

US Patent & Trademark Office

Patent Public Search | Text View

United States Patent	12395294
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Yoshioka; Shohei et al.

Terminal, radio communication method, base station, and system

Abstract

A terminal, as disclosed, includes: a receiver that receives a downlink control information (DCI) using a specific type of radio network temporary identifier (RNTI); and a processor that controls reception of a physical downlink shared channel (PDSCH) scheduled by the DCI, based on a configuration associated with the specific type. In other aspects, a radio communication method, a base station, and a system are also disclosed.

Inventors: Yoshioka; Shohei (Tokyo, JP), Nagata; Satoshi (Tokyo, JP), Wang; Lihui (Beijing, CN), Hou; Xiaolin (Beijing, CN)

Applicant: NTT DOCOMO, INC. (Tokyo, JP)

Family ID: 1000008763424

Assignee: NTT DOCOMO, INC. (Tokyo, JP)

Appl. No.: 18/647824

Filed: April 26, 2024

Prior Publication Data

Document Identifier	Publication Date
US 20240297757 A1	Sep. 05, 2024

Related U.S. Application Data

continuation parent-doc US 17620836 ABANDONED WO PCT/JP2019/024837 20190621 child-doc US 18647824

Publication Classification

Int. Cl.: H04L5/00 (20060101)

U.S. Cl.:

CPC **H04L5/0048** (20130101);

Field of Classification Search

CPC: H04L (5/0035); H04L (5/0044); H04L (5/0048)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
11405086	12/2021	Zhang et al.	N/A	N/A
2012/0250541	12/2011	Ko et al.	N/A	N/A
2013/0265951	12/2012	Ng et al.	N/A	N/A
2014/0192734	12/2013	Ng et al.	N/A	N/A
2015/0312927	12/2014	Ko	370/336	H04L 5/0094
2017/0347270	12/2016	Iouchi	N/A	H04L 5/0098
2018/0262882	12/2017	You	N/A	H04W 72/30
2019/0140729	12/2018	Zhang et al.	N/A	N/A
2019/0215119	12/2018	Kim et al.	N/A	N/A
2019/0306923	12/2018	Xiong	N/A	H04L 27/261
2020/0007296	12/2019	Papasakellariou	N/A	H04L 1/1861
2020/0021413	12/2019	Park et al.	N/A	N/A
2020/0052861	12/2019	Li et al.	N/A	N/A
2020/0127786	12/2019	Kwak	N/A	H04L 27/26
2020/0187170	12/2019	Shin	N/A	H04L 27/2666
2021/0014021	12/2020	Hunukumbure	N/A	H04L 5/0053
2022/0353710	12/2021	Yoshioka	N/A	H04W 72/1273
2022/0361154	12/2021	Yoshioka	N/A	H04L 1/1671
2023/0115798	12/2022	Lee et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
3787201	12/2020	EP	N/A

OTHER PUBLICATIONS

International Search Report issued in PCT/JP2019/024837 on Dec. 10, 2019 (2 pages). cited by applicant

Written Opinion of the International Searching Authority issued in PCT/JP2019/024837 on Dec. 10, 2019 (4 pages). cited by applicant

3GPP TS 36.300 V8.12.0; "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8)"; Mar. 2010 (149 pages). cited by applicant

Primary Examiner: Lin; Kenny S

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation application and, thereby, claims benefit under 35 U.S.C. § 120 to U.S. patent application Ser. No. 17/620,836, filed on Dec. 20, 2021, titled “TERMINAL AND RADIO COMMUNICATION METHOD,” which is a national stage application of PCT Application No. PCT/JP2019/024837, filed on Jun. 21, 2019. The contents of these applications are incorporated by reference in their entirety.

TECHNICAL FIELD

(1) The present disclosure relates to a terminal and a radio communication method in next-generation mobile communication systems.

BACKGROUND ART

(2) In a Universal Mobile Telecommunications System (UMTS) network, the specifications of Long-Term Evolution (LTE) have been drafted for the purpose of further increasing high speed data rates, providing lower latency and so on (see Non-Patent Literature 1). In addition, for the purpose of further high capacity, advancement and the like of the LTE (Third Generation Partnership Project (3GPP) Release (Rel.) 8 and Rel. 9), the specifications of LTE-Advanced (3GPP Rel. 10 to Rel. 14) have been drafted.

(3) Successor systems of LTE (e.g., referred to as “5th generation mobile communication system (5G),” “5G+ (plus),” “New Radio (NR),” “3GPP Rel. 15 (or later versions),” and so on) are also under study.

CITATION LIST

Non-Patent Literature

(4) Non-Patent Literature 1: 3GPP TS 36.300 V8.12.0 “Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8),” April, 2010

SUMMARY OF INVENTION

Technical Problem

(5) For future radio communication systems (hereinafter also referred to as NR), performing multicast transmission (also referred to as, for example, a multicast traffic channel (MTCH), multicast data, or the like for a logical channel) by using a physical downlink shared channel (e.g., a Physical Downlink Shared Channel (PDCCH)) is under study. Specifically, it is studied that the MTCH is mapped to a downlink shared channel (e.g., a Downlink Shared Channel (DL-SCH)) being a transport channel and the DL-SCH is mapped to the PDSCH.

(6) It is also studied that the PDSCH used for multicast transmission is scheduled by a physical downlink control channel (e.g., a Physical Downlink Control Channel (PDCCH)) in which cyclic redundancy check (CRC) bits are scrambled (CRC-scrambled) by a radio network temporary identifier (RNTI) common to one or more terminals. The RNTI may be referred to as a group (G)-RNTI, a single cell (SC)-RNTI, a multicast (M or MC)-RNTI, a groupcast RNTI, and so on.

(7) In this case, unless the UE can obtain information related to energy of the PDSCH scheduled with use of the G-RNTI and a reference signal (RS) associated with the PDSCH, appropriate reception of multicast transmission transmitted with use of the PDSCH may not be available.

(8) Thus, an object of the present disclosure is to provide a terminal and a radio communication method that can appropriately receive multicast transmission transmitted with use of a PDSCH.

Solution to Problem

(9) A terminal according to one aspect of the present disclosure includes a receiving section that

receives a physical downlink shared channel (PDSCH) scheduled with use of a specific type of radio network temporary identifier (RNTI), and a control section that uses a value associated with the specific type as a ratio between energy of the PDSCH and energy of a reference signal associated with the PDSCH.

Advantageous Effects of Invention

(10) According to one aspect of the present disclosure, it is possible to appropriately receive multicast transmission transmitted with use of a PDSCH.

Description

BRIEF DESCRIPTION OF DRAWINGS

- (1) FIG. 1 is a diagram to illustrate an example of multicast transmission in a single cell;
- (2) FIG. 2 is a diagram to illustrate an example of multicast transmission in a plurality of cells;
- (3) FIG. 3 is a diagram to illustrate an example of first scheduling of multicast transmission;
- (4) FIG. 4 is a diagram to illustrate an example of second scheduling of multicast transmission;
- (5) FIG. 5 is a diagram to illustrate an example of third scheduling of multicast transmission;
- (6) FIG. 6 is a diagram to illustrate an example of a PDSCH EPRE-to-DM-RS EPRE ratio in Rel. 15;
- (7) FIG. 7 is a diagram to illustrate an example of a PT-RS EPRE-to-PDSCH EPRE ratio per layer per RE for a PT-RS port in Rel. 15;
- (8) FIG. 8 is a diagram to illustrate an example of a PDSCH EPRE-to-DM-RS EPRE ratio for a unicast PDSCH and a multicast PDSCH;
- (9) FIG. 9 is a diagram to illustrate an example of a PDSCH EPRE-to-DM-RS EPRE ratio for a multicast PDSCH;
- (10) FIG. 10 is a diagram to illustrate an example of a schematic structure of a radio communication system according to one embodiment;
- (11) FIG. 11 is a diagram to illustrate an example of a structure of a base station according to one embodiment;
- (12) FIG. 12 is a diagram to illustrate an example of a structure of a user terminal according to one embodiment; and
- (13) FIG. 13 is a diagram to illustrate an example of a hardware structure of the base station and the user terminal according to one embodiment.

DESCRIPTION OF EMBODIMENTS

(14) (UE State)

(15) In future radio communication systems (hereinafter also referred to as NR), it is assumed that a terminal (also referred to as a user terminal, User Equipment (UE), a device, and so on) has a plurality of states depending on traffic activity.

(16) For example, the UE of NR may have three states such as an idle state, an inactive state, and a connected state in a radio resource control (RRC) layer. The states are also referred to as UE states, RRC states, and so on.

(17) Here, the idle state is a state in which RRC connection between the UE and a base station is not established, and is also referred to as an RRC idle state (RRC_IDLE state), RRC idle (RRC_IDLE), and so on. The UE in the idle state is required to perform a reconfiguration of the RRC connection in order to transit to the connected state in which data transfer can be performed.

(18) The inactive state is a state in which the RRC connection between the UE and the base station is established, but data transfer cannot be performed, and is also referred to as an RRC inactive state (RRC_INACTIVE state), RRC inactive (RRC_INACTIVE), and so on. The RRC connection is established for the UE in the inactive state, and thus the UE in the inactive state can transit to the connected state quicker than the UE in the idle state. Therefore, delay time until a start of data

transfer is shorter than that of the UE in the idle state.

(19) The connected state is a state in which the RRC connection between the UE and the base station is established and data transfer can be performed, and is also referred to as an RRC connected state (RRC_CONNECTED state), RRC connected (RRC_CONNECTED), and so on. The UE in the connected state monitors a downlink control channel (e.g., a Physical Downlink Control Channel (PDCCH)) for determination of whether data is scheduled, and thus power consumption of the UE is larger as compared to that of the UE in the idle state or inactive state.

(20) (Frequency Range)

(21) For NR, supporting a plurality of frequency ranges (FRs) is also under study. For example, a first FR (FR 1) is from 410 MHz to 7.125 GHz. A second FR (FR 2) is from 24.25 GHz to 52.6 GHz. A third FR (FR 3) is from 7.125 GHz to 24.25 GHz. A fourth FR (FR 4) is from 52.6 GHz to 114.25 GHz. The UE may support at least one of the plurality of FRs.

(22) (Multicast)

(23) For NR, supporting unicast being a Point To Point (PTP) communication scheme and multicast being a Point To Multipoint (PTM) communication scheme is also under study.

(24) In the multicast, identical contents are transmitted to one or more terminals (also referred to as user terminals, User Equipments (UEs), devices, and so on) located in a specific area (also referred to as, for example, a Multimedia Broadcast Multicast Service (MBMS) service area and so on). The specific area may be constituted by a single cell or a plurality of cells. The multicast in which the specific area is constituted by a single cell may be referred to as single cell (SC)-based PTM (SC-PTM) and so on.

(25) Multicast transmission and unicast transmission may be performed (may be time-multiplexed) in different time units (e.g., slots) in an identical cell. A time unit for performing multicast transmission in a radio frame may be determined in advance by specifications, or may be configured (notified) for the UE by higher layer signaling.

(26) Note that in the present disclosure, it is only necessary that the higher layer signaling is, for example, at least one of Radio Resource Control (RRC) signaling, system information (e.g., at least one of Remaining Minimum System Information (RMSI), Other system information (OSI), and System Information Block (SIB)), broadcast information (e.g., Physical Broadcast Channel (PBCH) or Master Information Block (MIB)), Medium Access Control (MAC) signaling, and Radio Link Control (RLC) signaling.

