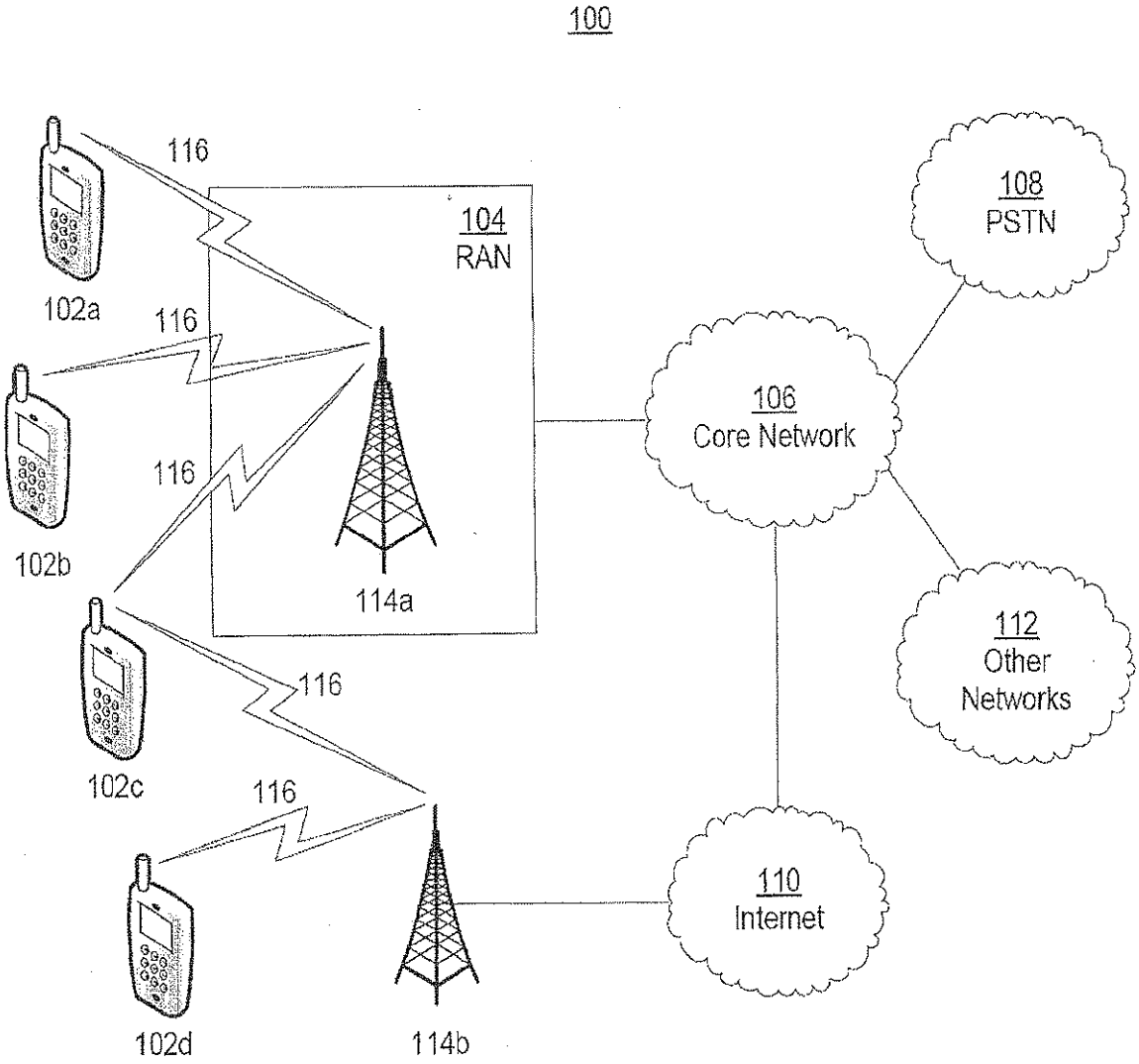

100
116
102a
116
102b
116
102c
116
102d
104
RAN
114a
114b
106
Core Network
108
PSTN
112
Other
Networks
110
Internet

Figure 1A

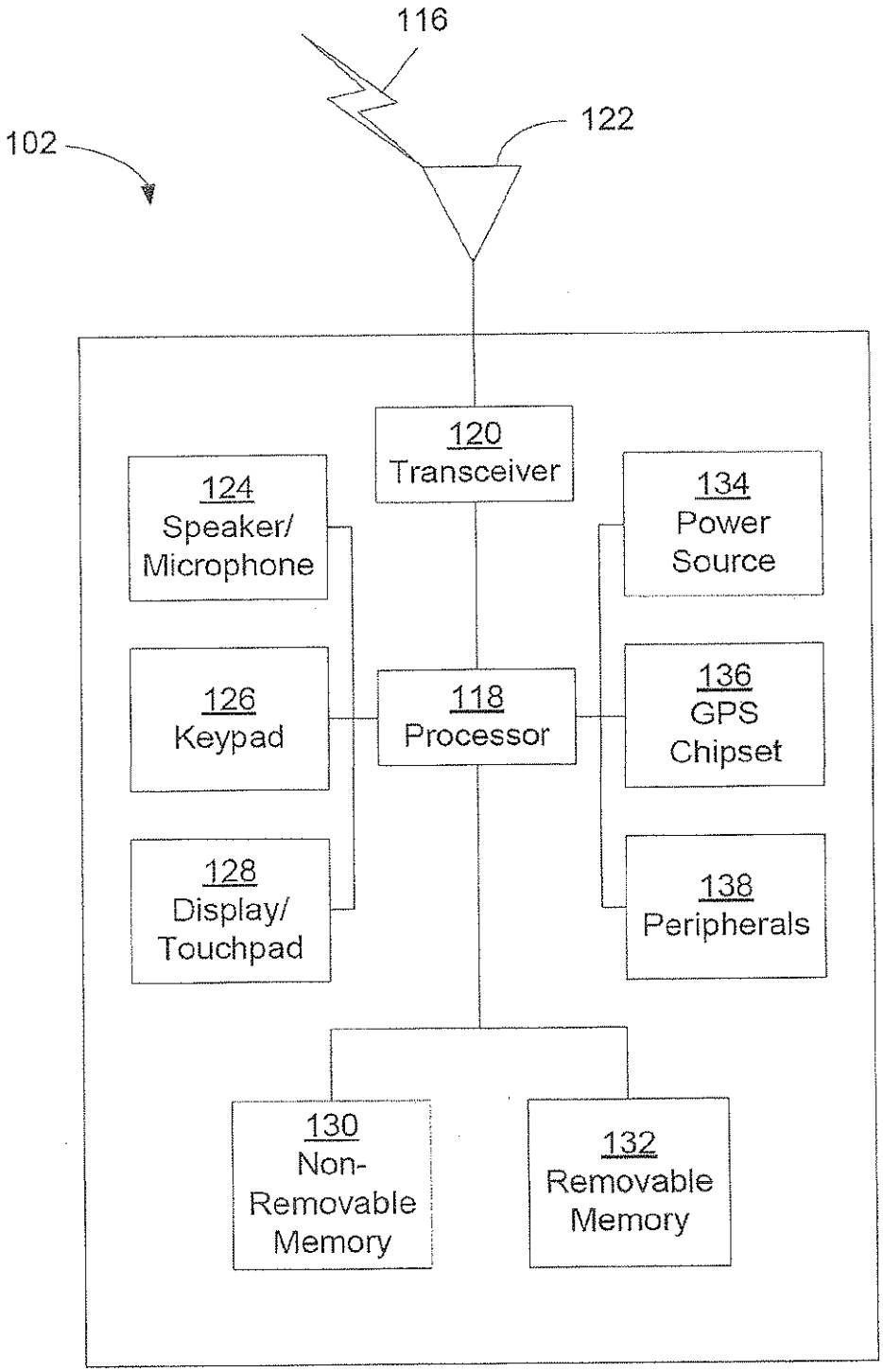

116
122
102
120
Transceiver
124
Speaker/
Microphone
134
Power
Source
126
Keypad
118
Processor
136
GPS
Chipset
128
Display/
Touchpad
138
Peripherals
130
Non-
Removable
Memory
132
Removable
Memory

Figure 1B

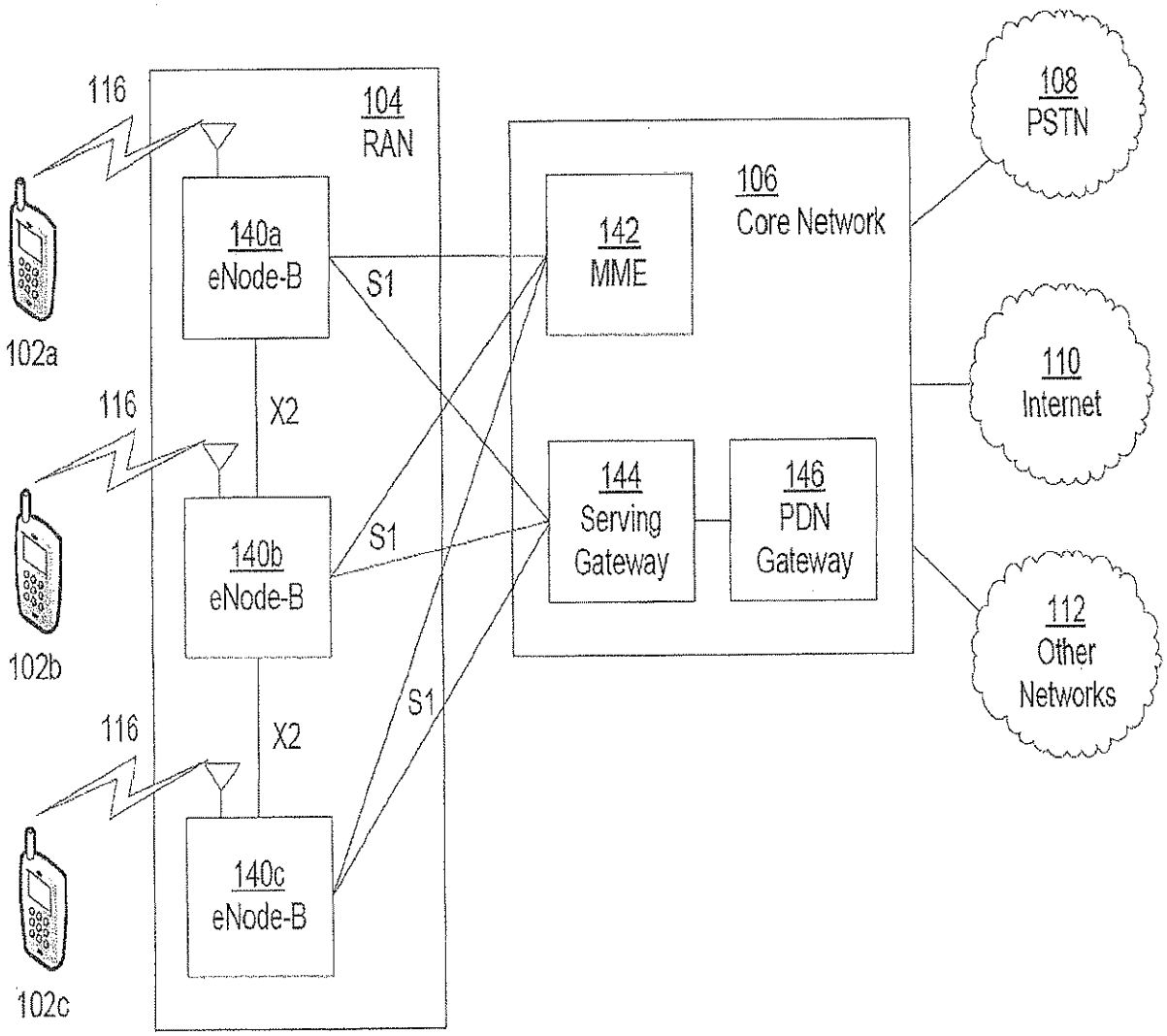

116
104
RAN
140a
eNode-B
S1
142
MME
106
Core Network
108
PSTN
102a
X2
110
Internet
116
144
Serving
Gateway
146
PDN
Gateway
140b
eNode-B
S1
102b
112
Other
Networks
116
X2
S1
140c
eNode-B
102c

