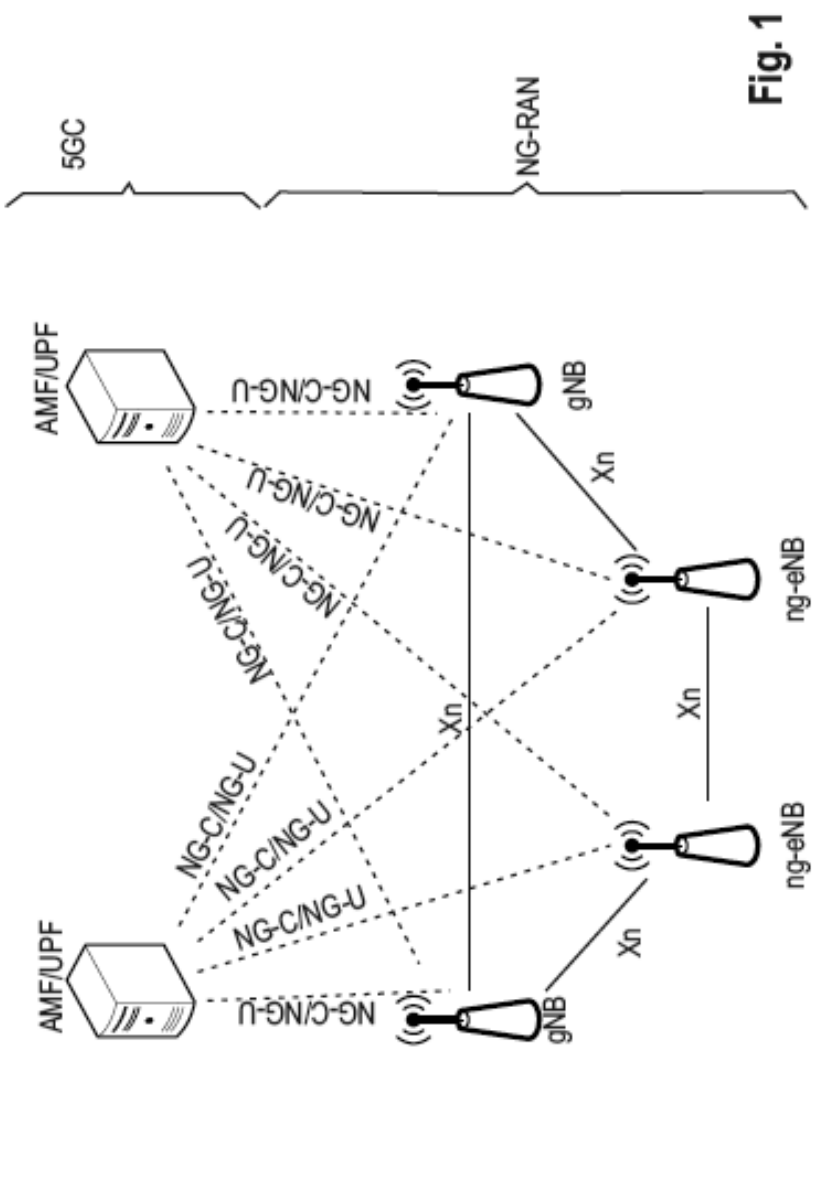

5GC
NG-RAN
AMF/UPF
AMF/UPF
NG-C/NG-U
NG-C/NG-U
NG-C/NG-U
NG-C/NG-U
NG-C/NG-U
NG-C/NG-U
NG-C/NG-U
NG-C/NG-U
gNB
gNB
ng-eNB
ng-eNB
Xn
Xn
Xn
Xn
100

Fig. 1

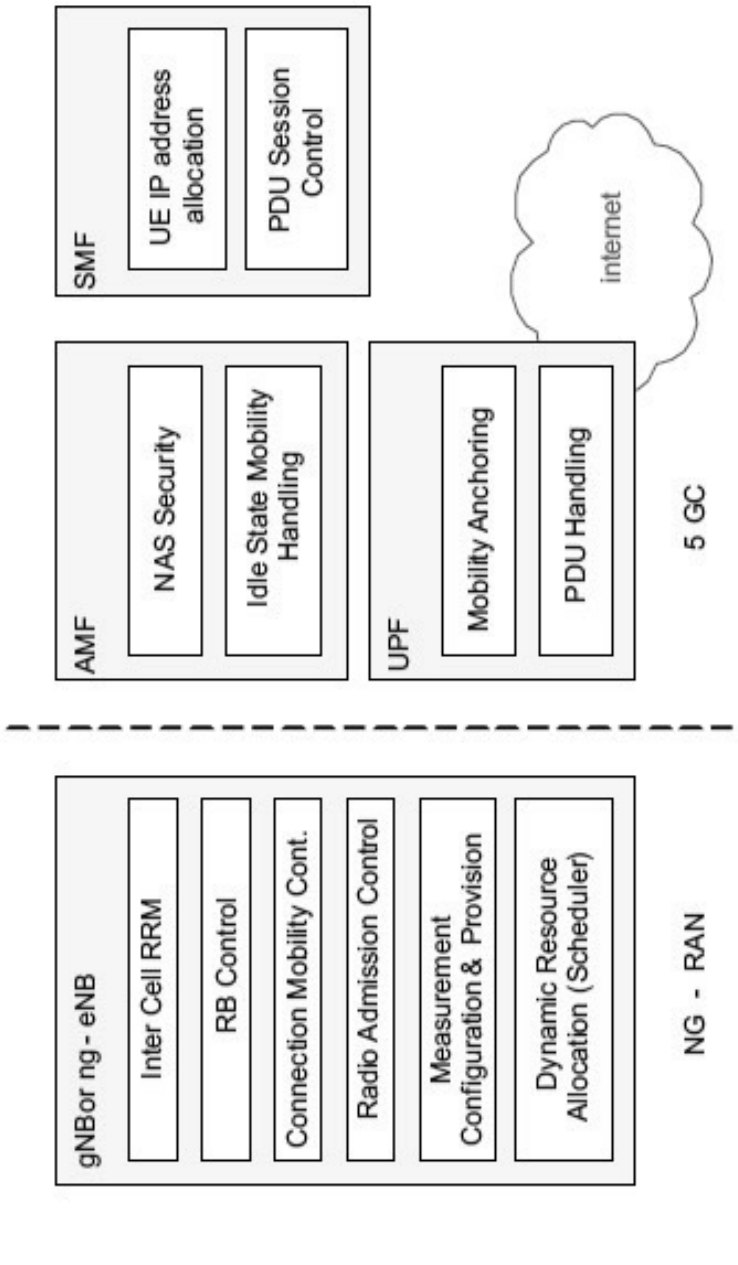

gNBor ng - eNB
Inter Cell RRM
RB Control
Connection Mobility Cont.
Radio Admission Control
Measurement Configuration & Provision
Dynamic Resource Allocation (Scheduler)
NG - RAN
AMF
NAS Security
Idle State Mobility Handling
UPF
Mobility Anchoring
PDU Handling
SMF
UE IP address allocation
PDU Session Control
internet
5 GC
200

