index 0. The type-0 PDCCH common search-space-set may be a common search-space-set with index 0.
- [0203] A search-space-set is associated with (included in, corresponding to) a control resource set. The index of the control resource set associated with the search-space-set may be indicated by higher-layer parameters.
- [0204] For a search-space-set, a part or all of 6A to 6C may be indicated at least by higher-layer parameters. The 6A is PDCCH monitoring period. The 6B is PDCCH monitoring pattern within a slot. The 6C is PDCCH monitoring offset.
- [0205] A monitoring occasion of a search-space-set may correspond to one or more OFDM symbols in which the first OFDM symbol of the control resource set associated with the search-space-set is allocated. A monitoring occasion of a search-space-set may correspond to resources identified by the first OFDM symbol of the control resource set associated with the search-space-set. A monitoring occasion of a search-space-set is given based on a part or all of PDCCH monitoring periodicity, PDCCH monitoring pattern within a slot, and PDCCH monitoring offset.
- [0206] Fig. 8 is a diagram showing an example of the monitoring occasion of search-space-sets according to an aspect of an example embodiment and mode. In Fig. 8, the

search-space-set 91 and the search-space-set 92 are configured in the primary cell 301, the search-space-set 93 is configured in the secondary cell 302, and the search-space-set 94 is configured in the secondary cell 303.

- [0207] In Fig. 8, the block indicated by the grid line indicates the search-space-set 91, the block indicated by the upper right diagonal line indicates the search-space-set 92, the block indicated by the upper left diagonal line indicates the search-space-set 93, and the block indicated by the horizontal line indicates the search-space-set 94.
- [0208] In Fig. 8, the PDCCH monitoring periodicity for the search-space-set 91 is set to 1 slot, the PDCCH monitoring offset for the search-space-set 91 is set to 0 slot, and the PDCCH monitoring pattern for the search-space-set 91 is [1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0]. That is, the monitoring occasion of the search-space-set 91 corresponds to the first OFDM symbol (OFDM symbol # 0) and the eighth OFDM symbol (OFDM symbol # 7) in each of the slots.
- [0209] In Fig. 8, the PDCCH monitoring periodicity for the search-space-set 92 is set to 2 slots, the PDCCH monitoring offset for the search-space-set 92 is set to 0 slots, and the PDCCH monitoring pattern for the search-space-set 92 is [1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]. That is, the monitoring occasion of the search-space-set 92 corresponds to the leading OFDM symbol (OFDM symbol # 0) in each of the even slots.
- [0210] In Fig. 8, the PDCCH monitoring periodicity for the search-space-set 93 is set to 2 slots, the PDCCH monitoring offset for the search-space-set 93 is set to 0 slots, and the PDCCH monitoring pattern for the search-space-set 93 is [0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0]. That is, the monitoring occasion of the search-space-set 93 corresponds to the eighth OFDM symbol (OFDM symbol # 8) in each of the even slots.
- [0211] In Fig. 8, the PDCCH monitoring periodicity for the search-space-set 94 is set to 2 slots, the PDCCH monitoring offset for the search-space-set 94 is set to 1 slot, and the PDCCH monitoring pattern for the search-space-set 94 is [1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]. That is, the monitoring occasion of the search-space-set 94 corresponds to the leading OFDM symbol (OFDM symbol # 0) in each of the odd slots.
- [0212] The type-0 PDCCH common search-space-set may be used for a DCI format with a cyclic redundancy check (CRC) sequence scrambled by an SI-RNTI (System Information-Radio Network Temporary Identifier).
- [0213] The type-0a PDCCH common search-space-set may be used for a DCI format with a cyclic redundancy check sequence scrambled by an SI-RNTI.
- [0214] The type-1 PDCCH common search-space-set may be used for a DCI format with a CRC sequence scrambled by an RA-RNTI (Random Access-Radio Network Temporary Identifier) or a CRC sequence scrambled by a TC-RNTI (Temporary Cell-Radio Network Temporary Identifier).
- [0215] The type-2 PDCCH common search-space-set may be used for a DCI format with a

CRC sequence scrambled by P-RNTI (Paging-Radio Network Temporary Identifier).

[0216] The type-3 PDCCH common search-space-set may be used for a DCI format with a CRC sequence scrambled by a C-RNTI (Cell-Radio Network Temporary Identifier).

[0217] The UE-specific search-space-set may be used for a DCI format with a CRC sequence scrambled by a C-RNTI.

[0218] In downlink communication, the terminal device 1 may detect a downlink DCI format. The detected downlink DCI format is used for resource assignment for a PDSCH. The detected downlink DCI format is also referred to as downlink assignment. The terminal device 1 attempts to receive the PDSCH. Based on a PUCCH resource indicated based on the detected downlink DCI format, an HARQ-ACK corresponding to the PDSCH (HARQ-ACK corresponding to a transport block included in the PDSCH) may be reported to the base station device 3.

[0219] In uplink communication, the terminal device 1 may detect an uplink DCI format. The detected uplink DCI format is used for resource assignment for a PUSCH. The detected uplink DCI format is also referred to as uplink grant. The terminal device 1 transmits the PUSCH.

[0220] 0.0 TRANSMITTING PUSCH IN ENHANCED DUPLEX OPERATION

0.1 ENHANCED DUPLEX OPERATION

Fig. 9 shows an example configuration of time-frequency subband grid for SubBand Full Duplex, SBFD, operation. Broken lines 900, 901, 902, 903, 904, and 905 represent respective points in the time domain. Lines 910, 911, 912, 913, and 914 represent respective time durations in the time domain. Broken lines 920, 921, 922, 923, 924, and 925 represent respective points in the frequency domain. Lines 930, 931, 932, 933, and 934 represent respective bandwidths in the frequency domain.

[0221] In the example shown in Fig. 9, it is assumed that the duration 910 represents a downlink, DL, region, the duration 913 represents Flexible region, and the duration 914 represents UL region. The DL region, flexible region, and UL region are configured by a cell-specific radio resource control, RRC, parameter for a time division duplex, TDD, pattern which may be referred to as common TDD parameter. Also, it is assumed that the duration from 900 to 905 is a period of the TDD pattern configured by the common TDD parameter.

[0222] There are 2 examples for configuration details of the duration 911 and 912. In one example, i.e., Example#1, the durations 911 and 912 are DL regions configured by the common TDD parameter. In another example, i.e., Example#2, the durations 911 and 912 are flexible regions configured by the common TDD parameter.

[0223] In the example shown in Fig. 9, it is assumed that the bandwidths 930 and 934 represent respective bandwidths of DL subbands 951 and 952, the bandwidth 932 represents the bandwidth of UL subband 950, and the bandwidths 931 and 933

represent respective bandwidths of guard bands.

[0224] In the example shown in Fig. 9, it is assumed that the terminal device 1 recognizes the region identified by duration 912 and bandwidth 932 as UL subband 950; recognizes the region identified by duration 912 and bandwidth 930 as DL subband 951; and, recognizes the region identified by duration 912 and bandwidth 934 as DL subband 952.

[0225] Base station device 3 may transmit information to terminal device 1 to enable terminal device 1 to determine various subbands, e.g., to determine size and/or location of the various subbands. Such information may be transmitted via an RRC parameter. The RRC parameter for determining UL subband 950 is referred to as the subband parameter. The subband parameter may be provided as a cell-specific RRC parameter or UE-specific RRC parameter. Examples of such transmitted information which enable the terminal device 1 to determine various subbands are described below:

- For example, base station device 3 may transmit a subband parameter for determining size and/or location of UL subband 950. For example, base station device 3 may transmit a subband parameter for indicating size and/or location of UL subband 950.
 - For example, base station device 3 may transmit a subband parameter for determining size and/or location of DL subband 951. For example, base station device 3 may transmit a subband parameter for indicating size and/or location of DL subband 951.
 - For example, base station device 3 may transmit a subband parameter for determining size and/or location of DL subband 952. For example, base station device 3 may transmit a subband parameter for indicating size and/or location of DL subband 952.
 - For example, base station device 3 may transmit a subband parameter for determining size and/or location of bandwidth 932. For example, base station device 3 may transmit a subband parameter for determining size and/or location of duration 912.
 - For example, base station device 3 may transmit a subband parameter for indicating size and/or location of bandwidth 932. For example, base station device 3 may transmit a subband parameter for indicating size and/or location of duration 912.
 - For example, base station device 3 may transmit a subband parameter for determining size and/or location of bandwidth 930, 932, and 934. For example, base station device 3 may transmit a subband parameter for determining size and/or location of duration 912.
 - For example, base station device 3 may transmit a subband parameter for indicating size and/or location of bandwidth 930, 932, and 934. For example, base station device 3 may transmit a subband parameter for indicating size and/or location of duration 912.
 - For example, a subband parameter for determining size and/or location of duration 912 may be a form of a RRC parameter for TDD pattern. For example, a symbol may be recognized as a part of duration 912 if the subband parameter indicates the symbol as UL while the common TDD parameter indicates the symbol as DL. For example, a symbol may be recognized as a part of duration 912 if the subband parameter indicates the symbol as flexible while the common TDD parameter indicates the symbol as DL.
- [0226] In the example shown in Fig. 9, it is possible that length of the duration 911 is 0 or more, and the length of the duration 913 is 0 or more.
- [0227] In the example shown in Fig. 9, it is possible that width of the bandwidth 931 is 0 or more, and width of the bandwidth 933 is 0 or more.
- [0228] In the example#2, the terminal device 1 may be further configured to monitor DCI format 2_0. The DCI format 2_0 comprises of an information field which indicates a usage type of the flexible region. For example, there are “downlink”, “flexible”, and “uplink” usage types.
- [0229] To monitor DCI format 2_0, the terminal device 1, e.g., UE, is provided a RRC parameter which indicates payload size of DCI format 2_0. The payload represents the number of bits in a DCI format 2_0 to be monitored excluding the number of bits in

the CRC sequence. In other expressions, the payload size represents the number of bits of N SFI fields.

[0230] To derive a slot format indicator, the UE is provided a RRC parameter which indicates starting bit location of a SFI field to be applied to the UE. Further, to derive a slot format indicator, the UE is provided with one or more RRC parameters which is used to determine the number of bits of the SFI field to be applied to the UE. Each of the one or more RRC parameters is an index for a slot format combination. Each slot format combination provides an index. The UE determines the largest index in the one or more RRC parameters. The UE determines the number of bits of the SFI field by the determined largest index. For example, the UE determines the number of bits of the SFI field by $\max(\text{ceil}(\log_2(\text{maxSFIindex}+1)), 1)$ where the maxSFIindex is the value of the determined largest index, $\max(A, B)$ represents operation to obtain the maximum of A and B.

[0231] A slot format combination comprises one or more slot formats. Each slot format comprises transmission direction configuration for each symbol in a slot. For example, a slot format represents “DDDDDDFFUUUUUU” where each capital letter indicates transmission direction for a OFDM symbol in a slot. Here, ‘D’ represents that the corresponding OFDM symbol in a slot is downlink symbol, ‘F’ represents that the corresponding OFDM symbol in a slot is flexible symbol, and ‘U’ represents that the corresponding OFDM symbol in a slot is uplink symbol. In another example, a slot format represents “DDDDDDDDDDFFUU”. In another example, a slot format represents downlink symbol for all OFDM symbols in a slot. In another example, a slot format represents flexible for all OFDM symbols in a slot. In another example, a slot format represents uplink symbol for all OFDM symbols in a slot. In another example, a slot format represents a special information that instructs UE to assume that the UE has not been configured with monitoring of DCI format 2_0.

[0232] In a case that a DCI format 2_0 has been detected in the slot with index n, one or more slot formats in a slot format combination identified by the DCI format 2_0 is applied to the number of slots starting at the slot with index n. For example, the first slot format in the one or more slot formats is applied to the slot with index n. Further, the second slot format in the one or more slot formats is applied to the slot with index n+1. Further, the xth slot format in the one or more slot formats is applied to the slot with index n+x-1.

[0233] Fig. 10 shows an example of configuration of potential transmission occasions according to an aspect of an example embodiment and mode. In Fig. 10, the horizontal axis represents the time domain. Partitions in the time domain represent slots. Slots are numbered starting at slot n in ascending order.

[0234] The period of the TDD pattern is provided by the common TDD parameter, and in

Fig. 10 the TDD pattern is set to 4 slots as an example. The TDD pattern is represented by a sequence of DL region 1001, flexible region 913, and UL region 914. DL region 1001 corresponds to the durations 910, 911 and 912 of Fig. 9. Also, DL region 1001', flexible region 913' and UL region 914' represents each duration in the next cycle of the TDD pattern represented by the sequence of DL region 1001, flexible region 913, and UL region 914.

[0235] pusch transmission for enhanced duplex operation

As mentioned above, a PUSCH is used to convey uplink data (a transport block) and/or uplink control information. The terminal device 1 transmits a PUSCH in which uplink data (a transport block) and/or uplink control information is arranged. The base station device 3 receives a PUSCH in which uplink data (a transport block) and/or uplink control information is arranged.

[0236] A slot is time domain resource unit; a PUSCH is a physical channel used to convey information originated from higher layers. The PUSCH is typically transmitted in time and frequency resources of the resource grid, and thus is transmitted in time domain slots of a resource grid. The technology disclosed herein includes, as one of its example aspects, how such slots for actual PUSCH transmission are determined. PUSCH transmission typically involves transmission of a first or initial version of the PUSCH. The first or initial version of the PUSCH may be transmitted in what is referred to herein as "leading slot", and thereafter redundant versions of the PUSCH may be transmitted. Both the initial or leading version of the PUSCH and the redundant versions are herein referred to as a PUSCH repetition.

[0237] In PUSCH repetition, transmission resource for the PUSCH is determined by the TDD pattern provided by the common TDD parameter. Referring back to Fig. 9 as an example,, in a case that region 912 is configured as DL region by the common TDD parameter, PUSCH transmission cannot be performed according to the existing procedure.

[0238] Aspects of the technology disclosed herein include apparatus, methods and techniques for determining an appropriate transmission occasion(s) for PUSCH repetition. A "transmission occasion" is a virtual concept, e.g., a virtual occasion that may or may not result in the transmission of a transport block included in a PUSCH from wireless terminal 1 to base station 3 in an enhanced duplex environment/operation.

[0239] In one of its example aspects the technology disclosed herein determines if a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH repetition is eligible for eventual transmission as an actual PUSCH repetition by checking, e.g., whether a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition has a strategic interaction with one or more orthogonal

frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a subband grid. In one example method, described herein as method #1, such strategic interaction comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid in the time domain. In another example, method described herein as method #2, such strategic interaction comprises determining whether the one or more OFDM symbols are confined in any uplink, UL, subband of the grid in the time and frequency domain.

- [0240] Fig. 11 is an example of a PUSCH generation routine that may be performed by a wireless terminal of the technology disclosed herein according to an aspect of an example embodiment and mode. Fig. 11 shows examples acts or steps that may be performed in a routine or logic to determine when and what instances of PUSCH repetition, e.g., which PUSCH potential transmission occasions, remain eligible for transmission by wireless terminal 1 to base station 3.
- [0241] In an example embodiment and mode, the PUSCH generation routine of Fig. 11 may be performed by control unit 14 of wireless terminal 1, and in particular may be performed by PUSCH generator 17 which may comprise or cooperate with control unit 14.
- [0242] In act 1101, wireless terminal 1 receives from base station device 3 information that schedules PUSCH repetition. Such information may be sent by base station 3 and received by wireless terminal 1 via a DCI format or RRC signaling.
- [0243] In act 1102, wireless terminal 1 determines transmission occasions for the PUSCH repetition. In an example embodiment and mode act 1102 may be performed by PUSCH repetition transmission occasion controller 18. The PUSCH repetition transmission occasion controller 18 may also comprise or cooperate with PUSCH generator 17. A purpose of act 1102 is to determine which potential transmission occasions for PUSCH repetition remain eligible, at least after act 1102, for actual transmission from wireless terminal 1 to base station 3 in an enhanced duplex environment/operation. Determination of a potential transmission occasions for PUSCH repetition as an “eligible” PUSCH repetition transmission occasion does not necessarily mean that the “eligible” PUSCH repetition transmission occasion will turn out to be an actual PUSCH repetition transmission occasion, since further acts of Fig. 11 may also be optionally performed and satisfied. Act 1102 thus eliminates some of the potential transmission occasions for PUSCH repetition that, as a result of performance of act 1102, become “ineligible” and thus are not qualified for inclusion in an actual PUSCH transmission.
- [0244] For example, in step 1102, wireless terminal 1 refers to the TDD pattern provided by the common TDD parameter to determine available slot for RV cycling, but not UL subband configuration. Therefore, irrespective of UL subband configuration, PUSCH

cannot be transmitted in UL subband 950. In basic terms, a solution provided by act 1102 is as follows:

If the PUSCH resource is contained in UL subband in frequency domain → transmit

If the PUSCH resource is not fully contained in UL subband in frequency domain → skip. [

In act 1103, described in further detail below, wireless terminal 1 maps Redundancy Versions RVs, for the determined transmission occasions, for the eligible transmission occasions. In other words, the PUSCH repetition transmission occasion controller 18 may perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions. That is, once a set of “transmission occasions” is determined for PUSCH repetition, RV mapping is determined for the set. In RV mapping, an index is attached to each eligible transmission occasion. For example, assuming a specific RV mapping rule (e.g., 0,2,3,1), RV indices are mapped to the set of eligible transmission occasions cyclically. Although RV mapping involves various operations known to the person skilled in the art, including CRC addition, code block segmentation, LDPC coding, rate matching, in basic terms here relevant RV mapping is used to identify a starting coded bit position to map the coded bits for the transport block to a PUSCH.

[0245] In step 1104, described in further detailed below, wireless terminal omits some of PUSCH transmissions in the determined transmission occasions. A purpose of act 1102 was to qualify one or more of the potential transmission occasions for PUSCH repetition as eligible transmission occasions for PUSCH repetition. However, in some instances the filtering, selecting, or eligibility qualifying determination of act 1102 may not be complete or definitive. Such may occur because in act 1102 a downlink region indicated by DCI format 2_0 may not be considered, in which case potential collision checking for the downlink was not complete. For example, if a TDD pattern consists of DDFU and DCI format 2_0 indicates that the ‘F’ slot as downlink, the eligible transmission occasions are to be determined as ‘F’ slot and ‘U’ slot. This rule provides less ambiguity in base station and wireless terminal. Because, sometimes the wireless terminal fails to decode DCI format 2_0 and if failed, understanding on RV mapping would have been different if downlink indicated by DCI format 2_0 is also considered in act 1102. Therefore, act 1104 is performed to omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid. After performance of act 1104, the PUSCH repetition transmission occasion controller 18 may include an eligible transmission occasion that is not omitted from the set in a transport block for the PUSCH repetition.

[0246] In act 1105, wireless terminal 1 transmits the PUSCH in the transmission occasions

not omitted in act 1104. For example, wireless terminal 1 transmits transport blocks for the eligible transmission occasions that are qualified as eligible by act 1102, RV mapped by act 1103, and not omitted from the set by act 1104.

- [0247] In a case that a UL subband is configured in a DL region, repetition should be available both in UL subband in DL region and in UL region. On the other hand, in the available slot counting repetitions in DL region are excluded in the step of determining transmission occasions. "Counting" of a PUSCH repetition includes the concept that the potential transmission occasion is considered eligible at least for the RV mapping of act 1103, and if not omitted at act 1104, may be eligible for actual transmission of a PUSCH.
- [0248] Two example types of methods for determining transmission occasions for PUSCH repetition are now described.
- [0249] The first example method of determining transmission occasions for PUSCH repetition is referred to as "physical slot counting". In the physical slot counting method, continuous slots starting at the leading slot are counted. For example, in a case that the leading slot is provided as the slot n and the number of slots for the PUSCH repetition is provided as 8, wireless terminal 1 determines 8 potential transmission occasions such as occasions 1011 to 1018 in each slot n to slot $n+7$ for the PUSCH repetition example of Fig. 10. A potential transmission occasion is defined in each slot with time and/or frequency domain resource of a PUSCH in each slot.
- [0250] The leading slot may be provided to wireless terminal 1 by base station device 3 via a DCI format which schedules the PUSCH or via a RRC parameter.
- [0251] The second method of determining transmission occasions for PUSCH repetition is referred to as "available slot counting". In the available slot counting method, continuous available slots starting at the leading slot are counted. Available slots are determined by (1) time domain resource of a potential transmission occasions, and (2) the TDD pattern provided by the common TDD parameter.
- [0252] For example, in the available slot counting method, in determining available slots, the wireless terminal 1, e.g., UE, may determine (a) whether or not a potential transmission occasion in a slot overlaps with the DL region in the TDD pattern provided by the common TDD parameter, and/or (b) whether or not a potential transmission occasion in a slot overlaps with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted. For example, in a case that the UE determines that one or more symbols in the potential transmission occasion overlaps with DL region in the TDD pattern provided by the common TDD parameter, or in a case that the UE determined that the one or more symbols in the potential transmission occasion overlaps with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted, the UE may determine the slot as unavailable for a PUSCH

transmission. On the other hand, in a case that the UE determines that no symbols in the potential transmission occasion overlaps with DL region in the TDD pattern provided by the common TDD parameter, and in a case that the UE determined that no symbols in the potential transmission occasion overlaps with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted, the UE may determine the slot as available for a PUSCH transmission.

