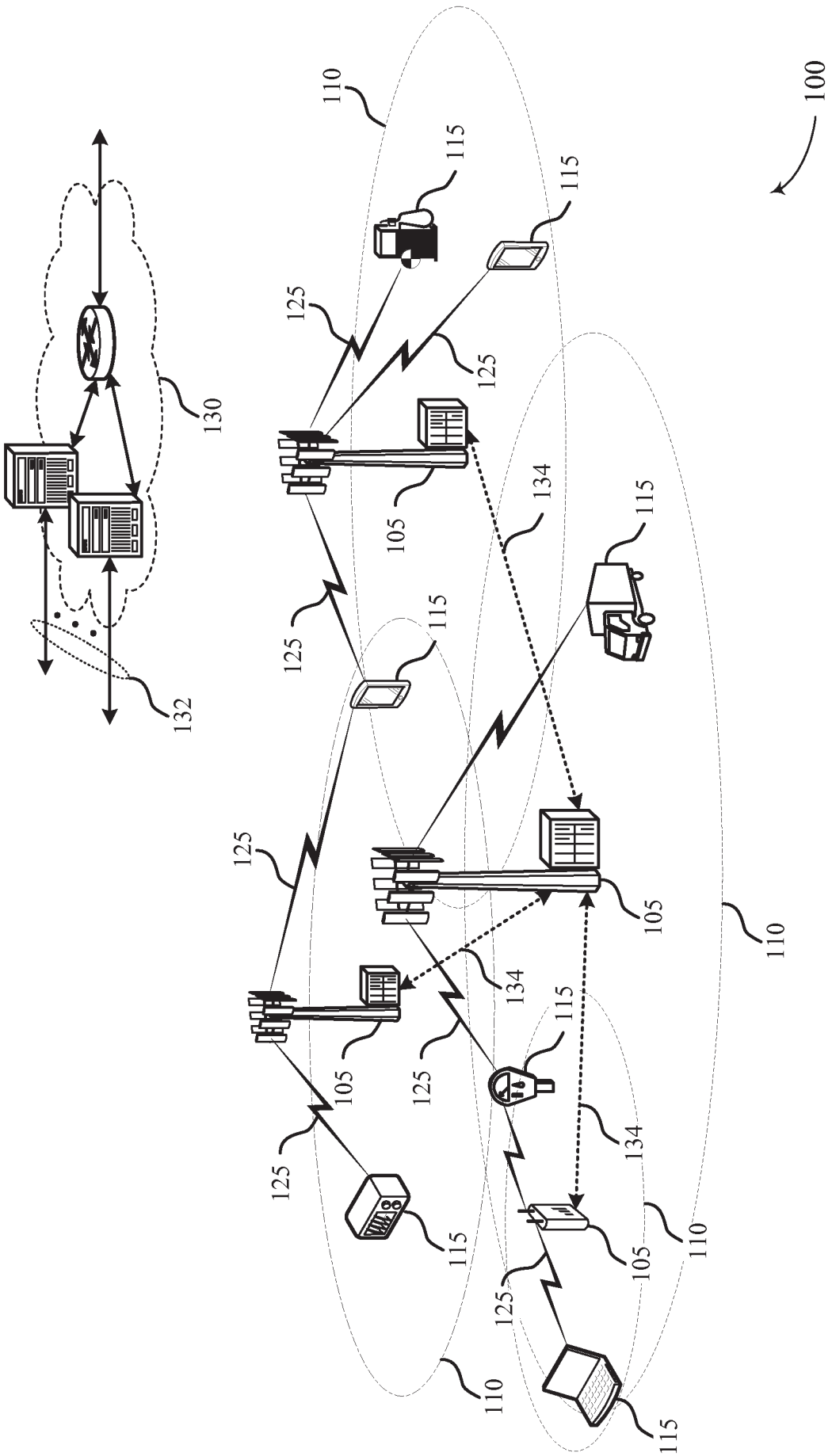

FIG. 1

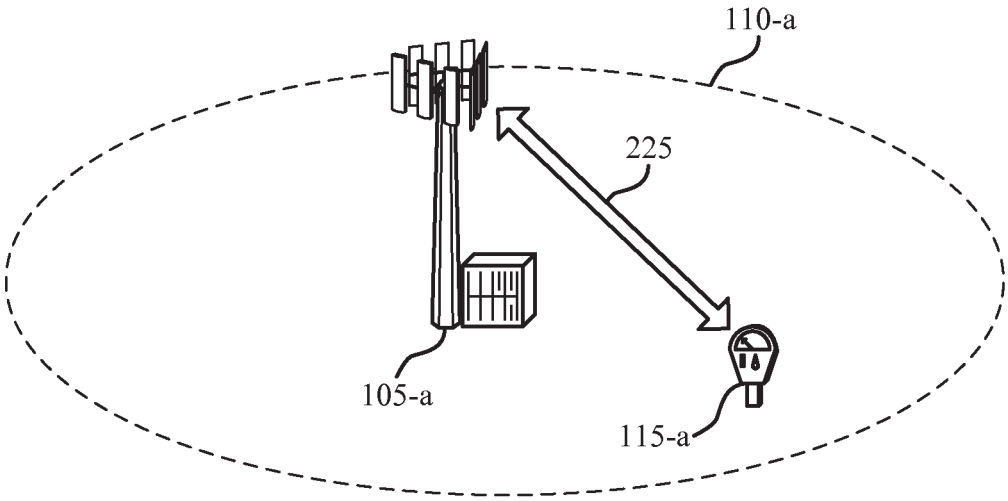

FIG. 2

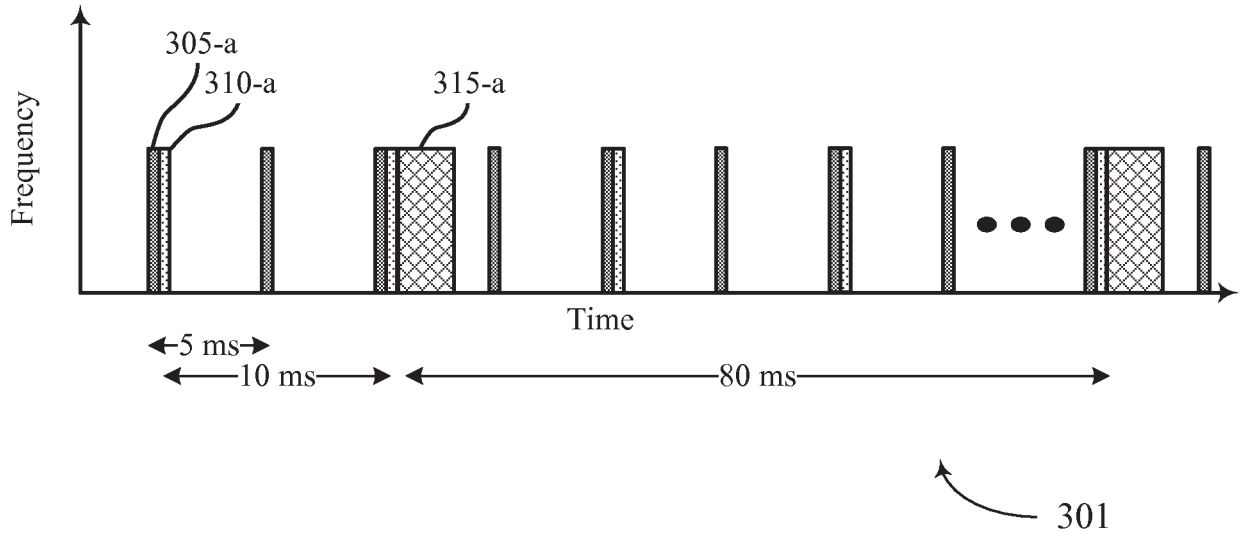
305-a
310-a
315-a
Frequency
Time
5 ms
10 ms
80 ms
301