Fig. 2

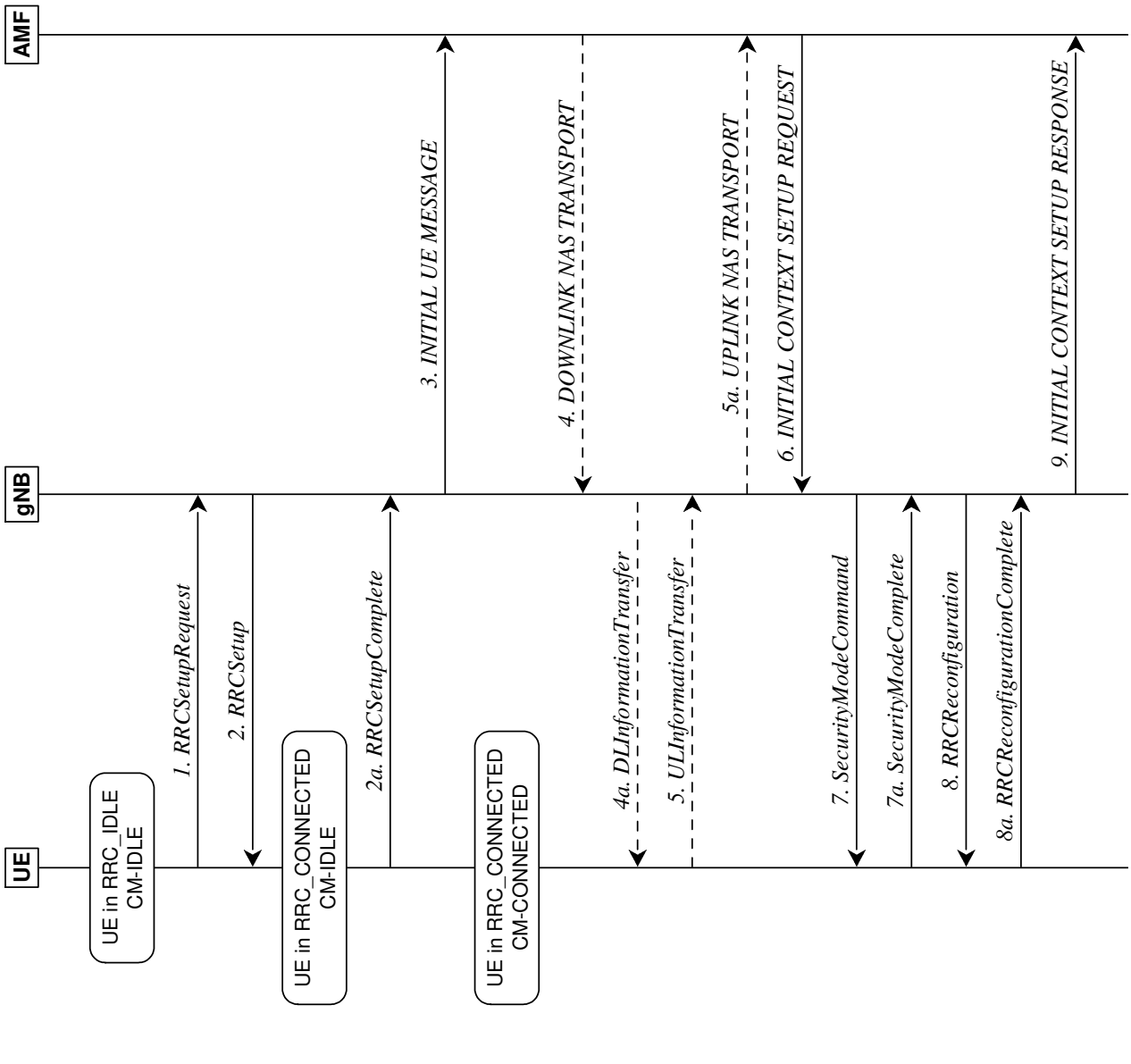

UE
gNB
AMF
UE in RRC_IDLE CM-IDLE
1. RRCSetupRequest
2. RRCSetup
UE in RRC_CONNECTED CM-IDLE
2a. RRCSetupComplete
UE in RRC_CONNECTED CM-CONNECTED
3. INITIAL UE MESSAGE
4. DOWNLINK NAS TRANSPORT
4a. DLInformationTransfer
5. ULInformationTransfer
5a. UPLINK NAS TRANSPORT
6. INITIAL CONTEXT SETUP REQUEST
7. SecurityModeCommand
7a. SecurityModeComplete
8. RRCReconfiguration
8a. RRCReconfigurationComplete
9. INITIAL CONTEXT SETUP RESPONSE
300

Fig. 3

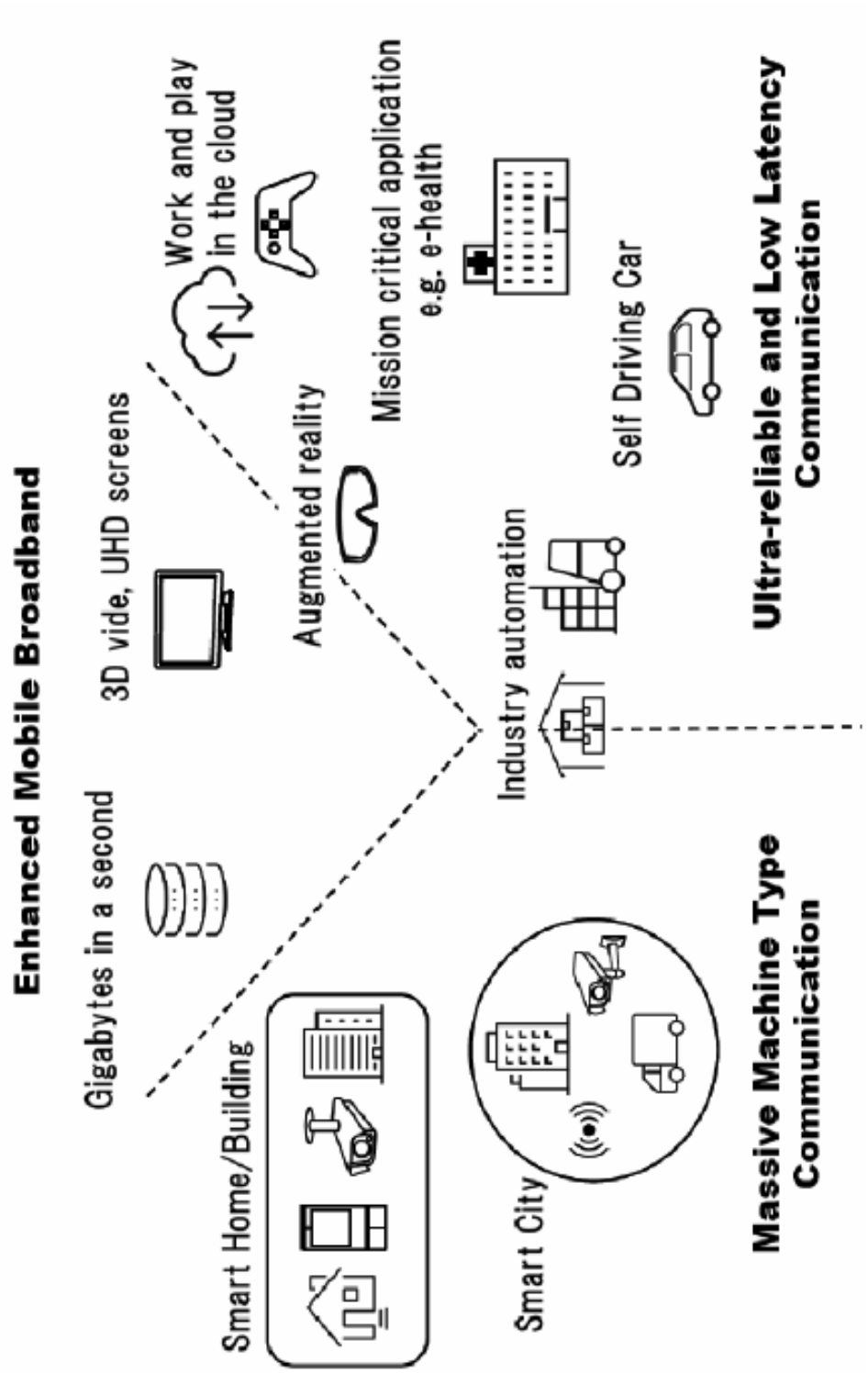

Enhanced Mobile Broadband
Gigabytes in a second
3D vide, UHD screens
Work and play in the cloud
Augmented reality
Mission critical application e.g. e-health
Smart Home/Building
Industry automation
Self Driving Car
Ultra-reliable and Low Latency Communication
Smart City
Massive Machine Type Communication
400