[0253] Time domain resource of a potential transmission occasions in each slot may be provided by combination of parameters or indicators 'S' and 'L', where 'S' represents the leading OFDM symbol of a potential transmission occasion in each slot and 'L' represents the number of OFDM symbols for the potential transmission occasion in each slot. For example, {S, L} = {0,14} represents that the leading OFDM symbol of a potential transmission occasion in each slot is the OFDM symbol with index 0, and the number of OFDM symbols for the potential transmission occasion in each slot is 14.

[0254] 1.0 PUSCH TRANSMISSION: METHOD #1:

Various example apparatus, methods, and techniques for determining PUSCH repetition transmission opportunities, as reflected by act 1102 of Fig. 11, are described herein, including basic method #1 with its alternative methods including method #1a and method #1b; and basic method #2 with its alternative methods including method #2a and method #2b. All such methods are considered as examples of the available slot counting method described above.

[0255] In a basic example embodiment and mode, method #1 comprises, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid. Fig. 21 shows example acts or steps which may comprise method #1. Act 21-1 comprises making the determination whether the potential transmission occasion corresponds to an eligible transmission occasion. Act 21-2 comprises transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0256] 1.1 PUSCH TRANSMISSION: METHOD #1: EXAMPLES

Method #1 may be performed with different configurations, non-limiting examples of which are illustrated by the following:

1.1.1 PUSCH TRANSMISSION: METHOD #1: FIRST EXAMPLE

For example, in the available slot counting method, in a case of Fig. 10 that time domain resource of a potential transmission occasion in each slot is provided as {S, L}

= {0, 14}, and the number of slots for PUSCH repetition is 2, wireless terminal 1 applies following series of acts comprising of act 100a to act 100g for determining transmission occasions:

Act 100a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in downlink, DL, region 1001. Therefore, wireless terminal 1 determines that the slot n is not counted, e.g., is not eligible, for the PUSCH repetition.

[0257] Act 100b: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1012 are in DL region 1001. Therefore, the wireless terminal 1 determines that the slot n+1 is not counted for the PUSCH repetition.

[0258] Act 100c: Wireless terminal 1 determines that one or more OFDM symbols of potential transmission occasion 1013 are in DL region 1001. Therefore, wireless terminal 1 determines that the slot n+2 is not counted for the PUSCH repetition.

[0259] Act 100d: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot n+3 is counted, e.g., is eligible, for the PUSCH repetition.

[0260] Act 100e: Wireless terminal 1 determines that the potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 1001'. Therefore, wireless terminal 1 determines that the slot n+4 is not counted for the PUSCH repetition.

[0261] Act 100f: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1016 are in DL region 1001'. Therefore, wireless terminal 1 determines that the slot n+5 is not counted for the PUSCH repetition.

[0262] Act 100g: Wireless terminal 1 determines that one or more OFDM symbols of potential transmission occasion 1017 are in DL region 1001. Therefore, wireless terminal 1 determines that the slot n+6 is not counted for the PUSCH repetition.

[0263] Act 100h: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1018 are in UL region 914. Therefore, wireless terminal 1 determines that the slot n+7 is counted for the PUSCH repetition.

[0264] Act 100i: Wireless terminal 1 determines that the count of slots for which PUSCH transmission may occur is 2, e.g., slot n+3, and slot n+7. Therefore, wireless terminal 1 determines that potential transmission occasions 1014 and 1018 as transmission occasions for the PUSCH repetition. The potential transmission occasions for the PUSCH repetition for which are thus determined by wireless terminal to be eligible for PUSCH repetition transmission may be referred to as eligible transmission occasions for PUSCH repetition transmission.

[0265] 1.1.2 PUSCH TRANSMISSION: METHOD #1: SECOND EXAMPLE

Fig. 12 shows another example of potential PUSCH transmission occasions

according to an aspect of an example embodiment and mode. In Fig. 12, the horizontal axis represents the time domain. Partitions in the time domain represent slots. Slots are numbered starting at slot n in ascending order. The example of Fig. 12 differs from the example of Fig. 10 by reason, e.g., of the time domain regions being differently defined and differently indicated with respect to transmission direction, e.g., either uplink, UL, downlink, DL, or flexible, F.

[0266] In Fig. 12, the period of the TDD pattern provided by the common TDD parameter is set to 4 slots as an example. The TDD pattern is represented by a sequence of DL region 910, duration 911, duration 912, flexible region 913, and UL region 914. Also, DL region 910', duration 911', duration 912', flexible region 913' and UL region 914' represents each duration in the next cycle of the TDD pattern represented by the sequence of DL region 910, duration 911, duration 912, flexible region 913, and UL region 914. The slot association with respect to the TDD pattern of Fig. 12 is thus different from Fig. 10.

[0267] Even when duration 912 of Fig. 12 is configured as a DL region in the TDD pattern, the UL subband 950 within the DL region 912 should be available for PUSCH repetition. Therefore, in determining transmission occasions for available slot counting, wireless terminal 1 may consider the time and/or frequency domain resource of UL subband 950.

[0268] In applying method#1 to Fig. 12, wireless terminal 1 considers the time domain resource of UL subband 950 for determining transmission occasions for PUSCH repetition. For example, in a case of Fig. 12 that the time domain resource of a potential transmission occasion in each slot is provided as $\{S, L\} = \{0, 14\}$, the number of slots for the PUSCH repetition is 4, and the duration 912 is configured as DL region in the TDD pattern provided by the common TDD parameter, wireless terminal 1 applies following series of acts comprising act 101a to act 101g for determining transmission occasions:

Act 101a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in DL region 910 and any UL subband is not configured in the one or more OFDM symbols. Therefore, wireless terminal 1 determines that the slot n is not counted for the PUSCH repetition, e.g., is not eligible for PUSCH transmission.

[0269] Act 101b: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1012 are in DL region 912. Further, all the OFDM symbols of potential transmission occasion 1012 overlap with UL subband 950 in the time domain. Therefore, the wireless terminal 1 determines that the slot $n+1$ is counted for the PUSCH repetition, e.g., is eligible for PUSCH transmission.

[0270] Act 101c: Wireless terminal 1 determines that a first set of OFDM symbols of

potential transmission occasion 1013 are in DL region 912, a second set of OFDM symbols of potential transmission occasion 1013 are in flexible region 913, and a third set of OFDM symbols of potential transmission occasion 1013 are in UL region 914. Further, wireless terminal 1 determines that all the OFDM symbols in the first set overlaps with UL subband 950 in time domain. Therefore, wireless terminal 1 determines that the slot $n+2$ is counted for the PUSCH repetition.

[0271] Act 101d: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+3$ is counted for the PUSCH repetition.

[0272] Act 101e: Wireless terminal 1 determines that the potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 910' and no UL subband is configured in the one or more OFDM symbols. Therefore, wireless terminal 1 determines that the slot $n+4$ is not counted for the PUSCH repetition.

[0273] Act 101f: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1016 are in DL region 912'. Further, all the OFDM symbols of the potential transmission occasion 1016 overlap with UL subband in the time domain. Therefore, wireless terminal 1 determines that the slot $n+5$ is counted for the PUSCH repetition.

[0274] Act 101g: Wireless terminal 1 determines that count on slots reached at 4 by slot $n+1$, slot $n+2$, slot $n+3$, and slot $n+5$. Therefore, wireless terminal 1 determines that potential transmission occasions 1012, 1013, 1014, and 1016 as transmission occasions for the PUSCH repetition. The potential transmission occasions for the PUSCH repetition for which are thus determined by wireless terminal to be eligible for PUSCH repetition transmission may be referred to as eligible transmission occasions for PUSCH repetition transmission.

[0275] Therefore, in method#1, whether UL subband overlaps with the potential transmission occasions in DL region in the time domain or not may be considered for determining eligible transmission occasions for PUSCH repetition.

[0276] For example, in method#1, in a case that a potential transmission occasion overlaps with one or more OFDM symbols in DL region in the time domain, wireless terminal 1 performs additional test of whether the one or more OFDM symbols overlap with any UL subband or not. For example, in a case that the one or more OFDM symbols overlaps with a UL subband in the time domain, wireless terminal 1 counts the slot for the PUSCH repetition. For example, in a case that at least one OFDM symbol in the one or more OFDM symbols does not overlap with any UL subband in the time domain, wireless terminal 1 does not count the slot for the PUSCH repetition.

[0277] 1.1.3 PUSCH TRANSMISSION: METHOD #1: THIRD EXAMPLE

In method#1, for example, in a case of Fig. 12 that the time domain resource of a

potential transmission occasion in each slot is provided as $\{S, L\} = \{0, 14\}$, the number of slots for the PUSCH repetition is 4, and duration 912 is configured as flexible region in the TDD pattern provided by the common TDD parameter (rather than duration 912 being a DL region as previously described), wireless terminal 1 applies following series of acts comprising act 102a to act 102g for determining transmission occasions:

Act 102a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in DL region 910 and any UL subband is not configured in the one or more OFDM symbols. Therefore, wireless terminal 1 determines that the slot n is not counted for the PUSCH repetition.

[0278] Act 102b: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1012 are in flexible region 912. Therefore, wireless terminal 1 determines that the slot $n+1$ is counted for the PUSCH repetition.

[0279] Act 102c: Wireless terminal 1 determines that a first set of OFDM symbols of potential transmission occasion 1013 are in flexible region 912, a second set of OFDM symbols of potential transmission occasion 1013 are in flexible region 913, and a third set of OFDM symbols of potential transmission occasion 1013 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+2$ is counted for the PUSCH repetition.

[0280] Act 102d: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+3$ is counted for the PUSCH repetition.

[0281] Act 102e: Wireless terminal 1 determines that potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 910' and no UL subband is configured in the one or more OFDM symbols. Therefore, wireless terminal 1 determines that the slot $n+4$ is not counted for the PUSCH repetition.

[0282] Act 102f: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1016 are in flexible region 912'. Therefore, wireless terminal 1 determines that the slot $n+5$ is counted for the PUSCH repetition.

[0283] Act 102g: Wireless terminal 1 determines that count on slots reached at 4 by slot $n+1$, slot $n+2$, slot $n+3$, and slot $n+5$. Therefore, wireless terminal 1 determines that potential transmission occasions 1012, 1013, 1014, and 1016 as transmission occasions for the PUSCH repetition and therefore are eligible for PUSCH transmission.

[0284] Therefore, in method#1, whether UL subband overlaps with the potential transmission occasions in flexible region in the time domain or not may not be considered for determining transmission occasions for PUSCH repetition.

[0285] PUSCH TRANSMISSION: METHOD #1a

Fig. 13 is an example of potential transmission occasions according to an aspect of

an example embodiment and mode. In Fig. 13, the horizontal axis represents the time domain. Partitions in the time domain represent slots. The vertical axis represents the frequency domain. Slots are numbered starting at slot n in ascending order.

[0286] In Fig. 13, the period of the TDD pattern provided by the common TDD parameter is set to 4 slots, again as an example. The TDD pattern is represented by a sequence of DL region 910, the duration 911, the duration 912, flexible region 913, and UL region 914. Also, the DL region 910', the duration 911', the duration 912', flexible region 913' and UL region 914' represents each duration in the next cycle of the TDD pattern represented by the sequence of DL region 910, the duration 911, the duration 912, flexible region 913, and UL region 914. Further, 1301 represents resource(s) of the grid that may be a synchronization signal/physical broadcast channel block candidate resource(s), SS/PBCH block candidate resource(s), e.g., a SS/PBCH candidate, in which a SS/PBCH block is expected to be transmitted according to a RRC parameter. As mentioned above, an SS/PBCH block candidate indicates a resource for which transmission of the SS/PBCH block may exist. An SS/PBCH block is transmitted at a resource indicated as the SS/PBCH block candidate. The base station device 3 transmits an SS/PBCH block at an SS/PBCH block candidate. The terminal device 1 receives the SS/PBCH block at the SS/PBCH block candidate.

[0287] Method#1a is considered as an alternative to method#1. For example, in a case of Fig. 13 that the time domain resource of a potential transmission occasion in each slot is provided as $\{S, L\} = \{0, 14\}$, the number of slots for the PUSCH repetition is 4, and duration 912 is configured as DL region in the TDD pattern provided by the common TDD parameter, wireless terminal 1 applies following series of acts comprising act 103a to act 103h for determining transmission occasions as method#1a:

Act 103a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in DL region 910 and no UL subband is configured in the one or more OFDM symbols. Therefore, wireless terminal 1 determines that the slot n is not counted for the PUSCH repetition.

[0288] Act 103b: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1012 are in DL region 912. Further, all the OFDM symbols of the potential transmission occasion 1012 overlap with UL subband 950 in the time domain. On the other hand, wireless terminal 1 also determines that SS/PBCH block candidate 1301 in which a SS/PBCH block is expected to be transmitted overlaps with one or more OFDM symbols of potential transmission occasion 1012. Therefore, wireless terminal 1 determines that the slot $n+1$ is not counted for the PUSCH repetition.

[0289] Act 103c: Wireless terminal 1 determines that a first set of OFDM symbols of potential transmission occasion 1013 are in DL region 912, a second set of OFDM

symbols of potential transmission occasion 1013 are in flexible region 913, and a third set of OFDM symbols of potential transmission occasion 1013 are in UL region 914. Further, wireless terminal 1 determines that all the OFDM symbols in the first set overlaps with UL subband 950 in the time domain. Further, wireless terminal 1 determines that potential transmission occasion 1013 does not overlap with any SS/PBCH block candidate in which a SS/PBCH block is expected to be transmitted. Therefore, wireless terminal 1 determines that the slot $n+2$ is counted for the PUSCH repetition.

[0290] Act 103d: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+3$ is counted for the PUSCH repetition.

[0291] Act 103e: Wireless terminal 1 determines that potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 910' and no UL subband is configured in the one or more OFDM symbols. Therefore, wireless terminal 1 determines that the slot $n+4$ is not counted for the PUSCH repetition.

[0292] Act 103f: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1016 are in DL region 912'. Further, all the OFDM symbols of potential transmission occasion 1016 overlap with UL subband 950 in the time domain. Further, wireless terminal 1 determines that potential transmission occasion 1016 does not overlap with any SS/PBCH block candidate in which a SS/PBCH block is expected to be transmitted. Therefore, wireless terminal 1 determines that the slot $n+5$ is counted for the PUSCH repetition.

[0293] Act 103g: Wireless terminal 1 determines that a first set of OFDM symbols of potential transmission occasion 1017 are in DL region 912', a second set of OFDM symbols of potential transmission occasion 1017 are in flexible region 913', and a third set of OFDM symbols of potential transmission occasion 1017 are in UL region 914'. Further, wireless terminal 1 determines that all the OFDM symbols in the first set overlaps with UL subband 950 in the time domain. Further, wireless terminal 1 determines that potential transmission occasion 1017 does not overlap with any SS/PBCH block candidate in which a SS/PBCH block is expected to be transmitted. Therefore, wireless terminal 1 determines that the slot $n+6$ is counted for the PUSCH repetition.

[0294] Act 103h: Wireless terminal 1 determines that count on slots reached at 4 by slot $n+2$, slot $n+3$, slot $n+5$, and slot $n+6$. Therefore, wireless terminal 1 determines that potential transmission occasions 1013, 1014, 1016, and 1017 as transmission occasions for the PUSCH repetition.

[0295] Therefore, in method#1a, whether a UL subband overlaps with the potential transmission occasions in DL region in the time domain or not is to be considered for

determining transmission occasions for PUSCH repetition in a case that the potential transmission occasions does not overlap with any SS/PBCH block candidates in which a SS/PBCH block is expected to be transmitted.

[0296] Fig. 14 shows example acts or steps of an example procedure of the method#1a according to an aspect of example embodiment and mode. In act 1401, wireless terminal 1 determines whether a potential transmission occasion in a slot overlaps with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted or not. In a case that wireless terminal 1 determines that the potential transmission occasion in the slot overlaps with a SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted, wireless terminal 1 performs act 1402 in which wireless terminal 1 determines that the slot is not counted for the PUSCH repetition. In a case that wireless terminal 1 determines that the potential transmission occasion does not overlap with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted, wireless terminal 1 proceeds to and performs act 1403.

[0297] In act 1403, wireless terminal 1 determines whether the potential transmission occasion overlaps with a DL region in one or more OFDM symbols or not. In a case that wireless terminal 1 determined that the potential transmission occasion does not overlap with DL region in any OFDM symbol, wireless terminal 1 performs act 1404 in which wireless terminal 1 determines that the slot is counted for the PUSCH repetition. In a case that wireless terminal 1 determines that the potential transmission occasion overlaps with a DL region in one or more OFDM symbols, wireless terminal 1 proceeds with act 1405.

[0298] In act 1405, wireless terminal 1 determines whether the potential transmission occasion overlaps with a UL subband in all the one or more OFDM symbols or not. In a case that wireless terminal 1 determines that the potential transmission occasion overlaps with UL subband in all the one or more OFDM symbols, wireless terminal 1 performs act 1406. As act 1406 wireless terminal 1 determines that the slot is counted for the PUSCH repetition. In a case that wireless terminal 1 determines that the potential transmission occasion does not overlap with any UL subband at least in one OFDM symbol among the one or more OFDM symbols, wireless terminal 1 performs act 1407 in which wireless terminal 1 determines that the slot is not counted for the PUSCH repetition.

[0299] 1.3 PUSCH TRANSMISSION: METHOD #1b

On the other hand, even when one or more SS/PBCH block candidates in which an SS/PBCH block is expected to be transmitted are configured as in Fig. 13, Method#1b may be considered as an alternative to method#1. For example, in a case of Fig. 13 that the time domain resource of a potential transmission occasion in each slot is provided

as $\{S, L\} = \{0, 14\}$, the number of slots for the PUSCH repetition is 4, and duration 912 is configured as DL region in the TDD pattern provided by the common TDD parameter, wireless terminal 1 applies following series of act comprising act Step 104a to act 104g for determining transmission occasions as method#1b:

Act 104a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in DL region 910 and any UL subband is not configured in the one or more OFDM symbols. Therefore, wireless terminal 1 determines that the slot n is not counted for the PUSCH repetition.

[0300] Act 104b: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1012 are in DL region 912. Further, all the OFDM symbols of the potential transmission occasion 1012 overlap with UL subband 950 in the time domain. Wireless terminal disregards SS/PBCH block candidates for determining transmission occasions in OFDM symbols with UL subband 950. Therefore, wireless terminal 1 determines that the slot $n+1$ is counted for the PUSCH repetition.

[0301] Method#1b ignores collision with SS/PBCH block even when a potential transmission occasion collides with the SS/PBCH block candidate. Method#1a does consider such collision. Method#1 and Method#1b and Method #1a are the same when a potential transmission occasion does not collide with any SS/PBCH block candidate.

[0302] Act 104c: Wireless terminal 1 determines that a first set of OFDM symbols of potential transmission occasion 1013 are in DL region 912, a second set of OFDM symbols of potential transmission occasion 1013 are in flexible region 913, and a third set of OFDM symbols of potential transmission occasion 1013 are in UL region 914. Further, wireless terminal 1 determines that all the OFDM symbols in the first set overlaps with UL subband 950 in the time domain. Further, wireless terminal 1 disregards SS/PBCH block candidates for determining transmission occasions in OFDM symbols with UL subband 950. Therefore, wireless terminal 1 determines that the slot $n+2$ is counted for the PUSCH repetition.

