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Zhang et al.

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(54) **METHODS TO SUPPORT CONFIGURED GRANT TRANSMISSION AND RETRANSMISSION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Jun. 19, 2020**

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Related U.S. Application Data

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(60) Provisional application No. 62/738,048, filed on Sep. 28, 2018.

(51) **Int. Cl.**

H04W 48/12	(2009.01)
H04W 48/16	(2009.01)
H04W 72/12	(2009.01)
H04W 72/14	(2009.01)
H04L 1/18	(2006.01)
H04L 5/00	(2006.01)
H04W 72/04	(2009.01)

(52) **U.S. Cl.**
CPC ***H04W 48/12*** (2013.01); ***H04L 1/1819*** (2013.01); ***H04L 5/0098*** (2013.01); ***H04W 48/16*** (2013.01); ***H04W 72/042*** (2013.01); ***H04W 72/1289*** (2013.01); ***H04W 72/14*** (2013.01)

(58) **Field of Classification Search**
CPC .. H04L 5/0098; H04L 1/1819; H04W 72/042; H04W 72/14
See application file for complete search history.

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(Continued)

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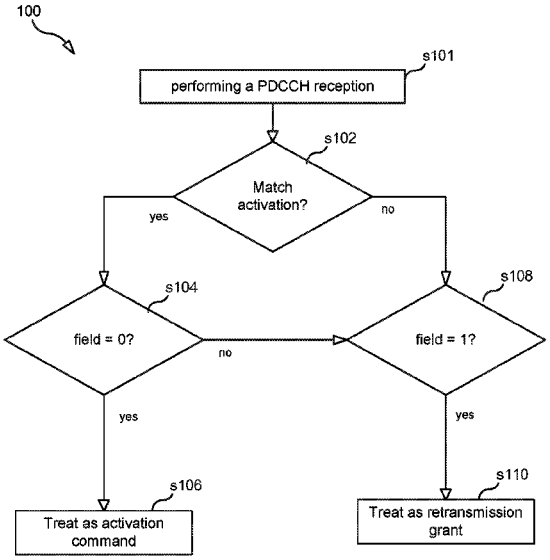
(74) *Attorney, Agent, or Firm* — Rothwell, Figg Ernst & Manbeck, P.C.

(57) **ABSTRACT**

In one aspect there is a method performed by a wireless device, WD. The method includes: (1) the WD receiving a PUSCH-Config IE from a base station, wherein the PUSCH-Config IE includes a first set of PUSCH configuration parameters, wherein the first set of PUSCH configuration parameters includes at least one of the following: txConfig, maxRank, or codebookSubset; and (2) the WD transmitting data on the PUSCH corresponding to a configured grant using the first set of PUSCH configuration parameters.

9 Claims, 17 Drawing Sheets



APPLE 1004

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LG Electronics, "Remaining issues on UL data transmission procedure", 3GPP TSG RAN WG1 Meeting #93, R1-1806628, Busan, Korea, May 21-25, 2018. (21 pages).
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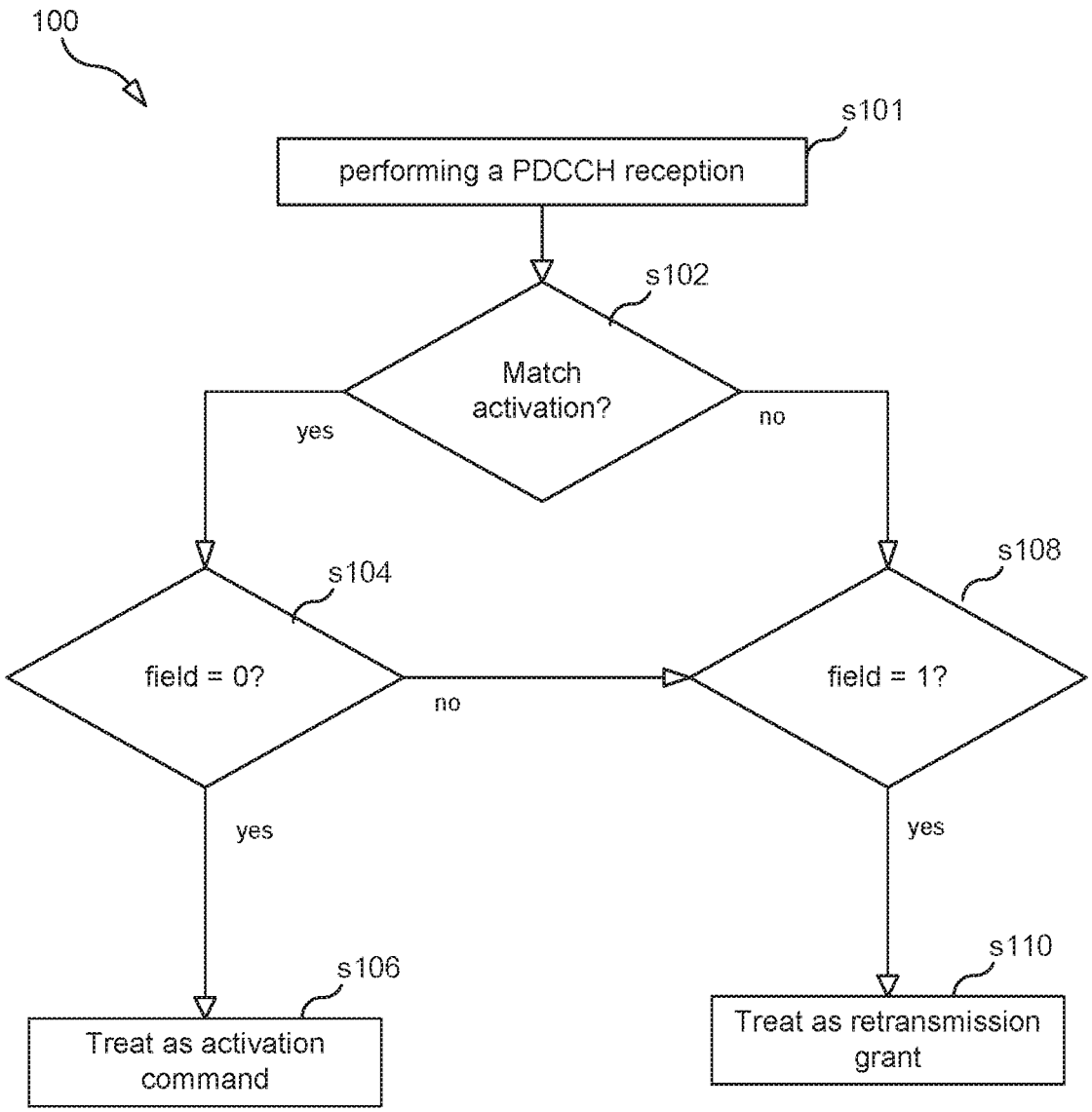
100
s101
performing a PDCCH reception
s102
Match activation?
yes
no
s104
field = 0?
no
s108
field = 1?
yes
yes
s106
Treat as activation command
s110
Treat as retransmission grant

FIG. 1

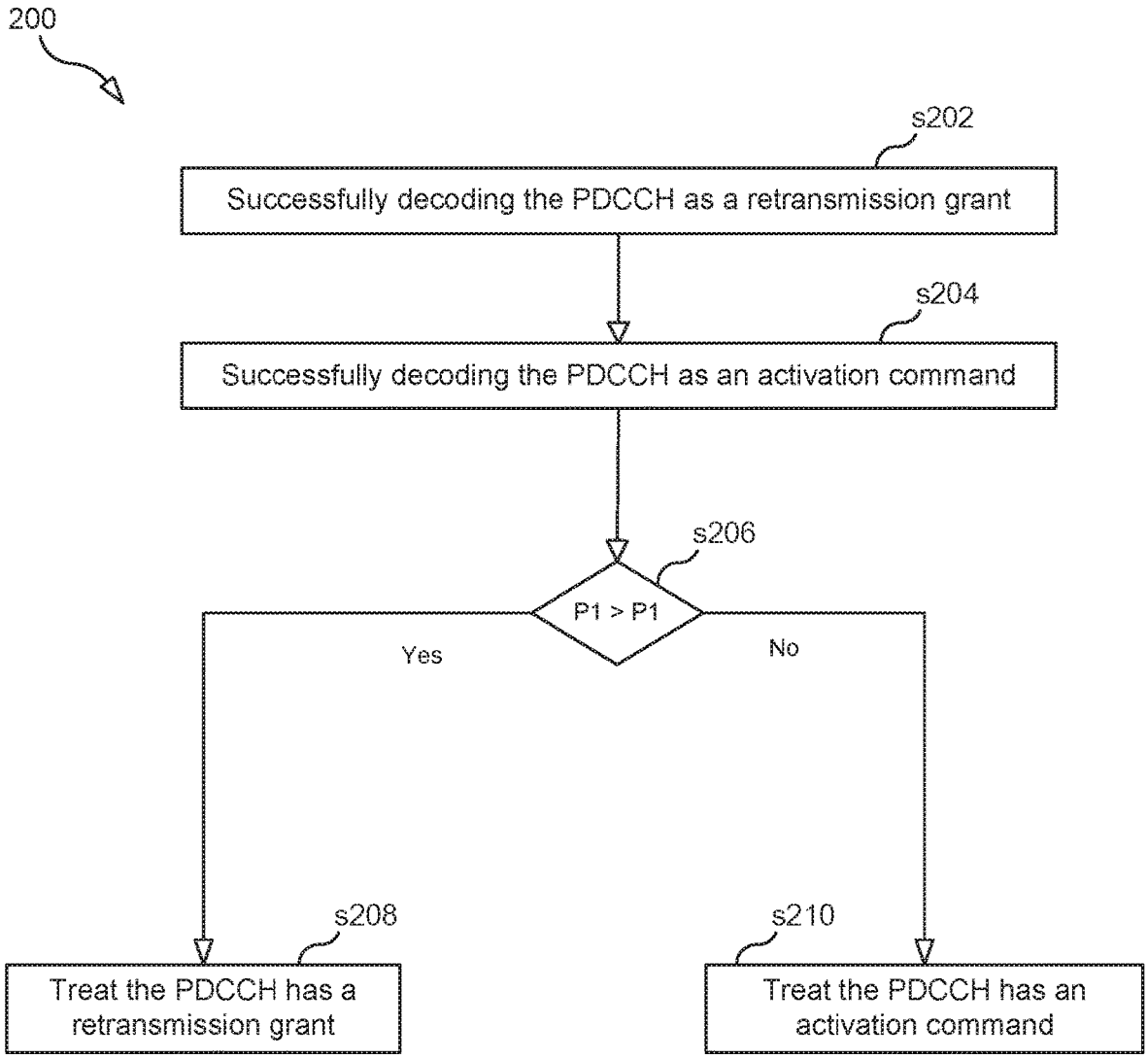
200
s202
Successfully decoding the PDCCH as a retransmission grant
s204
Successfully decoding the PDCCH as an activation command
s206
P1 > P1
Yes
No
s208
Treat the PDCCH has a retransmission grant
s210
Treat the PDCCH has an activation command

FIG. 2

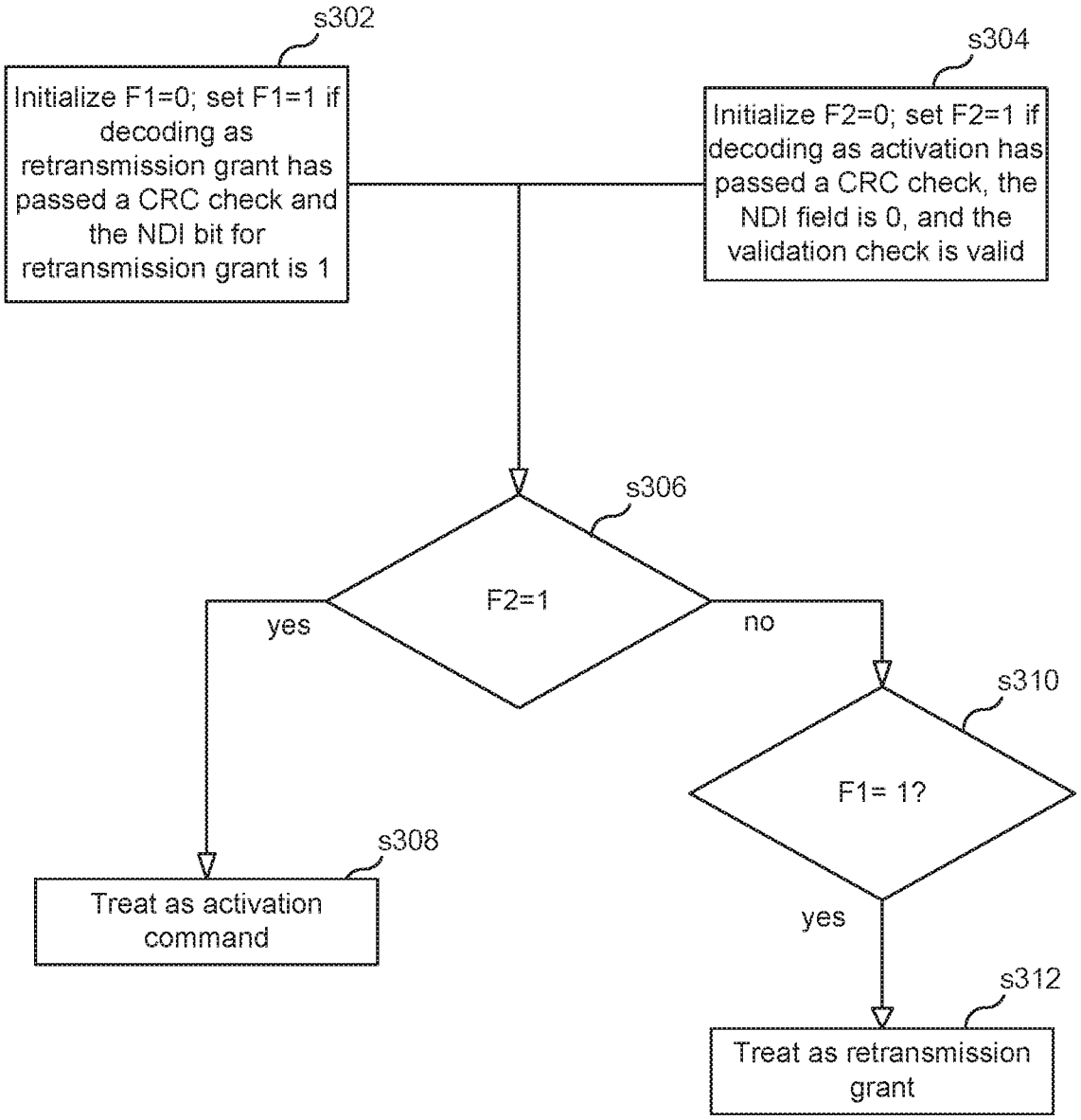
s302
Initialize F1=0; set F1=1 if decoding as retransmission grant has passed a CRC check and the NDI bit for retransmission grant is 1
s304
Initialize F2=0; set F2=1 if decoding as activation has passed a CRC check, the NDI field is 0, and the validation check is valid
s306
F2=1
yes
no
s310
F1= 1?
yes
s308
Treat as activation command
s312
Treat as retransmission grant

FIG. 3

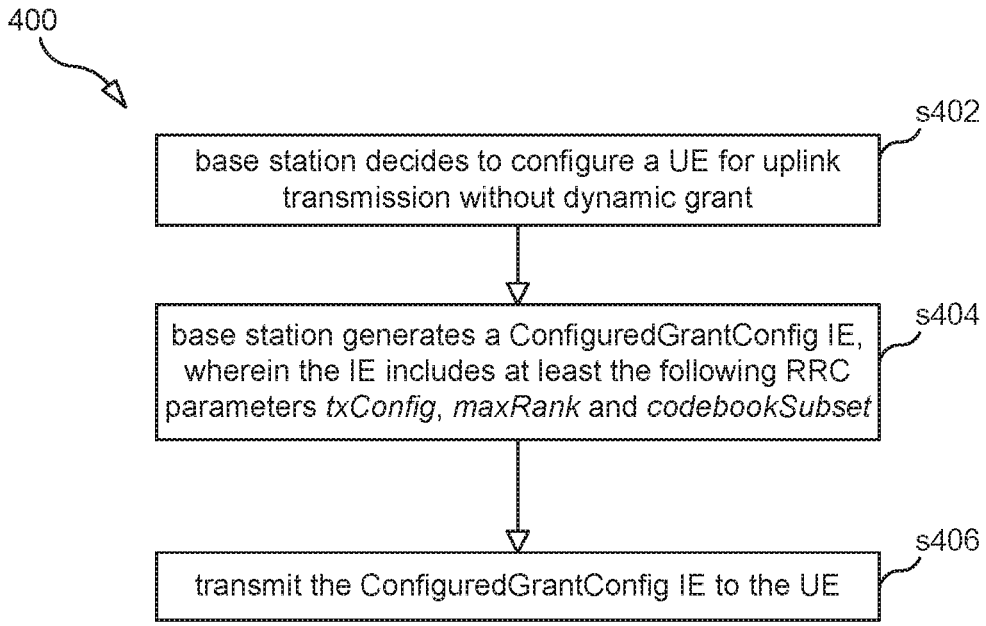
400
s402
base station decides to configure a UE for uplink transmission without dynamic grant
s404
base station generates a ConfiguredGrantConfig IE, wherein the IE includes at least the following RRC parameters txConfig, maxRank and codebookSubset
s406
transmit the ConfiguredGrantConfig IE to the UE

FIG. 4A

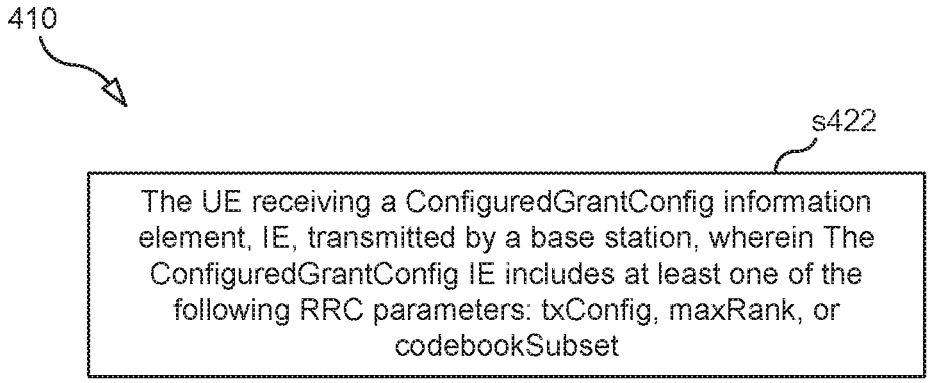
410
s422
The UE receiving a ConfiguredGrantConfig information element, IE, transmitted by a base station, wherein The ConfiguredGrantConfig IE includes at least one of the following RRC parameters: txConfig, maxRank, or codebookSubset

FIG. 4B

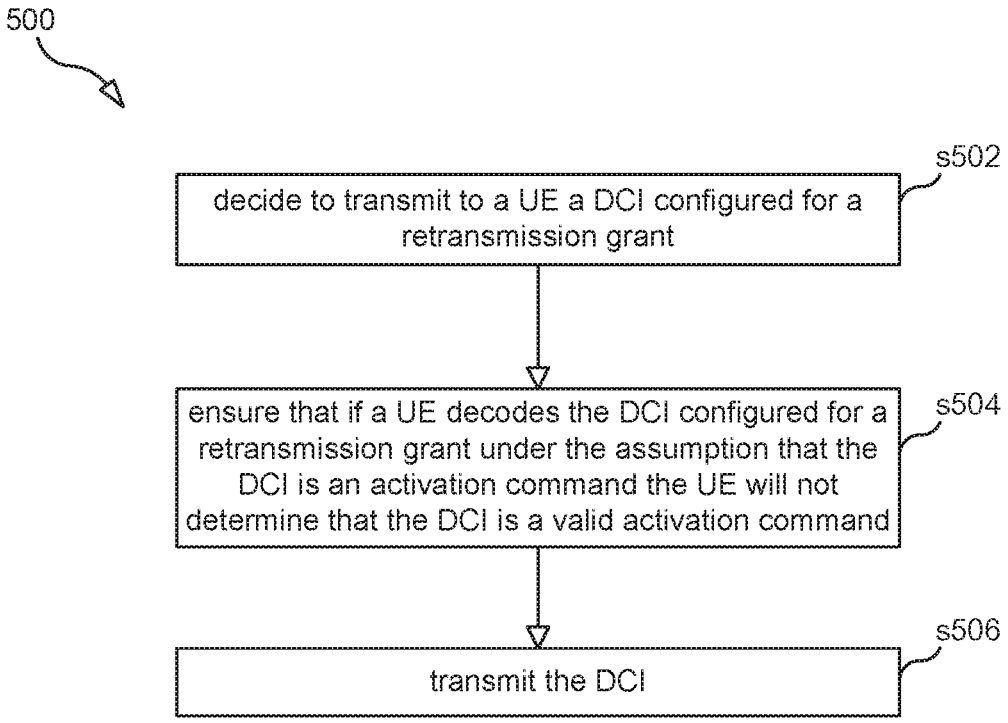
500
s502
decide to transmit to a UE a DCI configured for a retransmission grant
s504
ensure that if a UE decodes the DCI configured for a retransmission grant under the assumption that the DCI is an activation command the UE will not determine that the DCI is a valid activation command
s506
transmit the DCI