FIG. 3A

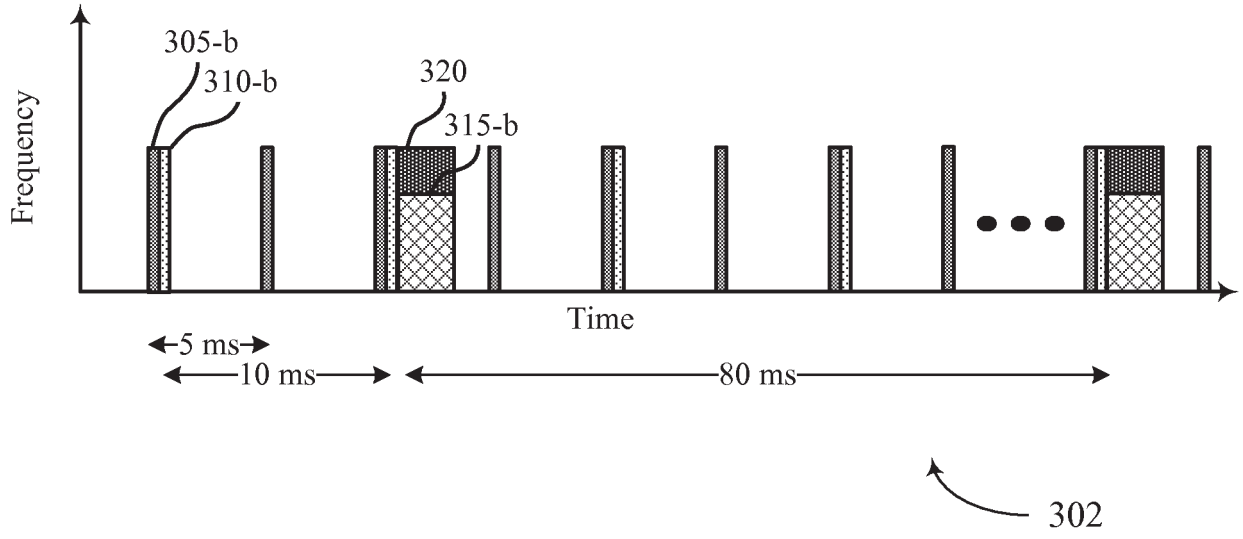
305-b
310-b
320
315-b
Frequency
Time
5 ms
10 ms
80 ms
302

FIG. 3B

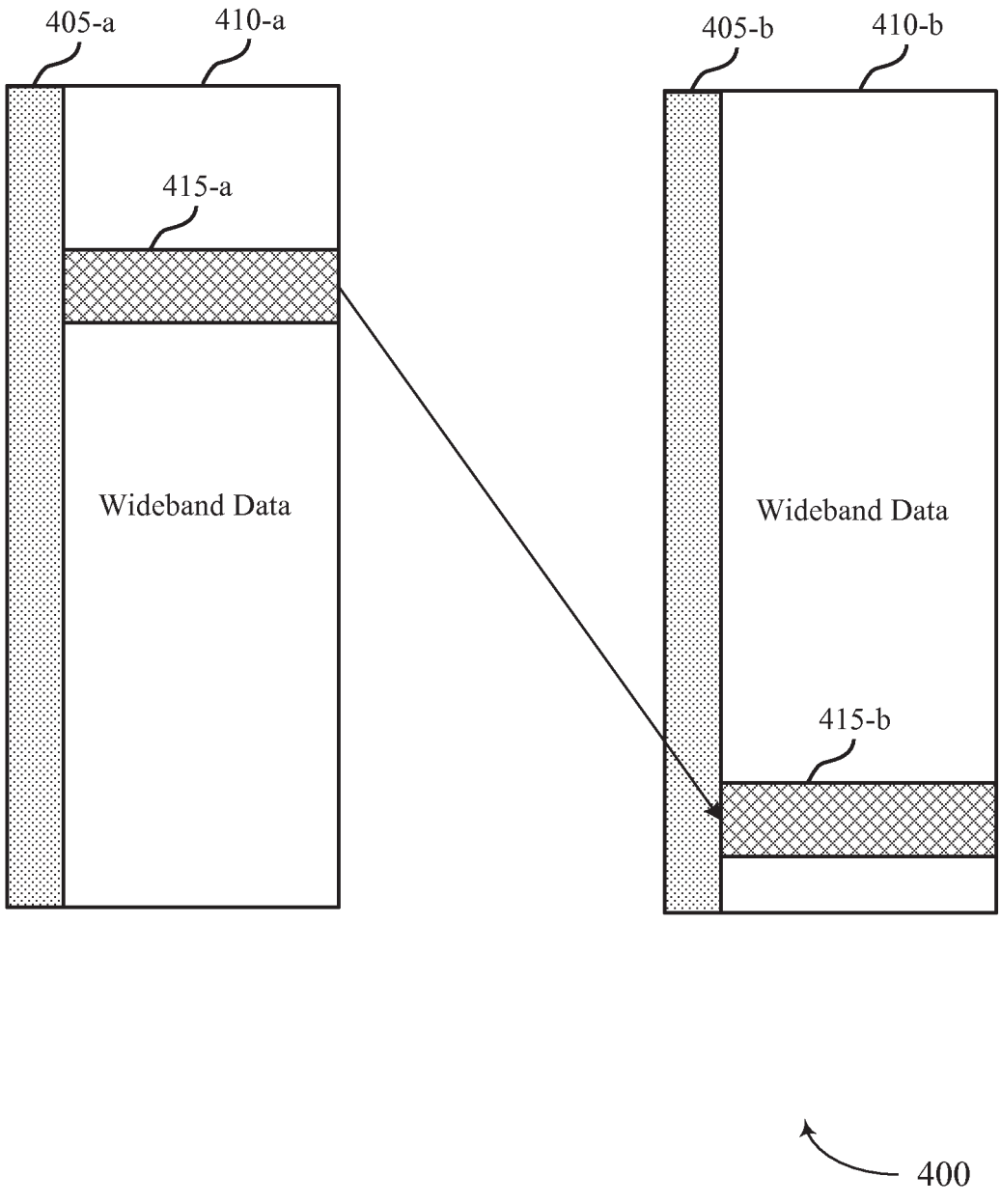
405-a
410-a
415-a
Wideband Data
405-b
410-b
Wideband Data
415-b
400

FIG. 4

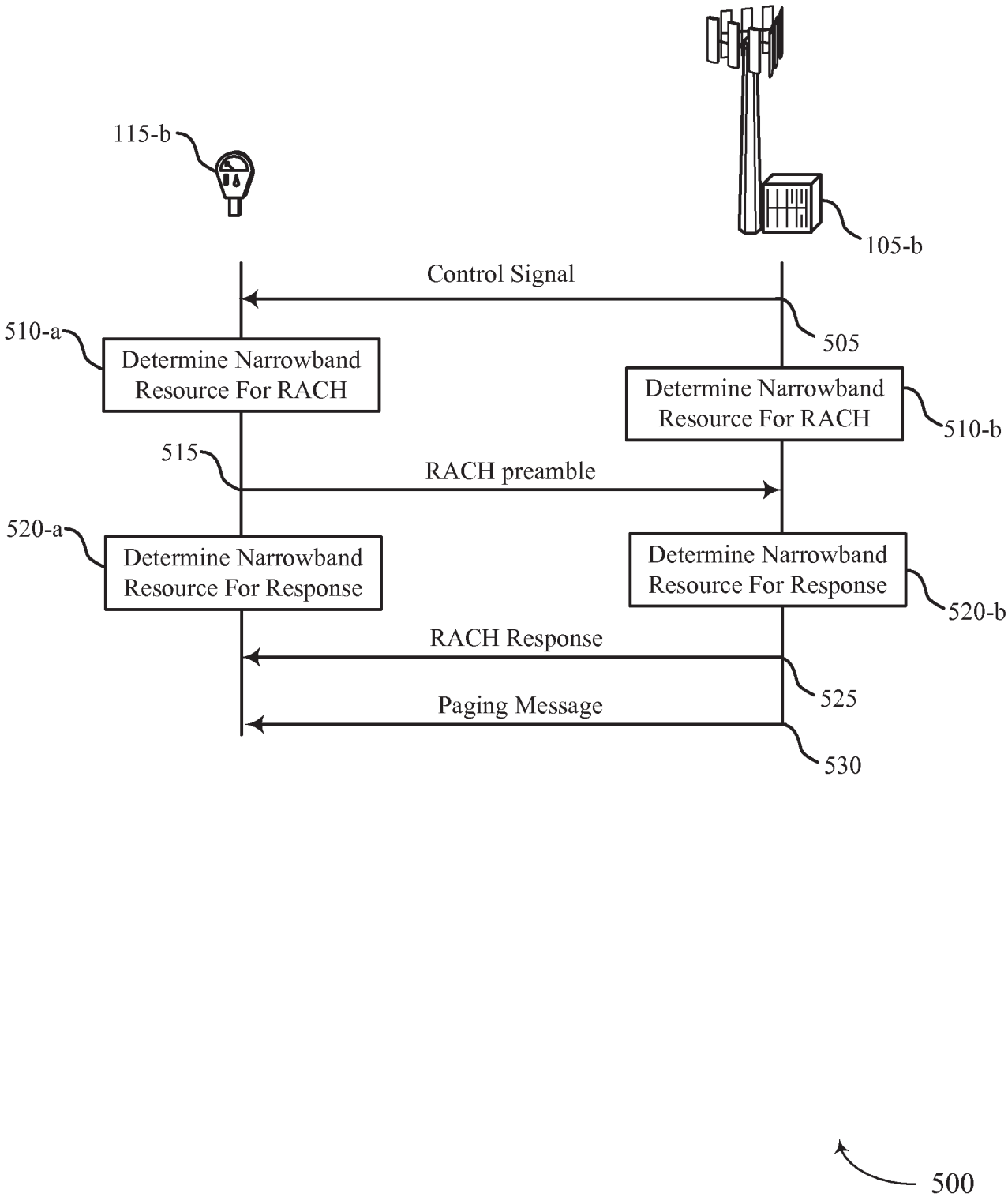
115-b
105-b
Control Signal
505
510-a
Determine Narrowband Resource For RACH
Determine Narrowband Resource For RACH
510-b
515
RACH preamble
520-a
Determine Narrowband Resource For Response
Determine Narrowband Resource For Response
520-b
RACH Response
525
Paging Message
530
500