[0303] Act 104d: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+3$ is counted for the PUSCH repetition.

[0304] Act 104e: Wireless terminal 1 determines that potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 910' and any UL subband is not configured in the one or more OFDM symbols. Therefore, wireless terminal 1 determines that the slot $n+4$ is not counted for the PUSCH repetition.

[0305] Act 104f: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1016 are in DL region 912'. Further, all the OFDM symbols of potential transmission occasion 1016 overlap with UL subband 950 in the time domain. Further, wireless terminal 1 disregards SS/PBCH block candidates for de-

termining transmission occasions in OFDM symbols with UL subband 950. Therefore, wireless terminal 1 determines that the slot $n+5$ is counted for the PUSCH repetition.

[0306] Act 104h: Wireless terminal 1 determines that count on slots reached at 4 by slot $n+1$, slot $n+2$, slot $n+3$, and slot $n+5$. Therefore, wireless terminal 1 determines that potential transmission occasions 1012, 1013, 1014, and 1016 as transmission occasions for the PUSCH repetition.

[0307] Therefore, in method#1b, whether a UL subband overlaps with the potential transmission occasions in DL region in the time domain or not is to be considered for determining transmission occasions for PUSCH repetition regardless of whether the potential transmission occasion overlaps with any SS/PBCH block candidates in which a SS/PBCH block is expected to be transmitted or not.

[0308] 2.0 PUSCH TRANSMISSION: METHOD #2

In a basic example embodiment and mode, method #2 comprises, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols is confined in any uplink, UL, subband of the grid. Fig. 22 shows example acts or steps which may comprise method #1. Act 21-2 comprises making the determination whether the potential transmission occasion corresponds to an eligible transmission occasion. Act 22-2 comprises transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0309] 2.0 PUSCH TRANSMISSION: METHOD #2: EXAMPLES

Method #2 may be performed with different configurations, non-limiting examples of which are illustrated by the following:

2.1.1 PUSCH TRANSMISSION: METHOD #2: FIRST EXAMPLE

Fig. 15 is an example of potential transmission occasions according to an aspect of an example embodiment and mode. In Fig. 15, the horizontal axis represents the time domain. Partitions in the time domain represent slots. The vertical axis represents the frequency domain. Slots are numbered starting at slot n in ascending order.

[0310] In Fig. 15, the period of the TDD pattern provided by the common TDD parameter is set to 4 slots. The TDD pattern is represented by a sequence of DL region 910, the duration 911, the duration 912, flexible region 913, and UL region 914. Also, the DL region 910', the duration 911', the duration 912', flexible region 913' and UL region 914' represent each duration in the next cycle of the TDD pattern represented by a sequence of DL region 910, the duration 911, the duration 912, flexible region 913,

and UL region 914.

[0311] Further, in Fig. 15, a frequency domain concept is provided for each of the potential transmission occasions, and particularly shows that the potential transmission occasions 1011 to 1018 are confined within the bandwidth which is indicated as bandwidth 932.

[0312] In method#2, wireless terminal 1 considers time and frequency domain resource of UL subband 950 for determining transmission occasions for PUSCH repetition. For example, in a case of Fig. 15 that the time domain resource of a potential transmission occasion in each slot is provided as $\{S, L\} = \{0, 14\}$, the number of slots for the PUSCH repetition is 4, and duration 912 is configured as DL region in the TDD pattern provided by the common TDD parameter, wireless terminal 1 applies series of act comprising act 201a to act 201g for determining transmission occasions:

Act 201a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in DL region 910 but that the time and frequency resource of potential transmission occasion 1011 is not confined in an UL subband. Therefore, wireless terminal 1 determines that the slot n is not counted for the PUSCH repetition.

[0313] Act 201b: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1012 are in DL region 912. Further, the time and frequency resource of potential transmission occasion 1012 is confined in UL subband 950. Therefore, wireless terminal 1 determines that the slot $n+1$ is counted for the PUSCH repetition.

[0314] Act 201c: Wireless terminal 1 determines that a first set of OFDM symbols of potential transmission occasion 1013 are in DL region 912, a second set of OFDM symbols of potential transmission occasion 1013 are in flexible region 913, and a third set of OFDM symbols of potential transmission occasion 1013 are in UL region 914. Further, wireless terminal 1 determines that the time and frequency resource of potential transmission occasion 1013 in the first set is confined in UL subband 950. Therefore, wireless terminal 1 determines that the slot $n+2$ is counted for the PUSCH repetition.

[0315] Act 201d: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+3$ is counted for the PUSCH repetition.

[0316] Act 201e: Wireless terminal 1 determines that potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 910' and the time and frequency resource of potential transmission occasion 1015 is not confined in an UL subband. Therefore, wireless terminal 1 determines that the slot $n+4$ is not counted for the PUSCH repetition.

- [0317] Act 201f: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1016 are in DL region 912'. Further, the time and frequency domain resource of potential transmission occasion 1016 is confined in UL subband 950. Therefore, wireless terminal 1 determines that the slot n+5 is counted for the PUSCH repetition.
- [0318] Act 201g: Wireless terminal 1 determines that count on slots reached at 4 by slot n+1, slot n+2, slot n+3, and slot n+5. Therefore, wireless terminal 1 determines that potential transmission occasions 1012, 1013, 1014, and 1016 as transmission occasions for the PUSCH repetition.
- [0319] Therefore, in method#2, whether time and frequency domain resource of a potential transmission occasion is confined in UL subband or not may be considered for determining transmission occasions for PUSCH repetition.
- [0320] For example, in method#2, in a case that a potential transmission occasion overlaps with one or more OFDM symbols in DL region in the time domain, wireless terminal 1 performs an additional test to determine whether the time and frequency domain resource of the potential transmission occasion in the one or more OFDM symbols is confined in UL subband or not. For example, in a case that the time and frequency domain resource of the potential transmission occasion in the one or more OFDM symbols is confined in UL subband, wireless terminal 1 counts the slot for the PUSCH repetition. For example, in a case that the time and frequency domain resource of the potential transmission occasion in the one or more OFDM symbols is not confined in UL subband, wireless terminal 1 does not count the slot for the PUSCH repetition.
- [0321] 2.1.2 PUSCH TRANSMISSION: METHOD #2: SECOND EXAMPLE
- In method#2, for example, in a case of Fig. 15 that the time domain resource of a potential transmission occasion in each slot is provided as $\{S, L\} = \{0, 14\}$, the number of slots for the PUSCH repetition is 4, and duration 912 is configured as flexible region in the TDD pattern provided by the common TDD parameter, wireless terminal 1 applies following series of acts comprising act 202a to act 202g for determining transmission occasions.
- [0322] Act 202a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in DL region 910 and the time and frequency resource of potential transmission occasion 1011 is not confined in UL subband. Therefore, wireless terminal 1 determines that the slot n is not counted for the PUSCH repetition.
- [0323] Act 202b: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1012 are in flexible region 912. Therefore, wireless terminal 1 determines that the slot n+1 is counted for the PUSCH repetition.
- [0324] Act 202c: Wireless terminal 1 determines that a first set of OFDM symbols of

potential transmission occasion 1013 are in flexible region 912, a second set of OFDM symbols of potential transmission occasion 1013 are in flexible region 913, and a third set of OFDM symbols of potential transmission occasion 1013 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+2$ is counted for the PUSCH repetition.

[0325] Act 202d: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+3$ is counted for the PUSCH repetition.

[0326] Act 202e: Wireless terminal 1 determines that potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 910' and the time and frequency resource of potential transmission occasion 1015 is not confined in UL subband. Therefore, wireless terminal 1 determines that the slot $n+4$ is not counted for the PUSCH repetition.

[0327] Act 202f: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1016 are in flexible region 912'. Therefore, wireless terminal 1 determines that the slot $n+5$ is counted for the PUSCH repetition.

[0328] Act 202g: Wireless terminal 1 determines that count on slots reached at 4 by slot $n+1$, slot $n+2$, slot $n+3$, and slot $n+5$. Therefore, wireless terminal 1 determines that potential transmission occasions 1012, 1013, 1014, and 1016 as transmission occasions for the PUSCH repetition.

[0329] Therefore, in method#2, whether the time and frequency resource of potential transmission occasion is confined in UL subband or not may not be considered for determining transmission occasions for PUSCH repetition.

[0330] 2.2 PUSCH TRANSMISSION: METHOD #2a

Fig. 16 is an example of potential transmission occasions according to an aspect of an example embodiment and mode. In Fig. 16, the horizontal axis represents the time domain. Partitions in the time domain represent slots. The vertical axis represents the frequency domain. Slots are numbered starting at slot n in ascending order.

[0331] In Fig. 16, the period of the TDD pattern provided by the common TDD parameter is set to 4 slots. The TDD pattern is represented by a sequence of DL region 910, the duration 911, the duration 912, flexible region 913, and UL region 914. Also, the DL region 910', the duration 911', the duration 912', flexible region 913' and UL region 914' represent each duration in the next cycle of the TDD pattern represented by a sequence of DL region 910, the duration 911, the duration 912, flexible region 913, and UL region 914.

[0332] Further, in Fig. 16, a frequency domain concept is provided for each of the potential transmission occasions, and particularly that each of potential transmission occasions 1011 to 1018 are confined within the bandwidth of 932.

- [0333] Further, 1301 represents a resources for a SS/PBCH block candidate in which a SS/PBCH block is expected to be transmitted according to a RRC parameter.
- [0334] Method#2a is considered as an alternative to method#2. For example, in a case of Fig. 16 that the time domain resource of a potential transmission occasion in each slot is provided as $\{S, L\} = \{0, 14\}$, the number of slots for the PUSCH repetition is 4, and duration 912 is configured as DL region in the TDD pattern provided by the common TDD parameter, wireless terminal 1 applies following series of acts comprising act 203a to act 203h for determining transmission occasions as method#2a.
- [0335] Act 203a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in DL region 910 and the time and frequency resource of potential transmission occasion 1011 is not confined in UL subband. Therefore, wireless terminal 1 determines that the slot n is not counted for the PUSCH repetition.
- [0336] Act 203b: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1012 are in DL region 912. Further, the time and frequency resource of potential transmission occasion 1012 is confined in UL subband 950. On the other hand, wireless terminal 1 also determines that SS/PBCH block candidate 1301 in which a SS/PBCH block is expected to be transmitted overlaps with one or more OFDM symbols of potential transmission occasion 1012. Therefore, wireless terminal 1 determines that the slot $n+1$ is not counted for the PUSCH repetition.
- [0337] Act 203c: Wireless terminal 1 determines that a first set of OFDM symbols of potential transmission occasion 1013 are in DL region 912, a second set of OFDM symbols of potential transmission occasion 1013 are in flexible region 913, and a third set of OFDM symbols of potential transmission occasion 1013 are in UL region 914. Further, wireless terminal 1 determines that the time and frequency domain resource of potential transmission occasion 1013 in the first set is confined in UL subband 950. Further, wireless terminal 1 determines that potential transmission occasion 1013 does not overlap with any SS/PBCH block candidate in which a SS/PBCH block is expected to be transmitted. Therefore, wireless terminal 1 determines that the slot $n+2$ is counted for the PUSCH repetition.
- [0338] Act 203d: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+3$ is counted for the PUSCH repetition.
- [0339] Act 203e: Wireless terminal 1 determines that potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 910' and the time and frequency resource of potential transmission occasion 1015 is not confined in UL subband. Therefore, wireless terminal 1 determines that the slot $n+4$ is not counted for the PUSCH repetition.

- [0340] Act 203f: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1016 are in DL region 912'. Further, the time and frequency resource of potential transmission occasion 1016 is confined in UL subband. Further, wireless terminal 1 determines that potential transmission occasion 1016 does not overlap with any SS/PBCH block candidate in which a SS/PBCH block is expected to be transmitted. Therefore, wireless terminal 1 determines that the slot $n+5$ is counted for the PUSCH repetition.
- [0341] Act 203g: Wireless terminal 1 determines that a first set of OFDM symbols of potential transmission occasion 1017 are in DL region 912', a second set of OFDM symbols of potential transmission occasion 1017 are in flexible region 913', and a third set of OFDM symbols of potential transmission occasion 1017 are in UL region 914'. Further, wireless terminal 1 determines that the time and frequency resource of potential transmission occasion 1011 in the first set is confined in UL subband 950. Further, wireless terminal 1 determines that potential transmission occasion 1017 does not overlap with any SS/PBCH block candidate in which a SS/PBCH block is expected to be transmitted. Therefore, wireless terminal 1 determines that the slot $n+6$ is counted for the PUSCH repetition.
- [0342] Act 203h: Wireless terminal 1 determines that count on slots reached at 4 by slot $n+2$, slot $n+3$, slot $n+5$, and slot $n+6$. Therefore, wireless terminal 1 determines that potential transmission occasions 1013, 1014, 1016, and 1017 as transmission occasions for the PUSCH repetition.
- [0343] Therefore, in method#2a, whether the time and frequency resource of a potential transmission occasion is confined in UL subband or not may be considered for determining transmission occasions for PUSCH repetition in a case that the potential transmission occasions does not overlap with any SS/PBCH block candidates in which a SS/PBCH block is expected to be transmitted.
- [0344] Fig. 17 is a flowchart showing example basic acts or steps for method #2a according to an aspect of example embodiment and mode. The flowchart of Fig. 17 is similar to the flowchart of Fig. 14 except for inclusion of act 1701. In act 1701, wireless terminal 1 determines whether the time and frequency domain resource(s) for all the one or more OFDM symbols of the potential transmission occasion is confined in UL subband or not. In a case that wireless terminal 1 determines that the time and frequency domain resource(s) for the one or more OFDM symbols of the potential transmission occasion is confined in UL subband, wireless terminal 1 performs step 1406. In a case that wireless terminal 1 determined that the time and frequency resource(s) for the one or more OFDM symbols of the potential transmission occasion is not confined in UL subband, wireless terminal 1 proceeds with step 1407.
- [0345] 2.3 PUSCH TRANSMISSION: METHOD #2b

On the other hand, even when one or more SS/PBCH block candidates in which an SS/PBCH block is expected to be transmitted are configured as in Fig. 16, Method#2b is considered as an alternative to method#2. For example, in a case of Fig. 16 that the time domain resource of a potential transmission occasion in each slot is provided as $\{S, L\} = \{0, 14\}$, the number of slots for the PUSCH repetition is 4, and duration 912 is configured as DL region in the TDD pattern provided by the common TDD parameter, wireless terminal 1 applies following series of acts comprising act 204a to act 204g for determining transmission occasions as method#2b:

Act 204a: Wireless terminal 1 determines that potential transmission occasion 1011 overlaps with one or more OFDM symbols in DL region 910 and the time and frequency resource of potential transmission occasion 1011 is not confined in UL subband. Therefore, wireless terminal 1 determines that the slot n is not counted for the PUSCH repetition.

[0346] Act 204b: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1012 are in DL region 912. Further, the time and frequency resource of potential transmission occasion 1012 is confined in UL subband 950. Wireless terminal 1 disregards SS/PBCH block candidates for determining transmission occasions in OFDM symbols with UL subband 950. Therefore, wireless terminal 1 determines that the slot $n+1$ is counted for the PUSCH repetition.

[0347] Act 204c: Wireless terminal 1 determines that a first set of OFDM symbols of potential transmission occasion 1013 are in DL region 912, a second set of OFDM symbols of potential transmission occasion 1013 are in flexible region 913, and a third set of OFDM symbols of potential transmission occasion 1013 are in UL region 914. Further, wireless terminal 1 determines that the time and frequency resource of potential transmission occasion 1013 in the first set is confined in UL subband 950. Further, wireless terminal 1 disregards SS/PBCH block candidates for determining transmission occasions in OFDM symbols with UL subband 950. Therefore, wireless terminal 1 determines that the slot $n+2$ is counted for the PUSCH repetition.

[0348] Act 204d: Wireless terminal 1 determines that all the OFDM symbols of the potential transmission occasion 1014 are in UL region 914. Therefore, wireless terminal 1 determines that the slot $n+3$ is counted for the PUSCH repetition.

[0349] Act 204e: Wireless terminal 1 determines that potential transmission occasion 1015 overlaps with one or more OFDM symbols in DL region 910' and the time and frequency resource of potential transmission occasion 1015 is not confined in UL subband. Therefore, wireless terminal 1 determines that the slot $n+4$ is not counted for the PUSCH repetition.

[0350] Act 204f: Wireless terminal 1 determines that all the OFDM symbols of potential transmission occasion 1016 are in DL region 912'. Further, the time and frequency

resource of potential transmission occasion 1016 is confined in UL subband 950. Further, wireless terminal 1 disregards SS/PBCH block candidates for determining transmission occasions in OFDM symbols with UL subband 950. Therefore, wireless terminal 1 determines that the slot $n+5$ is counted for the PUSCH repetition.

- [0351] Act 204h: Wireless terminal 1 determines that count on slots reached at 4 by slot $n+1$, slot $n+2$, slot $n+3$, and slot $n+5$. Therefore, wireless terminal 1 determines that potential transmission occasions 1012, 1013, 1014, and 1016 as transmission occasions for the PUSCH repetition.
- [0352] Therefore, in method#2b, whether the time and frequency resource of potential transmission occasion is confined in UL subband or not is to be considered for determining transmission occasions for PUSCH repetition regardless of whether the potential transmission occasion overlaps with any SS/PBCH block candidates in which a SS/PBCH block is expected to be transmitted or not.
- [0353] Much of the foregoing discussion concerns act 1102 of Fig. 11: wireless terminal 1 determining transmission occasions for the PUSCH repetition. Other acts of Fig. 11 are now further described.
- [0354] As mentioned above, In act 1103 of Fig. 11, wireless terminal 1 maps RVs (Redundancy Versions) for the determined eligible transmission occasions. In step 1103, wireless terminal determines an index for each transmission occasion. For example, in a case that potential transmission occasions 1012, 1013, 1014, and 1016 are determined as transmission occasions for PUSCH repetition, wireless terminal 1 determines indices for transmission occasions in ascending order in the time domain. For example, potential transmission occasion 1012 is regarded as transmission occasion with index 0, potential transmission occasion 1013 is regarded as transmission occasion with index 1, potential transmission occasion 1014 is regarded as transmission occasion with index 2, and potential transmission occasion 1016 is regarded as transmission occasion with index 3.
- [0355] Next, wireless terminal 1 determines RVs to be mapped to transmission occasion with index n based on a predetermined rule. For example, the predetermined rule may be defined based on $\text{mod}((n-\text{mod}(N,n))/N,4)$.
- [0356] Fig. 18 is an example of a table describing the predetermined rule according to an aspect of example embodiment and mode. The row represents value of rv_{id} where rv_{id} is the value indicated by a redundancy version information field in a DCI format which is used to scheduling PUSCH repetition. The column represents conditions based on $\text{mod}((n-\text{mod}(N,n))/N,4)$. Each value in the table identified by rv_{id} and the condition represents an index of RV for transmission occasion with index n . N is the number provided by base station device 3 via the DCI format or RRC signaling. N represents a value to control a size of a transport block to be delivered in the PUSCH repetition.

Specifically, in a case of N being 1, the condition is simplified as $\text{mod}(n,4)$.

[0357] In step 1104, wireless terminal 1 determines whether to omit PUSCH transmission in a transmission occasion or not. For example, PUSCH transmission may be omitted based on method#3, method#3a, or method#3b.

[0358] 3.0 PUSCH TRANSMISSION: METHOD #3

In method#3, wireless terminal 1 considers UL subband 950 for determining whether to omit PUSCH transmission in a transmission occasion or not. For example, in a case that time domain resource of the PUSCH transmission in a transmission occasion overlaps with one or more OFDM symbols in DL region in the time domain, wireless terminal 1 performs additional test of whether the time and frequency domain resource of the PUSCH transmission in the transmission occasion in the one or more OFDM symbols is confined within any UL subband or not. For example, in a case that the time and frequency domain resource of the PUSCH transmission in the transmission occasion in the one or more OFDM symbols is confined within a UL subband, wireless terminal 1 determines that the transmission occasion is not omitted. For example, in a case that the time and frequency domain resource of the PUSCH transmission in the transmission occasion in the one or more OFDM symbols is not confined within any UL subband, wireless terminal 1 determines that the transmission occasion is omitted.