FIG. 5

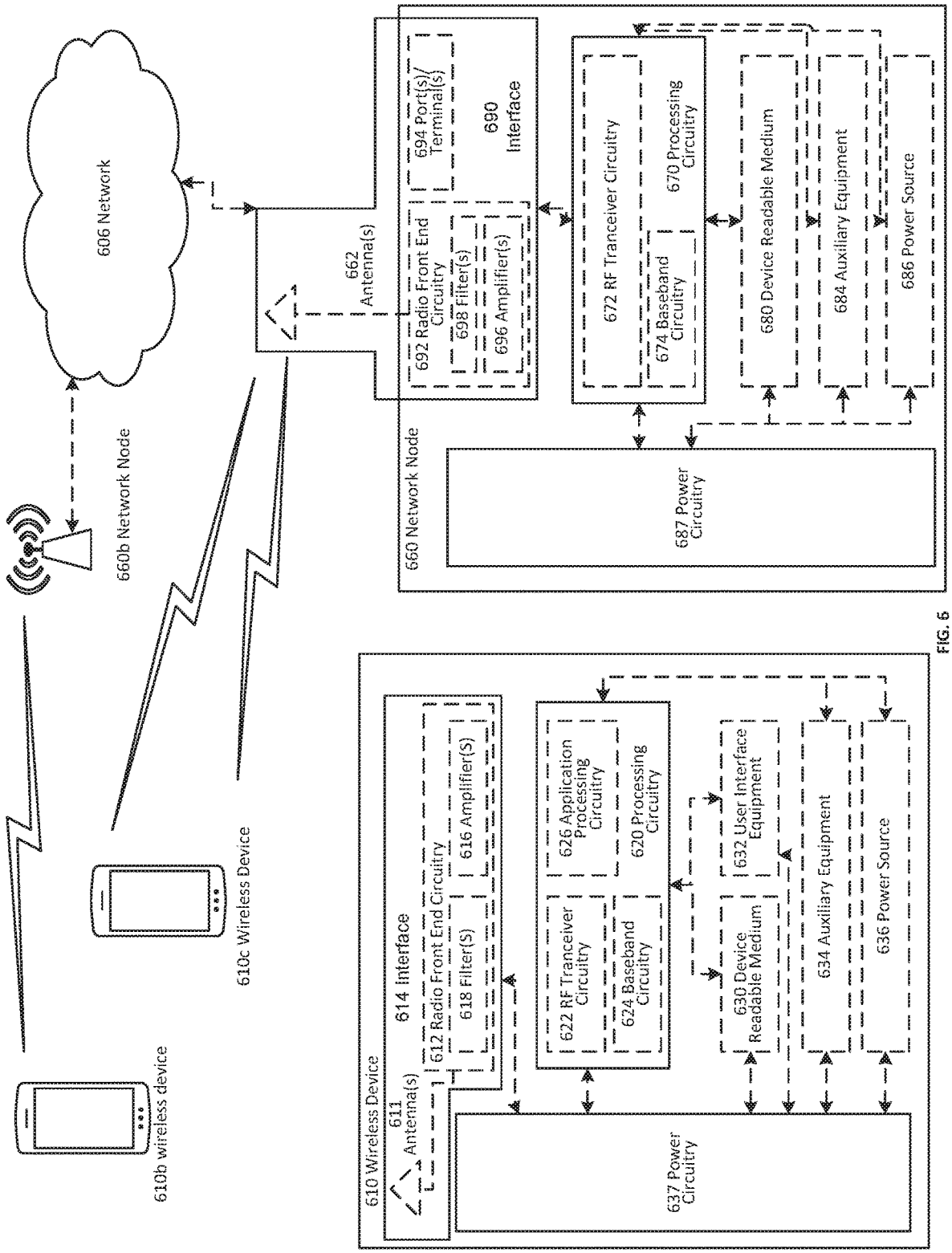
606 Network
660b Network Node
660 Network Node
662 Antenna(s)
692 Radio Front End Circuitry
698 Filter(s)
696 Amplifier(s)
694 Port(s)/ Terminal(s)
690 Interface
672 RF Tranceiver Circuitry
674 Baseband Circuitry
670 Processing Circuitry
680 Device Readable Medium
684 Auxiliary Equipment
686 Power Source
687 Power Circuitry
610c Wireless Device
610b wireless device
610 Wireless Device
611 Antenna(s)
614 Interface
612 Radio Front End Circuitry
618 Filter(S)
616 Amplifier(S)
622 RF Tranceiver Circuitry
624 Baseband Circuitry
626 Application Processing Circuitry
620 Processing Circuitry
630 Device Readable Medium
632 User Interface Equipment
634 Auxiliary Equipment
636 Power Source
637 Power Circuitry

FIG. 6

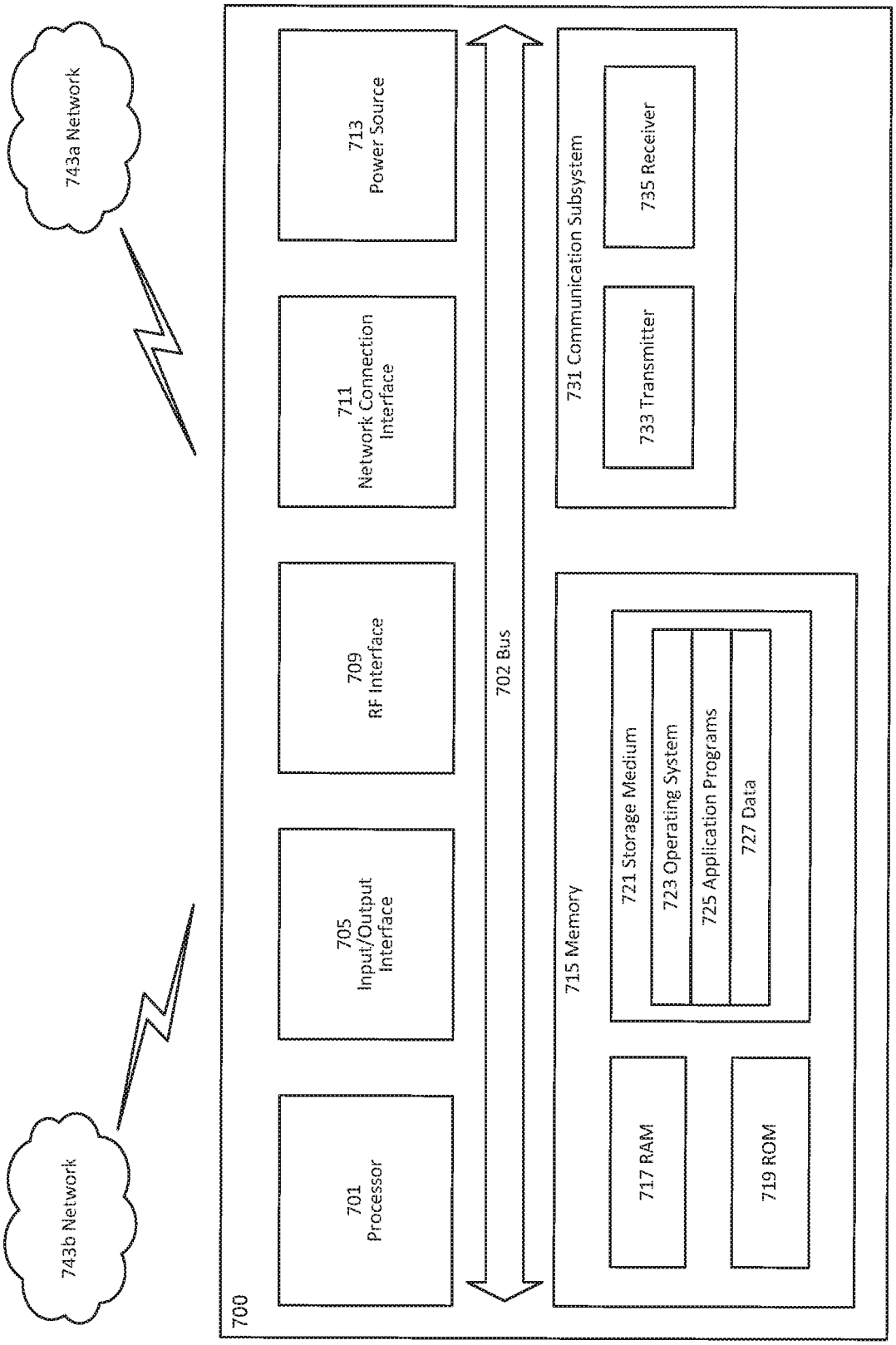
743a Network
743b Network
700
701
Processor
705
Input/Output
Interface
709
RF Interface
711
Network Connection
Interface
713
Power Source
702 Bus
715 Memory
721 Storage Medium
723 Operating System
725 Application Programs
727 Data
717 RAM
719 ROM
731 Communication Subsystem
733 Transmitter
735 Receiver

FIG. 7

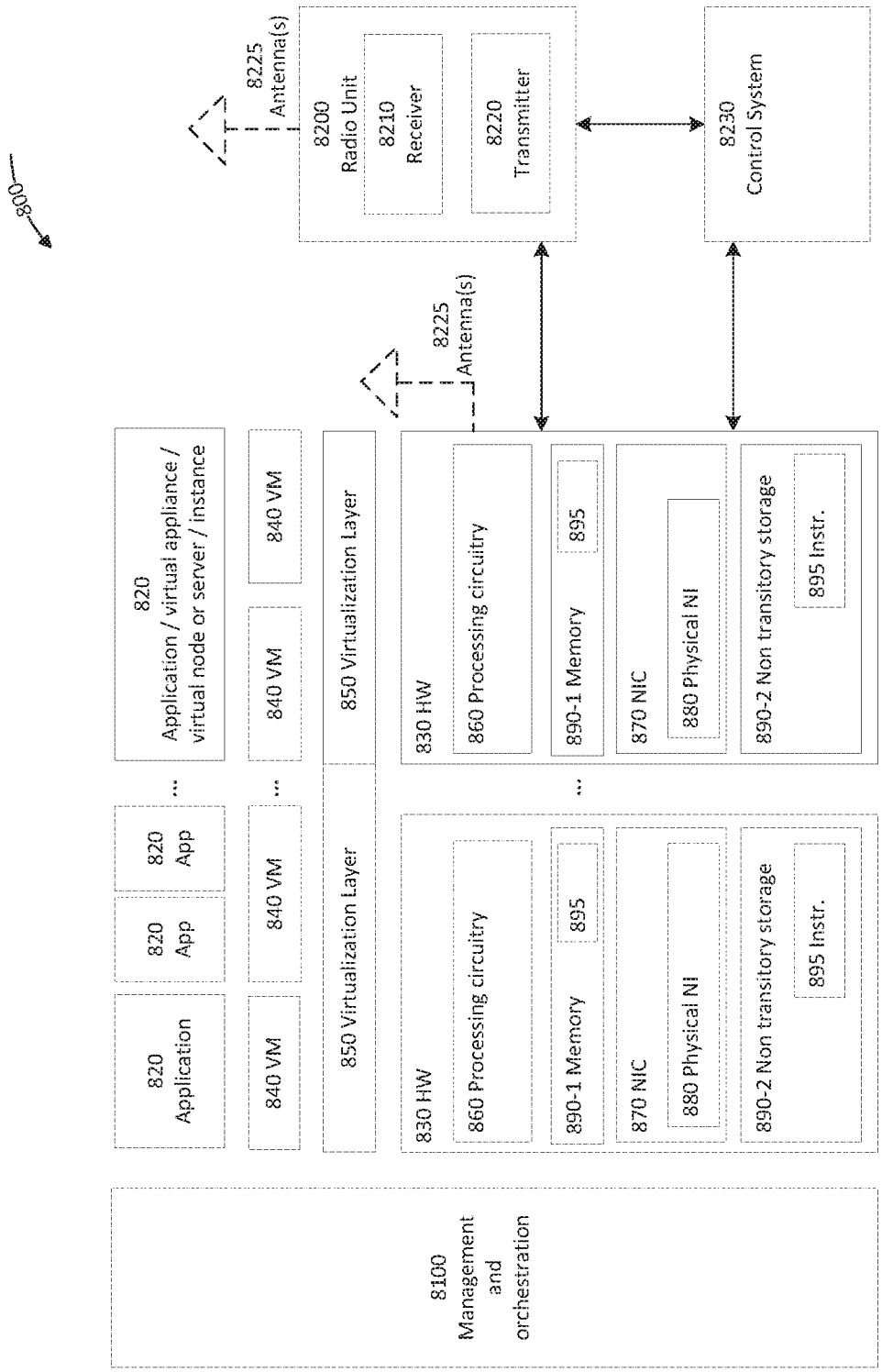
800
8225
Antenna(s)
8200
Radio Unit
8210
Receiver
8220
Transmitter
8230
Control System
8225
Antenna(s)
820
Application / virtual appliance / virtual node or server / instance
840 VM
850 Virtualization Layer
830 HW
860 Processing circuitry
890-1 Memory
895
870 NIC
880 Physical NI
890-2 Non transitory storage
895 Instr.
820
Application
820
App
820
App
840 VM
850 Virtualization Layer
830 HW
860 Processing circuitry
890-1 Memory
895
870 NIC
880 Physical NI
890-2 Non transitory storage
895 Instr.
8100
Management
and
orchestration

FIG. 8

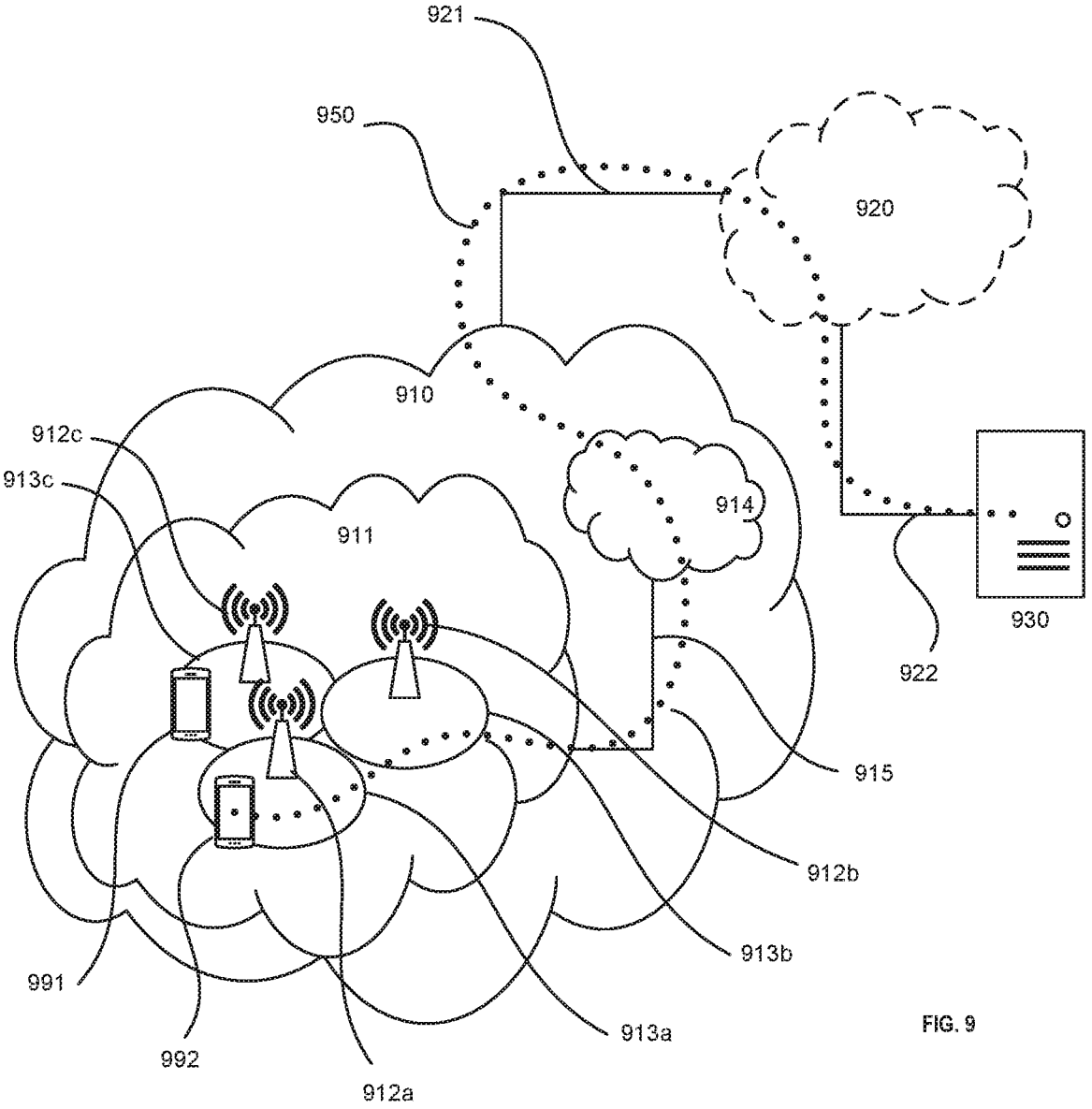
921
950
920
910
912c
913c
911
914
930
922
915
912b
913b
991
992
913a
912a

FIG. 9

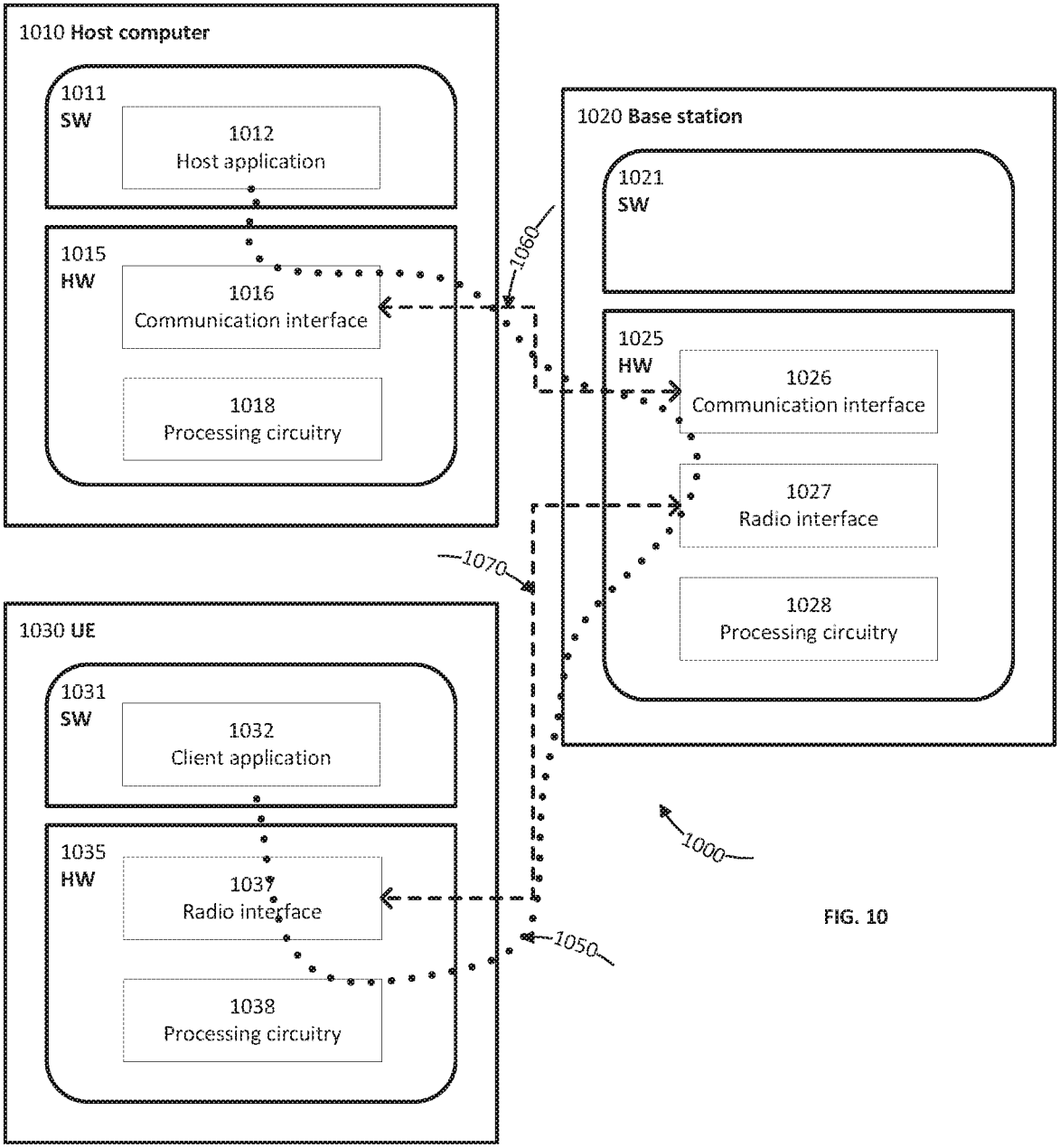
1010 Host computer
1011
SW
1012
Host application
1015
HW
1016
Communication interface
1018
Processing circuitry
1020 Base station
1021
SW
1025
HW
1026
Communication interface
1027
Radio interface
1028
Processing circuitry
1060
1070
1030 UE
1031
SW
1032
Client application
1035
HW
1037
Radio interface
1038
Processing circuitry
1050
1000

FIG. 10

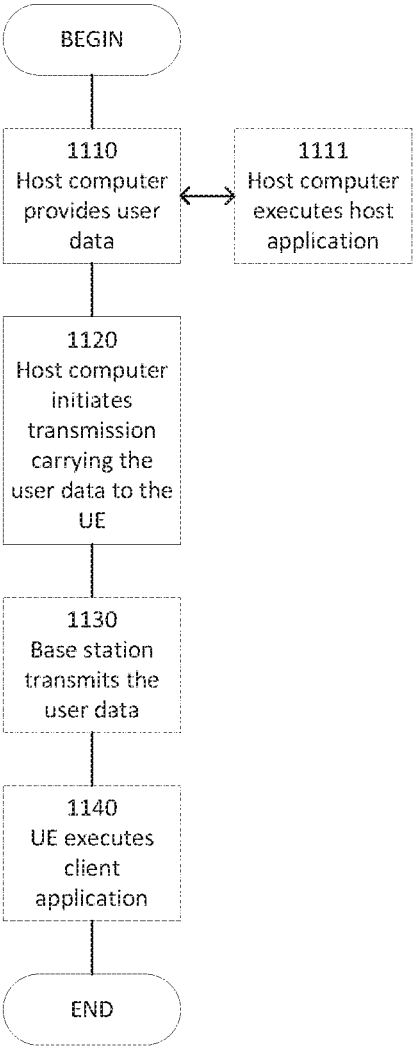
BEGIN
1110
Host computer provides user data
1111
Host computer executes host application
1120
Host computer initiates transmission carrying the user data to the UE
1130
Base station transmits the user data
1140
UE executes client application
END

FIG. 11

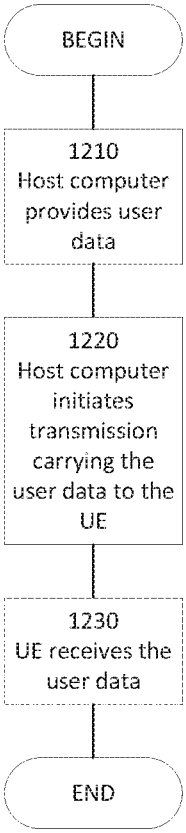
BEGIN
1210
Host computer provides user data
1220
Host computer initiates transmission carrying the user data to the UE
1230
UE receives the user data
END