(27) Alternatively, each of multicast transmission and unicast transmission may be performed in a different cell. The UE that can perform carrier aggregation (CA) or dual connectivity (DC) may receive multicast transmission in a cell, and may receive or transmit unicast transmission in another cell. Note that the UE that does not perform CA or DC may receive multicast transmission by being handed over to a cell in which multicast transmission is performed.

(28) Note that the cell may be rephrased as a serving cell, a component carrier (CC), a carrier, and so on.

(29) In multicast transmission, for example, a multicast traffic channel (MTCH), or an MTCH and a multicast control channel (MCCH) may be used as a logical channel.

(30) On the MTCH, data to be multicast-transmitted (also referred to as multicast data or traffic and so on) may be transferred. On the MCCH, control information necessary for MTCH reception may be transferred. Note that in the SC-PTM, the MTCH and MCCH may be referred to as an SC-MTCH and SC-MCCH or the like, respectively.

(31) The MTCH and MCCH being the logical channel may be mapped to a downlink shared channel (DL-SCH) being a transport channel in a Medium Access Control (MAC) layer. The DL-SCH may be mapped to a physical downlink shared channel (PDSCH) being a physical channel in a physical (PHY) layer.

(32) Note that in unicast transmission, for example, a dedicated traffic channel (DTCH), a dedicated control channel (DCCH), and the like may be used as the logical channel. The DTCH

and DCCH may be mapped to the DL-SCH in the MAC layer, and the DL-SCH may be mapped to the PDSCH in the physical layer. As described above, multicast transmission and unicast transmission may be associated with an identical transport channel and physical channel (in other words, the DL-SCH and PDSCH).

(33) <Multicast Transmission in BWP Unit>

(34) In NR, provision of one or more partial bands (bandwidth parts (BWPs)) in a cell is assumed. Thus, in NR, multicast transmission may be performed in not only a cell unit but also a BWP unit in the cell. An identical type multicast transmission may be performed between different BWPs in the cell, or different types of multicast transmission may be performed between different BWPs in the cell.

(35) FIG. 1 is a diagram to illustrate an example of multicast transmission in the single cell. In FIG. 1, for example, it is assumed that the UE performs CA or DC using a plurality of cells (here, cells #0 to #2). Here, in cell #0 being a PCell, it is assumed that a type (here, type a) multicast service is supported.

(36) As illustrated in FIG. 1, one or more BWPs (here, BWPs #0 to #2) are included in cell #0. In at least one BWP (here, BWP #1) in cell #0, multicast service may be supported. For example, in FIG. 1, a type a multicast service is supported in BWP #1 in cell #0.

(37) Note that FIG. 1 is merely an illustrative example, and the number, types, and the like of BWPs in which multicast transmission is supported in a single cell are not limited to those illustrated in the drawing. In FIG. 1, cells #0 and #1 are provided in FR 1 and cell #2 is provided in FR 2, but these are merely examples, and are not limited to those illustrated in the drawing. For example, cells #0 to #3 may belong to an identical FR, or at least two of cells #0 to #3 may belong to FRs different from each other.

(38) FIG. 2 is a diagram to illustrate an example of multicast transmission in the plurality of the cells. In FIG. 2, for example, it is assumed that the UE performs CA or DC using a plurality of cells (here, cells #0 to #3). Here, in cells #0 and #2 being PCells, it is assumed that one or more types of multicast services are supported.

(39) For example, in FIG. 2, a type a multicast service and type b multicast service are supported in cell #0, and a type c multicast service is supported in cell #2. The type a multicast service and type b multicast service are supported in BWP #1 for cell #0, whereas the type a multicast service is supported and the type b multicast service is not supported in BWP #2. In BWPs #0 to #2 for cell #2 of FIG. 2, an identical type c multicast service may be supported.

(40) At least one of types supported in each cell supporting multicast transmission may be supported in each BWP in each cell. Types to be supported between BWPs in an identical cell may be identical to each other, or may be different from each other.

(41) Note that FIG. 2 is just an illustrative example, and the number of cells supporting multicast transmission and the number, types, and the like of BWPs in which multicast transmission is supported in each cell are not limited to those illustrated in the drawing. In FIG. 2, although cells #0 and #1 are in FR 1, cells #2 and #3 are in FR 2, and a cell supporting multicast transmission for each FR is provided, which is just an illustrative example, and the present disclosure is not limited to those illustrated in the drawing. For example, a cell supporting multicast transmission for each cell group may be provided.

(42) <Scheduling of Multicast Transmission>

(43) Multicast transmission may be supported by at least one group of the following groups determined on the basis of a UE state (RRC state). (1) a group including only UE(s) in a specific UE state (e.g., the idle state, inactive state, or connected state), (2) any one of a group including UE(s) in a first UE state (e.g., the idle/inactive state) or a group including UE(s) in a second UE state (e.g., the connected state), and (3) supporting both of a first group including UE(s) in a first UE state (e.g., the idle/inactive state) and a second group including UE(s) in a second UE state (e.g., the connected state).

(44) Scheduling of multicast transmission for the groups (e.g., the above-described (1) to (3)) as described above will be described. For example, three scheduling methods below are assumed.

(45) In first scheduling, the UE may receive system information for multicast (e.g., step S11 of FIG. 3), may receive an MCCH on the basis of configuration information (MCCH configuration information) related to the MCCH included in the system information (e.g., step S12 of FIG. 3), and may receive an MTCH on the basis of information (MCCH information) transferred on the MCCH (e.g., step S13 of FIG. 3). The UE may be at least one of a UE in the idle state, a UE in the inactive state, and a UE in the connected state.

(46) In second scheduling, the UE may receive system information for multicast (e.g., step S21 of FIG. 4), and may receive an MTCH on the basis of multicast configuration information included in the system information (e.g., step S22 of FIG. 4). The UE may be at least one of a UE in the idle state, a UE in the inactive state, and a UE in the connected state.

(47) In third scheduling, the UE may receive an RRC message (e.g., an RRC reconfiguration message) (e.g., step S31 of FIG. 5), and may receive an MTCH on the basis of multicast configuration information included in the RRC message (e.g., step S31 of FIG. 5). The UE may be a UE in the connected state.

(48) In the first to third scheduling, the UE may receive the above-described MTCH via a PDSCH scheduled by DCI CRC-scrambled by a specific radio network temporary identifier (RNTI).

(49) The specific RNTI may be an RNTI for each multicast transmission (each multicast service type). The specific RNTI may be referred to as, for example, a group (G)-RNTI, a single cell (SC)-RNTI, a multicast (M or MC)-RNTI, a groupcast RNTI, and so on. A value of the G-RNTI may be the same between UEs belonging to an identical group (e.g., the above-described (1) to (3)).

(50) One or more G-RNTIs may be introduced to a UE. Each G-RNTI may be associated with one or more types of multicast transmission supported by the UE in a cell or a plurality of cells.

(51) For example, one or more G-RNTIs may be notified to the UE in the idle state or inactive state with use of at least one of system information for multicast and L1 signaling (e.g., at least one of information and DCI transferred on an MCCH).

(52) One or more G-RNTIs may be notified to the UE in the connected state with use of at least one of system information for multicast, L1 signaling (e.g., at least one of information and DCI transferred on an MCCH), and RRC signaling.

(53) The maximum number X of G-RNTIs configurable for a UE in a cell or a BWP may be determined by specifications, or may be configured on the basis of a UE capability. For example, the maximum number X of G-RNTIs may be configured such that the maximum number X does not exceed the UE capability reported from the UE.

(54) <<First Scheduling>>

(55) FIG. 3 is a diagram to illustrate an example of the first scheduling of multicast transmission. The first scheduling illustrated in FIG. 3 may be applied to a group including at least the UE in the idle/inactive state. The group may include the UE in the connected state, or need not include the UE in the connected state.

(56) As illustrated in FIG. 3, at step S11, the UE may receive system information for multicast (e.g., SIB20). Specifically, at step S111, the UE may monitor a search space set including one or more search spaces to detect a PDCCH (DCI) CRC-scrambled by a specific RNTI (e.g., a System Information (SI)-RNTI).

(57) At step S112, the UE may acquire (obtain) the system information via a PDSCH scheduled by the DCI. The system information may include configuration information (MCCH configuration information) related to an MCCH.

(58) The MCCH configuration information may include, for example, at least one of a period (repetition period) of MCCH transmission, time offset, and a period (update period (modification period)) of update of information transferred on the MCCH.

(59) At step S12, the UE receives the MCCH on the basis of the MCCH configuration information

in the system information. Specifically, at step **S121**, the UE may monitor a search space set to detect a PDCCH (DCI) CRC-scrambled by a specific identifier.

(60) The specific identifier may be a specific RNTI (e.g., a Single Cell (SC)-RNTI), or may be a temporary mobile group identifier. The specific identifier may be included in the above-described MCCH configuration information.

(61) At step **S122**, the UE may acquire the MCCH via the PDSCH scheduled by the DCI. The MCCH may be transmitted repetitively at the above-described repetition period. Identical information may be transmitted in the MCCH for each repetition period within the update period. When the information transferred on the MCCH is to be changed, this change of information transferred on the MCCH at the next update period may be notified at the last update period. The notification may be referred to as SC-MCCH change notification and so on.

(62) The PDCCH may be used for the notification. The UE may control discontinuous reception (DRX) on the basis of the notification. Specifically, the UE may be activated while the notification is performed, and may transit to a DRX state as long as the information transferred on the MCCH is not changed.

(63) At steps **S13a** and **13b**, the UE receives an MTCH on the basis of configuration information (MTCH configuration information) related to the MTCH transferred on the MCCH. The information transferred on the MTCH configuration information may include, for example, information indicating at least one of the following. G-RNTI, cell corresponding to multicast transmission, BWP corresponding to multicast transmission, multicast service type supported in each cell or BWP, control resource set (CORESET) in which PDCCH to schedule PDSCH to transfer MTCH is mapped, search space set used for monitoring of the PDCCH, and configuration information (PDSCH configuration information) related to PDSCH to transfer MTCH.

(64) At steps **S131a** and **S131b**, the UE may monitor the search space set to detect a PDCCH (DCI) CRC-scrambled by a specific RNTI (e.g., a G-RNTI). Note that the specific RNTI may be a different value for each multicast service type. For example, FIG. 3 illustrates G-RNTI_a corresponding to type a multicast service and G-RNTI_b corresponding to type b multicast service.

(65) At steps **S132a** and **S132b**, the UE may acquire an MTCH corresponding to each of the types a and b via the PDSCH scheduled by the DCI.

(66) Note that steps **S13a** and **13b**, steps **S131a** and **131b**, and steps **S132a** and **132b** are assumed to have different types of multicast service, but may include similar behavior.

(67) <<Second Scheduling>>

(68) FIG. 4 is a diagram to illustrate an example of the second scheduling of multicast transmission. The second scheduling illustrated in FIG. 4 may be applied to a group including at least the UE in the idle/inactive state. The group may include the UE in the connected state, or need not include the UE in the connected state.