FIG. 5

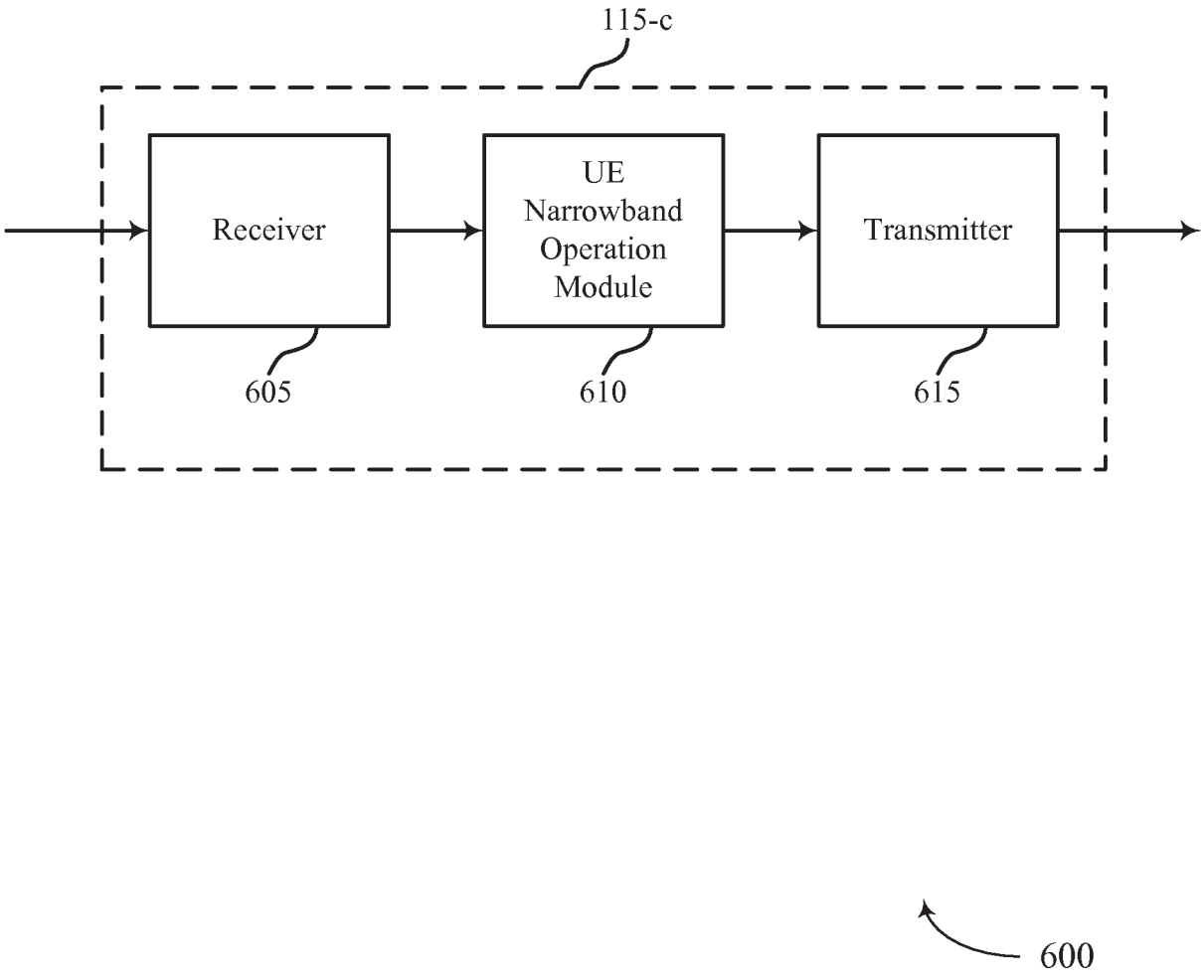
115-c
Receiver
UE
Narrowband
Operation
Module
Transmitter
605
610
615
600

FIG. 6

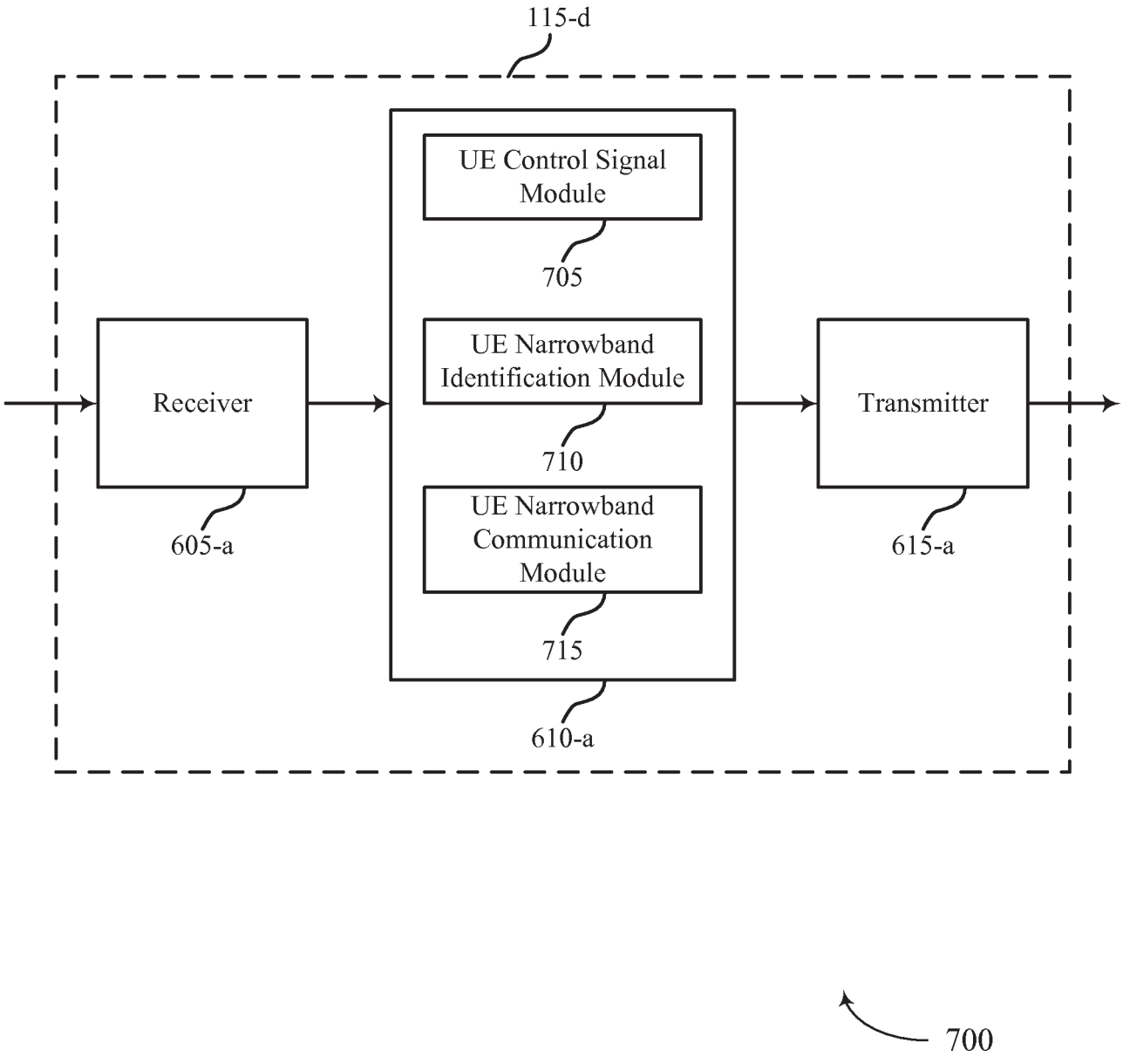
115-d
UE Control Signal Module
705
UE Narrowband Identification Module
710
UE Narrowband Communication Module
715
610-a
Receiver
605-a
Transmitter
615-a
700