FIG. 12

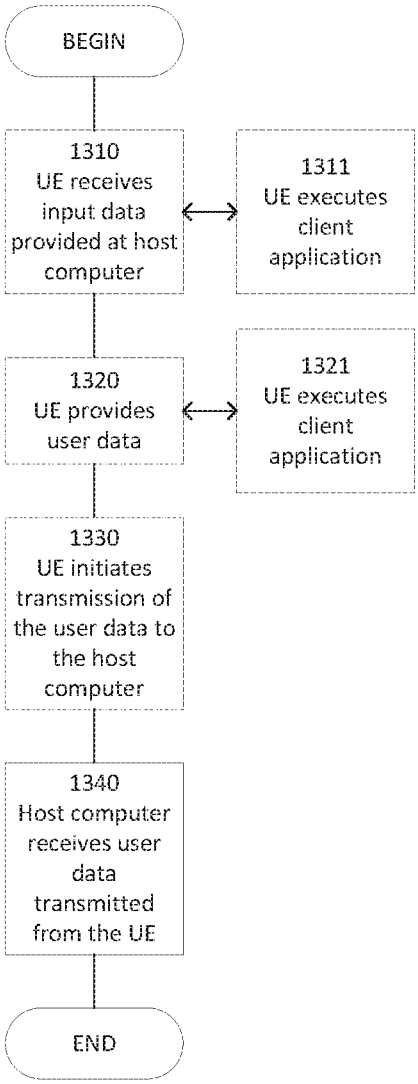
BEGIN
1310
UE receives input data provided at host computer
1311
UE executes client application
1320
UE provides user data
1321
UE executes client application
1330
UE initiates transmission of the user data to the host computer
1340
Host computer receives user data transmitted from the UE
END

FIG. 13

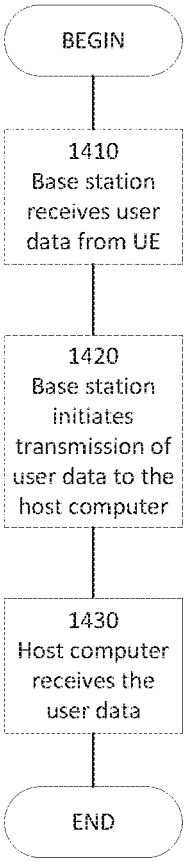
BEGIN
1410
Base station receives user data from UE
1420
Base station initiates transmission of user data to the host computer
1430
Host computer receives the user data
END

FIG. 14

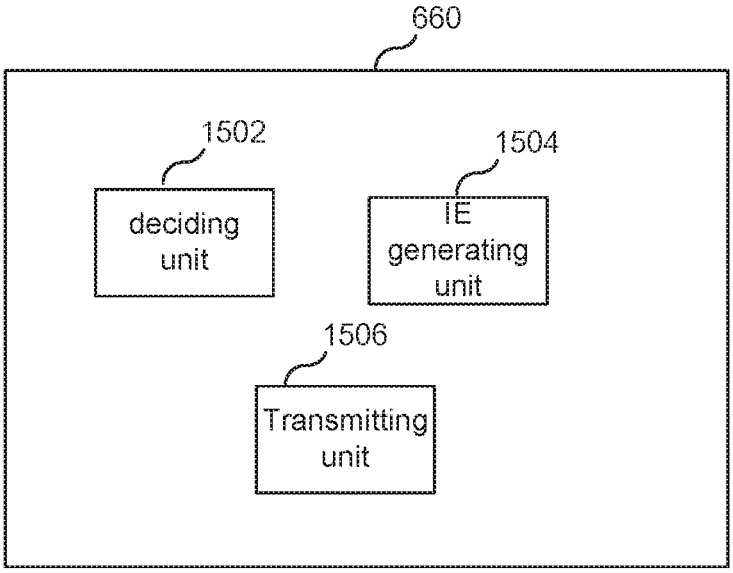

FIG.15A

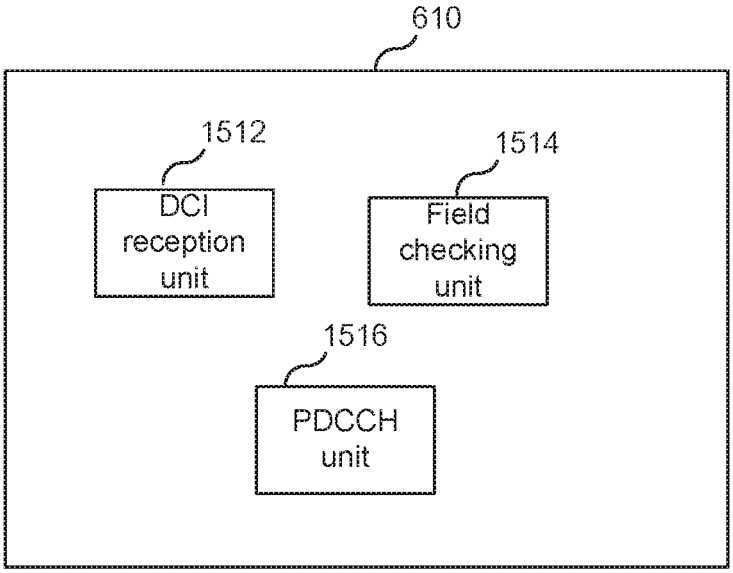

FIG.15B

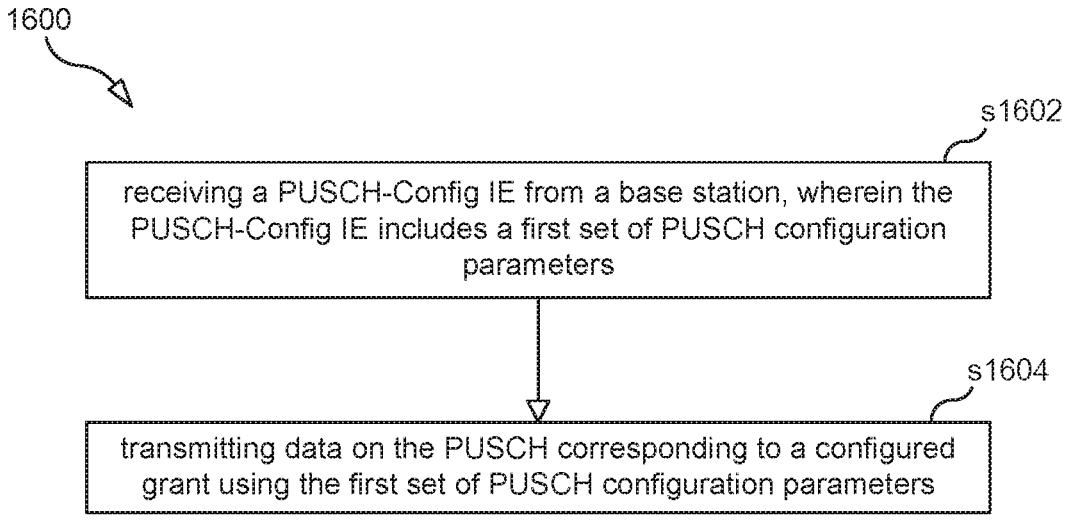

FIG. 16A

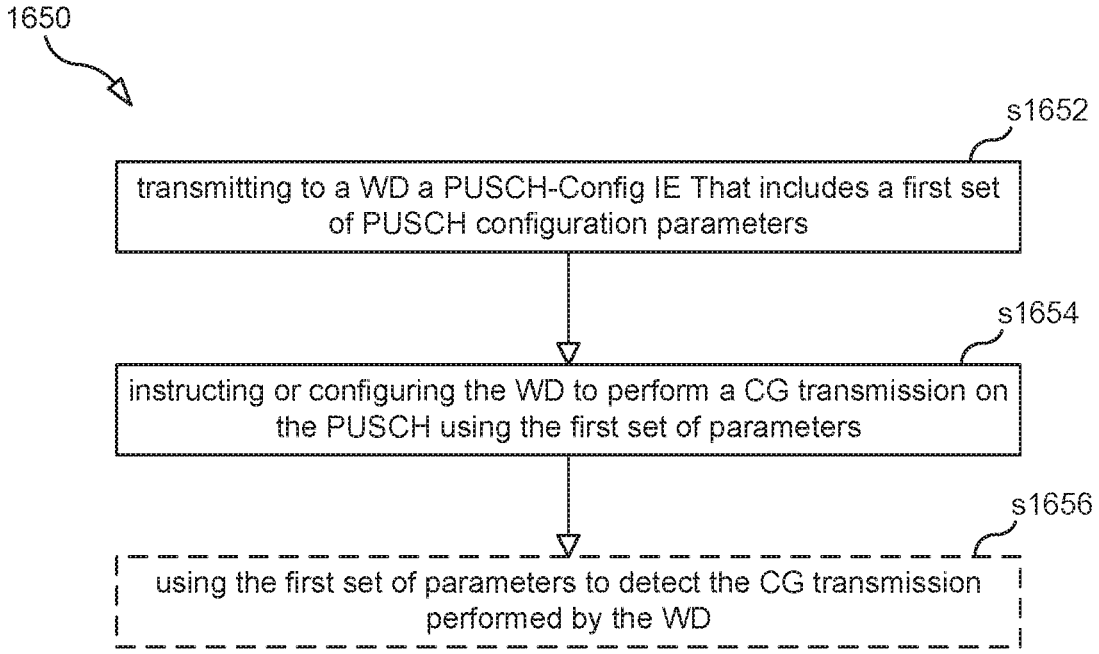

FIG. 16B

DCI 0_1 ConfiguredGrantConfig for activation

ID		FDRA	TDRA	MCS	NDI	RV	HARQ	...	Padding

DCI 0_1 PUSCH-Config for retransmission

ID		FDRA	TDRA	FH	MCS	NDI	RV	HARQ	...

FIG. 17

METHODS TO SUPPORT CONFIGURED GRANT TRANSMISSION AND RETRANSMISSION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of International Patent Application No. PCT/IB2019/058242, filed on Sep. 27, 2019, which claims priority to U.S. provisional patent application No. 62/738,048, filed on Sep. 28, 2018. The above identified applications are incorporated by this reference.

TECHNICAL FIELD

This disclosure relates to supporting configured grant transmission and retransmission.

BACKGROUND

1. PUSCH Transmission

PUSCH transmissions can be: (1) dynamically scheduled by an UL grant in a Downlink Control Information (DCI)

(this is referred to as a Dynamic Grant); (2) semi-statically configured and scheduled by higher layer parameters without detection of an UL grant in a DCI (this is referred to as a Type 1 Configured Grant); or (3) semi-statically configured by higher layer parameters and semi-persistently scheduled by an UL grant in a DCI (this is referred to as a Type 2 Configured Grant).

The higher layer RRC parameters to apply for a Dynamic Grant and the higher layer RRC parameters to apply for a Configured Grant are defined in 3GPP TS 38.331 15.3.0 ("TS 38.331") in information elements (IEs) PUSCH-Config and ConfiguredGrantConfig, respectively.

As explained in TS 38.331, "[t]he IE ConfiguredGrantConfig is used to configure uplink transmission without dynamic grant according to two possible schemes. The actual uplink grant may either be configured via RRC (type1) or provided via the PDCCH (addressed to CS-RNTI) (type2)." The ConfiguredGrantConfig IE as defined in TS 38.331 at section 6.3.2 is shown below:

```
-- ASN1 START
-- TAG-CONFIGUREDGRANTCONFIG-START
ConfiguredGrantConfig ::=                SEQUENCE {
  frequencyHopping                         ENUMERATED {intraSlot, interSlot}                    OPTIONAL,   --
Need S,
  cg-DMRS-Configuration                    DMRS-UplinkConfig,
  mcs-Table                        ENUMERATED {qam256, qam64LowSE}                              OPTIONAL,   -- Need S
  mcs-TableTransformPrecoder                ENUMERATED {qam256, qam64LowSE }                    OPTIONAL,
-- Need S
  uci-OnPUSCH                        SetupRelease { CG-UCI-OnPUSCH }                            OPTIONAL,   --
Need M
  resourceAllocation                 ENUMERATED { resourceAllocationTypeO, resourceAllocationType1,
dynamicSwitch },
  rbg-Size                         ENUMERATED {config2}                                         OPTIONAL,   -- Need S
  powerControlLoopToUse                  ENUMERATED {n0, n1},
  p0-PUSCH-Alpha                         P0-PUSCH-AlphaSetId,
  transformPrecoder                  ENUMERATED {enabled, disabled}                             OPTIONAL,   --
Need S
  nrofHARQ-Processes                   INTEGER(1..16),
  repK                             ENUMERATED {nl, n2, n4, n8},
  repK-RV                          ENUMERATED {s1-0231, s2-0303, s3-0000}                       OPTIONAL,   -- Need R
  periodicity                      ENUMERATED {
sym2, sym7, sym1x14, sym2x14, sym4x14, sym5x14, sym8x14, sym10x14, sym16x14, sym20x14, sym32x14,
sym40x14, sym64x14, sym80x14, sym128x14, sym160x14, sym256x14, sym320x14, sym512x14, sym640x14,
sym1024x14, sym1280x14, sym2560x14, sym5120x14, sym6, sym1x12, sym2x12, sym4x12, sym5x12, sym8x12,
sym10x12, sym16x12, sym20x12, sym32x12, sym40x12, sym64x12, sym80x12, sym128x12, sym160x12,
sym256x12, sym320x12, sym512x12, sym640x12, sym1280x12, sym2560x12
  },
  configuredGrantTimer                 INTEGER (1..64)                                            OPTIONAL,   -- Need R
  rrc-ConfiguredUplinkGrant              SEQUENCE {
    timeDomainOffset                    INTEGER (0..5119),
    timeDomainAllocation                INTEGER (0..15),
    frequencyDomainAllocation              BIT STRING (SIZE(18)),
    antennaPort                      INTEGER (0..31),
    dmrs-SeqInitialization             INTEGER (0..1)                                       OPTIONAL,   -- Need R
    precodingAndNumberOfLayers              INTEGER (0..63),
    srs-ResourceIndicator              INTEGER (0..15)                                      OPTIONAL,   -- Need R
    mcsAndTBS                        INTEGER (0..31),
    frequencyHoppingOffset               INTEGER (1.. maxNrofPhysicalResourceBlocks-1)      OPTIONAL,   --
Need R
    pathlossReferenceIndex              INTEGER (0..maxNrofPUSCH-PathlossReferenceRSs-1),
    ...
  }                                                                  OPTIONAL,      -- Need R
  ...
}
CG-UCI-OnPUSCH ::= CHOICE {
  dynamic                          SEQUENCE (SIZE (1..4)) OF BetaOffsets,
  semiStatic                       BetaOffsets
}-- TAG-CONFIGUREDGRANTCONFIG-STOP
-- ASN1STOP
```

The descriptions for the fields (parameters) included in the ConfiguredGrantConfig IE are provided below:

ConfiguredGrantConfig field descriptions
antennaPort Indicates the antenna port(s) to be used for this configuration, and the maximum bitwidth is 5. See 3GPP TS 38.214 ("TS 38.214"), section 6.1.2, and TS 38.212, section 7.3.1. cg-DMRS-Configuration DMRS configuration, corresponds to L1 parameter 'UL-TWG-DMRS' (see TS 38.214, section 6.1.2). configuredGrantTimer Indicates the initial value of the configured grant timer (see TS 38.321,) in number of periodicities. dmrs-SeqInitialization The network configures this field if transformPrecoder is disabled. Otherwise the field is absent. frequencyDomainAllocation Indicates the frequency domain resource allocation, see TS 38.214, section 6.1.2, and TS 38.212, section 7.3.1). frequencyHopping The value intraSlot enables 'Intra-slot frequency hopping' and the value interSlot enables 'Interslot frequency hopping'. If the field is absent, frequency hopping is not configured. frequencyHoppingOffset Enables intra-slot frequency hopping with the given frequency hopping offset. Frequency hopping offset used when requency hopping is enabled. Corresponds to L1 parameter 'Frequency-hopping-offset' (see TS 38.214, section 6.1.2). mcs-Table Indicates the MCS table the UE shall use for PUSCH without transform precoding. If the field is absent the UE applies the value 64QAM. mcs-TableTransformPrecoder Indicates the MCS table the UE shall use for PUSCH with transform precoding. If the field is absent the UE applies the value 64QAM. mcsAndTBS The modulation order, target code rate and TB size (see TS38.214, section 6.1.2). The NW does not configure the values 28~31 in this version of the specification. nrofHARQ-Processes The number of HARQ processes configured. It applies for both Type 1 and Type 2. See TS 38.321, section 5.4.1. p0-PUSCH-Alpha Index of the P0-PUSCH-AlphaSet to be used for this configuration. periodicity Periodicity for UL transmission without UL grant for type 1 and type 2. Corresponds to L1 parameter 'UL-TWG-periodicity' (see TS 38.321, section 5.8.2). The following periodicities are supported depending on the configured subcarrier spacing [symbols]: 15 kHz: 2, 7, n*14, where n = {1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 320, 640} 30 kHz: 2, 7, n*14, where n = {1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 256, 320, 640, 1280} 60 kHz with normal CP: 2, 7, n*14, where n = {1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 256, 320, 512, 640, 1280, 2560} 60 kHz with ECP: 2, 6, n*12, where n = {1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 256, 320, 512, 640, 1280, 2560} 120 kHz: 2, 7, n*14, where n = {1, 2, 4, 5, 8, 10, 16, 20, 32, 40, 64, 80, 128, 160, 256, 320, 512, 640, 1024, 1280, 2560, 5120} (see 38.214, Table 6.1.2.3-1) powerControlLoopToUse Closed control loop to apply. Corresponds to L1 parameter 'PUSCH-closed-loop-index' (see TS 38.213, section 7.7.1). rbg-Size Selection between configuration 1 and configuration 2 for RBG size for PUSCH. When the field is absent the UE applies the value config1. The NW may only set the field to config2 if resourceAllocation is set to resourceAllocationType0 or dynamicSwitch. Note: rbg-Size is used when the transformPrecoder parameter is disabled. repK-RV The redundancy version (RV) sequence to use. See TS 38.214, section 6.1.2. The network configures this field if repetitions are used, i.e., if repK is set to n2, n4 or n8. Otherwise, the field is absent. repK The number or repetitions of K. resourceAllocation Configuration of resource allocation type 0 and resource allocation type 1. For Type 1 UL data transmission without grant, "resourceAllocation" should be resourceAllocationType0 or resourceAllocationType1. rrc-ConfiguredUplinkGrant Configuration for "configured grant" transmission with fully RRC-configured UL grant (Type1). If this field is absent the UE uses UL grant configured by DCI addressed to CS-RNTI (Type2). Type 1 configured grant may be configured for UL or SUL, but not for both simultaneously. srs-ResourceIndicator

-continued

ConfiguredGrantConfig field descriptions
Indicates the SRS resource to be used. timeDomainAllocation Indicates a combination of start symbol and length and PUSCH mapping type, see TS 38.214, section 6.1.2 and TS 38.212, section 7.3.1. timeDomainOffset Offset related to SFN = 0, see TS 38.321, section 5.8.2. transformPrecoder Enables or disables transform precoding for type1 and type2. If the field is absent, the UE enables or disables transform precoding in accordance with the field msg3-transformPrecoder in RACH-ConfigCommon, see 38.214, section 6.1.3. uci-OnPUSCH Selection between and configuration of dynamic and semi-static beta-offset. For Type 1 UL data transmission without grant, uci-OnPUSCH should be set to semiStatic.

As explained in TS 38.331, "[t]he IE PUSCH-Config is used to configure the UE specific PUSCH parameters applicable to a particular BWP." The PUSCH-Config IE as defined in TS 38.331 at section 6.3.2 is shown below:

```
-- ASN1START
-- TAG-PUSCH-CONFIG-START
PUSCH-Config ::=                    SEQUENCE {
  dataScramblingIdentityPUSCH       INTEGER (0..1023)                                    OPTIONAL,   --
Need S
  txConfig                          ENUMERATED {codebook, nonCodebook}                   OPTIONAL,   -
- Need S
  dmrs-UplinkForPUSCH-MappingTypeA          SetupRelease {DMRS-UplinkConfig }
OPTIONAL, -- Need M
  dmrs-UplinkForPUSCH-MappingTypeB          SetupRelease {DMRS-UplinkConfig }
OPTIONAL, -- Need M
  pusch-PowerControl                PUSCH-PowerControl                                   OPTIONAL, --
Need M
  frequencyHopping                  ENUMERATED {intraS lot, interS lot}
OPTIONAL, -- Need S
  frequencyHoppingOffsetLists               SEQUENCE (SIZE (1..4)) OF INTEGER (1..
maxNrofPhysicalResourceBlocks-1)          OPTIONAL, -- Need M
  resourceAllocation                ENUMERATED { resourceAllocationTypeO, resourceAllocationType1,
dynamicSwitch},
  pusch-TimeDomainAllocationList            SetupRelease { PUSCH-TimeDomainResourceAllocationList }
OPTIONAL, -- Need M
  pusch-AggregationFactor           ENUMERATED { n2, n4, n8 }                            OPTIONAL,   --
Need S
  mcs-Table                         ENUMERATED {qam256, qam64LowSE}                      OPTIONAL,   --
Need S
  mcs-TableTransformPrecoder                ENUMERATED {qam256, qam64LowSE}
OPTIONAL, -- Need S
  transformPrecoder                 ENUMERATED {enabled, disabled}                       OPTIONAL,   -- Need
                                                                                         S
  codebookSubset                    ENUMERATED {fullyAndPartialAndNonCoherent, partialAndNonCoherent,
                                      nonCoherent }                                      OPTIONAL,   -- Cond codebookBased
  maxRank                           INTEGER (1..4)                                       OPTIONAL,   -- Cond
codebookBased
  rbg-Size                          ENUMERATED {config2}                                 OPTIONAL,   -- Need S
  uci-OnPUSCH                       SetupRelease {UCI-OnPUSCH}                           OPTIONAL, -- Need M
  tp-pi2BPSK                        ENUMERATED {enabled}                                 OPTIONAL,   -- Need S
  ...
}
UCI-OnPUSCH ::=                     SEQUENCE {
  betaOffsets                       CHOICE {
      dynamic                         SEQUENCE (SIZE (4)) OF BetaOffsets,
      semiStatic                      BetaOffsets
  }                                   OPTIONAL, -- Need M
  scaling                           ENUMERATED {f0p5, f0p65, f0p8, f1 }
}
-- TAG-PUSCH-CONFIG-STOP
-- ASN1STOP
```

The descriptions for the fields (parameters) included in the PUSCH-Config IE are provided below:

