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(54) **USER EQUIPMENT AND METHODS**

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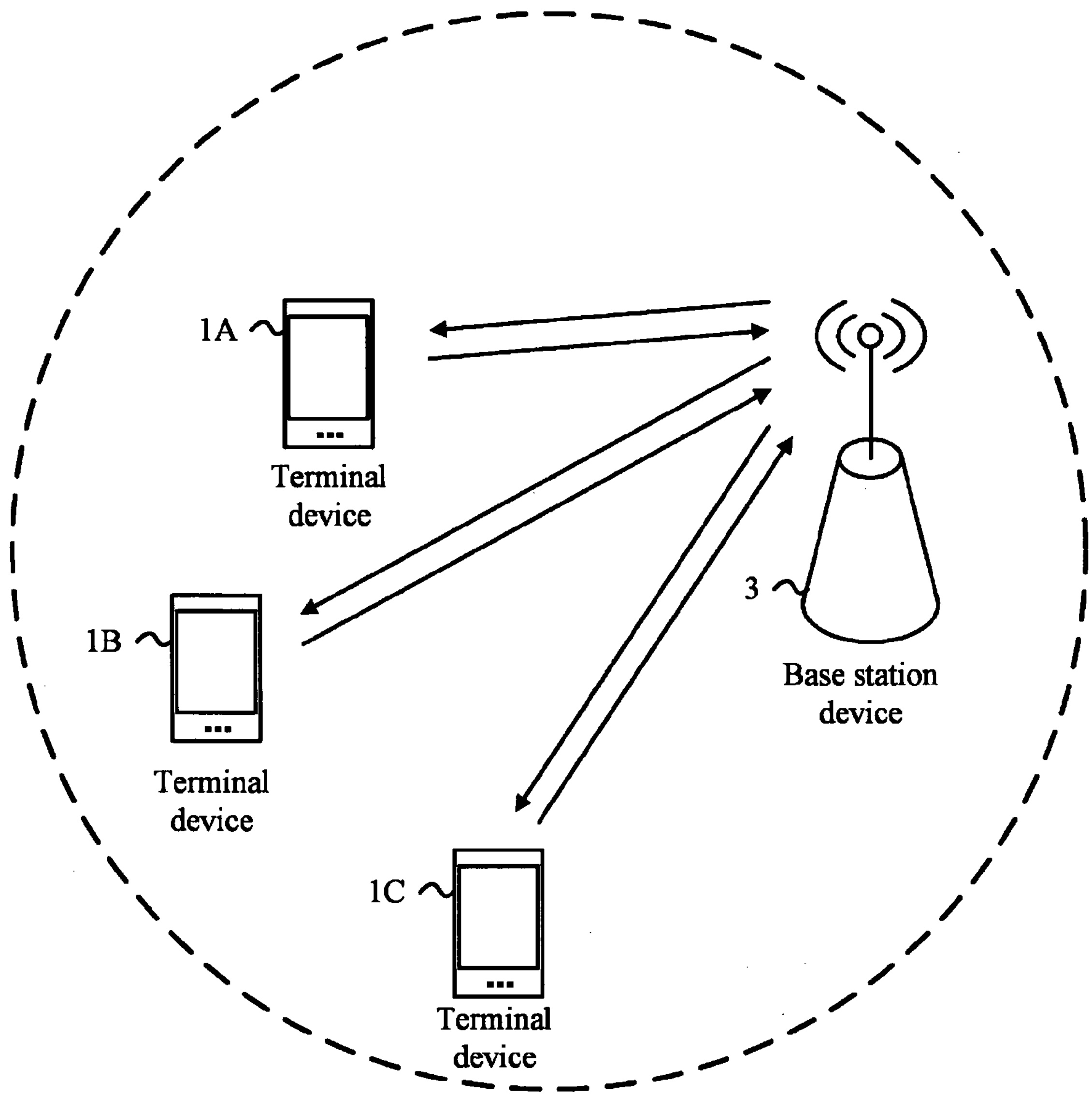
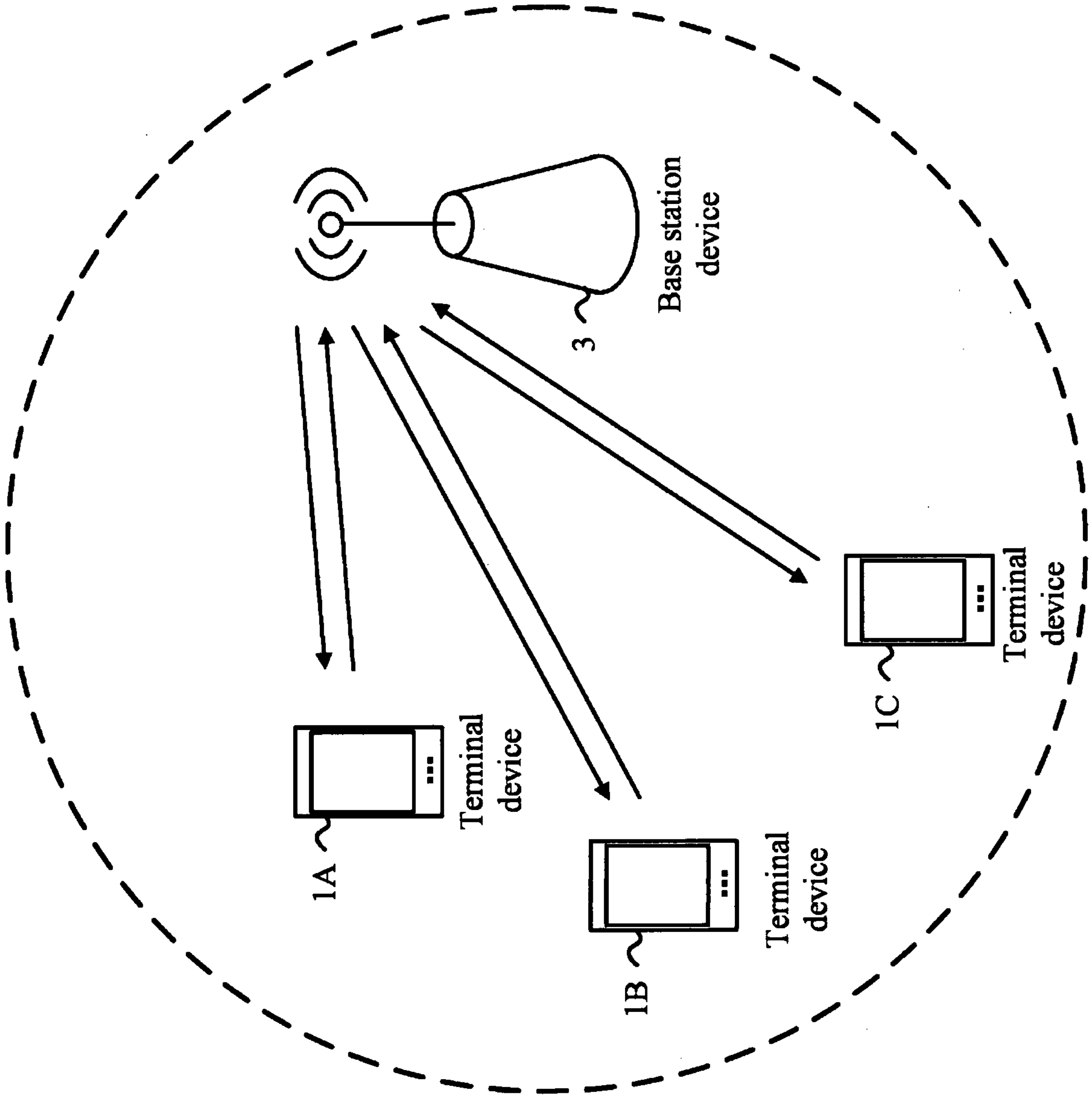
(57) **ABSTRACT**

A user equipment (UE) having PC5-RRC connection with other UE is described. The UE may comprise transmission circuitry configured to transmit, to the other UE, a reference signal for sidelink positioning; and higher layer processing circuitry configured to acquire a PC5-RRC message including a measurement result of sidelink positioning.





Base station device
3
1A
Terminal device
1B
Terminal device
1C
Terminal device

Figure 1

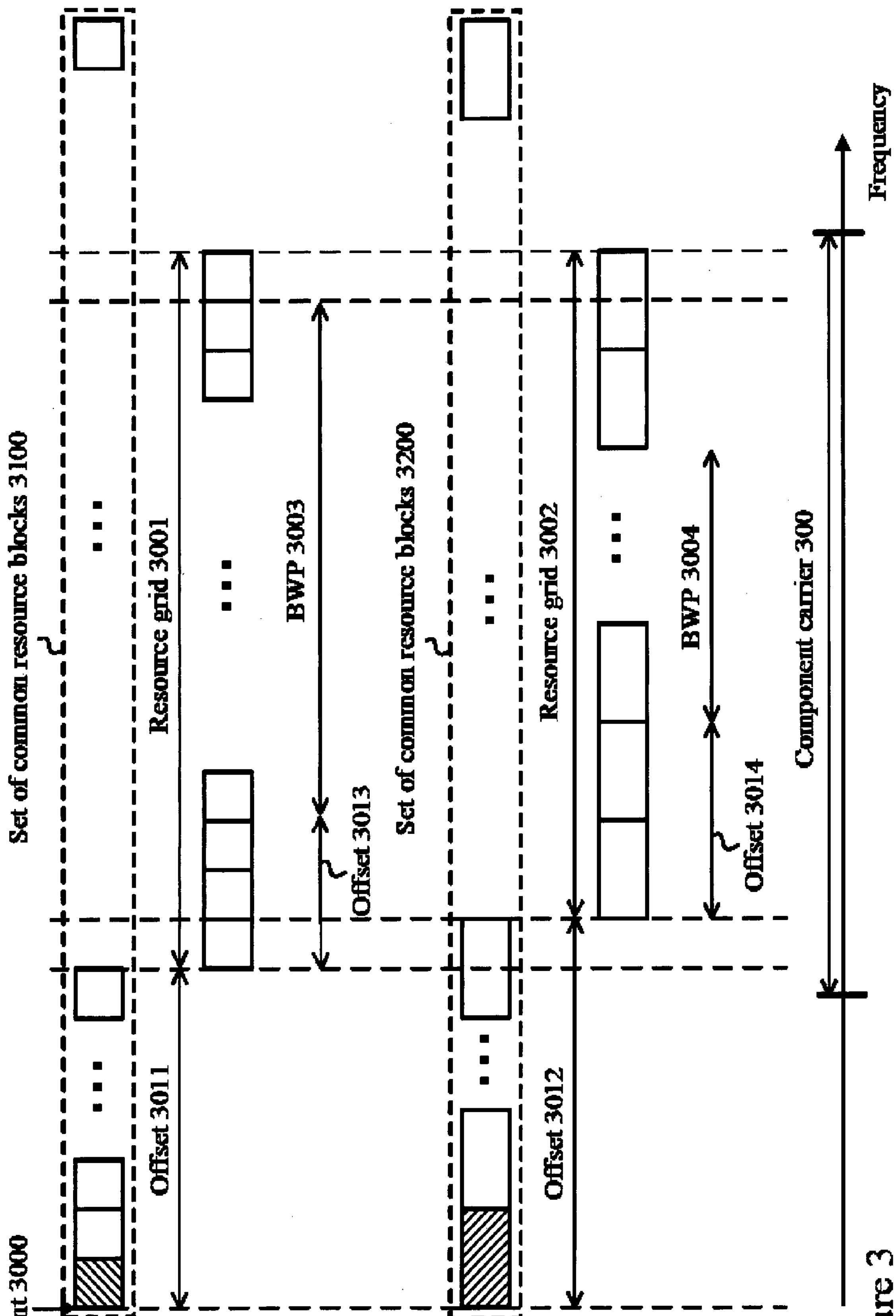
Figure 2A: Number of OFDM symbols per slot, slots per frame, and slots per subframe for normal cyclic prefix

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

Figure 2B: Number of OFDM symbols per slot, slots per frame, and slots per subframe for extended cyclic prefix

u	N^{slot}_{symb}	$N^{frame,u}_{slot}$	$N^{subframe,u}_{slot}$
2	12	40	4

Figure 2



Set of common resource blocks 3100
Point 3000
Resource grid 3001
Offset 3011
BWP 3003
Offset 3013
Set of common resource blocks 3200
Resource grid 3002
Offset 3012
BWP 3004
Offset 3014
Component carrier 300
Frequency

Figure 3

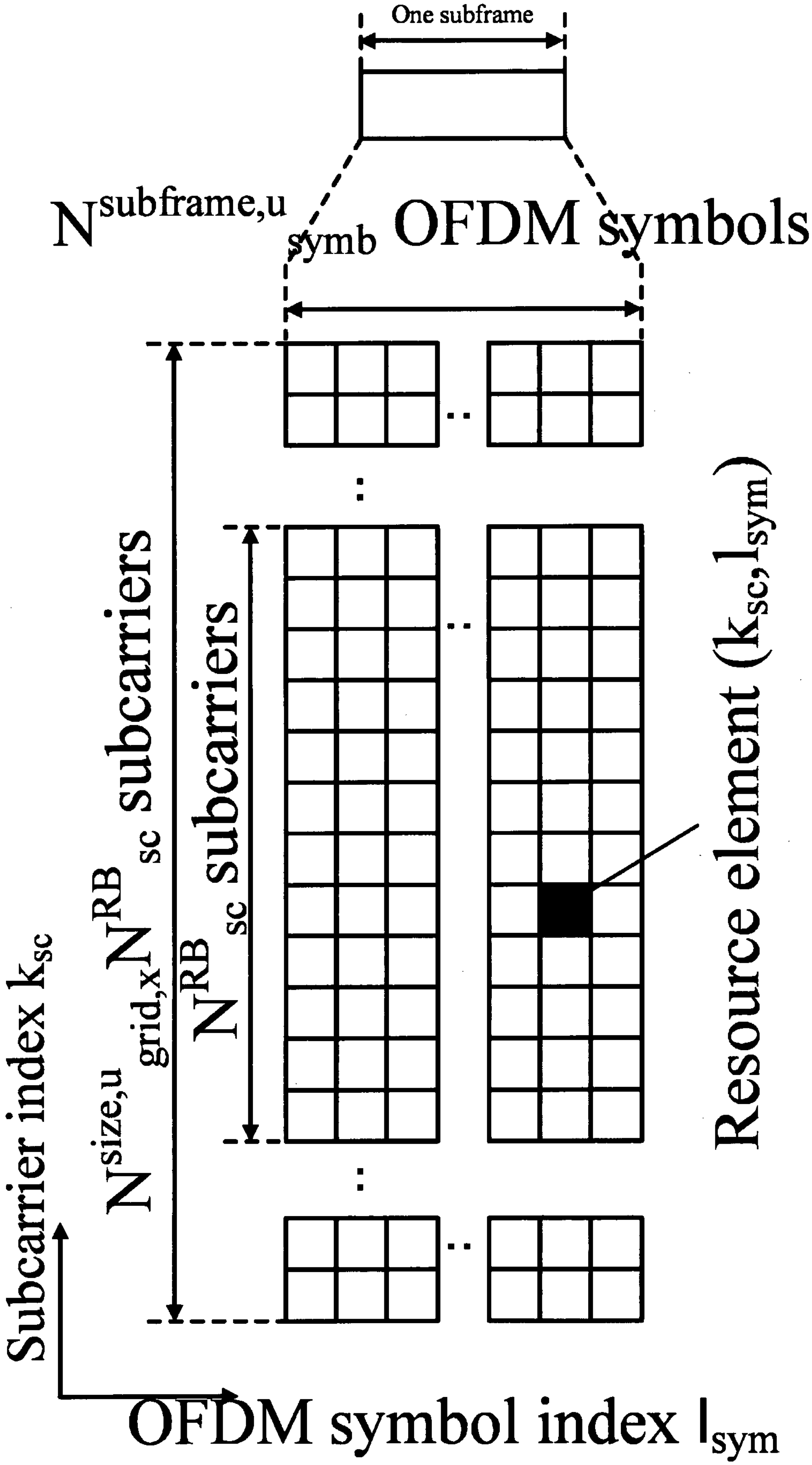

One subframe
$N^{subframe,u}_{symb}$ OFDM symbols
$N^{size,u}_{grid,x}N^{RB}_{sc}$ subcarriers
N^{RB}_{sc} subcarriers
Resource element (k_{sc},l_{sym})
Subcarrier index k_{sc}
OFDM symbol index l_{sym}

Figure 4

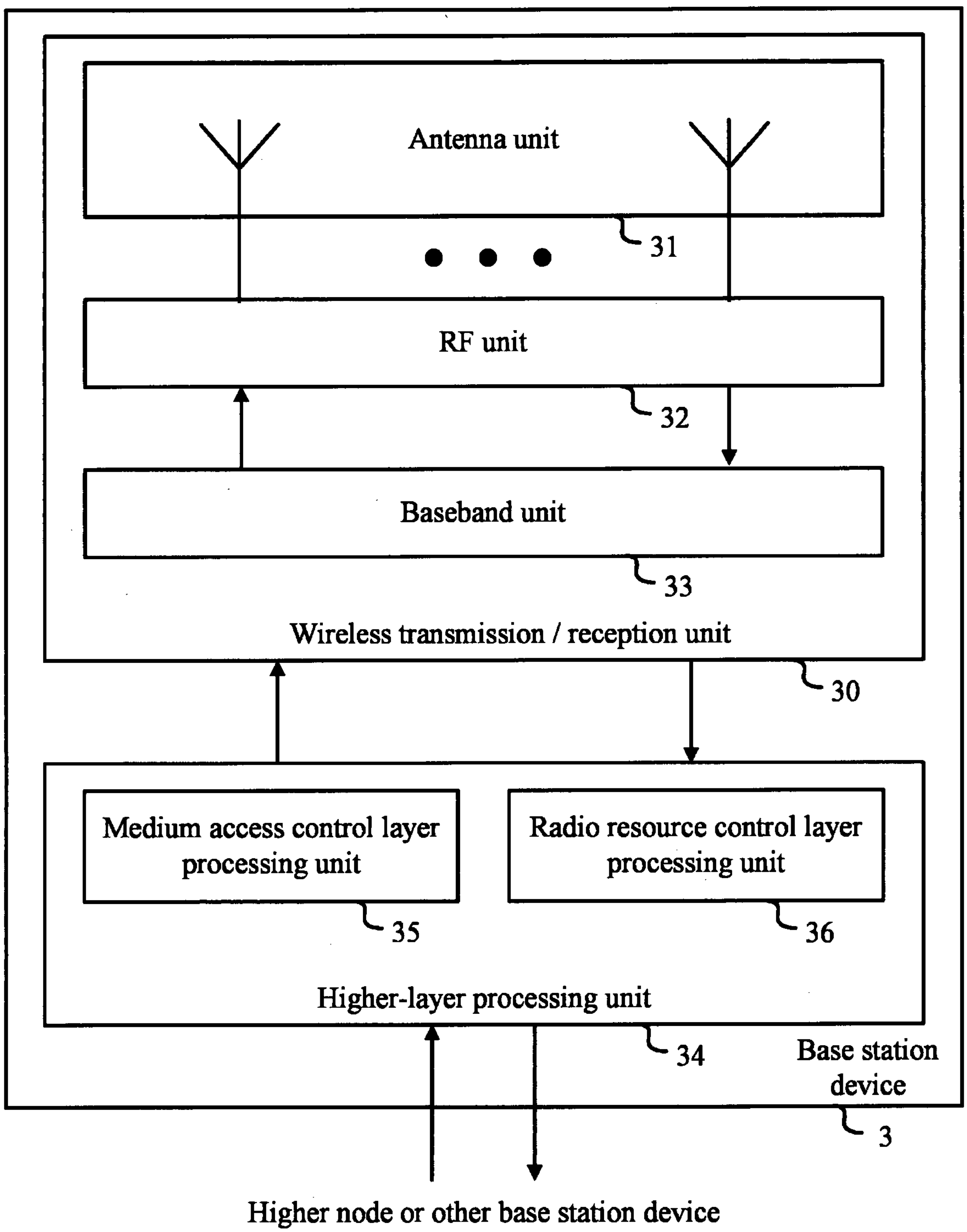

Antenna unit
31
RF unit
32
Baseband unit
33
Wireless transmission / reception unit
30
Medium access control layer processing unit
35
Radio resource control layer processing unit
36
Higher-layer processing unit
34
Base station device
3
Higher node or other base station device

Figure 5

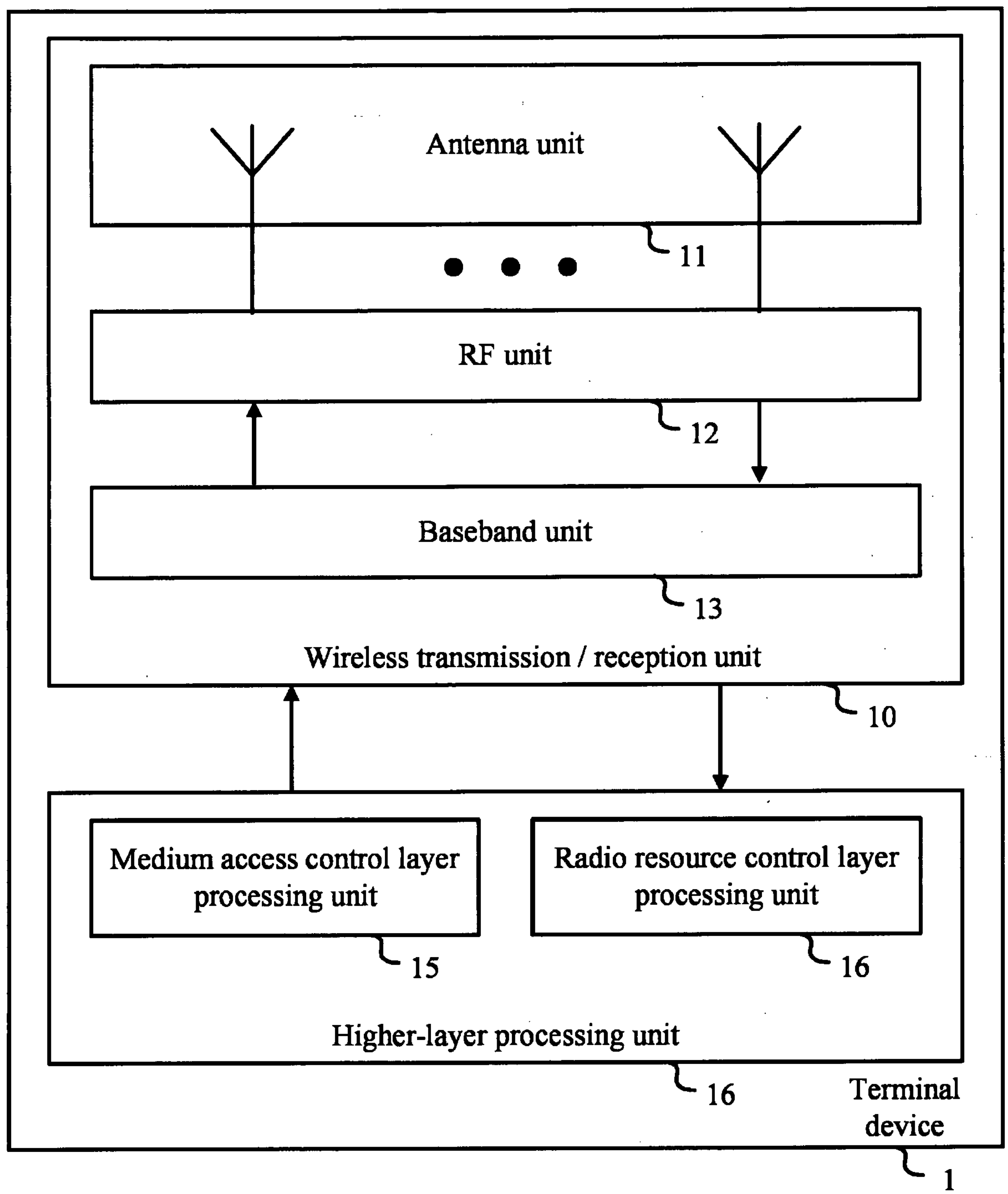

Antenna unit
11
RF unit
12
Baseband unit
13
Wireless transmission / reception unit
10
Medium access control layer processing unit
15
Radio resource control layer processing unit
16
Higher-layer processing unit
16
Terminal device
1