Figure 1C

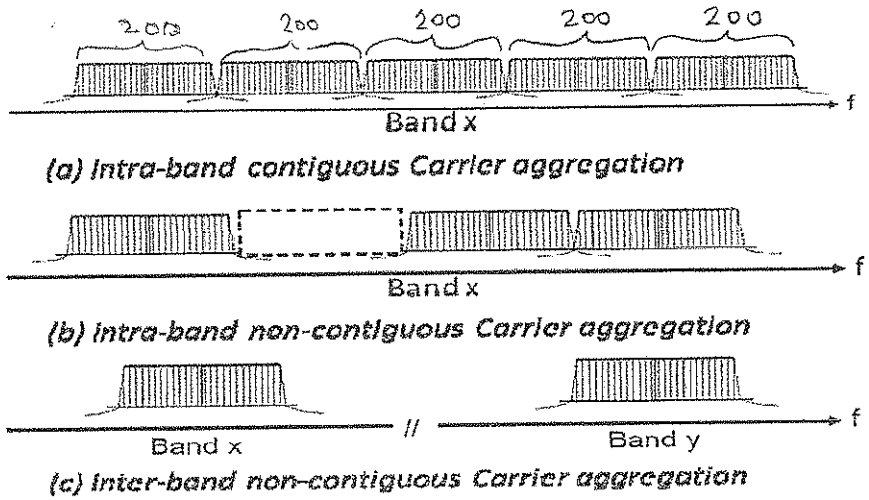


Figure 2

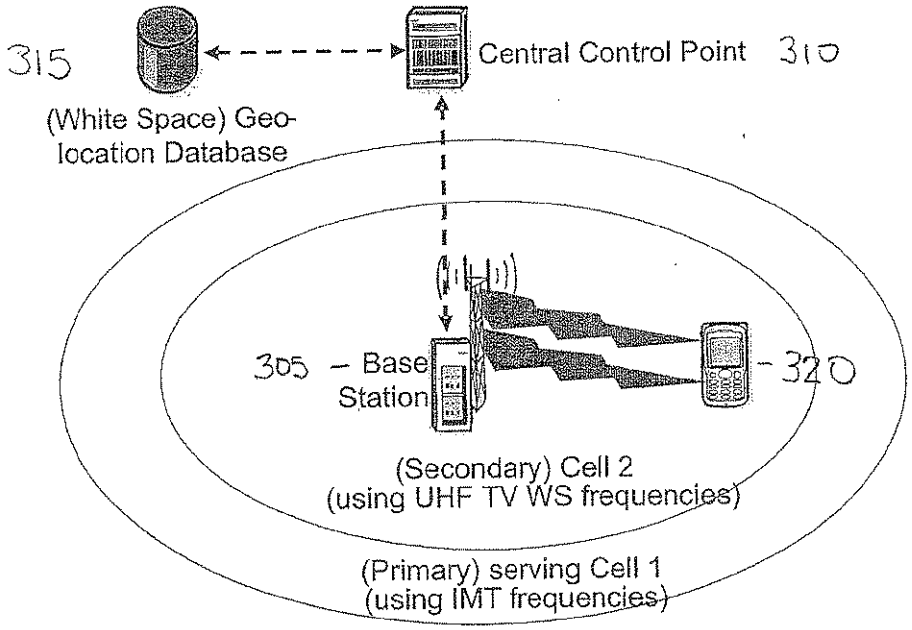


Figure 3

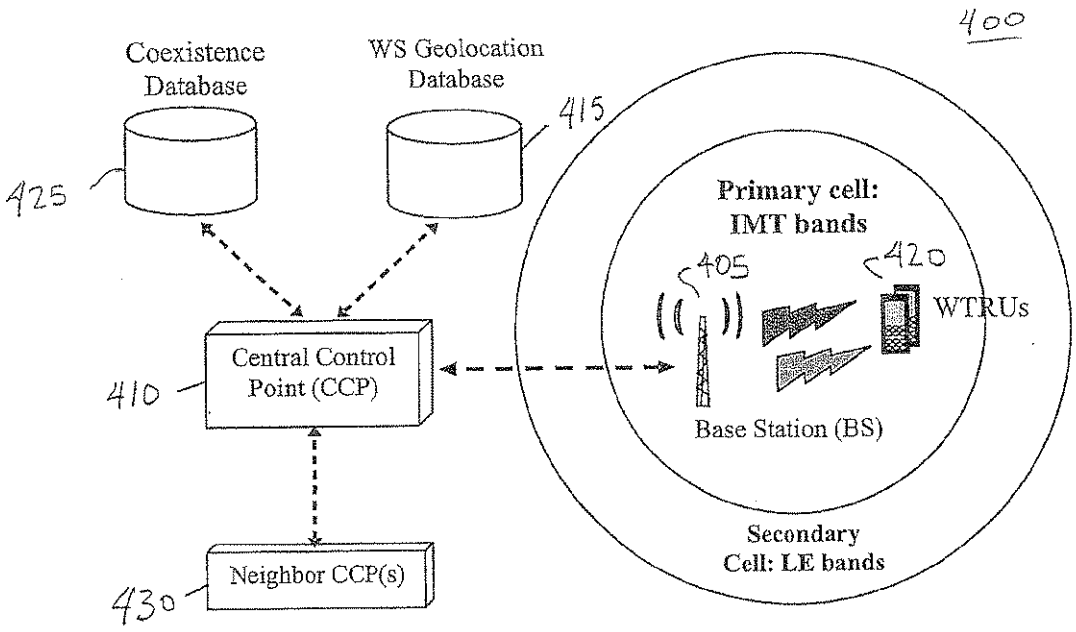

400
Coexistence Database
WS Geolocation Database
415
425
Primary cell: IMT bands
405
420
WTRUs
Central Control Point (CCP)
410
Base Station (BS)
Secondary Cell: LE bands
Neighbor CCP(s)
430

Figure 4

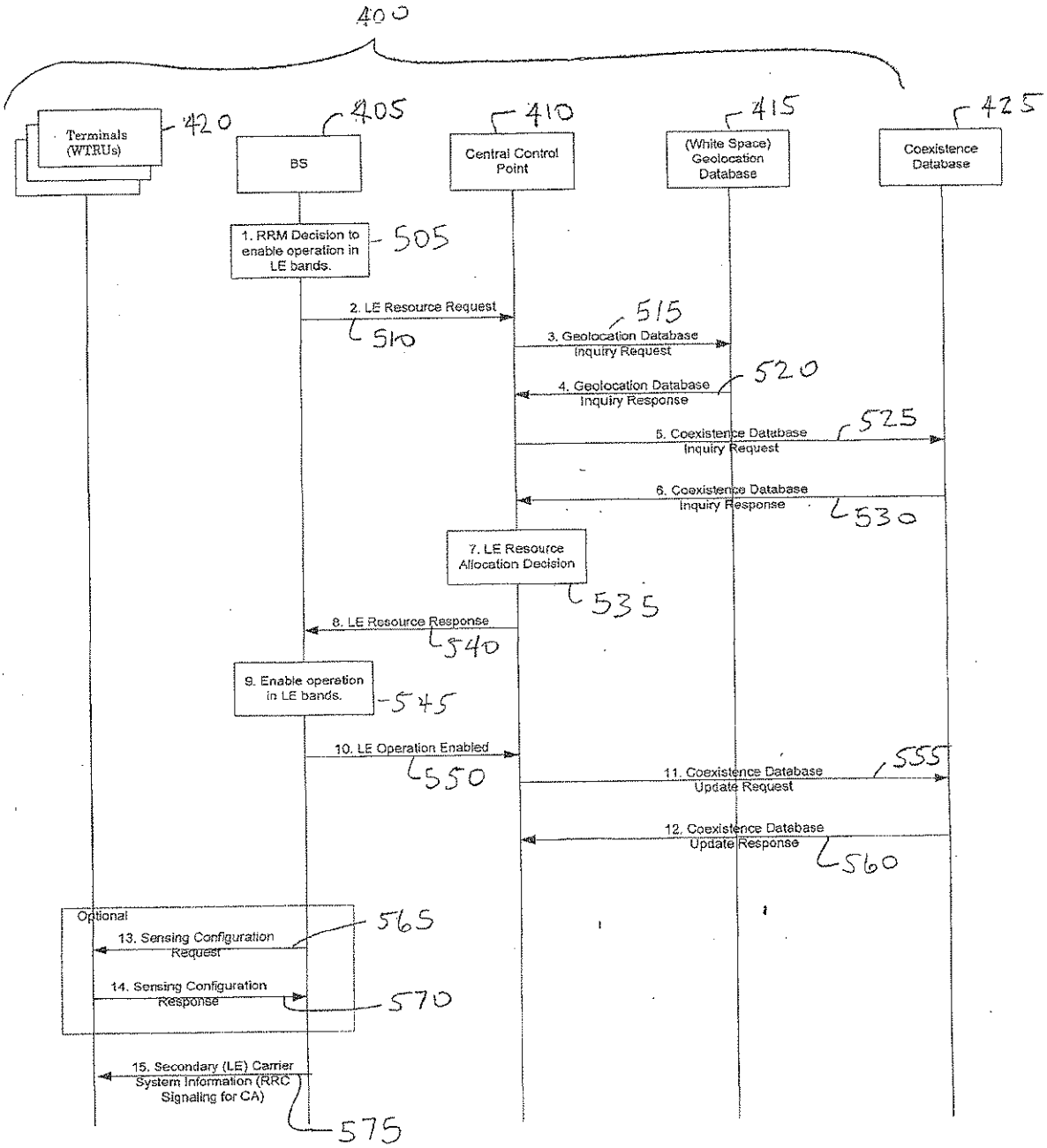

400
Terminals (WTRUs)
420
BS
405
Central Control Point
410
(White Space) Geolocation Database
415
Coexistence Database
425
1. RRM Decision to enable operation in LE bands.
505
2. LE Resource Request
510
3. Geolocation Database Inquiry Request
515
4. Geolocation Database Inquiry Response
520
5. Coexistence Database Inquiry Request
525
6. Coexistence Database Inquiry Response
530
7. LE Resource Allocation Decision
535
8. LE Resource Response
540
9. Enable operation in LE bands.
545
10. LE Operation Enabled
550
11. Coexistence Database Update Request
555
12. Coexistence Database Update Response
560
Optional
13. Sensing Configuration Request
565
14. Sensing Configuration Response
570
15. Secondary (LE) Carrier System Information (RRC Signaling for CA)
575

Figure 5

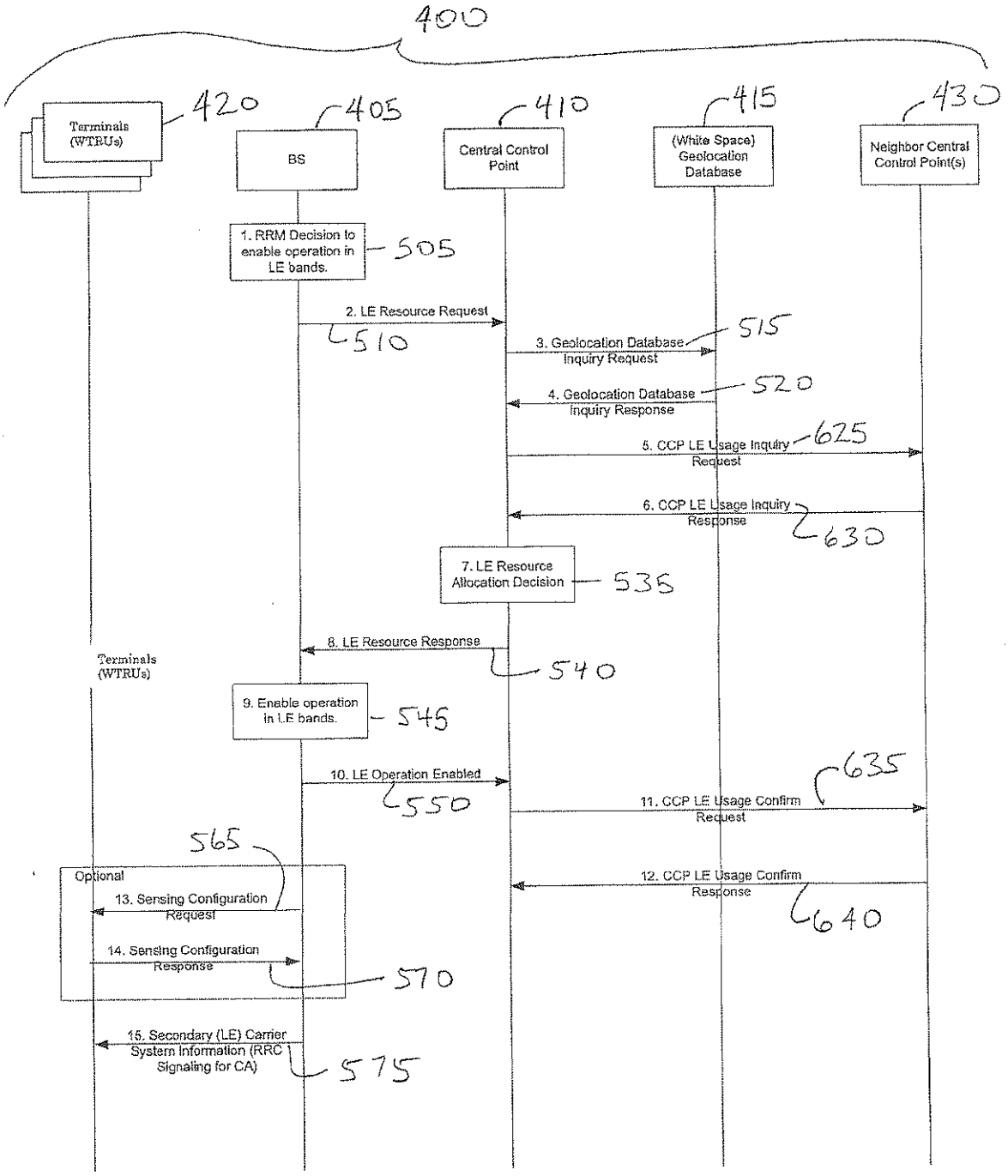

400
Terminals (WTRUs)
420
BS
405
Central Control Point
410
(White Space) Geolocation Database
415
Neighbor Central Control Point(s)
430
1. RRM Decision to enable operation in LE bands.
505
2. LE Resource Request
510
3. Geolocation Database Inquiry Request
515
4. Geolocation Database Inquiry Response
520
5. CCP LE Usage Inquiry Request
625
6. CCP LE Usage Inquiry Response
630
7. LE Resource Allocation Decision
535
8. LE Resource Response
540
Terminals (WTRUs)
9. Enable operation in LE bands.
545
10. LE Operation Enabled
550
11. CCP LE Usage Confirm Request
635
565
Optional
13. Sensing Configuration Request
12. CCP LE Usage Confirm Response
640
14. Sensing Configuration Response
570
15. Secondary (LE) Carrier System Information (RRC Signaling for CA)
575