Fig. 4

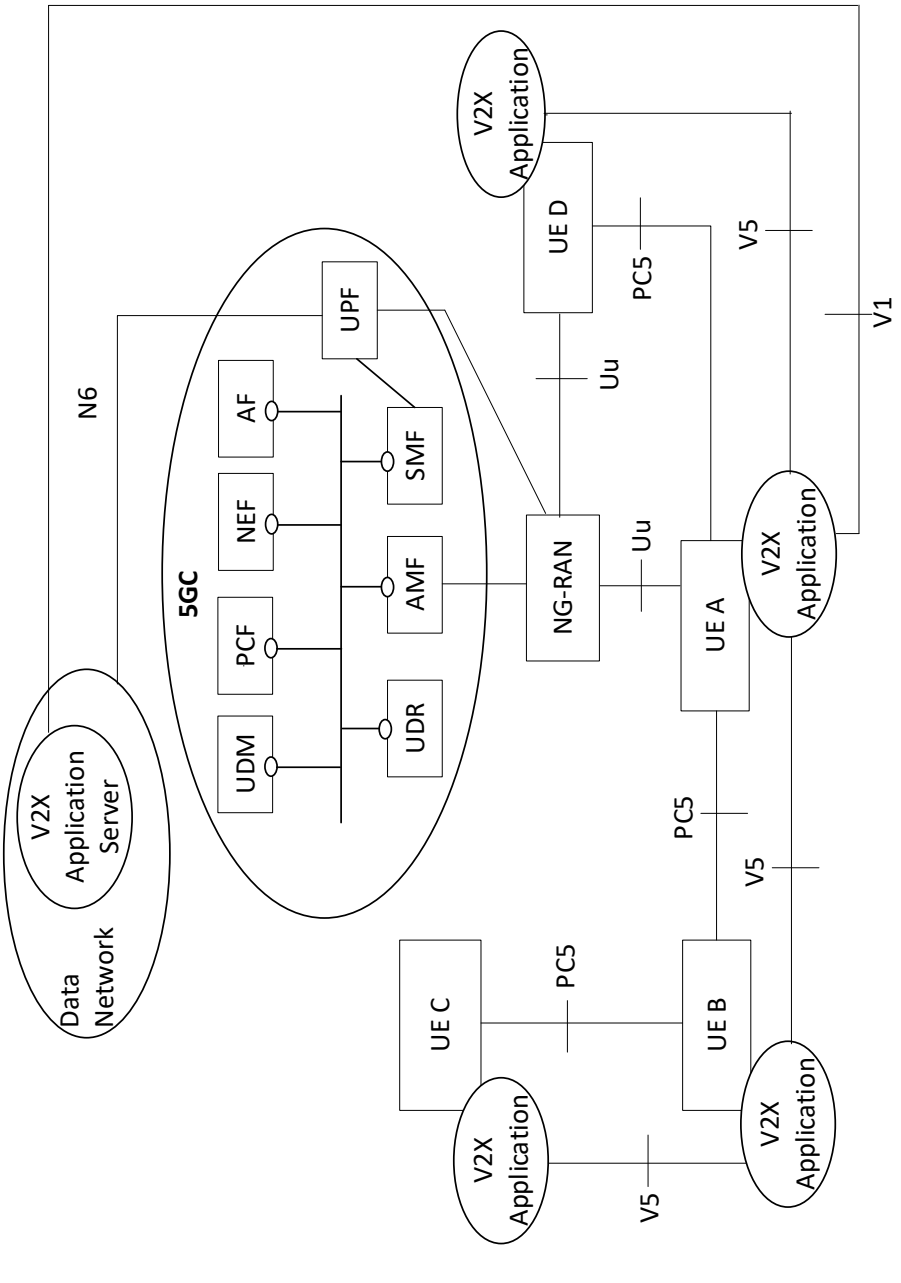

Data Network
V2X Application Server
N6
5GC
UPF
AF
NEF
PCF
UDM
SMF
AMF
UDR
NG-RAN
Uu
Uu
UE D
UE A
UE B
UE C
V2X Application
V2X Application
V2X Application
V2X Application
PC5
PC5
PC5
V5
V5
V5
V1
500