Figure 6

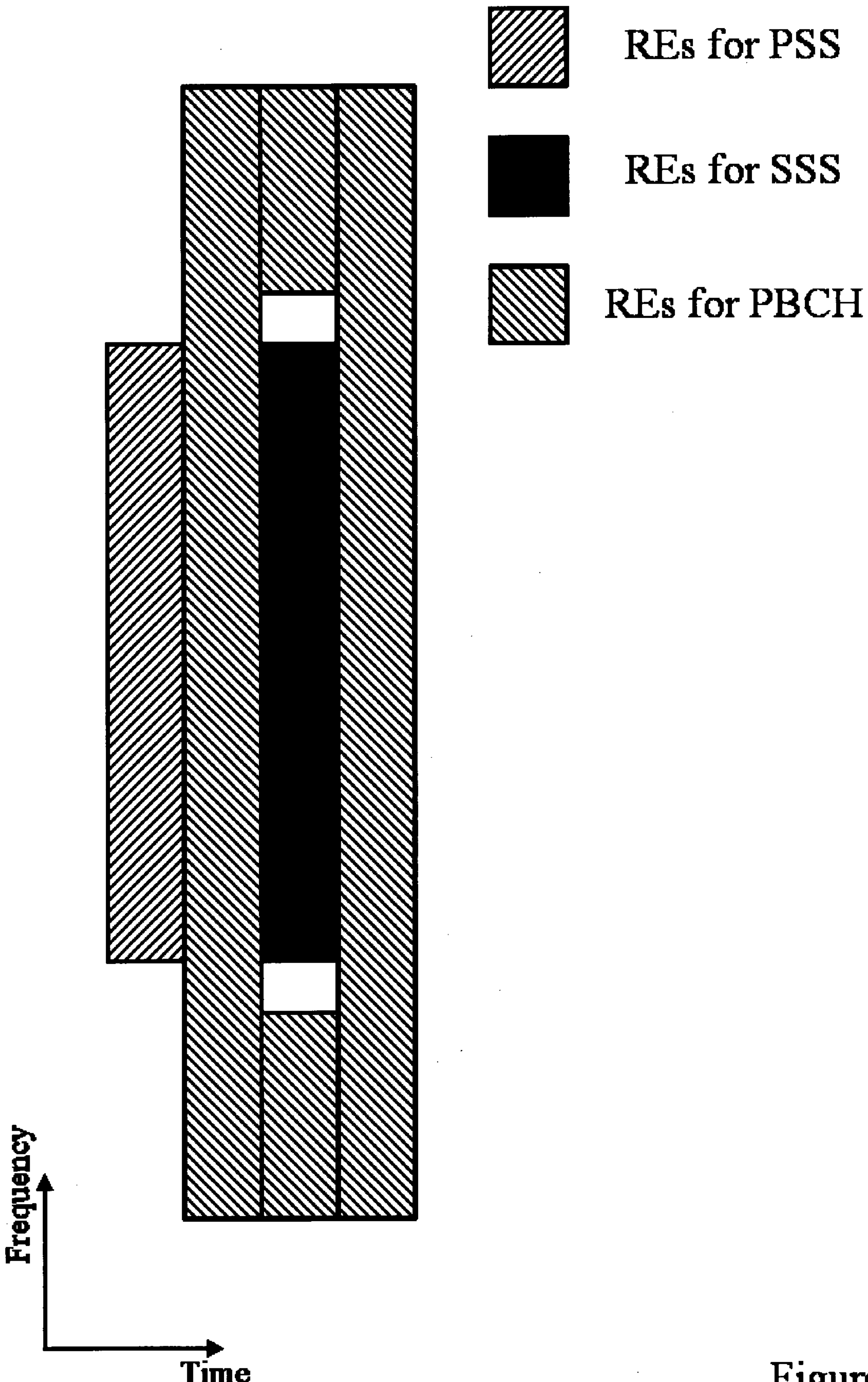


Figure 7

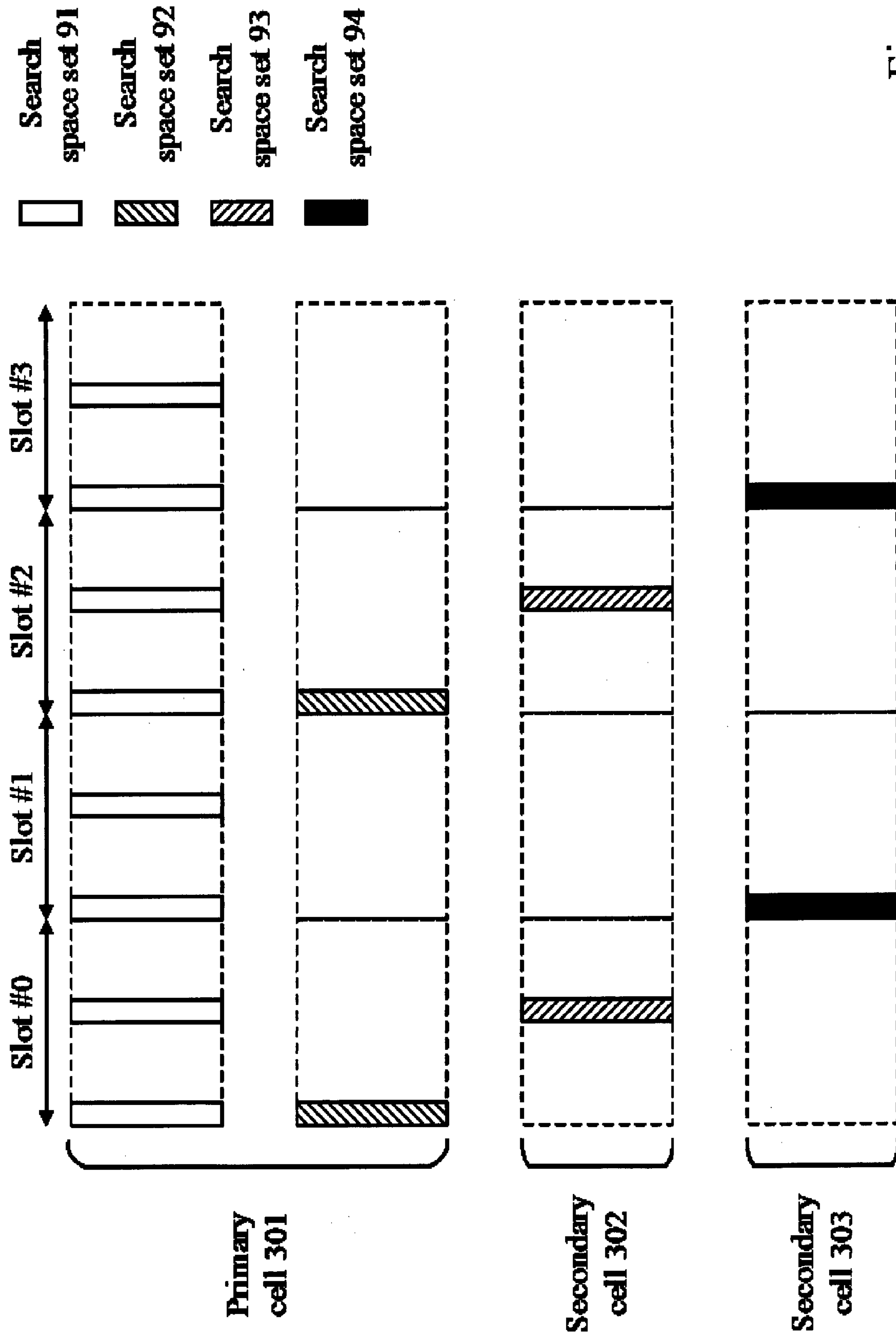

Search space set 91
Search space set 92
Search space set 93
Search space set 94
Slot #0
Slot #1
Slot #2
Slot #3
Primary cell 301
Secondary cell 302
Secondary cell 303

Figure 8

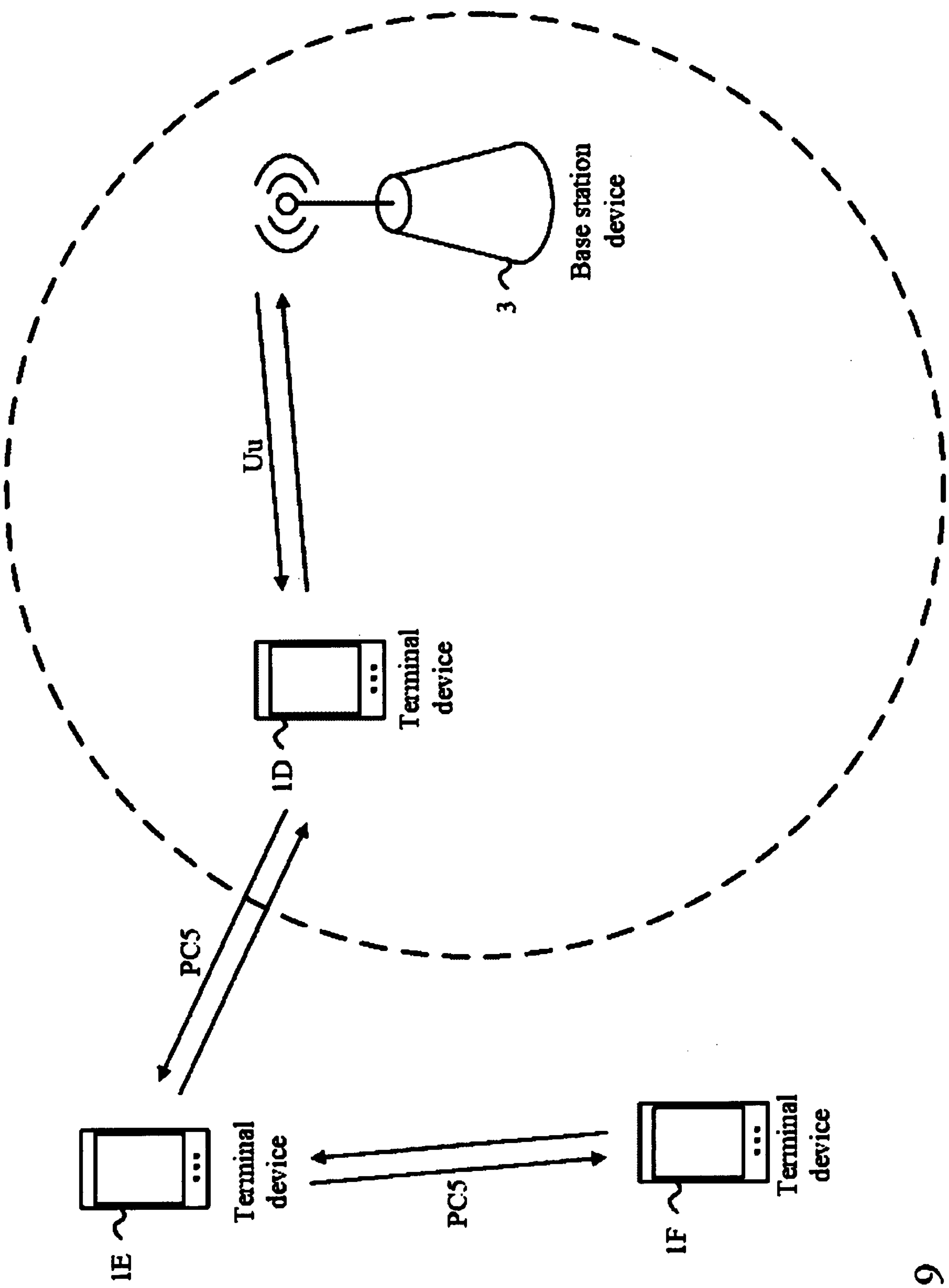
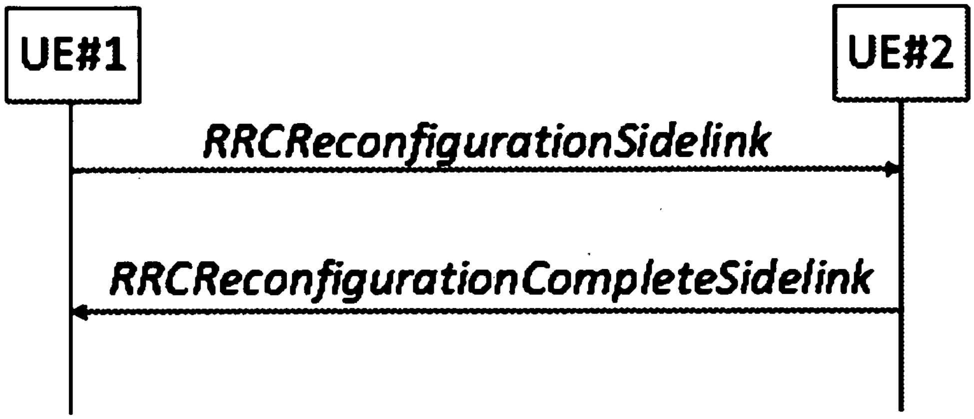
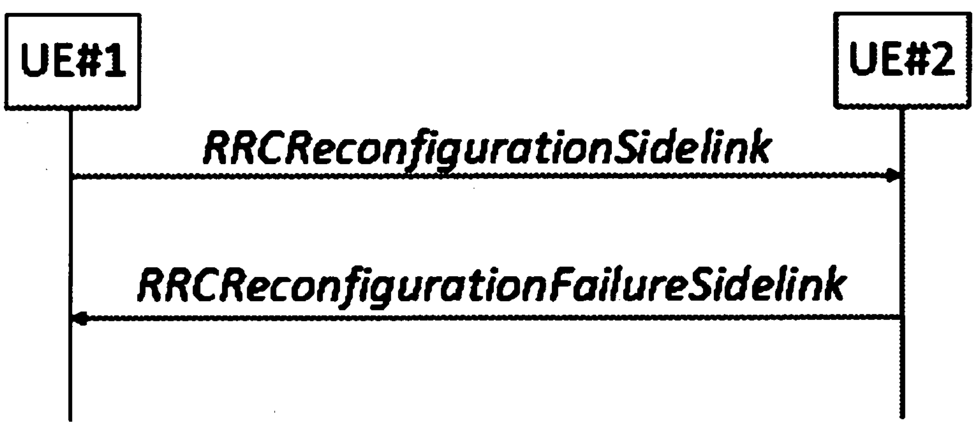

Base station device
3
Uu
Terminal device
1D
PC5
Terminal device
1E
PC5
Terminal device
1F

Figure 9



Procedure of sidelink RRC reconfiguration, successful



Procedure of sidelink RRC reconfiguration, failure

Figure 10

Sync Ref	Value of incoverage field of PSBCH from Sync Ref	SLSSID of SLSS from Sync Ref	Slot of SLSS from Sync Ref	Status on the frequency	SLSSID of SLSS	Value of incoverage field of PSBCH	Slot of SLSS
cell	-	-	-	In coverage	SLSSID in a *sl-SyncConfigList* entry	true	*sl-SSB-TimeAllocation1*
cell	-	-	-	Out of coverage & included in *sl-FreqInfoList*	SLSSID in a *sl-SyncConfigList* entry	true	*sl-SSB-TimeAllocation1*
GNSS	-	-	-	In coverage	0	true	*sl-SSB-TimeAllocation1*
GNSS	-	-	-	Out of coverage & included in *sl-FreqInfoList*	0	true	*sl-SSB-TimeAllocation1*
GNSS	-	-	-	Out of coverage & not included in *sl-FreqInfoList*	0	false	*sl-SSB-TimeAllocation3* (or *sl-SSB-TimeAllocation1*)
UE	true	any	*sl-SSB-TimeAllocation1*	Out of coverage & not included in *sl-FreqInfoList*	The same SLSSID as in SLSS from Sync Ref	false	*sl-SSB-TimeAllocation2*
UE	false	{336:671}	any	Out of coverage & not included in *sl-FreqInfoList*	The same SLSSID as in SLSS from Sync Ref	false	*sl-SSB-TimeAllocation1* or *sl-SSB-TimeAllocation2*
UE	false	0	*sl-SSB-TimeAllocation3*	Out of coverage & not included in *sl-FreqInfoList*	337	false	*sl-SSB-TimeAllocation2*
UE	false	{0:335}	*sl-SSB-TimeAllocation1* or *sl-SSB-TimeAllocation2*	Out of coverage & not included in *sl-FreqInfoList*	SLSSID of in SLSS from Sync Ref + 336	false	*sl-SSB-TimeAllocation1* or *sl-SSB-TimeAllocation2*
None	-	-	-	Out of coverage & not included in *sl-FreqInfoList*	Random selection from {338:671}	false	Based on pre-configuration

Figure 11

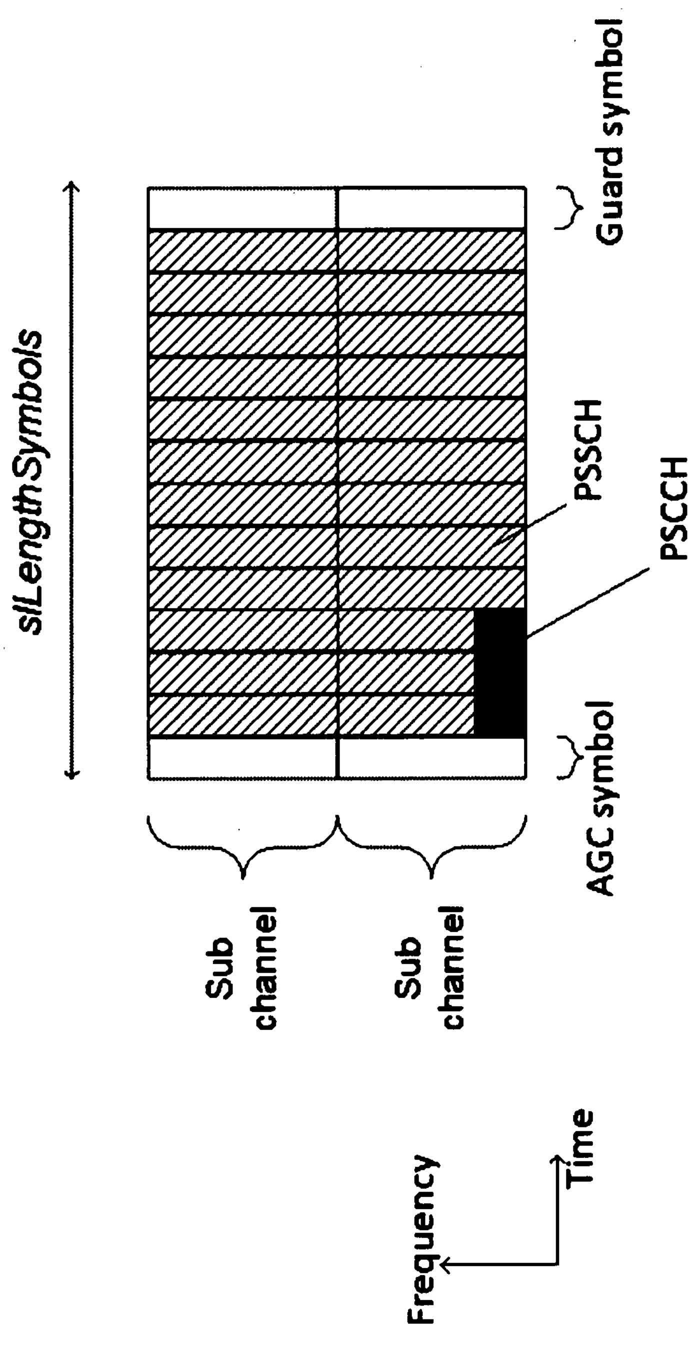

slLengthSymbols
Guard symbol
PSSCH
PSCCH
AGC symbol
Sub channel
Sub channel
Frequency
Time

Figure 12

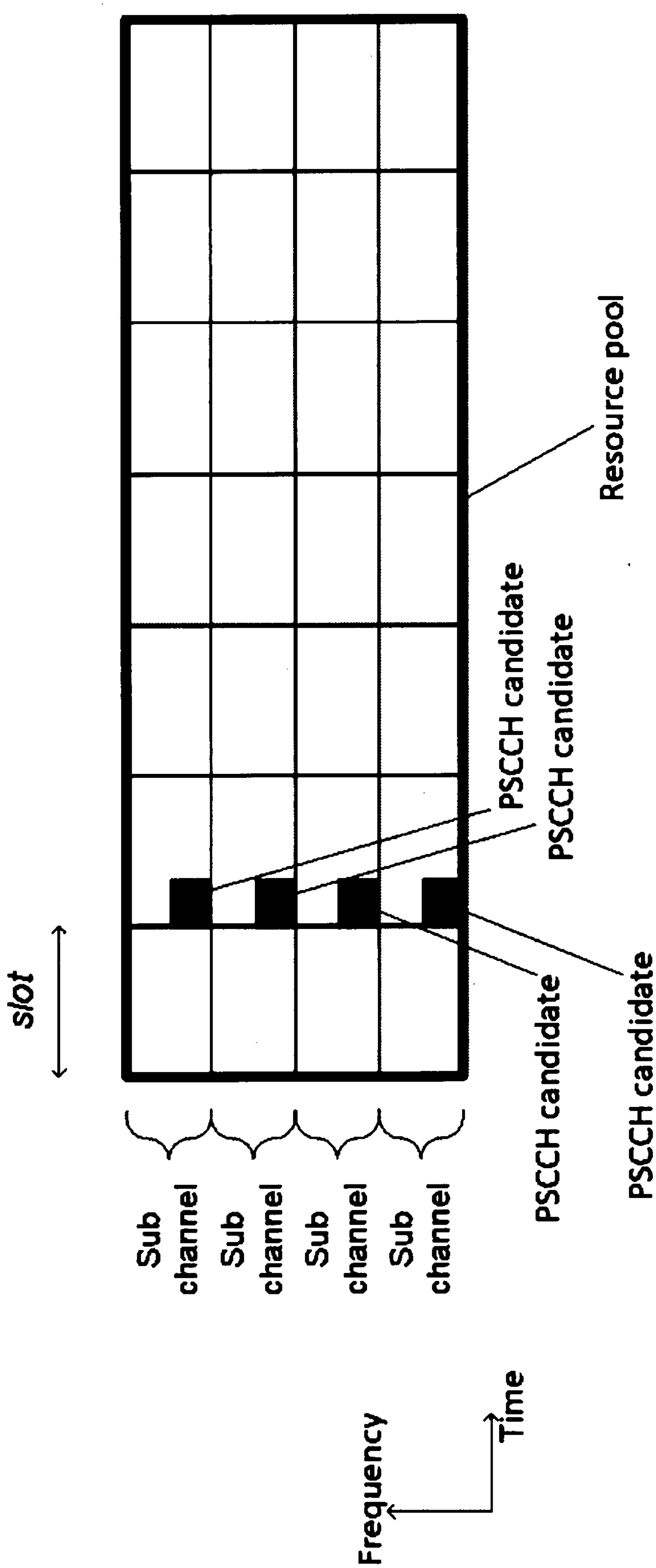
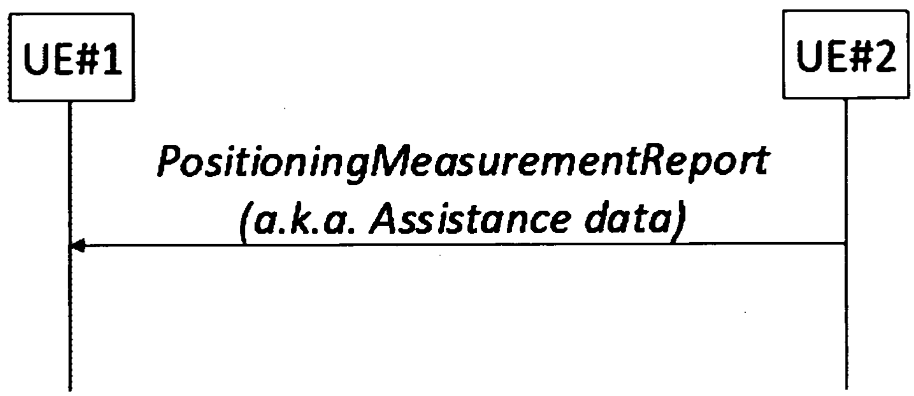

slot
Resource pool
PSCCH candidate
PSCCH candidate
PSCCH candidate
PSCCH candidate
Sub channel
Sub channel
Sub channel
Sub channel
Frequency
Time