Figure 6

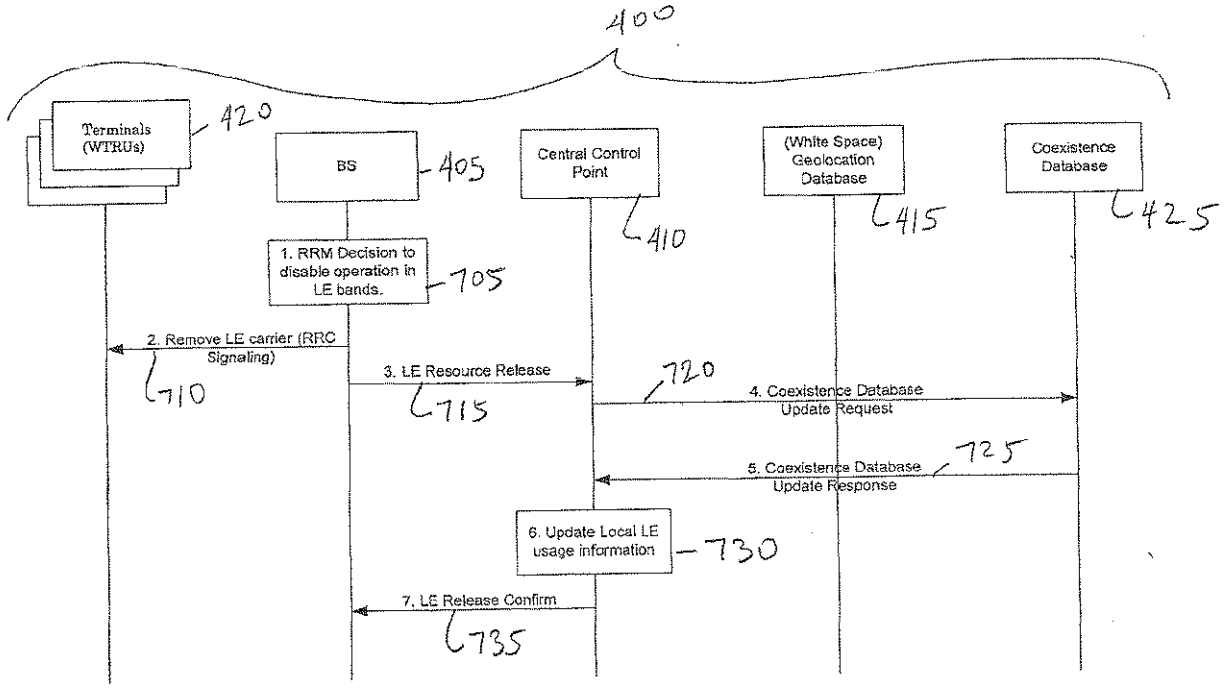


Figure 7

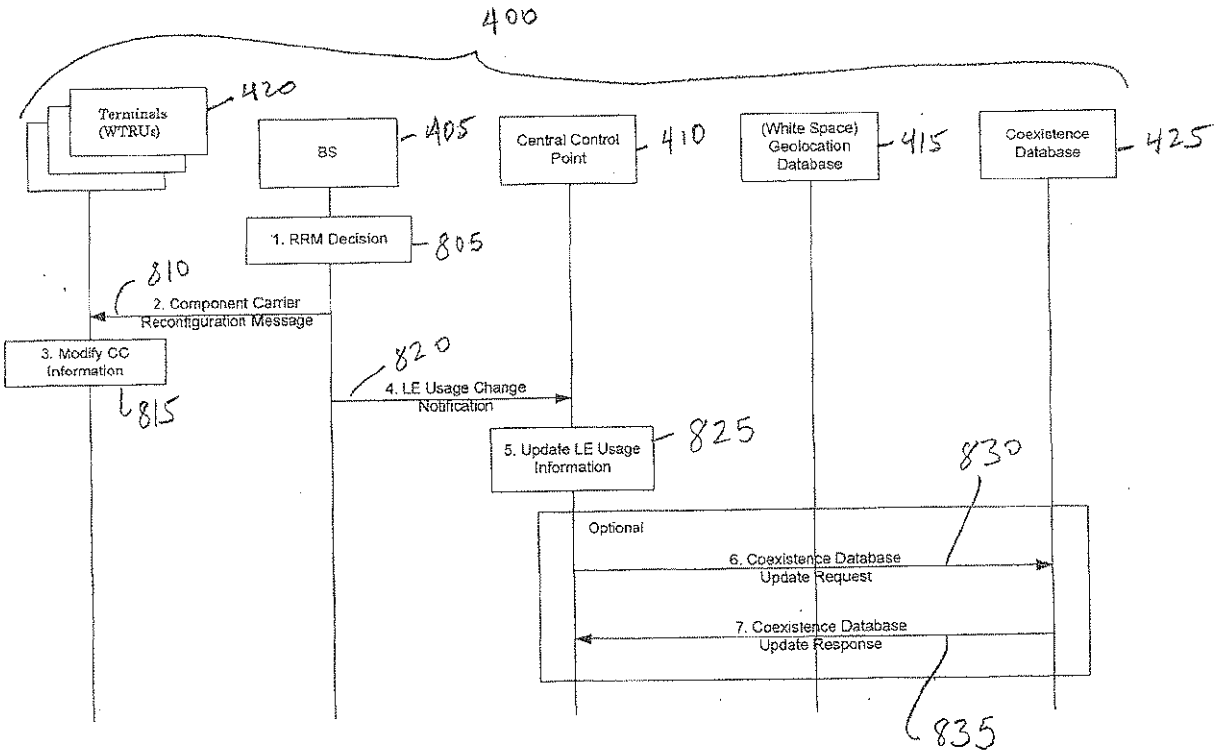


Figure 8

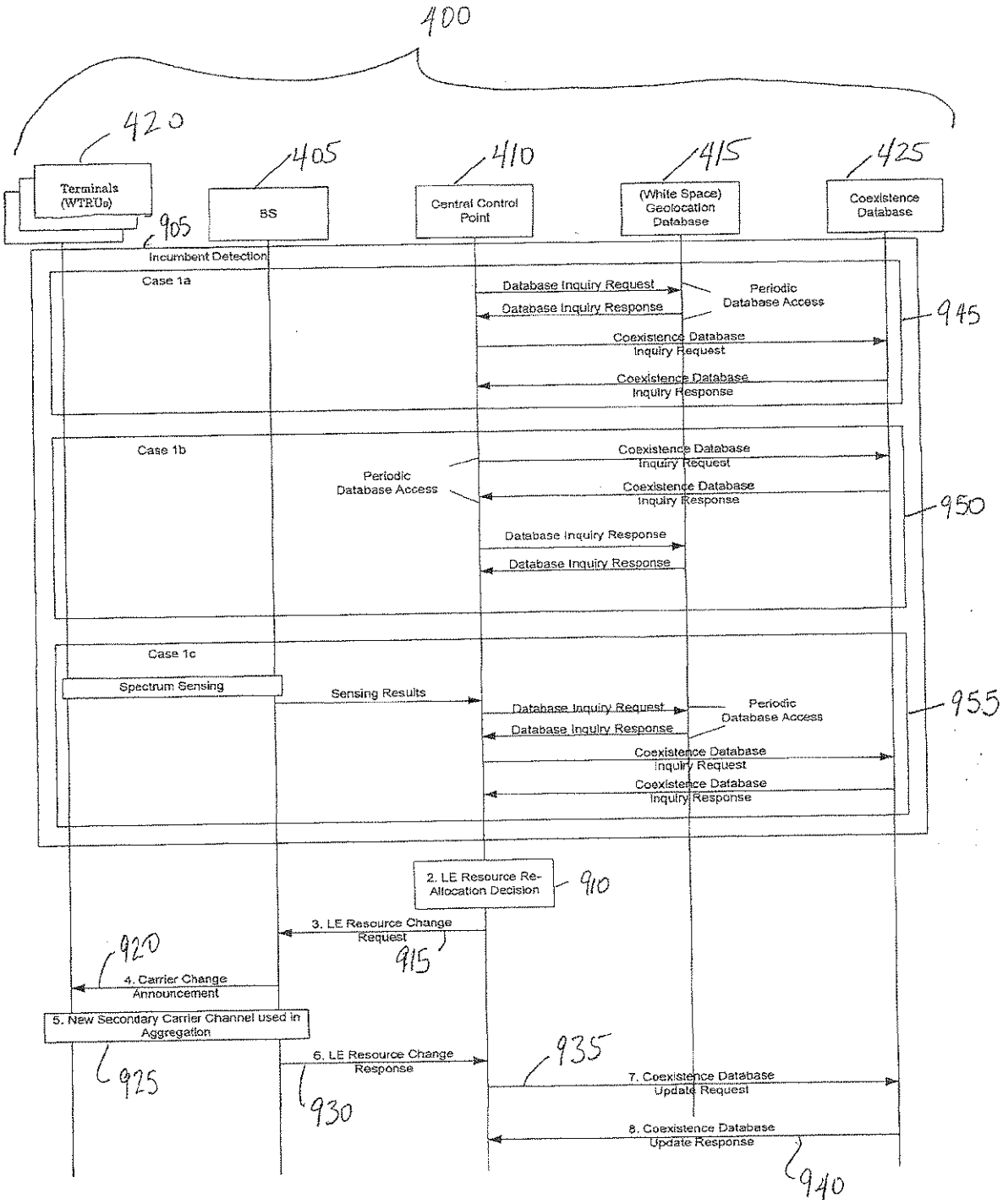

400
420
Terminals (WTRUs)
405
BS
410
Central Control Point
415
(White Space) Geolocation Database
425
Coexistence Database
905
Incumbent Detection
Case 1a
Database Inquiry Request
Database Inquiry Response
Periodic Database Access
945
Coexistence Database Inquiry Request
Coexistence Database Inquiry Response
Case 1b
Periodic Database Access
Coexistence Database Inquiry Request
Coexistence Database Inquiry Response
950
Database Inquiry Response
Database Inquiry Response
Case 1c
Spectrum Sensing
Sensing Results
Database Inquiry Request
Database Inquiry Response
Periodic Database Access
955
Coexistence Database Inquiry Request
Coexistence Database Inquiry Response
2. LE Resource Re-Allocation Decision
910
3. LE Resource Change Request
915
920
4. Carrier Change Announcement
5. New Secondary Carrier Channel used in Aggregation
925
6. LE Resource Change Response
930
935
7. Coexistence Database Update Request
8. Coexistence Database Update Response
940

Figure 9

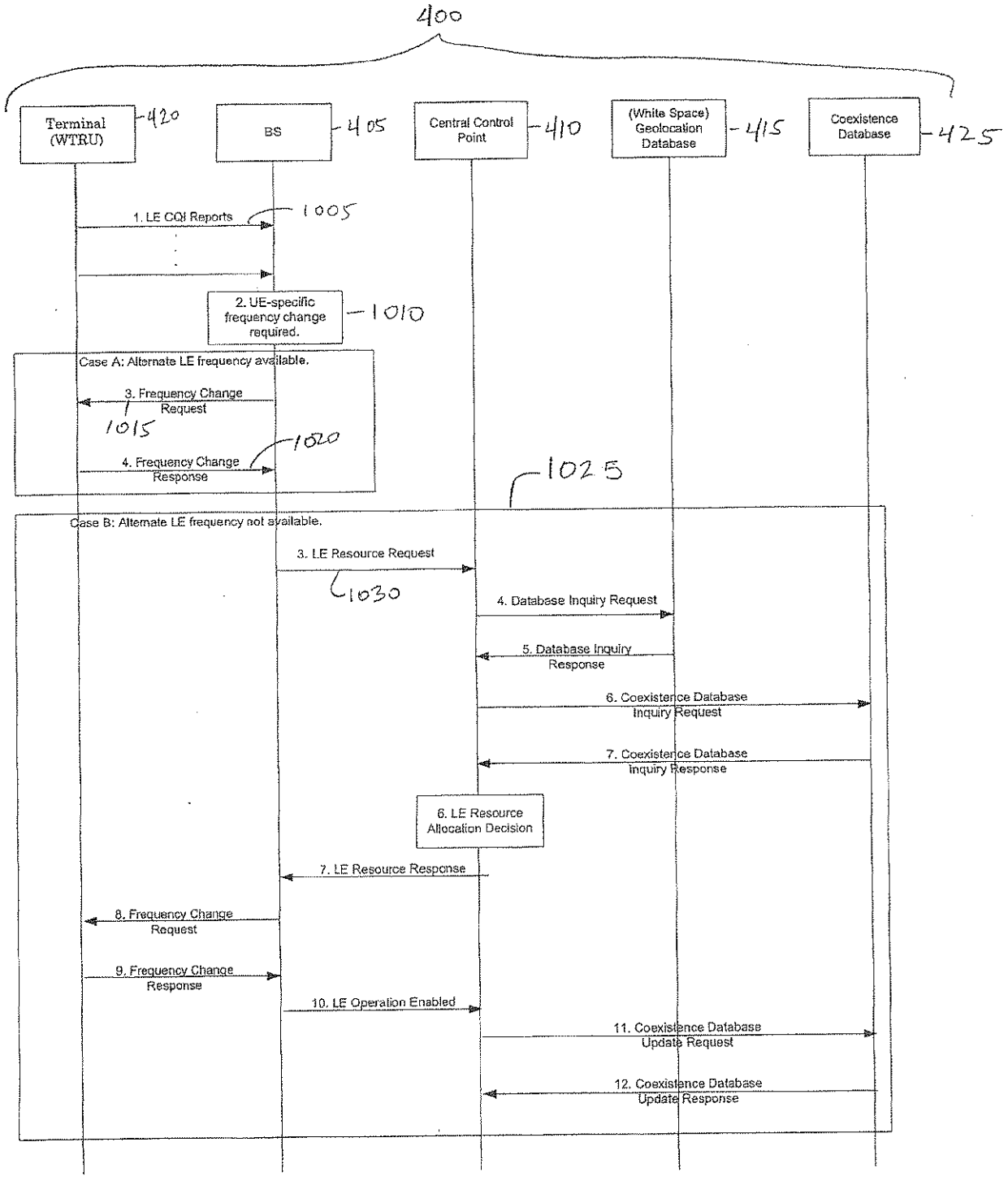

400
Terminal (WTRU)
420
BS
405
Central Control Point
410
(White Space) Geolocation Database
415
Coexistence Database
425
1. LE CQI Reports
1005
2. UE-specific frequency change required.
1010
Case A: Alternate LE frequency available.
3. Frequency Change Request
1015
4. Frequency Change Response
1020
1025
Case B: Alternate LE frequency not available.
3. LE Resource Request
1030
4. Database Inquiry Request
5. Database Inquiry Response
6. Coexistence Database Inquiry Request
7. Coexistence Database Inquiry Response
6. LE Resource Allocation Decision
7. LE Resource Response
8. Frequency Change Request
9. Frequency Change Response
10. LE Operation Enabled
11. Coexistence Database Update Request
12. Coexistence Database Update Response

Figure 10

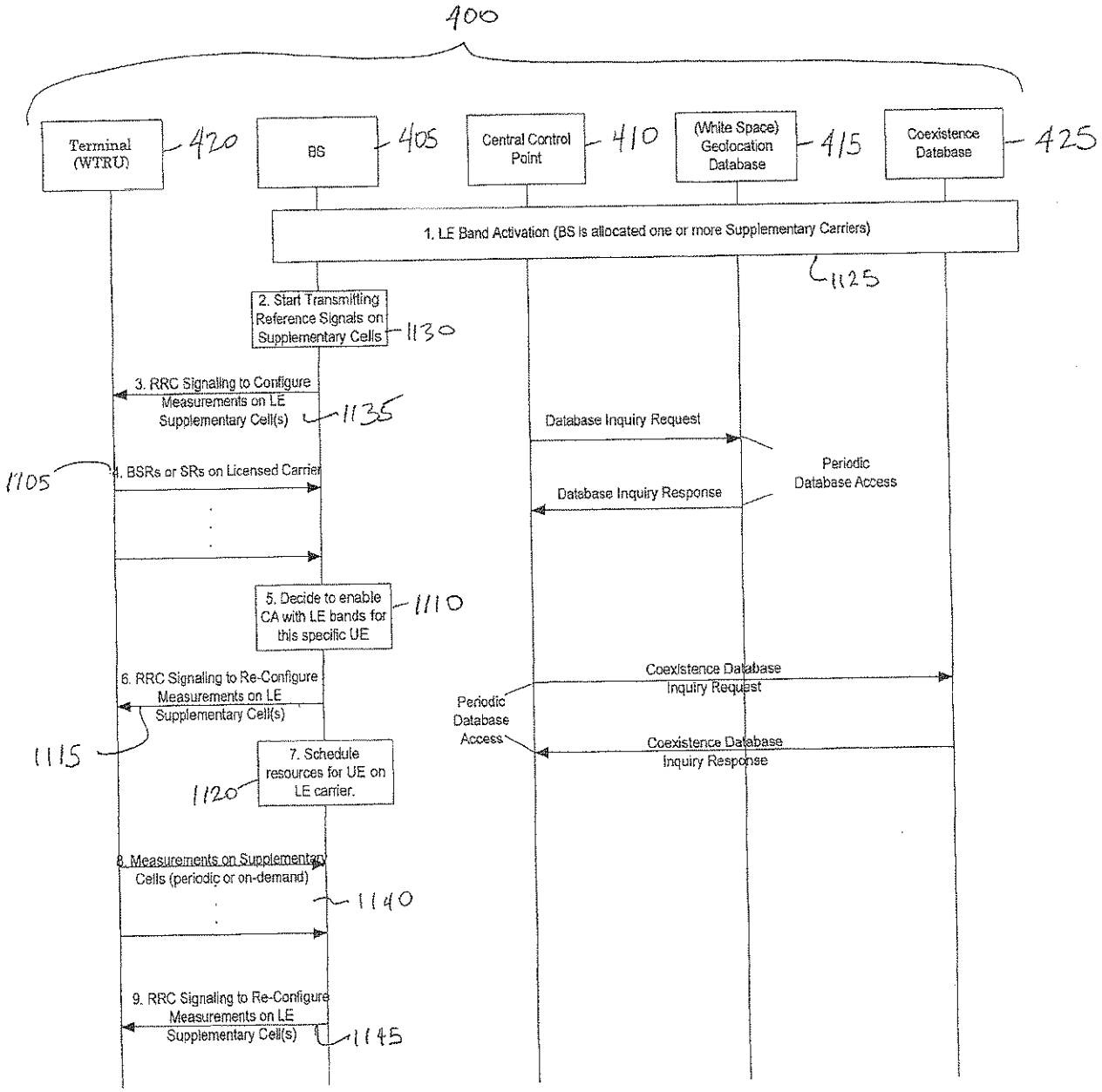

400
Terminal (WTRU)
420
BS
405
Central Control Point
410
(White Space) Geolocation Database
415
Coexistence Database
425
1. LE Band Activation (BS is allocated one or more Supplementary Carriers)
1125
2. Start Transmitting Reference Signals on Supplementary Cells
1130
3. RRC Signaling to Configure Measurements on LE Supplementary Cell(s)
1135
Database Inquiry Request
Periodic Database Access
Database Inquiry Response
1105
4. BSRs or SRs on Licensed Carrier
5. Decide to enable CA with LE bands for this specific UE
1110
6. RRC Signaling to Re-Configure Measurements on LE Supplementary Cell(s)
Coexistence Database Inquiry Request
Periodic Database Access
Coexistence Database Inquiry Response
1115
7. Schedule resources for UE on LE carrier.
1120
8. Measurements on Supplementary Cells (periodic or on-demand)
1140
9. RRC Signaling to Re-Configure Measurements on LE Supplementary Cell(s)
1145