Fig. 5

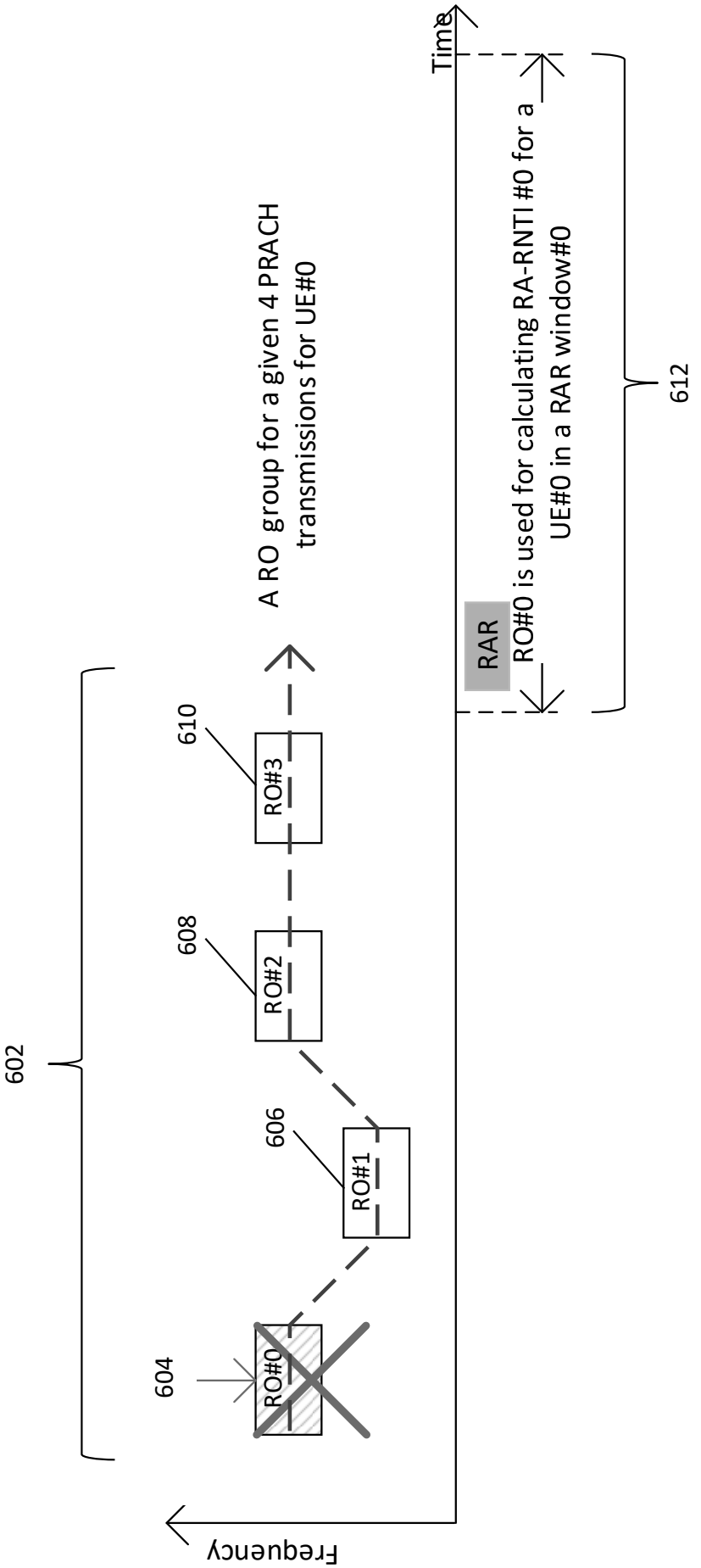

Time
Frequency
602
604
RO#0
606
RO#1
608
RO#2
610
RO#3
A RO group for a given 4 PRACH transmissions for UE#0
RAR
RO#0 is used for calculating RA-RNTI #0 for a UE#0 in a RAR window#0
612
600

Fig. 6

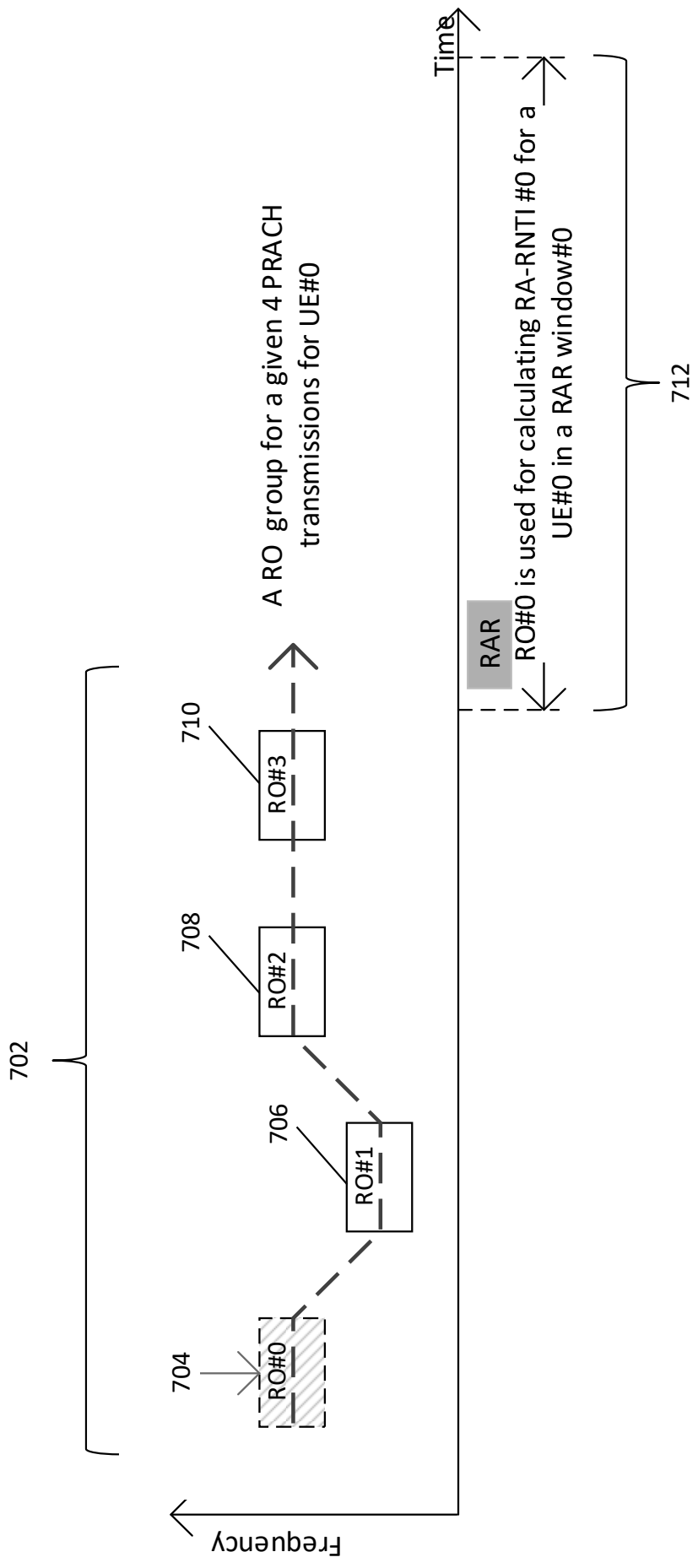

Time
Frequency
RAR
RO#0 is used for calculating RA-RNTI #0 for a UE#0 in a RAR window#0
712
A RO group for a given 4 PRACH transmissions for UE#0
RO#0
RO#1
RO#2
RO#3
704
706
708
710
702
700