Figure 13



PC-5 RRC Procedure of measurement report for sidelink positioning

Figure 14

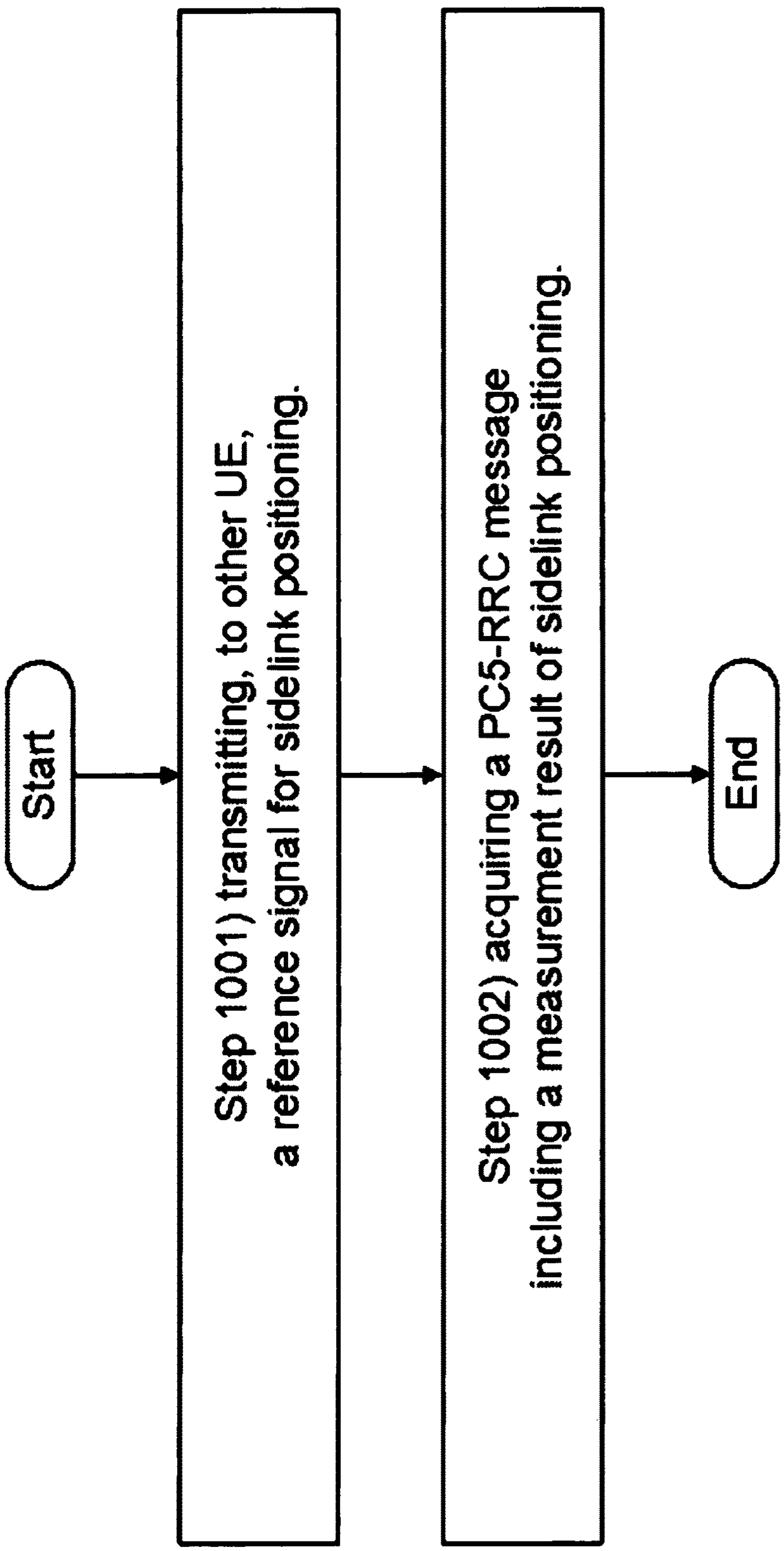

Start
Step 1001) transmitting, to other UE, a reference signal for sidelink positioning.
Step 1002) acquiring a PC5-RRC message including a measurement result of sidelink positioning.
End

Figure 15

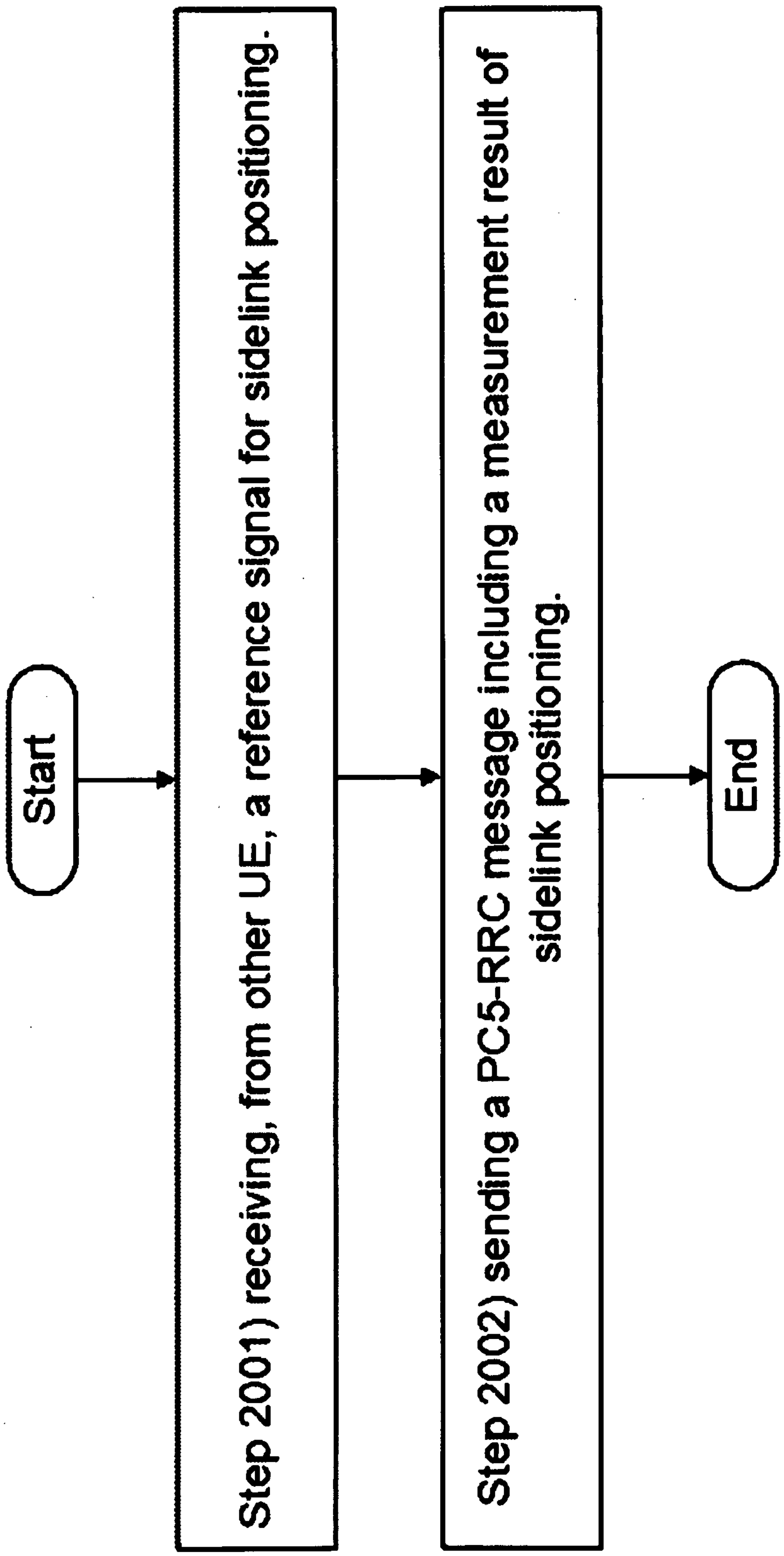

Start
Step 2001) receiving, from other UE, a reference signal for sidelink positioning.
Step 2002) sending a PC5-RRC message including a measurement result of sidelink positioning.
End

Figure 16

USER EQUIPMENT AND METHODS

TECHNICAL FIELD

[0001] The present invention relates to a user equipment and a method.

BACKGROUND ART

[0002] In the 3rd Generation Partnership Project (3GPP), a radio access method and a radio network for cellular mobile communications (hereinafter, referred to as Long Term Evolution, or Evolved Universal Terrestrial Radio Access) have been studied. In LTE (Long Term Evolution), a base station device is also referred to as an evolved NodeB (eNodeB), and a terminal device is also referred to as a User Equipment (UE). LTE is a cellular communication system in which multiple areas are deployed in a cellular structure, with each of the multiple areas being covered by a base station device. A single base station device may manage multiple cells. Evolved Universal Terrestrial Radio Access is also referred as E-UTRA.

[0003] In the 3GPP, the next generation standard (New Radio: NR) has been studied in order to make a proposal to the International-Mobile-Telecommunication—2020 (IMT-2020) which is a standard for the next generation mobile communication system defined by the International Telecommunications Union (ITU). NR has been expected to satisfy a requirement considering three scenarios of enhanced Mobile BroadBand (eMBB), massive Machine Type Communication (mMTC), and Ultra Reliable and Low Latency Communication (URLLC), in a single technology framework.

[0004] For example, wireless communication devices may communicate with one or more devices using a communication structure. However, the communication structure used may only offer limited flexibility and/or efficiency. As illustrated by this discussion, systems and methods that improve communication flexibility and/or efficiency may be beneficial.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a conceptual diagram of a wireless communication system;

[0006] FIG. **2** is an example showing the relationship between subcarrier-spacing configuration u, the number of OFDM symbols per slot N^{slot}_{symb}, and the CP configuration;

[0007] FIG. **3** is a diagram showing an example of a method of configuring a resource grid;

[0008] FIG. **4** is a diagram showing a configuration example of a resource grid **3001**;

[0009] FIG. **5** is a schematic block diagram showing a configuration example of the base station device;

[0010] FIG. **6** is a schematic block diagram showing a configuration example of the terminal device;

[0011] FIG. **7** is a diagram showing a configuration example of an SS/PBCH block;

[0012] FIG. **8** is a diagram showing an example of the monitoring occasion of the search-space-set;

[0013] FIG. **9** is another conceptual diagram of a wireless communication system;

[0014] FIG. **10** shows procedures of sidelink RRC reconfiguration;

[0015] FIG. **11** shows the table for SLSS parameter determination;

[0016] FIG. **12** shows an example of sub-channel structure for sidelink transmissions;

[0017] FIG. **13** shows an example of resource pool for sidelink transmissions;

[0018] FIG. **14** shows an example procedure of measurement report for sidelink positioning;

[0019] FIG. **15** shows an example of a method for a UE #1;

[0020] FIG. **16** shows an example of a method for a UE #2.

DESCRIPTION OF EMBODIMENTS

[0021] A user equipment (UE) having PC5-RRC connection with other UE is described. The UE may comprise transmission circuitry configured to transmit, to the other UE, a reference signal for sidelink positioning; and higher layer processing circuitry configured to acquire a PC5-RRC message including a measurement result of sidelink positioning.

[0022] A user equipment (UE) having PC5-RRC connection with other UE is described. The UE may comprise reception circuitry configured to receive, from the other UE, a reference signal for sidelink positioning; and higher layer processing circuitry configured to send a PC5-RRC message including a measurement result of sidelink positioning.

[0023] A method for a user equipment (UE) having PC5-RRC connection with other UE is described. The method may comprise transmitting, to the other UE, a reference signal for sidelink positioning; and acquiring a PC5-RRC message including a measurement result of sidelink positioning.

[0024] floor (CX) may be a floor function for real number CX. For example, floor (CX) may be a function that provides the largest integer within a range that does not exceed the real number CX. ceil (DX) may be a ceiling function to a real number DX. For example, ceil (DX) may be a function that provides the smallest integer within the range not less than the real number DX. mod (EX, FX) may be a function that provides the remainder obtained by dividing EX by FX. mod (EX, FX) may be a function that provides a value which corresponds to the remainder of dividing EX by FX. It is exp (GX)=e^GX. Here, e is Napier number. (HX)^(IX) indicates IX to the power of HX.

[0025] In a wireless communication system according to one aspect of the present embodiment, at least OFDM (Orthogonal Frequency Division Multiplex) is used. An OFDM symbol is a unit of time domain of the OFDM. The OFDM symbol includes at least one or more subcarriers. An OFDM symbol is converted to a time-continuous signal in baseband signal generation. In downlink, at least CP-OFDM (Cyclic Prefix-Orthogonal Frequency Division Multiplex) is used. In uplink, either CP-OFDM or DFT-s-OFDM (Discrete Fourier Transform-spread-Orthogonal Frequency Division Multiplex) is used. DFT-s-OFDM may be given by applying transform precoding to CP-OFDM. CP-OFDM is OFDM using CP (Cyclic Prefix).

[0026] The OFDM symbol may be a designation including a CP added to the OFDM symbol. That is, an OFDM symbol may be configured to include the OFDM symbol and a CP added to the OFDM symbol.

[0027] FIG. **1** is a conceptual diagram of a wireless communication system. In FIG. **1**, the wireless communication system includes at least terminal device **1**A to **1**C and a base station device **3** (BS #3: Base station #3). Hereinafter, the terminal devices **1**A to **1**C are also referred to as a terminal device **1** (UE #1: User Equipment #1).

[0028] The base station device **3** may be configured to include one or more transmission devices (or transmission points, transmission devices, reception devices, transmission points, reception points). When the base station device **3** is configured by a plurality of transmission devices, each of the plurality of transmission devices may be arranged at a different position.

[0029] The base station device **3** may provide one or more serving cells. A serving cell may be defined as a set of resources used for wireless communication. A serving cell is also referred to as a cell.

[0030] A serving cell may be configured to include at least one downlink component carrier (downlink carrier) and/or one uplink component carrier (uplink carrier). A serving cell may be configured to include at least two or more downlink component carriers and/or two or more uplink component carriers. A downlink component carrier and an uplink component carrier are also referred to as component carriers (carriers). The uplink component carrier can be used for sidelink communication.

[0031] For example, one resource grid may be provided for one component carrier. For example, one resource grid may be provided for one component carrier and a subcarrier-spacing configuration u. A subcarrier-spacing configuration u is also referred to as numerology. A resource grid includes $N^{size,\ u}_{grid,x}N^{RB}_{sc}$ subcarriers. The resource grid starts from a common resource block with index $N^{start,\ u}_{grid}$. The common resource block with the index $N^{start,\ u}_{grid}$ is also referred to as a reference point of the resource grid. The resource grid includes $N^{subframe,\ u}_{symb}$ OFDM symbols. The subscript x indicates the transmission direction and indicates either downlink or uplink. One resource grid is provided for an antenna port p, a subcarrier-spacing configuration u, and a transmission direction x. The resource grid may be applied to downlink, uplink and/or sidelink.

[0032] Resource grid is also referred to as carrier.

[0033] $N^{size,\ u}_{grid,x}$ and $N^{start,\ u}_{grid}$ are given based at least on an RRC parameter (e.g. referred to as RRC parameter CarrierBandwidth). The RRC parameter is used to define one or more SCS (SubCarrier-Spacing) specific carriers. One resource grid corresponds to one SCS specific carrier. One component carrier may comprise one or more SCS specific carriers. The SCS specific carrier may be included in a system information block (SIB). For each SCS specific carrier, a subcarrier-spacing configuration u may be provided.

[0034] FIG. **2** is an example showing the relationship between subcarrier-spacing configuration u, the number of OFDM symbols per slot N^{slot}_{symb}, and the CP configuration. In FIG. **2**A, for example, when the subcarrier-spacing configuration u is set to 2 and the CP configuration is set to normal CP (normal cyclic prefix), $N^{slot}_{symb}=14$, $N^{frame,\ u}_{slot}=40$, $N^{subframe,\ u}_{slot}=4$. Further, in FIG. **2**B, for example, when the subcarrier-spacing configuration u is set to 2 and the CP configuration is set to an extended CP (extended cyclic prefix), $N^{slot}_{symb}=12$, $N^{frame,\ u}_{slot}=40$, $N^{subframe,\ u}_{slot}=4$. The subcarrier-spacing configuration u may be applied to downlink, uplink and/or sidelink.

[0035] In the wireless communication system, a time unit T_c may be used to represent the length of the time domain. The time unit T_c is $T_c=1/(df_{max}*N_f)$. It is $df_{max}=480$ kHz. It is $N_f=4096$. The constant k is $k=df_{max}*N_f/(df_{ref}N_{f,\ ref})=64$. dfref is 15 kHz. N_f, ref is 2048.

[0036] Transmission of signals in the downlink and/or transmission of signals in the uplink and/or transmission of signals in the sidelink may be organized into radio frames (system frames, frames) of length T_f. It is $T_f=(df_{max}\ N_f/100)*T_s=10$ ms. One radio frame is configured to include ten subframes. The subframe length is $T_{sf}=(df_{max}N_f/1000)\ T_s=1$ ms. The number of OFDM symbols per subframe is $N^{subframe,\ u}_{symb}=N^{slot}_{symb}N^{subframe,\ u}_{slot}$.

[0037] For a subcarrier-spacing configuration u, the number of slots included in a subframe and indexes may be given. For example, slot index n^u_s may be given in ascending order with an integer value ranging from 0 to $N^{subframe,\ u}_{slot}-1$ in a subframe. For subcarrier-spacing configuration u, the number of slots included in a radio frame and indexes of slots included in the radio frame may be given. Also, the slot index $n^u_{s,f}$ may be given in ascending order with an integer value ranging from 0 to $N^{frame,u}_{slot}-1$ in the radio frame. Consecutive N^{slot}_{symb} OFDM symbols may be included in one slot. It is $N^{slot}_{symb}=14$.

[0038] FIG. **3** is a diagram showing an example of a method of configuring a resource grid. The horizontal axis in FIG. **3** indicates frequency domain. FIG. **3** shows a configuration example of a resource grid of subcarrier-spacing configuration $u=u_1$ in the component carrier **300** and a configuration example of a resource grid of subcarrier-spacing configuration $u=u_2$ in a component carrier. One or more subcarrier-spacing configuration may be set for a component carrier. Although it is assumed in FIG. **3** that $u_1=u_2-1$, various aspects of this embodiment are not limited to the condition of $u_1=u_2-1$.

[0039] The component carrier **300** is a band having a predetermined width in the frequency domain.

[0040] Point **3000** is an identifier for identifying a subcarrier. Point **3000** is also referred to as point A. The common resource block (CRB) set **3100** is a set of common resource blocks for the subcarrier-spacing configuration u_1.

[0041] Among the common resource block-set **3100**, the common resource block including the point **3000** (the block indicated by the upper right diagonal line in FIG. **3**) is also referred to as a reference point of the common resource block-set **3100**. The reference point of the common resource block-set **3100** may be a common resource block with index 0 in the common resource block-set **3100**.

[0042] The offset **3011** is an offset from the reference point of the common resource block-set **3100** to the reference point of the resource grid **3001**. The offset **3011** is indicated by the number of common resource blocks which is relative to the subcarrier-spacing configuration u_1. The resource grid **3001** includes $N^{size,u}_{grid1,x}$ common resource blocks starting from the reference point of the resource grid **3001**.

[0043] The offset **3013** is an offset from the reference point of the resource grid **3001** to the reference point ($N^{start,u}_{BWP,i1}$) of the BWP (BandWidth Part) **3003** of the index i1.

[0044] Common resource block-set **3200** is a set of common resource blocks with respect to subcarrier-spacing configuration u_2.

[0045] A common resource block including the point **3000** (a block indicated by a upper left diagonal line in FIG. **3**) in the common resource block-set **3200** is also referred to as a reference point of the common resource block-set **3200**. The reference point of the common resource block-set **3200** may be a common resource block with index 0 in the common resource block-set **3200**.

[0046] The offset **3012** is an offset from the reference point of the common resource block-set **3200** to the reference point of the resource grid **3002**. The offset **3012** is indicated by the number of common resource blocks for subcarrier-spacing configuration $u=u_2$. The resource grid **3002** includes $N^{size,u}{}_{grid2,x}$ common resource blocks starting from the reference point of the resource grid **3002**.

[0047] The offset **3014** is an offset from the reference point of the resource grid **3002** to the reference point ($N^{start,u}n_{BW,i2}$) of the BWP **3004** with index i_2.

[0048] FIG. **4** is a diagram showing a configuration example of a resource grid **3001**. In the resource grid of FIG. **4**, the horizontal axis indicates OFDM symbol index 1_{sym}, and the vertical axis indicates the subcarrier index k_{sc}. The resource grid **3001** includes $N^{size,u}{}_{grid1}$,$xN^{RB}{}_{sc}$ subcarriers, and includes $N^{subframes,u}{}_{symb}$ OFDM symbols. A resource specified by the subcarrier index ks_c and the OFDM symbol index 1_{sym} in a resource grid is also referred to as a resource element (RE).

[0049] A resource block (RB) includes $N^{RB}{}_{sc}$ consecutive subcarriers. A resource block is a generic name of a common resource block, a physical resource block (PRB), and a virtual resource block (VRB). It is $N^{RB}{}_{sc}=12$.