PUSCH-Config field descriptions
codebookSubset Subset of PMIs addressed by TPMI, where PMIs are those supported by UEs with maximum coherence capabilities Corresponds to L1 parameter 'ULCodebookSubset' (see 38.211, section 6.3.1.5). dataScramblingIdentityPUSCH Identifier used to initalite data scrambling (c_init) for PUSCH. If the field is absent, the UE applies the physical cell ID. (see 38.211, section 6.3.1.1). dmrs-UplinkForPUSCH-MappingTypeA DMRS configuration for PUSCH transmissions using PUSCH mapping type A (chosen dynamically via PUSCH-TimeDomainResourceAllocation). Only the fields dmrs-Type, dmrs-AdditionalPosition and maxLength may be set differently for mapping type A and B. dmrs-UplinkForPUSCH-MappingTypeB DMRS configuration for PUSCH transmissions using PUSCH mapping type B (chosen dynamically via PUSCH-TimeDomainResourceAllocation).Only the fields dmrs-Type, dmrs-AdditionalPosition and maxLength may be set differently for mapping type A and B. frequencyHopping The value intraSlot enables 'Intra-slot frequency hopping' and the value interSlot enables 'Interslot frequency hopping'. If the field is absent, frequency hopping is not configured. Corresponds to L1 parameter 'Frequency-hopping-PUSCH' (see 38.214, section 6). frequencyHoppingOffsetLists Set of frequency hopping offsets used when frequency hopping is enabled for granted transmission (not msg3) and type 2 Corresponds to L1 parameter 'Frequency-hopping-offsets-set' (see 38.214, section 6.3). maxRank Subset of PMIs addressed by TRIs from 1 to ULmaxRank. Corresponds to L1 parameter 'ULmaxRank' (see 38.211, section 6.3.1.5). mcs-Table Indicates which MCS table the UE shall use for PUSCH without transform precoder (see 38.214, section 6.1.4.1). If the field is absent the UE applies the value 64QAM mcs-TableTransformPrecoder Indicates which MCS table the UE shall use for PUSCH with transform precoding (see 38.214, section 6.1.4.1) If the field is absent the UE applies the value 64QAM pusch-AggregationFactor Number of repetitions for data. Corresponds to L1 parameter 'aggregation-factor-UL' (see 38.214, section FFS_Section). If the field is absent the UE applies the value 1. pusch-TimeDomainAllocationList List of time domain allocations for timing of UL assignment to UL data. If configured, the values provided herein override the values received in corresponding PUSCH-ConfigCommon for PDCCH scrambled with C-RNTI or CS-RNTI but not for CORESET#0 (see 38.214, table 6.1.2.1.1-1). rbg-Size Selection between configuration 1 and configuration 2 for RBG size for PUSCH. When the field is absent the UE applies the value config1. The NW may only set the field to config2 if resourceAllocation is set to resourceAllocationType0 or dynamicSwitch. Corresponds to L1 parameter 'RBG-size-PUSCH' (see 38.214, section 6.1.2.2.1). resourceAllocation Configuration of resource allocation type 0 and resource allocation type 1 for non-fallback DCI Corresponds to L1 parameter 'Resouce-allocation-config' (see 38.214, section 6.1.2). tp-pi2BPSK Enables pi/2-BPSK modulation with transform precoding if the field is present and disables it otherwise. transformPrecoder The UE specific selection of transformer precoder for PUSCH. When the field is absent the UE applies the value msg3-tp. Corresponds to L1 parameter 'PUSCH-tp' (see 38.211, section 6.3.1.4). txConfig Whether UE uses codebook based or non-codebook based transmission. Corresponds to L1 parameter 'ulTxConfig' (see 38.214, section 6.1.1). If the field is absent, the UE transmits PUSCH on one antenna port, see 38.214, section 6.1.1.

UCI-OnPUSCH field descriptions
beta Offsets Selection between and configuration of dynamic and semi-static beta-offset. If the field is absent or released, the UE applies the value 'semiStatic' and the BetaOffsets according to FFS [BetaOffsets and/or section 9.x.x). Corresponds to L1 parameter 'UCI-on-PUSCH' (see 38.213, section 9.3). scaling Indicates a scaling factor to limit the number of resource elements assigned to UCI on PUSCH. Value f0p5 corresponds to 0.5, value f0p65 corresponds to 0.65, and so on. The value configured herein is applicable for PUCCH with configured grant. Corresponds to L1 parameter 'uci-on- pusch-scaling' (see 38.212, section 6.3).

-continued

Conditional Presence	Explanation
codebookBased	The field is mandatory present if txConfig is set to codebook and absent otherwise.

2. Transmission Schemes

3GPP TS 38.214 section 6.1.1 states, "two transmission schemes are supported for PUSCH: codebook based transmission and non-codebook based transmission. The UE is configured with codebook based transmission when the higher layer parameter txConfig in PUSCH-Config is set to 'codebook', the UE is configured non-codebook based transmission when the higher layer parameter txConfig is set to 'nonCodebook'. If the higher layer parameter txConfig is not configured, the UE is not expected to be scheduled by DCI format 0_1."

3. Configured Grant Transmission and Retransmission

3GPP 38.321 states,

1>else if an uplink grant for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:
2>if the NDI in the received HARQ information is 1:
3>consider the NDI for the corresponding HARQ process not to have been toggled;
3>start or restart the configuredGrantTimer for the corresponding HARQ process, if configured;
3>deliver the uplink grant and the associated HARQ information to the HARQ entity.
2>else if the NDI in the received HARQ information is 0:
3>if PDCCH contents indicate configured grant Type 2 deactivation:
4>trigger configured uplink grant confirmation.
3>else if PDCCH contents indicate configured grant Type 2 activation:
4>trigger configured uplink grant confirmation;
4>store the uplink grant for this Serving Cell and the associated HARQ information as configured uplink grant;
4>initialise or re-initialise the configured uplink grant for this Serving Cell to start in the associated PUSCH duration and to recur according to rules in subclause 5.8.2;
4>set the HARQ Process ID to the HARQ Process ID associated with this PUSCH duration;
4>consider the NDI bit for the corresponding HARQ process to have been toggled;
4>stop the configuredGrantTimer for the corresponding HARQ process, if running;
4>deliver the configured uplink grant and the associated HARQ information to the HARQ entity.

4. Validation of Activation and Deactivation for Configured Grant(38.213)

A version of 3GPP 38.213 states:

10.2 PDCCH validation for DL SPS and UL grant Type 2

A UE validates, for scheduling activation or scheduling release, a DL SPS assignment PDCCH or configured UL grant Type 2 PDCCH if

the CRC of a corresponding DCI format is scrambled with a CS-RNTI provided by higher layer parameter cs-RNTI, and

the new data indicator field for the enabled transport block is set to '0'.

Validation of the DCI format is achieved if all fields for the DCI format are set according to Table 10.2-1 or Table 10.2-2.

If validation is achieved, the UE considers the information in the DCI format as a valid activation or valid release of DL SPS or configured UL grant Type 2. If validation is not achieved, the UE considers the DCI format as having been detected with a non-matching CRC.

TABLE 10.2-1

Special fields for DL SPS and UL grant Type 2 scheduling activation PDCCH validation

	DCI format 0_0/0_1	DCI format 1_0	DCI format 1_1
HARQ process number	set to all '0's	set to all '0's	set to all '0's
Redundancy version	set to '00'	set to '00'	For the enabled transport block: set to '00'

TABLE 10.2-2

Special fields for DL SPS and UL grant Type 2 scheduling release PDCCH validation

	DCI format 0_0	DCI format 1_0
HARQ process number	set to all '0's	set to all '0's
Redundancy version	set to '00'	set to '00'
Modulation and coding scheme	set to all '1's	set to all '1's
Resource block assignment	set to all '1's	set to all '1's

A UE is expected to provide HARQ-ACK information in response to a SPS PDSCH release after N symbols from the last symbol of a PDCCH providing the SPS PDSCH release. For UE processing capability 1 [6, TS 36.214] and for the subcarrier spacing of the PDCCH reception, N=10 for 15 kHz, N=12 for 30 kHz, N=22 for 60 kHz, and N=25 for 120 kHz. For a UE with capability 2 [6, TS 36.214] in frequency range 1 and for the subcarrier spacing of the PDCCH reception, N=5 for 15 kHz, N=5.5 for 30 kHz, and N=11 for 60 kHz.

5. DCI 0_1 in USS

The content of DCI 0_1 and DCI 1_1 depends on the Information Element the DCI is associated with. One example is, if the frequency hopping is enabled for PUSCH-Config, but disabled for ConfigureGrantConfig; the bit field for frequency hopping is 1 bit when DCI applies to PUSCH-Config, 0 bit when DCI applies to ConfigureGrantConfig.

6. Procedure in 38.321 for Determination of Retransmission, Activation and Deactivation/Release.

3GPP TS 38.321 5.4.1 states:

1>else if an uplink grant for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:
2>if the NDI in the received HARQ information is 1:
3>consider the NDI for the corresponding HARQ process not to have been toggled;
3>start or restart the configuredGrantTimer for the corresponding HARQ process, if configured;
3>deliver the uplink grant and the associated HARQ information to the HARQ entity.
2>else if the NDI in the received HARQ information is 0:
3>if PDCCH contents indicate configured grant Type 2 deactivation:
4>trigger configured uplink grant confirmation.
3>else if PDCCH contents indicate configured grant Type 2 activation:
4>trigger configured uplink grant confirmation;
4>store the uplink grant for this Serving Cell and the associated HARQ information as configured uplink grant;
4>initialise or re-initialise the configured uplink grant for this Serving Cell to start in the associated PUSCH duration and to recur according to rules in subclause 5.8.2;
4>set the HARQ Process ID to the HARQ Process ID associated with this PUSCH duration;
4>consider the NDI bit for the corresponding HARQ process to have been toggled;
4>stop the configuredGrantTimer for the corresponding HARQ process, if running;
4>deliver the configured uplink grant and the associated HARQ information to the HARQ entity.

SUMMARY

There currently exist certain challenge(s).

One challenge relates to missing and unclear RRC configuration for ConfigurationGrant. Several RRC parameters, such as, for example, txConifg, maxRank, and codebookSubset are only configured in PUSCH-Config. Hence, It is unclear how the type 2 configured grant PUSCH transmission can get configured with multiple layers.

The retransmission of uplink configured grant is not clearly specified in 3GPP. Whether the retransmission DCI shall apply the IE for dynamic PUSCH that is PUSCH-Config, or ConfiguredGrantConfig, or a mix of them is not clear.

Another challenge relates to an ambiguity of DCI for activation and retransmission, as illustrated below.

At the time a user equipment (UE) has received an activation, for the next received PDCCH that is scrambled with a CS-RNTI allocated to the UE, the PDCCH (DCI 0_1 message) can be possibly configured for activation or retransmission. The DCI format that used to construct the DCI message, how many bits shall be used for a field follows the RRC configuration that is associated with the message. If the retransmission applies the PUSCH-Config configuration, and if the PUSCH-Config configuration is different from the ConfiguredGrantConfig configuration, there's ambiguity issue of DCI if the same DCI fields are of different sizes because of the difference in the configurations.

The DCI bit field of NDI in the activate signal can be in a different location than for a retransmission signal. This is illustrated in FIG. **17**, which shows the DCI when the frequency hopping is enabled in dynamic grant but disabled for configured grant.

As shown in FIG. **17**, the NDI bit in the DCI 0_1 message associated with the ConfiguredGrantConfig IE is not located in the same position as the NDI bit in the DCI 0_1 message associated with the PUSCH-Config IE.

The ambiguity illustrated in FIG. **17** can only occur if the DCI is of DCI format 0_1, which is the normal DCI for scheduling PUSCH. This is because the length of FDRA, FH and TDRA fields can vary according to configuration, and these fields are ahead of the NDI field in DCI format 0_1 message.

With the existing procedure in 38.321, the UE considers the received PDCCH (e.g., DCI 0_1 message) is a retransmission if the NDI bit is set to a value of 1, and considers the received PDCCH is activation if the NDI bit is set to a value of 0.

Consider the following scenarios:

Scenario 1:

The network sends a retransmission PDCCH (DCI 0_1 message) to UE to indicate retransmission of a transport block (TB) of UL configured grant, where the CRC is scrambled by CS-RNTI. By coincidence, the DCI 0_1 content matches both 1) a valid retransmission grant and 2) a valid activation command. This is possible since the position of the NDI field might be different for activation commands and for retransmission grants as illustrated above. If the UE first tries to interpret the DCI content as an activation command it will find a valid command and might not check for a retransmission grant.

Scenario 2:

The network sends an activation to the UE, and, by coincidence, the DCI 0_1 message matches both a valid retransmission grant and a valid activation command. This is possible since the position of the NDI field might be different for activation commands and for retransmission grants. If the UE tries to interpret the DCI content as a retransmission grant it will find a valid retransmission grant and might not interpret the DCI content as an activation command (which is sometimes also referred to as an activation grant).

Scenario 3

The network sends a retransmission PDCCH to UE to indicate retransmission of a TB of UL configured grant, where the CRC is scrambled by CS-RNTI. If the UE tries to interpret the DCI content as an activation command based on the value of the bit in the position where the NDI would

be in an activation command but the rest of the DCI content does not match an activation command the UE might interpret the DCI contents as inconsistent and not check for a retransmission grant.

Certain aspects of the present disclosure and their embodiments may provide solutions to these or other challenges.

With respect to the first mentioned challenge, the RRC parameters txConfig, maxRank and codebookSubset that are related to multi-antenna and multiple layer transmission may be added to ConfiguredGrantConfig IE or the UE should simply use the values for these parameters as indicated in the PUSCH-config configuration. The configured grant can use DCI 0_1 for activation. In other words, the configuration in higher layer (RRC) shall support multiple layers transmission for configured grant by having the UE use the values of txConfig, maxRank and codebookSubset from the PUSCH-Config configuration or by adding txConfig, maxRank and codebookSubset to ConfiguredGrantConfig and having the UE use these values. The txConfig, maxRank and codebook-Subset values included in the ConfiguredGrantConfig IE may be different than the txConfig, maxRank and codebook-Subset values included in the PUSCH-Config IE.

With respect to the second mentioned challenge (DCI 0_1 message ambiguity), the UE can perform a decoding procedure, as described herein, to resolve the ambiguity.

For example, the UE performs detection of PDCCH and handles possible ambiguity of the signaling, the signal that has a stronger support for validation shall be assumed to have higher priority than the other signals. For example, for configured grant, the UE performs detection of Activation first, and if the validation of the signal fails, the UE performs detection of Retransmission signal. Another approach is for the UE to prioritize the results from Activation detection than Retransmission detection. From the network node, when the base station (gNb) sends PDCCH (DCI 0_1 message) to UE, the gNB shall try to avoid the combination that could cause a false detection at the UE side. For configured grant, the gNb can either avoid different NDI field position for Activation and Retransmission. Or avoid the false detection by taking care of the value in DCI field that used as indicator or validation.

There are, proposed herein, various embodiments which address one or more of the issues disclosed herein.

Wireless Device (WD) Embodiments

In one embodiment, a first method is performed by a wireless device, and the first method includes performing PDCCH reception assuming the PDCCH (e.g., a received PDCCH scrambled with CS-RNTI) is for activation and determining whether the content of the PDCCH matches (or indicates) an activation command. The method may also include, as a result of determining that the content of the PDCCH matches (or indicates) an activation command, checking a particular field in the PDCCH (e.g., the bit that is in the position of the NDI'field for a activation command) to determine whether the field (e.g., bit) is set to a value of 0. The method may also include, as a result of determining that that the field is 0, treating the PDCCH as an activation command.

In some embodiments, the method may also include determining whether the content of the PDCCH indicates configured grant Type 2 activation; and, optionally, as a result of determining that the content of the PDCCH indicates configured grant Type 2 activation, triggering configured uplink grant confirmation.

In some embodiments, the method may also include, as a result of determining that the content of the PDCCH s indicates configured grant Type 2 activation, storing an uplink grant and associated HARQ information as configured uplink grant and, optionally, initialising or re-initialising the configured uplink grant for the Serving Cell to start in an associated PUSCH duration and, optionally, to recur according to rules.

In another embodiment a second method is performed by a wireless device, and the second method includes the wireless device successfully decoding a PDCCH as a retransmission grant; the wireless device successfully decoding the PDCCH as an activation command; and the wireless device choosing based on priority whether to treat the PDCCH as a retransmission grant or as an activation command.

In some embodiments, the first method and the second method may also include providing user data; and forwarding the user data to a host computer via a transmission to the base station.

In another embodiment, a third method is performed by the wireless device, and the third method includes the WD receiving a ConfiguredGrantConfig information element, IE, transmitted by a base station, wherein the ConfiguredGrant-Config IE includes at least one of the following RRC parameters: txConfig, maxRank, or codebookSubset.

In another embodiment a fourth method is performed by the wireless device (WD). The fourth method includes the WD the WD receiving a PUSCH-Config information element, IE, from a base station, wherein the PUSCH-Config IE includes a first set of PUSCH configuration parameters, wherein the first set of PUSCH configuration parameters includes at least one of the following: txConfig, maxRank, or codebookSubset. The WD then transmits data on a Physical Uplink Shared Channel (PUSCH) corresponding to a configured grant using the first set of PUSCH configuration parameters. In some embodiments, the method further includes the WD receiving a ConfiguredGrantConfig IE from a base station. In such an embodiment the method may further include the WD also using a second set of PUSCH configuration parameters according to the ConfiguredGrant-Config IE to transmit the data on the PUSCH. In some embodiments, the PUSCH is associated with a CS-RNTI. In some embodiments, the PUSCH is associated with a type 1 configured grant transmission. In some embodiments, the PUSCH is associated with a type 2 configured grant transmission. In some embodiments, receiving the PUSCH-Config IE comprises the WD receiving a BWP-UplinkDedicated IE, which is used to configure dedicated parameters of an uplink Bandwidth Part, BWP, wherein the BWP-UplinkDedicated IE includes the PUSCH-Config IE. In some embodiments, the BWP-UplinkDedicated IE further includes a ConfiguredGrantConfig IE.

Base Station Embodiments

In one embodiment, a first method is performed by a base station, and the first method includes the base station deciding to configure a WD for uplink transmission without dynamic grant. The method may also include, as a result of deciding to configure the WD for uplink transmission without dynamic grant, the base station generating a ConfiguredGrantConfig wherein, optionally, the ConfiguredGrant-Config IE includes one or more of the following RRC parameters txConfig, maxRank and codebookSubset. The method may also include the base station transmitting the ConfiguredGrantConfig IE to the WD.

In some embodiments, transmitting the ConfiguredGrant-Config IE comprises at least one of the base station gener-

ating a BWP-UplinkDedicated IE, which, optionally, is used to configure the dedicated (WD specific) parameters of an uplink Bandwidth Part (BWP); and the base station transmitting to the WD the BWP-UplinkDedicated IE which, optionally, includes the generated ConfiguredGrantConfig IE.

In some embodiments, the BWP-UplinkDedicated IE further includes a PUSCH-Config IE that contains parameter values for the one or more of RRC parameters txConfig, maxRank and codebookSubset.

In some embodiments, the parameter values for the RRC parameters txConfig, maxRank and codebookSubset included in the PUSCH-Config IE are different than the parameter values for the RRC parameters txConfig, maxRank and codebookSubset included in the ConfiguredGrantconfig IE.

In one embodiment, a second method is performed by a base station, and the second method includes the base station deciding to transmit to a WD a DCI configured for a retransmission grant. The method may also include the base station ensuring that if a WD decodes the DCI configured for the retransmission grant under the assumption that the DCI is an activation command the WD will not determine that the DCI is a valid activation command. The method may also include the base station transmitting the DCI.

In some embodiments, the first method and the second method may also include the base station obtaining user data and forwarding the user data to a host computer or a wireless device.

In one embodiment, a third method is performed by a base station, and the third method includes the base station transmitting to a WD a PUSCH-Config IE, wherein the PUSCH-Config IE includes a first set of PUSCH configuration parameters, wherein the first set of PUSCH configuration parameters includes at least one of the following: txConfig, maxRank, or codebookSubset. The method also includes the base station instructing or configuring the WD to perform a configured grant (CG) transmission on the PUSCH using the first set of parameters.

In some embodiments, the method also includes the base station transmitting to the WD a ConfiguredGrantConfig IE. In some embodiments, the base station instructs or configures the WD to use a second set of PUSCH configuration parameters according to the ConfiguredGrantConfig IE to perform the CG transmission on the PUSCH.

In some embodiments, the PUSCH transmission is associated with a CS-RNTI. In some embodiments, the PUSCH transmission is associated with a type 1 configured grant transmission. In other embodiments, the PUSCH transmission is associated with a type 2 configured grant transmission.

In some embodiments, transmitting the PUSCH-Config IE comprises the base station transmitting a BWP-UplinkDedicated IE, which is used to configure dedicated parameters of an uplink Bandwidth Part, BWP, wherein the BWP-UplinkDedicated IE includes the PUSCH-Config IE. In some embodiments, the BWP-UplinkDedicated IE further includes a ConfiguredGrantConfig IE.

In some embodiments the method also includes the base station using the first set of parameters to detect the configured grant transmission performed by the WD.

Certain embodiments may provide one or more of the following technical advantage, including higher spectrum efficiency and low latency are achieved with supporting multiple layer transmissions for Configured Grant apply higher layer configurations and DCI format 0_1. Also, with WD performing activation detection first or with higher priority, the false detection of retransmission can be reduced significantly, thereby improving performance by decreasing latency and increasing spectrum efficiency, which can lead to higher data rates and longer battery life. With gNB implementation effort, the false detection because of the ambiguity of the signals can be avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a flowchart illustrating a process according to an embodiment.

FIG. **2** is a flowchart illustrating a process according to an embodiment.

FIG. **3** is a flowchart illustrating a process according to an embodiment.

FIG. **4**A is a flowchart illustrating a process according to an embodiment.

FIG. **4**B is a flowchart illustrating a process according to an embodiment.

FIG. **5** is a flowchart illustrating a process according to an embodiment.

FIG. **6** illustrates an example network.

FIG. **7** illustrates a WD according to an embodiment.

FIG. **8** is a schematic block diagram illustrating a virtualization environment.

FIG. **9** illustrates a communication system.

FIG. **10** illustrates an example implementation of a WD and a base station.

FIGS. **11-14** are flowcharts illustrating different processes according to various embodiments.

FIG. **15**A illustrates a schematic block diagram of network node according to an embodiment.

FIG. **15**B illustrates a schematic block diagram of a wireless device according to an embodiment.

FIG. **16**A is a flow chart illustrating a process according to an embodiment.

FIG. **16**B is a flow chart illustrating a process according to an embodiment.

FIG. **17** shows DCIs according to an embodiment.