Fig. 7

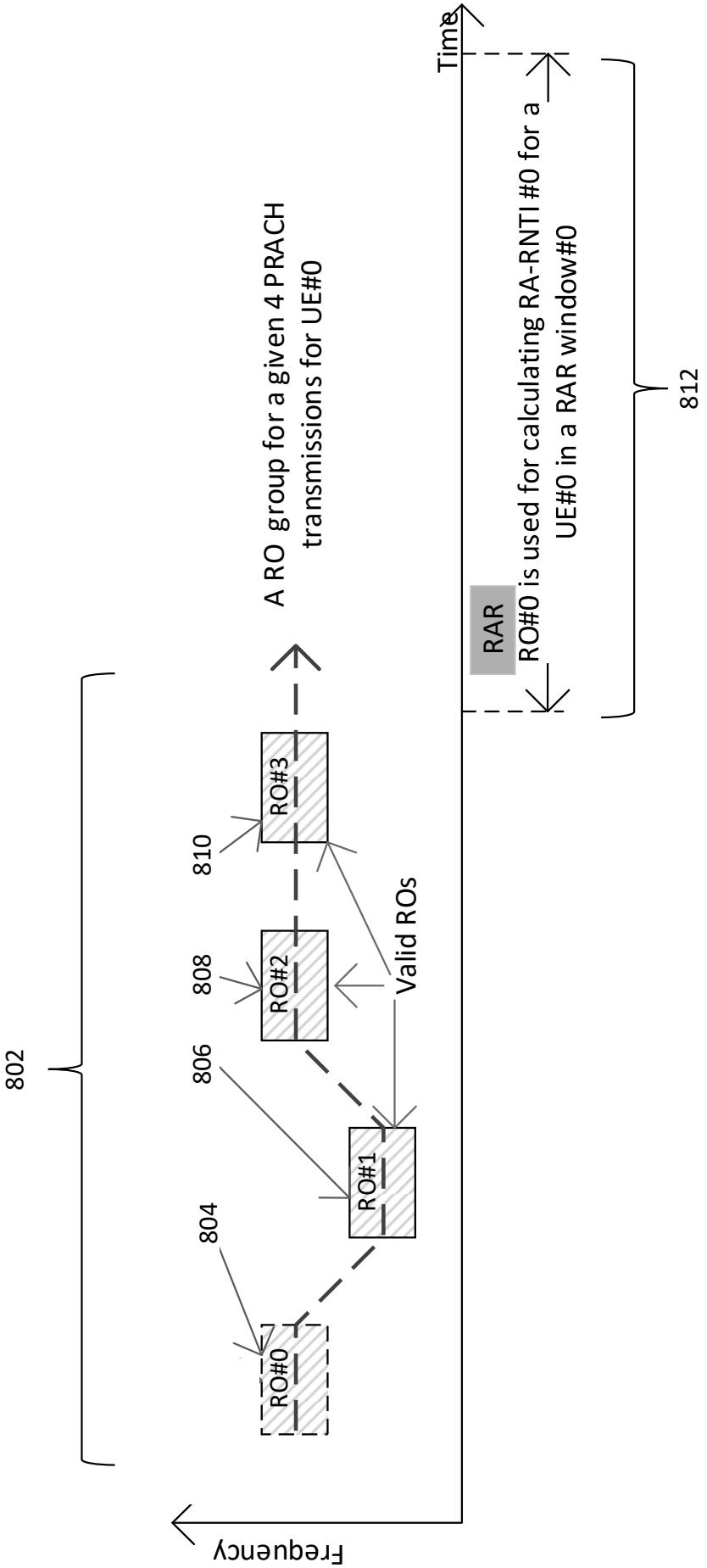

Time
Frequency
802
804
806
808
810
RO#0
RO#1
RO#2
RO#3
Valid ROs
A RO group for a given 4 PRACH transmissions for UE#0
RAR
RO#0 is used for calculating RA-RNTI #0 for a UE#0 in a RAR window#0
812
800

Fig. 8

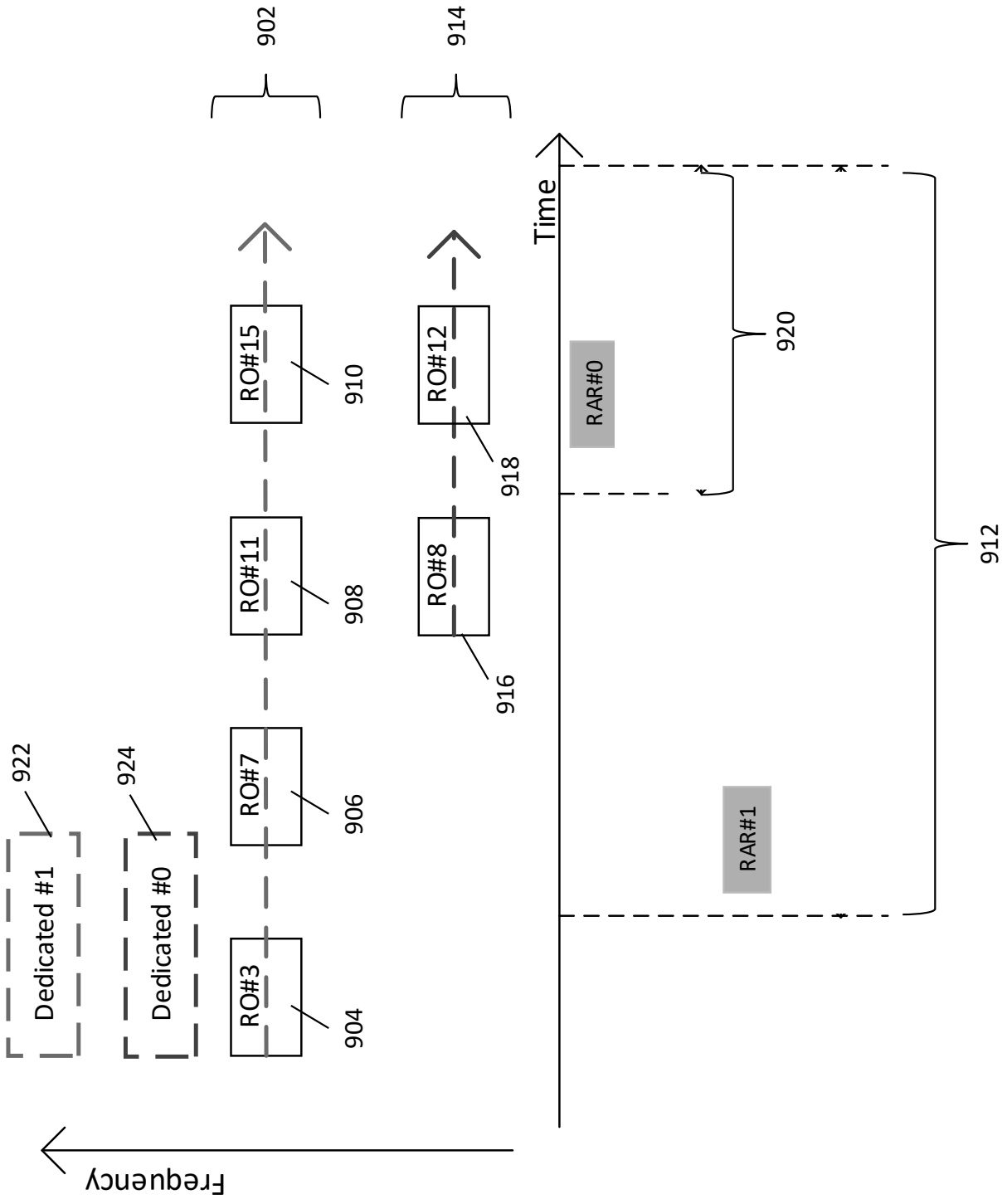

902
914
Time
Frequency
RO#15
RO#11
RO#7
RO#3
RO#12
RO#8
910
908
906
904
918
916
RAR#0
RAR#1
920
912
922
924
Dedicated #1
Dedicated #0