[0050] A resource block unit is a set of resources that corresponds to one OFDM symbol in one resource block. That is, one resource block unit includes 12 resource elements which corresponds to one OFDM symbol in one resource block.

[0051] Common resource blocks for a subcarrier-spacing configuration u are indexed in ascending order from 0 in the frequency domain in a common resource block-set. The common resource block with index 0 for the subcarrier-spacing configuration u includes (or collides with, matches) the point **3000**. The index $n^u{}_{CRB}$ of the common resource block with respect to the subcarrier-spacing configuration u satisfies the relationship of $n^u{}_{CRB}=\mathrm{ceil}\ (k_{sc}/N^{RB}{}_{sc})$. The subcarrier with $k_{sc}=0$ is a subcarrier with the same center frequency as the center frequency of the subcarrier which corresponds to the point **3000**.

[0052] Physical resource blocks for a subcarrier-spacing configuration u are indexed in ascending order from 0 in the frequency domain in a BWP. The index $n^u{}_{PRB}$ of the physical resource block with respect to the subcarrier-spacing configuration u satisfies the relationship of $n^u{}_{CRB}=n^u{}_{PRB}+N^{start,u}{}_{BWP,i}$. The $N^{start,u}{}_{BWP,i}$ indicates the reference point of BWP with index i.

[0053] A BWP is defined as a subset of common resource blocks included in the resource grid. The BWP includes $N^{size,\ u}{}_{BWP,i}$ common resource blocks starting from the reference points $N^{start,u}{}_{BWP,i}$. A BWP for the downlink component carrier is also referred to as a downlink BWP. A BWP for the uplink component carrier is also referred to as an uplink BWP. A BWP for the sidelink is also referred to as a sidelink BWP.

[0054] An antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed. For example, the channel may correspond to a physical channel. For example, the symbols may correspond to OFDM symbols. For example, the symbols may correspond to resource block units. For example, the symbols may correspond to resource elements.

[0055] Two antenna ports are said to be QCL (Quasi Co-Located) if the large-scale properties of the channel over which a symbol on one antenna port is conveyed can be inferred from the channel over which a symbol on the other antenna port is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, average delay, and spatial Rx parameters.

[0056] Carrier aggregation may be communication using a plurality of aggregated serving cells. Carrier aggregation may be communication using a plurality of aggregated component carriers. Carrier aggregation may be communication using a plurality of aggregated downlink component carriers. Carrier aggregation may be communication using a plurality of aggregated uplink component carriers.

[0057] FIG. **5** is a schematic block diagram showing a configuration example of the base station device **3**. As shown in FIG. **5**, the base station device **3** includes at least a part or all of the wireless transmission/reception unit (physical layer processing unit) **30** and the higher-layer processing unit **34**. The wireless transmission/reception unit **3**U includes at least a part or all of the antenna unit **31**, the RF unit **32** (Radio Frequency unit **32**), and the baseband unit **33**. The higher-layer processing unit **34** includes at least a part or all of the medium access control layer processing unit **35** and the radio resource control (RRC) layer processing unit **36**.

[0058] The wireless transmission/reception unit **30** includes at least a part of or all of a wireless transmission unit **30***a* and a wireless reception unit **30***b*. The configuration of the baseband unit **33** included in the wireless transmission unit **30***a* and the configuration of the baseband unit **33** included in the wireless reception unit **30***b* may be the same or different. The configuration of the RF unit **32** included in the wireless transmission unit **30***a* and the configuration of the RF unit **32** included in the wireless reception unit **30***b* may be the same or different. The configuration of the antenna unit **31** included in the wireless transmission unit **30***a* and the configuration of the antenna unit **31** included in the wireless reception unit **30***b* may be the same or different.

[0059] The higher-layer processing unit **34** provides downlink data (a transport block) to the wireless transmission/reception unit **30** (or the wireless transmission unit **30***a*). The higher-layer processing unit **34** performs processing of a medium access control (MAC) layer, a packet data convergence protocol layer (PDCP layer), a radio link control layer (RLC layer) and/or an RRC layer.

[0060] The medium access control layer processing unit **35** included in the higher-layer processing unit **34** performs processing of the MAC layer.

[0061] The radio resource control layer processing unit **36** included in the higher-layer processing unit **34** performs the process of the RRC layer. The radio resource control layer processing unit **36** manages various configuration information/parameters (RRC parameters) of the terminal device **1**. The radio resource control layer processing unit **36** configures an RRC parameter based on the RRC message received from the terminal device **1**.

[0062] The wireless transmission/reception unit **30** (or the wireless transmission unit **30***a*) performs processing such as encoding and modulation. The wireless transmission/reception unit **30** (or the wireless transmission unit **30***a*) generates a physical signal by encoding and modulating the downlink data. The wireless transmission/reception unit **30** (or the wireless transmission unit **30***a*) converts OFDM symbols in the physical signal to a baseband signal by conversion to a time-continuous signal. The wireless transmission/reception unit **30** (or the wireless transmission unit **30***a*) transmits the baseband signal (or the physical signal) to the terminal device **1** via radio frequency. The wireless transmission/reception unit **30** (or the wireless transmission unit **30***a*) may arrange the baseband signal (or the physical signal) on a component carrier and transmit the baseband signal (or the physical signal) to the terminal device **1**.

[0063] The wireless transmission/reception unit **30** (or the wireless reception unit **30***b*) performs processing such as demodulation and decoding. The wireless transmission/reception unit **30** (or the wireless reception unit **30***b*) separates, demodulates and decodes the received physical signal, and provides the decoded information to the higher-layer processing unit **34**. The wireless transmission/reception unit **30** (or the wireless reception unit **30***b*) may perform the channel access procedure prior to the transmission of the physical signal.

[0064] The RF unit **32** demodulates the physical signal received via the antenna unit **31** into a baseband signal (down convert), and/or removes extra frequency components. The RF unit **32** provides the processed analog signal to the baseband unit **33**.

[0065] The baseband unit **33** converts an analog signal (signals on radio frequency) input from the RF unit **32** into a digital signal (a baseband signal). The baseband unit **33** separates a portion which corresponds to CP (Cyclic Prefix) from the digital signal. The baseband unit **33** performs Fast Fourier Transformation (FFT) on the digital signal from which the CP has been removed. The baseband unit **33** provides the physical signal in the frequency domain.

[0066] The baseband unit **33** performs Inverse Fast Fourier Transformation (IFFT) on downlink data to generate an OFDM symbol, adds a CP to the generated OFDM symbol, generates a digital signal (baseband signal), and convert the digital signal into an analog signal. The baseband unit **33** provides the analog signal to the RF unit **32**.

[0067] The RF unit **32** removes extra frequency components from the analog signal (signals on radio frequency) input from the baseband unit **33**, up-converts the analog signal to a radio frequency, and transmits it via the antenna unit **31**. The RF unit **32** may have a function of controlling transmission power. The RF unit **32** is also referred to as a transmission power control unit.

[0068] At least one or more serving cells (or one or more component carriers, one or more downlink component carriers, one or more uplink component carriers) may be configured for the terminal device **1**.

[0069] Each of the serving cells set for the terminal device **1** may be any of PCell (Primary cell), PSCell (Primary SCG cell), and SCell (Secondary Cell).

[0070] A PCell is a serving cell included in a MCG (Master Cell Group). A PCell is a cell (implemented cell) which performs an initial connection establishment procedure or a connection re-establishment procedure by the terminal device **1**.

[0071] A PSCell is a serving cell included in a SCG (Secondary Cell Group). A PSCell is a serving cell in which random-access is performed by the terminal device **1** in a reconfiguration procedure with synchronization (Reconfiguration with synchronization).

[0072] A SCell may be included in either a MCG or a SCG.

[0073] The serving cell group (cell group) is a designation including at least MCG and SCG. The serving cell group may include one or more serving cells (or one or more component carriers). One or more serving cells (or one or more component carriers) included in the serving cell group may be operated by carrier aggregation.

[0074] One or more downlink BWPs may be configured for each serving cell (or each downlink component carrier). One or more uplink BWPs may be configured for each serving cell (or each uplink component carrier).

[0075] Among the one or more downlink BWPs set for the serving cell (or the downlink component carrier), one downlink BWP may be set as an active downlink BWP (or one downlink BWP may be activated). Among the one or more uplink BWPs set for the serving cell (or the uplink component carrier), one uplink BWP may be set as an active uplink BWP (or one uplink BWP may be activated).

[0076] A PDSCH, a PDCCH, a CSI-RS and other physical downlink channels/signals may be received in the active downlink BWP. The terminal device **1** may receive the PDSCH, the PDCCH, and the CSI-RS in the active downlink BWP. Additionally, in some case, the terminal device **1** may receive the CSI-RS or other physical downlink channels/signals (e.g., Positioning RS (PRS)) in the downlink BWP that is not active or in the cell that is not a serving cell. A PUCCH, a PUSCH, an SRS and other physical uplink channels/signals may be sent on the active uplink BWP. The terminal device **1** may transmit the PUCCH, the PUSCH, the SRS and other physical uplink channels/signals in the active uplink BWP. Additionally, in some case, the terminal device **1** may receive the SRS or other physical uplink channels/signals (e.g., SRS for Positioning) in the uplink BWP that is not active or in the cell that is not a serving cell. The active downlink BWP and the active uplink BWP are also referred to as active BWP.

[0077] Downlink BWP switching deactivates an active downlink BWP and activates one of inactive downlink BWPs which are other than the active downlink BWP. The downlink BWP switching may be controlled by a BWP field included in a downlink control information. The downlink BWP switching may be controlled based on higher-layer parameters.

[0078] Uplink BWP switching is used to deactivate an active uplink BWP and activate any inactive uplink BWP which is other than the active uplink BWP. Uplink BWP switching may be controlled by a BWP field included in a downlink control information. The uplink BWP switching may be controlled based on higher-layer parameters.

[0079] Among the one or more downlink BWPs set for the serving cell, two or more downlink BWPs may not be set as active downlink BWPs. For the serving cell, one downlink BWP may be active at a certain time.

[0080] Among the one or more uplink BWPs set for the serving cell, two or more uplink BWPs may not be set as active uplink BWPs. For the serving cell, one uplink BWP may be active at a certain time.

[0081] The aforementioned procedures for Uplink BWP may be applicable to Sidelink BWP.

[0082] FIG. **6** is a schematic block diagram showing a configuration example of the terminal device **1**. As shown in FIG. **6**, the terminal device **1** includes at least a part or all of the wireless transmission/reception unit (physical layer processing unit) **10** and the higher-layer processing unit **14**. The wireless transmission/reception unit **10** includes at least a part or all of the antenna unit **11**, the RF unit **12**, and the baseband unit **13**. The higher-layer processing unit **14** includes at least a part or all of the medium access control layer processing unit **15** and the radio resource control layer processing unit **16**.

[0083] The wireless transmission/reception unit **10** includes at least a part of or all of a wireless transmission unit **10***a* and a wireless reception unit **10***b*. The configuration of the baseband unit **13** included in the wireless transmission unit **10***a* and the configuration of the baseband unit **13** included in the wireless reception unit **10***b* may be the same or different. The configuration of the RF unit **12** included in the wireless transmission unit **10***a* and the RF unit **12** included in the wireless reception unit **10***b* may be the same or different. The configuration of the antenna unit **11** included in the wireless transmission unit **10***a* and the configuration of the antenna unit **11** included in the wireless reception unit **10***b* may be the same or different.

[0084] The higher-layer processing unit **14** provides uplink or sidelink data (a transport block) to the wireless transmission/reception unit **10** (or the wireless transmission unit **10***a*). The higher-layer processing unit **14** performs processing of a MAC layer, a packet data integration protocol layer, a radio link control layer, and/or an RRC layer. The higher-layer processing unit **14** may also performs processing of a MAC layer, a packet data integration protocol layer, a radio link control layer, and/or an RRC layer for PC5.

[0085] The medium access control layer processing unit **15** included in the higher-layer processing unit **14** performs processing of the MAC layer.

[0086] The radio resource control layer processing unit **16** included in the higher-layer processing unit **14** performs the process of the RRC layer and/or the PC5 RRC (PC5-RRC) process. The radio resource control layer processing unit **16** manages various configuration information/parameters (RRC parameters and/or PC5 RRC (PC5-RRC) parameters) of the terminal device **1**. The radio resource control layer processing unit **16** configures RRC parameters based on the RRC message received from the base station device **3** and/or PC5 RRC parameters based on the PC5 RRC (PC5-RRC) message received from another terminal device.

[0087] The wireless transmission/reception unit **10** (or the wireless transmission unit **10***a*) performs processing such as encoding and modulation. The wireless transmission/reception unit **10** (or the wireless transmission unit **10***a*) generates a physical signal by encoding and modulating the uplink data and/or sidelink data. The wireless transmission/reception unit **10** (or the wireless transmission unit **10***a*) converts OFDM symbols in the physical signal to a baseband signal by conversion to a time-continuous signal. The wireless transmission/reception unit **10** (or the wireless transmission unit **10***a*) transmits the baseband signal (or the physical signal) to the base station device **3** or to another terminal device via radio frequency. The wireless transmission/reception unit **10** (or the wireless transmission unit **10***a*) may arrange the baseband signal (or the physical signal) on a BWP (active uplink BWP) and transmit the baseband signal (or the physical signal) to the base station device **3**.

[0088] The wireless transmission/reception unit **10** (or the wireless reception unit **10***b*) performs processing such as demodulation and decoding. The wireless transmission/reception unit **10** (or the wireless reception unit **10***b*) may receive a physical signal in a BWP (active downlink BWP) of a serving cell and/or in a Sidelink BWP. The wireless transmission/reception unit **10** (or the wireless reception unit **10***b*) separates, demodulates and decodes the received physical signal, and provides the decoded information to the higher-layer processing unit **14**. The wireless transmission/reception unit **10** (or the wireless reception unit **10***b*) may perform the channel access procedure prior to the transmission of the physical signal.

[0089] The RF unit **12** demodulates the physical signal received via the antenna unit **11** into a baseband signal (down convert), and/or removes extra frequency components. The RF unit **12** provides the processed analog signal to the baseband unit **13**.

[0090] The baseband unit **13** converts an analog signal (signals on radio frequency) input from the RE unit **12** into a digital signal (a baseband signal). The baseband unit **13** separates a portion which corresponds to CP from the digital signal, performs fast Fourier transformation on the digital signal from which the CP has been removed, and provides the physical signal in the frequency domain.

[0091] The baseband unit **13** performs inverse fast Fourier transformation on uplink data to generate an OFDM symbol, adds a CP to the generated OFDM symbol, generates a digital signal (baseband signal), and convert the digital signal into an analog signal. The baseband unit **13** provides the analog signal to the RF unit **12**.

[0092] The RF unit **12** removes extra frequency components from the analog signal (signals on radio frequency) input from the baseband unit **13**, up-converts the analog signal to a radio frequency, and transmits it via the antenna unit **11** The RF unit **12** may have a function of controlling transmission power. The RF unit **12** is also referred to as a transmission power control unit.

[0093] Hereinafter, physical signals (signals) will be described.

[0094] Physical signal is a generic term for downlink physical channels, downlink physical signals, uplink physical channels, uplink physical channels, sidelink physical channels, and sidelink physical channels. The physical channel is a generic term tor downlink physical channels, uplink physical channels and sidelink physical channels.

[0095] An uplink physical channel may correspond to a set of resource elements that carry information originating from the higher-layer and/or uplink control information. The uplink physical channel may be a physical channel used in an uplink component carrier. The uplink physical channel may be transmitted by the terminal device **1**. The uplink physical channel may be received by the base station device **3**. In the wireless communication system according to one aspect of the present embodiment, at least part or all of PUCCH (Physical Uplink Control CHannel), PUSCH (Physical Uplink Shared CHannel), and PRACH (Physical Random Access CHannel) may be used.

[0096] A PUCCH may be used to transmit uplink control information (UCI). The PUCCH may be sent to deliver (transmission, convey) uplink control information. The uplink control information may be mapped to (or arranged in) the PUCCH. The terminal device **1** may transmit PUCCH in which uplink control information is arranged. The base station device **3** may receive the PUCCH in which the uplink control information is arranged.

[0097] Uplink control information (uplink control information bit, uplink control information sequence, uplink control information type) includes at least part or all of channel state information (CSI), scheduling request (SR), and HARQ-ACK (Hybrid Automatic Repeat request ACKnowledgement).

[0098] Channel state information is conveyed by using channel state information bits or a channel state information sequence. Scheduling request is also referred to as a scheduling request bit or a scheduling request sequence. HARQ-ACK information is also referred to as a HARQ-ACK information bit or a HARQ-ACK information sequence.

[0099] HARQ-ACK information may include HARQ-ACK status which corresponds to a transport block (TB: Transport block, MAC PDU: Medium Access Control Protocol Data Unit, DL-SCH: Downlink-Shared Channel, UL-SCH: Uplink-Shared Channel, PDSCH: Physical Downlink Shared CHannel, PUSCH: Physical Uplink Shared CHannel). The HARQ-ACK status may indicate ACK (acknowledgement) or NACK (negative-acknowledgement) corresponding to the transport block. The ACK may indicate that the transport block has been successfully decoded. The NACK may indicate that the transport block has not been successfully decoded. The HARQ-ACK information may include a HARQ-ACK codebook that includes one or more HARQ-ACK status (or HARQ-ACK bits).

[0100] For example, the correspondence between the HARQ-ACK information and the transport block may mean that the HARQ-ACK information and the PDSCH used for transmission of the transport block correspond.

[0101] HARQ-ACK status may indicate ACK or NACK which correspond to one CBG (Code Block Group) included in the transport block.

[0102] The scheduling request may at least be used to request PUSCH (or UL-SCH) resources for new transmission. The scheduling request may be used to indicate either a positive SR or a negative SR. The fact that the scheduling request indicates a positive SR is also referred to as "a positive SR is sent". The positive SR may indicate that the PUSCH (or UL-SCH) resource for initial transmission is requested by the terminal device **1**. A positive SR may indicate that a higher-layer is to trigger a scheduling request. The positive SR may be sent when the higher-layer instructs to send a scheduling request. The fact that the scheduling request bit indicates a negative SR is also referred to as "a negative SR is sent". A negative SR may indicate that the PUSCH (or UL-SCH) resource for initial transmission is not requested by the terminal device **1**. A negative SR may indicate that the higher-layer does not trigger a scheduling request. A negative SR may be sent if the higher-layer is not instructed to send a scheduling request.

[0103] The channel state information may include at least part or all of a channel quality indicator (CQI), a precoder matrix indicator (PMI), and a rank indicator (RI). CQI is an indicator related to channel quality (e.g., propagation quality) or physical channel quality, and PMI is an indicator related to a precoder. RI is an indicator related to transmission rank (or the number of transmission layers).

[0104] Channel state information may be provided at least based on receiving one or more physical signals (e.g., one or more CSI-RSs) used at least for channel measurement. The channel state information may be selected by the terminal device **1** at least based on receiving one or more physical signals used for channel measurement. Channel measurements may include interference measurements.

[0105] A PUCCH may correspond to a PUCCH format. A PUCCH may be a set of resource elements used to convey a PUCCH format. A PUCCH may include a PUCCH format. A PUCCH format may include UCI.

[0106] A PUSCH may be used to transmit uplink data (a transport block) and/or uplink control information. A PUSCH may be used to transmit uplink data (a transport block) corresponding to a UL-SCH and/or uplink control information. A PUSCH may be used to convey uplink data (a transport block) and/or uplink control information. A PUSCH may be used to convey uplink data (a transport block) corresponding to a UL-SCH and/or uplink control information. Uplink data (a transport block) may be arranged in a PUSCH. Uplink data (a transport block) corresponding to UL-SCH may be arranged in a PUSCH. Uplink control information may be arranged to a PUSCH. The terminal device **1** may transmit a PUSCH in which uplink data (a transport block) and/or uphnk control information is arranged. The base station device **3** may receive a PUSCH in which uplink data (a transport block) and/or uplink control information is arranged.

[0107] A PRACH may be used to transmit a random-access preamble. The PRACH may be used to convey a random-access preamble. The sequence $x_{u,\ v}$ (n) of the PRACH is defined by $x_{u,\ v}(n)=x_u(\mathrm{mod}\ (n+C_v,\ L_{RA}))$. The x_u may be a ZC sequence (Zadoff-Chu sequence). The x_u may be defined by $x_u=\exp\ (-jpui\ (i+1)/L_{RA})$. The j is an imaginary unit. The p is the circle ratio. The Cv corresponds to cyclic shift of the PRACH. L_{RA} corresponds to the length of the PRACH. The L_{RA} may be 839 or 139 or another value. The i is an integer in the range of 0 to $L_{RA}-1$. The u is a sequence index for the PRACH. The terminal device **1** may transmit the PRACH. The base station device **3** may receive the PRACH.

[0108] For a given PRACH opportunity, 64 random-access preambles are defined. The random-access preamble is specified (determined, given) at least based on the cyclic shift C, of the PRACH and the sequence index u for the PRACH.

[0109] An uplink physical signal may correspond to a set of resource elements. The uplink physical signal may not carry information generated in the higher-layer. The uplink physical signal may be a physical signal used in the uplink component carrier. The terminal device **1** may transmit an uplink physical signal. The base station device **3** may receive the uplink physical signal. In the radio communication system according to one aspect of the present embodiment, at least a part or all of UL DMRS (UpLink Demodulation Reference Signal), SRS (Sounding Reference Signal), UL PTRS (UpLink Phase Tracking Reference Signal) may be used.

[0110] UL DMRS is a generic name of a DMRS for a PUSCH and a DMRS for a PUCCH.

[0111] A set of antenna ports of a DMRS for a PUSCH (a DMRS associated with a PUSCH, a DMRS included in a PUSCH, a DMRS which corresponds to a PUSCH) may be given based on a set of antenna ports for the PUSCH. That is, the set of DMRS antenna ports for the PUSCH may be the same as the set of antenna ports for the PUSCH.

[0112] Transmission of a PUSCH and transmission of a DMRS for the PUSCH may be indicated (or scheduled) by one DCI format. The PUSCH and the DMRS for the PUSCH may be collectively referred to as a PUSCH. Transmission of the PUSCH may be transmission of the PUSCH and the DMRS for the PUSCH.

[0113] A PUSCH may be estimated from a DMRS for the PUSCH. That is, propagation path of the PUSCH may be estimated from the DMRS for the PUSCH.

[0114] A set of antenna ports of a DMRS for a PUCCH (a DMRS associated with a PUCCH, a DMRS included in a PUCCH, a DMRS which corresponds to a PUCCH) may be identical to a set of antenna ports for the PUCCH.

[0115] Transmission of a PUCCH and transmission of a DMRS for the PUCCH may be indicated (or triggered) by one DCI format. The arrangement of the PUCCH in resource elements (resource element mapping) and/or the arrangement of the DMRS in resource elements for the PUCCH may be provided at least by one PUCCH format. The PUCCH and the DMRS for the PUCCH may be collectively referred to as PUCCH. Transmission of the PUCCH may be transmission of the PUCCH and the DMRS for the PUCCH.

[0116] A PUCCH may be estimated from a DMRS for the PUCCH. That is, propagation path of the PUCCH may be estimated from the DMRS for the PUCCH.