(69) Behavior at step **S21** of FIG. 4 is similar to that at step **S11** of FIG. 3. On the other hand, system information (e.g., SIB20) for multicast acquired at step **S212** may include the above-described MTCH configuration information in place of the above-described MCCH configuration information. The information included in the MTCH configuration information is as described in the first scheduling.

(70) At steps **S22a** and **22b**, the UE receives an MTCH on the basis of MTCH configuration information in the system information acquired at step **S21**. Note that details of steps **S22a** and **S22b** are similar to those of steps **S13a** and **S13b** of FIG. 3.

(71) <<Third Scheduling>>

(72) FIG. 5 is a diagram to illustrate an example of the third scheduling of multicast transmission. The third scheduling illustrated in FIG. 5 may be applied to a group including the UE in the connected state. The group does not include the UE in the idle/inactive state.

(73) At step **S31** of FIG. 5, the UE may receive the above-described MTCH configuration information via RRC signaling. Specifically, at step **S311**, the UE may monitor a search space set

including one or more search spaces to detect a PDCCH (DCI) CRC-scrambled by a UE-specific RNTI (e.g., a Cell (C)-RNTI).

(74) At step **S312**, the UE may acquire the MTCH configuration information via the PDSCH scheduled by the DCI. The MTCH configuration information may be included in, for example, an RRC reconfiguration message. The information included in the MTCH configuration information is as described in the first scheduling.

(75) At steps **S32a** and **32b**, the UE receives an MTCH on the basis of MTCH configuration information in the system information acquired at step **S31**. Note that details of steps **S32a** and **S32b** are similar to those of steps **S13a** and **S13b** of FIG. 3.

(76) As described above, in NR, the MTCH (multicast data) is received on the basis of the MCCH, system information for multicast, or MTCH configuration information included in the RRC message via the PDSCH scheduled by the PDCCH (DCI) CRC-scrambled by the G-RNTI.

(77) In future radio communication systems (e.g., 5G or NR), for example, a plurality of communications (also referred to as use cases, services, communication types, and so on) with different required conditions (requirements or communication requirements), such as high speed and high capacity (e.g., eMBB (enhanced Mobile Broad Band)), ultra-multiple terminals (e.g., mMTC (massive Machine Type Communication) or IoT (Internet of Things)), ultra-high reliability and low latency (e.g., URLLC (Ultra Reliable and Low Latency Communications)), are assumed. Note that it is only necessary that the required conditions are requirements related to, for example, at least one of delay (latency), reliability (error rate), capacity, speed, and performance.

(78) Types of a plurality of services for multicast (multicast services) may be a plurality of communications (also referred to as use cases, services, communication types, and so on) having different requirements.

(79) (DL Power Distribution)

(80) In DL power distribution, making power of a reference signal (RS) higher than power of another channel allows channel estimation and detection to be simpler and more accurate. Transmission with constant power at all OFDM symbols is preferable for avoidance of power fluctuations in a receiver (UE).

(81) In Rel. 15 NR, the UE assumes that a PDSCH demodulation reference signal (DM-RS or DL DM-RS) is mapped to a physical resource in accordance with a DM-RS configuration type 1 or configuration type 2 given by a higher layer parameter “dmrs-Type.” The UE assumes that a sequence $r(m)$ of the PDSCH DM-RS is scaled by a factor $\beta_{\text{sub.PDSCH.sup.DMRS}}$ in order to follow defined transmit power. This scaling refers to multiplying the sequence $r(m)$ by the factor $\beta_{\text{sub.PDSCH.sup.DMRS}}$.

(82) The UE may assume that the ratio $\beta_{\text{sub.DMRS}}$ [dB] of PDSCH EPRE to DM-RS energy per resource element (EPRE) (PDSCH EPRE-to-DM-RS EPRE ratio or ratio of PDSCH EPRE to DM-RS EPRE) is given, in accordance with the number of DM-RS code division multiplexing (CDM) groups without data, to the DM-RS associated with the PDSCH from a table (FIG. 6) defined in specifications. The DM-RS scaling factor (amplitude ratio) $\beta_{\text{sub.PDSCH.sup.DMRS}}$ is given by $10^{\{\circlearrowleft(-\beta_{\text{sub.DMRS}}/20)\}}$. According to the table in the specifications, for example, when the number of DM-RS CDM groups without data is 2, $\beta_{\text{sub.DMRS}}$ is -3 dB and $\beta_{\text{sub.PDSCH.sup.DMRS}}$ is approximately the square root of two regardless of DM-RS configuration types, and thus amplitude of the DM-RS is scaled to amplitude approximately the square root of two times as high as the amplitude (power of the DM-RS is scaled to power approximately twice as high as the power).

(83) In Rel. 15 NR, the UE assumes that only when a higher layer parameter (phaseTrackingRS in DMRS configuration information for a PDSCH (DMRS-DownlinkConfig)) indicates that a phase-tracking reference signal (PT-RS or DL PT-RS) is used, the PT-RS exists only in a resource block (RB) used for the PDSCH. When the PT-RS exists, the UE assumes that a PDSCH PT-RS is scaled by a factor $\beta_{\text{sub.PT-RS}}$, in order for the PDSCH PT-RS to follow defined transmit power. This

scaling refers to multiplying a sequence $r_{\text{sub},k}$ by the factor $\beta_{\text{sub},\text{PT-RS},i}$.

(84) In a case where the UE is scheduled with use of a PT-RS port (PT-RS antenna port) associated with the PDSCH, when a higher layer parameter “e-pre-Ratio” is configured for the UE, the ratio $\rho_{\text{sub},\text{PTRS}}$ of PT-RS EPRE to PDSCH EPRE per layer per RE for the PT-RS port (PT-RS EPRE-to-PDSCH EPRE ratio or ratio of PT-RS EPRE to PDSCH EPRE per layer per RE for PT-RS port) is given from a table (FIG. 7) defined in the specifications in accordance with e-pre-Ratio, and a PT-RS scaling factor (amplitude ratio) $\beta_{\text{sub},\text{PTRS}}$ ($\beta_{\text{sub},\text{PT-RS},i}$) is given by $10^{\{\text{circumflex over } (\quad)\}(\rho_{\text{sub},\text{PTRS}}/20)}$. Unless e-pre-Ratio is configured for the UE, the UE assumes that e-pre-Ratio is set to a state “0.” According to the table in the specifications, for example, when the number of PDSCH layers is 2 and e-pre-Ratio is 0, $\rho_{\text{sub},\text{PTRS}}$ is 3 dB and $\beta_{\text{sub},\text{PTRS}}$ is approximately the square root of two, and thus amplitude of the PT-RS is scaled to amplitude approximately the square root of two times as high as the amplitude (power of the PT-RS is scaled to power approximately twice as high as the power).

(85) The UE uses the RS as a reference of phase and a reference of power or amplitude, for demodulation of a signal transmitted by higher order modulation (e.g., 16 quadrature amplitude modulation (QAM) or 64 QAM). Accordingly, the UE needs to acknowledge power offset between the RS and PDSCH for appropriate demodulation of higher order modulation.

(86) As mentioned above, in Rel. 15 NR, an EPRE ratio between unicast (UE-dedicated) transmission using the PDSCH (unicast PDSCH) and the RS (DM-RS or PT-RS) associated with that is defined. However, an EPRE ratio between multicast transmission using the PDSCH (multicast PDSCH) and the RS associated with that is not defined.

(87) Thus, the inventors of the present invention came up with the idea of a method for determining a ratio between energy of the multicast PDSCH and EPRE of the RS associated with the multicast PDSCH.

(88) In the present disclosure, energy, power, energy per unit resource, EPRE, and EPRE per layer per RE may be interchangeably interpreted.

(89) In the present disclosure, a ratio between PDSCH energy and EPRE of an RS associated with a multicast PDSCH, the ratio $\beta_{\text{sub},\text{DM-RS}}$ of PDSCH EPRE to DM-RS energy per resource element (EPRE), and the ratio $\rho_{\text{sub},\text{PTRS}}$ of PT-RS EPRE to PDSCH EPRE per layer per RE for a PT-RS port may be interchangeably interpreted.

(90) In the present disclosure, A/B may be interpreted as A or B, A and B, and at least one of A and B.

(91) (Radio Communication Method)

(92) The UE may receive the multicast PDSCH scheduled with use of a specific type of RNTI (e.g., a G-RNTI). The UE may receive the unicast PDSCH scheduled with use of a type of RNTI other than the specific type of RNTI.

(93) The multicast PDSCH, a PDSCH scheduled with use of the G-RNTI, a PDSCH mapped to an MTCH, a PDSCH to deliver multicast data, a PDSCH associated with a multicast service, and multicast transmission may be interchangeably interpreted. The unicast PDSCH, a PDSCH scheduled with use of an RNTI other than the G-RNTI, a PDSCH mapped to a DTCH, a PDSCH to deliver unicast data, a PDSCH associated with a multicast service, and unicast transmission may be interchangeably interpreted.

(94) The RNTI other than the G-RNTI may include, for example, at least one of a C-RNTI, a CS-RNTI, and an MCS-C-RNTI. The C-RNTI may be unique UE identification information used as an RRC connection identifier and an identifier for scheduling. The CS-RNTI may be unique UE identification information used for semi-persistent scheduling in DL or configured grant in UL. The MCS-C-RNTI may be unique UE identification information used for indication of an alternative MCS table for a PDSCH and PUSCH.

(95) A PDSCH scheduled with use of a RNTI (specific type of an RNTI, the G-RNTI, a type other than the specific type of the RNTI, and the like), a PDSCH scheduled by DCI having CRC

scrambled by the RNTI, a PDSCH scheduled by a PDCCH using DCI having CRC scrambled by the RNTI, a PDSCH scrambled by the RNTI, and a PDSCH associated with the RNTI may be interchangeably interpreted.

(96) The UE may use a value associated with a specific type (e.g., $\beta_{\text{sub.DMRS}}$ or $\rho_{\text{sub.PTRS}}$) as a ratio between EPRE of a PDSCH scheduled with use of the specific type of RNTI and EPRE of an RS associated with the PDSCH.

(97) The RS may be a DM-RS (DL DM-RS). The RS in a case where a PT-RS is supported for the multicast PDSCH may be the PT-RS (DL PT-RS).

(98) Note that in the present disclosure, it is only necessary that the information transferred on the MCCH is information for reception of multicast transmission (e.g., an MTCH). The information for reception of the multicast transmission (MTCH) may be information transferred on at least one of a PDCCH and PDSCH, or may be rephrased as information to be RLC-signaled and so on, and is not always limited to the information transferred on the MCCH.

Embodiment 1

(99) In a cell supporting multicast transmission, a PDSCH EPRE-to-DM-RS EPRE ratio $\beta_{\text{sub.DMRS}}$ [dB] may be determined, for a DL DM-RS associated with a PDSCH scheduled with use of a specific type of RNTI (e.g., a G-RNTI), for a UE by any one of following Embodiments 1-1 to 1-3.

(100) $\beta_{\text{sub.DMRS}}$ associated with the specific type of RNTI may be defined or configured separately from $\beta_{\text{sub.DMRS}}$ associated with a type other than the specific type. $\beta_{\text{sub.DMRS}}$ associated with the specific type of RNTI may be the same as $\beta_{\text{sub.DMRS}}$ associated with a type other than the specific type.