FIG. 7

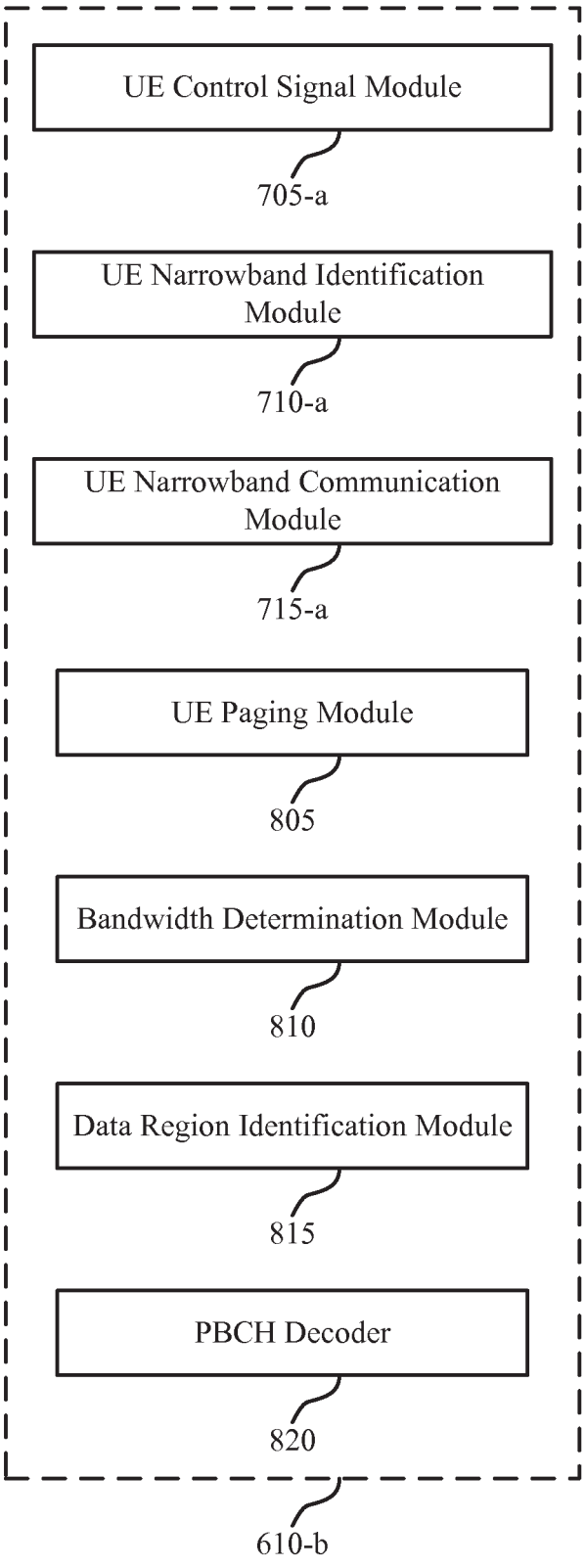
UE Control Signal Module
705-a
UE Narrowband Identification Module
710-a
UE Narrowband Communication Module
715-a
UE Paging Module
805
Bandwidth Determination Module
810
Data Region Identification Module
815
PBCH Decoder
820
610-b
800

FIG. 8

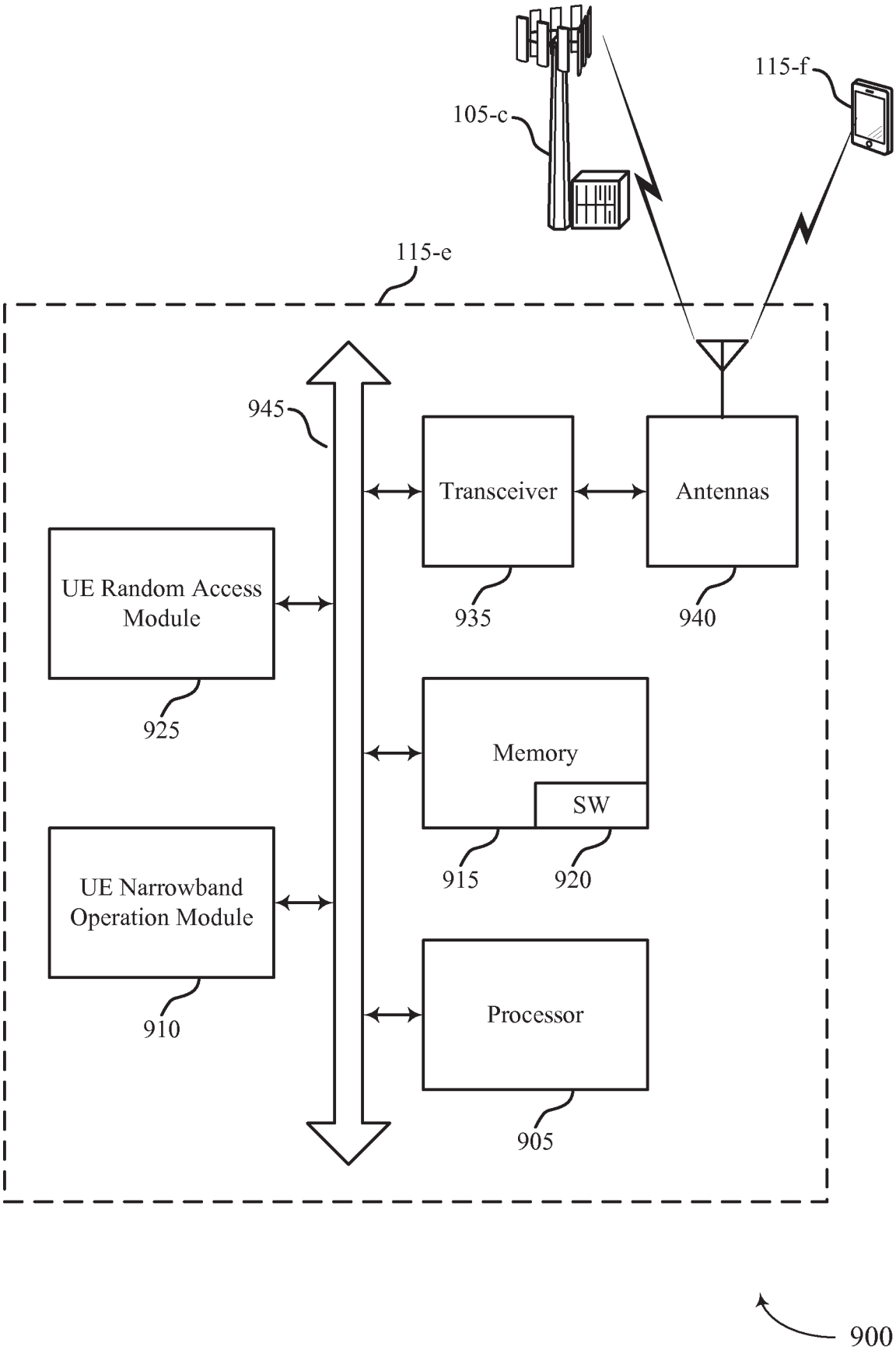
105-c
115-f
115-e
945
Transceiver
Antennas
UE Random Access Module
935
940
925
Memory
SW
915
920
UE Narrowband Operation Module
910
Processor
905
900