[0117] A downlink physical channel may correspond to a set of resource elements that carry information originating from the higher-layer and/or downlink control information. The downlink physical channel may be a physical channel used in the downlink component carrier. The base station device **3** may transmit the downlink physical channel. The terminal device **1** may receive the downlink physical channel. In the wireless communication system according to one aspect of the present embodiment, at least a part or all of PBCH (Physical Broadcast Channel), PDCCH (Physical Downlink Control Channel), and PDSCH (Physical Downlink Shared Channel) may be used.

[0118] The PBCH may be used to transmit a MIB (Master Information Block) and/or physical layer control information. The physical layer control information is a kind of downlink control information. The PBCH may be sent to deliver the MIB and/or the physical layer control information. A BCH may be mapped (or corresponding) to the PBCH. The terminal device **1** may receive the PBCH. The base station device **3** may transmit the PBCH. The physical layer control information is also referred to as a PBCH payload and a PBCH payload related to timing. The MIB may include one or more higher-layer parameters.

[0119] Physical layer control information includes 8 bits. The physical layer control information may include at least part or all of 0A to 0D. The 0A is radio frame information. The GB is half radio frame information (half system frame information). The 0C is SS/PBCH block index information. The GD is subcarrier offset information.

[0120] The radio frame information is used to indicate a radio frame in which the PBCH is transmitted (a radio frame including a slot in which the PBCH is transmitted). The radio frame information is represented by 4 bits. The radio frame information may be represented by 4 bits of a radio frame indicator. The radio frame indicator may include 10 bits. For example, the radio frame indicator may at least be used to identity a radio frame from index 0 to index 1023.

[0121] The half radio frame information is used to indicate whether the PBCH is transmitted in first five subframes or in second five subframes among radio frames in which the PBCH is transmitted. Here, the half radio frame may be configured to include five subframes. The half radio frame may be configured by five subframes of the first half of ten subframes included in the radio frame. The half radio frame may be configured by five subframes in the second half of ten subframes included in the radio frame.

[0122] The SS/PBCH block index information is used to indicate an SS/PBCH block index. The SS/PBCH block index information may be represented by 3 bits. The SS/PBCH block index information may consist of 3 bits of an SS/PBCH block index indicator. The SS/PBCH block index indicator may include 6 bits. The SS/PBCH block index indicator may at least be used to identify an SS/PBCH block from index 0 to index 63 (or from index 0 to index 3, from index 0 to index 7, from index 0 to index 9, from index 0 to index 19, etc.).

[0123] The subcarrier offset information is used to indicate subcarrier offset. The subcarrier offset information may be used to indicate the difference between the first subcarrier in which the PBCH is arranged and the first subcarrier in which the control resource set with index 0 is arranged.

[0124] A PDCCH may be used to transmit downlink control information (DCI). A PDCCH may be transmitted to deliver downlink control information. Downlink control information may be mapped to a PDCCH. The terminal device **1** may receive a PDCCH in which downlink control information is arranged. The base station device **3** may transmit the PDCCH in which the downlink control information is arranged.

[0125] Downlink control information may correspond to a DCI format. Downlink control information may be included in a DCI format. Downlink control information may be arranged in each field of a DCI format.

[0126] DCI format is a generic name for DCI format 0_0, DCI format 0_1, DCI format 1_0, and DCI format 1_1. Uplink DCI format is a generic name of the DCI format 0_0 and the DCI format 0_1. Downlink DCI format is a generic name of the DCI format 1_0 and the DCI format 1_1.

[0127] A PDSCH may be used to transmit one or more transport blocks. A PDSCH may be used to transmit one or more transport blocks which corresponds to a DL-SCH. A PDSCH may be used to convey one or more transport blocks. A PDSCH may be used to convey one or more transport blocks which corresponds to a DL-SCH. One or more transport blocks may be arranged in a PDSCH. One or more transport blocks which corresponds to a DL-SCH may be arranged in a PDSCH. The base station device **3** may transmit a PDSCH. The terminal device **1** may receive the PDSCH.

[0128] Downlink physical signals may correspond to a set of resource elements. The downlink physical signals may not carry the information generated in the higher-layer. The downlink physical signals may be physical signals used in the downlink component carrier. A downlink physical signal may be transmitted by the base station device **3**. The downlink physical signal may be transmitted by the terminal device **1**. In the wireless communication system according to one aspect of the present embodiment, at least a part or all of an SS (Synchronization signal), DL DMRS (DownLink DeModulation Reference Signal), CSI-RS (Channel State Information-Reference Signal), and DL PTRS (DownLink Phase Tracking Reference Signal) may be used.

[0129] The synchronization signal may be used at least for the terminal device **1** to synchronize in the frequency domain and/or time domain for downlink. The synchronization signal is a generic name of PSS (Primary Synchronization Signal) and SSS (Secondary Synchronization Signal).

[0130] FIG. **7** is a diagram showing a configuration example of an SS/PBCH block. In FIG. **7**, the horizontal axis indicates time domain (OFDM symbol index Lsym), and the vertical axis indicates frequency domain. The shaded blocks indicate a set of resource elements for a PSS. The blocks of grid lines indicate a set of resource elements for an SSS. Also, the blocks in the horizontal line indicate a set of resource elements for a PBCH and a set of resource elements for a DMRS for the PBCH (DMRS related to the PBCH, DMRS included in the PBCH, DMRS which corresponds to the PBCH).

[0131] As shown in FIG. **7**, the SS/PBCH block includes a PSS, an SSS, and a PBCH. The SS/PBCH block includes 4 consecutive OFDM symbols. The SS/PBCH block includes 240 subcarriers. The PSS is allocated to the 57th to 183rd subcarriers in the first OFDM symbol. The SSS is allocated to the 57th to 183rd subcarriers in the third OFDM symbol. The first to 56th subcarriers of the first OFDM symbol may be set to zero. The 184th to 240th subcarriers of the first OFDM symbol may be set to zero. The 49th to 56th subcarriers of the third OFDM symbol may be set to zero. The 184th to 192nd subcarriers of the third OFDM symbol may be set to zero. In the first to 240th subcarriers of the second OFDM symbol, the PBCH is allocated to subcarriers in which the DMRS for the PBCH is not allocated. In the first to 48th subcarriers of the third OFDM symbol, the PBCH is allocated to subcarriers in which the DMRS for the PBCH is not allocated. In the 193rd to 240th subcarriers of the third OFDM symbol, the PBCH is allocated to subcarriers in which the DMRS for the PBCH is not allocated. In the first to 240th subcarriers of the 4th OFDM symbol, the PBCH is allocated to subcarriers in which the DMRS for the PBCH is not allocated.

[0132] The antenna ports of a PSS, an SSS, a PBCH, and a DMRS for the PBCH in an SS/PBCH block may be identical.

[0133] A PBCH may be estimated from a DMRS for the PBCH. For the DM-RS for the PBCH, the channel over which a symbol for the PBCH on an antenna port is conveyed can be inferred from the channel over which another symbol for the DM-RS on the antenna port is conveyed only if the two symbols are within a SS/PBCH block transmitted within the same slot, and with the same SS/PBCH block index.

[0134] DL DMRS is a generic name of DMRS for a PBCH, DMRS for a PDSCH, and DMRS for a PDCCH.

[0135] A set of antenna ports for a DMRS for a PDSCH (a DMRS associated with a PDSCH, a DMRS included in a PDSCH, a DMRS which corresponds to a PDSCH) may be given based on the set of antenna ports for the PDSCH. The set of antenna ports for the DMRS for the PDSCH may be the same as the set of antenna ports for the PDSCH.

[0136] Transmission of a PDSCH and transmission of a DMRS for the PDSCH may be indicated (or scheduled) by one DCI format. The PDSCH and the DMRS for the PDSCH may be collectively referred to as PDSCH. Transmitting a PDSCH may be transmitting a PDSCH and a DMRS for the PDSCH.

[0137] A PDSCH may be estimated from a DMRS for the PDSCH. For a DM-RS associated with a PDSCH, the channel over which a symbol for the PDSCH on one antenna port is conveyed can be inferred from the channel over which another symbol for the DM-RS on the antenna port is conveyed only if the two symbols are within the same resource as the scheduled PDSCH, in the same slot, and in the same PRG (Precoding Resource Group).

[0138] Antenna ports for a DMRS for a PDCCH (a DMRS associated with a PDCCH, a DMRS included in a PDCCH, a DMRS which corresponds to a PDCCH) may be the same as an antenna port for the PDCCH.

[0139] A PDCCH may be estimated from a DMRS for the PDCCH. For a DM-RS associated with a PDCCH, the channel over which a symbol for the PDCCH on one antenna port is conveyed can be inferred from the channel over which another symbol for the DM-RS on the same antenna port is conveyed only if the two symbols are within resources for which the UE may assume the same precoding being used (i.e. within resources in a REG bundle).

[0140] A BCH (Broadcast CHannel), a UL-SCH (Uplink-Shared CHannel) and a DL-SCH (Downlink-Shared CHannel) are transport channels. A channel used in the MAC layer is called a transport channel. A unit of transport channel used in the MAC layer is also called transport block (TB) or MAC PDU (Protocol Data Unit). In the MAC layer, control of HARQ (Hybrid Automatic Repeat request) is performed for each transport block. The transport block is a unit of data delivered by the MAC layer to the physical layer. In the physical layer, transport blocks are mapped to codewords and modulation processing is performed for each codeword.

[0141] One UL-SCH and one DL-SCH may be provided for each serving cell. BCH may be given to PCell. BCH may not be given to PSCell and SCell.

[0142] A BCCH (Broadcast Control CHannel), a CCCH (Common Control CHannel), and a DCCH (Dedicated Control CHannel) are logical channels. The BCCH is a channel of the RRC layer used to deliver MIB or system information. The CCCH may be used to transmit a common RRC message in a plurality of terminal devices **1**. The UCH may be used for the terminal device **1** which is not connected by RRC. The DCCH may be used at least to transmit a dedicated RRC message to the terminal device **1**. The DCCH may be used for the terminal device **1** that is in RRC-connected mode.

[0143] The RRC message includes one or more RRC parameters (information elements, higher layer parameters). For example, the RRC message may include a MIB. For example, the RRC message may include system information (SIB: System Information Block, MIB). SIB is a generic name for various type of SIBs (e.g., SIB1, SIB2). For example, the RRC message may include a message which corresponds to a CCCH. For example, the RRC message may include a message which corresponds to a DCCH. RRC message is a general term for common RRC message and dedicated RRC message.

[0144] The BCCH in the logical channel may be mapped to the BCH or the DL-SCH in the transport channel. The CCCH in the logical channel may be mapped to the DL-SCH or the UL-SCH in the transport channel. The DCCH in the logical channel may be mapped to the DL-SCH or the UL-SCH in the transport channel.

[0145] The UL-SCH in the transport channel may be mapped to a PUSCH in the physical channel. The DL-SCH in the transport channel may be mapped to a PDSCH in the physical channel. The BCH in the transport channel may be mapped to a PBCH in the physical channel.

[0146] A higher-layer parameter is a parameter included in an RRC message or a MAC CE (Medium Access Control Control Element). The higher-layer parameter is a generic name of information included in a MIB, system information, a message which corresponds to CCCH, a message which corresponds to DCCH, and a MAC CE. A higher-layer parameter may be referred to as an RRC parameter or an RRC configuration if the higher-layer parameter is the parameter included in the RRC message.

[0147] A higher-layer parameter may be a cell-specific parameter or a UE-specific parameter. A cell-specific parameter is a parameter including a common configuration in a cell. A UE-specific parameter is a parameter including a configuration that may be configured differently for each UE.

[0148] The base station device may indicate change of cell-specific parameters by reconfiguration with random-access. The UE may change cell-specific parameters before triggering random-access. The base station device may indicate change of UE-specific parameters by reconfiguration with or without random-access. The UE may change UE-specific parameters before or after random-access.

[0149] The procedure performed by the terminal device **1** includes at least a part or all of the following 5A to 5C. The 5A is cell search. The 5B is random-access. The 5C is data communication.

[0150] The cell search is a procedure used by the terminal device **1** to synchronize with a cell in the time domain and/or the frequency domain and to detect a physical cell identity. The terminal device **1** may detect the physical cell ID by performing synchronization of time domain and/or frequency domain with a cell by the cell search.

[0151] A sequence of a PSS is given based at least on a physical cell ID. A sequence of an SSS is given based at least on the physical cell ID.

[0152] An SS/PBCH block candidate indicates a resource for which transmission of the SS/PBCH block may exist. An SS/PBCH block may be transmitted at a resource indicated as the SS/PBCH block candidate. The base station device **3** may transmit an SS/PBCH block at an SS/PBCH block candidate. The terminal device **1** may receive (detect) the SS/PBCH block at the SS/PBCH block candidate.

[0153] A set of SS/PBCH block candidates in a half radio frame is also referred to as an SS-burst-set. The SS-burst-set is also referred to as a transmission window, a SS transmission window, or a DRS transmission window (Discovery Reference Signal transmission window). The SS-burst-set is a generic name that includes at least a first SS-burst-set and a second SS-burst-set.

[0154] The base station device **3** transmits SS/PBCH blocks of one or more indexes at a predetermined cycle. The terminal device **1** may detect an SS/PBCH block of at least one of the SS/PBCH blocks of the one or more indexes. The terminal device **1** may attempt to decode the PBCH included in the SS/PBCH block.

[0155] The random-access is a procedure including at least a part or all of message **1**, message **2**, message **3**, and message **4**.

[0156] The message **1** is a procedure in which the terminal device **1** transmits a PRACH. The terminal device **1** transmits the PRACH in one PRACH occasion selected from among one or more PRACH occasions based on at least the index of the SS/PBCH block candidate detected based on the cell search.

[0157] The message **2** is a procedure in which the terminal device **1** attempts to detect a DCI format 1_0 with CRC (Cyclic Redundancy Check) scrambled by an RA-RNTI (Random Access-Radio Network Temporary Identifier). The terminal device **1** may attempt to detect the DCI format 1_0 in a search-space-set.

[0158] The message **3** (Msg **3**) is a procedure for transmitting a PUSCH scheduled by a random-access response grant included in the DCI format 1_0 detected in the message **2** procedure. The random-access response grant is indicated by the MAC CE included in the PDSCH scheduled by the DCI format 1_0.

[0159] The PUSCH scheduled based on the random-access response grant is either a message **3** PUSCH or a PUSCH. The message **3** PUSCH contains a contention resolution identifier MAC CE. The contention resolution ID MAC CE includes a contention resolution ID.

[0160] Retransmission of the message **3** PUSCH is scheduled by DCI format 0_0 with CRC scrambled by a TC-RNTI (Temporary Cell-Radio Network Temporary Identifier).

[0161] The message **4** is a procedure that attempts to detect a DCI format 1_0 with CRC scrambled by either a C-RNTI (Cell-Radio Network Temporary Identifier) or a TC-RNTI. The terminal device **1** receives a PDSCH scheduled based on the DCI format 1_0. The PDSCH may include a collision resolution ID.

[0162] Data communication is a generic term for downlink communication and uplink communication.

[0163] In data communication, the terminal device **1** attempts to detect a PDCCH (attempts to monitor a PDCCH, monitors a PDCCH). in a resource identified at least based on one or all of a control resource set and a search-space-set. It's also called as "the terminal device **1** attempts to detect a PDCCH in a control resource set", "the terminal device **1** attempts to detect a PDCCH in a search-space-set", "the terminal device **1** attempts to detect a PDCCH candidate in a control resource set", "the terminal device **1** attempts to detect a PDCCH candidate in a search-space-set", "the terminal device **1** attempts to detect a DCI format in a control resource set", or "the terminal device **1** attempts to detect a DCI format in a search-space-set". Monitonng a PDCCH may be equivalent as monitoring a DCI format in the PDCCH.

[0164] The control resource set is a set of resources configured by the number of resource blocks and a predetermined number of OFDM symbols in a slot.

[0165] The set of resources for the control resource set may be indicated by higher-layer parameters. The number of OFDM symbols included in the control resource set may be indicated by higher-layer parameters.

[0166] A PDCCH may be also called as a PDCCH candidate.

[0167] A search-space-set is defined as a set of PDCCH candidates. A search-space-set may be a Common Search Space (CSS) set or a UE-specific Search Space (USS) set.

[0168] The CSS set is a generic name of a type-0 PDCCH common search-space-set, a type-0a PDCCH common search-space-set, a type-1 PDCCH common search-space-set, a type-2 PDCCH common search-space-set, and a type-3 PDCCH common search-space-set. The USS set may be also called as UE-specific PDCCH search-space-set.

[0169] The type-0 PDCCH common search-space-set may be used as a common search-space-set with index 0. The type-0 PDCCH common search-space-set may be an common search-space-set with index 0.

[0170] A search-space-set is associated with (included in, corresponding to) a control resource set. The index of the control resource set associated with the search-space-set may be indicated by higher-layer parameters.

[0171] For a search-space-set, a part or all of 6A to 6C may be indicated at least by higher-layer parameters. The 6A is PDCCH monitoring period. The 6B is PDCCH monitoring pattern within a slot. The 6C is PDCCH monitoring offset.

[0172] A monitoring occasion of a search-space-set may correspond to one or more OFDM symbols in which the first OFDM symbol of the control resource set associated with the search-space-set is allocated. A monitoring occasion of a search-space-set may correspond to resources identified by the first OFDM symbol of the control resource set associated with the search-space-set. A monitoring occasion of a search-space-set is given based at least on a part or all of PDCCH monitoring periodicity, PDCCH monitoring pattern within a slot, and PDCCH monitoring offset.

[0173] FIG. **8** is a diagram showing an example of the monitoring occasion of the search-space-set. In FIG. **8**, the search-space-set **91** and the search-space-set **92** are sets in the primary cell **301**, the search-space-set **93** is a set in the secondary cell **302**, and the search-space-set **94** is a set in the secondary cell **303**.

[0174] In FIG. **8**, the block indicated by the grid line indicates the search-space-set **91**, the block indicated by the upper right diagonal line indicates the search-space-set **92**, the block indicated by the upper left diagonal line indicates the search-space-set **93**, and the block indicated by the horizontal line indicates the search-space-set **94**.

[0175] In FIG. **8**, the PDCCH monitoring periodicity for the search-space-set **91** is set to 1 slot, the PDCCH monitoring offset for the search-space-set **91** is set to 0_{slot}, and the PDCCH monitoring pattern for the search-space-set **91** is [1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0]. That is, the monitoring occasion of the search-space-set **91** corresponds to the first OFDM symbol (OFDM symbol #0) and the eighth OFDM symbol (OFDM symbol #7) in each of the slots.

[0176] In FIG. **8**, the PDCCH monitoring periodicity for the search-space-set **92** is set to 2 slots, the PDCCH monitoring offset for the search-space-set **92** is set to 0 slots, and the PDCCH monitoring pattern for the search-space-set **92** is [1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]. That is, the monitoring occasion of the search-space-set **92** corresponds to the leading OFDM symbol (OFDM symbol #0) in each of the even slots.

[0177] In FIG. **8**, the PDCCH monitoring periodicity for the search-space-set **93** is set to 2 slots, the PDCCH monitoring offset for the search-space-set **93** is set to 0 slots, and the PDCCH monitoring pattern for the search-space-set **93** is [0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0]. That is, the monitoring occasion of the search-space-set **93** corresponds to the eighth OFDM symbol (OFDM symbol #8) in each of the even slots.

[0178] In FIG. **8**, the PDCCH monitoring periodicity for the search-space-set **94** is set to 2 slots, the PDCCH monitoring offset for the search-space-set **94** is set to 1 slot, and the PDCCH monitoring pattern for the search-space-set **94** is [1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]. That is, the monitoring occasion of the search-space-set **94** corresponds to the leading OFDM symbol (OFDM symbol #0) in each of the odd slots.

[0179] The type-0 PDCCH common search-space-set may be at least used for a DCI format with a cyclic redundancy check (CRC) sequence scrambled by an SI-RNTI (System Information-Radio Network Temporary Identifier).

[0180] The type-0a PDCCH common search-space-set may be used at least for a DCI format with a cyclic redundancy check sequence scrambled by an SI-RNTI.

[0181] The type-1 PDCCH common search-space-set may be used at least for a DCI format with a CRC sequence scrambled by an RA-RNTI (Random Access-Radio Network Temporary Identifier) or a CRC sequence scrambled by a TC-RNTI (Temporary Cell-Radio Network Temporary Identifier).

[0182] The type-2 PDCCH common search-space-set may be used for a DCI format with a CRC sequence scrambled by P-RNTI (Paging-Radio Network Temporary Identifier).

[0183] The type-3 PDCCH common search-space-set may be used for a DCI format with a CRC sequence scrambled by a C-RNTI (Cell-Radio Network Temporary Identifier).

[0184] The UE-specific search-space-set may be used at least for a DCI format with a CRC sequence scrambled by a C-RNTI.

[0185] In downlink communication, the terminal device **1** may detect a downlink DCI format. The detected downlink DCI format is at least used for resource assignment for a PDSCH. The detected downlink DCI format is also referred to as downlink assignment. The terminal device **1** attempts to receive the PDSCH. Based on a PUCCH resource indicated based on the detected downlink DCI format, an HARQ-ACK corresponding to the PDSCH (HARQ-ACK corresponding to a transport block included in the PDSCH) may be reported to the base station device **3**.

[0186] In uplink communication, the terminal device **1** may detect an uplink DCI format. The detected uplink DCI format is at least used for resource assignment for a PUSCH. The detected uplink DCI format is also referred to as uplink grant. The terminal device **1** transmits the PUSCH.

[0187] PUSCH transmission(s) can be dynamically scheduled by an UL grant in a DCI, or the transmission can correspond to a configured grant Type 1 or Type 2. The configured grant Type 1 PUSCH transmission is semi-statically configured to operate upon the reception of higher layer parameter of configuredGrantConfig including rrc-ConfiguredUplinkGrant without the detection of an UL grant in a DCI. The configured grant Type 2 PUSCH transmission is semi-persistently scheduled by an UL grant in a valid activation DCI according to those procedure(s) after the reception of higher layer parameter configuredGrantConfig not including rrc-ConfiguredUplinkGrant. If configuredGrantConfigToAddModList is configured, more than one contigured grant configuration of configured grant Type 1 and/or configured grant Type 2 may be active at the same time on an active BWP of a serving cell.

[0188] Sidelink (SL) communication is described hereafter.

[0189] FIG. **9** is another conceptual diagram of a wireless communication system. In FIG. **9**, the wireless communication system using sidelink may include terminal device **1**D to **1**F and a base station device **3** (BS #3: Base station #3). Hereinafter, the terminal devices **1**D to **1**F are also referred to as a terminal device **1** (UE #1: User Equipment #1). The reference point between terminal devices is referred to as PC5 reference point (also referred to as PC5). The reference point between terminal device and the base station is referred to as Uu reference point (also referred to as Uu).