Embodiment 1-1

(101) $\beta_{\text{sub.DMRS}}$ for a multicast PDSCH may be given, from the table (FIG. 6) defined in the specifications, in accordance with the number of DM-RS CDM groups without data.

(102) A value of $\beta_{\text{sub.DMRS}}$ for the multicast PDSCH may be the same as a value of $\beta_{\text{sub.DMRS}}$ for a unicast PDSCH (Rel. 15).

(103) The UE may support a DM-RS configuration including a DM-RS configuration type and the number of DM-RS CDM groups without data. The DM-RS configuration for the multicast PDSCH may reuse part or all of design of $\beta_{\text{sub.DMRS}}$ for the unicast PDSCH (Rel. 15).

Embodiment 1-2

(104) $\beta_{\text{sub.DMRS}}$ may be X [dB].

(105) X may be determined by any one of following Embodiments 1-2-1 and 1-2-2.

Embodiment 1-2-1

(106) X may be a fixed value defined in specifications on the basis of a DM-RS configuration supported for multicast transmission.

(107) For example, when only 1 is supported as the number of DM-RS CDM groups without data for the multicast PDSCH, the UE may assume that X is 0 [dB]. For example, when only DM-RS configuration type 1 is supported and only 1 is supported as the number of DM-RS CDM groups without data for the multicast PDSCH, the UE may assume that X is 0 [dB].

(108) X may be the same as a value supported in the unicast PDSCH (Rel. 15), or may be different from the value.

(109) The same X may be used for different multicast services, or different Xs may be used for the different multicast services. When reliability of the different multicast services is different from each other, different Xs may be used for those multicast services.

Embodiment 1-2-2

(110) X may be a value that can be configured or indicated.

(111) X may be configured or indicated for the UE.

(112) X may be notified to the UE by at least one of a configuration by higher layer signaling and indication by L1 signaling. X may be indicated for the UE in the same manner as an MCCH of

LTE. When X is configured or indicated for the UE, the UE may use notified X for the multicast PDSCH, otherwise the UE may assume that X is 0 [dB].

(113) A plurality of Xs corresponding to the different multicast services respectively may be separately configured for the UE, or may be jointly configured for the UE.

Embodiment 1-3

(114) $\beta_{\text{sub.DMRS}}$ may be given, from a new table defined in specifications, in accordance with the number of DM-RS CDM groups without data. The new table may be a table obtained by adding a value of $\beta_{\text{sub.DMRS}}$ for a multicast PDSCH to a table for a unicast PDSCH (Rel. 15), or may be a table including only the value of $\beta_{\text{sub.DMRS}}$ for the multicast PDSCH.

(115) A value of at least one ratio in the new table may be different from a value of ratio in the table in the unicast PDSCH (Rel. 15).

(116) DM-RS configurations for the multicast PDSCH may be different from DM-RS configurations for the unicast PDSCH (Rel. 15). Some of the DM-RS configurations for the unicast PDSCH (Rel. 15) may be supported for the multicast PDSCH. Only DMRS configuration type 1 may be supported for the multicast PDSCH. A DMRS configuration type (e.g., DMRS configuration type 3) different from DMRS configuration types 1 and 2 may be supported for the multicast PDSCH.

(117) The number of DM-RS CDM groups without data for the multicast PDSCH may be different from the number of DM-RS CDM groups without data for the unicast PDSCH (Rel. 15). Some of the numbers of DM-RS CDM groups without data for the unicast PDSCH (Rel. 15) may be supported for the multicast PDSCH. For example, 1 and 2 as the numbers of the DM-RS CDM groups may be supported for the multicast PDSCH.

(118) For example, as illustrated in FIG. 8, the new table may associate a plurality of $\beta_{\text{sub.DMRS}}$ value candidates with a plurality of combinations of an RNTI type (e.g., which of a G-RNTI or an RNTI other than that the G-RNTI is) used for scheduling of the PDSCH, the number of DM-RS CDM groups without data, and a DM-RS configuration type. The new table may include a value of $\beta_{\text{sub.DMRS}}$ for the unicast PDSCH and a value of $\beta_{\text{sub.DMRS}}$ for the multicast PDSCH (Rel. 15). The type of RNTI may indicate whether the PDSCH is a PDSCH (multicast PDSCH) scheduled with use of the G-RNTI or the PDSCH is a PDSCH (unicast PDSCH) scheduled with use of an RNTI other than the G-RNTI.

(119) For example, as illustrated in FIG. 9, the new table may associate a plurality of $\beta_{\text{sub.DMRS}}$ value candidates with a plurality of values of at least one of the number of DM-RS CDM groups without data and a DM-RS configuration type for the multicast PDSCH. When some of DM-RS configuration types for the unicast PDSCH (Rel. 15) are supported for the multicast PDSCH, only DM-RS configuration type supported for the multicast PDSCH may be indicated. When some of the numbers of DM-RS CDM groups without data for the unicast PDSCH (Rel. 15) are supported for the multicast PDSCH, only the number of DM-RS CDM groups without data supported for the multicast PDSCH may be indicated. In this example, DM-RS configuration type 1 and the numbers 1 and 2 of DM-RS CDM groups without data are used for the PDSCH scheduled with use of the G-RNTI. The new table associates two $\beta_{\text{sub.DMRS}}$ value candidates with the numbers 1 and 2 of the DM-RS CDM groups without data, respectively.

(120) According to Embodiment 1, the PDSCH EPRE-to-DM-RS EPRE ratio $\beta_{\text{sub.DMRS}}$ can be appropriately given to the multicast PDSCH, and thus the UE can appropriately demodulate the multicast PDSCH.

Embodiment 2

(121) In a cell supporting multicast transmission, a UE may assume any one of following Embodiments 2-1 and 2-2 for a PDSCH scheduled with use of a G-RNTI.

Embodiment 2-1

(122) The UE may assume that a PT-RS does not exist. The UE may assume that the PT-RS does not exist in an RB used for the PDSCH scheduled with use of the G-RNTI.

Embodiment 2-2

(123) When existence of the PT-RS is configured for the UE by higher layer signaling (e.g., phaseTrackingRS), the UE may assume that the PT-RS exists. When existence of the PT-RS is configured for the UE by the higher layer signaling, the UE may assume that the PT-RS exists in the RB used for the PDSCH scheduled with use of the G-RNTI.

(124) When existence of the PT-RS is configured for the UE by the higher layer signaling and the UE is scheduled with use of a PT-RS port associated with the PDSCH, any one of the methods for determining the PDSCH EPRE-to-DM-RS EPRE ratio $\beta_{\text{sub.DMRS}}$ of Embodiment 1 may be employed in a method for determining a PT-RS EPRE-to-PDSCH EPRE ratio $\rho_{\text{sub.PTRS}}$ per layer per RE for the PT-RS port.

(125) For example, similarly to Embodiment 1-1, $\rho_{\text{sub.PTRS}}$ for a multicast PDSCH may be given, from the table (FIG. 7) for a unicast PDSCH defined in the specifications, in accordance with epre-Ratio.

(126) For example, similarly to Embodiment 1-2, $\rho_{\text{sub.PTRS}}$ for the multicast PDSCH may be Y. For example, similarly to Embodiment 1-2-1, Y may be a fixed value defined in the specifications. For example, similarly to Embodiment 1-2-2, Y may be a configurable value.

(127) For example, similarly to Embodiment 1-3, $\rho_{\text{sub.PTRS}}$ for the multicast PDSCH may be given, from a new table different from that for the unicast PDSCH (Rel. 15), in accordance with epre-Ratio. The number of PDSCH layers for the multicast PDSCH may be different from the number of PDSCH layers for the unicast PDSCH (Rel. 15). Some of the numbers of PDSCH layers for the unicast PDSCH (Rel. 15) may be supported for the multicast PDSCH. epre-Ratio for the multicast PDSCH may be different from epre-Ratio for the unicast PDSCH (Rel. 15). Some of epre-Ratios for the unicast PDSCH (Rel. 15) may be supported for the multicast PDSCH.

(128) For example, the new table may associate a plurality of $\rho_{\text{sub.PTRS}}$ value candidates with a plurality of combinations of an RNTI type (e.g., which of a G-RNTI or an RNTI other than that the G-RNTI is) used for scheduling of the PDSCH, a value of a higher layer parameter “epre-Ratio”, and the number of the PDSCH layers. The new table may associate the plurality of the $\rho_{\text{sub.PTRS}}$ value candidates with a plurality of values of at least one of the higher layer parameter “epre-Ratio” and the number of the PDSCH layers, for multicast PDSCH, respectively. The new table may include, with respect to at least one of the value of the higher layer parameter “epre-Ratio” and the number of the PDSCH layers, only a value supported for the multicast PDSCH.

(129) According to Embodiment 2, the PT-RS EPRE-to-PDSCH EPRE ratio $\rho_{\text{sub.PTRS}}$ per layer per RE for the PT-RS port can be appropriately given for the multicast PDSCH, and thus the UE can appropriately demodulate the multicast PDSCH.

(130) (Radio Communication System)

(131) Hereinafter, a structure of a radio communication system according to one embodiment of the present disclosure will be described. In this radio communication system, the radio communication method according to each embodiment of the present disclosure described above may be used alone or may be used in combination for communication.

(132) FIG. 10 is a diagram to illustrate an example of a schematic structure of the radio communication system according to one embodiment. The radio communication system 1 may be a system implementing a communication using Long Term Evolution (LTE), 5th generation mobile communication system New Radio (5G NR) and so on the specifications of which have been drafted by Third Generation Partnership Project (3GPP).

(133) The radio communication system 1 may support dual connectivity (multi-RAT dual connectivity (MR-DC)) between a plurality of Radio Access Technologies (RATs). The MR-DC may include dual connectivity (E-UTRA-NR Dual Connectivity (EN-DC)) between LTE (Evolved Universal Terrestrial Radio Access (E-UTRA)) and NR, dual connectivity (NR-E-UTRA Dual Connectivity (NE-DC)) between NR and LTE, and so on.

(134) In EN-DC, a base station (eNB) of LTE (E-UTRA) is a master node (MN), and a base station

(gNB) of NR is a secondary node (SN). In NE-DC, a base station (gNB) of NR is an MN, and a base station (eNB) of LTE (E-UTRA) is an SN.

(135) The radio communication system **1** may support dual connectivity between a plurality of base stations in the same RAT (for example, dual connectivity (NR-NR Dual Connectivity (NN-DC)) where both of an MN and an SN are base stations (gNB) of NR).

(136) The radio communication system **1** may include a base station **11** that forms a macro cell **C1** of a relatively wide coverage, and base stations **12** (**12a** to **12c**) that form small cells **C2**, which are placed within the macro cell **C1** and which are narrower than the macro cell **C1**. The user terminal **20** may be located in at least one cell. The arrangement, the number, and the like of each cell and user terminal **20** are by no means limited to the aspect illustrated in the diagram. Hereinafter, the base stations **11** and **12** will be collectively referred to as “base stations **10**,” unless specified otherwise.

(137) The user terminal **20** may be connected to at least one of the plurality of base stations **10**. The user terminal **20** may use at least one of carrier aggregation (CA) and dual connectivity (DC) using a plurality of component carriers (CCs).

