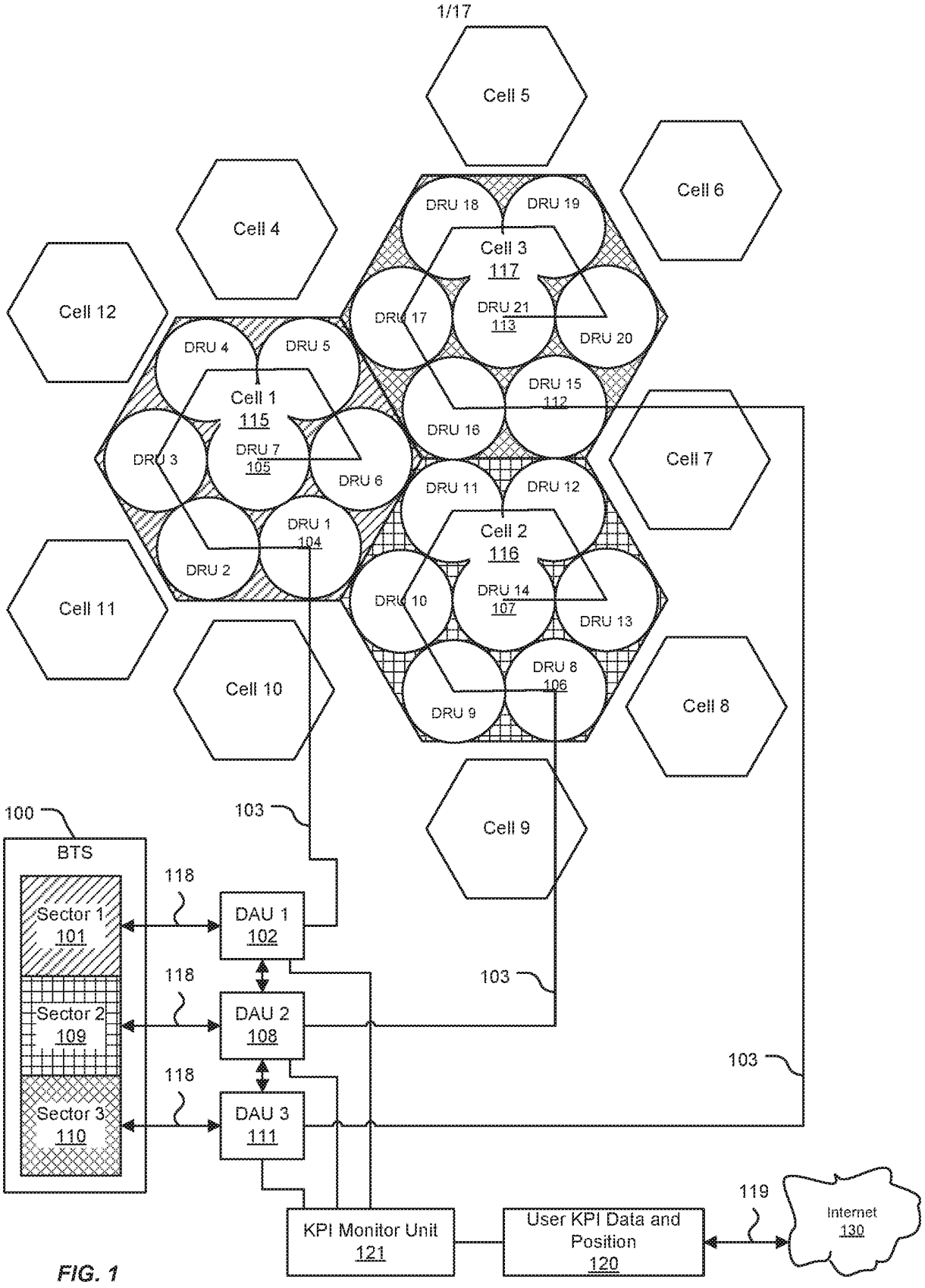

Cell 5
Cell 6
Cell 4
Cell 12
Cell 7
Cell 11
Cell 10
Cell 8
Cell 9
Cell 1
115
Cell 2
116
Cell 3
117
DRU 1
104
DRU 2
DRU 3
DRU 4
DRU 5
DRU 6
DRU 7
105
DRU 9
DRU 10
DRU 11
DRU 12
DRU 13
DRU 14
107
DRU 15
112
DRU 16
DRU 17
DRU 18
DRU 19
DRU 20
DRU 21
113
DRU 6
106
100
BTS
Sector 1
101
Sector 2
109
Sector 3
110
118
118
118
DAU 1
102
DAU 2
108
DAU 3
111
103
103
103
KPI Monitor Unit
121
User KPI Data and
Position
120
119
Internet
130