[0190] The sidelink communication can be done over the PC5. FIG. **10** shows procedures of sidelink RRC reconfiguration. The procedure may include a step that UE #1 sends a PC5 RRC message (i.e. RRCReconfigurationSidelink) to the peer UE (i.e. UE #2). The procedure may also include a step that UE #2 sends a response PC5 RRC message (i.e. RRCReconfigurationCompleteSidelink when completed or RRCReconfigurationFairureSidelink when failed) to UE #1. The purpose of this procedures may be to modify a PC5-RRC connection, e.g. to establish/modify/release sidelink DRBs associated with the peer UE, to (re-)configure the peer UE to perform NR sidelink measurement and reporting, to (re-)configure sidelink CSI reference signal resources and CSI reporting latency bound, to (re-)configure the peer UE to perform measurement and reporting for sidelink based positioning, and/or to (re-)configure reference signal resources for sidelink based positioning. In RRC_CONNECTED, the UE may apply the NR sidelink communications parameters provided in RRCReconfiguration (dedicated RRC message) that is provided by a base station **3**, if any. In RRC_IDLE or RRC_INACTIVE, the UE may apply the NR sidelink communications parameters provided in system information that is provided by a base station **3**, if any. For other cases, UEs may apply the NR sidelink communications parameters provided in SidelinkPreconfigNR, if any.

[0191] Sidelink supports UE-to-UE direct communication using two sidelink resource allocation modes. In mode 1, the sidelink resource allocation may be provided by the network. In mode 2, UE may decide the SL transmission resources in the resource pool(s). For the sidelink communication over PC5, the operator may pre-configure the UEs with required provisioning parameters for the sidelink communication, without the need for the UEs to connect to the 5G Core network to get initial configuration. The memory storing the pre-configured parameters (e.g. parameters in SidelinkPreconfigNR) may be prospectively incorporated in the UE or in UICC (Universal Integrated Circuit Card) or both of them. In mode 2, the pre-configured parameters may be used.

[0192] The base station device **3** may be configured to include one or more transmission devices (or transmission points, transmission devices, reception devices, transmission points, reception points). When the base station device **3** is configured by a plurality of transmission devices, each of the plurality of transmission devices may be arranged at a different position. The base station device **3** may send or broadcast SIB (system information block) containing sidelink configuration information for sidelink communication.

[0193] The terminal device **1**D may detect at least one cell on the frequency which the terminal device **1**D is configured to perform NR sidelink communication on fulfilling the criterion (e.g. cell selection or cell reselection criterion). In this case, the terminal device **1**D may consider itself to be in-coverage for NR sidelink communication on that frequency. The terminal devices **1**E and **1**F cannot detect any cell on that frequency meeting the criterion, they may consider themselves to be out-of-coverage for NR sidelink communication on that frequency. The sidelink communication between in-coverage UEs may be referred to as in-coverage scenario. The sidelink communication between in-coverage UE (e.g. the terminal device ID) and out-of-coverage UE (e.g. the terminal device **1**E) may be referred to as partial-coverage scenario. The sidelink communication between out-of-coverage UEs (e.g. the terminal devices **1**E and **1**F) may be referred to as out-of-coverage scenario. The in-coverage UE may acquire the SIB containing sidelink configuration information for sidelink communication.

[0194] A sidelink physical channel may correspond to a set of resource elements carrying information originating from higher layers and/or sidelink control information. The sidelink physical channels may include Physical Sidelink Shared Channel (PSSCH), Physical Sidelink Broadcast Channel (PSBCH), Physical Sidelink Control Channel (PSCCH) and Physical Sidelink Feedback Channel (PSFCH). PSCCH may indicate resource and other transmission parameters used by a UE for PSSCH. PSCCH transmission may be associated with a DM-RS. The PSSCH may transmit the TBs of data themselves, and control information for HARQ procedures and CSI feedback triggers, etc. At least 6 OFDM symbols within a slot may be used for PSSCH transmission. PSSCH transmission may be associated with a DM-RS and may be associated with a PT-RS. PSFCH may carry HARQ feedback over the sidelink from a UE which is an intended recipient of a PSSCH transmission to the UE which performed the transmission. PSFCH sequence may be transmitted in one PRB repeated over two OFDM symbols near the end of the sidelink resource in a slot. PSBCH may occupy 9 and 5 symbols for normal and extended CP cases respectively, including the associated DM-RS.

[0195] A sidelink physical signal may correspond to a set of resource elements used by the physical layer but may not carry information originating from higher layers. The sidelink physical signals may include Demodulation reference signals (DM-RS), Channel-state information reference signal (CSI-RS), Phase-tracking reference signal (PT-RS), Sidelink primary synchronization signal (S-PSS) and Sidelink secondary synchronization signal (S-SSS). S-PSS and 5-SSS may be referred to as SLSS (SideLink Synchronization Signal). Each of S-PSS and S-SSS may occupy 2 symbols and 127 subcarriers. There may be 672 unique physical-layer sidelink synchronization identities given by N^SL_ID, where N^SL_ID denotes SLSSIDs (SideLink Synchronization Signal IDendities). The sidelink synchronization identities are divided into two sets, id_net (i.e., the ID set for in-coverage) consisting of N^SL_ID=0, 1, . . . , 355 and id_ooc (i.e., the ID set for out-of-coverage) consisting of N^SL_ID=336, 337, . . . , 671. The sequences used for S-PSS and S-SSS are generated depending on the SLSSID. A UE may receive the S-PSS and S-SSS in order to acquire time and frequency synchronization with the source (e.g., a cell, another UE or Global Navigation Satellite System (GNSS)) of the synchronization signal and to detect the SLSSID of the source. Sidelink Synchronization Signal Block (S-SSB) may include SLSS and PSBCH. The S-SSB may be also referred to as S-SS/PSBCH block.

[0196] A UE capable of NR sidelink communication and SLSS/PSBCH transmission may, when transmitting NR sidelink communication, transmit sidelink SSB (i.e., SLSS and PSBCH) on the frequency used for NR sidelink communication when conditions are met. The conditions may be that the UE is in coverage on the frequency used for NR sidelink communication and has selected GNSS or the cell as synchronization reference. The conditions may be that the UE is out of coverage on the frequency used for NR sidelink communication and has no selected GNSS or no cell as synchronization reference. The conditions may be that the UE is out of coverage on the frequency used for NR sidelink communication and has selected GNSS or the cell as synchronization reference, and the frequency is included in the sidelink frequency information list (the list of one or more frequencies where a base station allows UEs to perform the sidelink transmission) provided by a cell (i.e., provided by a base station).

[0197] The UE may select SLSS parameters including the SLSSID and the slot in which to transmit SLSS. FIG. **11** shows the table for SLSS parameter determination. This table may specify an example of how S-SSB parameters (e.g. SLSSID of SLSS, value of incoverage field of PSBCH, slot of SLSS) of S-SSB to be transmitted may be determined from parameters related to the received SSB, S-SSB or GNSS (e.g. Sync Ref, value of incoverage field of PSBCH from Sync Ref, SLSSID of SLSS from Sync Ref, Slot of SLSS from Sync Ref) and status on the frequency for the sidelink communication.

[0198] When a UE transmits SLSS, the UE may select synchronization reference (Sync Ref) which is used as a reference (e.g. a reference of timing and/or frequency) for synchronization of the transmitted SLSS, where the synchronization may include the synchronization of symbol boundaries, slot boundaries and/or frame boundaries. The synchronization reference may be also referred to as a synchronization source or a synchronization reference source, and may be a cell, GNSS or UE which transmits a SLSS. If a UE does not have any of a cell, GNSS or a UE available for the synchronization, the UE may have no selected Sync Ref. The UE may also receive SLSS and PSBCH which are transmitted by the synchronization reference when the synchronization reference is another UE. The UE may acquire SLSSID of the received SLSS from the received SLSS. UE may acquire MaterInormationBlock-Sidelink (SL-MIB) contained in the received PSBCH. SL-MIB may include information fields named sl-TDD-Config, inCoverage, directFrameNumber, slotindex and reserved-Bits. The value of directFrameNumber field may indicate the frame number in which S-SSB transmitted. The Boolean value of inCoverage field may indicate in coverage or out of coverage. More specifically, the value true may indicate that the UE transmitting the SL-MIB is in network coverage or selects GNSS timing as the synchronization reference source, while the value false may indicate that the UE transmitting the SL-MIB is out of network coverage and does not select GNSS timing as the synchronization reference source. The value of slotIndex field may indicate the slot index in which S-SSB transmitted.

[0199] If the Sync Ref is a cell and the UE transmitting S-SSB is in coverage on the frequency for the sidelink communication, SLSSID of the transmitted SLSS may be set to the SLSSID in a sl-SyncConfigList entry, the value of incoverage field of the transmitted PSBCH may be set to true, and the slot of transmitted SLSS may be the slot indicated by sl-SSB-TimeAllocation1 which may be included in RRCReconfiguration or SIB.

[0200] If the Sync Ref is GNSS and the UE transmitting S-SSB is out of coverage on the frequency for the sidelink communication and the frequency is not indicated in sl-FreqInfoList provided in RRCReconfiguration or SIB, SLSSID of the transmitted SLSS may be set to 0, the value of incoverage field of the transmitted PSBCH may be set to false, and the slot of transmitted SLSS may be the slot indicated by sl-SSB-TimeAllocation3 which may be included in SidelinkPreconfigNR.

[0201] If the Sync Ref is another UE and the UE transmitting S-SSB is out of coverage on the frequency for the sidelink communication and the frequency is not indicated in sl-FreqInfoList provided in RRCReconfiguration or SIB, SLSSID of the transmitted SLSS, the value of incoverage field of the transmitted PSBCH and the slot of transmitted SLSS may depend on the combination of the value of incoverage field of PSBCH from Sync Ref, SLSSID of SLSS from Sync Ref and Slot of SLSS from Sync Ref.

[0202] If the UE transmitting S-SSB has no Sync Ref and the UE transmitting S-SSB is out of coverage on the frequency for the sidelink communication and the frequency is not indicated in sl-FreqInfoList provided in RRCReconfiguration or SIB, SLSSID of the transmitted SLSS may be randomly selected from id_ooc, the value of incoverage field of the transmitted PSBCH may be set to false, and the slot of transmitted SLSS may the slot indicated by sl-SSB-TimeAllocation1 or sl-SSB-TimeAllocation2 which is included in SidelinkPreconfigNR.

[0203] FIG. **12** shows an example of sub-channel structure for sidelink transmissions. FIG. **13** shows an example of resource pool for sidelink transmissions. A UE may be provided by SL-BWP-Config a BWP for SL transmissions (SL BWP) with numerology and resource grid. For a resource pool within the SL BWP, the UE is provided by sl-NumSubchannel a number of sub-channels where each sub-channel includes a number of contiguous RBs provided by sl-SubchannelSize. The first RB of the first sub-channel in the SL BWP may be indicated by sl-StartRB-Subchannel. Available slots for a resource pool may be provided by sl-TimeResource and may occur with a periodicity of 10240 ms. For an available slot without S-SS/PSBCH blocks, SL transmissions can start from a first symbol indicated by sl-StartSymbol and be within a number of consecutive symbols indicated by sl-LengthSymbols. For an available slot with S-SS/PSBCH blocks, the first symbol and the number of consecutive symbols is predetermined.

[0204] A UE can be provided a number of symbols in a resource pool, by sl-TimeResourcePSCCH, starting from a second symbol that is available for SL transmissions in a slot, and a number of PRBs in the resource pool, by sl-FreqResourcePSCCH, starting from the lowest PRB of the lowest sub-channel of the associated PSSCH, for a PSCCH transmission with a SideLink Control Information (SCI) format 1-A.

[0205] Each PSSCH transmission may be associated with an PSCCH transmission. That PSCCH transmission may carry the 1st stage of the SCI associated with the PSSCH transmission, and the 2nd stage of the associated SCI may be carried within the resource of the PSSCH.

[0206] A DCI may transport downlink control information for one or more cells with one RNTI.

[0207] DCI format 30 may be used for scheduling of NR PSCCH and NR PSSCH in one cell. The following information may be transmitted by means of the DCI format 3_0 with CRC scrambled by SL-RNTI or SL-CS-RNTI:

- **[0208]** Resource pool index—$\lceil \log_2 I \rceil$ bits, where I is the number of resource pools for transmission configured by the higher layer parameter sl-TxPoolScheduling;

[0209] Time gap—3 bits determined by higher layer parameter sl-DCI-ToSL-Trans;

[0210] HARQ process number—4 bits;

[0211] New data indicator—1 bit;

[0212] Lowest index of the subchannel allocation to the initial transmission—$\lceil \log_2(N_{subChannel}{}^{SL}\rceil$ bits;

[0213] SCI format 1-A fields including Frequency resource assignment field and Time resource assignment field;

[0214] PSFCH-to-HARQ feedback timing indicator—$\lceil \log_2 N_{fb\_timing}\rceil$ bits, where N_{f_timing} *is the number of entries in the higher layer parameter sl-PSFCH-ToPUCCH*;

[0215] PUCCH resource indicator—3 bits;

[0216] Configuration index—0 bit if the UE is not configured to monitor DCI format 3_0 with CRC scrambled by SL-CS-RNTI; otherwise 3 bits. If the UE is configured to monitor DCI format 3_0 with CRC scrambled by SL-CS-RNTI, this field is reserved for DCI format 3_0 with CRC scrambled by SL-RNTI;

[0217] Counter sidelink assignment index—2 bits;

[0218] Padding bits, if required;

[0219] If multiple transmit resource pools are provided in sl-TxPoolScheduling, zeros may be appended to the DCI format 3_0 until the payload size is equal to the size of a DCI format 3_0 given by a configuration of the transmit resource pool resulting in the largest number of information bits for DCI format 3_0. If the UE is configured to monitor DCI format 3_1 and the number of information bits in DCI format 3_0 is less than the payload of DCI format 3_1, zeros may be appended to DCI format 3_0 until the payload size equals that of DCI format 3_1.

[0220] DCI format 3_1 may be used for scheduling of LTE PSCCH and LTE PSSCH in one cell. The following information is transmitted by means of the DCI format 3_1 with CRC scrambled by SL Semi-Persistent Scheduling V-RNTI:

[0221] Timing offset—3 bits determined by higher layer parameter sl-TimeOffsetEUTRA;

[0222] Carrier indicator—3 bits;

[0223] Lowest index of the subchannel allocation to the initial transmission—$\lceil \log_2(N_{subchannel}{}^{SL})\rceil$ bits;

[0224] Frequency resource location of initial transmission and retransmission;

[0225] Time gap between initial transmission and retransmission;

[0226] SL index—2 bits;

[0227] SL SPS configuration index—3 bits;

[0228] Activation/release indication—1 bit;

[0229] If the UE is configured to monitor DCI format 3_0 and the number of information bits in DCI format 3_1 is less than the payload of DCI format 3_0, zeros may be appended to DCI format 3_1 until the payload size equals that of DCI format 3_0.

[0230] SCI carried on PSCCH is a 1^{st}-stage SCI, which transports sidelink scheduling information.

[0231] SCI format 1-A is a 1^{st}-stage SCI and may be used for the scheduling of PSSCH and 2^{nd}-stage-SCI on PSSCH. The following information is transmitted by means of the SCI format 1-A:

[0232] Priority—3 bits, where value '000' of Priority field corresponds to priority value '1', value '001' of Priority field corresponds to priority value '2', and so on;

[0233] Frequency resource assignment

$$-\left\lceil \log_2\left(\frac{N^{SL}_{subChannel}\left(N^{SL}_{subChannel}+1\right)}{2}\right)\right\rceil \text{bits}$$

when the value of the higher layer parameter sl-MaxNumPerReserve is configured to 2; otherwise

$$\left\lceil \log_2\left(\frac{N^{SL}_{subChannel}\left(N^{SL}_{subChannel}+1\right)\left(2N^{SL}_{subChannel}+1\right)}{6}\right)\right\rceil \text{bits}$$

when the value of the higher layer parameter sl-MaxNumPerReserve is configured to 3;

[0234] Time resource assignment—5 bits when the value of the higher layer parameter sl-MaxNumPerReserve is configured to 2; otherwise 9 bits when the value of the higher layer parameter sl-MaxNumPerReserve is configured to 3;

[0235] Resource reservation period—$\lceil \log_2 N_{rsv\_period}\rceil$ bits, where N_{rsv_period} is the number of entries in the higher layer parameter sl-ResourceReservePeriodList, if higher layer parameter sl-MultiReserveResource is configured; 0 bit otherwise;

[0236] DMRS pattern—$\lceil \log_2 N_{pattern}\rceil$ bits, where $N_{pattern}$ is the number of DMRS patterns configured by higher layer parameter sl-PSSCH-DMRS-TimePatternList;

[0237] 2^{nd}-stage SCI format—2 bits;

[0238] Beta_offset indicator—2 bits as provided by higher layer parameter sl-BetaOffsets2ndSCI;

[0239] Number of DMRS port—1 bit;

[0240] Modulation and coding scheme—5 bits;

[0241] Additional MCS table indicator—1 bit if one MCS table is configured by higher layer parameter sl-Additional-MCS-Table; 2 bits if two MCS tables are configured by higher layer parameter sl-Additional-MCS-Table; 0 bit otherwise;

[0242] PSFCH overhead indication—1 bit if higher layer parameter sl-PSFCH-Period=2 or 4; 0 bit otherwise;

[0243] Reserved—a number of bits as: $N_{reserved}$ bits as configured by higher layer parameter sl-NumReservedBits, with value set to zero, if higher layer parameter indicationUEBScheme2 is not configured, or if higher layer parameter indicationUEBScheme2 is configured to 'Disabled'; ($N_{reserved}$–1) bits otherwise, with value set to zero;

[0244] Conflict information receiver flag—0 or 1 bit, where 1 bit if higher layer parameter indication UEBScheme2 is configured to 'Enabled', where the bit value of 0 indicates that the UE cannot be a UE to receive conflict information and the bit value of 1 indicates that the UE can be a UE to receive conflict information, 0 bit otherwise;

[0245] SCI carried on PSSCH is a 2^{nd}-stage SCI, which transports sidelink scheduling information, and/or inter-UE coordination related information.

[0246] SCI format 2-A is a 2^{nd}-stage SCI and may be used for the decoding of PSSCH, with HARQ operation when HARQ-ACK information includes ACK or NACK, when HARQ-ACK information includes only NACK, or when there is no feedback of HARQ-ACK information. The following information may be transmitted by means of the SCI format 2-A:

[0247] HARQ process number—4 bits;

[0248] New data indicator—1 bit;

[0249] Redundancy version—2 bits;

[0250] Source ID—8 bits;

[0251] Destination ID—16 bits;

[0252] HARQ feedback enabled/disabled indicator—1 bit;

[0253] Cast type indicator—2 bits;

[0254] CSI request—1 bit;

[0255] SCI format 2-B is a 2^{nd}-stage SCI and may be u used for the decoding of PSSCH, with HARQ operation when HARQ-ACK information includes only NACK, or when there is no feedback of HARQ-ACK information. The following information may be transmitted by means of the SCI format 2-B:

[0256] HARQ process number—4 bits;

[0257] New data indicator—1 bit;

[0258] Redundancy version—2 bits;

[0259] Source ID—8 bits;

[0260] Destination ID—16 bits;

[0261] HARQ feedback enabled/disabled indicator—1 bit;

[0262] Zone ID—12 bits;

[0263] Communication range requirement—4 bits determined by higher layer parameter sl-ZoneConfigMCR-Index;

[0264] The UE may transmit the PSSCH in the same slot as the associated PSCCH. The minimum resource allocation unit in the time domain may be a slot. The UE may transmit the PSSCH in consecutive symbols within the slot. The UE may not be allowed to transmit PSSCH in symbols which are not configured for sidelink. A symbol may be configured for sidelink, according to higher layer parameters sl-StartSymbol and sl-LengthSymbols, where sl-StartSymbol is the symbol index of the first symbol of sl-LengthSymbols consecutive symbols configured for sidelink. Within the slot, PSSCH resource allocation may start at symbol sl-StartSymbol+1. The UE may not be allowed to transmit PSSCH in symbols which are configured for use by PSFCH, if PSFCH is configured in this slot. The UE may not be allowed to transmit PSSCH in the last symbol configured for sidelink. The UE may not be allowed to transmit PSSCH in the symbol immediately preceding the symbols which are configured for use by PSFCH, if PSFCH is configured in this slot.

[0265] The resource allocation unit in the frequency domain may be the sub-channel. The sub-channel assignment for sidelink transmission may be determined using the "Frequency resource assignment" field in the associated SCI. The lowest sub-channel for sidelink transmission may be the sub-channel on which the lowest PRB of the associated PSCCH is transmitted. If a PSSCH scheduled by a PSCCH would overlap with resources containing the PSCCH, the resources corresponding to a union of the PSCCH that scheduled the PSSCH and associated PSCCH DM-RS are not available for the PSSCH.

[0266] The mapping operation of PSSCH to REs of the assigned RBs may be done in two steps. In the first step, the complex-valued symbols corresponding to the bit for the 2nd-stage SCI in increasing order of first the index k' over the assigned virtual resource blocks and then the index 1, starting from the first PSSCH symbol carrying an associated DM-RS and meeting all of the criteria that the corresponding resource elements in the corresponding physical resource blocks are not used for transmission of the associated DM-RS, PT-RS, or PSCCH. In the second step, the complex-valued modulation symbols not corresponding to the 2nd-stage SCI may be in increasing order of first the index k' over the assigned virtual resource blocks, and then the index 1 with the starting position given and meeting all of the following criteria that the resource elements are not used for 2nd-stage SCI in the first step and the corresponding resource elements in the corresponding physical resource blocks are not used for transmission of the associated DM-RS, PT-RS, CSI-RS, or PSCCH.

[0267] The resource elements used for the PSCCH and/or PSSCH in the first OFDM symbol, including any DM-RS, PT-RS, or CSI-RS occurring in the first OFDM symbol, may be duplicated in the OFDM symbol (also referred to as Automatic Gain Control (AGC) symbol, which may be used for AGC purpose) immediately preceding the first OFDM symbol in the mapping. The OFDM symbol immediately following the last symbol used for PSSCH, PSFCH, or S-SSB serves as a guard symbol, which may be left unused as place holder.

[0268] A UE may monitor a set of PSCCH candidates in the configured resource pool where monitoring may imply receiving each PSCCH candidate and decoding according to the monitored SCI formats. Each of PSCCH candidates in the configured resource pool may take place on a respective sub-channel in the configured resource pool. Every single sub-channel in the resource pool may include one PSCCH candidate. If the SCI format on a PSCCH candidate is successfully decoded, the UE may consider the SCI format on PSCCH is detected. For sidelink resource allocation mode 1, a UE upon detection of SCI format 1-A on PSCCH can decode PSSCH according to the detected SCI formats 2-A and 2-B, and associated PSSCH resource configuration configured by higher layers. The UE is not required to decode more than one PSCCH at each PSCCH resource candidate. For sidelink resource allocation mode 2, a UE upon detection of SCI format 1-A on PSCCH can decode PSSCH according to the detected SCI formats 2-A and 2-B, and associated PSSCH resource configuration configured by higher layers. The UE is not required to decode more than one PSCCH at each PSCCH resource candidate.

[0269] A UE can be indicated by an SCI format scheduling a PSSCH reception to transmit a PSFCH with HARQ-ACK information to the UE that the PSSCH was transmitted, in response to the PSSCH reception. The UE transmitting PSFCH may provide HARQ-ACK information that includes ACK or NACK; or only NACK.

[0270] Downlink and/or uplink positioning is described hereafter.

[0271] Positioning functionality may provide a means to determine the geographic position and/or velocity of the UE based on measuring radio signals. The position information may be requested by and reported to a client (e.g., an application) associated with the UE, or by a client within or attached to the core network.