Figure 11

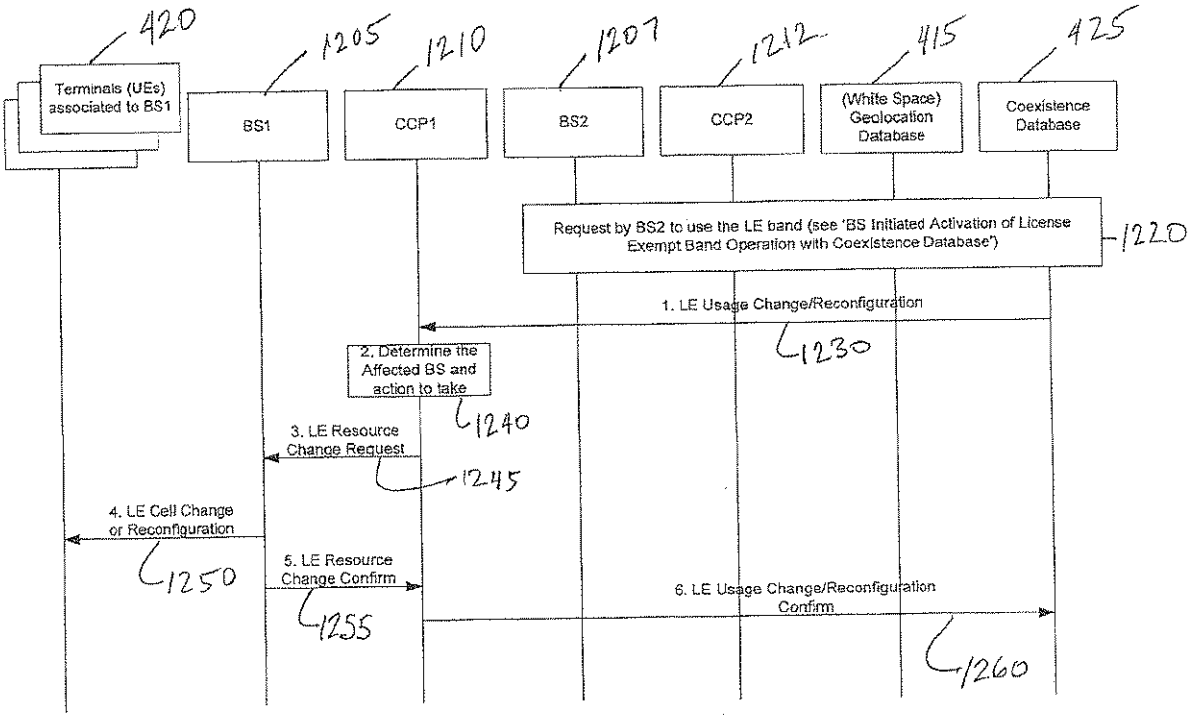

420
1205
1210
1207
1212
415
425
Terminals (UEs) associated to BS1
BS1
CCP1
BS2
CCP2
(White Space) Geolocation Database
Coexistence Database
Request by BS2 to use the LE band (see 'BS Initiated Activation of License Exempt Band Operation with Coexistence Database')
1220
1. LE Usage Change/Reconfiguration
1230
2. Determine the Affected BS and action to take
1240
3. LE Resource Change Request
1245
4. LE Cell Change or Reconfiguration
1250
5. LE Resource Change Confirm
1255
6. LE Usage Change/Reconfiguration Confirm
1260

Figure 12

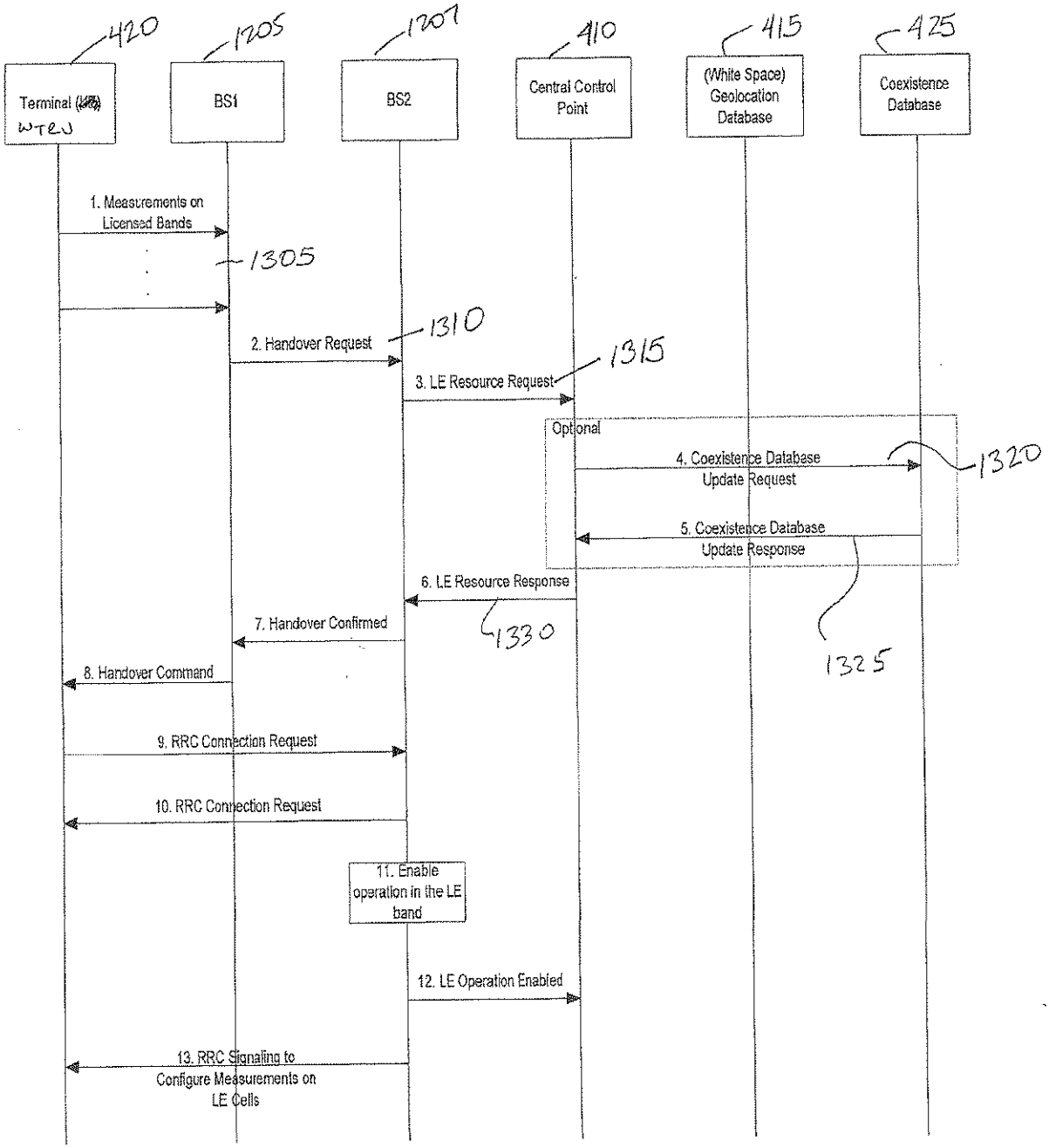

420
1205
1207
410
415
425
Terminal (WTRU)
BS1
BS2
Central Control Point
(White Space) Geolocation Database
Coexistence Database
1. Measurements on Licensed Bands
1305
2. Handover Request
1310
3. LE Resource Request
1315
Optional
4. Coexistence Database Update Request
1320
5. Coexistence Database Update Response
1325
6. LE Resource Response
1330
7. Handover Confirmed
8. Handover Command
9. RRC Connection Request
10. RRC Connection Request
11. Enable operation in the LE band
12. LE Operation Enabled
13. RRC Signaling to Configure Measurements on LE Cells

Figure 13

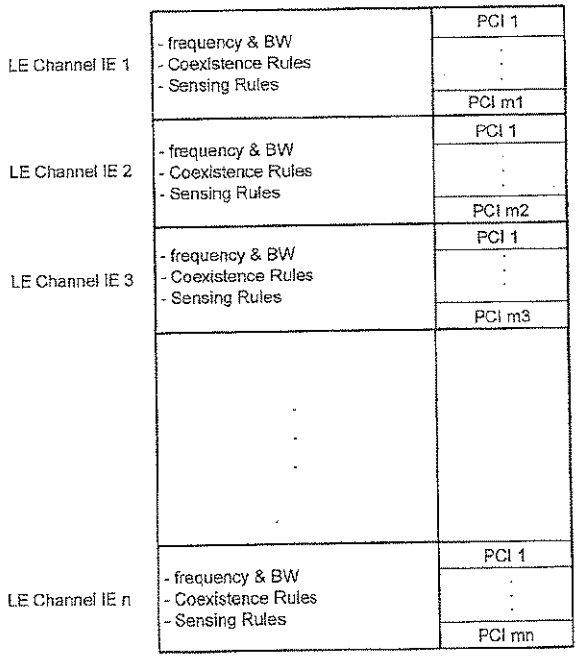

LE Channel IE 1
- frequency & BW
- Coexistence Rules
- Sensing Rules
PCI 1
PCI m1
LE Channel IE 2
- frequency & BW
- Coexistence Rules
- Sensing Rules
PCI 1
PCI m2
LE Channel IE 3
- frequency & BW
- Coexistence Rules
- Sensing Rules
PCI 1
PCI m3
LE Channel IE n
- frequency & BW
- Coexistence Rules
- Sensing Rules
PCI 1
PCI mn

Figure 14

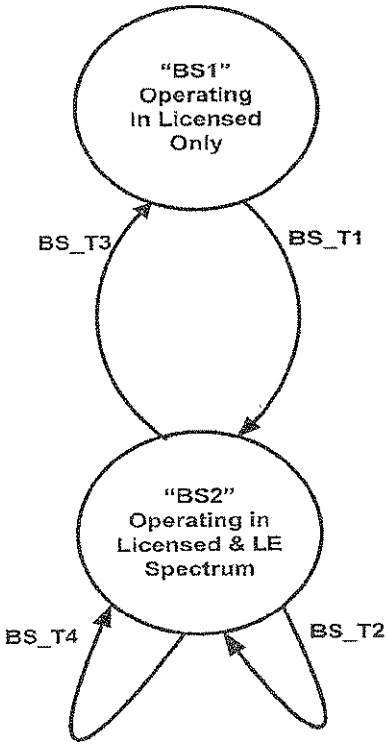

"BS1"
Operating
In Licensed
Only
BS_T3
BS_T1
"BS2"
Operating in
Licensed & LE
Spectrum
BS_T4
BS_T2

Figure 15

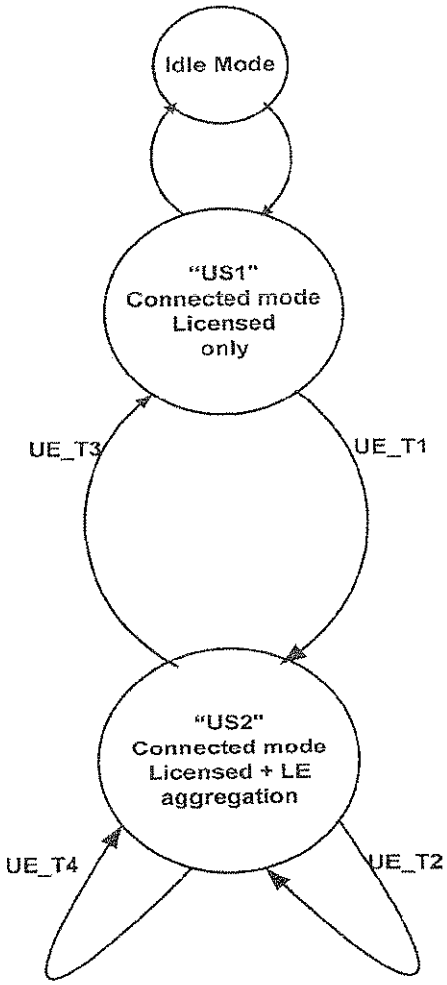

Idle Mode
"US1"
Connected mode
Licensed
only
UE_T3
UE_T1
"US2"
Connected mode
Licensed + LE
aggregation
UE_T4
UE_T2

Figure 16

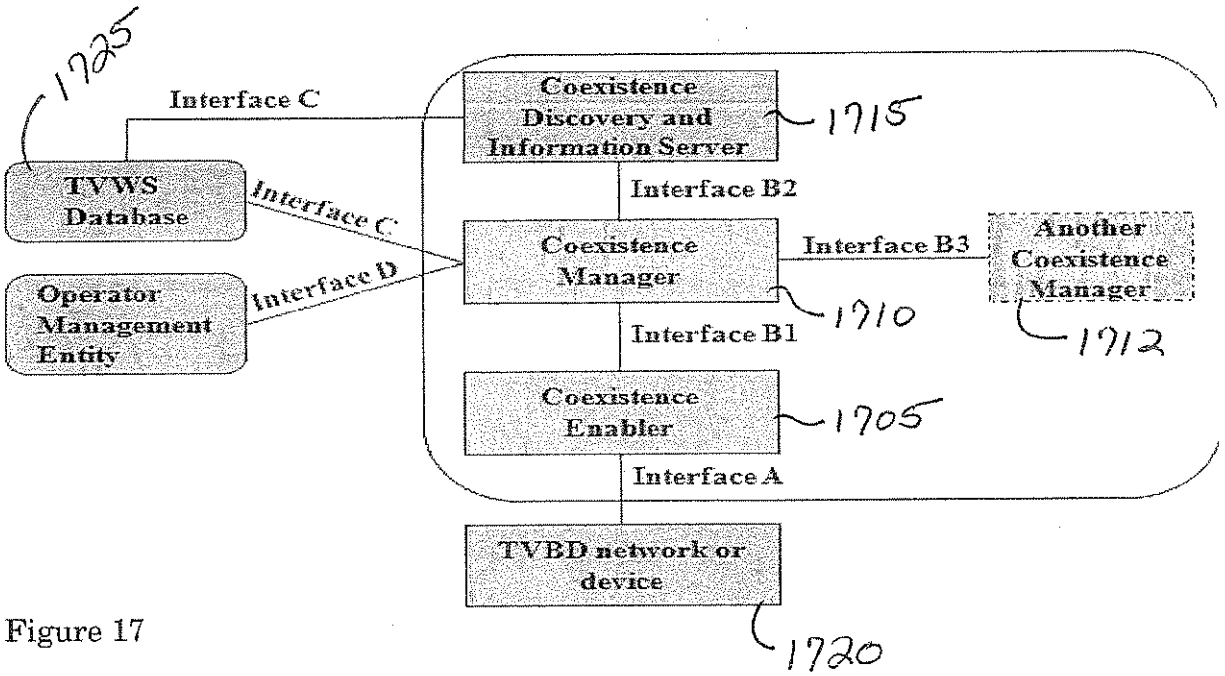

1725
Interface C
TVWS Database
Interface C
Operator Management Entity
Interface D
Coexistence Discovery and Information Server
1715
Interface B2
Coexistence Manager
Interface B3
Another Coexistence Manager
1710
1712
Interface B1
Coexistence Enabler
1705
Interface A
TVBD network or device
1720