DETAILED DESCRIPTION

Generally, all terms used herein are to be interpreted according to their ordinary meaning in the relevant technical field, unless a different meaning is clearly given and/or is implied from the context in which it is used. All references to a/an/the element, apparatus, component, means, step, etc. are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any methods disclosed herein do not have to be performed in the exact order disclosed, unless a step is explicitly described as following or preceding another step and/or where it is implicit that a step must follow or precede another step. Any feature of any of the embodiments disclosed herein may be applied to any other embodiment, wherever appropriate. Likewise, any advantage of any of the embodiments may apply to any other embodiments, and vice versa. Other objectives, features and advantages of the enclosed embodiments will be apparent from the following description.

Some of the embodiments contemplated herein will now be described more fully with reference to the accompanying drawings. Other embodiments, however, are contained within the scope of the subject matter disclosed herein, the disclosed subject matter should not be construed as limited to only the embodiments set forth herein; rather, these embodiments are provided by way of example to convey the

scope of the subject matter to those skilled in the art. Additional information may also be found in the Appendix.

I. Adding or reusing existing RRC parameter to support DCI 0_1 and multiple layer transmission for configured grant.

In one embodiment, RRC parameters such as txConfig, maxRank and codebookSubset are added to the ConfiguredGrantConfig IE. Adding these RRC parameters to the ConfiguredGrantConfig IE allows the values of these parameters to be specifically defined for the configured grant process, without being aligned with parameter values in PUSCH-Config, which is used for dynamically scheduled PUSCH (i.e., not according to configured grant)

In this embodiment, a base station (e.g., gNB) may perform process **400** (see FIG. **4**A), which may begin in step s**402**. In step s**402**, the base station decides to configure a UE for uplink transmission without dynamic grant. As a result, the base station generates a ConfiguredGrantConfig IE, wherein the IE includes at least the following RRC parameters txConfig, maxRank and codebookSubset (step s**404**). In step s**406**, the base station transmits the ConfiguredGrantConfig IE to the UE, which then receives the ConfiguredGrantConfig IE (see step s**422** of process **410** shown in FIG. **4**B). For example, in step s**406**, the base station: 1) generates a BWP-UplinkDedicated IE, which is used to configure the dedicated (UE specific) parameters of an uplink Bandwidth Part (BWP), and 2) transmits to the UE the BWP-UplinkDedicated IE which includes the generated ConfiguredGrantConfig IE. The BWP-UplinkDedicated IE may also include a PUSCH-Config IE that also contains parameter values for the RRC parameters txConfig, maxRank and codebookSubset. The parameter values for the RRC parameters txConfig, maxRank and codebookSubset included in the PUSCH-Config IE may be different than the parameter values for the RRC parameters txConfig, maxRank and codebookSubset included in the ConfiguredGrantconfig IE.

The table belows shows the ConfiguredGrantconfig IE with the RRC parameters txConfig, maxRank and codebookSubset included:

```
ASN1START
-- TAG-CONFIGUREDGRANTCONFIG-START
ConfiguredGrantConfig ::=          SEQUENCE {
  frequencyHopping                 ENUMERATED {intraSlot, interSlot}                OPTIONAL,   --
Need S,
  cg-DMRS -Configuration           DMRS-UplinkConfig,
  mcs-Table                        ENUMERATED {qam256, qam64LowSE}                  OPTIONAL,   -- Need S
  mcs-TableTransformPrecoder       ENUMERATED {qam256, qam64LowSE }                 OPTIONAL,
-- Need S
  uci-OnPUSCH                      SetupRelease { CG-UCI-OnPUSCH }                  OPTIONAL,   --
Need M
  resourceAllocation               ENUMERATED { resourceAllocationTypeO, resourceAllocationType1,
dynamicSwitch },
  rbg-Size                         ENUMERATED {config2}                             OPTIONAL,   -- Need S
  powerControlLoopToUse            ENUMERATED {n0, n1},
  p0-PUS CH-Alpha                  P0-PUSCH-AlphaSetId,
  transformPrecoder                ENUMERATED {enabled, disabled}                   OPTIONAL,   --
Need S
  txConfig                         ENUMERATED {codebook, nonCodebook}               OPTIONAL,   -- Need S
   codebookSubset                  ENUMERATED {fullyAndPartialAndNonCoherent, partialAndNonCoherent,
nonCoherent}                       OPTIONAL, -- Cond codebookBased
  maxRank                          INTEGER (1..4)                                   OPTIONAL,   -- Cond codebookBased
  nrofHARQ-Processes               INTEGER(1..16),
  repK                             ENUMERATED {n1, n2, n4, n8},
  repK-RV                          ENUMERATED {s1-0231, s2-0303, s3-0000}           OPTIONAL,   -- Need R
  periodicity                      ENUMERATED {
sym2, sym7, sym1x14, sym2x14, sym4x14, sym5x14, sym8x14, sym10x14, sym16x14, sym20x14, sym32x14,
sym40x14, sym64x14, sym80x14, sym128x14, sym160x14, sym256x14, sym320x14, sym512x14, sym640x14,
sym1024x14, sym1280x14, sym2560x14, sym5120x14, sym6, sym1x12, sym2x12, sym4x12, sym5x12, sym8x12,
sym10x12, sym16x12, sym20x12, sym32x12, sym40x12, sym64x12, sym80x12, sym128x12, sym160x12,
sym256x12, sym320x12, sym512x12, sym640x12, sym1280x12, sym2560x12
  },
  configuredGrantTimer             INTEGER (1..64)                                  OPTIONAL,   -- Need R
  rrc-ConfiguredUplinkGrant        SEQUENCE {
    timeDomainOffset               INTEGER (0..5119),
    timeDomainAllocation           INTEGER (0..15),
    frequencyDomainAllocation      BIT STRING (SIZE(18)),
    antennaPort                    INTEGER (0..31),
    dmrs-SeqInitialization         INTEGER (0..1)                                   OPTIONAL,   -- Need R
    precodingAndNumberOfLayers     INTEGER (0..63),
    srs-ResourceIndicator          INTEGER (0..15)                                  OPTIONAL,   -- Need R
    mcsAndTBS                      INTEGER (0..31),
    frequencyHoppingOffset         INTEGER (1.. maxNrofPhysicalResourceBlocks−1)    OPTIONAL,   --
Need R
    pathlossReferenceIndex         INTEGER (0..maxNrofPUSCH-Pathloss-
                                   ReferenceRSs−1),
    ...
  }                                                                                  OPTIONAL,   -- Need R
  ...
}
CG-UCI-OnPUSCH ::= CHOICE {
  dynamic                          SEQUENCE (SIZE (1..4)) OF BetaOffsets,
  semiStatic                       BetaOffsets
}
-- TAG-CONFIGUREDGRANTCONFIG-STOP
-- ASN1 STOP
```

In another embodiment, for configured grant, instead of including the missing RRC parameter in ConfiguredgrantConfig, the UE uses txConfig, maxRank and codebookSubset parameter values contained in the PUSCH-config configuration. Using this approach both PUSCH according to configured grant and PUSCH according to dynamic scheduling share the same parameter values.

Accordingly, in one aspect there is provided a process **1600** (see FIG. **16**A) performed by a WD and a process **1650** (see FIG. **16**B) performed by a base station.

Process **1600** performed by the WD includes: (1) the WD receiving a PUSCH-Config information element, IE, from a base station (step s**1602**), wherein the PUSCH-Config IE includes a first set of PUSCH configuration parameters, wherein the first set of PUSCH configuration parameters includes at least one of the following: txConfig, maxRank, or codebookSubset; and (2) the WD performing a transmission of data on the PUSCH wherein the transmission corresponds to a configured grant using the first set of PUSCH configuration parameters (step s**1604**). In some embodiments, the process **1600** further includes the WD receiving a ConfiguredGrantConfig IE from a base station. In such an embodiment the process **1600** may further include the WD also using a second set of PUSCH configuration parameters according to the ConfiguredGrantConfig IE to transmit the data on the PUSCH. In some embodiments, the PUSCH is associated with a CS-RNTI. In some embodiments, the PUSCH is associated with a type 1 configured grant transmission. In some embodiments, the PUSCH is associated with a type 2 configured grant transmission. In some embodiments, receiving the PUSCH-Config IE comprises the WD receiving a BWP-UplinkDedicated IE, which is used to configure dedicated parameters of an uplink Bandwidth Part, BWP, wherein the BWP-UplinkDedicated IE includes the PUSCH-Config IE. In some embodiments, the BWP-UplinkDedicated IE further includes a ConfiguredGrantConfig IE.

And the process **1650** performed by the base station includes: the base station transmitting to a WD a PUSCH-Config IE (step s**1652**), wherein the PUSCH-Config IE includes a first set of PUSCH configuration parameters, wherein the first set of PUSCH configuration parameters includes at least one of the following: txConfig, maxRank, or codebookSubset. The process **1650** also includes the base station instructing or configuring the WD to perform a configured grant (CG) transmission on the PUSCH using the first set of parameters (step s**1654**). In some embodiments, process **1650** also includes the base station using the first set of parameters to detect the CG transmission performed by the WD (step s**1656**). In some embodiments, the process **1650** also includes the base station transmitting to the WD a ConfiguredGrantConfig IE. In some embodiments, the base station instructs or configures the WD to use a second set of PUSCH configuration parameters according to the ConfiguredGrantConfig IE to perform the CG transmission on the PUSCH. In some embodiments, the PUSCH transmission is associated with a CS-RNTI. In some embodiments, the PUSCH transmission is associated with a type 1 configured grant transmission. In other embodiments, the PUSCH transmission is associated with a type 2 configured grant transmission. In some embodiments, transmitting the PUSCH-Config IE comprises the base station transmitting a BWP-UplinkDedicated IE, which is used to configure dedicated parameters of an uplink Bandwidth Part, BWP, wherein the BWP-UplinkDedicated IE includes the PUSCH-Config IE. In some embodiments, the BWP-UplinkDedicated IE further includes a ConfiguredGrantConfig IE.

The configured grant can use DCI 0_1 for activation, which DCI can have an ambiguity. DCI format 0_0, which is used for deactivation of UL configured grant, does not have the ambiguity problem because FDRA, TDRA and FH are fixed sized in DCI 0_0.

II. DCI Ambiguity

II.A. UE DCI Detection Effort

II.A.i. DCI Detection Order

If the UE is not expected to be scheduled with a retransmission grant using CRC scrambled by CS-RNTI with DCI content that matches an activation command no ambiguity exists.

The following process **100** (see FIG. **1**) can be implemented in the UE to ensure no ambiguity. Process **100** may begin with step s**101**.

Step s**101** comprises the UE performing DCI (PDCCH) reception assuming the PDCCH is for activation.

In step s**102**, the UE then determines whether the content of the PDCCH matches an activation command. For example, as explained above, if the PDCCH is for activation, then the bits for HARQ process number and Redundancy version will be all zero. Thus, the UE can check these bits to determine whether the PDCCH matches an activation command. If the UE determines that the content of the PDCCH matches an activation command, then the UE performs step s**104**, otherwise it proceeds to step s**108**.

In step s**104**, the UE checks a particular field (e.g., particular bit) in the PDCCH (e.g., the bit that is in the position of the NDI field for an activation command) to determine whether the field is set to a value of 0. If the UE determines that the field is 0, then the UE performs step s**106**, otherwise performs step s**108**.

In step s**106**, as a result of determining that the field is 0, then the UE assumes that PDCCH is indeed for the corresponding purpose (i.e., activation), and not a PDCCH scheduling a retransmission. That is, the UE treats the PDCCH as an activation command.

In step s**108**, the UE checks a particular field in the PDCCH (e.g., the bit that is in the position of the NDI field for a retransmission grant) to determine whether the field is set to a value of 1. If the UE determines that the field is 1, then the UE performs step s**110**, otherwise the process ends and the UE may ignore the PDCCH. In step s**110**, as a result of determining that the bit is 1, the UE decodes the PDCCH as a retransmission grant.

In some embodiments, the UE skips step s**108**, i.e. the UE assumes that the PDCCH is a retransmission grant if it doesn't match an activation command and does not check the value of the bit in the position where the NDI field would be if the PDCCH content is a retransmission grant.

In one embodiment, the following change is made to TS 38.321

1> else if an uplink grant for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:

2> if the NDI bit follows activation or deactivation DCI in the received HARQ information is 0:

3> if PDCCH contents indicate configured grant Type 2 deactivation:

4> trigger configured uplink grant confirmation.

-continued

3> else if PDCCH contents indicate configured grant Type 2 activation:
4> trigger configured uplink grant confirmation;
4> store the uplink grant for this Serving Cell and the associated HARQ information as configured uplink grant;
4> initialise or re-initialise the configured uplink grant for this Serving Cell to start in the associated PUSCH duration and to recur according to rules in subclause 5.8.2;
4> set the HARQ Process ID to the HARQ Process ID associated with this PUSCH duration;
4> consider the NDI bit for the corresponding HARQ process to have been toggled;
4> stop the configuredGrantTimer for the corresponding HARQ process, if running;
4> deliver the configured uplink grant and the associated HARQ information to the HARQ entity.
3> else if the PDCCH content is not valid for activation or deactivation:
4> if the NDI bit follows retransmission DCI in the received HARQ information is 1:
5> consider the NDI for the corresponding HARQ process not to have been toggled;
5> start or restart the configuredGrantTimer for the corresponding HARQ process, if configured;
5> deliver the uplink grant and the associated HARQ information to the HARQ entity.

II.A.ii Detection Priority

In this embodiment, shown in FIG. **2**, the UE performs in parallel decoding of the PDCCH for both the activation command and the retransmission grant. For example, assuming that a) the UE successfully decoded the PDCCH as a retransmission grant (step s**202**) (i.e., decoding as retransmission grant has passed a CRC check and the NDI bit for retransmission grant is 1) and b) the UE successfully decoded the PDCCH as an activation command (step s**204**) (i.e., decoding as activation has passed a CRC check, the NDI field is 0, and the validation check is valid), then the UE can choose based on priority (step s**206**) whether to treat the PDCCH as a retransmission grant (step s**208**) or as an activation command (step s**210**). In FIG. **2**, p1 represents the priority of retransmission grant and p2 represents the priority of activation command.

In one embodiment, a detection of valid activate grant has higher priority than retransmission grant and thus, in the above scenario, the UE will chose to treat the PDCCH as an activation command. On possible implementation of this embodiment is illustrated in FIG. **3** which is a flow chart showing steps performed by the UE. Step s**302** and step s**304** are performed in parallel. In s**302**, UE sets a first flag (f2) to a value of 1 if decoding as retransmission grant has passed a CRC check and the NDI bit for retransmission grant is 1. In s**304**, UE set a second flag (f2) to a value of 1 if decoding as activation has passed a CRC check, the NDI field is 0, and the validation check is valid. In step s**306**, UE determines whether f2=1. If f2=1, then the UE treats the PDCCH as an activation command (step s**308**). If f2=0, then UE determines whether f1=1 (step s**310**). If f1=1, then the UE treats the PDCCH as a retransmission grant (step s**312**). This illustrates how activation is given priority over retransmission grant.

II.B. Base Station (e.g., gNB) Implementation

The confusion between the two DCI functions only occur if:

(i) the DCI is of format 0_1,

(ii) the NDI field is not aligned between the two functions associated with CSI—i.e., 1) DCI_dynamic: DCI for scheduling retransmission of a TB of Type 2 UL configured grant and 2) DCI_UL_GF: DCI for activation of the Type 2 UL configured grant; and

(iii) the fields used for validation of activation happen to satisfy the criteria of validation. The GF in DCI_UL_GF stands for "grant free," another name for configured grant.

There are 3 fields in DCI format 0_1 that are ahead of NDI, and can have different sizes between DCI_dynamic and DCI_UL_GF. These three fields are: (1) Frequency domain resource assignment (FDRA), (2) Time domain resource assignment (TDRA), and (3) Frequency hopping flag (FH).

If the total length of the 3 fields are not the same between the two DCI functions, then, when DCI (of format 0_1) is sent for scheduling retransmission of configured grant, the base station implementation needs to ensure the following condition does not occur: the "fake" NDI field has a value of 0 and the "fake" fields used for validation of activation satisfy the criteria of validation. In the above, the "fake" fields are according to the interpretation that the DCI is for activation, and the FDRA, TDRA, and FH field sizes are determined according to RRC configuration of UL configured grant (i.e., not configuration of dynamic PUSCH). In other words, when DCI (of format 0_1) is sent for scheduling retransmission of configured grant, the base station implementation needs to ensure that if a UE decodes the DCI under the assumption that the DCI is an activation command the UE does not determine that the DCI is valid activation command. This feature is illustrated in FIG. **5** which is a flowchart illustrating a process performed by the base station. The process may begin in step s**502**, where the base station decides to transmit to a UE a DCI configured for a retransmission grant. In step s**504**, the base station ensures that if a UE decodes the DCI configured for the retransmission grant under the assumption that the DCI is an activation command the UE will not determine that the DCI is a valid activation command. In step s**506**, the base station transmits the DCI.

II.C. Alignment of DCI Field Sizes

An alternative method to avoid ambiguity is to ensure that the total length of the sizes of the following three fields do not change between the two DCI functions: (1) Frequency domain resource assignment (FDRA), (2) Time domain resource assignment (TDRA), and (3) Frequency hopping flag (FH). This can be achieved by the following methods.

Method (A): for both DCI_Dynamic and DCI_UL_GF of format 0_1 use non-varying size, similar to that of DCI format 0_0.

Method (B): for both DCI_Dynamic and DCI_UL_GF of format 0_1 use FDRA, TDRA, and FH configuration according to higher layer configuration ConfiguredGrantConfig.

Method (C): for both DCI_Dynamic and DCI_UL_GF of format 0_1 use FDRA, TDRA, and FH configuration according to higher layer configuration PUSCH-Config.

Furthermore, considering the DCI blind decoding burden of UE, it is desirable to align overall size of DCI_dynamic and DCI_UL_GF for format 0_1.

Although the subject matter described herein may be implemented in any appropriate type of system using any suitable components, the embodiments disclosed herein are described in relation to a wireless network, such as the example wireless network illustrated in FIG. **6**. For simplicity, the wireless network of FIG. **6** only depicts network **606**, network nodes **660** and **660***b*, and WDs **610**, **610***b*, and **610***c*. In practice, a wireless network may further include any additional elements suitable to support communication between wireless devices or between a wireless device (e.g., a UE) and another communication device, such as a landline telephone, a service provider, or any other network node or end device. Of the illustrated components, network node **660** and wireless device (WD) **610** are depicted with additional detail. The wireless network may provide communication and other types of services to one or more wireless devices to facilitate the wireless devices' access to and/or use of the services provided by, or via, the wireless network.

The wireless network may comprise and/or interface with any type of communication, telecommunication, data, cellular, and/or radio network or other similar type of system. In some embodiments, the wireless network may be configured to operate according to specific standards or other types of predefined rules or procedures. Thus, particular embodiments of the wireless network may implement communication standards, such as Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Long Term Evolution (LTE), and/or other suitable 2G, 3G, 4G, or 5G standards; wireless local area network (WLAN) standards, such as the IEEE 802.11 standards; and/or any other appropriate wireless communication standard, such as the Worldwide Interoperability for Microwave Access (WiMax), Bluetooth, Z-Wave and/or ZigBee standards.

Network **606** may comprise one or more backhaul networks, core networks, IP networks, public switched telephone networks (PSTNs), packet data networks, optical networks, wide-area networks (WANs), local area networks (LANs), wireless local area networks (WLANs), wired networks, wireless networks, metropolitan area networks, and other networks to enable communication between devices.

Network node **660** and WD **610** comprise various components described in more detail below. These components work together in order to provide network node and/or wireless device functionality, such as providing wireless connections in a wireless network. In different embodiments, the wireless network may comprise any number of wired or wireless networks, network nodes, base stations, controllers, wireless devices, relay stations, and/or any other components or systems that may facilitate or participate in the communication of data and/or signals whether via wired or wireless connections.

As used herein, network node refers to equipment capable, configured, arranged and/or operable to communicate directly or indirectly with a wireless device and/or with other network nodes or equipment in the wireless network to enable and/or provide wireless access to the wireless device and/or to perform other functions (e.g., administration) in the wireless network. Examples of network nodes include, but are not limited to, access points (APs) (e.g., radio access points), base stations (BSs) (e.g., radio base stations, Node Bs, evolved Node Bs (eNBs) and NR NodeBs (gNBs)). Base stations may be categorized based on the amount of coverage they provide (or, stated differently, their transmit power level) and may then also be referred to as femto base stations, pico base stations, micro base stations, or macro base stations. A base station may be a relay node or a relay donor node controlling a relay. A network node may also include one or more (or all) parts of a distributed radio base station such as centralized digital units and/or remote radio units (RRUs), sometimes referred to as Remote Radio Heads (RRHs). Such remote radio units may or may not be integrated with an antenna as an antenna integrated radio. Parts of a distributed radio base station may also be referred to as nodes in a distributed antenna system (DAS). Yet further examples of network nodes include multi-standard radio (MSR) equipment such as MSR BSs, network controllers such as radio network controllers (RNCs) or base station controllers (BSCs), base transceiver stations (BTSs), transmission points, transmission nodes, multi-cell/multicast coordination entities (MCEs), core network nodes (e.g., MSCs, MMEs), O&M nodes, OSS nodes, SON nodes, positioning nodes (e.g., E-SMLCs), and/or MDTs. As another example, a network node may be a virtual network node as described in more detail below. More generally, however, network nodes may represent any suitable device (or group of devices) capable, configured, arranged, and/or operable to enable and/or provide a wireless device with access to the wireless network or to provide some service to a wireless device that has accessed the wireless network.

In FIG. **6**, network node **660** includes processing circuitry **670**, device readable medium **680**, interface **690**, auxiliary equipment **684**, power source **686**, power circuitry **687**, and antenna **662**. Although network node **660** illustrated in the example wireless network of FIG. **6** may represent a device that includes the illustrated combination of hardware components, other embodiments may comprise network nodes with different combinations of components. It is to be understood that a network node comprises any suitable combination of hardware and/or software needed to perform the tasks, features, functions and methods disclosed herein. Moreover, while the components of network node **660** are depicted as single boxes located within a larger box, or nested within multiple boxes, in practice, a network node may comprise multiple different physical components that make up a single illustrated component (e.g., device readable medium **680** may comprise multiple separate hard drives as well as multiple RAM modules).