[0359] In method#3a, wireless terminal 1 determines whether the time domain resource of PUSCH transmission in a transmission occasion overlaps with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted or not. For example, in a case that the time domain resource of PUSCH transmission in a transmission occasion overlaps with an SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted, wireless terminal 1 determines that the transmission occasion is omitted. For example, in a case that the time domain resource of PUSCH transmission in a transmission occasion does not overlap with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted, wireless terminal 1 determines that the transmission occasion is not omitted.

[0360] In method#3b, wireless terminal 1 determines whether the time and frequency domain resource of PUSCH transmission in a transmission occasion overlaps with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted or not. For example, in a case that the time and frequency domain resource of PUSCH transmission in a transmission occasion overlaps with an SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted, wireless terminal 1 determines that the transmission occasion is omitted. For example, in a case that the time and frequency domain resource of PUSCH transmission in a transmission occasion does not overlap with any SS/PBCH block candidate in which an SS/PBCH block is expected to be transmitted, wireless terminal 1 determines that the transmission

occasion is not omitted.

- [0361] In step 1105, wireless terminal 1 performs PUSCH transmission in transmission occasions not omitted in step 1104.
- [0362] In PUSCH transmission, wireless terminal 1 may determine time domain windows in each of which phase continuity and/or power consistency should be maintained for PUSCH transmission.
- [0363] Fig. 19 is an example of time domain windows according to an aspect of an example embodiment and mode. In Fig. 19, the horizontal axis represents the time domain. Partitions in the time domain represent slots. Slots are numbered starting at slot n in ascending order.
- [0364] In Fig. 19, the period of the TDD pattern provided by the common TDD parameter is set to 4 slots. The TDD pattern is represented by a sequence of DL region 910, duration 911, duration 912, flexible region 913, and UL region 914. Also, DL region 910', duration 911', duration 912', flexible region 913' and UL region 914' represents each duration in the next cycle of the TDD pattern represented by the sequence of DL region 910, duration 911, duration 912, flexible region 913, and UL region 914.
- [0365] In Fig. 19, 1901 and 1902 represent respective time domain window. Time domain window 1901 has duration which includes slots n , $n+1$, $n+2$, and $n+3$. Time domain window 1902 has duration which includes slots $n+4$, and $n+5$.
- [0366] In a case that wireless terminal 1 determined one or more time domain windows, wireless terminal 1 is expected to maintain phase continuity and/or power consistency for PUSCH repetition within each time domain window.
- [0367] Fig. 20 is a flowchart showing example acts or steps of an example time domain window determination procedure according to an aspect of an example embodiment and mode.
- [0368] In act 2001, wireless terminal 1 determines one or more nominal time domain windows. In determining one or more nominal time domain windows, wireless terminal 1 determines starting slot and duration in terms of slots for each nominal time domain window.
- [0369] In a case that available slot counting is applied to determine transmission occasions for PUSCH repetition, availability of slots is referred for determining starting slots. For example, for the leading nominal time domain window for PUSCH repetition, the starting slot is the leading available slot for the PUSCH repetition. For example, for time domain windows for the PUSCH repetition other than the leading nominal time domain window, the starting slot is the leading available slot after the ending slot of the previous nominal time domain window.
- [0370] Duration of nominal time domain windows is provided by a RRC parameter. In a case that any RRC parameter for the duration is not provided to wireless terminal 1,

wireless terminal 1 determines duration based on wireless terminal 1's capability which has been reported to base station device 3.

[0371] For example, in a case of Fig. 12 that duration of the nominal time domain window is 3 slots and the duration 912 is configured as DL region, the starting slot of the leading nominal time domain window for the PUSCH is slot with index $n+1$, and the leading nominal time domain window is comprised of slot with index $n+1$, $n+2$, and $n+3$. Further, the starting slot of the next nominal time domain window is slot with index $n+5$ since the first available slot after the ending slot of the leading nominal time domain window is that slot.

[0372] On the other hand, available slot since the PUSCH repetition ends at slot with index 5, the next time domain window is comprised of only slot with index $n+5$.

[0373] In act 2002, actual time domain windows are determined for which phase continuity and/or power consistency should be maintained within each window.

[0374] 4.0 FURTHER CONSIDERATIONS

Thus, the foregoing provides, e.g., various implementation techniques or solutions germane to act 1102 of Fig. 11, e.g., for determining transmission occasions for the PUSCH repetition. Among the solutions/techniques herein provided are the following:

Method#1 (time domain approach):

- In a case that a potential transmission occasion overlaps with one or more OFDM symbols in DL region in the time domain, wireless terminal 1 performs additional test of whether the one or more OFDM symbols overlap with any UL subband or not.
 - in a case that the one or more OFDM symbols overlaps with a UL subband in the time domain, wireless terminal 1 counts the slot for the PUSCH repetition.
 - in a case that at least one OFDM symbol in the one or more OFDM symbols does not overlap with any UL subband in the time domain, wireless terminal 1 does not count the slot for the PUSCH repetition.

Method#1a (alternative to method#1):

- Whether a UL subband overlaps with the potential transmission occasions in DL region in the time domain or not is to be considered for determining transmission occasions for PUSCH repetition in a case that the potential transmission occasions does not overlap with any SS/PBCH block candidates in which a SS/PBCH block is expected to be transmitted.

Method#1b (alternative to method#1):

- Whether a UL subband overlaps with the potential transmission occasions in DL region in the time domain or not is to be considered for determining transmission occasions for PUSCH repetition regardless of whether the potential transmission occasion overlaps with any SS/PBCH block candidates in which a SS/PBCH block is expected to be transmitted or not.

Method#2 (time and frequency domain approach):

- In a case that a potential transmission occasion overlaps with one or more OFDM symbols in DL region in the time domain, wireless terminal 1 performs additional test of whether the time and frequency domain resource of the potential transmission occasion in the one or more OFDM symbols is confined in UL subband or not.
 - in a case that the time and frequency domain resource of the potential transmission occasion in the one or more OFDM symbols is confined in UL subband, wireless terminal 1 counts the slot for the PUSCH repetition.
 - in a case that the time and frequency domain resource of the potential transmission occasion in the one or more OFDM symbols is not confined in UL subband, wireless terminal 1 does not count the slot for the PUSCH repetition.

Method#2a (alternative to method#2):

- whether the time and frequency resource of a potential transmission occasion is confined in UL subband or not may be considered for determining transmission occasions for PUSCH repetition in a case that the potential transmission occasions does not overlap with any SS/PBCH block candidates in which a SS/PBCH block is expected to be transmitted.

Method#2b (alternative to method#2)

- whether the time and frequency resource of potential transmission occasion is confined in UL subband or not is to be considered for determining transmission occasions for PUSCH repetition regardless of whether the potential transmission occasion overlaps with any SS/PBCH block candidates in which a SS/PBCH block is expected to be transmitted or not.

Method#3

- wireless terminal 1 considers UL subband 950 for determining whether to omit PUSCH transmission in a transmission occasion or not. For example, in a case that time domain resource of the PUSCH transmission in a transmission occasion overlaps with one or more OFDM symbols in DL region in the time domain, wireless terminal 1 performs additional test of whether the time and frequency domain resource of the PUSCH transmission in the transmission occasion in the one or more OFDM symbols is confined within any UL subband or not.

[0375] Example, non-limiting representative embodiments of the technology disclosed herein include the following:

Example Embodiment 1: A wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising:

processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid.

[0376] Example Embodiment 2: The wireless terminal of Example Embodiment 1, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0377] Example Embodiment 3: The wireless terminal of Example Embodiment 3, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.

[0378] Example Embodiment 4: The wireless terminal of Example Embodiment 3, wherein the processor circuitry is configured to:

omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid;

include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and

further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.

[0379] Example Embodiment 5: The wireless terminal of Example Embodiment 3, wherein in performing the redundancy version mapping the processor circuitry is configured associate an index to each eligible transmission occasion.

[0380] Example Embodiment 6: The wireless terminal of Example Embodiment 1, wherein when the one or more OFDM symbols of a slot of the grid corresponding to the potential transmission occasion overlap with the UL subband in the time domain, the processor circuitry is configured to count the slot for the PUSCH repetition and to determine that the potential transmission occasion corresponds to the eligible transmission occasion.

[0381] Example Embodiment 7: The wireless terminal of Example Embodiment 1, wherein when the one or more OFDM symbols of a slot of the grid corresponding to the potential transmission occasion do not overlap with any UL subband in the time

domain, the processor circuitry is configured to not count the slot for the PUSCH repetition and to determine that the potential transmission occasion does not correspond to the eligible transmission occasion.

[0382] Example Embodiment 8: The wireless terminal of Example Embodiment 1, further comprising receiver circuitry configured to receive, from the radio access network, a parameter which configures one or more regions of in a time domain of the radio resource grid as a DL region, a flexible region, or an UL region for a time division duplex.

[0383] Example Embodiment 9: The wireless terminal of Example Embodiment 8, wherein the parameter further specifies a period of the TDD pattern.

[0384] Example Embodiment 10: A method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising:
in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid;

transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0385] Example Embodiment 11: A wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising:

processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid.

[0386] Example Embodiment 12: The wireless terminal of Example Embodiment 11, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0387] Example Embodiment 13: The wireless terminal of Example Embodiment 11, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.

[0388] Example Embodiment 14: The wireless terminal of Example Embodiment 13,

wherein the processor circuitry is configured to:

omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid;

include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and

further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.

[0389] Example Embodiment 15: The wireless terminal of Example Embodiment 13, wherein in performing the redundancy version mapping the processor circuitry is configured associate an index to each eligible transmission occasion.

[0390] Example Embodiment 16: The wireless terminal of Example Embodiment 11, wherein when the one or more OFDM symbols of a slot of the grid corresponding to the potential transmission occasion is confined in any UL subband in the time domain, the processor circuitry is configured to count the slot for the PUSCH repetition and to determine that the potential transmission occasion does correspond to the eligible transmission occasion.

[0391] Example Embodiment 17: The wireless terminal of Example Embodiment 11, wherein when the one or more OFDM symbols of a slot of the grid corresponding to the potential transmission occasion is not confined in any UL subband in the time domain, the processor circuitry is configured to not count the slot for the PUSCH repetition and to determine that the potential transmission occasion does not correspond to the eligible transmission occasion.

[0392] Example Embodiment 18: The wireless terminal of Example Embodiment 11, further comprising receiver circuitry configured to receive, from the radio access network, a parameter which configures one or more regions of in a time domain of the radio resource grid as a DL region, a flexible region, or an UL region for a time division duplex.

[0393] Example Embodiment 19: The wireless terminal of Example Embodiment 18, wherein the parameter further specifies a period of the TDD pattern.

[0394] Example Embodiment 20: The wireless terminal of Example Embodiment 11, wherein when the one or more OFDM symbols of a slot of the grid corresponding to the potential transmission occasion is not confined in any UL subband in the time domain, the processor circuitry is configured to not count the slot for the PUSCH repetition and to determine that the potential transmission occasion does not correspond to the eligible transmission occasion.

[0395] Example Embodiment 21: The wireless terminal of Example Embodiment 11, further comprising receiver circuitry configured to receive, from the radio access network, a

parameter which configures one or more regions of in a time domain of the radio resource grid as a DL region, a flexible region, or an UL region for a time division duplex.

[0396] Example Embodiment 22: The wireless terminal of Example Embodiment 21, wherein the parameter further specifies a period of the TDD pattern.

[0397] Example Embodiment 23: A method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising:

in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid;

transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0398] Example Embodiment 24: A wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising:

processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both:

(1) whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid; and

(2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.

[0399] Example Embodiment 25: The wireless terminal of Example Embodiment 24, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0400] Example Embodiment 26: The wireless terminal of Example Embodiment 24, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.

[0401] Example Embodiment 27: The wireless terminal of Example Embodiment 26,

wherein the processor circuitry is configured to:

omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid;

include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and

further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.

[0402] Example Embodiment 28: A method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising:

in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both:

(1) whether the one or more OFDM symbols overlap with any uplink,

UL, subband of the grid; and

(2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and,

transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0403] Example Embodiment 29: A wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising:

processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.

[0404] Example Embodiment 30: The wireless terminal of Example Embodiment 29, further comprising transmitter circuitry configured to transmit the eligible transmission

occasion for the PUSCH repetition to the radio access network.

- [0405] Example Embodiment 31: The wireless terminal of Example Embodiment 29, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.
- [0406] Example Embodiment 32: The wireless terminal of Example Embodiment 31, wherein the processor circuitry is configured to:
- omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid;
 - include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and
 - further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.
- [0407] Example Embodiment 33: A method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising:
- in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and
 - transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.
- [0408] Example Embodiment 34: A wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising:
- processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both:

- (1) whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid; and
- (2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.

[0409] Example Embodiment 35: The wireless terminal of Example Embodiment 34, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0410] Example Embodiment 36: The wireless terminal of Example Embodiment 34, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.

[0411] Example Embodiment 37: The wireless terminal of Example Embodiment 36, wherein the processor circuitry is configured to:

omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid;

include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and

further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.

[0412] Example Embodiment 38: A method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising:

in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both:

- (1) whether the one or more OFDM symbols is confined in an any uplink, UL, subband of the grid; and
- (2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and,

transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

- [0413] Example Embodiment 39: A wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising:
processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.
- [0414] Example Embodiment 40: The wireless terminal of Example Embodiment 39, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.
- [0415] Example Embodiment 41: The wireless terminal of Example Embodiment 39, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.
- [0416] Example Embodiment 42: The wireless terminal of Example Embodiment 41, wherein the processor circuitry is configured to:
omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid;
include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and
further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.
- [0417] Example Embodiment 43: A method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising:
in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/

PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and, transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0418] Duplex communications are also described in the following, all of which are incorporated herein by reference in its entirety:

United States Patent Application 17/981,667, filed November 7, 2022, entitled “COMMUNICATIONS NETWORK AND METHODS WITH ENHANCED DUPLEX”.

[0419] United States Patent Application 17/728,014, filed April 25, 2022, entitled “USER EQUIPMENTS AND METHODS FOR DETERMINING TIME-FREQUENCY RESOURCE SET FOR ENHANCED DUPLEX OPERATION”.

[0420] United States Provisional Patent Application 63/367,463, filed June 30, 2022, entitled “USER EQUIPMENTS AND METHODS FOR DETERMINING TIME-FREQUENCY RESOURCE SET FOR ENHANCED DUPLEX OPERATION”.

[0421] United States Provisional Patent Application 63/367,465, filed June 30, 2022, entitled “USER EQUIPMENTS AND METHODS FOR DETERMINING TIME-FREQUENCY RESOURCE SET FOR ENHANCED DUPLEX OPERATION”.

[0422] United States Provisional Patent Application 63/369,138, filed July 22, 2022, entitled “APPARATUS AND METHODS WITH DOWNLINK CHANNEL RESOURCE MAPPING”.

[0423] United States Patent Application 18/148,121, filed December 28, 2022, entitled “USER EQUIPMENTS, BASE STATIONS AND METHODS FOR ENHANCED DUPLEX”.

[0424] The various foregoing example embodiments and modes may be utilized in conjunction with one another, e.g., in combination with one another, and/or in conjunction with the technologies and embodiments of one or more of the patent applications incorporated by reference herein.

[0425] As used herein, the term “and/or” should be interpreted to mean one or more items. For example, the phrase “A, B and/or C” should be interpreted to mean any of: only A, only B, only C, A and B (but not C), B and C (but not A), A and C (but not B), or all of A, B, and C. As used herein, the phrase “at least one of” should be interpreted to mean one or more items. For example, the phrase “at least one of A, B and C” or the phrase “at least one of A, B or C” should be interpreted to mean any of: only A, only B, only C, A and B (but not C), B and C (but not A), A and C (but not B), or all of A, B, and C. As used herein, the phrase “one or more of” should be interpreted to mean one or more items. For example, the phrase “one or more of A, B and C” or the phrase “one or more of A, B or C” should be interpreted to mean any of: only A, only B, only C, A and B (but not C), B and C (but not A), A and C (but not B), or all of A, B, and C.

Certain units and functionalities described herein may be implemented by electronic machinery. For example, electronic machinery may refer to the processor circuitry described herein, such as terminal processor circuitry 19 and base station processor 39. Moreover, the term “processor circuitry” is not limited to mean one processor, but may include plural processors, with the plural processors operating at one or more sites. Moreover, as used herein the term “server” is not confined to one server unit but may encompass plural servers and/or other electronic equipment and may be co-located at one site or distributed to different sites. With these understandings, Fig. 23 shows an example of electronic machinery, e.g., processor circuitry, as comprising one or more processors 100, program instruction memory 102; other memory 104 (e.g., RAM, cache, etc.); input/output interfaces 106 and 107, peripheral interfaces 108; support circuits 109; and busses 110 for communication between the aforementioned units. The processor(s) 100 may comprise the processor circuitries described herein, for example, terminal processor circuitry 60 and node processor circuitry 34, or any processor(s) of a network entity of the core network and suffixed versions thereof.

[0426] A memory or register described herein may be depicted by memory 104, or any computer-readable medium, may be one or more of readily available memory such as random access memory (RAM), read only memory (ROM), floppy disk, hard disk, flash memory or any other form of digital storage, local or remote, and is preferably of non-volatile nature, as and such may comprise memory. The support circuits 109 are coupled to the processors 100 for supporting the processor in a conventional manner. These circuits include cache, power supplies, clock circuits, input/output circuitry and subsystems, and the like.

[0427] The term “configured” may relate to the capacity of a device whether the device is in an operational or non-operational state. Configured may also refer to specific settings in a device that affect the operational characteristics of the device whether the device is in an operational or nonoperational state. In other words, the hardware, software, firmware, registers, memory values, and/or the like may be “configured” within a device, whether the device is in an operational or nonoperational state, to provide the device with specific characteristics.

[0428] An interface may be a hardware interface, a firmware Interface, a software interface, and/or a combination thereof. The hardware interface may include connectors, wires, electronic devices such as drivers, amplifiers, and/or the like. A software interface may include code stored in a memory device to implement protocol(s), protocol layers, communication drivers, device drivers, combinations thereof, and/or the like. A firmware interface may include a combination of embedded hardware and code stored in and/or in communication with a memory device to implement connections, electronic device operations, protocol(s), protocol layers, communication drivers,

device drivers, hardware operations, combinations thereof, and/or the like.

[0429] Although the processes and methods of the disclosed embodiments may be discussed as being implemented as a software routine, some of the method steps that are disclosed therein may be performed in hardware as well as by a processor running software. As such, the embodiments may be implemented in software as executed upon a computer system, in hardware as an application specific integrated circuit or other type of hardware implementation, or a combination of software and hardware. The software routines of the disclosed embodiments are capable of being executed on any computer operating system and is capable of being performed using any CPU architecture.

[0430] The functions of the various elements including functional blocks, including but not limited to those labeled or described as “computer”, “processor” or “controller”, may be provided through the use of hardware such as circuit hardware and/or hardware capable of executing software in the form of coded instructions stored on computer readable medium. Thus, such functions and illustrated functional blocks are to be understood as being either hardware-implemented and/or computer-implemented, and thus machine-implemented.

[0431] In terms of hardware implementation, the functional blocks may include or encompass, without limitation, digital signal processor (DSP) hardware, reduced instruction set processor, hardware (e.g., digital or analog) circuitry including but not limited to application specific integrated circuit(s) [ASIC], and/or field programmable gate array(s) (FPGA(s)), and (where appropriate) state machines capable of performing such functions.

[0432] In terms of computer implementation, a computer is generally understood to comprise one or more processors or one or more controllers, and the terms computer and processor and controller may be employed interchangeably herein. When provided by a computer or processor or controller, the functions may be provided by a single dedicated computer or processor or controller, by a single shared computer or processor or controller, or by a plurality of individual computers or processors or controllers, some of which may be shared or distributed. Moreover, use of the term “processor” or “controller” may also be construed to refer to other hardware capable of performing such functions and/or executing software, such as the example hardware recited above.