FIG. 9

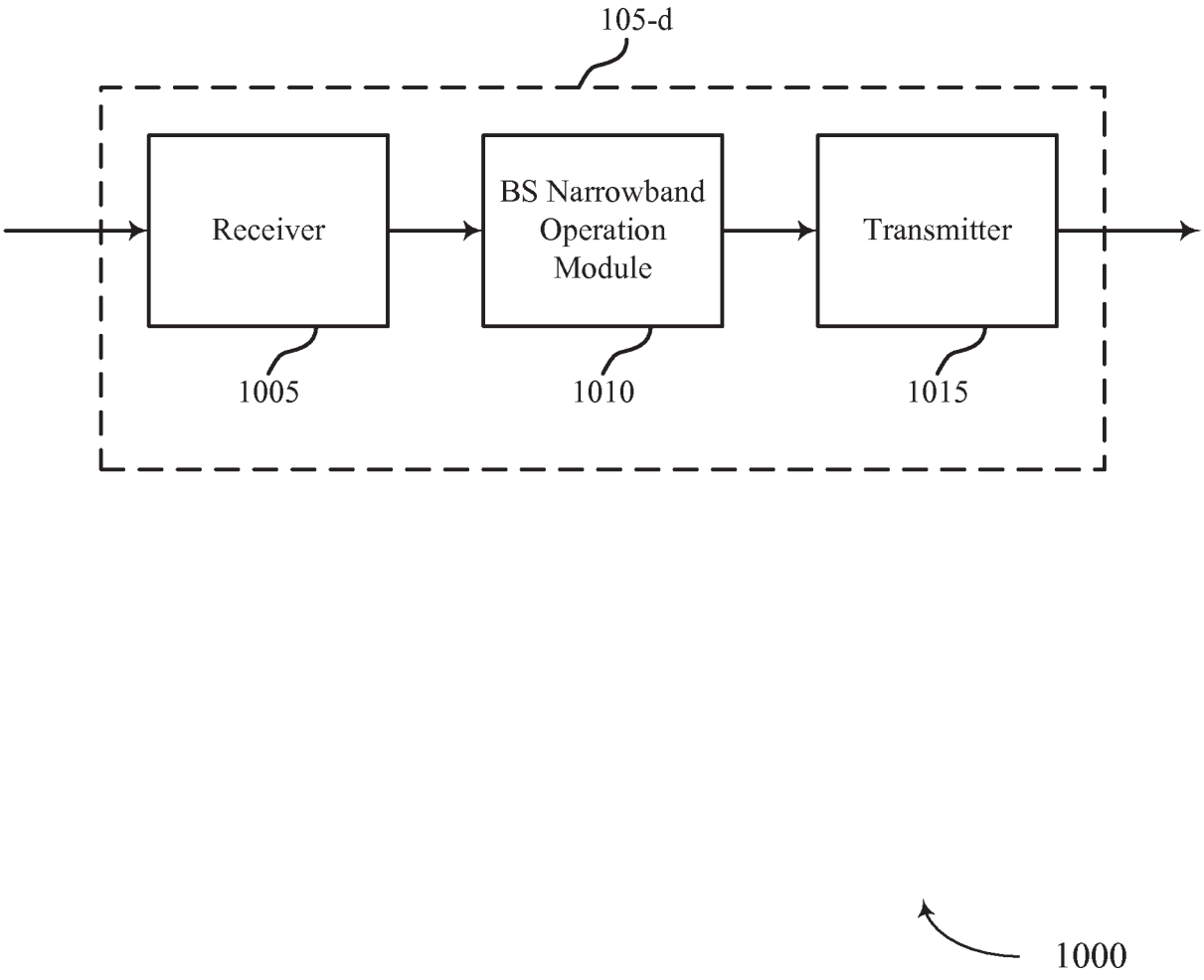
105-d
Receiver
BS Narrowband Operation Module
Transmitter
1005
1010
1015
1000

FIG. 10

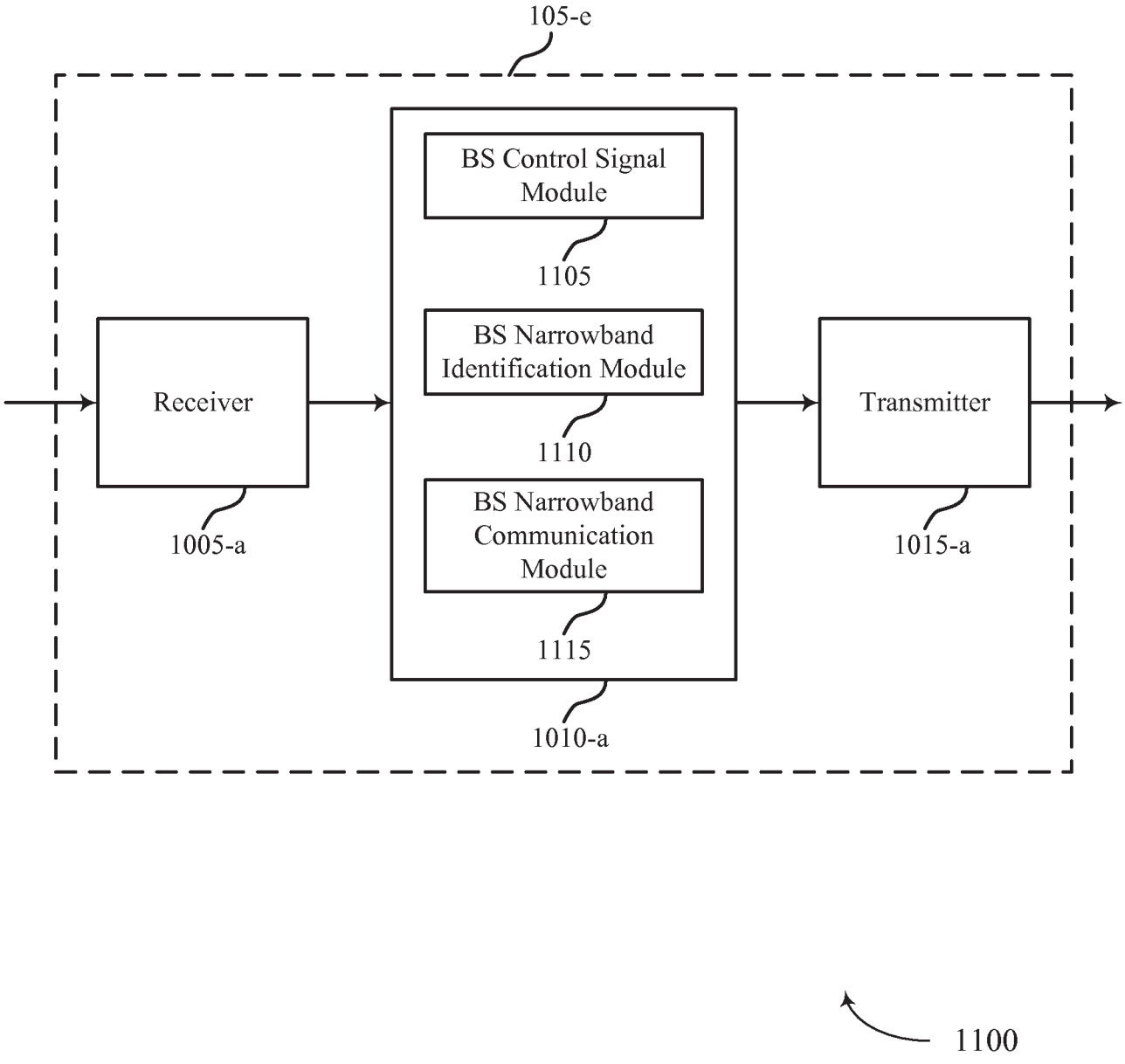
105-e
BS Control Signal Module
1105
BS Narrowband Identification Module
1110
BS Narrowband Communication Module
1115
1010-a
Receiver
1005-a
Transmitter
1015-a
1100