Similarly, network node **660** may be composed of multiple physically separate components (e.g., a NodeB component and a RNC component, or a BTS component and a BSC component, etc.), which may each have their own respective components. In certain scenarios in which network node **660** comprises multiple separate components (e.g., BTS and BSC components), one or more of the separate components may be shared among several network nodes. For example, a single RNC may control multiple NodeB's. In such a scenario, each unique NodeB and RNC pair, may in some instances be considered a single separate network node. In some embodiments, network node **660** may be configured to support multiple radio access technologies (RATs). In such embodiments, some components may be duplicated (e.g., separate device readable medium **680** for the different RATs) and some components may be reused (e.g., the same antenna **662** may be shared by the RATs). Network node **660** may also include multiple sets of the various illustrated components for different wireless technologies integrated into network node **660**, such as, for example, GSM, WCDMA, LTE, NR, WiFi, or Bluetooth wireless technologies. These wireless technologies may be

integrated into the same or different chip or set of chips and other components within network node **660**.

Processing circuitry **670** is configured to perform any determining, calculating, or similar operations (e.g., certain obtaining operations) described herein as being provided by a network node. These operations performed by processing circuitry **670** may include processing information obtained by processing circuitry **670** by, for example, converting the obtained information into other information, comparing the obtained information or converted information to information stored in the network node, and/or performing one or more operations based on the obtained information or converted information, and as a result of said processing making a determination.

Processing circuitry **670** may comprise a combination of one or more of a microprocessor, controller, microcontroller, central processing unit, digital signal processor, application-specific integrated circuit, field programmable gate array, or any other suitable computing device, resource, or combination of hardware, software and/or encoded logic operable to provide, either alone or in conjunction with other network node **660** components, such as device readable medium **680**, network node **660** functionality. For example, processing circuitry **670** may execute instructions stored in device readable medium **680** or in memory within processing circuitry **670**. Such functionality may include providing any of the various wireless features, functions, or benefits discussed herein. In some embodiments, processing circuitry **670** may include a system on a chip (SOC).

In some embodiments, processing circuitry **670** may include one or more of radio frequency (RF) transceiver circuitry **672** and baseband processing circuitry **674**. In some embodiments, radio frequency (RF) transceiver circuitry **672** and baseband processing circuitry **674** may be on separate chips (or sets of chips), boards, or units, such as radio units and digital units. In alternative embodiments, part or all of RF transceiver circuitry **672** and baseband processing circuitry **674** may be on the same chip or set of chips, boards, or units

In certain embodiments, some or all of the functionality described herein as being provided by a network node, base station, eNB or other such network device may be performed by processing circuitry **670** executing instructions stored on device readable medium **680** or memory within processing circuitry **670**. In alternative embodiments, some or all of the functionality may be provided by processing circuitry **670** without executing instructions stored on a separate or discrete device readable medium, such as in a hard-wired manner. In any of those embodiments, whether executing instructions stored on a device readable storage medium or not, processing circuitry **670** can be configured to perform the described functionality. The benefits provided by such functionality are not limited to processing circuitry **670** alone or to other components of network node **660**, but are enjoyed by network node **660** as a whole, and/or by end users and the wireless network generally.

Device readable medium **680** may comprise any form of volatile or non-volatile computer readable memory including, without limitation, persistent storage, solid-state memory, remotely mounted memory, magnetic media, optical media, random access memory (RAM), read-only memory (ROM), mass storage media (for example, a hard disk), removable storage media (for example, a flash drive, a Compact Disk (CD) or a Digital Video Disk (DVD)), and/or any other volatile or non-volatile, non-transitory device readable and/or computer-executable memory devices that store information, data, and/or instructions that may be used by processing circuitry **670**. Device readable medium **680** may store any suitable instructions, data or information, including a computer program, software, an application including one or more of logic, rules, code, tables, etc. and/or other instructions capable of being executed by processing circuitry **670** and, utilized by network node **660**. Device readable medium **680** may be used to store any calculations made by processing circuitry **670** and/or any data received via interface **690**. In some embodiments, processing circuitry **670** and device readable medium **680** may be considered to be integrated.

Interface **690** is used in the wired or wireless communication of signalling and/or data between network node **660**, network **606**, and/or WDs **610**. As illustrated, interface **690** comprises port(s)/terminal(s) **694** to send and receive data, for example to and from network **606** over a wired connection. Interface **690** also includes radio front end circuitry **692** that may be coupled to, or in certain embodiments a part of, antenna **662**. Radio front end circuitry **692** comprises filters **698** and amplifiers **696**. Radio front end circuitry **692** may be connected to antenna **662** and processing circuitry **670**. Radio front end circuitry may be configured to condition signals communicated between antenna **662** and processing circuitry **670**. Radio front end circuitry **692** may receive digital data that is to be sent out to other network nodes or WDs via a wireless connection. Radio front end circuitry **692** may convert the digital data into a radio signal having the appropriate channel and bandwidth parameters using a combination of filters **698** and/or amplifiers **696**. The radio signal may then be transmitted via antenna **662**. Similarly, when receiving data, antenna **662** may collect radio signals which are then converted into digital data by radio front end circuitry **692**. The digital data may be passed to processing circuitry **670**. In other embodiments, the interface may comprise different components and/or different combinations of components.

In certain alternative embodiments, network node **660** may not include separate radio front end circuitry **692**, instead, processing circuitry **670** may comprise radio front end circuitry and may be connected to antenna **662** without separate radio front end circuitry **692**. Similarly, in some embodiments, all or some of RF transceiver circuitry **672** may be considered a part of interface **690**. In still other embodiments, interface **690** may include one or more ports or terminals **694**, radio front end circuitry **692**, and RF transceiver circuitry **672**, as part of a radio unit (not shown), and interface **690** may communicate with baseband processing circuitry **674**, which is part of a digital unit (not shown).

Antenna **662** may include one or more antennas, or antenna arrays, configured to send and/or receive wireless signals. Antenna **662** may be coupled to radio front end circuitry **690** and may be any type of antenna capable of transmitting and receiving data and/or signals wirelessly. In some embodiments, antenna **662** may comprise one or more omni-directional, sector or panel antennas operable to transmit/receive radio signals between, for example, 2 GHz and 66 GHz. An omni-directional antenna may be used to transmit/receive radio signals in any direction, a sector antenna may be used to transmit/receive radio signals from devices within a particular area, and a panel antenna may be a line of sight antenna used to transmit/receive radio signals in a relatively straight line. In some instances, the use of more than one antenna may be referred to as MIMO. In certain embodiments, antenna **662** may be separate from network node **660** and may be connectable to network node **660** through an interface or port.

Antenna **662**, interface **690**, and/or processing circuitry **670** may be configured to perform any receiving operations and/or certain obtaining operations described herein as being performed by a network node. Any information, data and/or signals may be received from a wireless device, another network node and/or any other network equipment. Similarly, antenna **662**, interface **690**, and/or processing circuitry **670** may be configured to perform any transmitting operations described herein as being performed by a network node. Any information, data and/or signals may be transmitted to a wireless device, another network node and/or any other network equipment.

Power circuitry **687** may comprise, or be coupled to, power management circuitry and is configured to supply the components of network node **660** with power for performing the functionality described herein. Power circuitry **687** may receive power from power source **686**. Power source **686** and/or power circuitry **687** may be configured to provide power to the various components of network node **660** in a form suitable for the respective components (e.g., at a voltage and current level needed for each respective component). Power source **686** may either be included in, or external to, power circuitry **687** and/or network node **660**. For example, network node **660** may be connectable to an external power source (e.g., an electricity outlet) via an input circuitry or interface such as an electrical cable, whereby the external power source supplies power to power circuitry **687**. As a further example, power source **686** may comprise a source of power in the form of a battery or battery pack which is connected to, or integrated in, power circuitry **687**. The battery may provide backup power should the external power source fail. Other types of power sources, such as photovoltaic devices, may also be used.

Alternative embodiments of network node **660** may include additional components beyond those shown in FIG. **6** that may be responsible for providing certain aspects of the network node's functionality, including any of the functionality described herein and/or any functionality necessary to support the subject matter described herein. For example, network node **660** may include user interface equipment to allow input of information into network node **660** and to allow output of information from network node **660**. This may allow a user to perform diagnostic, maintenance, repair, and other administrative functions for network node **660**.

As used herein, the terms wireless device (WD) and user equipment (UE) both refer to a device capable, configured, arranged and/or operable to communicate wirelessly with network nodes and/or other wireless devices. Accordingly, unless otherwise noted, the term WD may be used interchangeably herein with user equipment (UE). Communicating wirelessly may involve transmitting and/or receiving wireless signals using electromagnetic waves, radio waves, infrared waves, and/or other types of signals suitable for conveying information through air. In some embodiments, a WD may be configured to transmit and/or receive information without direct human interaction. For instance, a WD may be designed to transmit information to a network on a predetermined schedule, when triggered by an internal or external event, or in response to requests from the network. Examples of a WD include, but are not limited to, a smart phone, a mobile phone, a cell phone, a voice over IP (VoIP) phone, a wireless local loop phone, a desktop computer, a personal digital assistant (PDA), a wireless cameras, a gaming console or device, a music storage device, a playback appliance, a wearable terminal device, a wireless endpoint, a mobile station, a tablet, a laptop, a laptop-embedded equipment (LEE), a laptop-mounted equipment (LME), a smart device, a wireless customer-premise equipment (CPE). a vehicle-mounted wireless terminal device, etc. A WD may support device-to-device (D2D) communication, for example by implementing a 3GPP standard for sidelink communication, vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-everything (V2X) and may in this case be referred to as a D2D communication device. As yet another specific example, in an Internet of Things (IoT) scenario, a WD may represent a machine or other device that performs monitoring and/or measurements, and transmits the results of such monitoring and/or measurements to another WD and/or a network node. The WD may in this case be a machine-to-machine (M2M) device, which may in a 3GPP context be referred to as an MTC device. As one particular example, the WD may be a UE implementing the 3GPP narrow band internet of things (NB-IoT) standard. Particular examples of such machines or devices are sensors, metering devices such as power meters, industrial machinery, or home or personal appliances (e.g. refrigerators, televisions, etc.) personal wearables (e.g., watches, fitness trackers, etc.). In other scenarios, a WD may represent a vehicle or other equipment that is capable of monitoring and/or reporting on its operational status or other functions associated with its operation. A WD as described above may represent the endpoint of a wireless connection, in which case the device may be referred to as a wireless terminal. Furthermore, a WD as described above may be mobile, in which case it may also be referred to as a mobile device or a mobile terminal.

As illustrated, wireless device **610** includes antenna **611**, interface **614**, processing circuitry **620**, device readable medium **630**, user interface equipment **632**, auxiliary equipment **634**, power source **636** and power circuitry **637**. WD **610** may include multiple sets of" one or more of the illustrated components for different wireless technologies supported by WD **610**, such as, for example, GSM, WCDMA, MTE, NR, WiFi, WiMAX, or Bluetooth wireless technologies, just to mention a few. These wireless technologies may be integrated into the same or different chips or set of chips as other components within WD **610**.

Antenna **611** may include one or more antennas or antenna arrays, configured to send and/or receive wireless signals, and is connected to interface **614**. In certain alternative embodiments, antenna **611** may be separate from WD **610** and be connectable to WD **610** through an interface or port. Antenna **611**, interface **614**, and/or processing circuitry **620** may be configured to perform any receiving or transmitting operations described herein as being performed by a WD. Any information, data and/or signals may be received from a network node and/or another WD. In some embodiments, radio front end circuitry and/or antenna **611** may be considered an interface.

As illustrated, interface **614** comprises radio front end circuitry **612** and antenna **611**. Radio front end circuitry **612** comprise one or more filters **618** and amplifiers **616**. Radio front end circuitry **614** is connected to antenna **611** and processing circuitry **620**, and is configured to condition signals communicated between antenna **611** and processing circuitry **620**. Radio front end circuitry **612** may be coupled to or a part of antenna **611**. In some embodiments, WD **610** may not include separate radio front end circuitry **612**; rather, processing circuitry **620** may comprise radio front end circuitry and may be connected to antenna **611**. Similarly, in some embodiments, some or all of RF transceiver circuitry **622** may be considered a part of interface **614**. Radio front end circuitry **612** may receive digital data that is to be sent out to other network nodes or WDs via a wireless

connection. Radio front end circuitry **612** may convert the digital data into a radio signal having the appropriate channel and bandwidth parameters using a combination of filters **618** and/or amplifiers **616**. The radio signal may then be transmitted via antenna **611**. Similarly, when receiving data, antenna **611** may collect radio signals which are then converted into digital data by radio front end circuitry **612**. The digital data may be passed to processing circuitry **620**. In other embodiments, the interface may comprise different components and/or different combinations of components.

Processing circuitry **620** may comprise a combination of one or more of a microprocessor, controller, microcontroller, central processing unit, digital signal processor, application-specific integrated circuit, field programmable gate array, or any other suitable computing device, resource, or combination of hardware, software, and/or encoded logic operable to provide, either alone or in conjunction with other WD **610** components, such as device readable medium **630**, WD **610** functionality. Such functionality may include providing any of the various wireless features or benefits discussed herein. For example, processing circuitry **620** may execute instructions stored in device readable medium **630** or in memory within processing circuitry **620** to provide the functionality disclosed herein.

As illustrated, processing circuitry **620** includes one or more of RF transceiver circuitry **622**, baseband processing circuitry **624**, and application processing circuitry **626**. In other embodiments, the processing circuitry may comprise different components and/or different combinations of components. In certain embodiments processing circuitry **620** of WD **610** may comprise a SOC. In some embodiments, RF transceiver circuitry **622**, baseband processing circuitry **624**, and application processing circuitry **626** may be on separate chips or sets of chips. In alternative embodiments, part or all of baseband processing circuitry **624** and application processing circuitry **626** may be combined into one chip or set of chips, and RF transceiver circuitry **622** may be on a separate chip or set of chips. In still alternative embodiments, part or all of RF transceiver circuitry **622** and baseband processing circuitry **624** may be on the same chip or set of chips, and application processing circuitry **626** may be on a separate chip or set of chips. In yet other alternative embodiments, part or all of RF transceiver circuitry **622**, baseband processing circuitry **624**, and application processing circuitry **626** may be combined in the same chip or set of chips. In some embodiments, RF transceiver circuitry **622** may be a part of interface **614**. RF transceiver circuitry **622** may condition RF signals for processing circuitry **620**.

In certain embodiments, some or all of the functionality described herein as being performed by a WD may be provided by processing circuitry **620** executing instructions stored on device readable medium **630**, which in certain embodiments may be a computer-readable storage medium. In alternative embodiments, some or all of the functionality may be provided by processing circuitry **620** without executing instructions stored on a separate or discrete device readable storage medium, such as in a hard-wired manner. In any of those particular embodiments, whether executing instructions stored on a device readable storage medium or not, processing circuitry **620** can be configured to perform the described functionality. The benefits provided by such functionality are not limited to processing circuitry **620** alone or to other components of WD **610**, but are enjoyed by WD **610** as a whole, and/or by end users and the wireless network generally.

Processing circuitry **620** may be configured to perform any determining, calculating, or similar operations (e.g., certain obtaining operations) described herein as being performed by a WD. These operations, as performed by processing circuitry **620**, may include processing information obtained by processing circuitry **620** by, for example, converting the obtained information into other information, comparing the obtained information or converted information to information stored by WD **610**, and/or performing one or more operations based on the obtained information or converted information, and as a result of said processing making a determination.

Device readable medium **630** may be operable to store a computer program, software, an application including one or more of logic, rules, code, tables, etc. and/or other instructions capable of being executed by processing circuitry **620**. Device readable medium **630** may include computer memory (e.g., Random Access Memory (RAM) or Read Only Memory (ROM)), mass storage media (e.g., a hard disk), removable storage media (e.g., a Compact Disk (CD) or a Digital Video Disk (DVD)), and/or any other volatile or non-volatile, non-transitory device readable and/or computer executable memory devices that store information, data, and/or instructions that may be used by processing circuitry **620**. In some embodiments, processing circuitry **620** and device readable medium **630** may be considered to be integrated.

User interface equipment **632** may provide components that allow for a human user to interact with WD **610**. Such interaction may be of many forms, such as visual, audial, tactile, etc. User interface equipment **632** may be operable to produce output to the user and to allow the user to provide input to WD **610**. The type of interaction may vary depending on the type of user interface equipment **632** installed in WD **610**. For example, if WD **610** is a smart phone, the interaction may be via a touch screen; if WD **610** is a smart meter, the interaction may be through a screen that provides usage (e.g., the number of gallons used) or a speaker that provides an audible alert (e.g., if smoke is detected). User interface equipment **632** may include input interfaces, devices and circuits, and output interfaces, devices and circuits. User interface equipment **632** is configured to allow input of information into WD **610**, and is connected to processing circuitry **620** to allow processing circuitry **620** to process the input information. User interface equipment **632** may include, for example, a microphone, a proximity or other sensor, keys/buttons, a touch display, one or more cameras, a USB port, or other input circuitry. User interface equipment **632** is also configured to allow output of information from WD **610**, and to allow processing circuitry **620** to output information from WD **610**. User interface equipment **632** may include, for example, a speaker, a display, vibrating circuitry, a USB port, a headphone interface, or other output circuitry. Using one or more input and output interfaces, devices, and circuits, of user interface equipment **632**, WD **610** may communicate with end users and/or the wireless network, and allow them to benefit from the functionality described herein.

Auxiliary equipment **634** is operable to provide more specific functionality which may not be generally performed by WDs. This may comprise specialized sensors for doing measurements for various purposes, interfaces for additional types of communication such as wired communications etc. The inclusion and type of components of auxiliary equipment **634** may vary depending on the embodiment and/or scenario.

Power source **636** may, in some embodiments, be in the form of a battery or battery pack. Other types of power sources, such as an external power source (e.g., an electricity

outlet), photovoltaic devices or power cells, may also be used. WD **610** may further comprise power circuitry **637** for delivering power from power source **636** to the various parts of WD **610** which need power from power source **636** to carry out any functionality described or indicated herein. Power circuitry **637** may in certain embodiments comprise power management circuitry. Power circuitry **637** may additionally or alternatively be operable to receive power from an external power source; in which case WD **610** may be connectable to the external power source (such as an electricity outlet) via input circuitry or an interface such as an electrical power cable. Power circuitry **637** may also in certain embodiments be operable to deliver power from an external power source to power source **636**. This may be, for example, for the charging of power source **636**. Power circuitry **637** may perform any formatting, converting, or other modification to the power from power source **636** to make the power suitable for the respective components of WD **610** to which power is supplied.

FIG. **7** illustrates one embodiment of a UE in accordance with various aspects described herein. As used herein, a user equipment or UE may not necessarily have a user in the sense of a human user who owns and/or operates the relevant device. Instead, a UE may represent a device that is intended for sale to, or operation by, a human user but which may not, or which may not initially, be associated with a specific human user (e.g., a smart sprinkler controller). Alternatively, a UE may represent a device that is not intended for sale to, or operation by, an end user but which may be associated with or operated for the benefit of a user (e.g., a smart power meter). UE **7200** may be any UE identified by the 3rd Generation Partnership Project (3GPP), including a NB-IoT UE, a machine type communication (MTC) UE, and/or an enhanced MTC (eMTC) UE. UE **700**, as illustrated in FIG. **7**, is one example of a WD configured for communication in accordance with one or more communication standards promulgated by the 3rd Generation Partnership Project (3GPP), such as 3GPP's GSM, UMTS, LTE, and/or 5G standards. As mentioned previously, the term WD and UE may be used interchangeable. Accordingly, although FIG. **7** is a UE, the components discussed herein are equally applicable to a WD, and vice-versa.

In FIG. **7**, UE **700** includes processing circuitry **701** that is operatively coupled to input/output interface **705**, radio frequency (RF) interface **709**, network connection interface **711**, memory **715** including random access memory (RAM) **717**, read-only memory (ROM) **719**, and storage medium **721** or the like, communication subsystem **731**, power source **733**, and/or any other component, or any combination thereof. Storage medium **721** includes operating system **723**, application program **725**, and data **727**. In other embodiments, storage medium **721** may include other similar types of information. Certain UEs may utilize all of the components shown in FIG. **7**, or only a subset of the components. The level of integration between the components may vary from one UE to another UE. Further, certain UEs may contain multiple instances of a component, such as multiple processors, memories, transceivers, transmitters, receivers, etc.

In FIG. **7**, processing circuitry **701** may be configured to process computer instructions and data. Processing circuitry **701** may be configured to implement any sequential state machine operative to execute machine instructions stored as machine-readable computer programs in the memory, such as one or more hardware-implemented state machines (e.g., in discrete logic, FPGA, ASIC, etc.); programmable logic together with appropriate firmware; one or more stored program, general-purpose processors, such as a microprocessor or Digital Signal Processor (DSP), together with appropriate software; or any combination of the above. For example, the processing circuitry **701** may include two central processing units (CPUs). Data may be information in a form suitable for use by a computer.

In the depicted embodiment, input/output interface **705** may be configured to provide a communication interface to an input device, output device, or input and output device. UE **700** may be configured to use an output device via input/output interface **705**. An output device may use the same type of interface port as an input device. For example, a USB port may be used to provide input to and output from UE **700**. The output device may be a speaker, a sound card, a video card, a display, a monitor, a printer, an actuator, an emitter, a smartcard, another output device, or any combination thereof. UE **700** may be configured to use an input device via input/output interface **705** to allow a user to capture information into UE **700**. The input device may include a touch-sensitive or presence-sensitive display, a camera (e.g., a digital camera, a digital video camera, a web camera, etc.), a microphone, a sensor, a mouse, a trackball, a directional pad, a trackpad, a scroll wheel, a smartcard, and the like. The presence-sensitive display may include a capacitive or resistive touch sensor to sense input from a user. A sensor may be, for instance, an accelerometer, a gyroscope, a tilt sensor, a force sensor, a magnetometer, an optical sensor, a proximity sensor, another like sensor, or any combination thereof. For example, the input device may be an accelerometer, a magnetometer, a digital camera, a microphone, and an optical sensor.

In FIG. **7**, RF interface **709** may be configured to provide a communication interface to RF components such as a transmitter, a receiver, and an antenna. Network connection interface **711** may be configured to provide a communication interface to network **743***a*. Network **743***a* may encompass wired and/or wireless networks such as a local-area network (LAN), a wide-area network (WAN), a computer network, a wireless network, a telecommunications network, another like network or any combination thereof. For example, network **743***a* may comprise a Wi-Fi network. Network connection interface **711** may be configured to include a receiver and a transmitter interface used to communicate with one or more other devices over a communication network according to one or more communication protocols, such as Ethernet, TCP/IP, SONET, ATM, or the like. Network connection interface **711** may implement receiver and transmitter functionality appropriate to the communication network links (e.g., optical, electrical, and the like). The transmitter and receiver functions may share circuit components, software or firmware, or alternatively may be implemented separately.