Fig. 9

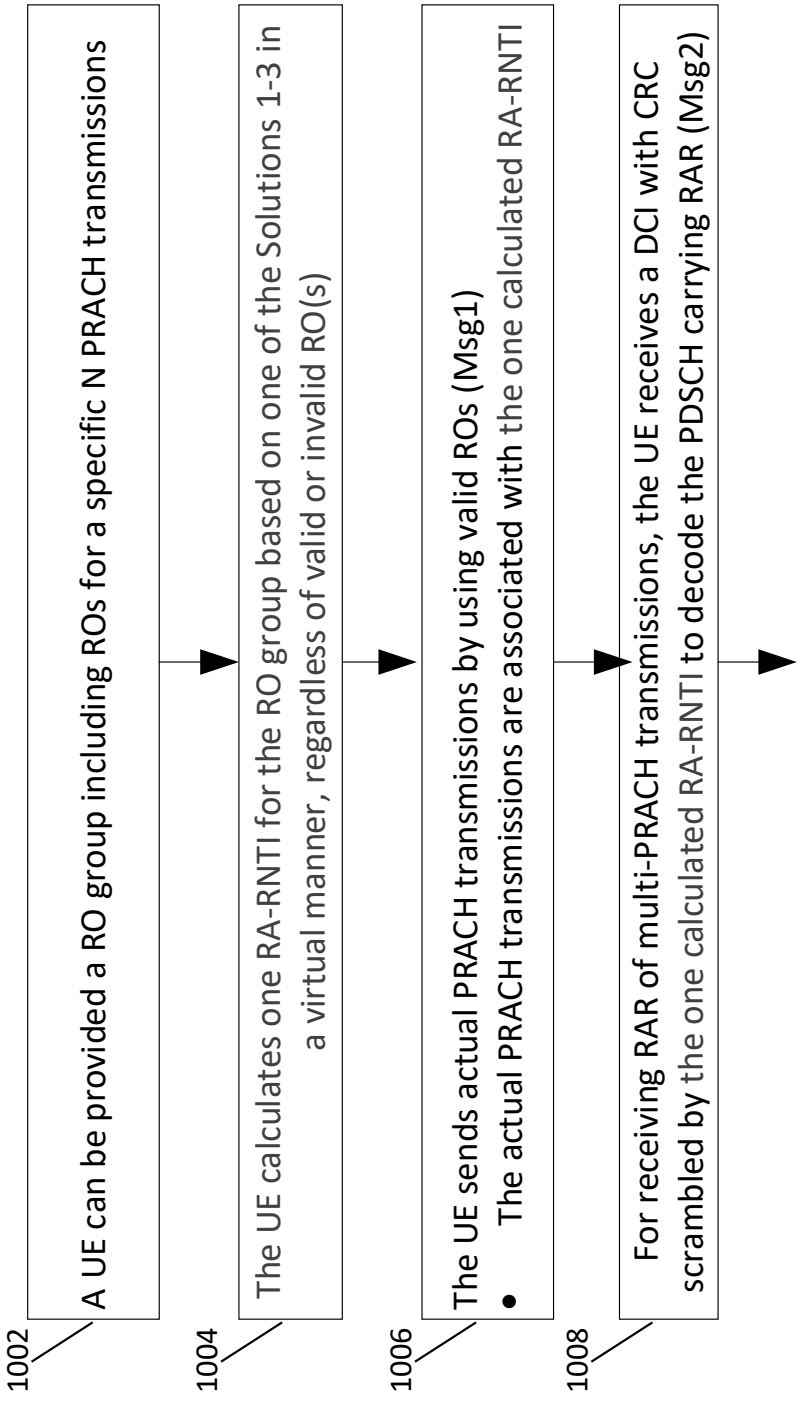

A UE can be provided a RO group including ROs for a specific N PRACH transmissions
1002
The UE calculates one RA-RNTI for the RO group based on one of the Solutions 1-3 in a virtual manner, regardless of valid or invalid RO(s)
1004
The UE sends actual PRACH transmissions by using valid ROs (Msg1)
• The actual PRACH transmissions are associated with the one calculated RA-RNTI
1006
For receiving RAR of multi-PRACH transmissions, the UE receives a DCI with CRC scrambled by the one calculated RA-RNTI to decode the PDSCH carrying RAR (Msg2)
1008
1000

Fig. 10

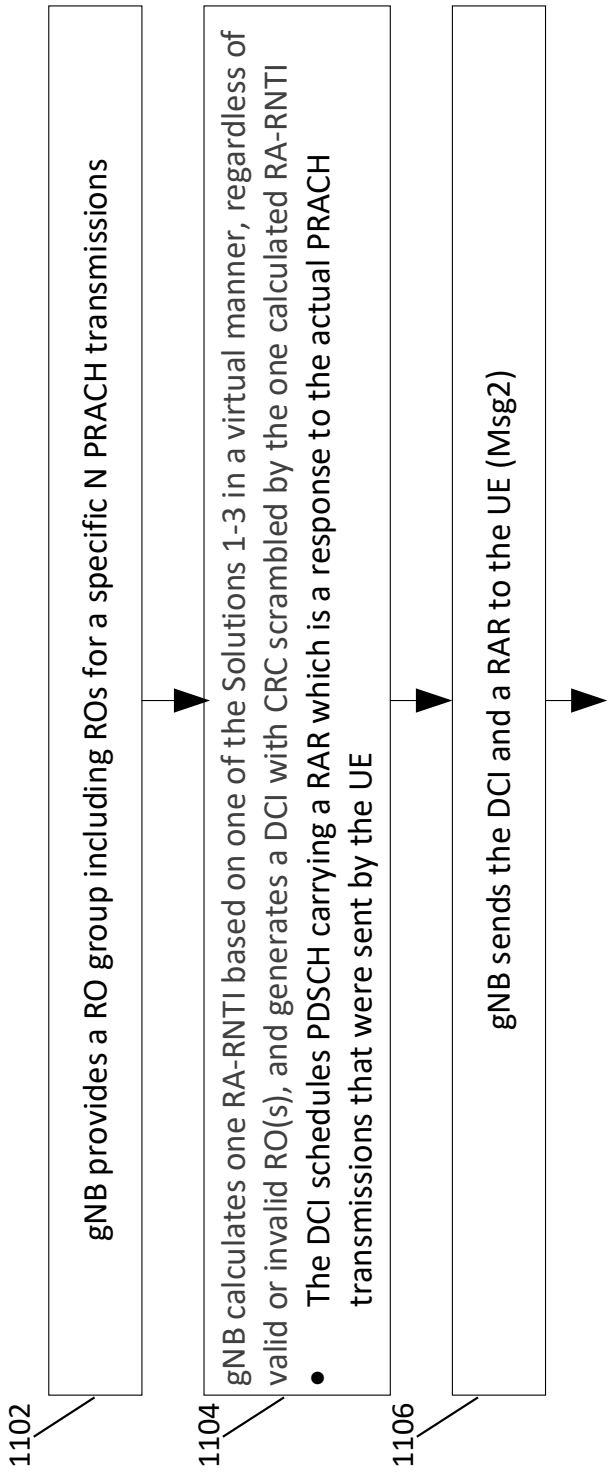

gNB provides a RO group including ROs for a specific N PRACH transmissions
gNB calculates one RA-RNTI based on one of the Solutions 1-3 in a virtual manner, regardless of valid or invalid RO(s), and generates a DCI with CRC scrambled by the one calculated RA-RNTI
The DCI schedules PDSCH carrying a RAR which is a response to the actual PRACH transmissions that were sent by the UE
gNB sends the DCI and a RAR to the UE (Msg2)
1102
1104
1106
1100