Figure 17

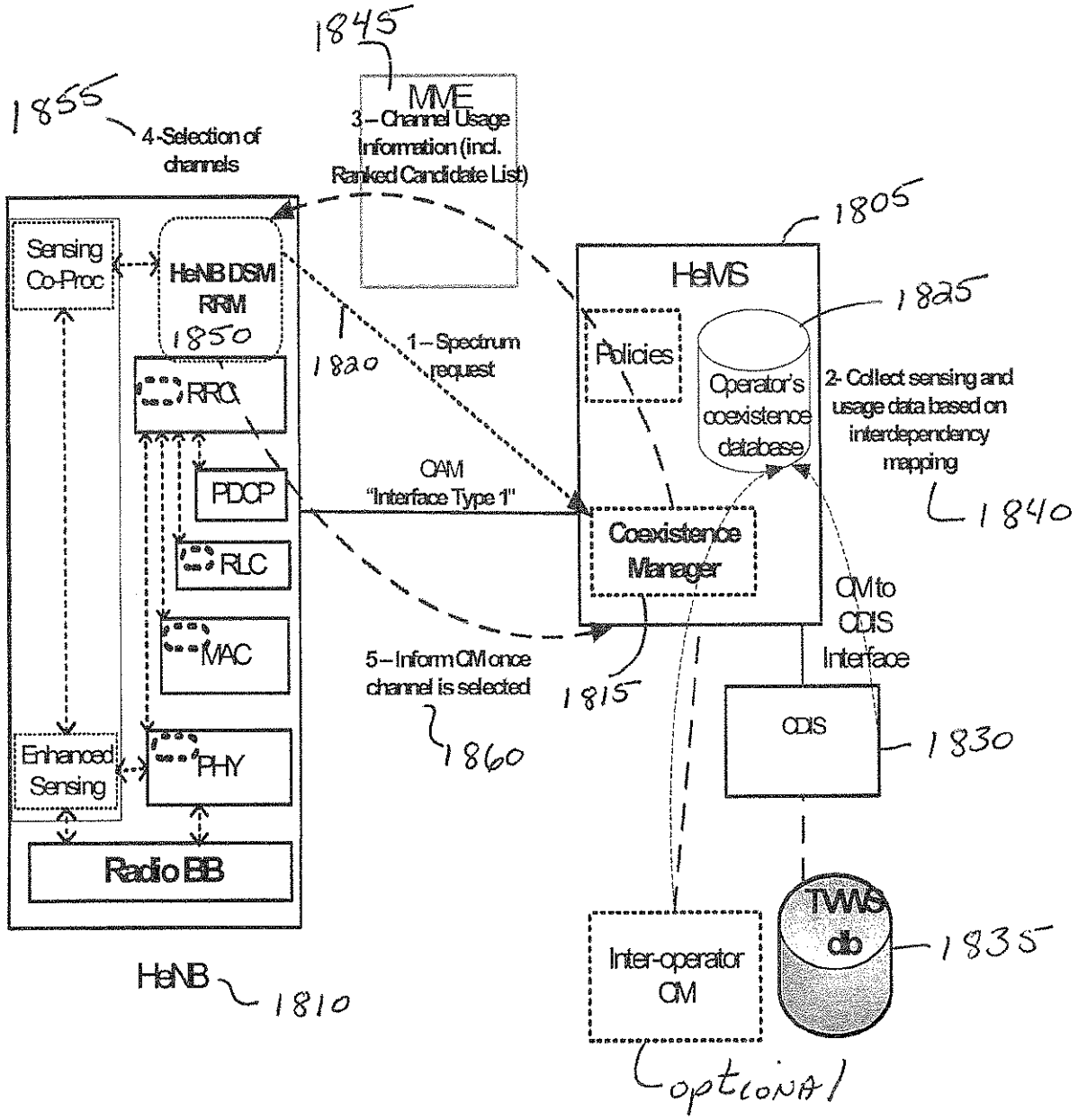

1845
MME
3 – Channel Usage Information (incl. Ranked Candidate List)
1855
4-Selection of channels
1805
HeMS
1825
Policies
Operator's coexistence database
2- Collect sensing and usage data based on interdependency mapping
1840
Sensing Co-Proc
HeNB DSM RRM
1850
RRC
PDCP
RLC
MAC
PHY
Enhanced Sensing
Radio BB
HeNB
1810
1820
1 – Spectrum request
OAM "Interface Type 1"
Coexistence Manager
5 – Inform CM once channel is selected
1860
1815
CM to CDIS Interface
CDIS
1830
TVWS db
1835
Inter-operator CM
optional

Figure 18

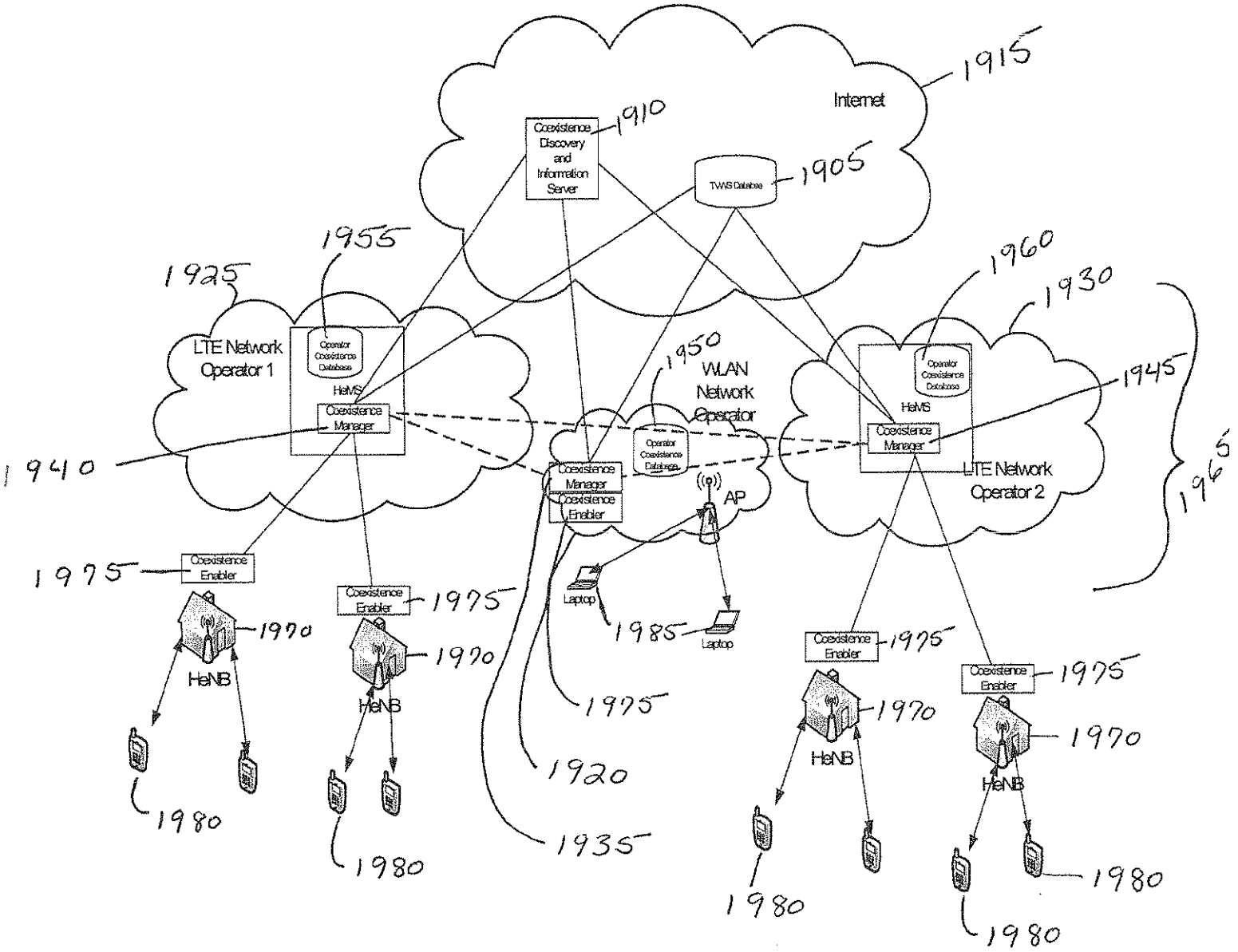

Internet
1915
Coexistence Discovery and Information Server
1910
TVWS Database
1905
1955
1925
1960
1930
LTE Network Operator 1
Operator Coexistence Database
HeMS
Coexistence Manager
1950
WLAN Network Operator
1945
1940
Coexistence Manager
Coexistence Enabler
AP
LTE Network Operator 2
1965
1975
Coexistence Enabler
1970
HeNB
Laptop
1985
1980
1920
1935

Figure 19

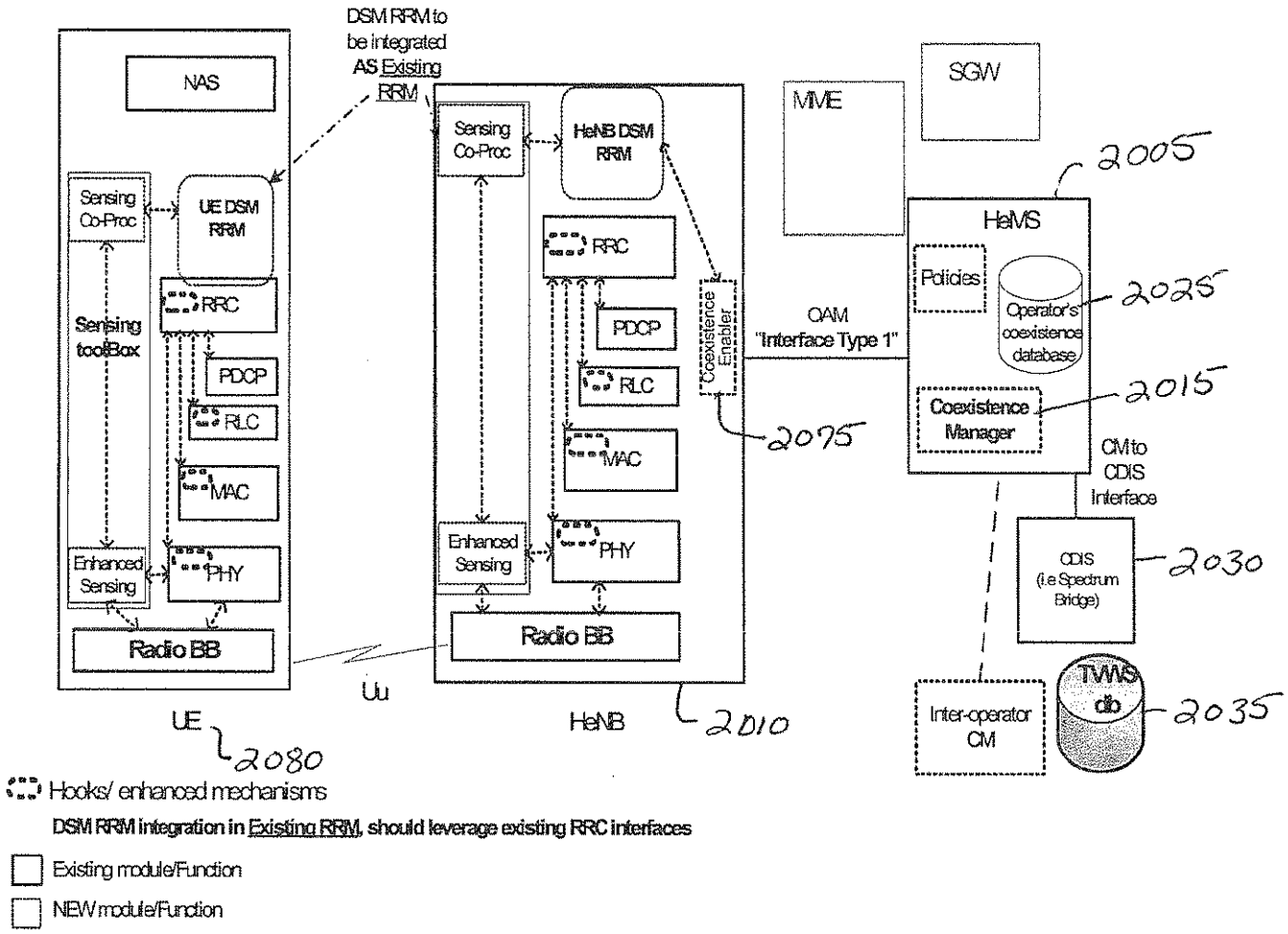

DSM RRM to be integrated AS Existing RRM
NAS
Sensing Co-Proc
UE DSM RRM
Sensing toolBox
RRC
PDCP
RLC
MAC
Enhanced Sensing
PHY
Radio BB
UE
2080
Uu
Sensing Co-Proc
HeNB DSM RRM
RRC
PDCP
RLC
MAC
PHY
Enhanced Sensing
Radio BB
HeNB
2010
Coexistence Enabler
2075
MME
SGW
OAM "Interface Type 1"
2005
HeMS
Policies
Operator's coexistence database
2025
Coexistence Manager
2015
CM to CDIS Interface
CDIS (i.e Spectrum Bridge)
2030
Inter-operator CM
TVWS db
2035
Hooks/ enhanced mechanisms
DSM RRM integration in Existing RRM, should leverage existing RRC interfaces
Existing module/Function
NEW module/Function