[0433] Nodes that communicate using the air interface also have suitable radio communications circuitry. Moreover, the technology disclosed herein may additionally be considered to be embodied entirely within any form of computer-readable memory, such as solid-state memory, magnetic disk, or optical disk containing an appropriate set of computer instructions that would cause a processor to carry out the techniques

described herein.

[0434] Moreover, each functional block or various features of the wireless terminals and nodes employed in each of the aforementioned embodiments may be implemented or executed by circuitry, which is typically an integrated circuit or a plurality of integrated circuits. The circuitry designed to execute the functions described in the present specification may comprise a general-purpose processor, a digital signal processor (DSP), an application specific or general application integrated circuit (ASIC), a field programmable gate array (FPGA), or other programmable logic devices, discrete gates or transistor logic, or a discrete hardware component, or a combination thereof. The general-purpose processor may be a microprocessor, or alternatively, the processor may be a conventional processor, a controller, a microcontroller or a state machine. The general-purpose processor or each circuit described above may be configured by a digital circuit or may be configured by an analogue circuit. Further, when a technology of making into an integrated circuit superseding integrated circuits at the present time appears due to advancement of a semiconductor technology, the integrated circuit by this technology is also able to be used.

[0435] It will be appreciated that the technology disclosed herein is directed to solving radio communications-centric issues and is necessarily rooted in computer technology and overcomes problems specifically arising in radio communications. Moreover, the technology disclosed herein improves reception and transmission in a telecommunications system.

[0436] Although the description above contains many specificities, these should not be construed as limiting the scope of the technology disclosed herein but as merely providing illustrations of some of the presently preferred embodiments of the technology disclosed herein. Thus, the scope of the technology disclosed herein should be determined by the appended claims and their legal equivalents. Therefore, it will be appreciated that the scope of the technology disclosed herein fully encompasses other embodiments which may become obvious to those skilled in the art, and that the scope of the technology disclosed herein is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more." All structural, chemical, and functional equivalents to the elements of the above-described preferred embodiment that are known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the present claims. Moreover, it is not necessary for a device or method to address each and every problem sought to be solved by the technology disclosed herein, for it to be encompassed by the present claims. Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether

the element, component, or method step is explicitly recited in the claims.

- [0437] In one example, a wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising: processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both: (1) whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid; and (2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.
- [0438] In one example, the wireless terminal, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.
- [0439] In one example, the wireless terminal, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.
- [0440] In one example, the wireless terminal, wherein the processor circuitry is configured to: omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid; include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.
- [0441] In one example, a method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising: in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both: (1) whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid; and (2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and, transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

- [0442] In one example, a wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising: processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.
- [0443] In one example, the wireless terminal, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.
- [0444] In one example, the wireless terminal, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.
- [0445] In one example, the wireless terminal, wherein the processor circuitry is configured to: omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid; include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.
- [0446] In one example, a method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising: in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and, transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.
- [0447] In one example, a wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising: processor circuitry

configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both: (1) whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid; and (2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.

[0448] In one example, the wireless terminal, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0449] In one example, the wireless terminal, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.

[0450] In one example, the wireless terminal, wherein the processor circuitry is configured to: omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid; include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.

[0451] In one example, a method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising: in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both: (1) whether the one or more OFDM symbols is confined in an any uplink, UL, subband of the grid; and (2) that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and, transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0452] In one example, a wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising: processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink

Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.

[0453] In one example, the wireless terminal, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0454] In one example, the wireless terminal, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.

[0455] In one example, the wireless terminal, wherein the processor circuitry is configured to: omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid; include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.

[0456] In one example, a method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising: in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols is confined in an uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted; and, transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[0457] <Cross Reference>

This Nonprovisional application claims priority under 35 U.S.C. § 119 on provisional Application No. 63/481,536 on January 5, 2023, the entire contents of which are hereby incorporated by reference.

Claims

- [Claim 1] A wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising:
processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both:
whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid; and
that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.
- [Claim 2] The wireless terminal of claim 1, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.
- [Claim 3] The wireless terminal of claim 1, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.
- [Claim 4] The wireless terminal of claim 3, wherein
the processor circuitry is configured to:
omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid;
include an eligible transmission occasion that is not omitted from the set in the PUSCH repetition; and
further comprising transmitter circuitry configured to transmit the PUSCH repetition to the radio access network.
- [Claim 5] A method in a wireless terminal which communicates across a radio interface with a radio access network, the method comprising:
in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, making

a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining both:
whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid; and
that the potential transmission occasion does not overlap with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted;
and,
transmitting the eligible transmission occasion for the PUSCH repetition to the radio access network.

[Claim 6] A wireless terminal which communicates across a radio interface with a radio access network, the wireless terminal comprising:
processor circuitry configured, in a case that a potential transmission occasion for a Physical Uplink Shared Channel, PUSCH, repetition overlaps with one or more orthogonal frequency division multiplexing, OFDM, symbols in a downlink, DL, region in a time domain of a radio resource grid, to make a determination whether the potential transmission occasion corresponds to an eligible transmission occasion, and wherein making the determination comprises determining whether the one or more OFDM symbols overlap with any uplink, UL, subband of the grid regardless of whether the potential transmission occasion overlaps with any synchronization signal/physical broadcast channel, SS/PBCH, block candidates in which a SS/PBCH block is expected to be transmitted.

[Claim 7] The wireless terminal of claim 6, further comprising transmitter circuitry configured to transmit the eligible transmission occasion for the PUSCH repetition to the radio access network.

[Claim 8] The wireless terminal of claim 6, wherein the processor circuitry is configured to perform a redundancy version mapping of the eligible transmission occasion to a set of one or more eligible transmission occasions.

[Claim 9] The wireless terminal of claim 8, wherein
the processor circuitry is configured to:
omit from the set of the one or more eligible transmission occasions any eligible transmission occasion that conflicts with a downlink resource of the radio resource grid;
include an eligible transmission occasion that is not omitted from the

set in the PUSCH repetition; and
further comprising transmitter circuitry configured to transmit the
PUSCH repetition to the radio access network.

[Fig. 1]

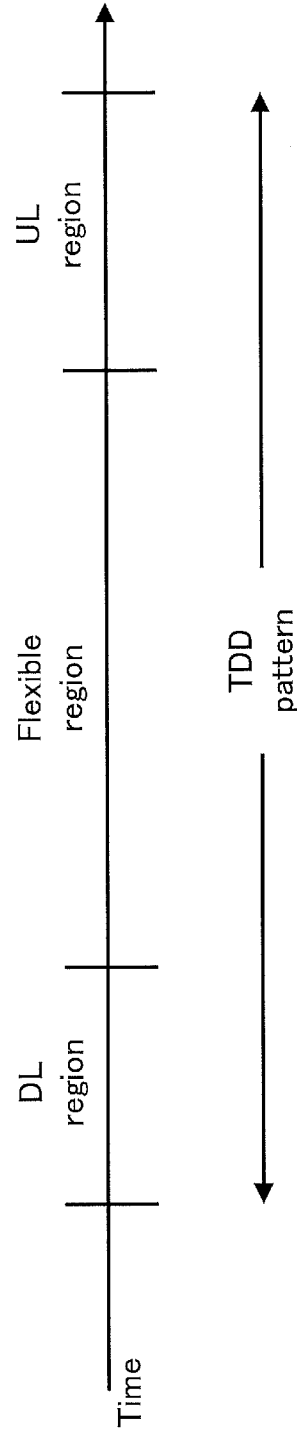
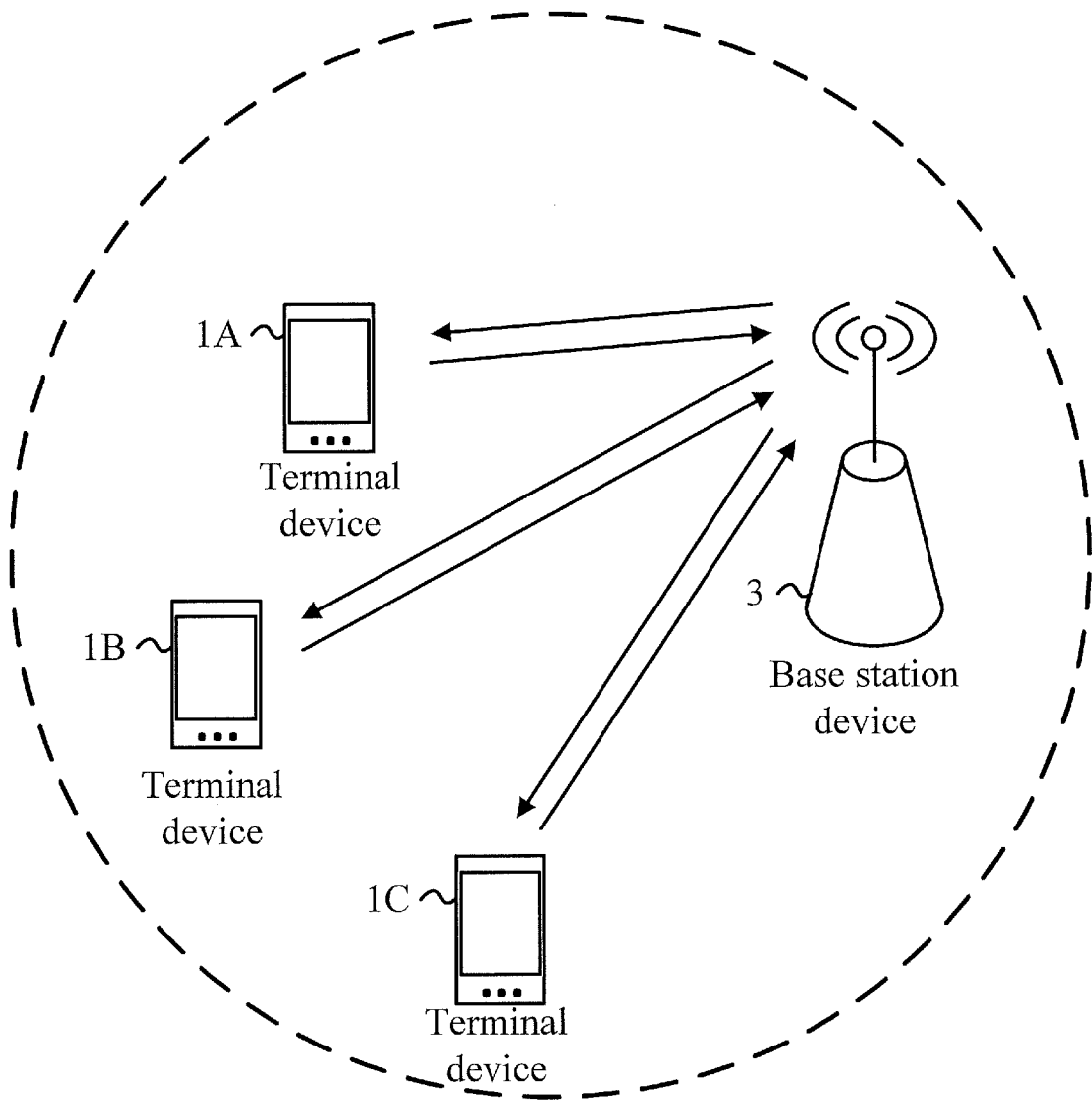


Fig. 1

[Fig. 2]

*Fig. 2*

[Fig. 3]

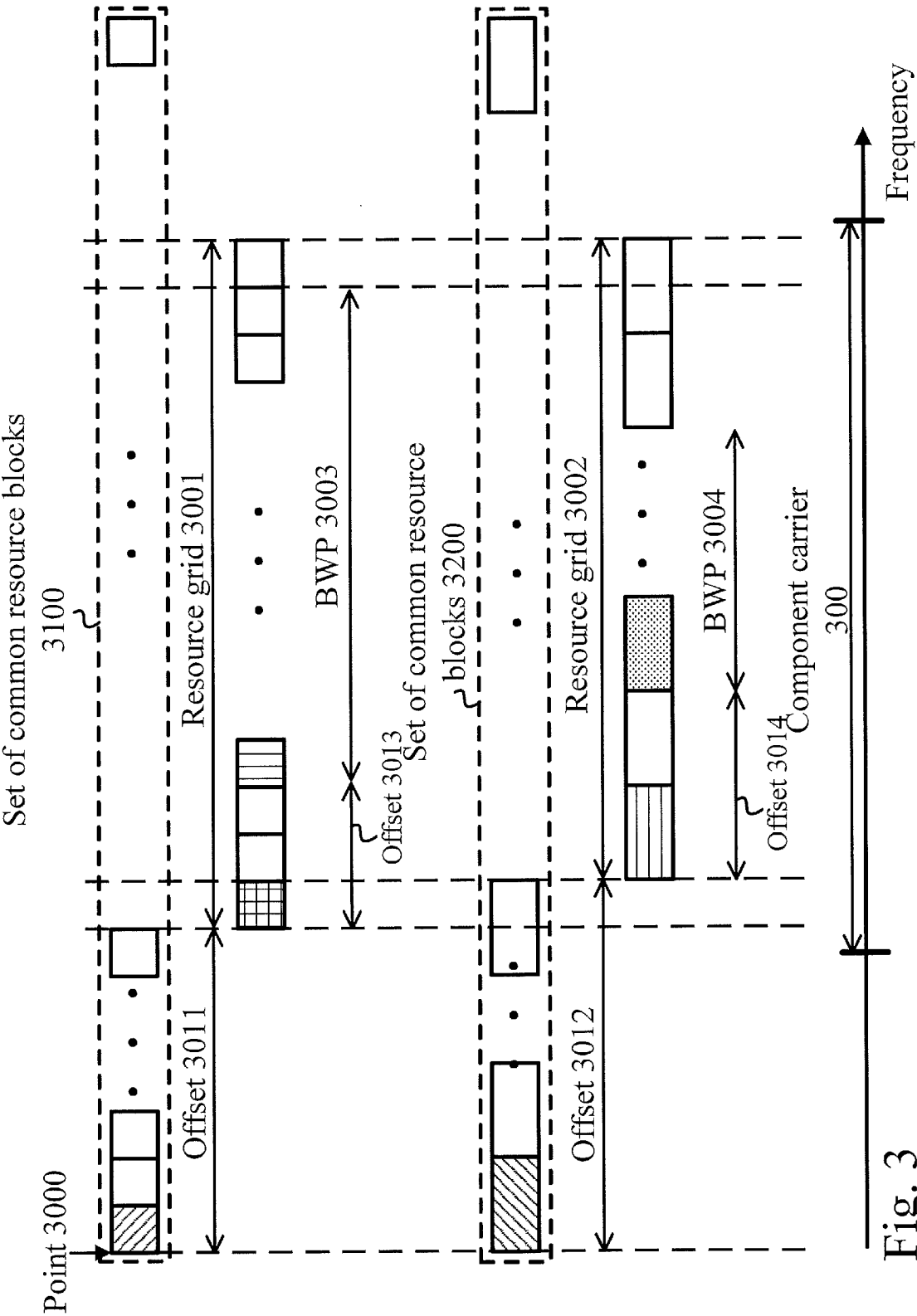


Fig. 3

[Fig. 4]

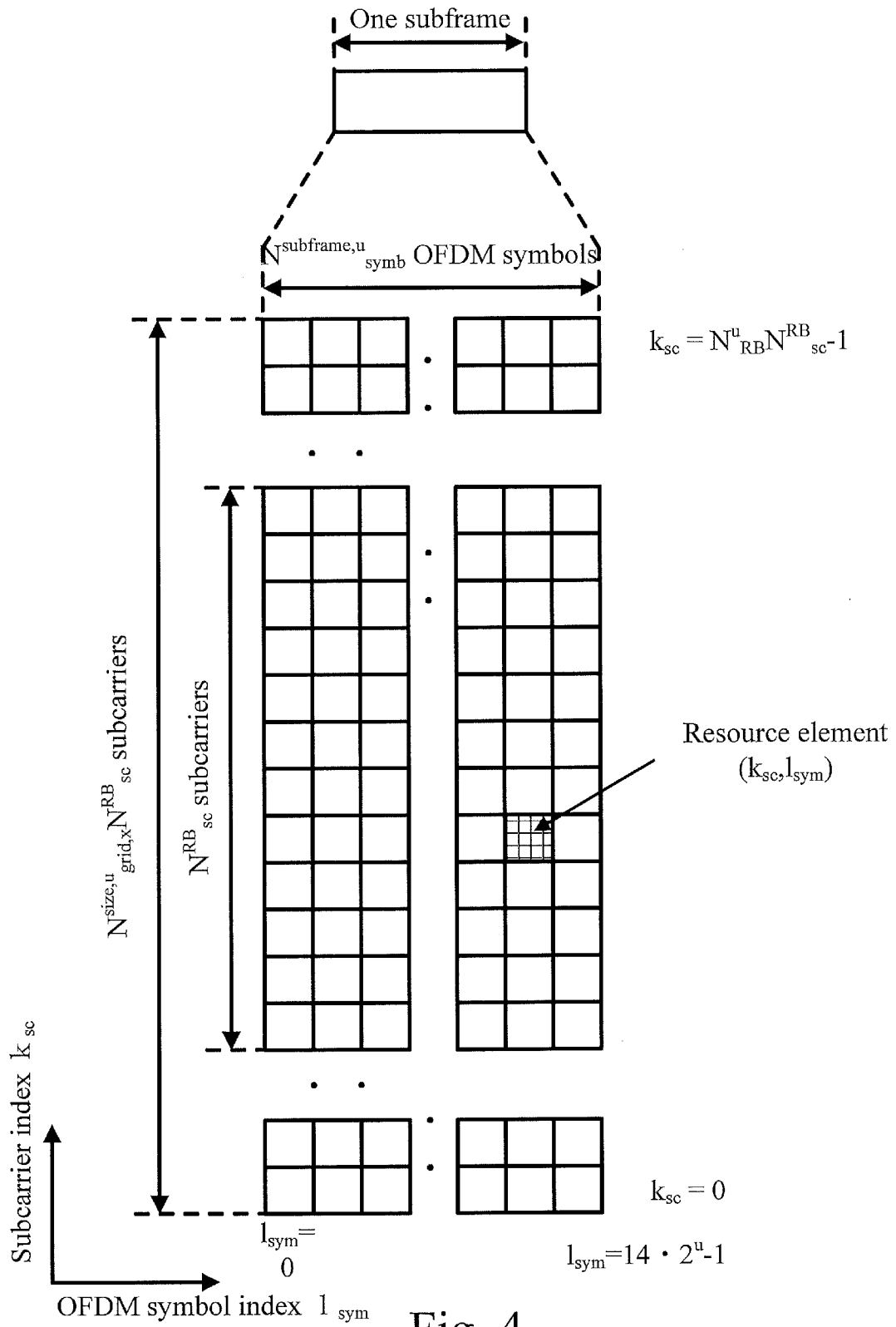


Fig. 4

[Fig. 5]