Fig. 11

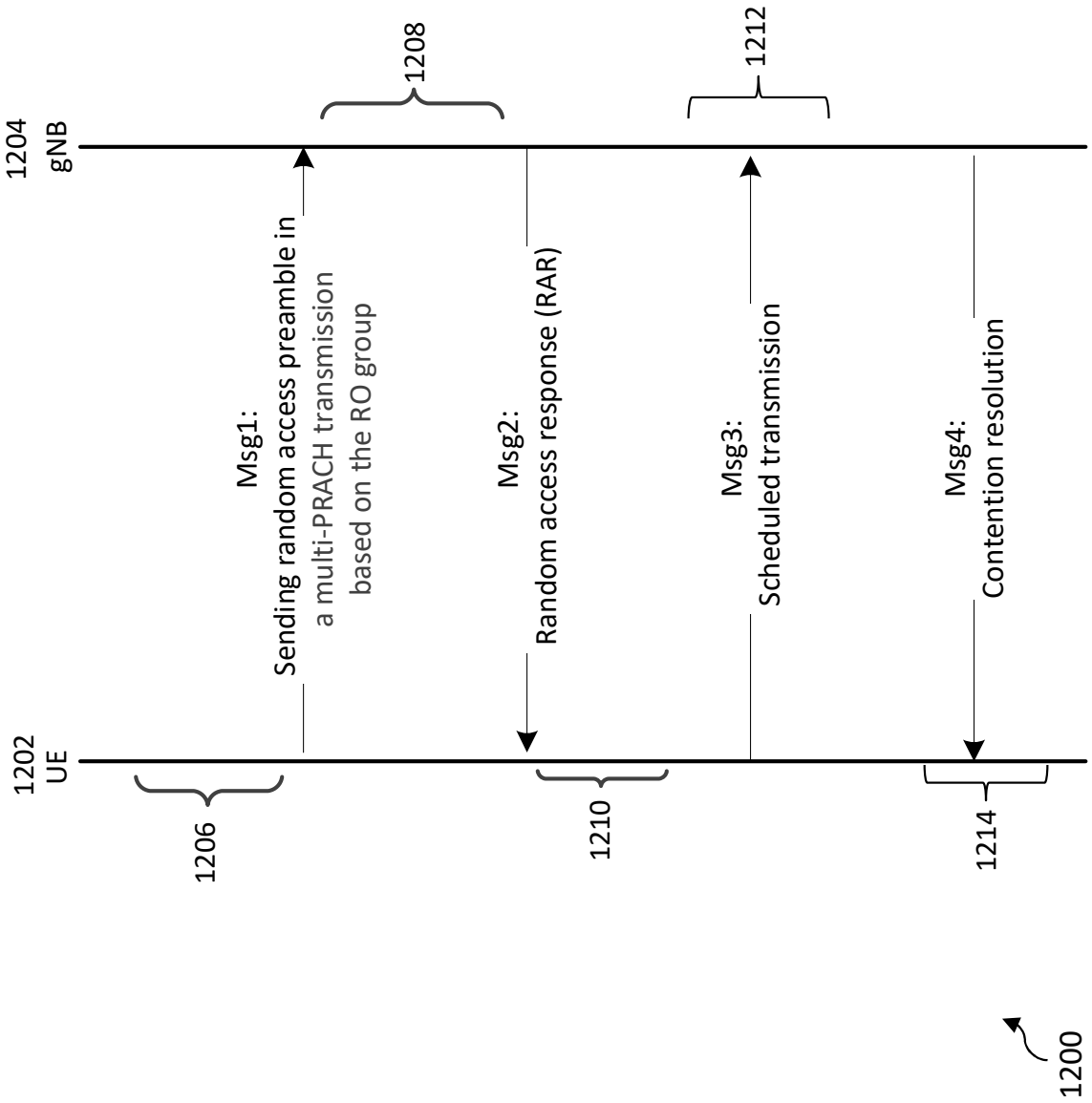

1204
gNB
1202
UE
1208
1212
Msg1:
Sending random access preamble in
a multi-PRACH transmission
based on the RO group
Msg2:
Random access response (RAR)
Msg3:
Scheduled transmission
Msg4:
Contention resolution
1206
1210
1214
1200

Fig. 12

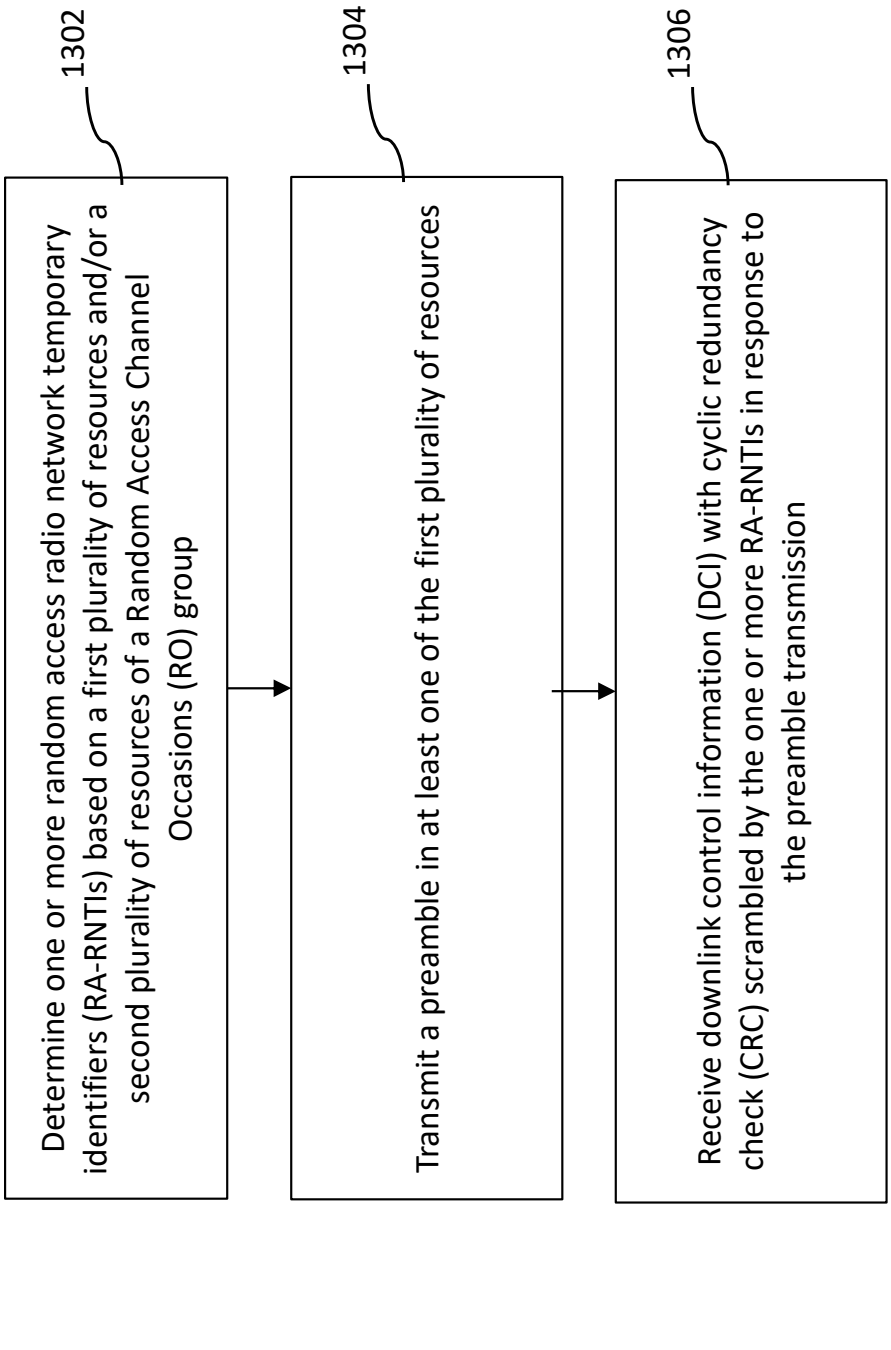

1302
Determine one or more random access radio network temporary identifiers (RA-RNTIs) based on a first plurality of resources and/or a second plurality of resources of a Random Access Channel Occasions (RO) group
1304
Transmit a preamble in at least one of the first plurality of resources
1306
Receive downlink control information (DCI) with cyclic redundancy check (CRC) scrambled by the one or more RA-RNTIs in response to the preamble transmission
1300