FIG. 11

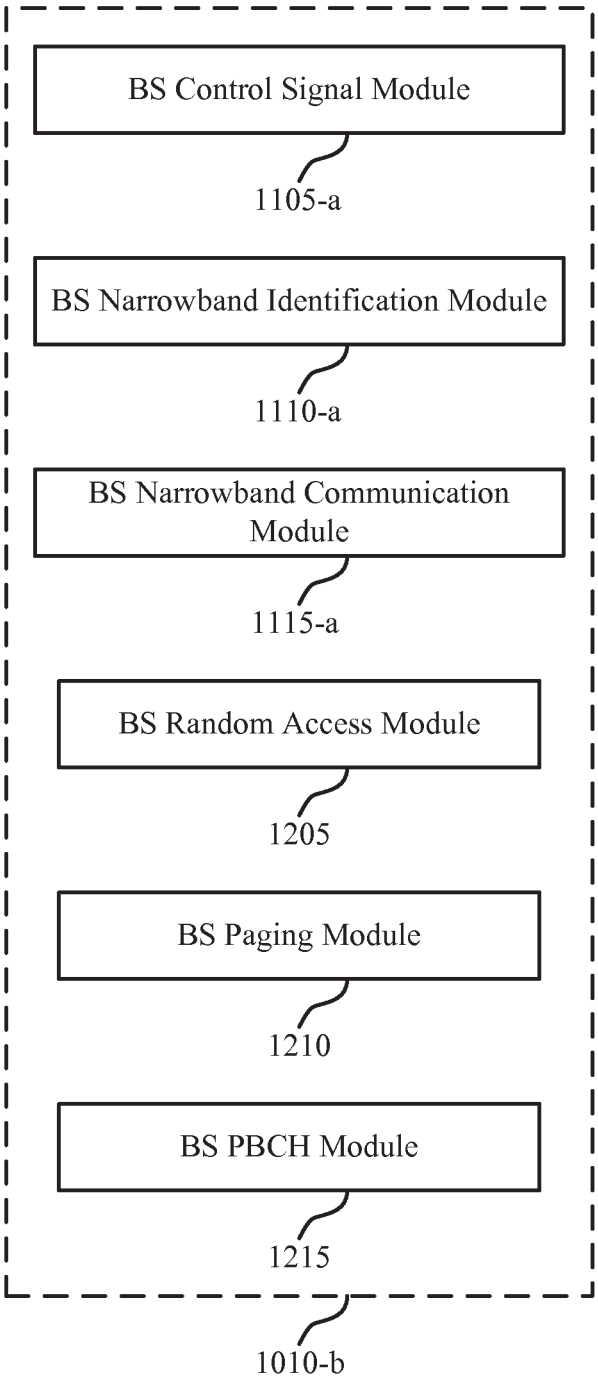
BS Control Signal Module
1105-a
BS Narrowband Identification Module
1110-a
BS Narrowband Communication Module
1115-a
BS Random Access Module
1205
BS Paging Module
1210
BS PBCH Module
1215
1010-b
1200

FIG. 12

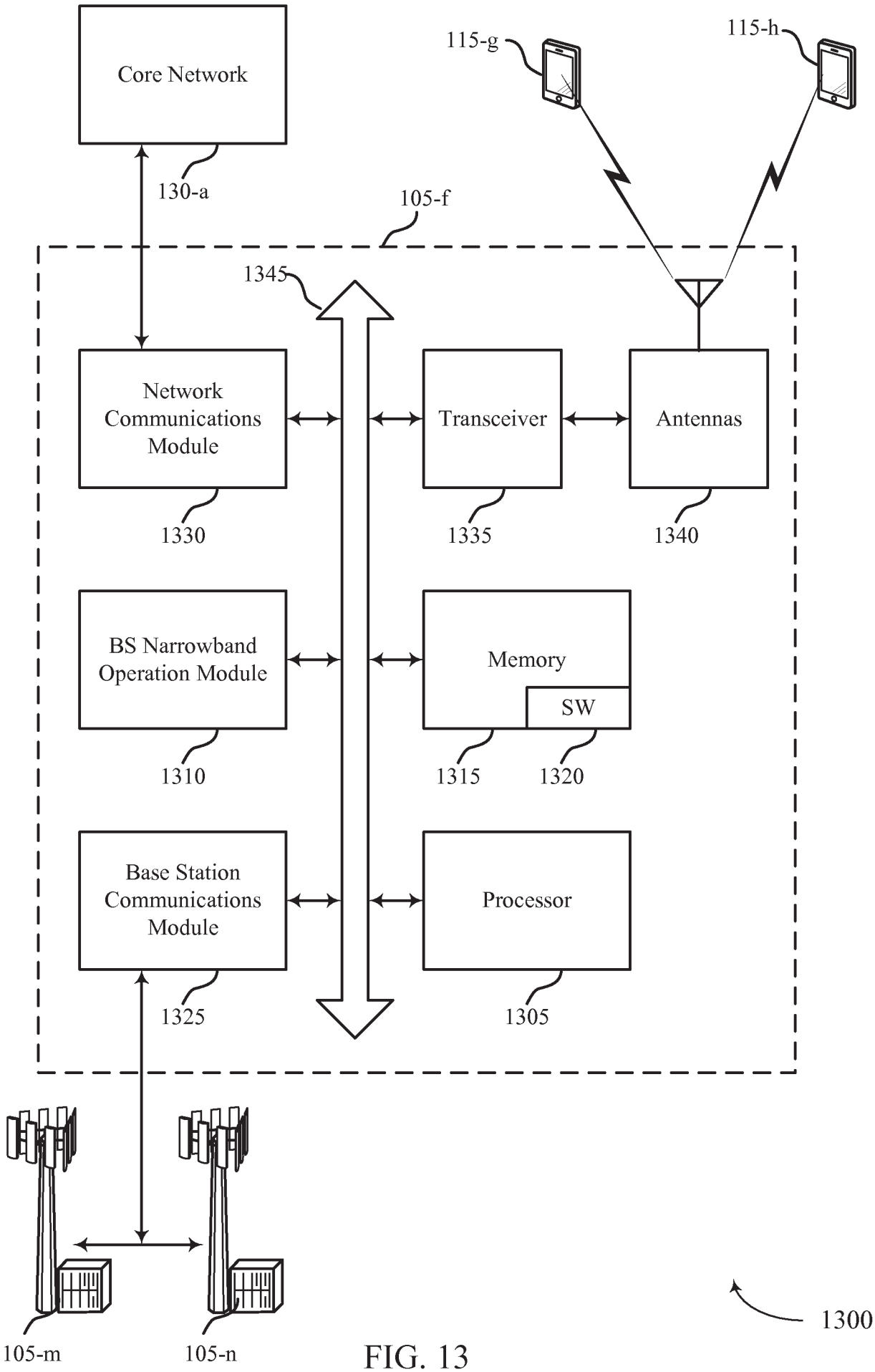
Core Network
130-a
115-g
115-h
105-f
1345
Network Communications Module
1330
Transceiver
1335
Antennas
1340
BS Narrowband Operation Module
1310
Memory
SW
1315
1320
Base Station Communications Module
1325
Processor
1305
105-m
105-n
1300