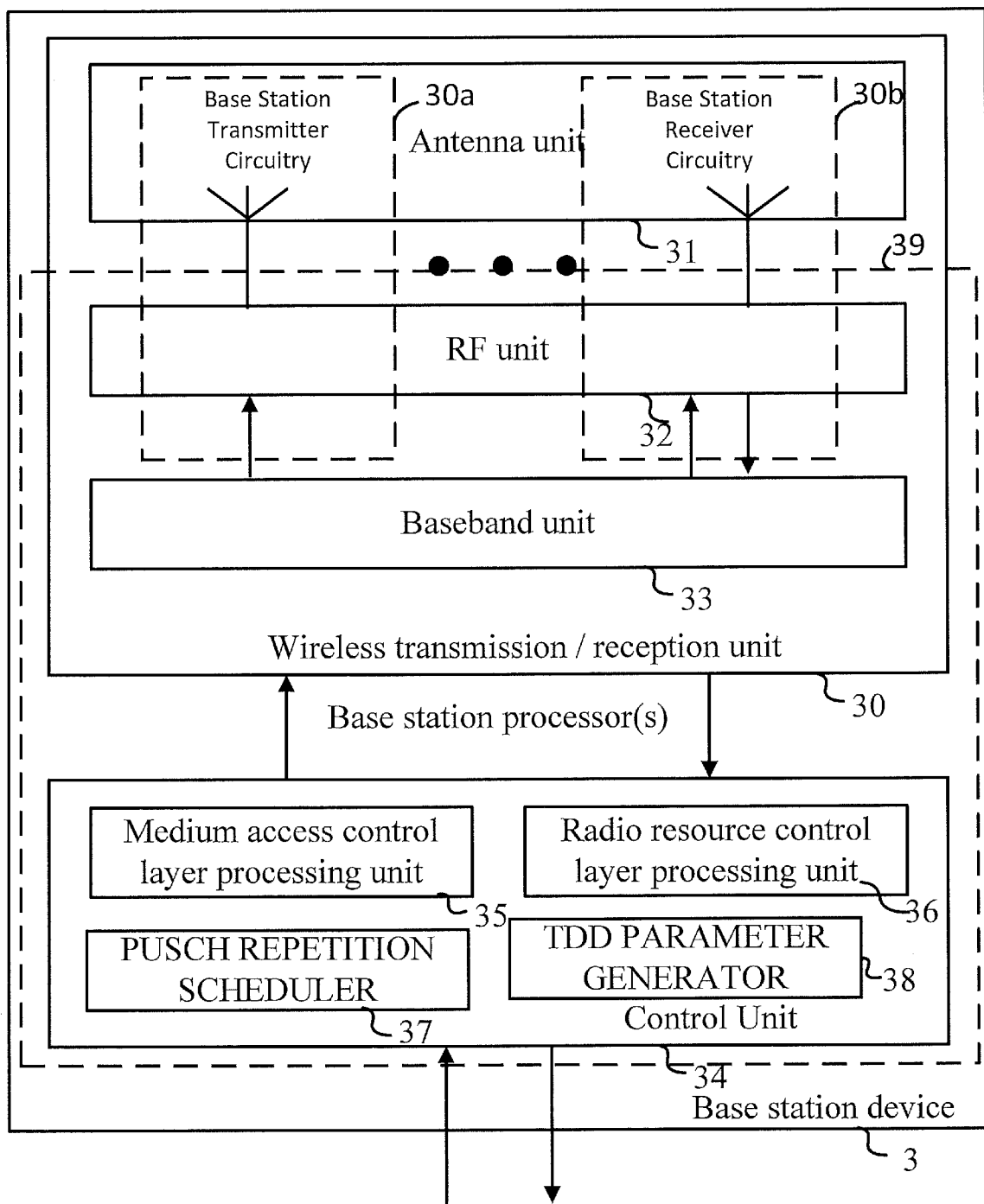


Fig. 5

Higher node or other base station device

[Fig. 6]

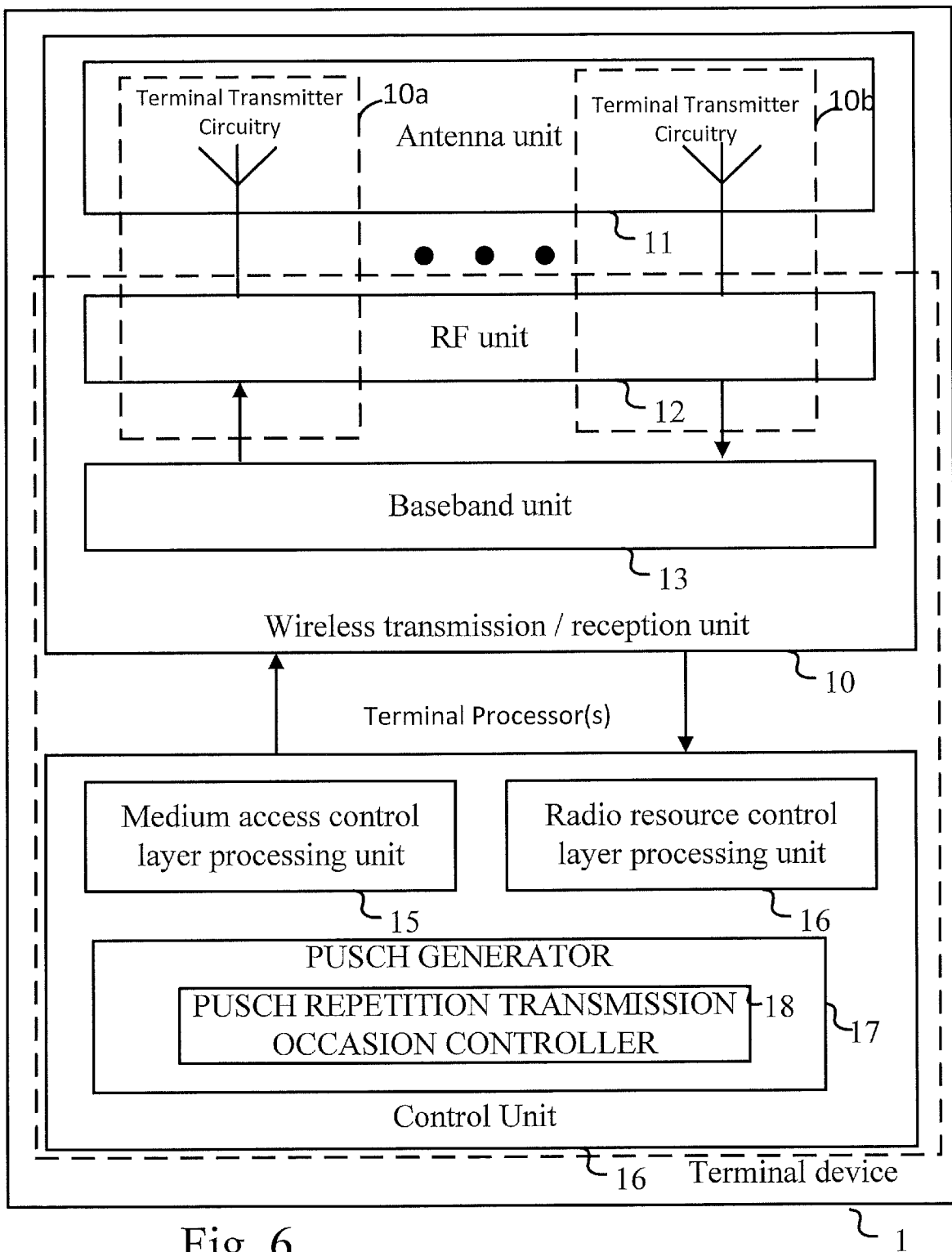
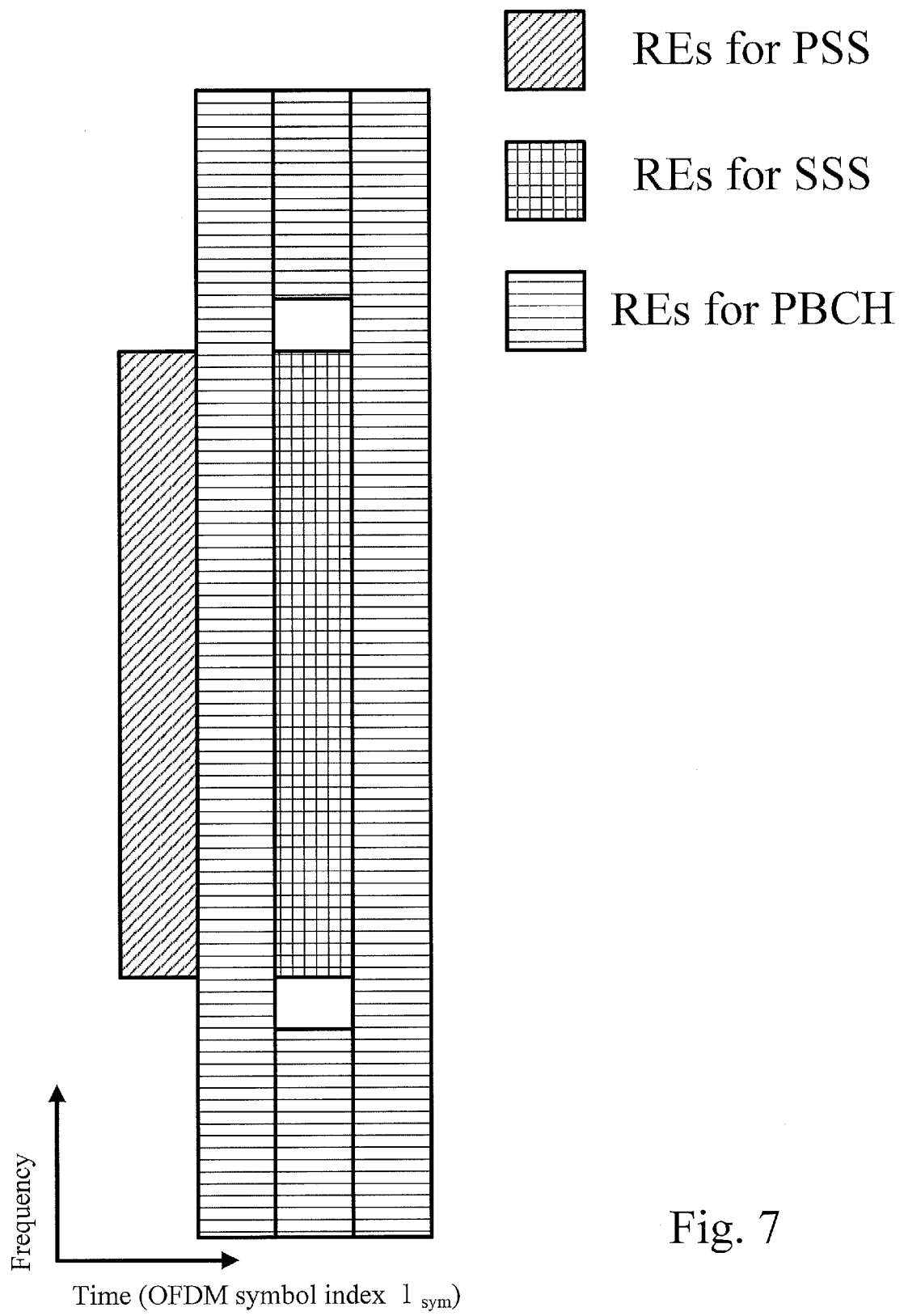


Fig. 6

[Fig. 7]



[Fig. 8]

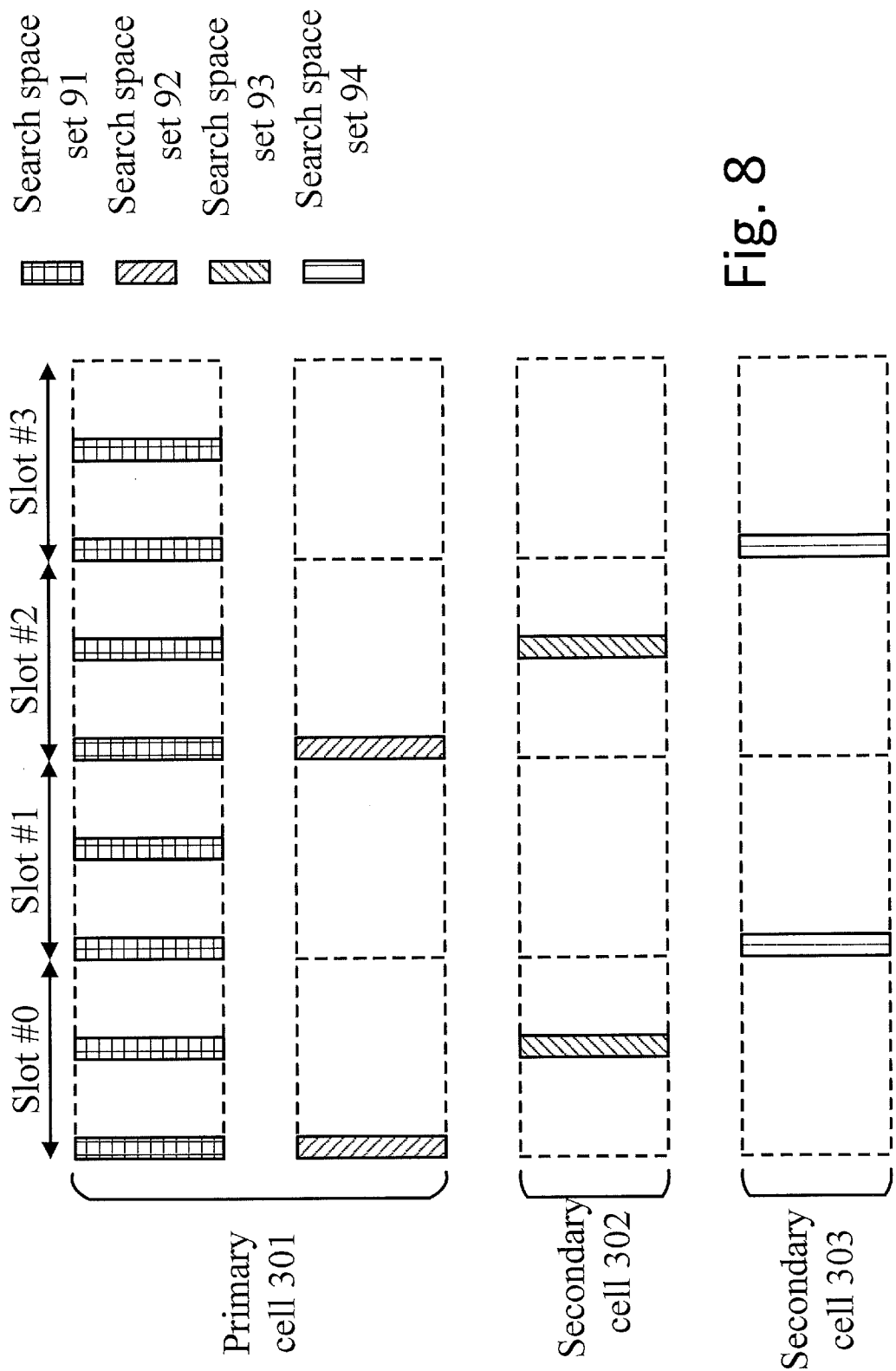


Fig. 8

[Fig. 10]

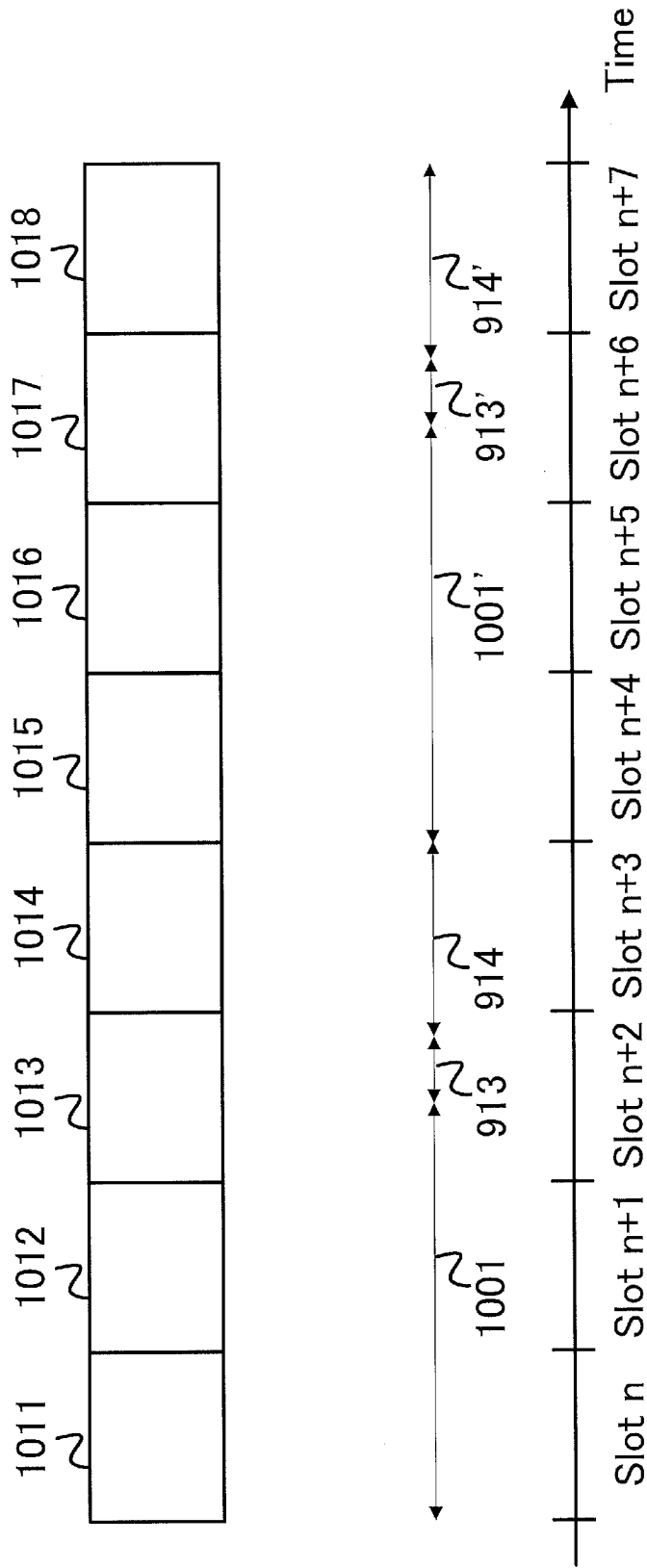
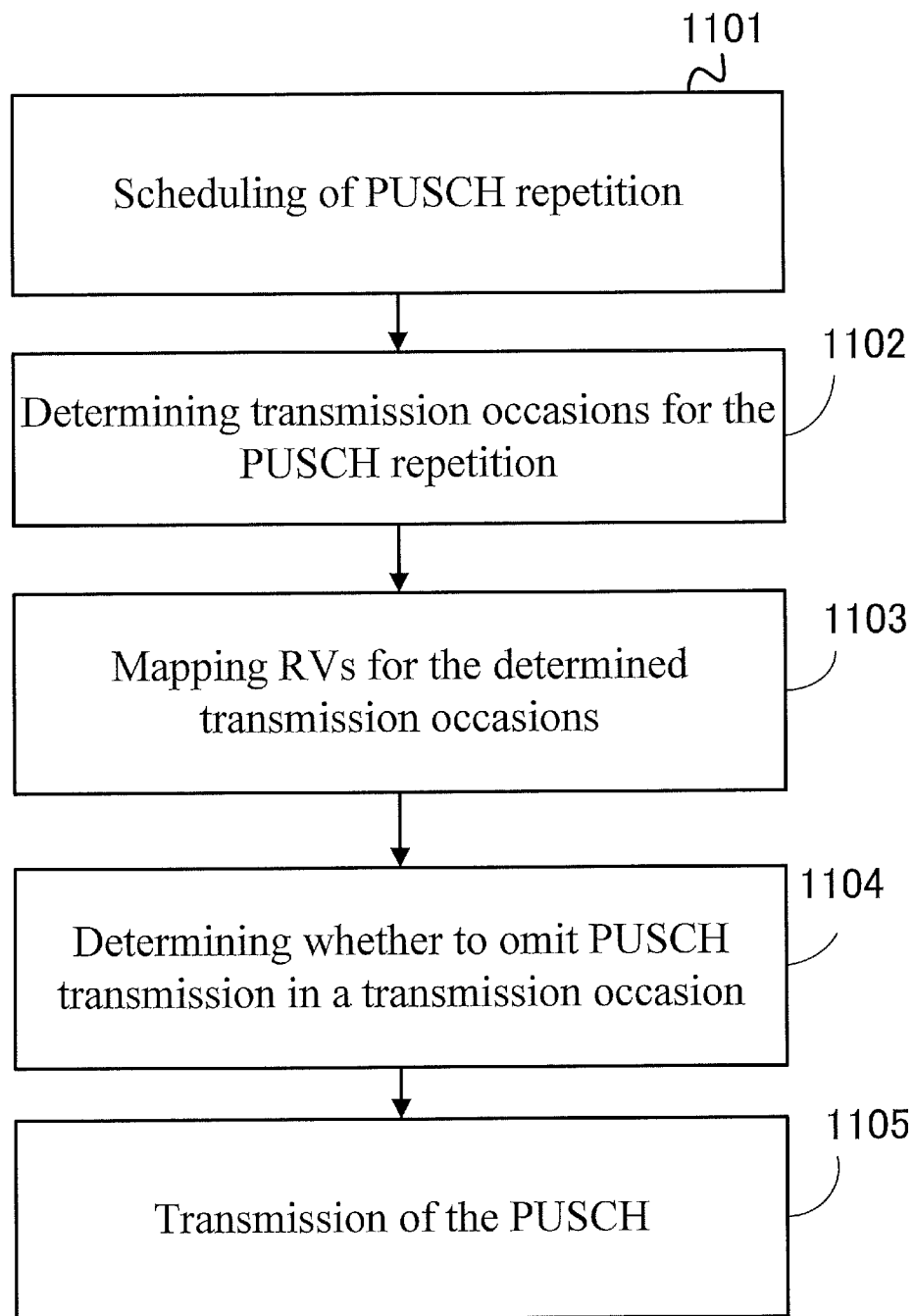
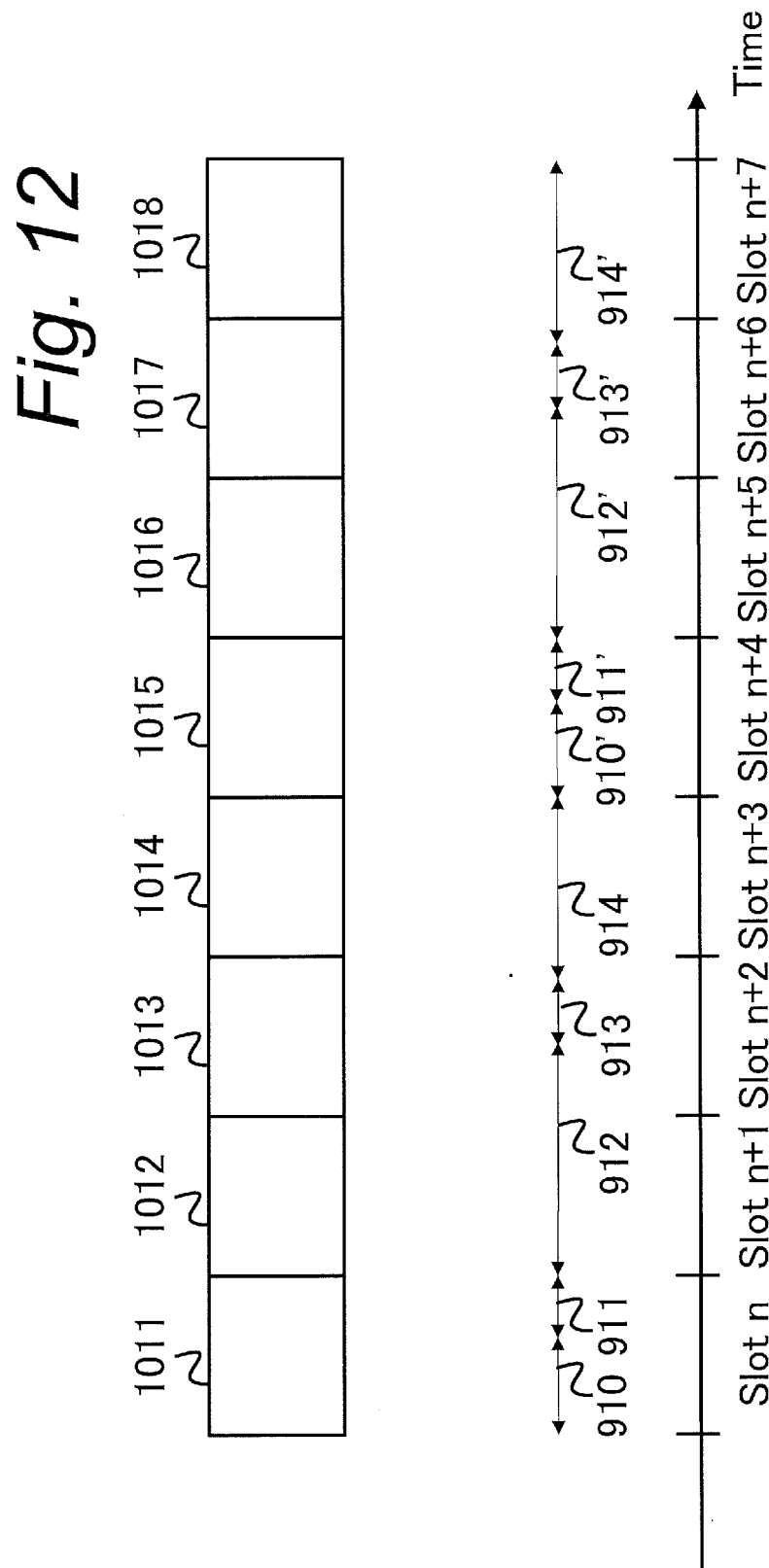