Figure 20

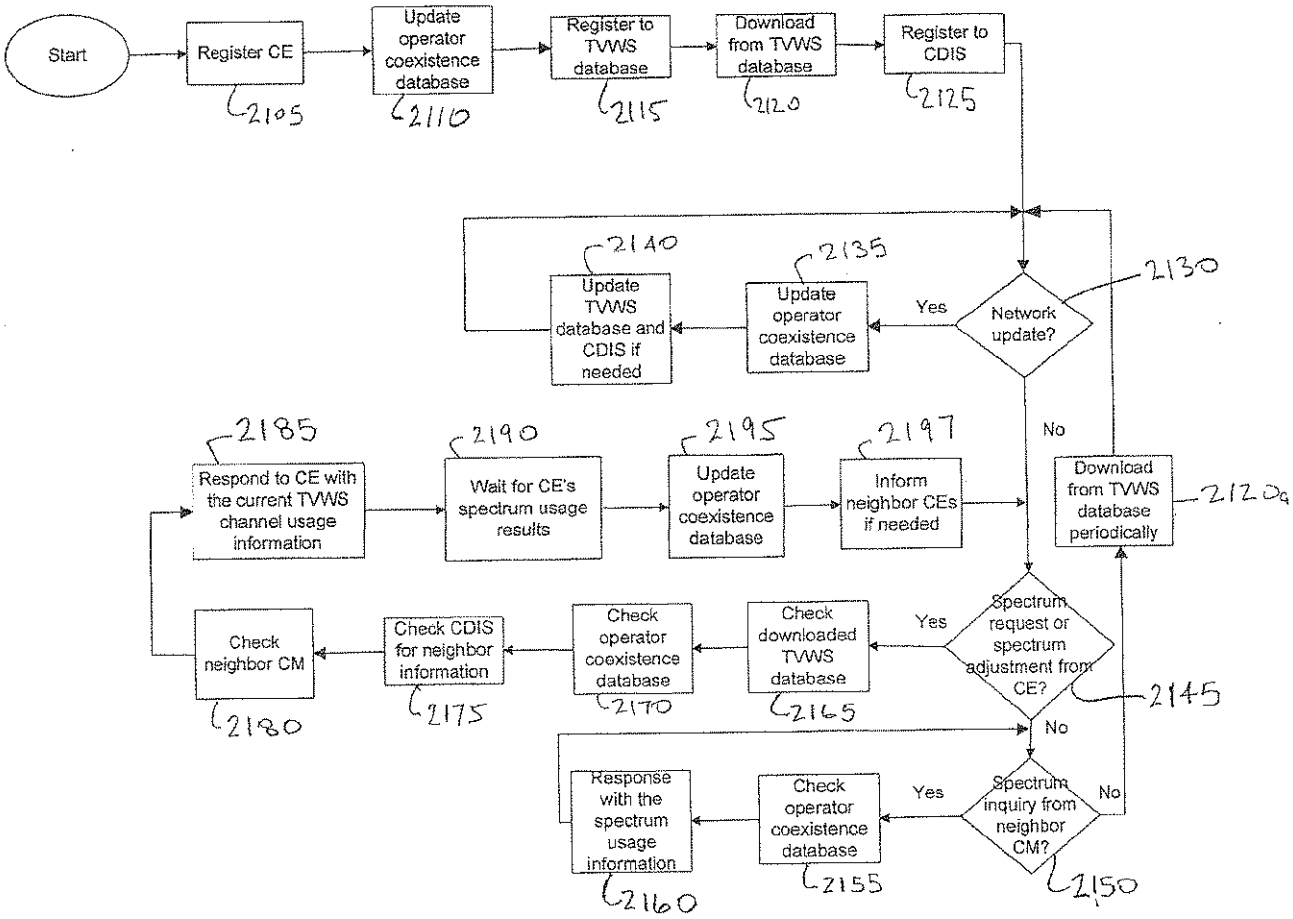

Start
Register CE
2105
Update operator coexistence database
2110
Register to TVWS database
2115
Download from TVWS database
2120
Register to CDIS
2125
Network update?
2130
Yes
Update operator coexistence database
2135
Update TVWS database and CDIS if needed
2140
No
Download from TVWS database periodically
2120a
Inform neighbor CEs if needed
2197
Update operator coexistence database
2195
Wait for CE's spectrum usage results
2190
Respond to CE with the current TVWS channel usage information
2185
Spectrum request or spectrum adjustment from CE?
2145
Yes
Check downloaded TVWS database
2165
Check operator coexistence database
2170
Check CDIS for neighbor information
2175
Check neighbor CM
2180
No
Spectrum inquiry from neighbor CM?
2150
Yes
No
Check operator coexistence database
2155
Response with the spectrum usage information
2160

Figure 21

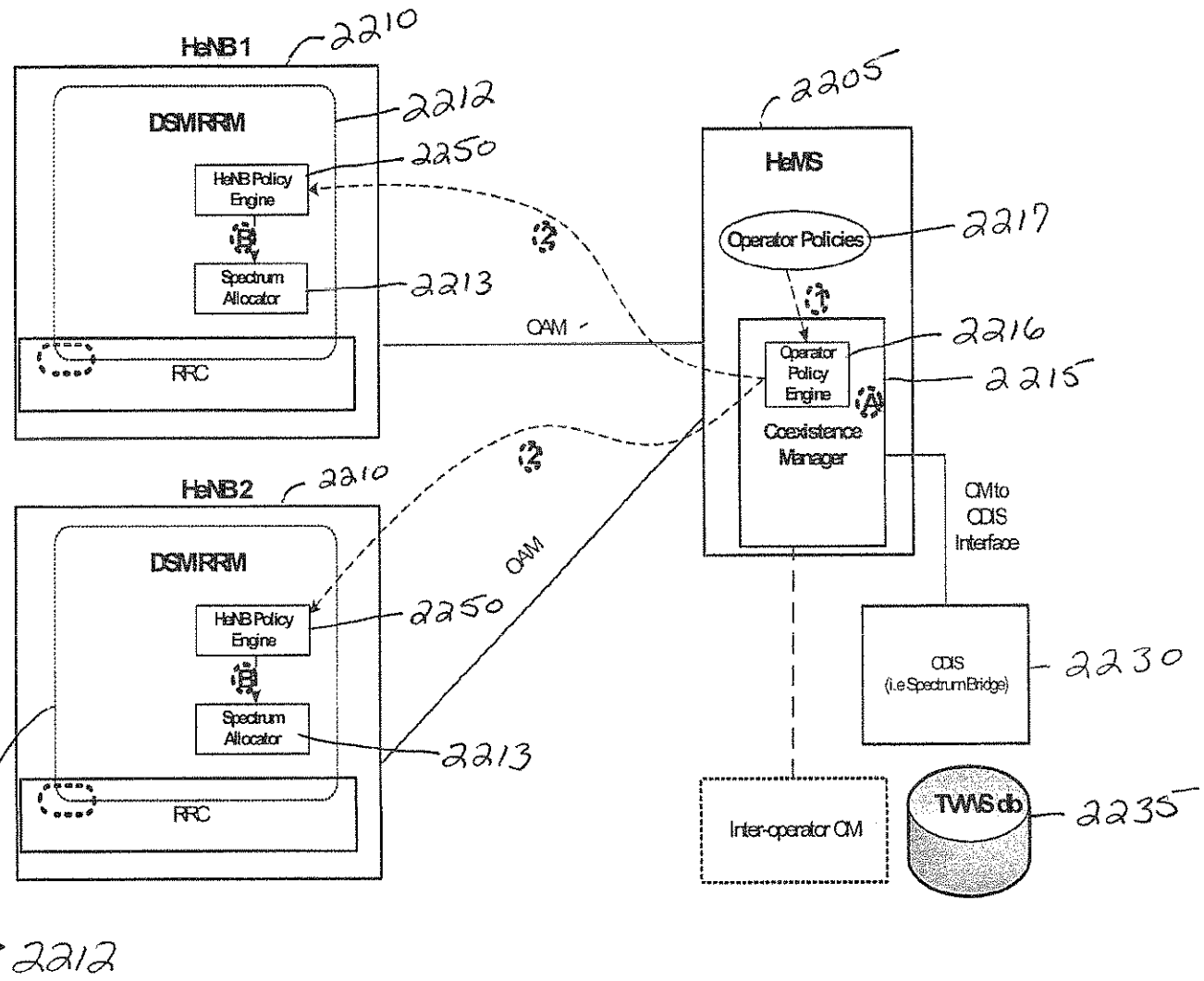

HeNB1
2210
DSM/RRM
2212
2250
HeNB Policy Engine
Spectrum Allocator
2213
RRC
OAM
HeMS
2205
Operator Policies
2217
Operator Policy Engine
2216
2215
Coexistence Manager
OM to CDIS Interface
HeNB2
2210
DSM/RRM
2250
HeNB Policy Engine
Spectrum Allocator
2213
RRC
OAM
CDIS (i.e SpectrumBridge)
2230
Inter-operator OM
TVWS db
2235
2212

Figure 22

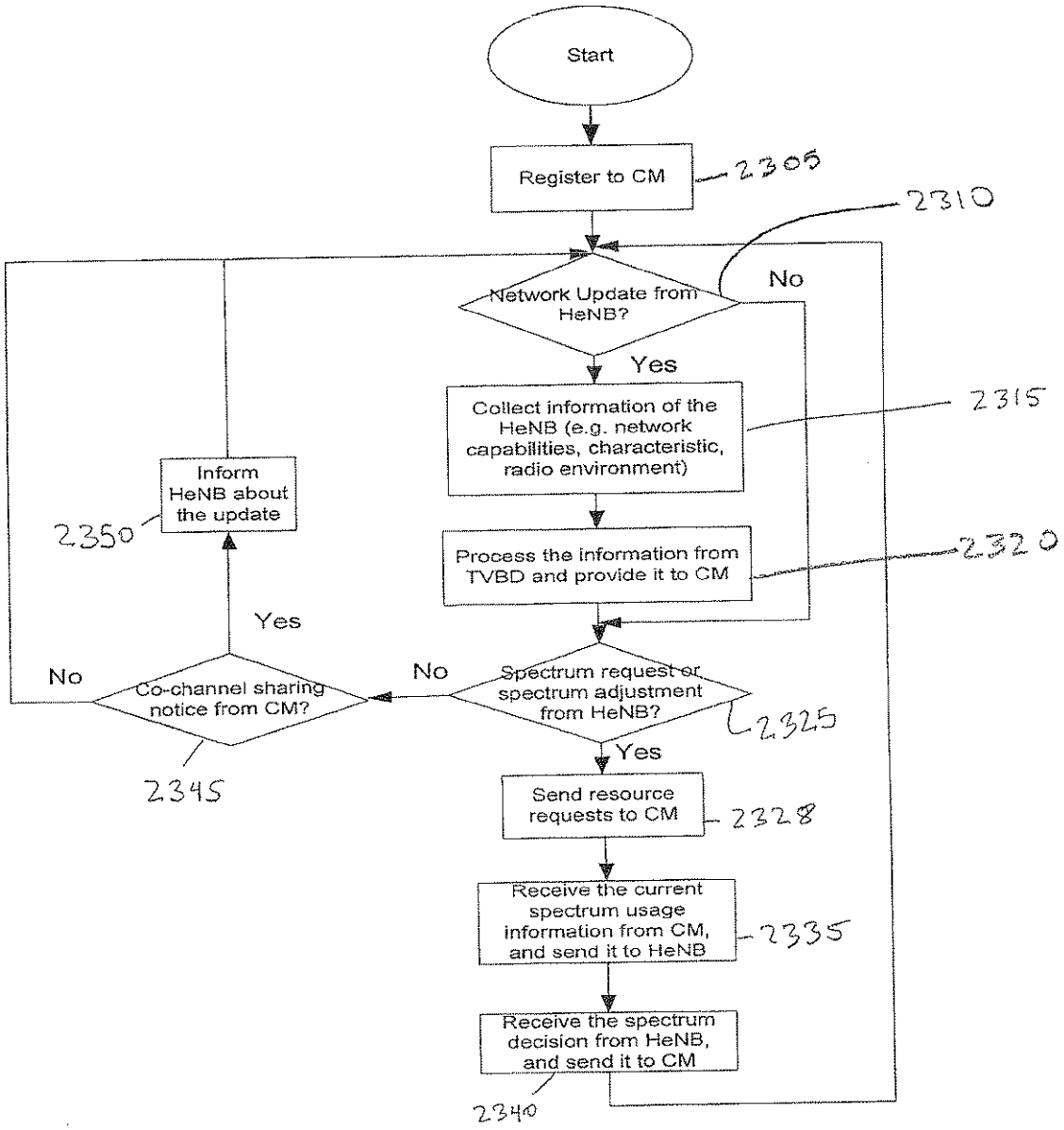

Start
Register to CM
2305
2310
Network Update from HeNB?
No
Yes
Collect information of the HeNB (e.g. network capabilities, characteristic, radio environment)
2315
Process the information from TVBD and provide it to CM
2320
Spectrum request or spectrum adjustment from HeNB?
2325
No
Yes
Co-channel sharing notice from CM?
No
Yes
2345
Inform HeNB about the update
2350
Send resource requests to CM
2328
Receive the current spectrum usage information from CM, and send it to HeNB
2335
Receive the spectrum decision from HeNB, and send it to CM
2340