[0272] The NG-RAN may utilize one or more positioning methods in order to determine the position of an UE. Positioning the UE involves two main steps: signal measurements; and position estimate and optional velocity computation based on the measurements. The signal measurements may be made by the UE or by the serving ng-eNB or gNB. The basic signals measured for terrestrial position methods are typically the LTE or NR radio transmissions; however, other methods may make use of other transmissions such as general radio navigation signals including those from GNSSs. The position estimate computation may be made by the UE or by the Location Management Function (LMF) server.

[0273] The standard positioning methods for downlink and/or uplink positioning supported for NG-RAN access may include:

[0274] network-assisted GNSS methods;

[0275] observed time difference of arrival (OTDOA) positioning based on LTE signals;

[0276] enhanced cell ID methods based on LTE signals;

[0277] WLAN positioning;

[0278] Bluetooth positioning;

[0279] terrestrial beacon system (TBS) positioning;

[0280] sensor based methods:

[0281] NR enhanced cell ID methods (NR E-CID) based on NR signals;

[0282] Multi-Round Trip Time Positioning (Multi-RTT based on NR signals);

[0283] Downlink Angle-of-Departure (DL-AoD) based on NR signals;

[0284] Downlink Time Difference of Arrival (DL-TDOA) based on NR signals;

[0285] Uplink Time Difference of Arrival (UL-TDOA) based on NR signals;

[0286] Uplink Angle-of-Arrival (UL-AoA), including A-AoA and Z-AoA based on NR signals.

[0287] Separately from location service support for particular UEs, an LMF may interact with elements in the NG-RAN in order to obtain measurement information to help assist one or more position methods for all UEs. An LMF may also interact with NG-RAN node to provide assistance data information for broadcasting. An LMF can interact with any NG-RAN node reachable from any of the AMFs with signalling access to the LMF in order to provide assistance data information for broadcasting. The information can include positioning System Information Blocks (posSIBs) together with assistance information meta data, broadcast cells and broadcast periodicity.

[0288] These positioning methods may be supported in UE-based, UE-assisted/LMF-based, and NG-RAN node assisted versions. The LTE Positioning Protocol (LPP) may be terminated between a target device (the UE in the control-plane case) and a positioning server (the LMF in the control-plane case). LPP messages may be carried as transparent PDUs across intermediate network interfaces using the appropriate protocols (e.g., NAS/RRC over the NR-Uu interfaces).

[0289] Positioning assistance data can be included in positioning System Information Blocks (posSIBs). The posSIBs are carried in RRC System Information (SI) messages. The mapping of posSIBs (assistance data) to SI messages is flexibly configurable and provided to the UE in SIB1 for NG-RAN node. The UE may request posSI by means of on-demand SI request in RRC_IDLE/RRC_INACTIVE and also request posSIBs by means of on-demand SI request in RRC_CONNECTED. For each assistance data element, a separate posSIB-type may be used. Each posSIB may be ciphered by the LMF using the 128-bit Advanced Encryption Standard (AES) algorithm (with counter mode).

[0290] The measurements of DL signals/channels at the UE side for positioning are described. The DL Positioning Reference Signals (DL PRS) are defined to facilitate support of different positioning methods such as DL Time Difference Of Arrival (DL-TDOA), DL Angle of Departure (DL-AoD), multi-Round Trip Time (multi-RTT) through the following set of UE measurements DL Reference Signal Time Difference (DL RSTD), DL PRS Reference Signal Received Power (DL PRS-RSRP), and UE Rx-Tx time difference respectively. Besides DL PRS signals, UE can use SSB and CSI-RS for RRM (e.g. RSRP and RSRQ) measurements for E-CID type of positioning.

[0291] DL PRS-RSRP may be defined as the linear average over the power contributions (in [W]) of the resource elements that carry DL PRS reference signals configured for RSRP measurements within the considered measurement frequency bandwidth. DL PRS-RSRP may be applicable for RRC_CONNECTED and RRC_INACTIVE.

[0292] DL RSTD may be the DL relative timing difference between the Transmission Point (TP) j and the reference TP i, defined as $T_{SubframeRxj}-T_{SubframeRxi}$, where $T_{SubframeRxj}$ may be the time when the UE receives the start of one subframe from TP j, and $T_{SubframeRxi}$ may be the time when the UE receives the corresponding start of one subframe from TP i that is closest in time to the subframe received from TP j. Multiple DL PRS resources can be used to determine the start of one subframe from a TP. DL RSTD may be applicable for RRC_CONNECTED and RRC_INACTIVE.

[0293] The UE Rx−Tx time difference is defined as $T_{UE\text{-}RX}-T_{UE\text{-}TX}$, where $T_{UE\text{-}RX}$ is the UE received timing of downlink subframe #i from a TP, defined by the first detected path in time, and $T_{UE\text{-}TX}$ is the UE transmit timing of uplink subframe #j that is closest in time to the subframe #i received from the TP. Multiple DL PRS or CSI-RS for tracking resources, as instructed by higher layers, can be used to determine the start of one subframe of the first arrival path of the TP. UE Rx−Tx time difference may be applicable for RRC_CONNECTED and RRC_INACTIVE.

[0294] DL PRS reference signal received path power (DL PRS-RSRPP), may be defined as the power of the linear average of the channel response at the i-th path delay of the resource elements that carry DL PRS signal configured for the measurement, where DL PRS-RSRPP for the 1st path delay is the power contribution corresponding to the first detected path in time. DL PRS-RSRPP may be applicable for RRC_CONNECTED and RRC_INACTIVE.

[0295] The measurements of UL signals/channels at the gNB side for positioning are described. The periodic, semi-persistent and aperiodic transmission of SRS may be used for gNB UL Relative Time of Arrival (gNB UL RTOA), UL SRS-RSRP, UL Angle Of Arrival (UL-AoA) measurements to facilitate support of UL TDOA and UL AoA positioning methods.

[0296] The UL Relative Time of Arrival ($T_{UL\text{-}RTOA}$) may be the beginning of subframe i containing SRS received in Reception Point (RP) j, relative to the RTOA Reference Time. The UL RTOA reference time is defined as T_0+t_{SRS}, where T_0 is the nominal beginning time of SFN 0 provided by SFN Initialization Time, and $t_{SRS}=(10n_f+n_{sf})\times10^{-3}$, where n_f and n_{sf} are the system frame number and the subframe number of the SRS, respectively. Multiple SRS resources can be used to determine the beginning of one subframe containing SRS received at a RP.

[0297] The gNB Rx−Tx time difference may be defined as $T_{gNB-RX}-T_{gNB-TX}$, where T_{gNB-RX} is the Transmission and Reception Point (TRP) received timing of uplink subframe #i containing SRS associated with UE, defined by the first detected path in time, and T_{gNB-TX} is the TRP transmit timing of downlink subframe #j that is closest in time to the subframe #i received from the UE. Multiple SRS resources can be used to determine the start of one subframe containing SRS.

[0298] UL Angle of Arrival (UL AoA) may be defined as the estimated azimuth angle and vertical angle of a UE with respect to a reference direction, wherein the reference direction is defined: in the global coordinate system (GCS), wherein estimated azimuth angle is measured relative to geographical North and is positive in a counter-clockwise direction and estimated vertical angle is measured relative to zenith and positive to horizontal direction; in the local coordinate system (LCS), wherein estimated azimuth angle is measured relative to x-axis of LCS and positive in a counter-clockwise direction and estimated vertical angle is measured relative to z-axis of LCS and positive to x-y plane direction. The UL AoA is determined at the gNB antenna for an UL channel corresponding to this UE.

[0299] UL SRS reference signal received power (UL SRS-RSRP) may be defined as linear average of the power contributions (in [W]) of the resource elements carrying sounding reference signals (SRS). UL SRS RSRP shall be measured over the configured resource elements within the considered measurement frequency bandwidth in the configured measurement time occasions.

[0300] UL SRS reference signal received path power (UL SRS-RSRPP) may be defined as the power of the linear average of the channel response at the i-th path delay of the resource elements that carry the received UL SRS signal configured for the measurement, where UL SRS-RSRPP for 1st path delay is the power contribution corresponding to the first detected path in time.

[0301] Sidelink positioning is described hereafter.

[0302] Positioning functionality may provide a means to determine the geographic position and/or velocity of the UE based on measuring radio signals. The position information may be requested by and reported to a client (e.g., an application) associated with the UE, or by a client within or attached to the core network.

[0303] For sidelink positioning in Out-of-coverage scenario, positioning functionality may work between UEs and NG-RAN or core network and/or LMF may not be involved.

[0304] The standard positioning methods for sidelink positioning may include:

- **[0305]** observed time difference of arrival (OTDOA) positioning based on LTE signals;
- **[0306]** enhanced cell ID methods based on LTE signals;
- **[0307]** WLAN positioning;
- **[0308]** Bluetooth positioning;
- **[0309]** terrestrial beacon system (TBS) positioning;
- **[0310]** sensor based methods:
- **[0311]** NR enhanced cell ID methods (NR E-CID) based on NR signals;
- **[0312]** Multi-Round Trip Time Positioning (Multi-RTT based on NR signals);
- **[0313]** Sidelink Angle-of-Departure (SL-AoD) based on NR signals;
- **[0314]** Sidelink Angle-of-Arrival (SL-AoA) based on NR signals;
- **[0315]** Sidelink Time Difference of Arrival (SL-TDOA) based on NR signals.

[0316] The measurements of SL signals/channels at the UE side for positioning are described. The reference signal for sidelink positioning (SL Positioning Reference Signals (SL PRS) and/or the periodic, semipersistent and aperiodic transmission of SL Sounding Reference Signals (SL SRS)) may be defined to facilitate support of different positioning methods such as SL Time Difference Of Arrival (SL-TDOA), SL Angle of Departure (SL-AoD), SL Angle Of Arrival (UL-AoA), multi-Round Trip Time (multi-RTT) through the following set of UE measurements such as SL Reference Signal Time Difference (SL RSTD), SL PRS-RSRP, SL SRS-RSRP, SL PRS-RSRPP, SL SRS-RSRPP, UE SL Relative Time of Arrival (UE SL RTOA), SL-AoA and/or UE Rx-Tx time difference. Besides SL PRS signals and/or SL SRS, UE can use S-SS/PSBCH block and CSI-RS for RRM (e.g. RSRP and RSRQ) measurements for E-CID type of positioning.

[0317] SL PRS may be SL reference signal(s) used for sidelink positioning. The sequence of the SL PRS may be defined using pseudo-random sequence. The pseudo-random sequence may be initialized using slot number, sidelink PRS sequence ID (e.g. 0, 1, . . . , 4095) which is given by the higher-layer parameter sl-PRS-SequenceID, and the OFDM symbol within the slot to which the sequence is mapped.

[0318] SL PRS may be mapped a sidelink PRS resource configured. The defined SL PRS sequence may be mapped to resource elements within the resource block occupied by the sidelink PRS resource configured and to symbols not used by any S-SS/PBSCH block.

[0319] The first symbol of the sidelink PRS within a slot may be given by the higher-layer parameter (can be in PC5-RRC message) sl-PRS-ResourceSymbolOffset.

[0320] The size of the sidelink PRS resource in the time domain LSL-PRS is given by the higher-layer parameter sl-PRS-NumSymbols. The candidate values for the LsL-PRS may be 2, 4, 6, 12.

[0321] The comb size $K^{SL\text{-}PRS}_{comb}$ for the SL PRS frequency resource may be given by the higher-layer parameter sl-PRS-CombSizeN. The comb size $K^{SL\text{-}PRS}_{comb}$ defines subcarrier interval the SL PRS is assigned. The candidate values for the comb size $K^{SL\text{-}PRS}_{comb}$ may be 2, 4, 6, 12.

[0322] The resource-element offset for the SL PRS frequency resource $k^{SL\text{-}PRS}_{offset}$ may be obtained from the higher-layer parameter sl-PRS-CombSizeN-AndReOffset.

[0323] For a sidelink PRS resource in a sidelink PRS resource set, the UE shall assume the sidelink PRS resource being transmitted when the slot and frame number fulfil a condition. The condition may be defined by the periodicity for SL PRS, slot offset for SL PRS, the sidelink PRS resource slot offset, the repetition factor for SL PRS, the muting repetition factor for SL PRS and/or the time gap for SL PRS, which are given by the higher-layer parameters, respectively.

[0324] SL SRS may be SL reference signal(s) used for sidelink positioning.

[0325] The resource for the SL SRS (sidelink SRS resource) may be configured by the higher-layer parameter sl-SRS-Resource or the sl-SRS-PosResource.

[0326] The number of antenna ports for the SL SRS may be given by the higher-layer parameter nrofSL-SRS-Ports if configured, otherwise 1.

[0327] The number of consecutive OFDM symbols for the SL SRS may be given by the field nrofSymbols contained in the higher-layer parameter resourceMapping.

[0328] The starting position in the time domain for the SL SRS may be given by the symbol offset l_{offset} which counts symbols backwards from the end of the slot and can be the value range from 0 to 13. The l_{offset} may be given by the field startPosition contained in the higher layer parameter resourceMapping.

[0329] The frequency-domain starting position of SL SRS maybe configured by the field in higher-layer parameter sl-SRS-Resource or the sl-SRS-PosResource.

[0330] SL PRS-RSRP may be defined as the linear average over the power contributions (in [W]) of the resource elements that carry SL PRS reference signals configured for RSRP measurements within the considered measurement frequency bandwidth.

[0331] SL PRS-RSRPP may be defined as the power of the linear average of the channel response at the i-th path delay of the resource elements that carry SL PRS signal configured for the measurement, where SL PRS-RSRPP for the 1st path delay is the power contribution corresponding to the first detected path in time.

[0332] SL SRS-RSRP may be defined as linear average of the power contributions (in [W]) of the resource elements carrying SL SRS. SL SRS RSRP shall be measured over the configured resource elements within the considered measurement frequency bandwidth in the configured measurement time occasions.

[0333] SL SRS-RSRPP may be defined as the power of the linear average of the channel response at the i-th path delay of the resource elements that carry the received SL SRS signal configured for the measurement, where SL SRS-RSRPP for 1st path delay is the power contribution corresponding to the first detected path in time

[0334] SL RSTD may be the SL relative timing difference between the Transmission Point (TP) j and the reference TP i, defined as $T_{SubframeRxj}-T_{SubframeRxi}$, where $T_{SubframeRxj}$ may be the time when the UE receives the start of one subframe from TPj, and $T_{SubframeRxi}$ may be the time when the UE receives the corresponding start of one subframe from TP i that is closest in time to the subframe received from TP j. Multiple SL PRS resources can be used to determine the start of one subframe from a TP.

[0335] SL Relative Time of Arrival ($T_{UL-RTOA}$) may be the beginning of subframe i containing SL SRS received in RP (can be peer UE) j, relative to the RTOA Reference Time. The SL RTOA reference time is defined as T_0+t_{SRS}, where T_0 is the nominal beginning time of SFN 0 provided by SFN Initialization Time, and $t_{SRS}=(10n_f+n_{sf})\times10^{-3}$, where n_f and n_{sf} are the system frame number and the subframe number of the SL SRS, respectively. Multiple SL SRS resources can be used to determine the beginning of one subframe containing SL SRS received at a RP.

[0336] SL AoA may be defined as the estimated azimuth angle and vertical angle of a UE with respect to a reference direction, wherein the reference direction is defined: in the GCS, wherein estimated azimuth angle is measured relative to geographical North and is positive in a counter-clockwise direction and estimated vertical angle is measured relative to zenith and positive to horizontal direction; in the LCS, wherein estimated azimuth angle is measured relative to x-axis of LCS and positive in a counter-clockwise direction and estimated vertical angle is measured relative to z-axis of LCS and positive to x-y plane direction. The UL AoA is determined at the peer UE antenna for a SL channel corresponding to this UE.

[0337] The UE Rx−Tx time difference is defined as $T_{UE-RX}-T_{UE-TX}$, where T_{UE-RX} is the UE received timing of downlink subframe #i from a TP, defined by the first detected path in time, and T_{UE-TX} is the UE transmit timing of uplink subframe #j that is closest in time to the subframe #i received from the TP. Multiple SL PRS, SL SRS or CSI-RS for tracking resources, as instructed by higher layers, can be used to determine the start of one subframe of the first arrival path of the TP.

[0338] For sidelink positioning using sidelink, the aforementioned UE can be UE #1 (can be also called as source device). Additionally or alternatively, the aforementioned UE can be UE #2 (can be also called as target device).

[0339] The UE #1 may transmit physical sidelink reference signal(s) for positioning. The UE #2 may receive the physical sidelink reference signal(s) for positioning and may perform measurement based on them.

[0340] The UE #1 may have a function of a physical or logical entity that manages sidelink positioning for the UE #2 by obtaining measurements and other location information from one or more positioning units and providing assistance data to positioning units to help determine this. The assistance data may provide assistance information for positioning operation. The UE #2 may also compute or verify the final location estimate.

[0341] Alternatively, the UE #1 may initiate sidelink positioning procedure and may transmit sidelink reference signal (s) for positioning. The UE #2 may receive the sidelink reference signal(s) for positioning and measure it. The UE #1 may compute the final location estimate. Additionally, the UE #1 may provide assistance data to the UE #2. Alternatively, and/or additionally, the UE #2 may provide assistance data to the UE #1.

[0342] The assistance data may be used by the UE #1 to provide SL PRS assistance data and/or SL SRS assistance data. The assistance data may be provided by PC5-RRC message.

[0343] The SL PRS assistance data may include the information about the configuration of SL PRS (e.g. time and/or frequency location of SL PRS) and/or the configuration of sidelink positioning measurement using SL PRS. The UE #1 may transmit SL PRS corresponding to the configuration of SL PRS to the UE #2. The UE #1 may send the configuration of sidelink positioning measurement using SL PRS corresponding to the SL PRS to the UE #2. The UE #2 may receive SL PRS corresponding to the configuration of SL PRS from the UE #1. The UE #2 may acquire the configuration of sidelink positioning measurement using SL PRS corresponding to the SL PRS from the UE #1.

[0344] The SL SRS assistance data may include the information about the configuration of SL SRS (e.g. time and/or frequency location of SL SRS) and/or the configuration of sidelink positioning measurement using SL SRS. The UE #1 may transmit SL SRS corresponding to the configuration of SL SRS to the UE #2. The UE #1 may send the configuration of sidelink positioning measurement using SL SRS corresponding to the SL SRS to the UE #2. The UE #2 may receive SL SRS corresponding to the configuration of SL SRS from the UE #1. The UE #2 may acquire the configuration of sidelink positioning measurement using SL SRS corresponding to the SL SRS from the UE #1.

[0345] The UE #1 and the UE #2 may perform the procedure related to assistance data (including the configuration of sidelink PRS, the configuration of sidelink SRS, the configuration of sidelink positioning measurement using sidelink PRS and/or the configuration of sidelink positioning measurement using sidelink SRS) transfer.

[0346] The UE #2 may send a RequestAssistanceData message to the UE #1. The RequestAssistanceData in a PC5-RRC (PC5 RRC) message (can be also an LPP message) is used by the UE #2 to request assistance data from the UE #1.

[0347] The UE #1 may respond with a ProvideAssistanceData message to the UE #2 containing assistance data. The ProvideAssistanceData in an PC5-RRC message (can be an LPP message) is used by the UE #1 to provide assistance data to the UE #2 either in response to a request from the UE #2 or in an unsolicited manner. The transferred assistance data should match or be a subset of the assistance data requested by the UE #2. The UE #1 may also provide any not requested information that it consider useful to the UE #2.

[0348] The UE #1 may transmit one or more additional ProvideAssistanceData messages to the UE #2 containing further assistance data. The transferred assistance data should match or be a subset of the assistance data requested by the UE #2. The UE #1 may also provide any not requested information that it considers useful to the UE #2.

[0349] Hereinafter, sidelink RRC (PC5-RRC) procedure is described.

[0350] NR sidelink communication (including NR sidelink positioning) may consist of unicast, groupcast and broadcast. For unicast, the PC5-RRC connection is a logical connection between two UEs with Layer 2 ID (e.g. a Source Layer-2 ID for UE #1 and a Destination Layer-2 ID for UE #2) in the Access Stratum (AS). The PC5-RRC signalling can be initiated after its corresponding PC5 unicast link establishment. The PC5-RRC connection and the corresponding sidelink SRBs and sidelink DRB(s) are released when the PC5 unicast link is released as indicated by higher (upper) layers. For each PC5-RRC connection of unicast, one sidelink Signalling Radio Bearer (SRB) (i.e. SL-SRB0) may be used to transmit the PC5-Smessage(s) before the PC5-S security has been established, where PC5-S may be the protocol used for the control plane signalling over the PC5 reference point for the secure layer-2 link. One sidelink SRB (i.e. SL-SRB1) may be used to transmit the PC5-S messages to establish the PC5-S security. One sidelink SRB (i.e. SL-SRB2) may be used to transmit the PC5-S messages after the PC5-S security has been established, which is protected. One sidelink SRB (i.e. SL-SRB3) may be used to transmit the PC5-RRC signalling, which is protected and only sent after the PC5-S security has been established. For unicast of NR sidelink communication, AS security may comprise of integrity protection of PC5 signalling (SL-SRB1, SL-SRB2 and SL-SRB3) and user data (SL-DRBs), and it may further comprise of ciphering of PC5 signaling (SL-SRB1 only for the Direct Link Security Mode Complete message, SL-SRB2 and SL-SRB3) and user data (SL-DRBs). The ciphering and integrity protection algorithms and parameters for a PC5 unicast link may be exchanged by PC5-S messages in the upper layers, and may apply to the corresponding PC5-RRC connection in the AS. Once AS security is activated for a PC5 unicast link in the upper layers all messages on SL-SRB2 and SL-SRB3 and/or user data on SL-DRBs of the corresponding PC5-RRC connection may be integrity protected and/or ciphered by the PDCP.

[0351] The PC5-RRC connection differs with RRC connection in that the PC5-RRC connection is the connection between two UEs though the RRC connection is the connection between a UE and network. For NR sidelink communication, the radio configuration may include the sidelink RRC configuration received from the network, but may not include the sidelink RRC reconfiguration and sidelink UE capability received from other UEs via PC5-RRC.

[0352] The sidelink RRC procedure is performed to modify a PC5-RRC connection, e.g. to establish/modify/release sidelink DRB, to (re-)configure NR sidelink measurement and reporting, to (re-)configure sidelink CSI reference signal resources and CSI reporting latency bound, to (re-)configure NR sidelink positioning measurement and reporting, and to (re-)configure sidelink PRS resources and other configuration of sidelink PRS.

[0353] The UE #1 may initiate the sidelink RRC reconfiguration procedure and perform the operation on the corresponding PC5-RRC connection in following cases:

[0354] the release of sidelink DRBs associated with the UE #2 (can be called as peer UE);

[0355] the establishment of sidelink DRBs associated with the UE #2 (can be called as peer UE);

[0356] the modification for the parameters included in SLRB-Config of sidelink DRBs associated with the UE #2 (can be also called as peer UE);

[0357] the (re-)configuration of the UE #2 (can be also called as peer UE) to perform NR sidelink measurement and report;

[0358] the (re-)configuration of the sidelink CSI reference signal resources and CSI reporting latency bound;

[0359] the (re-)configuration of the UE #2 (can be also called as peer UE) to perform NR sidelink positioning measurement and report;

[0360] the (re-)configuration of the sidelink PRS resources and the other configuration of sidelink PRS.