FIG. 13

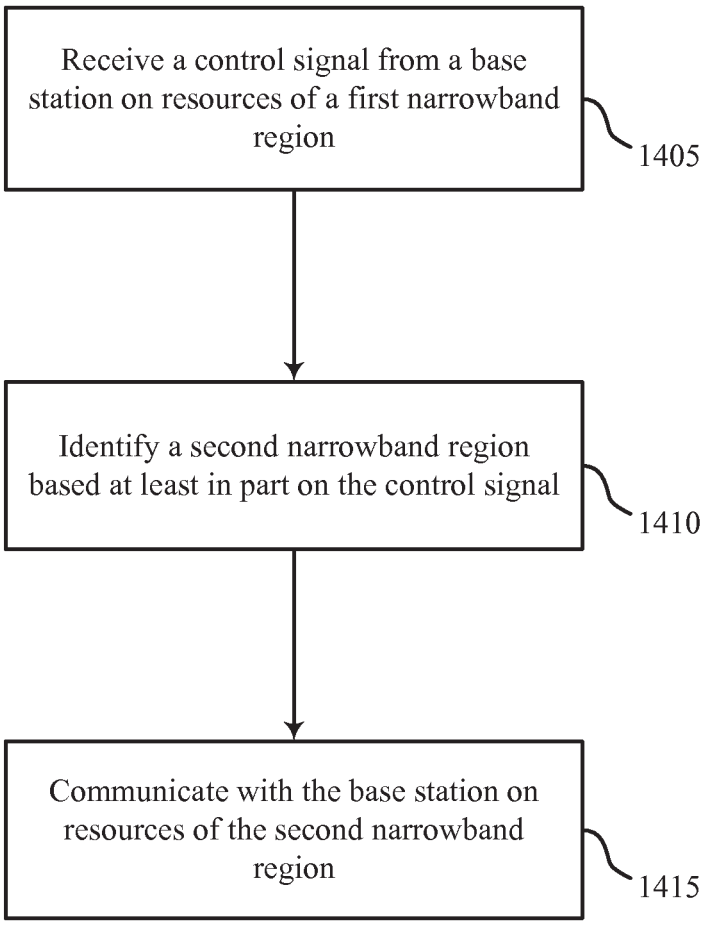
Receive a control signal from a base station on resources of a first narrowband region
1405
Identify a second narrowband region based at least in part on the control signal
1410
Communicate with the base station on resources of the second narrowband region
1415
1400

FIG. 14

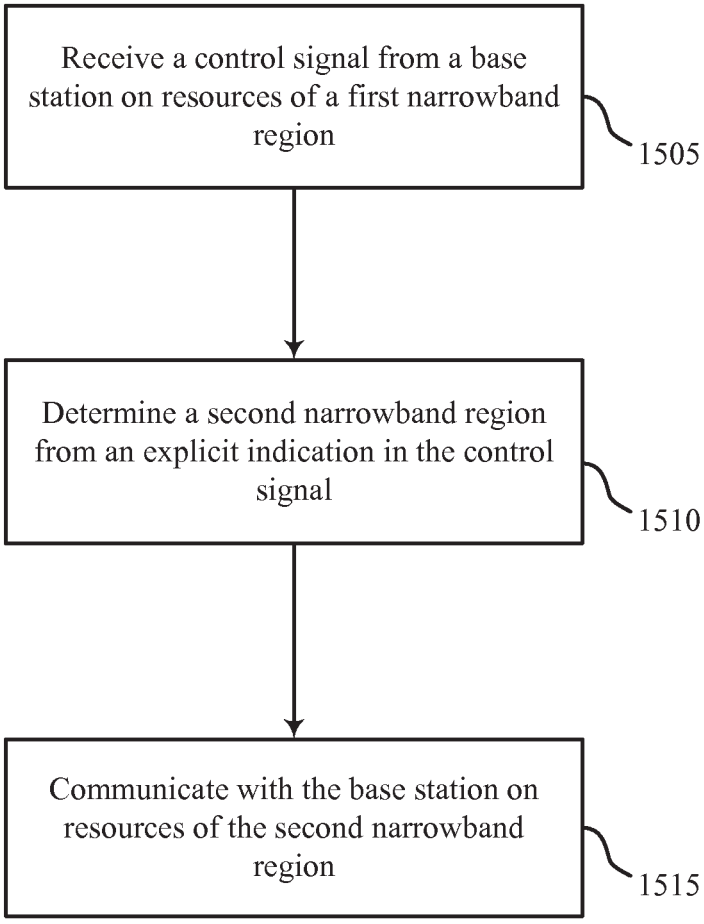
Receive a control signal from a base station on resources of a first narrowband region
1505
Determine a second narrowband region from an explicit indication in the control signal
1510
Communicate with the base station on resources of the second narrowband region
1515
1500

FIG. 15

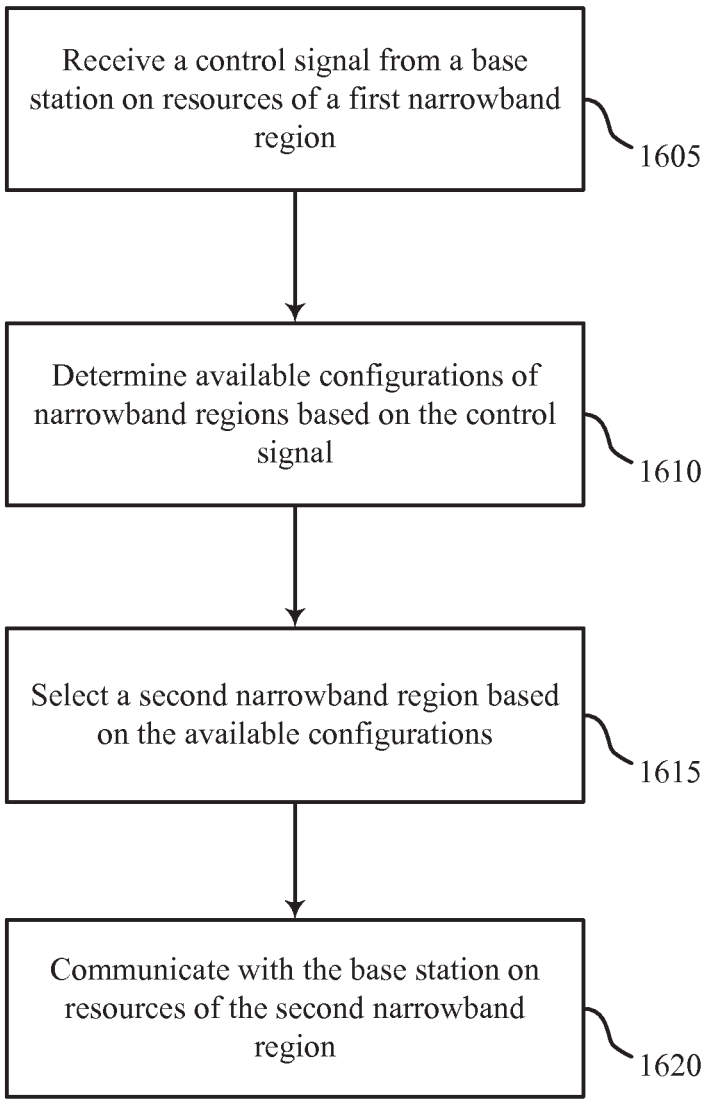
Receive a control signal from a base station on resources of a first narrowband region
1605
Determine available configurations of narrowband regions based on the control signal
1610
Select a second narrowband region based on the available configurations
1615
Communicate with the base station on resources of the second narrowband region
1620
1600

FIG. 16

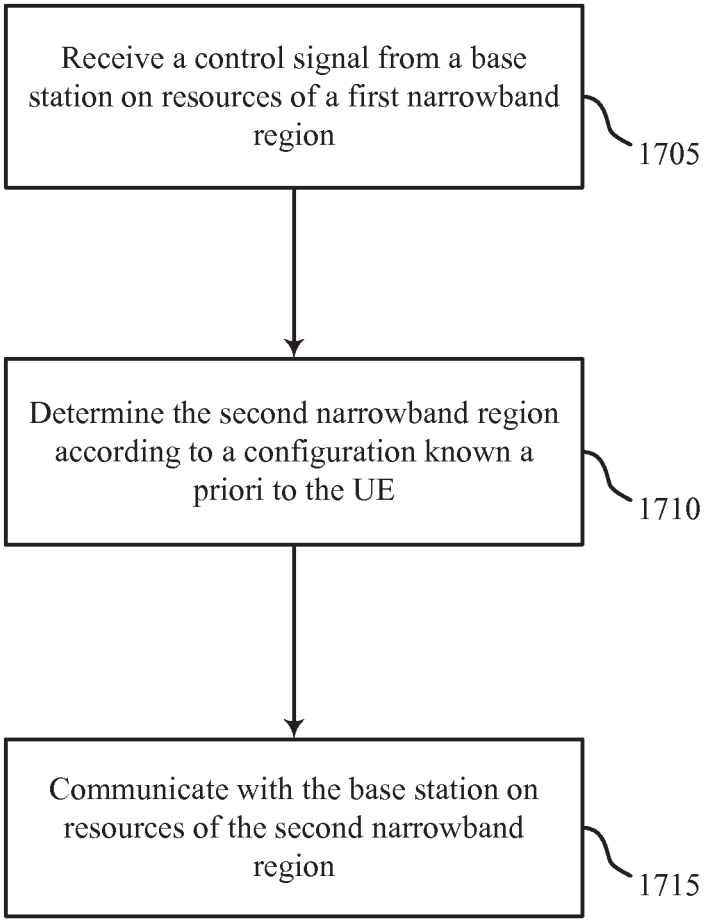
Receive a control signal from a base station on resources of a first narrowband region
1705
Determine the second narrowband region according to a configuration known a priori to the UE
1710
Communicate with the base station on resources of the second narrowband region
1715
1700