(138) Each CC may be included in at least one of a first frequency band (Frequency Range 1 (FR1)) and a second frequency band (Frequency Range 2 (FR2)). The macro cell **C1** may be included in FR1, and the small cells **C2** may be included in FR2. For example, FR1 may be a frequency band of 6 GHz or less (sub-6 GHz), and FR2 may be a frequency band which is higher than 24 GHz (above-24 GHz). Note that frequency bands, definitions and so on of FR1 and FR2 are by no means limited to these, and for example, FR1 may correspond to a frequency band which is higher than FR2.

(139) The user terminal **20** may communicate using at least one of time division duplex (TDD) and frequency division duplex (FDD) in each CC.

(140) The plurality of base stations **10** may be connected by a wired connection (for example, optical fiber in compliance with the Common Public Radio Interface (CPRI), the X2 interface and so on) or a wireless connection (for example, an NR communication). For example, if an NR communication is used as a backhaul between the base stations **11** and **12**, the base station **11** corresponding to a higher station may be referred to as an “Integrated Access Backhaul (IAB) donor,” and the base station **12** corresponding to a relay station (relay) may be referred to as an “IAB node.”

(141) The base station **10** may be connected to a core network **30** through another base station **10** or directly. For example, the core network **30** may include at least one of Evolved Packet Core (EPC), 5G Core Network (5GCN), Next Generation Core (NGC), and so on.

(142) The user terminal **20** may be a terminal supporting at least one of communication schemes such as LTE, LTE-A, 5G, and so on.

(143) In the radio communication system **1**, an orthogonal frequency division multiplexing (OFDM)-based wireless access scheme may be used. For example, in at least one of the downlink (DL) and the uplink (UL), Cyclic Prefix OFDM (CP-OFDM), Discrete Fourier Transform Spread OFDM (DFT-s-OFDM), Orthogonal Frequency Division Multiple Access (OFDMA), Single Carrier Frequency Division Multiple Access (SC-FDMA), and so on may be used.

(144) The wireless access scheme may be referred to as a “waveform.” Note that, in the radio communication system **1**, another wireless access scheme (for example, another single carrier transmission scheme, another multi-carrier transmission scheme) may be used for a wireless access scheme in the UL and the DL.

(145) In the radio communication system **1**, a downlink shared channel (Physical Downlink Shared Channel (PDSCH)), which is used by each user terminal **20** on a shared basis, a broadcast channel (Physical Broadcast Channel (PBCH)), a downlink control channel (Physical Downlink Control Channel (PDCCH)) and so on, may be used as downlink channels.

(146) In the radio communication system **1**, an uplink shared channel (Physical Uplink Shared

Channel (PUSCH)), which is used by each user terminal **20** on a shared basis, an uplink control channel (Physical Uplink Control Channel (PUCCH)), a random access channel (Physical Random Access Channel (PRACH)) and so on may be used as uplink channels.

(147) User data, higher layer control information, System Information Blocks (SIBs) and so on are communicated on the PDSCH. User data, higher layer control information and so on may be communicated on the PUSCH. The Master Information Blocks (MIBs) may be communicated on the PBCH.

(148) Lower layer control information may be communicated on the PDCCH. For example, the lower layer control information may include downlink control information (DCI) including scheduling information of at least one of the PDSCH and the PUSCH.

(149) Note that DCI for scheduling the PDSCH may be referred to as “DL assignment,” “DL DCI,” and so on, and DCI for scheduling the PUSCH may be referred to as “UL grant,” “UL DCI,” and so on. Note that the PDSCH may be interpreted as “DL data”, and the PUSCH may be interpreted as “UL data”.

(150) For detection of the PDCCH, a control resource set (CORESET) and a search space may be used. The CORESET corresponds to a resource to search DCI. The search space corresponds to a search area and a search method of PDCCH candidates. One CORESET may be associated with one or more search spaces. The UE may monitor a CORESET associated with a certain search space, based on search space configuration.

(151) One search space may correspond to a PDCCH candidate corresponding to one or more aggregation levels. One or more search spaces may be referred to as a “search space set.” Note that a “search space,” a “search space set,” a “search space configuration,” a “search space set configuration,” a “CORESET,” a “CORESET configuration” and so on of the present disclosure may be interchangeably interpreted.

(152) Uplink control information (UCI) including at least one of channel state information (CSI), transmission confirmation information (for example, which may be also referred to as Hybrid Automatic Repeat reQuest ACKnowledgement (HARQ-ACK), ACK/NACK, and so on), and scheduling request (SR) may be communicated by means of the PUCCH. By means of the PRACH, random access preambles for establishing connections with cells may be communicated.

(153) Note that the downlink, the uplink, and so on in the present disclosure may be expressed without a term of “link.” In addition, various channels may be expressed without adding “Physical” to the head.

(154) In the radio communication system **1**, a synchronization signal (SS), a downlink reference signal (DL-RS), and so on may be communicated. In the radio communication system **1**, a cell-specific reference signal (CRS), a channel state information-reference signal (CSI-RS), a demodulation reference signal (DMRS), a positioning reference signal (PRS), a phase tracking reference signal (PTRS), and so on may be communicated as the DL-RS.

(155) For example, the synchronization signal may be at least one of a primary synchronization signal (PSS) and a secondary synchronization signal (SSS). A signal block including an SS (PSS, SSS) and a PBCH (and a DMRS for a PBCH) may be referred to as an “SS/PBCH block,” an “SS Block (SSB),” and so on. Note that an SS, an SSB, and so on may be also referred to as a “reference signal.”

(156) In the radio communication system **1**, a sounding reference signal (SRS), a demodulation reference signal (DMRS), and so on may be communicated as an uplink reference signal (UL-RS). Note that DMRS may be referred to as a “user terminal specific reference signal (UE-specific Reference Signal).”

(157) (Base Station)

(158) FIG. **11** is a diagram to illustrate an example of a structure of the base station according to one embodiment. The base station **10** includes a control section **110**, a transmitting/receiving section **120**, transmitting/receiving antennas **130** and a communication path interface (transmission

line interface) **140**. Note that the base station **10** may include one or more control sections **110**, one or more transmitting/receiving sections **120**, one or more transmitting/receiving antennas **130**, and one or more communication path interfaces **140**.

(159) Note that, the present example primarily illustrates functional blocks that pertain to characteristic parts of the present embodiment, and it is assumed that the base station **10** may include other functional blocks that are necessary for radio communication as well. Part of the processes of each section described below may be omitted.

(160) The control section **110** controls the whole of the base station **10**. The control section **110** can be constituted with a controller, a control circuit, or the like described based on general understanding of the technical field to which the present disclosure pertains.

(161) The control section **110** may control generation of signals, scheduling (for example, resource allocation, mapping), and so on. The control section **110** may control transmission and reception, measurement and so on using the transmitting/receiving section **120**, the transmitting/receiving antennas **130**, and the communication path interface **140**. The control section **110** may generate data, control information, a sequence and so on to transmit as a signal, and forward the generated items to the transmitting/receiving section **120**. The control section **110** may perform call processing (setting up, releasing) for communication channels, manage the state of the base station **10**, and manage the radio resources.

(162) The transmitting/receiving section **120** may include a baseband section **121**, a Radio Frequency (RF) section **122**, and a measurement section **123**. The baseband section **121** may include a transmission processing section **1211** and a reception processing section **1212**. The transmitting/receiving section **120** can be constituted with a transmitter/receiver, an RF circuit, a baseband circuit, a filter, a phase shifter, a measurement circuit, a transmitting/receiving circuit, or the like described based on general understanding of the technical field to which the present disclosure pertains.

(163) The transmitting/receiving section **120** may be structured as a transmitting/receiving section in one entity, or may be constituted with a transmitting section and a receiving section. The transmitting section may be constituted with the transmission processing section **1211**, and the RF section **122**. The receiving section may be constituted with the reception processing section **1212**, the RF section **122**, and the measurement section **123**.

(164) The transmitting/receiving antennas **130** can be constituted with antennas, for example, an array antenna, or the like described based on general understanding of the technical field to which the present disclosure pertains.

(165) The transmitting/receiving section **120** may transmit the above-described downlink channel, synchronization signal, downlink reference signal, and so on. The transmitting/receiving section **120** may receive the above-described uplink channel, uplink reference signal, and so on.

(166) The transmitting/receiving section **120** may form at least one of a transmit beam and a receive beam by using digital beam forming (for example, precoding), analog beam forming (for example, phase rotation), and so on.

(167) The transmitting/receiving section **120** (transmission processing section **1211**) may perform the processing of the Packet Data Convergence Protocol (PDCP) layer, the processing of the Radio Link Control (RLC) layer (for example, RLC retransmission control), the processing of the Medium Access Control (MAC) layer (for example, HARQ retransmission control), and so on, for example, on data and control information and so on acquired from the control section **110**, and may generate bit string to transmit.

(168) The transmitting/receiving section **120** (transmission processing section **1211**) may perform transmission processing such as channel coding (which may include error correction coding), modulation, mapping, filtering, discrete Fourier transform (DFT) processing (as necessary), inverse fast Fourier transform (IFFT) processing, precoding, digital-to-analog conversion, and so on, on the bit string to transmit, and output a baseband signal.

(169) The transmitting/receiving section **120** (RF section **122**) may perform modulation to a radio frequency band, filtering, amplification, and so on, on the baseband signal, and transmit the signal of the radio frequency band through the transmitting/receiving antennas **130**.

(170) On the other hand, the transmitting/receiving section **120** (RF section **122**) may perform amplification, filtering, demodulation to a baseband signal, and so on, on the signal of the radio frequency band received by the transmitting/receiving antennas **130**.

(171) The transmitting/receiving section **120** (reception processing section **1212**) may apply reception processing such as analog-digital conversion, fast Fourier transform (FFT) processing, inverse discrete Fourier transform (IDFT) processing (as necessary), filtering, de-mapping, demodulation, decoding (which may include error correction decoding), MAC layer processing, the processing of the RLC layer and the processing of the PDCP layer, and so on, on the acquired baseband signal, and acquire user data, and so on.

(172) The transmitting/receiving section **120** (measurement section **123**) may perform the measurement related to the received signal. For example, the measurement section **123** may perform Radio Resource Management (RRM) measurement, Channel State Information (CSI) measurement, and so on, based on the received signal. The measurement section **123** may measure a received power (for example, Reference Signal Received Power (RSRP)), a received quality (for example, Reference Signal Received Quality (RSRQ)), a Signal to Interference plus Noise Ratio (SINR), a Signal to Noise Ratio (SNR)), a signal strength (for example, Received Signal Strength Indicator (RSSI)), channel information (for example, CSI), and so on. The measurement results may be output to the control section **110**.

(173) The communication path interface **140** may perform transmission/reception (backhaul signaling) of a signal with an apparatus included in the core network **30** or other base stations **10**, and so on, and acquire or transmit user data (user plane data), control plane data, and so on for the user terminal **20**.

(174) Note that the transmitting section and the receiving section of the base station **10** in the present disclosure may be constituted with at least one of the transmitting/receiving section **120**, the transmitting/receiving antennas **130**, and the communication path interface **140**.