[0361] In RRC_CONNECTED, the UE #1 may apply the NR sidelink communications parameters provided in RRCReconfiguration (if any). In RRC_IDLE or RRC_INACTIVE, the UE #1 may apply the NR sidelink communications parameters provided in system information (if any). For other cases, UE #1 may apply the NR sidelink communications parameters provided in SidelinkPreconfigNR (if any). When UE #1 performs state transition between above three cases, the UE #1 may apply the NR sidelink communications parameters provided in the new state, after acquisition of the new configurations. Before acquisition of the new configurations, the UE #1 may continue applying the NR sidelink communications parameters provided in the old state.

[0362] The parameter SidelinkPreconfigNR is the sidelink pre-configured parameters used for NR sidelink communication.

[0363] The UE #1 may transmit RRCReconfigurationSidelink message to the UE #2 via PC5-RRC connection. The UE #1 may set the contents of RRCReconfigurationSidelink message as follows.

[0364] For each sidelink DRB that is to be released due to configuration by sl-ConfigDedicatedNR, SIB12, SidelinkPreconfigNR or by upper layers, the UE #1 may set the SLRB-PC5-ConfigIndex included in the slrb-ConfigToReleaseList corresponding to the sidelink DRB, as the contents of RRCReconfigurationSidelink message.

[0365] For each sidelink DRB that is to be established or modified due to receiving sl-ConfigDedicatedNR, SIB12 or SidelinkPreconfigNR, the UE #1 may set the SLRB-Config included in the slrb-ConfigToAddModList, according to the received sl-RadioBearerConfig and sl-RLC-BearerConfig corresponding to the sidelink DRB, as the contents of RRCReconfigurationSidelink message.

[0366] If the frequency used for NR sidelink communication is included in sl-FreqInfoToAddModList in sl-ConfigDedicatedNR within RRCReconfiguration message or included in sl-ConfigCommonNR within SIB12 and if the UE #1 is in RRC_CONNECTED, the UE #1 may set the sl-MeasConfig according to stored NR sidelink measurement configuration information for this destination, as the contents of RRCReconfigurationSidelink message.

[0367] If the frequency used for NR sidelink communication is included in sl-FreqInfoToAddModList in sl-ConfigDedicatedNR within RRCReconfiguration message or included in sl-ConfigCommonNR within SIB12 and if the UE #1 is in RRC_IDLE or RRC_INACTIVE, the UE #1 may set the sl-MeasConfig according to stored NR sidelink measurement configuration received from SIB12, as the contents of RRCReconfigurationSidelink message.

[0368] If the frequency used for NR sidelink communication is not included in sl-FreqInfoToAddModList in sl-ConfigDedicatedNR within RRCReconfiguration message and not included in sl-ConfigCommonNR within SIB12, the UE #1 may set the sl-MeasConfig according to the sl-MeasPreconfig in SidelinkPreconfigNR, as the contents of RRCReconfigurationSidelink message.

[0369] If the frequency used for NR sidelink positioning is included in sl-FreqInfoToAddModList in sl-ConfigDedicatedNR within RRCReconfiguration message or included in sl-ConfigCommonNR within SIB12 and if the UE #1 is in RRC_CONNECTED, the UE #1 may set the sl-PRS-MeasConfig according to stored NR sidelink positioning measurement configuration information for this destination, as the contents of RRCReconfigurationSidelink message.

[0370] If the frequency used for NR sidelink positioning is included in sl-FreqInfoToAddModList in sl-ConfigDedicatedNR within RRCReconfiguration message or included in sl-ConfigCommonNR within SIB12 and if the UE #1 is in RRC_IDLE or RRC_INACTIVE, the UE #1 may set the sl-PRS-MeasConfig according to stored NR sidelink positioning measurement configuration received from SIB12 (can be other SIB), as the contents of RRCReconfigurationSidelink message.

[0371] If the frequency used for NR sidelink positioning is not included in sl-FreqInfoToAddModList in sl-ConfigDedicatedNR within RRCReconfiguration message and not included in sl-ConfigCommonNR within SIB12 (can be other SIB), the UE #1 may set the sl-PRS-MeasConfig according to the sl-PRS-MeasPreconfig in SidelinkPreconfigNR, as the contents of RRCReconfigurationSidelink message.

[0372] The UE #1 may set the sl-CSI-RS-Config, as the contents of RRCReconfigurationSidelink message.

[0373] The UE #1 may set the sl-LatencyBoundCSI-Report, as the contents of RRCReconfigurationSidelink message.

[0374] The UE #1 may set the sl-PRS-Config, as the contents of RRCReconfigurationSidelink message.

[0375] When higher layers request the release of the PC5-RRC connection, the UE #1 (can be UE #2) may initiate the PC5-RRC connection release procedure. As the procedure, if the PC5-RRC connection release for the specific destination (e.g. UE #2) is requested by higher layers, the UE #1 may discard the NR sidelink communication related configuration of the destination, may release the DRBs of this destination, may release the SRBs of the destination, may reset the sidelink specific MAC of the destination, and may consider the PC5-RRC connection is released for the destination.

[0376] The UE #2 may receive RRCReconfigurationSidelink message from the UE #1 via PC5-RRC connection. The UE #2 may perform the following actions upon reception of the RRCReconfigurationSidelink message.

[0377] If the RRCReconfigurationSidelink includes the sl-ResetConfig, the UE #2 may perform the sidelink reset configuration procedure.

[0378] If the RRCReconfigurationSidelink includes the slrb-ConfigToReleaseList, the UE #2 may perform the sidelink DRB release procedure for each SLRB-PC5-ConfigIndex value included in the slrb-ConfigToReleaseList that is part of the current UE sidelink configuration.

[0379] If the RRCReconfigurationSidelink includes the slrb-ConfigToAddModList, the UE #2 may perform the sidelink DRB addition procedure for each slrb-PC5-ConfigIndex value included in the slrb-ConfigToAddModList that is not part of the current UE sidelink configuration.

[0380] If the RRCReconfigurationSidelink includes the slrb-ConfigToAddModList, and if the sidelink DRB release conditions are met, the UE #2 may perform the sidelink DRB release procedure for each slrb-PC5-ConfigIndex value included in the slrb-ConfigToAddModList that is part of the current UE sidelink configuration.

[0381] If the RRCReconfigurationSidelink includes the slrb-ConfigToAddModList, and if the sidelink DRB modification conditions are met, the UE #2 may perform the sidelink DRB modification procedure for each slrb-PC5-ConfigIndex value included in the slrb-ConfigToAddModList that is part of the current UE sidelink configuration.

[0382] If the RRCReconfigurationSidelink includes the sl-MeasConfig, the UE #2 may perform the sidelink measurement configuration procedure.

[0383] If the RRCReconfigurationSidelink includes the sl-PRS-MeasConfig, the UE #2 may perform the sidelink positioning measurement configuration procedure.

[0384] If the RRCReconfigurationSidelink includes the sl-CSI-RS-Config, the UE #2 may apply the sidelink CSI-RS configuration indicated by the sl-CSI-RS-Config.

[0385] If the RRCReconfigurationSidelink includes the sl-LatencyBoundCSI-Report, the UE #2 may apply the sidelink CSI report latency bound configured by the sl-LatencyBoundCSI-Report.

[0386] If the RRCReconfigurationSidelinkincludesthesl-PRS-Config, theUE #2 may apply the sidelink PRS configuration indicated by the sl-PRS-Config.

[0387] If the UE #2 is unable to comply with all or part of the configuration included in the RRCReconfigurationSidelink, the UE #2 may continue using the configuration used prior to the reception of the RRCReconfigurationSidelink message and may set the content of the RRCReconfigurationFailureSidelink message and may transmit the RRCReconfigurationFailureSidelink message.

[0388] If the UE #2 can comply with all the configuration included in the RRCReconfigurationSidelink, the UE #2 may set the content of the RRCReconfigurationCompleteSidelink message and may transmit the RRCReconfigurationCompleteSidelink message.

[0389] The parameter sl-CSI-RS-Config includes the configuration information of CSI-RS used for sidelink communication. The parameter sl-CSI-RS-Config may include the parameter sl-CSI-RS-FreaAllocation and the parameter sl-CSI-RS-FirstSymbol. The sl-CSI-RS-FreqAllocation indicates the frequency domain position for sidelink CSI-RS. The sl-CSI-RS-FirstSymbol indicates the position of first symbol of sidelink CSI-RS.

[0390] The parameter sl-PRS-MeasConfig indicates the sidelink positioning measurement configuration for the unicast destination. The contents of the parameter sl-PRS-MeasConfig may be included in sl-MeasConfig. The parameter sl-PRS-MeasConfig may include sl-PRS-MeasObjectToRemoveList, sl-PRS-MeasObjectToAddModList, sl-PRS-ReportConfigToRemoveList, sl-PRS-ReportConfigToAddModList, sl-PRS-QuantityConfig, sl-PRS-MeasldToRemoveList and/or sl-PRS-MeasldToAddModList.

[0391] The parameter sl-PRS-MeasObjectToRemoveList is a list of sidelink PRS measurement objects to remove. In case that the received sl-PRS-MeasConfig includes the sl-PRS-MeasObjectToRemoveList, the UE #2 may perform the sidelink PRS measurement object removal procedure.

[0392] The parameter sl-PRS-MeasObjectToAddModList is a list of sidelink PRS measurement objects to add and/or modify. In case that the received sl-PRS-MeasConfig includes the sl-PRS-MeasObjectToAddModList, the UE #2 may perform the sidelink PRS measurement object addition/modification procedure.

[0393] The parameter sl-PRS-ReportConfigToRemoveList is a list of sidelink PRS reporting configurations to remove. In case that the received sl-PRS-MeasConfig includes the sl-PRS-ReportConfigToRemoveList, the UE #2 may perform the sidelink PRS reporting configuration removal procedure.

[0394] The parameter sl-PRS-ReportConfigToAddModList is a list of sidelink PRS reporting configurations to add and/or modify. In case that the received sl-PRS-MeasConfig includes the sl-PRS-ReportConfigToAddModList, the UE #2 may perform the sidelink PRS reporting configuration addition/modification procedure.

[0395] The parameter sl-PRS-MeasldToRemoveList is a list of sidelink PRS measurement identities to remove. In case that the received sl-PRS-MeasConfig includes the sl-PRS-MeasldToRemoveList, the UE #2 may perform the sidelink PRS measurement identity removal procedure.

[0396] The parameter sl-PRS-MeasldToAddModList is a list of sidelink PRS measurement identities to add and/or modify. In case that the received sl-PRS-MeasConfig includes the sl-PRS-MeasldToAddModList, the UE #2 may perform the sidelink PRS measurement identity addition/modification procedure.

[0397] The parameter sl-PRS-QuantityConfig indicates the layer 3 filtering coefficient for sidelink PRS measurement. In case that the received sl-PRS-MeasConfig includes the sl-PRS-QuantityConfig, the UE #2 may perform the sidelink PRS quantity configuration procedure.

[0398] FIG. **14** shows an example procedure of measurement report for sidelink positioning. The purpose of this procedure may be to transfer measurement results from the UE #2 to the UE #1 via PC5-RRC. The UE #2 may initiate this procedure only after successful AS security activation. For the measld for which the measurement reporting procedure was triggered, the UE #2 may set the sl-pos-measResults (i.e., PC5 RRC information element of measurement result(s) of sidelink positioning) within the PositioningMeasurementReport message (also referred to as the assistance data). The sl-pos-measResults may include measurement result(s) such as such as SL RSTD, SL PRS-RSRP, SL SRS-RSRP, SL PRS-RSRPP, SL SRS-RSRPP, UE SL RTOA, SL-AoA and/or UE Rx-Tx time difference, derived based on sidelink reference signal(s). The type of the measurement result(s) may be configured by the parameter sl-PRS-QuantityConfig.

[0399] The parameter sl-PRS-Config includes the configuration information of PRS used for sidelink positioning. The parameter sl-PRS-Config may include sl-PRS-ID, sl-PRS-SubcarrierSpacing, sl-PRS-ResourceBandwidth, sl-PRS-StartPRB, sl-PRS-PointA, sl-PRS-CombSizeN, and/or sl-PRS-CyclicPrefix.

[0400] The parameter sl-PRS-ID is used to identify a SL-PRS resource.

[0401] The parameter sl-PRS-SubcarrierSpacing specifies the subcarrier spacing of the sidelink PRS resource. All sidelink PRS resources and sidelink PRS resource sets in the same positioning frequency layer may have the same value of sl-PRS-SubcarrierSpacing.

[0402] The parameter sl-PRS-ResourceBandwidth specifies the number of PRBs allocated for the sidelink PRS resource (allocated sidelink PRS bandwidth). The parameter sl-PRS-ResourceBandwidth may specify the number of subchannels allocated for the sidelink PRS resource. All sidelink PRS resources of the sidelink PRS resource set may have the same bandwidth. All sidelink PRS resource sets belonging the same positioning frequency layer may have the same value of sidelink PRS bandwidth and start PRB. The parameter sl-PRS-ResourceBandwidth may specify the number of subchannels allocated for the sidelink PRS resource.

[0403] The parameter sl-PRS-StartPRB specifies the start PRB index defined as offset with respect to reference sidelink PRS Point A for the positioning frequency layer. The parameter sl-PRS-StartPRB may specify the start subchannel index for the positioning frequency layer. The start subchannel index may be the absolute subchannel index or start subchannel index defined as offset with respect to reference sidelink PRS Point A. All sidelink PRS resources sets belonging to the same positioning frequency layer may have the same value of sl-PRS-StartPRB.

[0404] The parameter sl-PRS-PointA specifies the absolute frequency of the reference resource block for the sidelink PRS. Its lowest subcarrier is also known as sidelink PRS Point A. A single sidelink PRS Point A for sidelink PRS resource allocation is provided per positioning frequency layer. All sidelink PRS resources belonging to the same sidelink PRS resource set may have the same sidelink PRS Point A.

[0405] The parameter sl-PRS-CombSizeN specifies the resource element spacing in each symbol of the sidelink PRS resource. All sidelink PRS resource sets belonging to the same positioning frequency layer have the same value of comb size N.

[0406] The parameter sl-PRS-CyclicPrefix specifies the cyclic prefix length of the sidelink PRS resource. All sidelink PRS resources sets belonging to the same positioning frequency layer may have the same value of sl-PRS-CyclicPrefix.

[0407] The UE #1 may configure (send a configuration message) the associated peer UE to perform NR sidelink measurement and report on the corresponding PC5-RRC connection in accordance with the NR sidelink measurement configuration for unicast by RRCReconfigurationSidelink message. The UE #1 may transmit sidelink reference signal (s) for positioning (e.g. SL PRS and/or SL SRS). The UE #1 may receive (acquire) a sidelink positioning measurement report from the UE #2. More specifically, the higher-layer processing unit and/or Radio resource control layer processing unit may send the configuration message. Wireless transmission/reception unit may transmit the sidelink reference signal(s) for positioning. The higher-layer processing unit and/or radio resource control layer processing unit may receive (acquire) the sidelink positioning measurement report.

[0408] The UE #2 may perform NR sidelink measurement and report on the corresponding PC5-RRC connection in accordance with the NR sidelink measurement configuration for unicast by RRCReconfigurationSidelink message which the UE #2 acquire. The UE #2 may receive sidelink reference signal(s) for positioning. The UE #2 may report (send) a sidelink positioning measurement report to the UE #1. More specifically, the higher-layer processing unit and/or radio resource control layer processing unit may acquire the configuration message. Wireless transmission/reception unit may receive and/or measure the sidelink reference signal(s) for positioning. The higher-layer processing unit and/or radio resource control layer processing unit may report (send) the sidelink positioning measurement report.

[0409] The NR sidelink measurement configuration may include (1) NR sidelink measurement objects, (2) NR sidelink reporting configurations, (3) NR sidelink measurement identities, and (4) NR sidelink quantity configurations, for a PC5-RRC connection.

[0410] NR sidelink measurement objects are the object(s) on which the associated peer UE shall perform the NR sidelink measurements. The NR sidelink measurement object may indicate the NR sidelink frequency of reference signals to be measured.

[0411] NR sidelink reporting configurations are the configuration(s) where there can be one or multiple NR sidelink reporting configurations per NR sidelink measurement object. Each NR sidelink reporting configuration consists of reporting criterion, RS type and reporting format. Reporting criterion is the criterion that triggers the UE to send a NR sidelink measurement report. RS type may indicate the RS (e.g., DMRS) that the UE #1 and the UE #2 use for NR sidelink measurement results. Reporting format may be the quantities (e.g., RSRP) that the UE #2 includes in the measurement report.

[0412] NR sidelink measurement identities indicate a list ofNR sidelink measurement identities where each NR sidelink measurement identity links one NR sidelink measurement object with one NR sidelink reporting configuration.

[0413] NR sidelink quantity configuration defines the NR sidelink measurement filtering configuration used for all event evaluation and related reporting, and for periodical reporting of that NR sidelink measurement.

[0414] In this embodiment, the UE #1 and the UE #2 perform the sidelink positioning using sidelink PRS with sidelink PRS configuration and sidelink PRS measurement configuration. The same principle can be applied for the case that the UE #1 and the UE #2 perform the sidelink positioning using sidelink SRS. For that case, RRCReconfigurationSidelink may include sl-SRS-Config and/or sl-SRS-MeasConfig instead of sl-PRS-Config and/or sl-PRS-MeasConfig. The sl-SRS-Config and/or the sl-SRS-MeasConfig can have same structure with the sl-PRS-Config and/or the sl-PRS-MeasConfig though these are the configuration of sidelink SRS for sidelink positioning and the configuration of sidelink positioning reporting with sidelink SRS.

[0415] FIG. **15** shows an example of a method for a UE #1. The method may comprise transmitting, to other UE, a reference signal for sidelink positioning (Step **1001**). The method may also acquiring a PC5-RRC message including a measurement result of sidelink positioning (Step S**1002**).

[0416] FIG. **16** shows an example of a method for a UE #2. The method may comprise receiving, from other UE, a reference signal for sidelink positioning (Step **2001**). The method may also comprise sending a PC5-RRC message including a measurement result of sidelink positioning (Step S**2002**).

[0417] Each of a program running on the base station device and the terminal device according to an aspect of the present invention may be a program that controls a Central Processing Unit (CPU) and the like, such that the program causes a computer to operate in such a manner as to realize the functions of the above-described embodiment according to the present invention. The information handled in these devices is transitorily stored in a Random-Access-Memory (RAM) while being processed. Thereafter, the information is stored in various types of Read-Only-Memory (ROM) such as a Flash ROM and a Hard-Disk-Drive (HDD), and when necessary, is read by the CPU to be modified or rewritten.

[0418] Note that the terminal device **1** and the base station device **3** according to the above-described embodiment may be partially achieved by a computer. In this case, this configuration may be realized by recording a program for realizing such control functions on a computer-readable recording medium and causing a computer system to read the program recorded on the recording medium for execution.

[0419] Note that it is assumed that the "computer system" mentioned here refers to a computer system built into the terminal device **1** or the base station device **3**, and the computer system includes an OS and hardware components such as a peripheral device. Furthermore, the "computer-readable recording medium" refers to a portable medium such as a flexible disk, a magneto-optical disk, a ROM, a CD-ROM, and the like, and a storage device built into the computer system such as a hard disk.

[0420] Moreover, the "computer-readable recording medium" may include a medium that dynamically retains a program for a short period of time, such as a communication line that is used to transmit the program over a network such as the Internet or over a communication line such as a telephone line, and may also include a medium that retains a program for a fixed period of time, such as a volatile memory within the computer system for functioning as a server or a client in such a case. Furthermore, the program may be configured to realize some of the functions described above, and also may be configured to be capable of realizing the functions described above in combination with a program already recorded in the computer system.

[0421] Furthermore, the base station device **3** according to the above-described embodiment may be achieved as an aggregation (an device group) including multiple devices. Each of the devices configuring such an device group may include some or all of the functions or the functional blocks of the base station device **3** according to the above-described embodiment. The device group may include each general function or each functional block of the base station device **3**. Furthermore, the terminal device **1** according to the above-described embodiment can also communicate with the base station device as the aggregation.

[0422] Furthermore, the base station device **3** according to the above-described embodiment may serve as an Evolved Universal Terrestrial Radio Access Network (E-UTRAN) and/or NG-RAN (Next Gen RAN, NR-RAN). Furthermore, the base station device **3** according to the above-described embodiment may have some or all of the functions of a node higher than an eNodeB or the gNB.

[0423] Furthermore, some or all portions of each of the terminal device **1** and the base station device **3** according to the above-described embodiment may be typically achieved as an LSI which is an integrated circuit or may be achieved as a chip set. The functional blocks of each of the terminal device **1** and the base station device **3** may be individually achieved as a chip, or some or all of the functional blocks may be integrated into a chip. Furthermore, a circuit integration technique is not limited to the LSI, and may be realized with a dedicated circuit or a general-purpose processor. Furthermore, in a case that with advances in semiconductor technology, a circuit integration technology with which an LSI is replaced appears, it is also possible to use an integrated circuit based on the technology.

[0424] Furthermore, according to the above-described embodiment, the terminal device has been described as an example of a communication device, but the present invention is not limited to such a terminal device, and is applicable to a terminal device or a communication device of a fixed-type or a stationary-type electronic device installed indoors or outdoors, for example, such as an Audio-Video (AV) device, a kitchen device, a cleaning or washing machine, an air-conditioning device, office equipment, a vending machine, and other household devices.

[0425] Furthermore, according to the above-described embodiment, the words/parameters described by Italic may be RRC parameter, higher layer parameter, PC5-RRC parameter and/or preconfigured parameter.

[0426] The embodiments of the present invention have been described in detail above referring to the drawings, but the specific configuration is not limited to the embodiments and includes, for example, an amendment to a design that falls within the scope that does not depart from the gist of the present invention. Furthermore, various modifications are possible within the scope of one aspect of the present invention defined by claims, and embodiments that are made by suitably combining technical means disclosed according to the different embodiments are also included in the technical scope of the present invention. Furthermore, a configuration in which constituent elements, described in the respective embodiments and having mutually the same effects, are substituted for one another is also included in the technical scope of the present invention.

1. A user equipment (UE) having PC5-RRC connection with other UE, comprising:

transmission circuitry configured to transmit, to the other UE, a reference signal for sidelink positioning; and

higher layer processing circuitry configured to acquire a PC5-RRC message including a measurement result of sidelink positioning.

2. The UE according to the claim **1**:

the measurement result of sidelink positioning includes RSRPP of the reference signal for sidelink positioning.

3. A user equipment (UE) having PC5-RRC connection with other UE, comprising:

reception circuitry configured to receive, from the other UE, a reference signal for sidelink positioning; and

higher layer processing circuitry configured to send a PC5-RRC message including a measurement result of sidelink positioning.

4. The UE according to the claim **3**:

the measurement result of sidelink positioning includes RSRPP of the reference signal for sidelink positioning.

5. A method for a user equipment (UE) having PC5-RRC connection with other UE, the method comprising:

transmitting, to the other UE, a reference signal for sidelink positioning; and

acquiring a PC5-RRC message including a measurement result of sidelink positioning.

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