RAM **717** may be configured to interface via bus **702** to processing circuitry **701** to provide storage or caching of data or computer instructions during the execution of software programs such as the operating system, application programs, and device drivers. ROM **719** may be configured to provide computer instructions or data to processing circuitry **701**. For example, ROM **719** may be configured to store invariant low-level system code or data for basic system functions such as basic input and output (I/O), startup, or reception of keystrokes from a keyboard that are stored in a non-volatile memory. Storage medium **721** may be configured to include memory such as RAM, ROM, programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), mag-

netic disks, optical disks, floppy disks, hard disks, removable cartridges, or flash drives. In one example, storage medium **721** may be configured to include operating system **723**, application program **725** such as a web browser application, a widget or gadget engine or another application, and data file **727**. Storage medium **721** may store, for use by UE **700**, any of a variety of various operating systems or combinations of operating systems.

Storage medium **721** may be configured to include a number of physical drive units, such as redundant array of independent disks (RAID), floppy disk drive, flash memory, USB flash drive, external hard disk drive, thumb drive, pen drive, key drive, high-density digital versatile disc (HD-DVD) optical disc drive, internal hard disk drive, Blu-Ray optical disc drive, holographic digital data storage (HDDS) optical disc drive, external mini-dual in-line memory module (DIMM), synchronous dynamic random access memory (SDRAM), external micro-DIMM SDRAM, smartcard memory such as a subscriber identity module or a removable user identity (SIM/RUIM) module, other memory, or any combination thereof. Storage medium **721** may allow UE **700** to access computer-executable instructions, application programs or the like, stored on transitory or non-transitory memory media, to off-load data, or to upload data. An article of manufacture, such as one utilizing a communication system may be tangibly embodied in storage medium **721**, which may comprise a device readable medium.

In FIG. **7**, processing circuitry **701** may be configured to communicate with network **743***b* using, communication subsystem **731**. Network **743***a* and network **743***b* may be the same network or networks or different network or networks. Communication subsystem **731** may be configured to include one or more transceivers used to communicate with network **743***b*. For example, communication subsystem **731** may be configured to include one or more transceivers used to communicate with one or more remote transceivers of another device capable of wireless communication such as another WD, UE, or base station of a radio access network (RAN) according to one or more communication protocols, such as IEEE 802.7, CDMA, WCDMA, GSM, LTE, UTRAN, WiMax, or the like. Each transceiver may include transmitter **733** and/or receiver **735** to implement transmitter or receiver functionality, respectively, appropriate to the RAN links (e.g., frequency allocations and the like). Further, transmitter **733** and receiver **735** of each transceiver may share circuit components, software or firmware, or alternatively may be implemented separately.

In the illustrated embodiment, the communication functions of communication subsystem **731** may include data communication, voice communication, multimedia communication, short-range communications such as Bluetooth, near-field communication, location-based communication such as the use of the global positioning system (GPS) to determine a location, another like communication function, or any combination thereof. For example, communication subsystem **731** may include cellular communication, Wi-Fi communication, Bluetooth communication, and GPS communication. Network **743***b* may encompass wired and/or wireless networks such as a local-area network (LAN), a wide-area network (WAN), a computer network, a wireless network, a telecommunications network, another like network or any combination thereof. For example, network **743***b* may be a cellular network, a Wi-Fi network, and/or a near-field network. Power source **713** may be configured to provide alternating current (AC) or direct current (DC) power to components of UE **700**.

The features, benefits and/or functions described herein may be implemented in one of the components of UE **700** or partitioned across multiple components of UE **700**. Further, the features, benefits, and/or functions described herein may be implemented in any combination of hardware, software or firmware. In one example, communication subsystem **731** may be configured to include any of the components described herein. Further, processing circuitry **701** may be configured to communicate with any of such components over bus **702**. In another example, any of such components may be represented by program instructions stored in memory that when executed by processing circuitry **701** perform the corresponding functions described herein. In another example, the functionality of any of such components may be partitioned between processing circuitry **701** and communication subsystem **731**. In another example, the non-computationally intensive functions of any of such components may be implemented in software or firmware and the computationally intensive functions may be implemented in hardware.

FIG. **8** is a schematic block diagram illustrating a virtualization environment **800** in which functions implemented by some embodiments may be virtualized. In the present context, virtualizing means creating virtual versions of apparatuses or devices which may include virtualizing hardware platforms, storage devices and networking resources. As used herein, virtualization can be applied to a node (e.g., a virtualized base station or a virtualized radio access node) or to a device (e.g., a UE, a wireless device or any other type of communication device) or components thereof and relates to an implementation in which at least a portion of the functionality is implemented as one or more virtual components (e.g., via one or more applications, components, functions, virtual machines or containers executing on one or more physical processing nodes in one or more networks).

In some embodiments, some or all of the functions described herein may be implemented as virtual components executed by one or more virtual machines implemented in one or more virtual environments **800** hosted by one or more of hardware nodes **830**. Further, in embodiments in which the virtual node is not a radio access node or does not require radio connectivity (e.g., a core network node), then the network node may be entirely virtualized.

The functions may be implemented by one or more applications **820** (which may alternatively be called software instances, virtual appliances, network functions, virtual nodes, virtual network functions, etc.) operative to implement some of the features, functions, and/or benefits of some of the embodiments disclosed herein. Applications **820** are run in virtualization environment **800** which provides hardware **830** comprising processing circuitry **860** and memory **890**. Memory **890** contains instructions **895** executable by processing circuitry **860** whereby application **820** is operative to provide one or more of the features, benefits, and/or functions disclosed herein.

Virtualization environment **800**, comprises general-purpose or special-purpose network hardware devices **830** comprising a set of one or more processors or processing circuitry **860**, which may be commercial off-the-shelf (COTS) processors, dedicated Application Specific Integrated Circuits (ASICs), or any other type of processing circuitry including digital or analog hardware components or special purpose processors. Each hardware device may comprise memory **890-1** which may be non-persistent memory for temporarily storing instructions **895** or software executed by processing circuitry **860**. Each hardware device may comprise one or more network interface controllers

(NICs) **870**, also known as network interface cards, which include physical network interface **880**. Each hardware device may also include non-transitory, persistent, machine-readable storage media **890-2** having stored therein software **895** and/or instructions executable by processing circuitry **860**. Software **895** may include any type of software including software for instantiating one or more virtualization layers **850** (also referred to as hypervisors), software to execute virtual machines **840** as well as software allowing it to execute functions, features and/or benefits described in relation with some embodiments described herein.

Virtual machines **840**, comprise virtual processing, virtual memory, virtual networking or interface and virtual storage, and may be run by a corresponding virtualization layer **850** or hypervisor. Different embodiments of the instance of virtual appliance **820** may be implemented on one or more of virtual machines **840**, and the implementations may be made in different ways.

During operation, processing circuitry **860** executes software **895** to instantiate the hypervisor or virtualization layer **850**, which may sometimes be referred to as a virtual machine monitor (VMM). Virtualization layer **850** may present a virtual operating platform that appears like networking hardware to virtual machine **840**.

As shown in FIG. **8**, hardware **830** may be a standalone network node with generic or specific components. Hardware **830** may comprise antenna **8225** and may implement some functions via virtualization. Alternatively, hardware **830** may be part of a larger cluster of hardware (e.g. such as in a data center or customer premise equipment (CPE)) where many hardware nodes work together and are managed via management and orchestration (MANO) **8100**, which, among others, oversees lifecycle management of applications **820**.

Virtualization of the hardware is in some contexts referred to as network function virtualization (NFV). NFV may be used to consolidate many network equipment types onto industry standard high volume server hardware, physical switches, and physical storage, which can be located in data centers, and customer premise equipment.

In the context of NFV, virtual machine **840** may be a software implementation of a physical machine that runs programs as if they were executing on a physical, non-virtualized machine. Each of virtual machines **840**, and that part of hardware **830** that executes that virtual machine, be it hardware dedicated to that virtual machine and/or hardware shared by that virtual machine with others of the virtual machines **840**, forms a separate virtual network elements (VNE).

Still in the context of NFV, Virtual Network Function (VNF) is responsible for handling specific network functions that run in one or more virtual machines **840** on top of hardware networking infrastructure **830** and corresponds to application **820** in FIG. **8**.

In some embodiments, one or more radio units **8200** that each include one or more transmitters **8220** and one or more receivers **8210** may be coupled to one or more antennas **8225**. Radio units **8200** may communicate directly with hardware nodes **830** via one or more appropriate network interfaces and may be used in combination with the virtual components to provide a virtual node with radio capabilities, such as a radio access node or a base station.

In some embodiments, some signalling can be effected with the use of control system **8230** which may alternatively be used for communication between the hardware nodes **830** and radio units **8200**.

With reference to FIG. **9**, a communication system in accordance with an embodiment is shown. The illustrated communication system includes telecommunication network **910**, such as a 3GPP-type cellular network, which comprises access network **911**, such as a radio access network, and core network **914**. Access network **911** comprises a plurality of base stations **912***a*, **912***b*, **912***c*, such as NBs, eNBs, gNBs or other types of wireless access points, each defining a corresponding coverage area **913***a*, **913***b*, **913***c*. Each base station **912***a*, **912***b*, **912***c* is connectable to core network **914** over a wired or wireless connection **915**. A first UE **991** located in coverage area **913***c* is configured to wirelessly connect to, or be paged by, the corresponding base station **912***c*. A second UE **992** in coverage area **913***a* is wirelessly connectable to the corresponding base station **912***a*. While a plurality of UEs **991**, **992** are illustrated in this example, the disclosed embodiments are equally applicable to a situation where a sole UE is in the coverage area or where a sole UE is connecting to the corresponding base station **912**.

Telecommunication network **910** is itself connected to host computer **930**, which may be embodied in the hardware and/or software of a standalone server, a cloud-implemented server, a distributed server or as processing resources in a server farm. Host computer **930** may be under the ownership or control of a service provider, or may be operated by the service provider or on behalf of the service provider. Connections **921** and **922** between telecommunication network **910** and host computer **930** may extend directly from core network **914** to host computer **930** or may go via an optional intermediate network **920**. Intermediate network **920** may be one of, or a combination of more than one of, a public, private or hosted network; intermediate network **920**, if any, may be a backbone network or the Internet; in particular, intermediate network **920** may comprise two or more subnetworks (not shown).

The communication system of FIG. **9** as a whole enables connectivity between the connected UEs **991**, **992** and host computer **930**. The connectivity may be described as an over-the-top (OTT) connection **950**. Host computer **930** and the connected UEs **991**, **992** are configured to communicate data and/or signaling via OTT connection **950**, using access network **911**, core network **914**, any intermediate network **920** and possible further infrastructure (not shown) as intermediaries. OTT connection **950** may be transparent in the sense that the participating communication devices through which OTT connection **950** passes are unaware of routing of uplink and downlink communications. For example, base station **912** may not or need not be informed about the past routing of an incoming downlink communication with data originating from host computer **930** to be forwarded (e.g., handed over) to a connected UE **991**. Similarly, base station **912** need not be aware of the future routing of an outgoing uplink communication originating from the UE **991** towards the host computer **930**.

Example implementations, in accordance with an embodiment, of the UE, base station and host computer discussed in the preceding paragraphs will now be described with reference to FIG. **10**. In communication system **1000**, host computer **1010** comprises hardware **1015** including communication interface **1016** configured to set up and maintain a wired or wireless connection with an interface of a different communication device of communication system **1000**. Host computer **1010** further comprises processing circuitry **1018**, which may have storage and/or processing capabilities. In particular, processing circuitry **1018** may comprise one or more programmable processors, applica-

tion-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. Host computer **1010** further comprises software **1011**, which is stored in or accessible by host computer **1010** and executable by processing circuitry **1018**. Software **1011** includes host application **1012**. Host application **1012** may be operable to provide a service to a remote user, such as UE **1030** connecting via OTT connection **1050** terminating at UE **1030** and host computer **1010**. In providing the service to the remote user, host application **1012** may provide user data which is transmitted using OTT connection **1050**.

Communication system **1000** further includes base station **1020** provided in a telecommunication system and comprising hardware **1025** enabling it to communicate with host computer **1010** and with UE **1030**. Hardware **1025** may include communication interface **1026** for setting up and maintaining a wired or wireless connection with an interface of a different communication device of communication system **1000**, as well as radio interface **1027** for setting up and maintaining at least wireless connection **1070** with UE **1030** located in a coverage area (not shown in FIG. **10**) served by base station **1020**. Communication interface **1026** may be configured to facilitate connection **1060** to host computer **1010**. Connection **1060** may be direct or it may pass through a core network (not shown in FIG. **10**) of the telecommunication system and/or through one or more intermediate networks outside the telecommunication system. In the embodiment shown, hardware **1025** of base station **1020** further includes processing circuitry **1028**, which may comprise one or more programmable processors, application-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. Base station **1020** further has software **1021** stored internally or accessible via an external connection.

Communication system **1000** further includes UE **1030** already referred to. Its hardware **1035** may include radio interface **1037** configured to set up and maintain wireless connection **1070** with a base station serving a coverage area in which UE **1030** is currently located. Hardware **1035** of UE **1030** further includes processing circuitry **1038**, which may comprise one or more programmable processors, application-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. UE **1030** further comprises software **1031**, which is stored in or accessible by UE **1030** and executable by processing circuitry **1038**. Software **1031** includes client application **1032**. Client application **1032** may be operable to provide a service to a human or non-human user via UE **1030**, with the support of host computer **1010**. In host computer **1010**, an executing host application **1012** may communicate with the executing client application **1032** via OTT connection **1050** terminating at UE **1030** and host computer **1010**. In providing the service to the user, client application **1032** may receive request data from host application **1012** and provide user data in response to the request data. OTT connection **1050** may transfer both the request data and the user data. Client application **1032** may interact with the user to generate the user data that it provides.

It is noted that host computer **1010**, base station **1020** and UE **1030** illustrated in FIG. **10** may be similar or identical to host computer **930**, one of base stations **912***a*, **912***b*, **912***c* and one of UEs **991**, **992** of FIG. **9**, respectively. This is to say, the inner workings of these entities may be as shown in FIG. **10** and independently, the surrounding network topology may be that of FIG. **9**.

In FIG. **10**, OTT connection **1050** has been drawn abstractly to illustrate the communication between host computer **1010** and UE **1030** via base station **1020**, without explicit reference to any intermediary devices and the precise routing of messages via these devices. Network infrastructure may determine the routing, which it may be configured to hide from UE **1030** or from the service provider operating host computer **1010**, or both. While OTT connection **1050** is active, the network infrastructure may further take decisions by which it dynamically changes the routing (e.g., on the basis of load balancing consideration or reconfiguration of the network).

Wireless connection **1070** between UE **1030** and base station **1020** is in accordance with the teachings of the embodiments described throughout this disclosure. One or more of the various embodiments improve the performance of OTT services provided to UE **1030** using OTT connection **1050**, in which wireless connection **1070** forms the last segment. More precisely, the teachings of DCI ambiguity embodiments reduce false detections (e.g., reduce likelihood that a UE will wrongly interpret a DCI 0_1), thereby improving performance by decreasing latency and increasing spectrum efficiency, which can lead to higher data rates and longer battery life. Additionally, by including the RRC parameters txConfig, maxRank and codebookSubset in the ConfiguredGrantConfig IE, higher spectrum efficiency and low latency get achieved with supporting multiple layer transmissions for Configured Grant.

A measurement procedure may be provided for the purpose of monitoring data rate, latency and other factors on which the one or more embodiments improve. There may further be an optional network functionality for reconfiguring OTT connection **1050** between host computer **1010** and UE **1030**, in response to variations in the measurement results. The measurement procedure and/or the network functionality for reconfiguring OTT connection **1050** may be implemented in software **1011** and hardware **1015** of host computer **1010** or in software **1031** and hardware **1035** of UE **1030**, or both. In embodiments, sensors (not shown) may be deployed in or in association with communication devices through which OTT connection **1050** passes; the sensors may participate in the measurement procedure by supplying values of the monitored quantities exemplified above, or supplying values of other physical quantities from which software **1011**, **1031** may compute or estimate the monitored quantities. The reconfiguring of OTT connection **1050** may include message format, retransmission settings, preferred routing etc.; the reconfiguring need not affect base station **1020**, and it may be unknown or imperceptible to base station **1020**. Such procedures and functionalities may be known and practiced in the art. In certain embodiments, measurements may involve proprietary UE signaling facilitating host computer **1010**'s measurements of throughput, propagation times, latency and the like. The measurements may be implemented in that software **1011** and **1031** causes messages to be transmitted, in particular empty or 'dummy' messages, using OTT connection **1050** while it monitors propagation times, errors etc.

FIG. **11** is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station and a UE which may be those described with reference to FIGS. **9** and **10**. For simplicity of the present disclosure, only drawing references to FIG. **11** will be

included in this section. In step **1110**, the host computer provides user data. In substep **1111** (which may be optional) of step **1110**, the host computer provides the user data by executing a host application. In step **1120**, the host computer initiates a transmission carrying the user data to the UE. In step **1130** (which may be optional), the base station transmits to the UE the user data which was carried in the transmission that the host computer initiated, in accordance with the teachings of the embodiments described throughout this disclosure. In step **1140** (which may also be optional), the UE executes a client application associated with the host application executed by the host computer.

FIG. **12** is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station and a UE which may be those described with reference to FIGS. **9** and **10**. For simplicity of the present disclosure, only drawing references to FIG. **12** will be included in this section. In step **1210** of the method, the host computer provides user data. In an optional substep (not shown) the host computer provides the user data by executing a host application. In step **1220**, the host computer initiates a transmission carrying the user data to the UE. The transmission may pass via the base station, in accordance with the teachings of the embodiments described throughout this disclosure. In step **1230** (which may be optional), the UE receives the user data carried in the transmission.

FIG. **13** is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station and a UE which may be those described with reference to FIGS. **9** and **10**. For simplicity of the present disclosure, only drawing references to FIG. **13** will be included in this section. In step **1310** (which may be optional), the UE receives input data provided by the host computer. Additionally or alternatively, in step **1320**, the UE provides user data. In substep **1321** (which may be optional) of step **1320**, the UE provides the user data by executing a client application. In substep **1311** (which may be optional) of step **1310**, the UE executes a client application which provides the user data in reaction to the received input data provided by the host computer. In providing the user data, the executed client application may further consider user input received from the user. Regardless of the specific manner in which the user data was provided, the UE initiates, in substep **1330** (which may be optional), transmission of the user data to the host computer. In step **1340** of the method, the host computer receives the user data transmitted from the UE, in accordance with the teachings of the embodiments described throughout this disclosure.

FIG. **14** is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station and a UE which may be those described with reference to FIGS. **9** and **10**. For simplicity of the present disclosure, only drawing references to FIG. **14** will be included in this section. In step **1410** (which may be optional), in accordance with the teachings of the embodiments described throughout this disclosure, the base station receives user data from the UE. In step **1420** (which may be optional), the base station initiates transmission of the received user data to the host computer. In step **1430** (which may be optional), the host computer receives the user data carried in the transmission initiated by the base station.

Any appropriate steps, methods, features, functions, or benefits disclosed herein may be performed through one or more functional units or modules of one or more virtual apparatuses. Each virtual apparatus may comprise a number of these functional units. These functional units may be implemented via processing circuitry, which may include one or more microprocessor or microcontrollers, as well as other digital hardware, which may include digital signal processors (DSPs), special-purpose digital logic, and the like. The processing circuitry may be configured to execute program code stored in memory, which may include one or several types of memory such as read-only memory (ROM), random-access memory (RAM), cache memory, flash memory devices, optical storage devices, etc. Program code stored in memory includes program instructions for executing one or more telecommunications and/or data communications protocols as well as instructions for carrying out one or more of the techniques described herein. In some implementations, the processing circuitry may be used to cause the respective functional unit to perform corresponding functions according one or more embodiments of the present disclosure.

FIG. **15**A illustrates a schematic block diagram of network node **660** according to an embodiment. As illustrated in FIG. **15**A, network node **660** includes a deciding unit **1502**, an IE generating unit **1504**, and a transmitting unit **1506** for performing steps **502**, **504**, and **506**, respectively.

FIG. **15**B illustrates a schematic block diagram of wireless device **610** according to an embodiment. As illustrated in FIG. **15**B, wireless device **610** includes: a DCI reception unit **1512** for performing DCI (PDCCH) reception assuming the PDCCH is for activation and for determining whether the content of the PDCCH matches an activation command; a field checking unit **1514** for checking a particular field in the PDCCH (e.g., the bit that is in the position of the NDI field for a activation command) to determine whether the field is set to a value of 0; and a first PDCCH unit **1516** for treating the PDCCH as an activation command as a result of the DCI reception unit determining that the content of the PDCCH matches an activation command and the checking unit **1514** determines that the field is set to a value of 0.

The term unit may have conventional meaning in the field of electronics, electrical devices and/or electronic devices and may include, for example, electrical and/or electronic circuitry, devices, modules, processors, memories, logic solid state and/or discrete devices, computer programs or instructions for carrying out respective tasks, procedures, computations, outputs, and/or displaying functions, and so on, as such as those that are described herein.

Concise Description of Various Embodiments

UE Embodiments

A1. A method performed by a wireless device, the method comprising at least one of: performing PDCCH reception assuming the PDCCH (e.g., a received PDCCH scrambled with CS-RNTI) is for activation and determining whether the content of the PDCCH matches (or indicates) an activation command; as a result of determining that the content of the PDCCH matches (or indicates) an activation command, checking a particular field in the PDCCH (e.g., the bit that is in the position of the NDI field for a activation command) to determine whether the field (e.g., bit) is set to a value of 0; and as a result of determining that that the field is 0, treating the PDCCH as an activation command.

A2. The method of embodiment A1, further comprising determining whether the content of the PDCCH indicates configured grant Type 2 activation; and, optionally, as a result of determining that the content of the PDCCH indi-

cates configured grant Type 2 activation, triggering configured uplink grant confirmation.

A3. The method of embodiment A2, further comprising: as a result of determining that the content of the PDCCH s indicates configured grant Type 2 activation, storing an uplink grant and associated HARQ information as configured uplink grant and, optionally, initialising or re-initialising the configured uplink grant for the Serving Cell to start in an associated PUSCH duration and, optionally, to recur according to rules.

A4. A method performed by a wireless device, the method comprising at least one of: the wireless device successfully decoding a PDCCH as a retransmission grant; the wireless device successfully decoding the PDCCH as an activation command; and the wireless device choosing based on priority whether to treat the PDCCH as a retransmission grant or as an activation command.

A5. The method of any of the previous embodiments, further comprising: providing user data; and forwarding the user data to a host computer via a transmission to the base station.