Figure 23

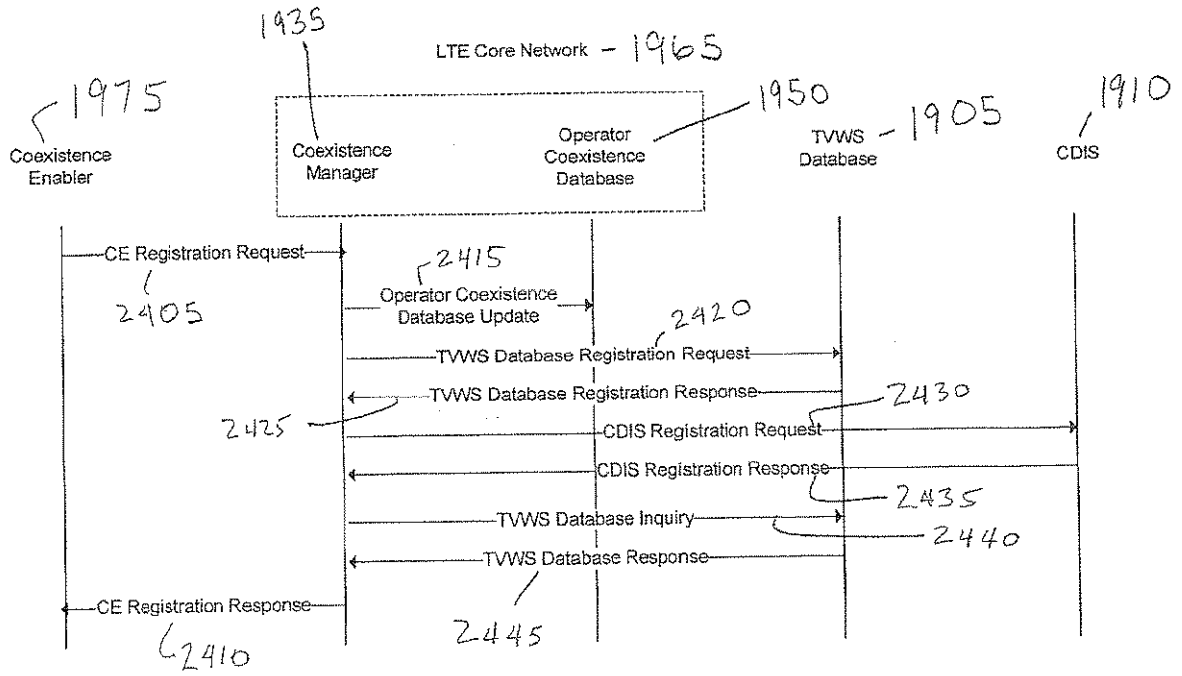


Figure 24: Exemplary CE Registration Procedure

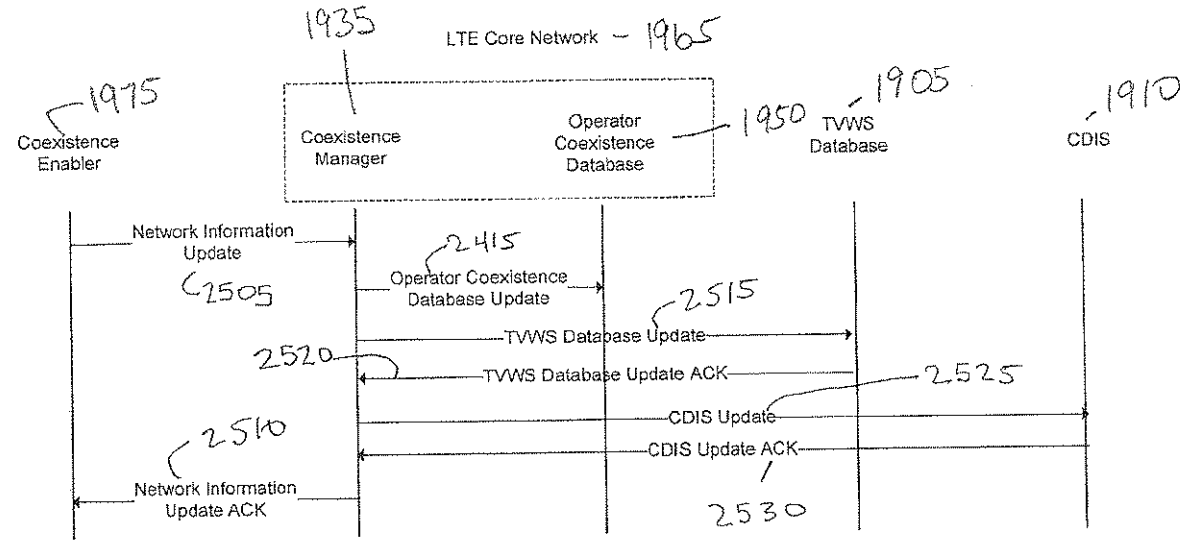


Figure 25

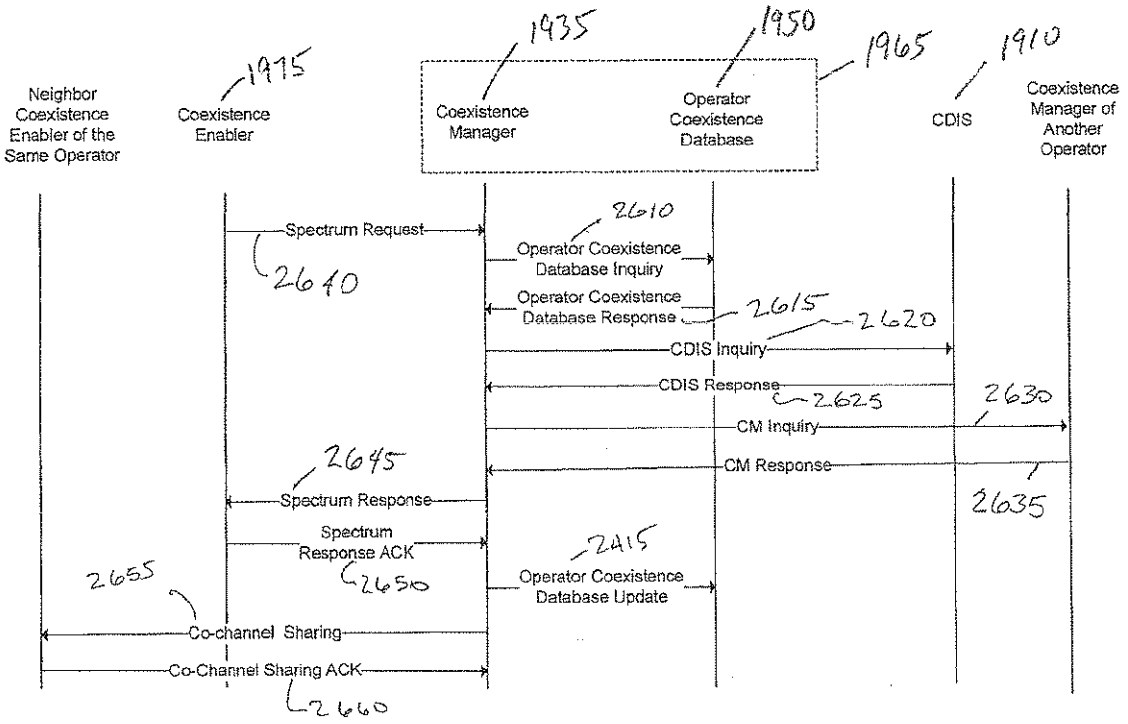

1935
1950
1965
1910
1975
Neighbor Coexistence Enabler of the Same Operator
Coexistence Enabler
Coexistence Manager
Operator Coexistence Database
CDIS
Coexistence Manager of Another Operator
2610
Spectrum Request
Operator Coexistence Database Inquiry
2640
Operator Coexistence Database Response
2615
2620
CDIS Inquiry
CDIS Response
2625
2630
CM Inquiry
CM Response
2635
2645
Spectrum Response
Spectrum Response ACK
2650
2415
Operator Coexistence Database Update
2655
Co-channel Sharing
Co-Channel Sharing ACK
2660

Figure 26

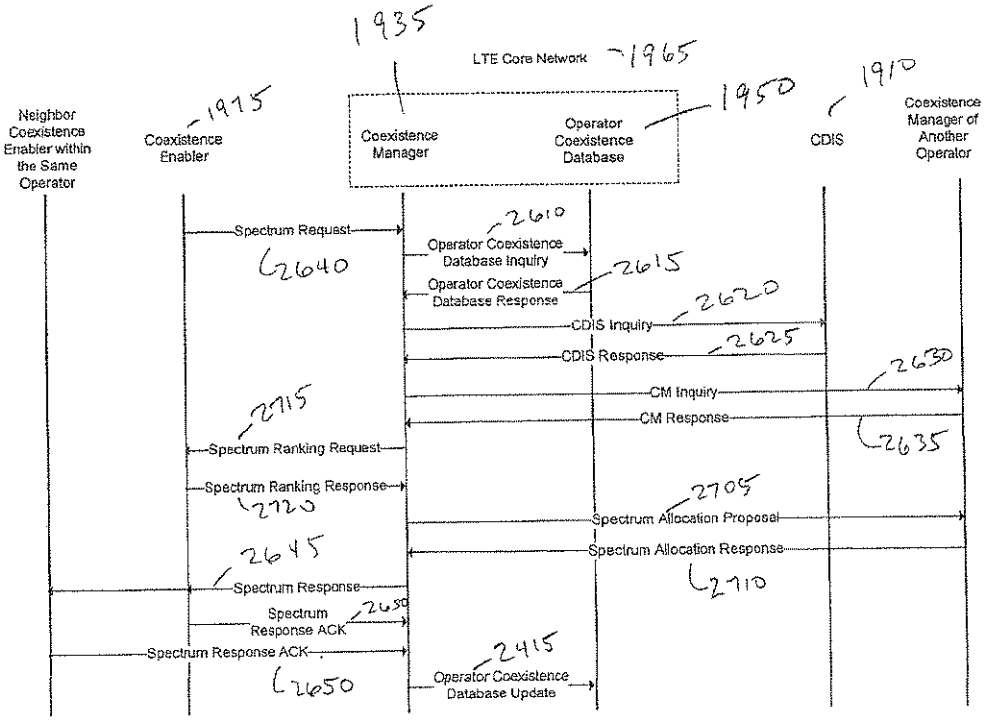

1935
LTE Core Network
1965
Neighbor Coexistence Enabler within the Same Operator
Coexistence Enabler
1975
Coexistence Manager
Operator Coexistence Database
1950
CDIS
1910
Coexistence Manager of Another Operator
Spectrum Request
2610
Operator Coexistence Database Inquiry
2640
2615
Operator Coexistence Database Response
2620
CDIS Inquiry
2625
CDIS Response
2630
CM Inquiry
CM Response
2635
2715
Spectrum Ranking Request
Spectrum Ranking Response
2720
2705
Spectrum Allocation Proposal
Spectrum Allocation Response
2710
2645
Spectrum Response
Spectrum Response ACK
2650
Spectrum Response ACK
2415
Operator Coexistence Database Update

Figure 27

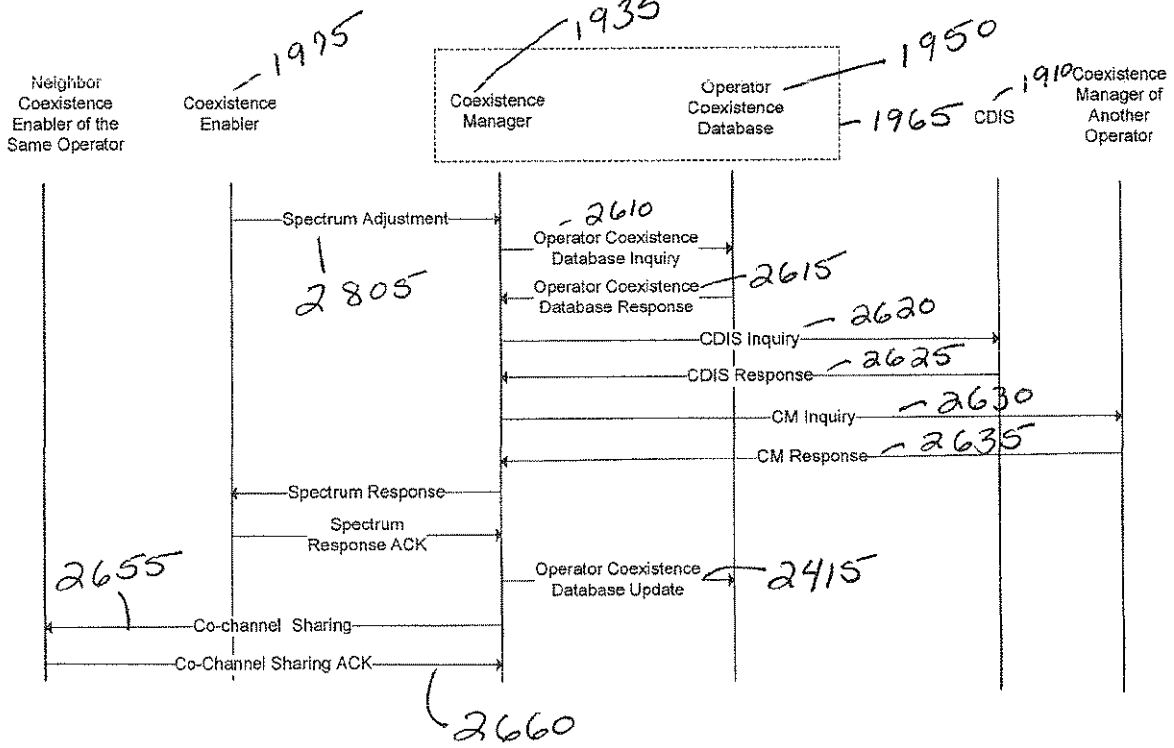

1935
1975
1950
1965
1910
Neighbor Coexistence Enabler of the Same Operator
Coexistence Enabler
Coexistence Manager
Operator Coexistence Database
CDIS
Coexistence Manager of Another Operator
Spectrum Adjustment
2610
Operator Coexistence Database Inquiry
2805
Operator Coexistence Database Response
2615
CDIS Inquiry
2620
CDIS Response
2625
CM Inquiry
2630
CM Response
2635
Spectrum Response
Spectrum Response ACK
2655
Operator Coexistence Database Update
2415
Co-channel Sharing
Co-Channel Sharing ACK
2660

Figure 28

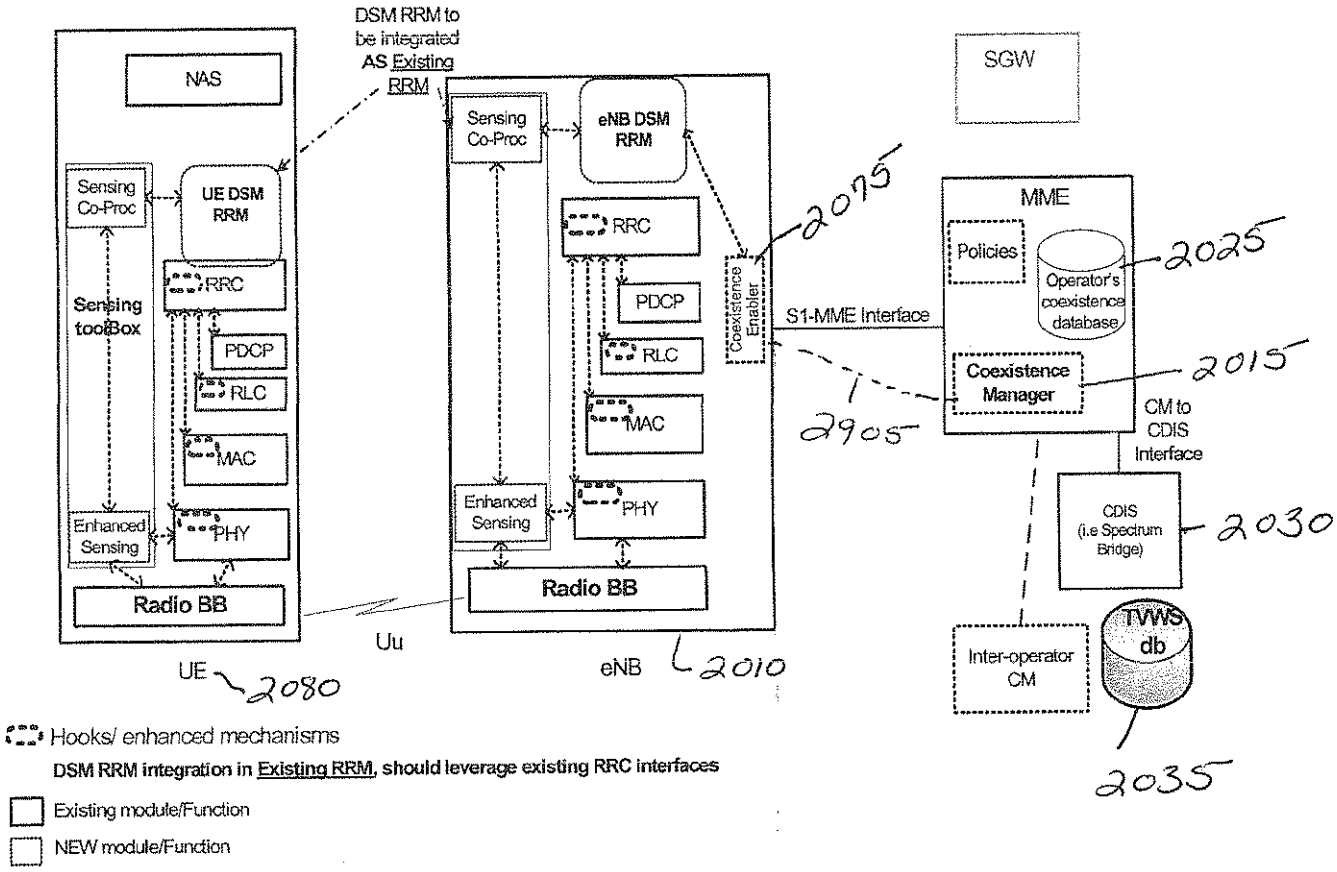

DSM RRM to be integrated AS Existing RRM
NAS
Sensing Co-Proc
UE DSM RRM
Sensing toolBox
RRC
PDCP
RLC
MAC
PHY
Enhanced Sensing
Radio BB
UE
2080
Uu
Sensing Co-Proc
eNB DSM RRM
RRC
PDCP
RLC
MAC
PHY
Enhanced Sensing
Radio BB
eNB
2010
Coexistence Enabler
2075
S1-MME Interface
2905
SGW
MME
Policies
Operator's coexistence database
2025
Coexistence Manager
2015
CM to CDIS Interface
CDIS (i.e Spectrum Bridge)
2030
Inter-operator CM
TVWS db
2035
Hooks/ enhanced mechanisms
DSM RRM integration in Existing RRM, should leverage existing RRC interfaces
Existing module/Function
NEW module/Function