Fig. 10

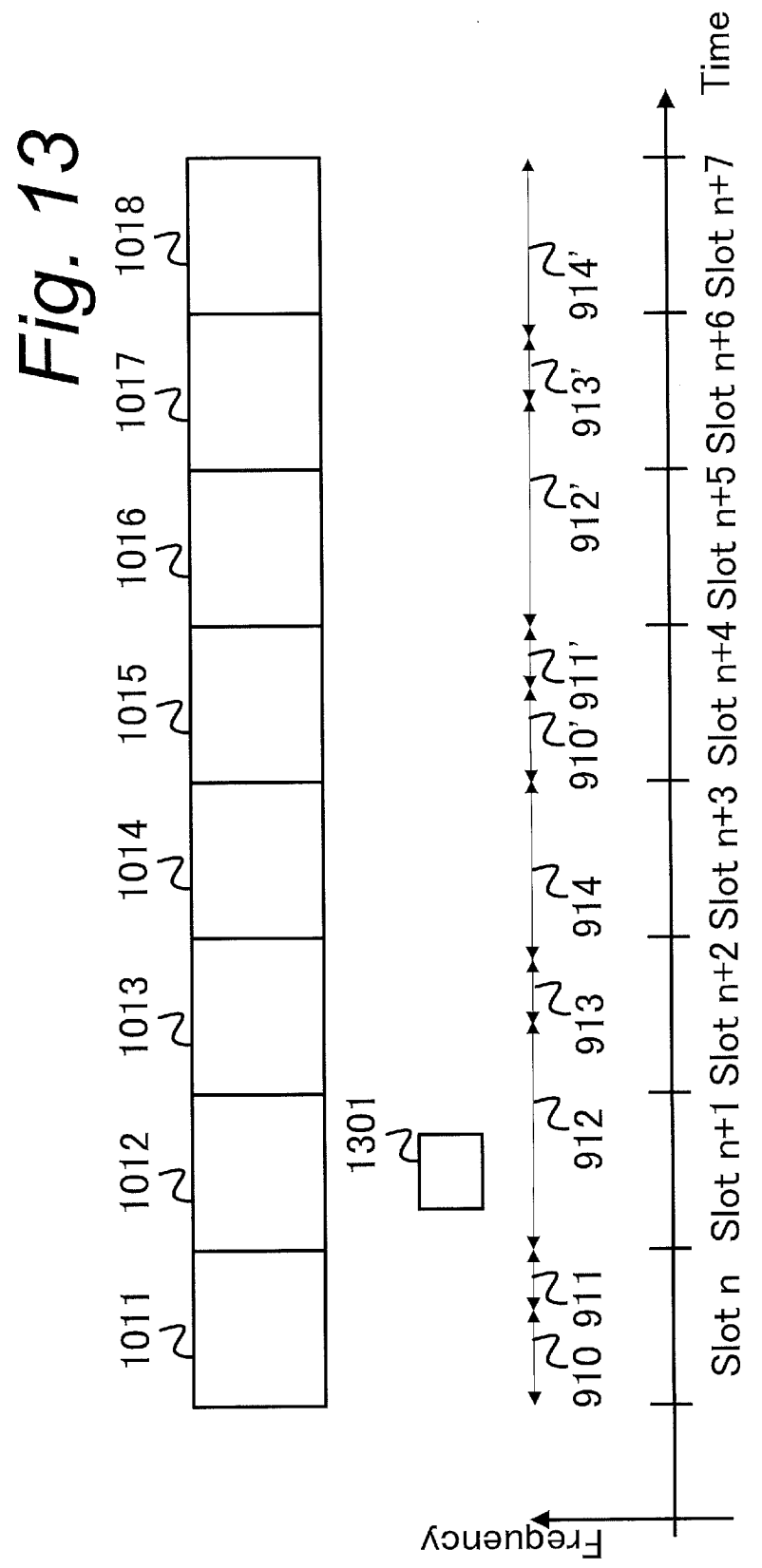
[Fig. 11]

*Fig. 11*

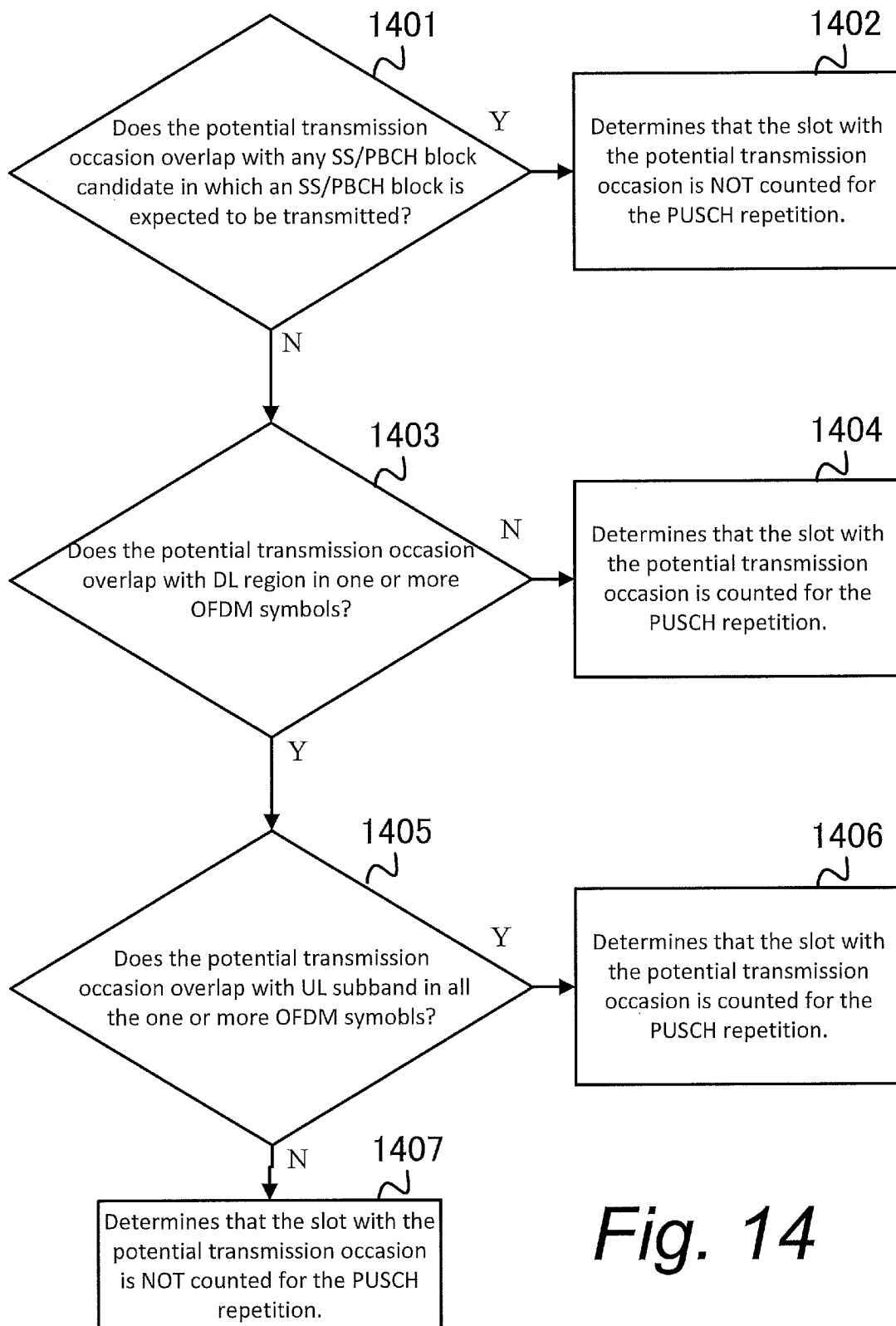
[Fig. 12]



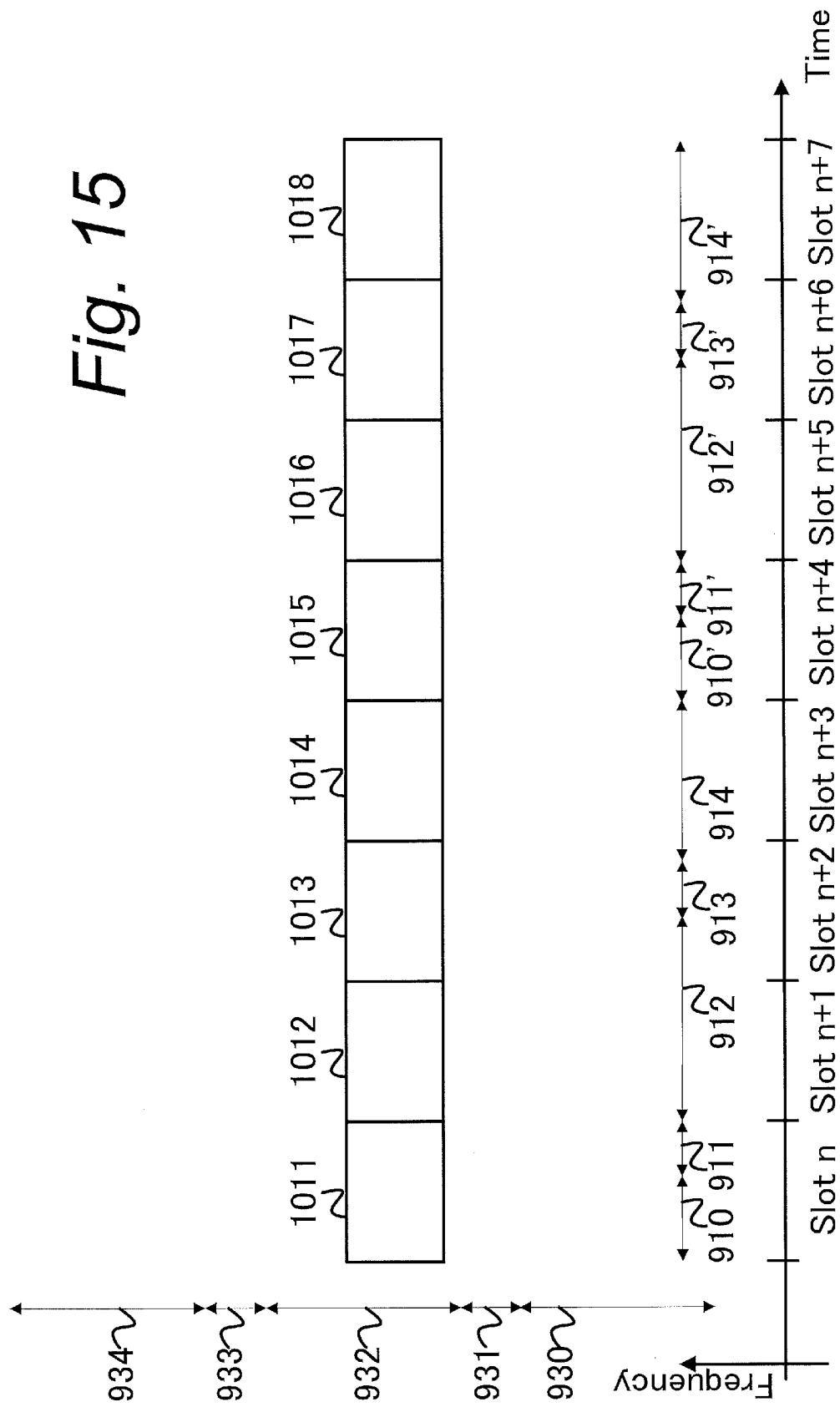
[Fig. 13]



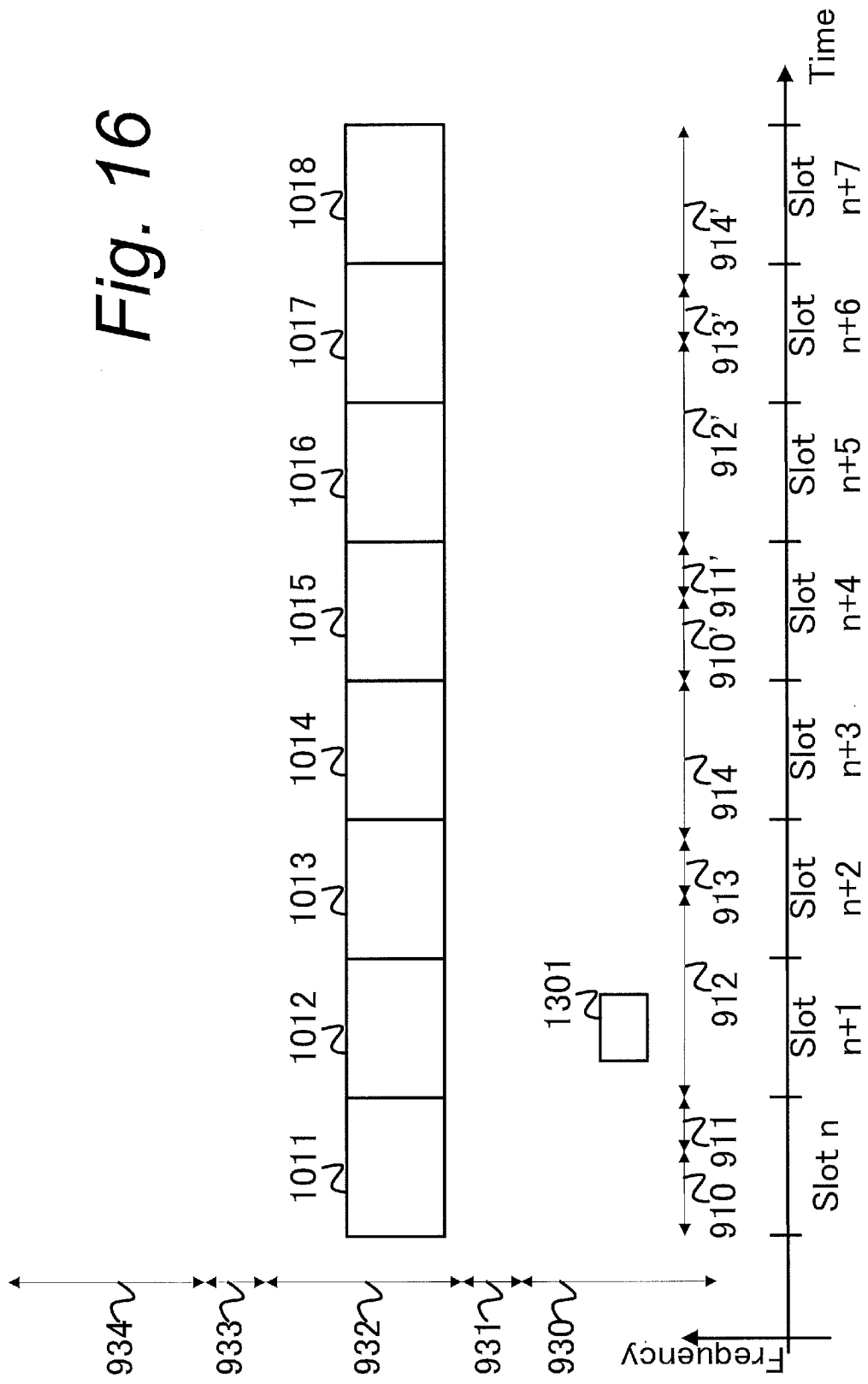
[Fig. 14]