Fig. 13

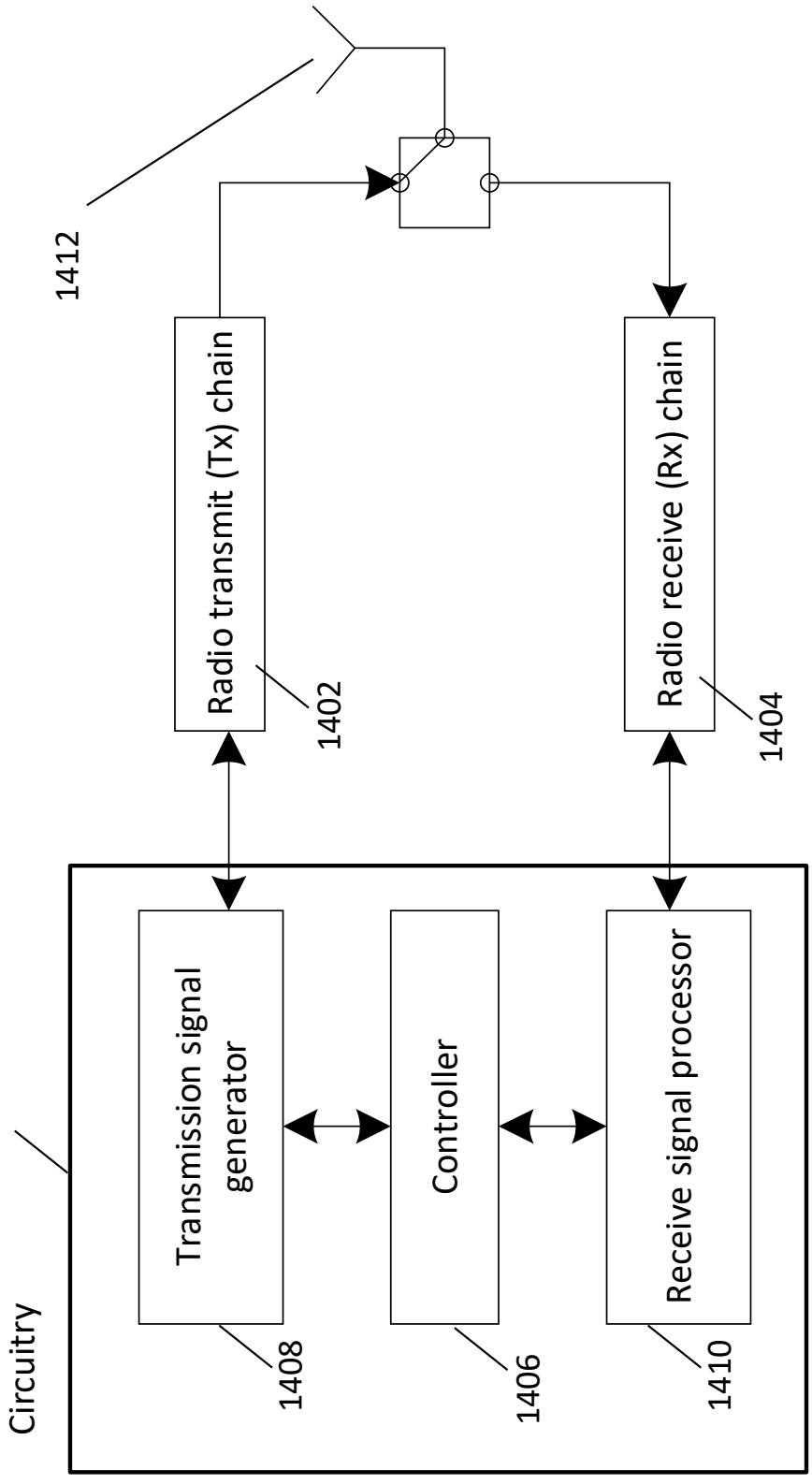

1412
Radio transmit (Tx) chain
1402
Radio receive (Rx) chain
1404
1414
Circuitry
Transmission signal generator
1408
Controller
1406
Receive signal processor
1410
1400

Fig. 14

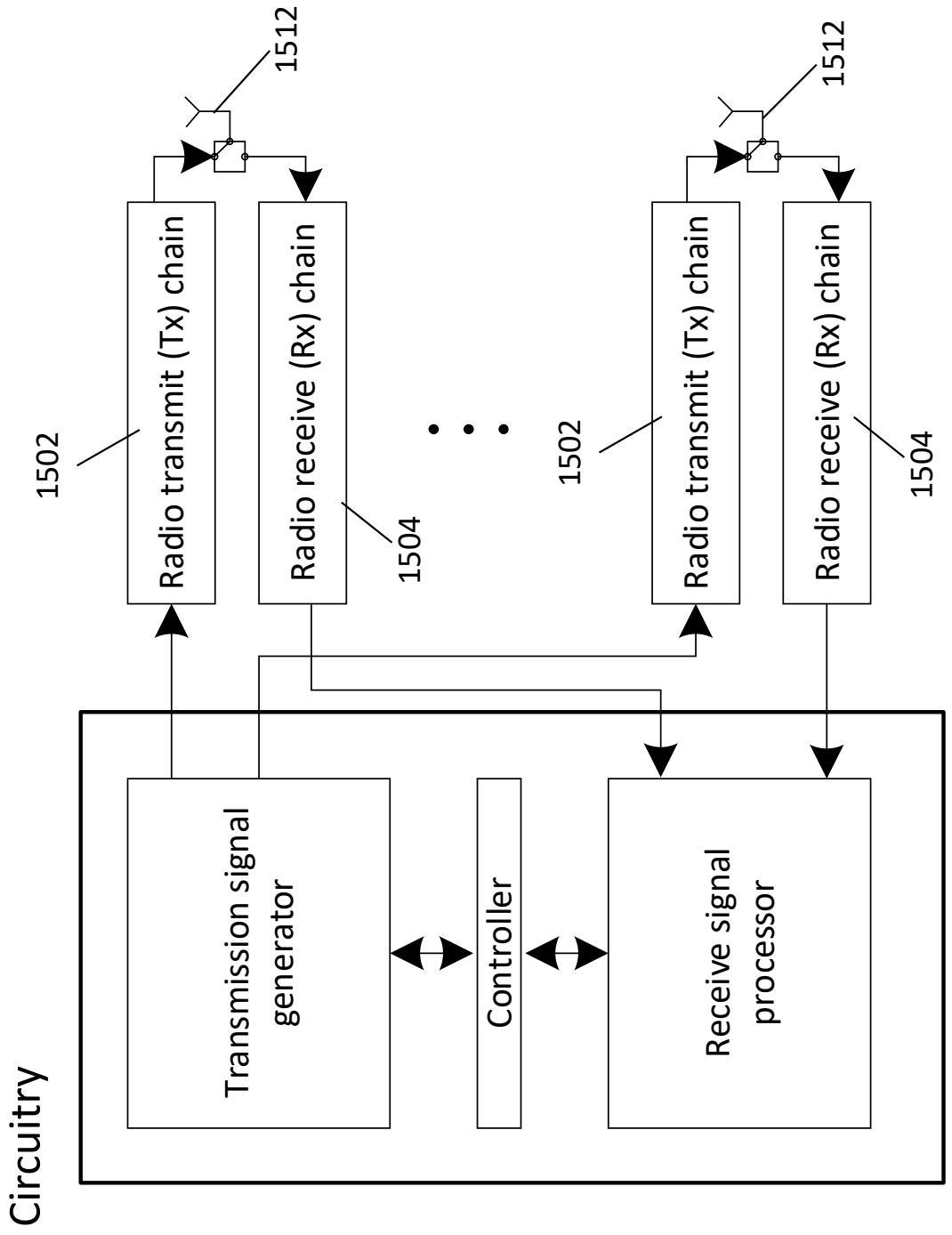

Circuitry
Transmission signal generator
Controller
Receive signal processor
1500
Radio transmit (Tx) chain
Radio receive (Rx) chain
1502
1504
1512

Fig. 15