(175) Note that the transmitting/receiving section **120** may transmit a reference signal (e.g., an SSB, a CSI-RS, or the like). The transmitting/receiving section **120** may transmit information (MAC CE or DCI) to indicate a TCI state for specific DL transmission. The TCI state may indicate at least one of a reference signal (e.g., an SSB, a CSI-RS, or the like), a QCL type, and a cell to transmit the reference signal. The TCI state may indicate one or more reference signals. The one or more reference signals may include a QCL type A reference signal, or may include a QCL type D reference signal.

(176) The control section **110** may assume that a first reference signal for a spatial relationship of specific uplink transmission (e.g., an SRS, a PUCCH, a PUSCH, or the like) is in a transmission control indication (TCI) state for a specific downlink channel (e.g., a PDCCH, a PDSCH, or the like) or a QCL type D second reference signal (e.g., an SSB, a CSI-RS, or the like) in a quasi-co-location (QCL) assumption.

(177) (User Terminal)

(178) FIG. **12** is a diagram to illustrate an example of a structure of the user terminal according to one embodiment. The user terminal **20** includes a control section **210**, a transmitting/receiving section **220**, and transmitting/receiving antennas **230**. Note that the user terminal **20** may include one or more control sections **210**, one or more transmitting/receiving sections **220**, and one or more transmitting/receiving antennas **230**.

(179) Note that, the present example primarily illustrates functional blocks that pertain to characteristic parts of the present embodiment, and it is assumed that the user terminal **20** may include other functional blocks that are necessary for radio communication as well. Part of the processes of each section described below may be omitted.

(180) The control section **210** controls the whole of the user terminal **20**. The control section **210** can be constituted with a controller, a control circuit, or the like described based on general understanding of the technical field to which the present disclosure pertains.

(181) The control section **210** may control generation of signals, mapping, and so on. The control section **210** may control transmission/reception, measurement and so on using the transmitting/receiving section **220**, and the transmitting/receiving antennas **230**. The control section **210** generates data, control information, a sequence and so on to transmit as a signal, and may forward the generated items to the transmitting/receiving section **220**.

(182) The transmitting/receiving section **220** may include a baseband section **221**, an RF section **222**, and a measurement section **223**. The baseband section **221** may include a transmission processing section **2211** and a reception processing section **2212**. The transmitting/receiving section **220** can be constituted with a transmitter/receiver, an RF circuit, a baseband circuit, a filter, a phase shifter, a measurement circuit, a transmitting/receiving circuit, or the like described based on general understanding of the technical field to which the present disclosure pertains.

(183) The transmitting/receiving section **220** may be structured as a transmitting/receiving section in one entity, or may be constituted with a transmitting section and a receiving section. The transmitting section may be constituted with the transmission processing section **2211**, and the RF section **222**. The receiving section may be constituted with the reception processing section **2212**, the RF section **222**, and the measurement section **223**.

(184) The transmitting/receiving antennas **230** can be constituted with antennas, for example, an array antenna, or the like described based on general understanding of the technical field to which the present disclosure pertains.

(185) The transmitting/receiving section **220** may receive the above-described downlink channel, synchronization signal, downlink reference signal, and so on. The transmitting/receiving section **220** may transmit the above-described uplink channel, uplink reference signal, and so on.

(186) The transmitting/receiving section **220** may form at least one of a transmit beam and a receive beam by using digital beam forming (for example, precoding), analog beam forming (for example, phase rotation), and so on.

(187) The transmitting/receiving section **220** (transmission processing section **2211**) may perform the processing of the PDCP layer, the processing of the RLC layer (for example, RLC retransmission control), the processing of the MAC layer (for example, HARQ retransmission control), and so on, for example, on data and control information and so on acquired from the control section **210**, and may generate bit string to transmit.

(188) The transmitting/receiving section **220** (transmission processing section **2211**) may perform transmission processing such as channel coding (which may include error correction coding), modulation, mapping, filtering, DFT processing (as necessary), IFFT processing, precoding, digital-to-analog conversion, and so on, on the bit string to transmit, and output a baseband signal.

(189) Note that, whether to apply DFT processing or not may be based on the configuration of the transform precoding. The transmitting/receiving section **220** (transmission processing section **2211**) may perform, for a channel (for example, PUSCH), the DFT processing as the above-described transmission processing to transmit the channel by using a DFT-s-OFDM waveform if transform precoding is enabled, and otherwise, does not need to perform the DFT processing as the above-described transmission process.

(190) The transmitting/receiving section **220** (RF section **222**) may perform modulation to a radio frequency band, filtering, amplification, and so on, on the baseband signal, and transmit the signal of the radio frequency band through the transmitting/receiving antennas **230**.

(191) On the other hand, the transmitting/receiving section **220** (RF section **222**) may perform amplification, filtering, demodulation to a baseband signal, and so on, on the signal of the radio frequency band received by the transmitting/receiving antennas **230**.

(192) The transmitting/receiving section **220** (reception processing section **2212**) may apply a

receiving process such as analog-digital conversion, FFT processing, IDFT processing (as necessary), filtering, de-mapping, demodulation, decoding (which may include error correction decoding), MAC layer processing, the processing of the RLC layer and the processing of the PDCP layer, and so on, on the acquired baseband signal, and acquire user data, and so on.

(193) The transmitting/receiving section **220** (measurement section **223**) may perform the measurement related to the received signal. For example, the measurement section **223** may perform RRM measurement, CSI measurement, and so on, based on the received signal. The measurement section **223** may measure a received power (for example, RSRP), a received quality (for example, RSRQ, SINR, SNR), a signal strength (for example, RSSI), channel information (for example, CSI), and so on. The measurement results may be output to the control section **210**.

(194) Note that the transmitting section and the receiving section of the user terminal **20** in the present disclosure may be constituted with at least one of the transmitting/receiving section **220** and the transmitting/receiving antennas **230**.

(195) The transmitting/receiving section **220** may receive a physical downlink shared channel (PDSCH or multicast data) scheduled with use of a specific type of radio network temporary identifier (RNTI) (e.g., a G-RNTI). The control section **210** may use a value (e.g., a value defined in a table) associated with the specific type as a ratio (e.g., ratio of PDSCH EPRE to DM-RS EPRE $\beta_{\text{sub.DMRS}}$, ratio of PT-RS EPRE to PDSCH EPRE per layer per RE $\rho_{\text{sub.PTRS}}$, or the like) between power (EPRE) of the PDSCH per resource element and EPRE of a reference signal (e.g., a DM-RS or a PT-RS) associated with the PDSCH.

(196) The value may be defined or configured separately from a value (e.g., $\beta_{\text{sub.DMRS}}$ or $\rho_{\text{sub.PTRS}}$ for unicast or Rel. 15) associated with a type (e.g., a C-RNTI, an MCS-C-RNTI, a CS-RNTI, or the like) other than the specific type (Embodiment 1).

(197) The reference signal may be a demodulation reference signal (DM-RS). Candidates for the value may be associated with a type of RNTI (e.g., which of a G-RNTI or an RNTI other than that the RNTI is) used for scheduling of the PDSCH, the number of DM-RS code division multiplexing (CDM) groups without data, and a DM-RS configuration type (Embodiment 1-3).

(198) The reference signal may be a phase-tracking reference signal (PT-RS). Existence of the PT-RS may be configured for the control section **210** by higher layer signaling (e.g., phaseTrackingRS) (Embodiment 2-2).

(199) Candidates for the value may be associated with a type of RNTI (e.g., which of a G-RNTI or an RNTI other than that the RNTI is) used for scheduling of the PDSCH, a higher layer parameter, and the number of PDSCH layers (Embodiment 2-2).

(200) (Hardware Structure)

(201) Note that the block diagrams that have been used to describe the above embodiments illustrate blocks in functional units. These functional blocks (components) may be implemented in arbitrary combinations of at least one of hardware and software. Also, the method for implementing each functional block is not particularly limited. That is, each functional block may be realized by one piece of apparatus that is physically or logically coupled, or may be realized by directly or indirectly connecting two or more physically or logically separate pieces of apparatus (for example, via wire, wireless, or the like) and using these plurality of pieces of apparatus. The functional blocks may be implemented by combining softwares into the apparatus described above or the plurality of apparatuses described above.

(202) Here, functions include judgment, determination, decision, calculation, computation, processing, derivation, investigation, search, confirmation, reception, transmission, output, access, resolution, selection, designation, establishment, comparison, assumption, expectation, considering, broadcasting, notifying, communicating, forwarding, configuring, reconfiguring, allocating (mapping), assigning, and the like, but function are by no means limited to these. For example, functional block (components) to implement a function of transmission may be referred to as a “transmitting section (transmitting unit),” a “transmitter,” and the like. The method for

implementing each component is not particularly limited as described above.

(203) For example, a base station, a user terminal, and so on according to one embodiment of the present disclosure may function as a computer that executes the processes of the radio communication method of the present disclosure. FIG. 13 is a diagram to illustrate an example of a hardware structure of the base station and the user terminal according to one embodiment. Physically, the above-described base station 10 and user terminal 20 may each be formed as a computer apparatus that includes a processor 1001, a memory 1002, a storage 1003, a communication apparatus 1004, an input apparatus 1005, an output apparatus 1006, a bus 1007, and so on.

(204) Note that in the present disclosure, the words such as an apparatus, a circuit, a device, a section, a unit, and so on can be interchangeably interpreted. The hardware structure of the base station 10 and the user terminal 20 may be configured to include one or more of apparatuses illustrated in the drawings, or may be configured not to include part of apparatuses.

(205) For example, although only one processor 1001 is illustrated, a plurality of processors may be provided. Furthermore, processes may be implemented with one processor or may be implemented at the same time, in sequence, or in different manners with two or more processors. Note that the processor 1001 may be implemented with one or more chips.

(206) Each function of the base station 10 and the user terminals 20 is implemented, for example, by allowing certain software (programs) to be read on hardware such as the processor 1001 and the memory 1002, and by allowing the processor 1001 to perform calculations to control communication via the communication apparatus 1004 and control at least one of reading and writing of data in the memory 1002 and the storage 1003.

(207) The processor 1001 controls the whole computer by, for example, running an operating system. The processor 1001 may be configured with a central processing unit (CPU), which includes interfaces with peripheral apparatus, control apparatus, computing apparatus, a register, and so on. For example, at least part of the above-described control section 110 (210), the transmitting/receiving section 120 (220), and so on may be implemented by the processor 1001.

(208) Furthermore, the processor 1001 reads programs (program codes), software modules, data, and so on from at least one of the storage 1003 and the communication apparatus 1004, into the memory 1002, and executes various processes according to these. As for the programs, programs to allow computers to execute at least part of the operations of the above-described embodiments are used. For example, the control section 110 (210) may be implemented by control programs that are stored in the memory 1002 and that operate on the processor 1001, and other functional blocks may be implemented likewise.

(209) The memory 1002 is a computer-readable recording medium, and may be constituted with, for example, at least one of a Read Only Memory (ROM), an Erasable Programmable ROM (EPROM), an Electrically EPROM (EEPROM), a Random Access Memory (RAM), and other appropriate storage media. The memory 1002 may be referred to as a “register,” a “cache,” a “main memory (primary storage apparatus)” and so on. The memory 1002 can store executable programs (program codes), software modules, and the like for implementing the radio communication method according to one embodiment of the present disclosure.