Figure 29

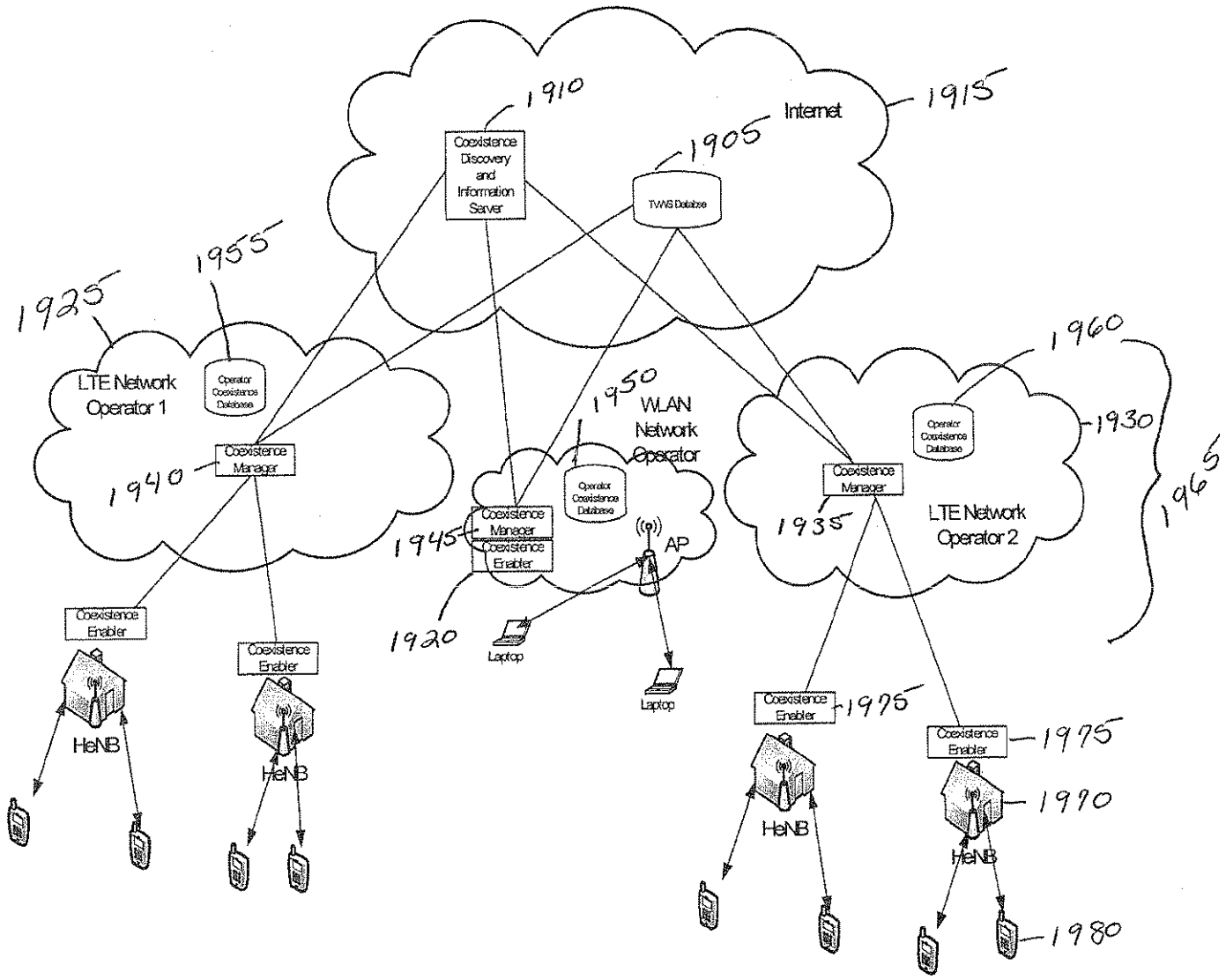

1910
Internet
1915
Coexistence Discovery and Information Server
1905
TVWS Database
1925
1955
LTE Network Operator 1
Operator Coexistence Database
Coexistence Manager
1940
1950
WLAN Network Operator
Operator Coexistence Database
1945
Coexistence Manager
Coexistence Enabler
AP
1920
Laptop
Laptop
1960
1930
Operator Coexistence Database
Coexistence Manager
1935
LTE Network Operator 2
1965
Coexistence Enabler
HeNB
Coexistence Enabler
HeNB
Coexistence Enabler
1975
HeNB
Coexistence Enabler
1975
1990
HeNB
1980

Figure 30

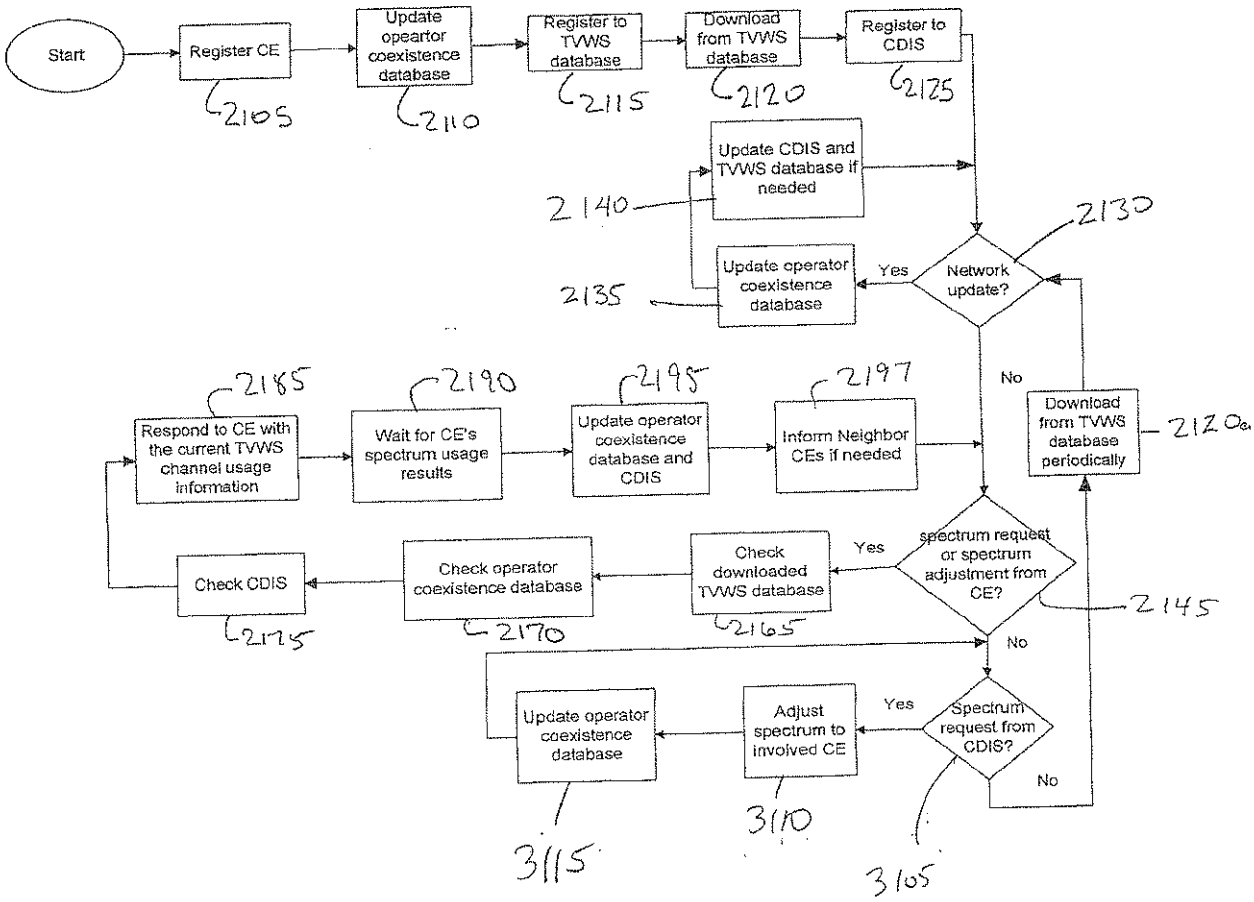

Start
Register CE
2105
Update opeartor coexistence database
2110
Register to TVWS database
2115
Download from TVWS database
2120
Register to CDIS
2125
Update CDIS and TVWS database if needed
2140
Update operator coexistence database
2135
Yes
Network update?
2130
No
Download from TVWS database periodically
2120a
Respond to CE with the current TVWS channel usage information
2185
Wait for CE's spectrum usage results
2190
Update operator coexistence database and CDIS
2195
Inform Neighbor CEs if needed
2197
spectrum request or spectrum adjustment from CE?
Yes
2145
Check downloaded TVWS database
2165
Check operator coexistence database
2170
Check CDIS
2175
No
Spectrum request from CDIS?
Yes
No
Adjust spectrum to involved CE
3110
Update operator coexistence database
3115
3105

Figure 31

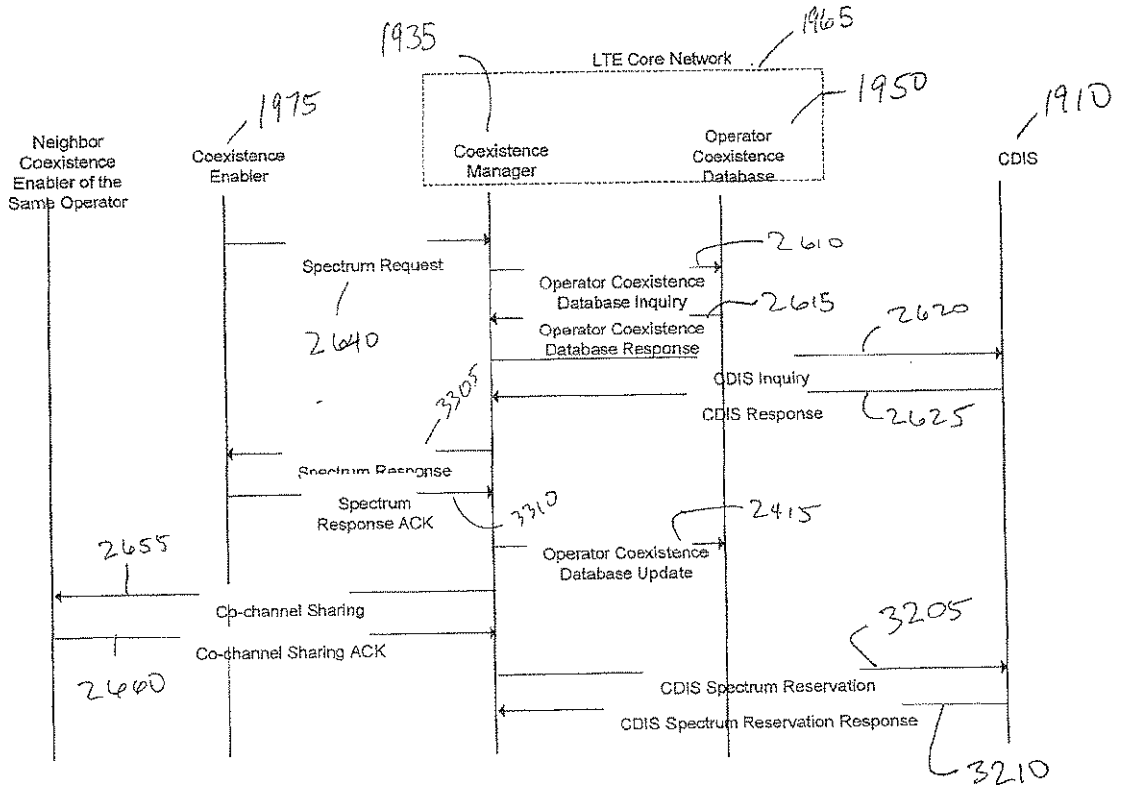

1935
1965
LTE Core Network
1950
1910
1975
Neighbor Coexistence Enabler of the Same Operator
Coexistence Enabler
Coexistence Manager
Operator Coexistence Database
CDIS
2610
Spectrum Request
Operator Coexistence Database Inquiry
2615
2620
2640
Operator Coexistence Database Response
CDIS Inquiry
3305
CDIS Response
2625
Spectrum Response
Spectrum Response ACK
3310
2415
2655
Operator Coexistence Database Update
Co-channel Sharing
3205
Co-channel Sharing ACK
2600
CDIS Spectrum Reservation
CDIS Spectrum Reservation Response
3210

Figure 32:

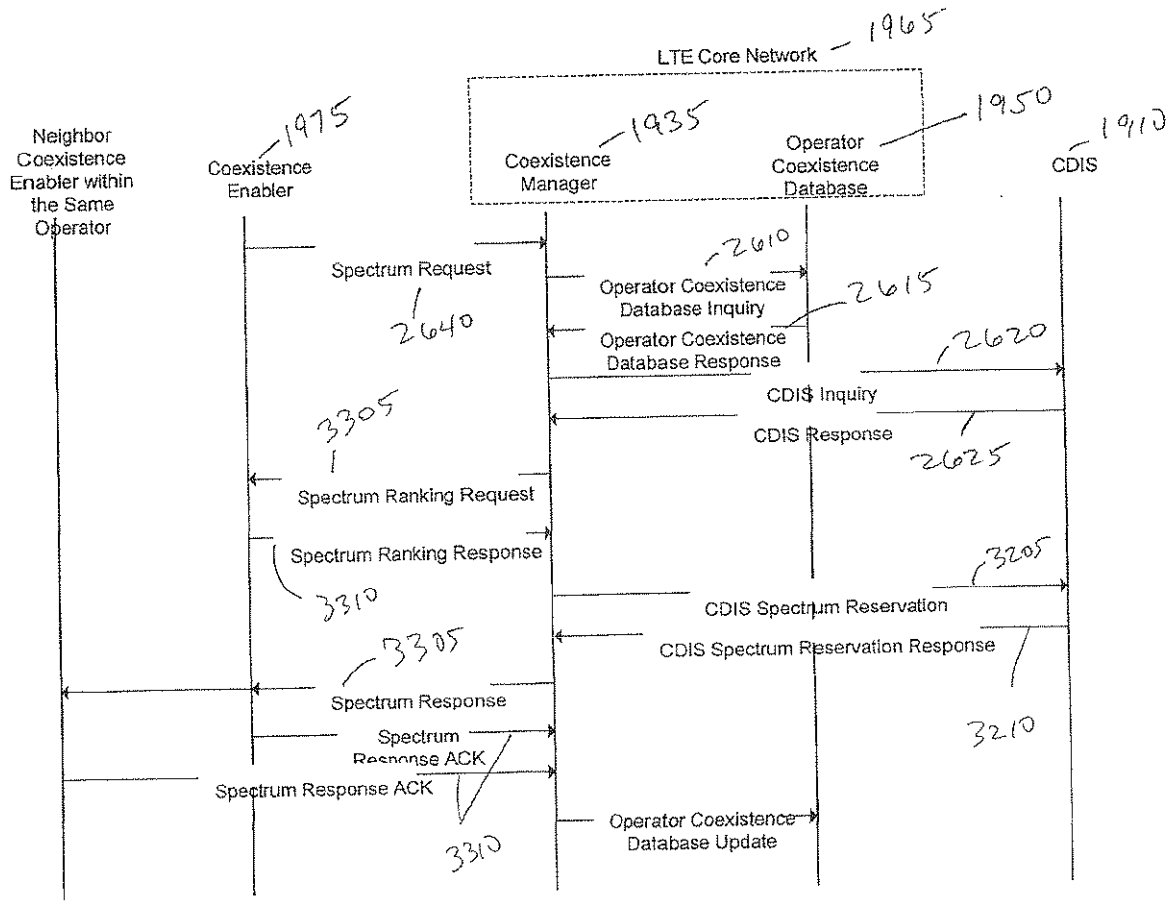

LTE Core Network
1965
Neighbor Coexistence Enabler within the Same Operator
Coexistence Enabler
1975
Coexistence Manager
1935
Operator Coexistence Database
1950
CDIS
1910
Spectrum Request
2640
Operator Coexistence Database Inquiry
2610
Operator Coexistence Database Response
2615
CDIS Inquiry
2620
CDIS Response
2625
3305
Spectrum Ranking Request
Spectrum Ranking Response
3310
CDIS Spectrum Reservation
3205
CDIS Spectrum Reservation Response
3210
3305
Spectrum Response
Spectrum Response ACK
Spectrum Response ACK
3310
Operator Coexistence Database Update

Figure 33