Base Station Embodiments

B1. A method performed by a base station, the method comprising at least one of: the base station deciding to configure a UE for uplink transmission without dynamic grant; as a result of deciding to configure the UE for uplink transmission without dynamic grant, the base station generating a ConfiguredGrantConfig IE, wherein, optionally, the ConfiguredGrantConfig IE includes one or more of the following RRC parameters txConfig, maxRank and codebookSubset; and the base station transmitting the ConfiguredGrantConfig IE to the UE.

B2. The method of embodiment B1, wherein transmitting the ConfiguredGrantConfig IE comprises at least one of the base station generating a BWP-UplinkDedicated IE, which, optionally, is used to configure the dedicated (UE specific) parameters of an uplink Bandwidth Part (BWP); and the base station transmitting to the UE the BWP-UplinkDedicated IE which, optionally, includes the generated ConfiguredGrantConfig IE.

B3. The method of embodiment B2, wherein the BWP-UplinkDedicated IE further includes a PUSCH-Config IE that, optionally, contains parameter values for the one or more of RRC parameters txConfig, maxRank and codebookSubset.

B4. The method of embodiment B3, wherein the parameter values for the RRC parameters txConfig, maxRank and codebookSubset included in the PUSCH-Config IE are different than the parameter values for the RRC parameters txConfig, maxRank and codebookSubset included in the ConfiguredGrantconfig IE.

B5. A method performed by a base station, the method comprising at least one of: the base station deciding to transmit to a UE a DCI configured for a retransmission grant; the base station ensuring that if a UE decodes the DCI configured for the retransmission grant under the assumption that the DCI is an activation command the UE will not determine that the DCI is a valid activation command; and the base station transmuting the DCI.

B6. The method of any of the embodiments B1-B5, further comprising at least one of: obtaining user data; and forwarding the user data to a host computer or a wireless device.

Group C Embodiments

C1. A wireless device, the wireless device comprising: processing circuitry configured to perform any of the steps of any of the Group A embodiments; and power supply circuitry configured to supply power to the wireless device.

C2. A base station, the base station comprising: processing circuitry configured to perform any of the steps of any of the Group B embodiments; power supply circuitry configured to supply power to the wireless device.

C3. A user equipment (UE) for, the UE comprising: an antenna configured to send and receive wireless signals; radio front-end circuitry connected to the antenna and to processing circuitry, and configured to condition signals communicated between the antenna and the processing circuitry; the processing circuitry being configured to perform any of the steps of any of the Group A embodiments; an input interface connected to the processing circuitry and configured to allow input of information into the UE to be processed by the processing circuitry; an output interface connected to the processing circuitry and configured to output information from the UE that has been processed by the processing circuitry; and a battery connected to the processing circuitry and configured to supply power to the UE.

C4. A communication system including a host computer comprising: processing circuitry configured to provide user data; and a communication interface configured to forward the user data to a cellular network for transmission to a user equipment (UE), wherein the cellular network comprises a base station having a radio interface and processing circuitry, the base station's processing circuitry configured to perform any of the steps of any of the Group B embodiments.

C5. The communication system of the pervious embodiment further including the base station.

C6. The communication system of the previous 2 embodiments, further including the UE, wherein the UE is configured to communicate with the base station.

C7. The communication system of the previous 3 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application, thereby providing the user data; and the UE comprises processing circuitry configured to execute a client application associated with the host application.

C8. A method implemented in a communication system including a host computer, a base station and a user equipment (UE), the method comprising: at the host computer, providing user data; and at the host computer, initiating a transmission carrying the user data to the UE via a cellular network comprising the base station, wherein the base station performs any of the steps of any of the Group B embodiments.

C9. The method of the previous embodiment, further comprising, at the base station, transmitting the user data.

C10. The method of the previous 2 embodiments, wherein the user data is provided at the host computer by executing a host application, the method further comprising, at the UE, executing a client application associated with the host application.

C11. A user equipment (UE) configured to communicate with a base station, the UE comprising a radio interface and processing circuitry configured to performs the of the previous 3 embodiments.

C12. A communication system including a host computer comprising: processing circuitry configured to provide user data; and a communication interface configured to forward user data to a cellular network for transmission to a user equipment (UE), wherein the UE comprises a radio interface

and processing circuitry, the UE's components configured to perform any of the steps of any of the Group A embodiments.

C13. The communication system of the previous embodiment, wherein the cellular network further includes a base station configured to communicate with the UE.

C14. The communication system of the previous 2 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application, thereby providing the user data; and the UE's processing circuitry is configured to execute a client application associated with the host application.

C15. A method implemented in a communication system including a host computer, a base station and a user equipment (UE), the method comprising: at the host computer, providing user data; and at the host computer, initiating a transmission carrying the user data to the UE via a cellular network comprising the base station, wherein the UE performs any of the steps of any of the Group A embodiments.

C16. The method of the previous embodiment, further comprising at the UE, receiving the user data from the base station.

C17. A communication system including a host computer comprising: communication interface configured to receive user data originating from a transmission from a user equipment (UE) to a base station, wherein the UE comprises a radio interface and processing circuitry, the UE's processing circuitry configured to perform any of the steps of any of the Group A embodiments.

C18. The communication system of the previous embodiment, further including the UE.

C19. The communication system of the previous 2 embodiments, further including the base station, wherein the base station comprises a radio interface configured to communicate with the UE and a communication interface configured to forward to the host computer the user data carried by a transmission from the UE to the base station.

C20. The communication system of the previous 3 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application; and the UE's processing circuitry is configured to execute a client application associated with the host application, thereby providing the user data.

C21. The communication system of the previous 4 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application, thereby providing request data; and the UE's processing circuitry is configured to execute a client application associated with the host application, thereby providing the user data in response to the request data.

C22. A method implemented in a communication system including a host computer, a base station and a user equipment (UE), the method comprising: at the host computer, receiving user data transmitted to the base station from the UE, wherein the UE performs any of the steps of any of the Group A embodiments.

C23. The method of the previous embodiment, further comprising, at the UE, providing the user data to the base station.

C24. The method of the previous 2 embodiments, further comprising: at the UE, executing a client application, thereby providing the user data to be transmitted; and at the host computer, executing a host application associated with the client application.

C25. The method of the previous 3 embodiments, further comprising: at the UE, executing a client application; and at the UE, receiving input data to the client application, the input data being provided at the host computer by executing a host application associated with the client application, wherein the user data to be transmitted is provided by the client application in response to the input data.

C26. A communication system including a host computer comprising a communication interface configured to receive user data originating from a transmission from a user equipment (UE) to a base station, wherein the base station comprises a radio interface and processing circuitry, the base station's processing circuitry configured to perform any of the steps of any of the Group B embodiments.

C27. The communication system of the previous embodiment further including the base station.

C28. The communication system of the previous 2 embodiments, further including the UE, wherein the UE is configured to communicate with the base station.

C29. The communication system of the previous 3 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application; the UE is configured to execute a client application associated with the host application, thereby providing the user data to be received by the host computer.

C30. A method implemented in a communication system including a host computer, a base station and a user equipment (UE), the method comprising: at the host computer, receiving, from the base station, user data originating from a transmission which the base station has received from the UE, wherein the UE performs any of the steps of any of the Group A embodiments.

C31. The method of the previous embodiment, further comprising at the base station, receiving the user data from the UE.

C32. The method of the previous 2 embodiments, further comprising at the base station, initiating a transmission of the received user data to the host computer.

While various embodiments of the present disclosure are described herein, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of the present disclosure should not be limited by any of the above described exemplary embodiments. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

Additionally, while the processes described above and illustrated in the drawings are shown as a sequence of steps, this was done solely for the sake of illustration. Accordingly, it is contemplated that some steps may be added, some steps may be omitted, the order of the steps may be re-arranged, and some steps may be performed in parallel.

REFERENCES

[1] TS 38.212

ABBREVIATIONS

At least some of the following abbreviations may be used in this disclosure. If there is an inconsistency between abbreviations, preference should be given to how it is used above. If listed multiple times below, the first listing should be preferred over any subsequent listing(s).

3GPP 3rd Generation Partnership Project
5G 5th Generation
ABS Almost Blank Subframe
ARQ Automatic Repeat Request
AWGN Additive White Gaussian Noise

BCCH Broadcast Control Channel
BCH Broadcast Channel
CA Carrier Aggregation
CC Carrier Component
CCCH SDU Common Control Channel SDU
CDMA Code Division Multiplexing Access
CGI Cell Global Identifier
CIR Channel Impulse Response
CP Cyclic Prefix
CPICH Common Pilot Channel
CPICH Ec/No CPICH Received energy per chip divided by the power density in the band
CQI Channel Quality information
C-RNTI Cell RNTI
CSI Channel State Information
CS-RNTI Configured Scheduling RNTI
DCCH Dedicated Control Channel
DCI Downlink Control Information
DL Downlink
DM Demodulation
DMRS Demodulation Reference Signal
DRX Discontinuous Reception
DTX Discontinuous Transmission
DTCH Dedicated Traffic Channel
DUT Device Under Test
E-CID Enhanced Cell-ID (positioning method)
E-SMLC Evolved-Serving Mobile Location Centre
ECGI Evolved CGI
eNB E-UTRAN Node
BePDCCH enhanced Physical Downlink Control Channel
E-SMLC evolved Serving Mobile Location Center
E-UTRA Evolved UTRA
E-UTRAN Evolved UTRAN
FDD Frequency Division Duplex
FFS For Further Study
GERAN GSM EDGE Radio Access Network
gNB Base station in NR
GNSS Global Navigation Satellite System
GSM Global System for Mobile communication
HARQ Hybrid Automatic Repeat Request
HO Handover
HSPA High Speed Packet Access
HRPD High Rate Packet Data
L1 Layer **1**
LOS Line of Sight
LPP LTE Positioning Protocol
LTE Long-Term Evolution
MAC Medium Access Control
MBMS Multimedia Broadcast Multicast Services
MBSFN Multimedia Broadcast multicast service Single Frequency Network
MBSFN ABS MBSFN Almost Blank Subframe
MDT Minimization of Drive Tests
MIB Master Information Block
MME Mobility Management Entity
MSC Mobile Switching Center
NPDCCH Narrowband Physical Downlink Control Channel
NR New Radio
OCNG OFDMA Channel Noise Generator
OFDM Orthogonal Frequency Division Multiplexing
OFDMA Orthogonal Frequency Division Multiple Access
OSS Operations Support System
OTDOA Observed Time Difference of Arrival
O&M Operation and Maintenance
PBCH Physical Broadcast Channel
P-CCPCH Primary Common Control Physical Channel
PCell Primary Cell
PCFICH Physical Control Format Indicator Channel
PDCCH Physical Downlink Control Channel
PDP Profile Delay Profile
PDSCH Physical Downlink Shared Channel
PGW. Packet Gateway
PHICH Physical Hybrid-ARQ Indicator Channel
PLMN Public Land Mobile Network
PMI Precoder Matrix Indicator
PRACH Physical Random Access Channel
PRS Positioning Reference Signal
PSS Primary Synchronization Signal
PUCCH Physical Uplink Control Channel
PUSCH Physical Uplink Shared Channel
RACH Random Access Channel
QAM Quadrature Amplitude Modulation
RAN Radio Access Network
RAT Radio Access Technology
RLM Radio Link Management
RNC Radio Network Controller
RNTI Radio Network Temporary Identifier
RRC Radio Resource Control
RRM Radio Resource Management
RS Reference Signal
RSCP. Received Signal Code Power
RSRP Reference Symbol Received Power OR Reference Signal Received Power
RSRQ Reference Signal Received Quality OR Reference Symbol Received Quality
RSSI Received Signal Strength Indicator
RSTD Reference Signal Time Difference
SCH Synchronization Channel
SCell Secondary Cell
SDU Service Data Unit
SFN System Frame Number
SGW Serving Gateway
SI System Information
SIB System Information Block
SNR Signal to Noise Ratio
SON Self Optimized Network
SS Synchronization Signal
SSS Secondary Synchronization Signal
TDD Time Division Duplex
TDOA Time Difference of Arrival
TOA Time of Arrival
TSS Tertiary Synchronization Signal
TTI Transmission Time Interval
UE User Equipment
UL Uplink
UMTS Universal Mobile Telecommunication System
USIM Universal Subscriber Identity Module
UTDOA Uplink Time Difference of Arrival
UTRA Universal Terrestrial Radio Access
UTRAN Universal Terrestrial Radio Access Network
WCDMA Wide CDMA
WLAN Wide Local Area Network

APPENDIX

This appendix is a draft of a contribution to be submitted for consideration.

2.1 Inconsistent RRC Configurations for Type 2 Configured Grant

The RRC parameter txConfig, maxRank and codebookSubset that related to multi-antenna and multiple layer transmission are absent from type 2 configured grant configuration. In 3GPP TS 38.214 6.1.1 states that, if the higher layer parameter txConfig is not configured, the UE is not expected to be scheduled by DCI format 0_1.

The ConfiguredGrantConfig contains resourceAllocation alternatives for type 2 that only can be used for DCI 0_1.

A way to mitigate the configuration problem is to clarify in TS 38.214 6.1.1 regarding transmission schemes for configured grant.

Proposal 1: Adopt the text proposals provided in section 2.1.

>>>Text Proposal for TS 38.214 Section 6.1.2.3>>>

- For Type 2 PUSCH transmissions with a configured grant: the resource allocation follows the higher layer configuration according to [10, TS 38.321], and UL grant received on the DCI. The configuration for txConfig, maxRank and codebookSubset follow PUSCH-Config.

>>>End Text Proposal >>>

An alternative way is to add those missing parameters into the type 2 configuration in ConfiguredGrantConfig

Proposal 2: Include txConfig, maxRank and codebookSubset in the ConfiguredGrantConfig

2.2 Retransmission of Configured Grant

It was discussed at the RAN #94 meeting how to handle the ambiguity among activation, deactivation and retransmission that might occur for UE at receiving PDCCH scrambled with CS-RNTI. For retransmission of configured grant that applies PUSCH-Config IE the DCI bit field can be different from the PDCCH for activation and deactivation applies ConfiguredGrantConfig. The NDI flag used to indicate an activation or retransmission can present at a different place in PDCCH and therefore cause some problem for UE to detect and interpret the received PDCCH.

The DCI bit field of NDI in the activate signal can be other field (location) in retransmission signal. FIG. **17** illustrates the DCI when the frequency hopping is enabled in dynamic grant but disabled for configured grant.

The ambiguity illustrated in FIG. **17** can only occur if the DCI is of DCI format 0_1, which is the normal DCI for scheduling PUSCH. This is because the length of FDRA, FH and TDRA fields can vary according to configuration, and these fields are ahead of the NDI field in DCI format 0_1.

There are 3 fields in DCI format 0_1 that are ahead of NDI, and can have different sizes between DCI_dynamic and DCI_UL_GF: Frequency domain resource assignment (FDRA), Time domain resource assignment (TDRA), Frequency hopping flag (FH).

Validation of Activation Signal:

TABLE 10.2-1

Special Fields for DL SPS and UL grant Type 2 scheduling activation PDCCH validation

	DCI Format 0_0/0_1	DCI format 1_0	DCI format 1_1
HARQ Process No.	Set to all '0's	Set to all '0's	Set to all '0's
Redundancy version	Set to all '00'	Set to all '00'	For the enabled transport block set to '00'

The IE for configured grant and normal transmission should not differ much for same UE and same network. The network may ensure that the DCI field interpretation will not cause ambiguity for that UE. Either network configuration aligns the two IEs that the DCI field are matched at the bit of NDI, or network choose different configuration for the two IEs but make sure that the validation field shall be sufficient for UE to differentiate the retransmission from other 2 DCI formats addressing activation and deactivation. It is the network's issue to guarantee that there should be minimum ambiguity for the configured grant mechanism to work, no further modification is needed in DCI format regarding the retransmission issue.

From network configuration perspective, the PUSCH-Config shall be addressed with best UE capability, and configure grant configuration should be a subset under the PUSCH configuration. Retransmission of configured grant is dynamically triggered by pdcch and therefore follows the PUSCH-Config that is designed for dynamic grant.

Proposal 3: Configure Grant Retransmission Shall Apply PUSCH-Config Configuration.

Observation 1: Network can avoid sending ambiguity DCIs by:

a) Ensure that the total length of the sizes of the following three fields do not change between the two DCI functions: i) Frequency domain resource assignment (FDRA); ii) Time domain resource assignment (TDRA), Frequency hopping flag (FH);

b) Ensure the "fake" DCI field of NDI and "fake" validation values to be invalid in a retransmission.

Proposal 4: UE detection should prioritize the valid detection of activation/deactivation than retransmission.

Proposal 5: Send LS to RAN2 and adopt the text proposals provided section 2.2

>>> Text Proposal for 38.321 Section 5.4.1>>>

. . .

1> else if an uplink grant for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:

2> if the NDI follows activation or deactivation DCI in the received HARQ information is 0:

3> if PDCCH contents indicate configured grant Type 2 deactivation:

4> trigger configured uplink grant confirmation.

3> else if PDCCH contents indicate configured grant Type 2 activation:

4> trigger configured uplink grant confirmation;

4> store the uplink grant for this Serving Cell and the associated HARQ information as configured uplink grant;

4> initialise or re-initialise the configured uplink grant for this Serving Cell to start in the associated PUSCH duration and to recur according to rules in subclause 5.8.2;

4> set the HARQ Process ID to the HARQ Process ID associated with this PUSCH duration;

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4> consider the NDI bit for the corresponding HARQ process to have been toggled;
4> stop the configuredGrantTimer for the corresponding HARQ process, if running;
4> deliver the configured uplink grant and the associated HARQ information to the HARQ entity.
3> else if the PDCCH content is not valid for activation or deactivation:
4>if the NDI follows retransmission DCI in the received HARQ information is 1:
5> consider the NDI for the corresponding HARQ process not to have been toggled;
5> start or restart the configuredGrantTimer for the corresponding HARQ process, if configured;
5> deliver the uplink grant and the associated HARQ information to the HARQ entity.
>>> End Text Proposal >>>

2.3 Deactivation of SPS DL and Type 2 Configured Grant

It is not clear in 38.213 on which DCI field to use for the validation of release signal.

"Resource block assignment" shall align with the naming in DCI format that is the "Frequency domain resource alignment".

Proposal 6: Adopt the text proposal provided in section 2.3

Text Proposal for 38.213 Section 10.2>>>

TABLE 10.2-2

Special fields for DL SPS and UL grant
Type 2 scheduling release PDCCH validation

	DCI format 0_0	DCI format 1_0
HARQ process number	set to all '0's	set to all '0's
Redundancy version	set to '00'	set to '00'
Modulation and coding scheme	set to all '1's	set to all '1's
Frequency domain resource assignment	set to all '1's	set to all '1's

>>>End Text Proposal>>>

OTHER TEXT PROPOSAL FOR SCHEDULING AND HARQ
3.1 TP for 38.212:
>>>Text Proposal for 38.212 Section 6.3.2.1.1 >>>
6.3.2.1.1 HARQ-ACK
If HARQ-ACK bits are transmitted on a PUSCH, the UCI bit sequence $a_0,a_1,a_2,a_3,\ldots,a_{A-1}$ is determined as follows:
- If UCI is transmitted on PUSCH without UL-SCH and the UCI includes CSI part 1 without CSI part 2,
  - if there is no HARQ-ACK bit given by Subclause 9.1 of [5, TS 38.213], set $a_0 = 0$, $a_1 = 0$, and $A = 2$;
  - if there is only one HARQ-ACK bit $\tilde{o}_0^{ACK}$ given by Subclause 9.1 of [5, TS 38.213], set $a_0 = \tilde{o}_0^{ACK}$, $a_1 = 0$, and $A = 2$;
- otherwise, set $a_i = \tilde{o}_i^{ACK}$, i for $i=0,1,\ldots,O^{ACK}-1$ and $A = O^{ACK}$, where the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK},\ldots,\tilde{o}_{O^{ACK}-1}^{ACK}$ is given by Subclause 9.1 of [5, TS 38.213].
>>>End Text Proposal >>>

The invention claimed is:

1. A method performed by a wireless device, the method comprising:

performing a physical downlink control channel (PDCCH) reception, thereby receiving content of the PDCCH;

determining whether the content of the PDCCH matches or indicates an activation command based at least in part on HARQ process number and redundancy version values of the received PDCCH;

as a result of determining that the content of the PDCCH matches or indicates the activation command, checking a particular field in the content of the PDCCH to determine whether the field is set to a first value; and

as a result of determining that that the particular field is set to the first value, treating the content of the PDCCH as an activation command.

2. The method of claim **1**, wherein

the content of the PDCCH comprises downlink control information (DCI) comprising a new data indicator (NDI) field, and

checking the particular field in the content of the PDCCH to determine whether the field is set to the particular value comprises checking the NDI field to determine whether the NDI field is set to the first value.

3. The method of claim **1**, further comprising

determining whether the content of the PDCCH indicates configured grant Type 2 activation.

4. The method of claim **3**, further comprising:

as a result of determining that the content of the PDCCH indicates configured grant Type 2 activation, triggering configured uplink grant confirmation.

5. The method of claim **3**, further comprising:

as a result of determining that the content of the PDCCH indicates configured grant Type 2 activation, storing an uplink grant and associated HARQ information as configured uplink grant and initialising or re-initialising the configured uplink grant for the serving cell to start in an associated PUSCH duration.

6. The method of claim **1** further comprising:

as a result of determining that the content of the PDCCH does not match or indicate the activation command, checking the particular field in the content of the PDCCH to determine whether the field is set to a second value; and

as a result of determining that that the particular field is set to the second value, treating the content of the PDCCH as retransmission grant.

7. The method of claim **1**, further comprising:

as a result of determining that the particular field is not set to the first value, checking the particular field to determine whether the field is set to a second value; and

as a result of determining that that the particular field is set to the second value, treating the content of the PDCCH as retransmission grant.

8. The method of claim **1**, further comprising:

as a result of determining that the content of the PDCCH does not match or indicate the activation command, treating the content of the PDCCH as retransmission grant.

9. A wireless device (WD), the WD comprising:

at least one processor; and

a non-transitory memory including software instructions configured to control the WD to perform steps of:

performing a physical downlink control channel (PDCCH) reception, thereby receiving content of the PDCCH;

determining whether the content of the PDCCH matches or indicates an activation command based at least in part on HARQ process number and redundancy version values of the received PDCCH;

as a result of determining that the content of the PDCCH matches or indicates the activation command, checking a particular field in the content of the PDCCH to determine whether the field is set to a first value; and

as a result of determining that that the particular field is set to the first value, treating the content of the PDCCH as an activation command.

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