(210) The storage 1003 is a computer-readable recording medium, and may be constituted with, for example, at least one of a flexible disk, a floppy (registered trademark) disk, a magneto-optical disk (for example, a compact disc (Compact Disc ROM (CD-ROM) and so on), a digital versatile disc, a Blu-ray (registered trademark) disk), a removable disk, a hard disk drive, a smart card, a flash memory device (for example, a card, a stick, and a key drive), a magnetic stripe, a database, a server, and other appropriate storage media. The storage 1003 may be referred to as “secondary storage apparatus.”

(211) The communication apparatus 1004 is hardware (transmitting/receiving device) for allowing inter-computer communication via at least one of wired and wireless networks, and may be referred

to as, for example, a “network device,” a “network controller,” a “network card,” a “communication module,” and so on. The communication apparatus **1004** may be configured to include a high frequency switch, a duplexer, a filter, a frequency synthesizer, and so on in order to realize, for example, at least one of frequency division duplex (FDD) and time division duplex (TDD). For example, the above-described transmitting/receiving section **120** (**220**), the transmitting/receiving antennas **130** (**230**), and so on may be implemented by the communication apparatus **1004**. In the transmitting/receiving section **120** (**220**), the transmitting section **120a** (**220a**) and the receiving section **120b** (**220b**) can be implemented while being separated physically or logically.

(212) The input apparatus **1005** is an input device that receives input from the outside (for example, a keyboard, a mouse, a microphone, a switch, a button, a sensor, and so on). The output apparatus **1006** is an output device that allows sending output to the outside (for example, a display, a speaker, a Light Emitting Diode (LED) lamp, and so on). Note that the input apparatus **1005** and the output apparatus **1006** may be provided in an integrated structure (for example, a touch panel).

(213) Furthermore, these types of apparatus, including the processor **1001**, the memory **1002**, and others, are connected by a bus **1007** for communicating information. The bus **1007** may be formed with a single bus, or may be formed with buses that vary between pieces of apparatus.

(214) Also, the base station **10** and the user terminals **20** may be structured to include hardware such as a microprocessor, a digital signal processor (DSP), an Application Specific Integrated Circuit (ASIC), a Programmable Logic Device (PLD), a Field Programmable Gate Array (FPGA), and so on, and part or all of the functional blocks may be implemented by the hardware. For example, the processor **1001** may be implemented with at least one of these pieces of hardware.

(215) (Variations)

(216) Note that the terminology described in the present disclosure and the terminology that is needed to understand the present disclosure may be replaced by other terms that convey the same or similar meanings. For example, a “channel,” a “symbol,” and a “signal” (or signaling) may be interchangeably interpreted. Also, “signals” may be “messages.” A reference signal may be abbreviated as an “RS,” and may be referred to as a “pilot,” a “pilot signal,” and so on, depending on which standard applies. Furthermore, a “component carrier (CC)” may be referred to as a “cell,” a “frequency carrier,” a “carrier frequency” and so on.

(217) A radio frame may be constituted of one or a plurality of periods (frames) in the time domain. Each of one or a plurality of periods (frames) constituting a radio frame may be referred to as a “subframe.” Furthermore, a subframe may be constituted of one or a plurality of slots in the time domain. A subframe may be a fixed time length (for example, 1 ms) independent of numerology.

(218) Here, numerology may be a communication parameter applied to at least one of transmission and reception of a signal or a channel. For example, numerology may indicate at least one of a subcarrier spacing (SCS), a bandwidth, a symbol length, a cyclic prefix length, a transmission time interval (TTI), the number of symbols per TTI, a radio frame structure, a particular filter processing performed by a transceiver in the frequency domain, a particular windowing processing performed by a transceiver in the time domain, and so on.

(219) A slot may be constituted of one or a plurality of symbols in the time domain (Orthogonal Frequency Division Multiplexing (OFDM) symbols, Single Carrier Frequency Division Multiple Access (SC-FDMA) symbols, and so on). Furthermore, a slot may be a time unit based on numerology.

(220) A slot may include a plurality of mini-slots. Each mini-slot may be constituted of one or a plurality of symbols in the time domain. A mini-slot may be referred to as a “sub-slot.” A mini-slot may be constituted of symbols less than the number of slots. A PDSCH (or PUSCH) transmitted in a time unit larger than a mini-slot may be referred to as “PDSCH (PUSCH) mapping type A.” A PDSCH (or PUSCH) transmitted using a mini-slot may be referred to as “PDSCH (PUSCH) mapping type B.”

(221) A radio frame, a subframe, a slot, a mini-slot, and a symbol all express time units in signal communication. A radio frame, a subframe, a slot, a mini-slot, and a symbol may each be called by other applicable terms. Note that time units such as a frame, a subframe, a slot, mini-slot, and a symbol in the present disclosure may be interchangeably interpreted.

(222) For example, one subframe may be referred to as a “TTI,” a plurality of consecutive subframes may be referred to as a “TTI,” or one slot or one mini-slot may be referred to as a “TTI.” That is, at least one of a subframe and a TTI may be a subframe (1 ms) in existing LTE, may be a shorter period than 1 ms (for example, 1 to 13 symbols), or may be a longer period than 1 ms. Note that a unit expressing TTI may be referred to as a “slot,” a “mini-slot,” and so on instead of a “subframe.”

(223) Here, a TTI refers to the minimum time unit of scheduling in radio communication, for example. For example, in LTE systems, a base station schedules the allocation of radio resources (such as a frequency bandwidth and transmit power that are available for each user terminal) for the user terminal in TTI units. Note that the definition of TTIs is not limited to this.

(224) TTIs may be transmission time units for channel-encoded data packets (transport blocks), code blocks, or codewords, or may be the unit of processing in scheduling, link adaptation, and so on. Note that, when TTIs are given, the time interval (for example, the number of symbols) to which transport blocks, code blocks, codewords, or the like are actually mapped may be shorter than the TTIs.

(225) Note that, in the case where one slot or one mini-slot is referred to as a TTI, one or more TTIs (that is, one or more slots or one or more mini-slots) may be the minimum time unit of scheduling. Furthermore, the number of slots (the number of mini-slots) constituting the minimum time unit of the scheduling may be controlled.

(226) A TTI having a time length of 1 ms may be referred to as a “normal TTI” (TTI in 3GPP Rel. 8 to Rel. 12), a “long TTI,” a “normal subframe,” a “long subframe,” a “slot” and so on. A TTI that is shorter than a normal TTI may be referred to as a “shortened TTI,” a “short TTI,” a “partial or fractional TTI,” a “shortened subframe,” a “short subframe,” a “mini-slot,” a “sub-slot,” a “slot” and so on.

(227) Note that a long TTI (for example, a normal TTI, a subframe, and so on) may be interpreted as a TTI having a time length exceeding 1 ms, and a short TTI (for example, a shortened TTI and so on) may be interpreted as a TTI having a TTI length shorter than the TTI length of a long TTI and equal to or longer than 1 ms.

(228) A resource block (RB) is the unit of resource allocation in the time domain and the frequency domain, and may include one or a plurality of consecutive subcarriers in the frequency domain. The number of subcarriers included in an RB may be the same regardless of numerology, and, for example, may be 12. The number of subcarriers included in an RB may be determined based on numerology.

(229) Also, an RB may include one or a plurality of symbols in the time domain, and may be one slot, one mini-slot, one subframe, or one TTI in length. One TTI, one subframe, and so on each may be constituted of one or a plurality of resource blocks.

(230) Note that one or a plurality of RBs may be referred to as a “physical resource block (Physical RB (PRB)),” a “sub-carrier group (SCG),” a “resource element group (REG),” a “PRB pair,” an “RB pair” and so on.

(231) Furthermore, a resource block may be constituted of one or a plurality of resource elements (REs). For example, one RE may correspond to a radio resource field of one subcarrier and one symbol.

(232) A bandwidth part (BWP) (which may be referred to as a “fractional bandwidth,” and so on) may represent a subset of contiguous common resource blocks (common RBs) for numerology in a carrier. Here, a common RB may be specified by an index of the RB based on the common reference point of the carrier. A PRB may be defined by a BWP and may be numbered in the BWP.

(233) The BWP may include a UL BWP (BWP for the UL) and a DL BWP (BWP for the DL). One or a plurality of BWPs may be configured in one carrier for a UE.

(234) At least one of configured BWPs may be active, and a UE does not need to assume to transmit/receive a given signal/channel outside active BWPs. Note that a “cell,” a “carrier,” and so on in the present disclosure may be interpreted as a “BWP”.

(235) Note that the above-described structures of radio frames, subframes, slots, mini-slots, symbols, and so on are merely examples. For example, structures such as the number of subframes included in a radio frame, the number of slots per subframe or radio frame, the number of mini-slots included in a slot, the numbers of symbols and RBs included in a slot or a mini-slot, the number of subcarriers included in an RB, the number of symbols in a TTI, the symbol length, the cyclic prefix (CP) length, and so on can be variously changed.

(236) Also, the information, parameters, and so on described in the present disclosure may be represented in absolute values or in relative values with respect to given values, or may be represented in another corresponding information. For example, radio resources may be specified by given indices.

(237) The names used for parameters and so on in the present disclosure are in no respect limiting. Furthermore, mathematical expressions that use these parameters, and so on may be different from those expressly disclosed in the present disclosure. For example, since various channels (PUCCH, PDCCH, and so on) and information elements can be identified by any suitable names, the various names allocated to these various channels and information elements are in no respect limiting.

(238) The information, signals, and so on described in the present disclosure may be represented by using any of a variety of different technologies. For example, data, instructions, commands, information, signals, bits, symbols, chips, and so on, all of which may be referenced throughout the herein-contained description, may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or photons, or any combination of these.

(239) Also, information, signals, and so on can be output in at least one of from higher layers to lower layers and from lower layers to higher layers. Information, signals, and so on may be input and/or output via a plurality of network nodes.

(240) The information, signals, and so on that are input and/or output may be stored in a specific location (for example, a memory) or may be managed by using a management table. The information, signals, and so on to be input and/or output can be overwritten, updated, or appended. The information, signals, and so on that are output may be deleted. The information, signals, and so on that are input may be transmitted to another apparatus.

(241) Reporting of information is by no means limited to the aspects/embodiments described in the present disclosure, and other methods may be used as well. For example, reporting of information in the present disclosure may be implemented by using physical layer signaling (for example, downlink control information (DCI), uplink control information (UCI), higher layer signaling (for example, Radio Resource Control (RRC) signaling, broadcast information (master information block (MIB), system information blocks (SIBs), and so on), Medium Access Control (MAC) signaling and so on), and other signals or combinations of these.

(242) Note that physical layer signaling may be referred to as “Layer 1/Layer 2 (L1/L2) control information (L1/L2 control signals),” “L1 control information (L1 control signal),” and so on. Also, RRC signaling may be referred to as an “RRC message,” and can be, for example, an RRC connection setup message, an RRC connection reconfiguration message, and so on. Also, MAC signaling may be reported using, for example, MAC control elements (MAC CEs).

(243) Also, reporting of given information (for example, reporting of “X holds”) does not necessarily have to be reported explicitly, and can be reported implicitly (by, for example, not reporting this given information or reporting another piece of information).

(244) Determinations may be made in values represented by one bit (0 or 1), may be made in Boolean values that represent true or false, or may be made by comparing numerical values (for

example, comparison against a given value).