*Fig. 14*

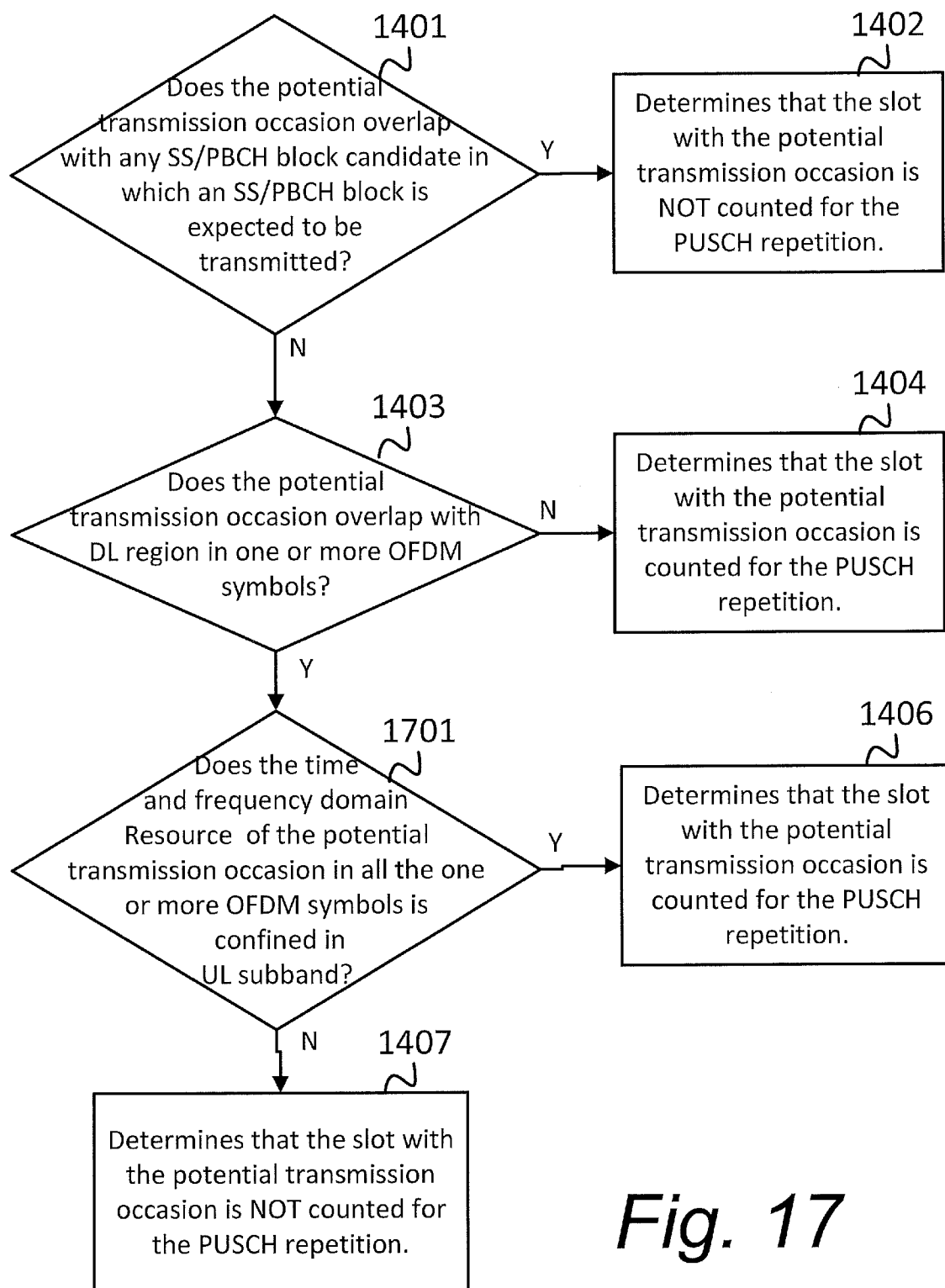
[Fig. 15]



[Fig. 16]



[Fig. 17]

*Fig. 17*

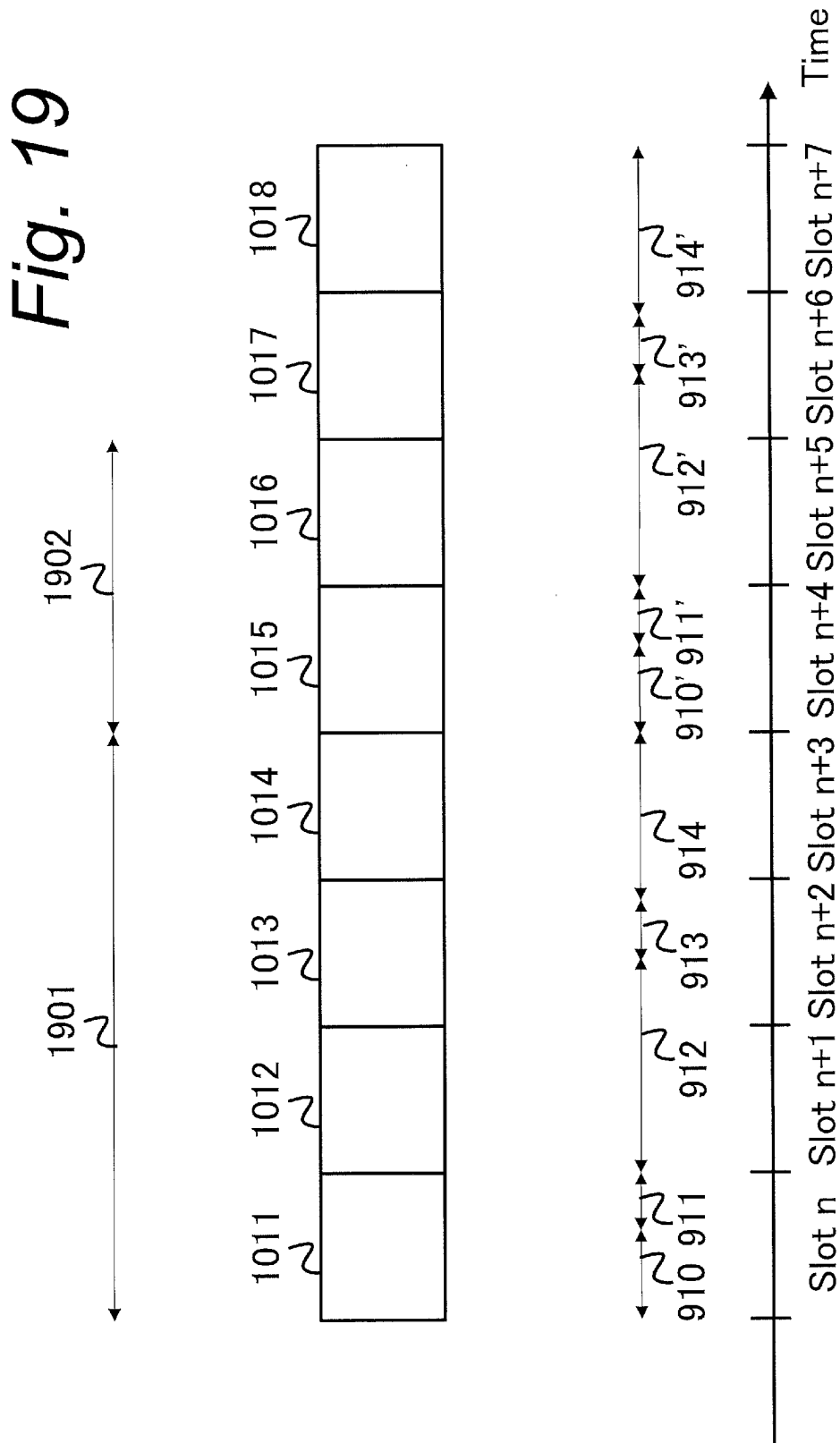
[Fig. 18]

Table 6.1.2.1-2: Redundancy version for PUSCH transmission

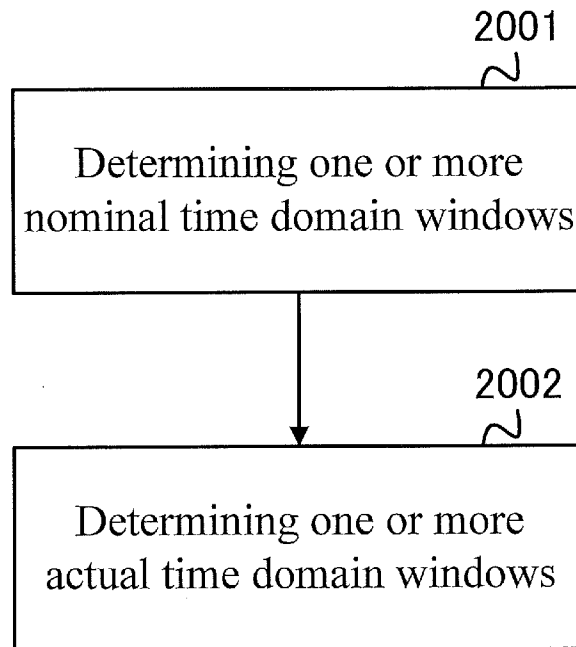
rv_{id} indicated by the DCI scheduling the PUSCH	rv_{id} to be applied to n^{th} transmission occasion (repetition Type A) or TB processing over multiple slots) or n^{th} actual repetition (repetition Type B)			
	$((n-(n \bmod N))/N) \bmod 4 = 0$	$((n-(n \bmod N))/N) \bmod 4 = 1$	$((n-(n \bmod N))/N) \bmod 4 = 2$	$((n-(n \bmod N))/N) \bmod 4 = 3$
0	0	2	3	1
2	2	3	1	0
3	3	1	0	2
1	1	0	2	3

Fig. 18

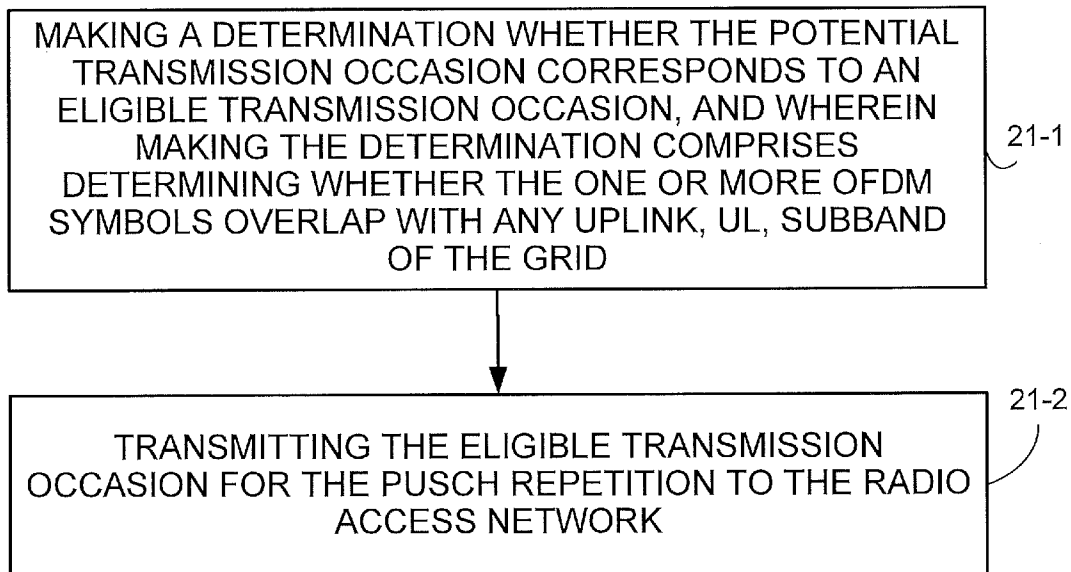
[Fig. 19]



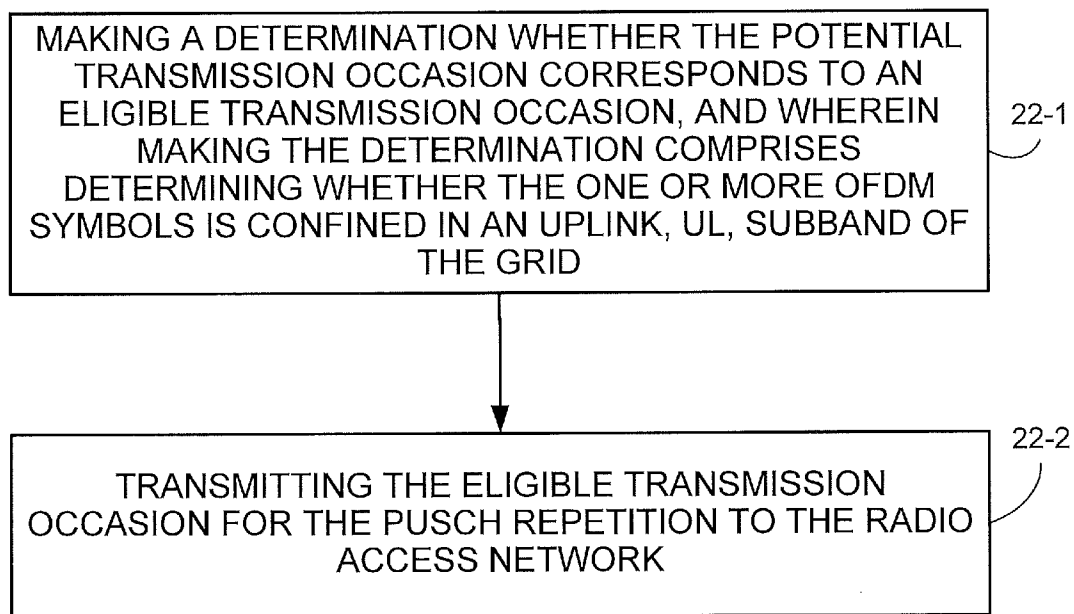
[Fig. 20]

*Fig. 20*

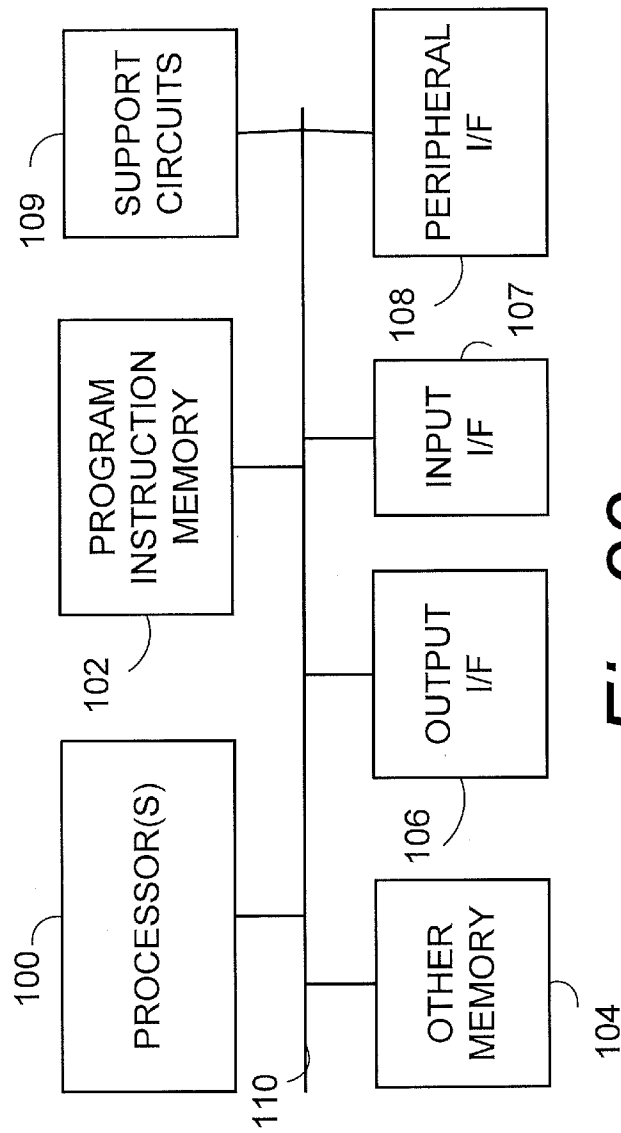
[Fig. 21]

*Fig. 21*

[Fig. 22]

*Fig. 22*

[Fig. 23]

*Fig. 23*

[Fig. 24]

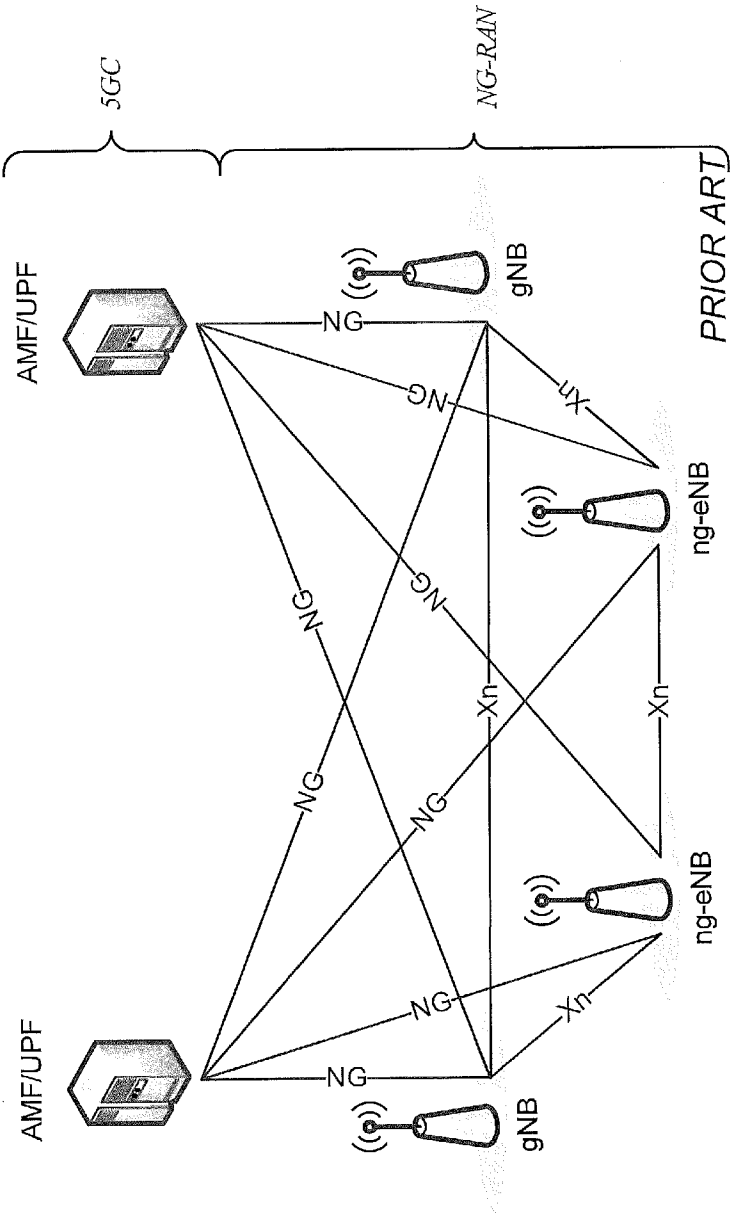


Fig. 24

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/001516

A. CLASSIFICATION OF SUBJECT MATTER H04W 72/1268 (2023.01)i; H04W 48/10 (2009.01)i FI: H04W72/1268; H04W48/10 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) H04W72/1268; H04W48/10 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2024 Registered utility model specifications of Japan 1996-2024 Published registered utility model applications of Japan 1994-2024 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Sharp, Discussion on subband non-overlapping full duplex[online], 3GPP TSG RAN WG1 #111 R1-2212149, 2022.11.18, Internet:<URL:https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_111/Docs/R1-2212149.zip>,[retrieved on 2024.03.01]	1,2,5-7
Y	section 3.1.4.2	3,4,8,9
Y	US 2022/0225388 A1 (LG ELECTRONICS INC.) 14 July 2022 (2022-07-14) [0249]-[0258]	3,4,8,9
☐ 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 “D” document cited by the applicant in the international application “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 01 March 2024		Date of mailing of the international search report 19 March 2024
Name and mailing address of the ISA/JP Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan		Authorized officer KOBAYASHI, Masaaki 5J 4241 Telephone No. +81-3-3581-1101 Ext. 3534

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2024/001516

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2022/0225388	A1	14 July 2022	JP	2023-529747	A	
					paragraphs [0224]-[0233]		
				KR	10-2022-0144839	A	
				CN	115606147	A	