FIG. 17

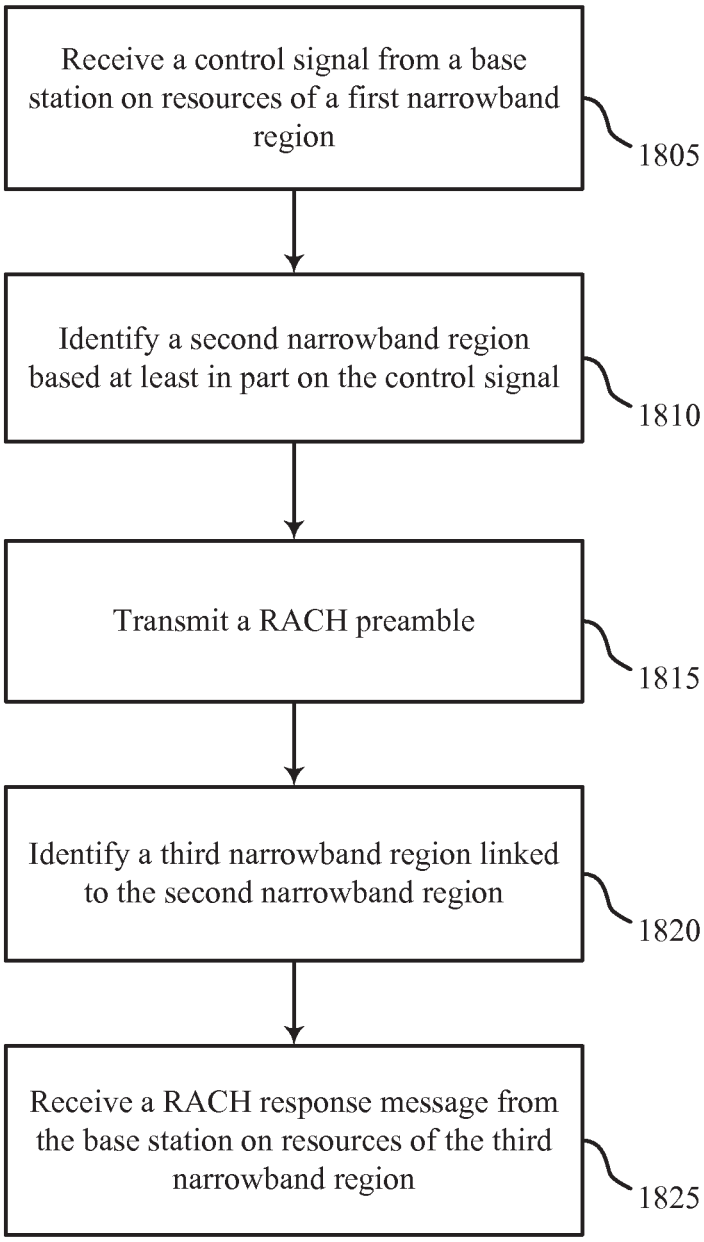
Receive a control signal from a base station on resources of a first narrowband region
1805
Identify a second narrowband region based at least in part on the control signal
1810
Transmit a RACH preamble
1815
Identify a third narrowband region linked to the second narrowband region
1820
Receive a RACH response message from the base station on resources of the third narrowband region
1825
1800

FIG. 18

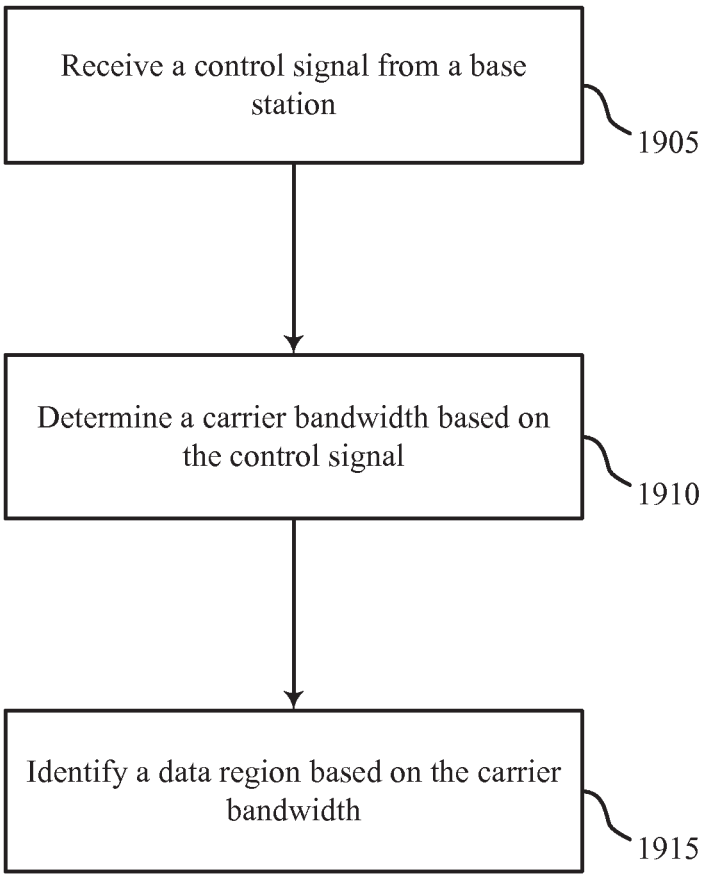
Receive a control signal from a base station
1905
Determine a carrier bandwidth based on the control signal
1910
Identify a data region based on the carrier bandwidth
1915
1900

FIG. 19

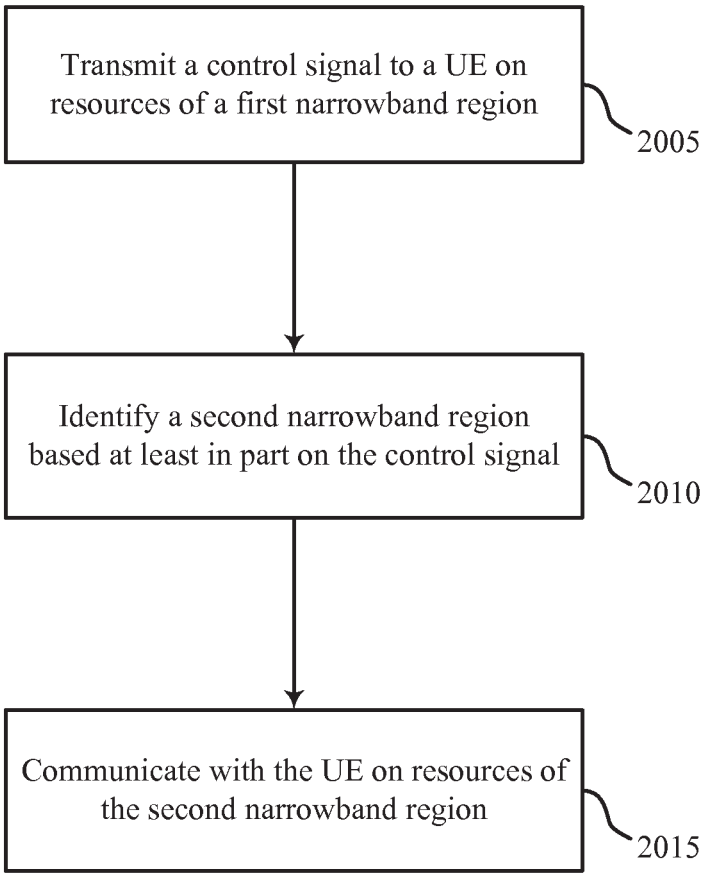
Transmit a control signal to a UE on resources of a first narrowband region
2005
Identify a second narrowband region based at least in part on the control signal
2010
Communicate with the UE on resources of the second narrowband region
2015
2000

FIG. 20