(245) Software, whether referred to as “software,” “firmware,” “middleware,” “microcode,” or “hardware description language,” or called by other terms, should be interpreted broadly to mean instructions, instruction sets, code, code segments, program codes, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executable files, execution threads, procedures, functions, and so on.

(246) Also, software, commands, information, and so on may be transmitted and received via communication media. For example, when software is transmitted from a website, a server, or other remote sources by using at least one of wired technologies (coaxial cables, optical fiber cables, twisted-pair cables, digital subscriber lines (DSL), and so on) and wireless technologies (infrared radiation, microwaves, and so on), at least one of these wired technologies and wireless technologies are also included in the definition of communication media.

(247) The terms “system” and “network” used in the present disclosure can be used interchangeably. The “network” may mean an apparatus (for example, a base station) included in the network.

(248) In the present disclosure, the terms such as “precoding,” a “precoder,” a “weight (precoding weight),” “quasi-co-location (QCL),” a “Transmission Configuration Indication state (TCI state),” a “spatial relation,” a “spatial domain filter,” a “transmit power,” “phase rotation,” an “antenna port,” an “antenna port group,” a “layer,” “the number of layers,” a “rank,” a “resource,” a “resource set,” a “resource group,” a “beam,” a “beam width,” a “beam angular degree,” an “antenna,” an “antenna element,” a “panel,” and so on can be used interchangeably.

(249) In the present disclosure, the terms such as a “base station (BS),” a “radio base station,” a “fixed station,” a “NodeB,” an “eNB (eNodeB),” a “gNB (gNodeB),” an “access point,” a “transmission point (TP),” a “reception point (RP),” a “transmission/reception point (TRP),” a “panel,” a “cell,” a “sector,” a “cell group,” a “carrier,” a “component carrier,” and so on can be used interchangeably. The base station may be referred to as the terms such as a “macro cell,” a small cell,” a “femto cell,” a “pico cell,” and so on.

(250) A base station can accommodate one or a plurality of (for example, three) cells. When a base station accommodates a plurality of cells, the entire coverage area of the base station can be partitioned into multiple smaller areas, and each smaller area can provide communication services through base station subsystems (for example, indoor small base stations (Remote Radio Heads (RRHs))). The term “cell” or “sector” refers to part of or the entire coverage area of at least one of a base station and a base station subsystem that provides communication services within this coverage.

(251) In the present disclosure, the terms “mobile station (MS),” “user terminal,” “user equipment (UE),” and “terminal” may be used interchangeably.

(252) A mobile station may be referred to as a “subscriber station,” “mobile unit,” “subscriber unit,” “wireless unit,” “remote unit,” “mobile device,” “wireless device,” “wireless communication device,” “remote device,” “mobile subscriber station,” “access terminal,” “mobile terminal,” “wireless terminal,” “remote terminal,” “handset,” “user agent,” “mobile client,” “client,” or some other appropriate terms in some cases.

(253) At least one of a base station and a mobile station may be referred to as a “transmitting apparatus,” a “receiving apparatus,” a “radio communication apparatus,” and so on. Note that at least one of a base station and a mobile station may be device mounted on a moving object or a moving object itself, and so on. The moving object may be a vehicle (for example, a car, an airplane, and the like), may be a moving object which moves unmanned (for example, a drone, an automatic operation car, and the like), or may be a robot (a manned type or unmanned type). Note that at least one of a base station and a mobile station also includes an apparatus which does not necessarily move during communication operation. For example, at least one of a base station and a mobile station may be an Internet of Things (IoT) device such as a sensor, and the like.

(254) Furthermore, the base station in the present disclosure may be interpreted as a user terminal. For example, each aspect/embodiment of the present disclosure may be applied to the structure that replaces a communication between a base station and a user terminal with a communication between a plurality of user terminals (for example, which may be referred to as “Device-to-Device (D2D),” “Vehicle-to-Everything (V2X),” and the like). In this case, user terminals **20** may have the functions of the base stations **10** described above. The words “uplink” and “downlink” may be interpreted as the words corresponding to the terminal-to-terminal communication (for example, “side”). For example, an uplink channel, a downlink channel and so on may be interpreted as a side channel.

(255) Likewise, the user terminal in the present disclosure may be interpreted as base station. In this case, the base station **10** may have the functions of the user terminal **20** described above.

(256) Actions which have been described in the present disclosure to be performed by a base station may, in some cases, be performed by upper nodes. In a network including one or a plurality of network nodes with base stations, it is clear that various operations that are performed to communicate with terminals can be performed by base stations, one or more network nodes (for example, Mobility Management Entities (MMEs), Serving-Gateways (S-GWs), and so on may be possible, but these are not limiting) other than base stations, or combinations of these.

(257) The aspects/embodiments illustrated in the present disclosure may be used individually or in combinations, which may be switched depending on the mode of implementation. The order of processes, sequences, flowcharts, and so on that have been used to describe the aspects/embodiments in the present disclosure may be re-ordered as long as inconsistencies do not arise. For example, although various methods have been illustrated in the present disclosure with various components of steps in exemplary orders, the specific orders that are illustrated herein are by no means limiting.

(258) The aspects/embodiments illustrated in the present disclosure may be applied to Long Term Evolution (LTE), LTE-Advanced (LTE-A), LTE-Beyond (LTE-B), SUPER 3G, IMT-Advanced, 4th generation mobile communication system (4G), 5th generation mobile communication system (5G), Future Radio Access (FRA), New-Radio Access Technology (RAT), New Radio (NR), New radio access (NX), Future generation radio access (FX), Global System for Mobile communications (GSM (registered trademark)), CDMA 2000, Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi (registered trademark)), IEEE 802.16 (WiMAX (registered trademark)), IEEE 802.20, Ultra-WideBand (UWB), Bluetooth (registered trademark), systems that use other adequate radio communication methods and next-generation systems that are enhanced based on these. A plurality of systems may be combined (for example, a combination of LTE or LTE-A and 5G, and the like) and applied.

(259) The phrase “based on” (or “on the basis of”) as used in the present disclosure does not mean “based only on” (or “only on the basis of”), unless otherwise specified. In other words, the phrase “based on” (or “on the basis of”) means both “based only on” and “based at least on” (“only on the basis of” and “at least on the basis of”).

(260) Reference to elements with designations such as “first,” “second,” and so on as used in the present disclosure does not generally limit the quantity or order of these elements. These designations may be used in the present disclosure only for convenience, as a method for distinguishing between two or more elements. Thus, reference to the first and second elements does not imply that only two elements may be employed, or that the first element must precede the second element in some way.

(261) The term “judging (determining)” as in the present disclosure herein may encompass a wide variety of actions. For example, “judging (determining)” may be interpreted to mean making “judgments (determinations)” about judging, calculating, computing, processing, deriving, investigating, looking up, search and inquiry (for example, searching a table, a database, or some other data structures), ascertaining, and so on.

(262) Furthermore, “judging (determining)” may be interpreted to mean making “judgments (determinations)” about receiving (for example, receiving information), transmitting (for example, transmitting information), input, output, accessing (for example, accessing data in a memory), and so on.

(263) In addition, “judging (determining)” as used herein may be interpreted to mean making “judgments (determinations)” about resolving, selecting, choosing, establishing, comparing, and so on. In other words, “judging (determining)” may be interpreted to mean making “judgments (determinations)” about some action.

(264) In addition, “judging (determining)” may be interpreted as “assuming,” “expecting,” “considering,” and the like.

(265) The terms “connected” and “coupled,” or any variation of these terms as used in the present disclosure mean all direct or indirect connections or coupling between two or more elements, and may include the presence of one or more intermediate elements between two elements that are “connected” or “coupled” to each other. The coupling or connection between the elements may be physical, logical, or a combination thereof. For example, “connection” may be interpreted as “access.”

(266) In the present disclosure, when two elements are connected, the two elements may be considered “connected” or “coupled” to each other by using one or more electrical wires, cables and printed electrical connections, and, as some non-limiting and non-inclusive examples, by using electromagnetic energy having wavelengths in radio frequency regions, microwave regions, (both visible and invisible) optical regions, or the like.

(267) In the present disclosure, the phrase “A and B are different” may mean that “A and B are different from each other.” Note that the phrase may mean that “A and B is each different from C.” The terms “separate,” “be coupled,” and so on may be interpreted similarly to “different.”

(268) When terms such as “include,” “including,” and variations of these are used in the present disclosure, these terms are intended to be inclusive, in a manner similar to the way the term “comprising” is used. Furthermore, the term “or” as used in the present disclosure is intended to be not an exclusive disjunction.

(269) For example, in the present disclosure, when an article such as “a,” “an,” and “the” in the English language is added by translation, the present disclosure may include that a noun after these articles is in a plural form.

(270) Now, although the invention according to the present disclosure has been described in detail above, it should be obvious to a person skilled in the art that the invention according to the present disclosure is by no means limited to the embodiments described in the present disclosure. The invention according to the present disclosure can be implemented with various corrections and in various modifications, without departing from the spirit and scope of the invention defined by the recitations of claims. Consequently, the description of the present disclosure is provided only for the purpose of explaining examples, and should by no means be construed to limit the invention according to the present disclosure in any way.

Claims

1. A terminal comprising: a receiver that receives a downlink control information (DCI) using a specific type of radio network temporary identifier (RNTI) for scheduling a multicast physical downlink shared channel (PDSCH); and a processor that determines a ratio between energy of the multicast PDSCH and energy of a demodulation reference signal (DM-RS) for the multicast PDSCH, based on a number of DM-RS code division multiplexing (CDM) groups without data for the multicast PDSCH.
2. The terminal according to claim 1, wherein the receiver receives a configuration for the multicast PDSCH, and the configuration is configured separately from a configuration for a unicast PDSCH.

3. The terminal according to claim 1, wherein a range of the number of DM-RS CDM groups without data for the multicast PDSCH is different from a range of a number of DM-RS CDM groups without data for a unicast PDSCH.
4. A radio communication method for a terminal, the method comprising: receiving a downlink control information (DCI) using a specific type of radio network temporary identifier (RNTI) for scheduling a multicast physical downlink shared channel (PDSCH); and determining a ratio between energy of the multicast PDSCH and energy of a demodulation reference signal (DM-RS) for the multicast PDSCH, based on a number of DM-RS code division multiplexing (CDM) groups without data for the multicast PDSCH.
5. A base station comprising: a transmitter that transmits a downlink control information (DCI) using a specific type of radio network temporary identifier (RNTI) for scheduling a multicast physical downlink shared channel (PDSCH); and a processor that determines a ratio between energy of the multicast PDSCH and energy of a demodulation reference signal (DM-RS) for the multicast PDSCH, based on a number of DM-RS code division multiplexing (CDM) groups without data for the multicast PDSCH.
6. A system comprising: a terminal that comprises: a receiver that receives a downlink control information (DCI) using a specific type of radio network temporary identifier (RNTI) for scheduling a multicast physical downlink shared channel (PDSCH); and a processor that determines a ratio between energy of the multicast PDSCH and energy of a demodulation reference signal (DM-RS) for the multicast PDSCH, based on a number of DM-RS code division multiplexing (CDM) groups without data for the multicast PDSCH; and a base station that transmits the DCI.
-