FIG. 1

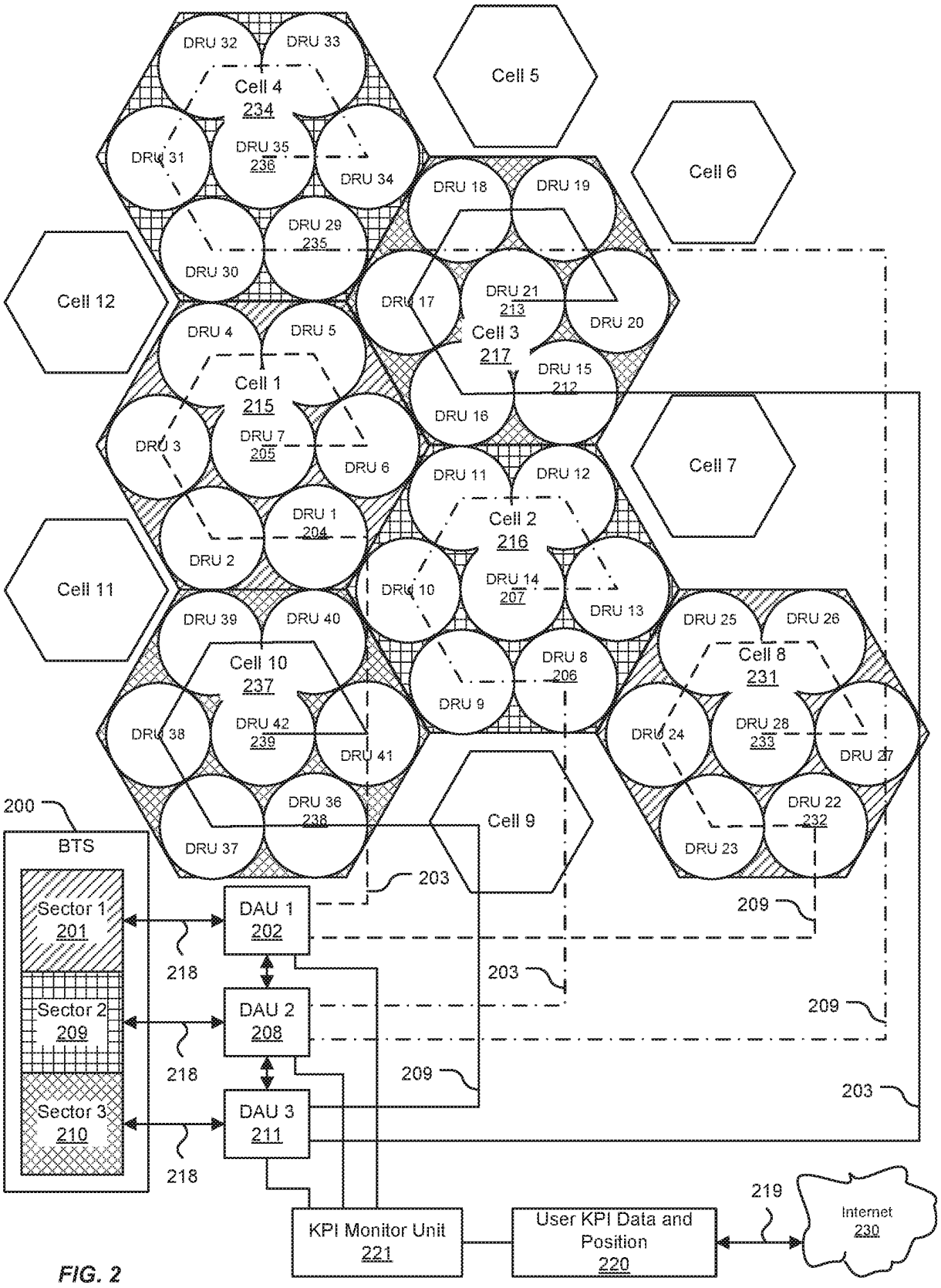

Cell 4
234
Cell 5
Cell 6
Cell 12
Cell 1
215
Cell 3
217
Cell 7
Cell 11
Cell 2
216
Cell 10
237
Cell 8
231
Cell 9
DRU 32
DRU 33
DRU 31
DRU 35
236
DRU 34
DRU 18
DRU 19
DRU 29
235
DRU 30
DRU 17
DRU 21
213
DRU 20
DRU 4
DRU 5
DRU 15
212
DRU 16
DRU 3
DRU 7
205
DRU 6
DRU 11
DRU 12
DRU 1
204
DRU 2
DRU 10
DRU 14
207
DRU 13
DRU 25
DRU 26
DRU 39
DRU 40
DRU 6
206
DRU 9
DRU 24
DRU 28
233
DRU 27
DRU 38
DRU 42
239
DRU 41
DRU 36
238
DRU 37
DRU 22
232
DRU 23
200
BTS
Sector 1
201
Sector 2
209
Sector 3
210
DAU 1
202
DAU 2
208
DAU 3
211
218
218
218
203
209
203
209
209
203
219
KPI Monitor Unit
221
User KPI Data and
Position
220
Internet
230

FIG. 2

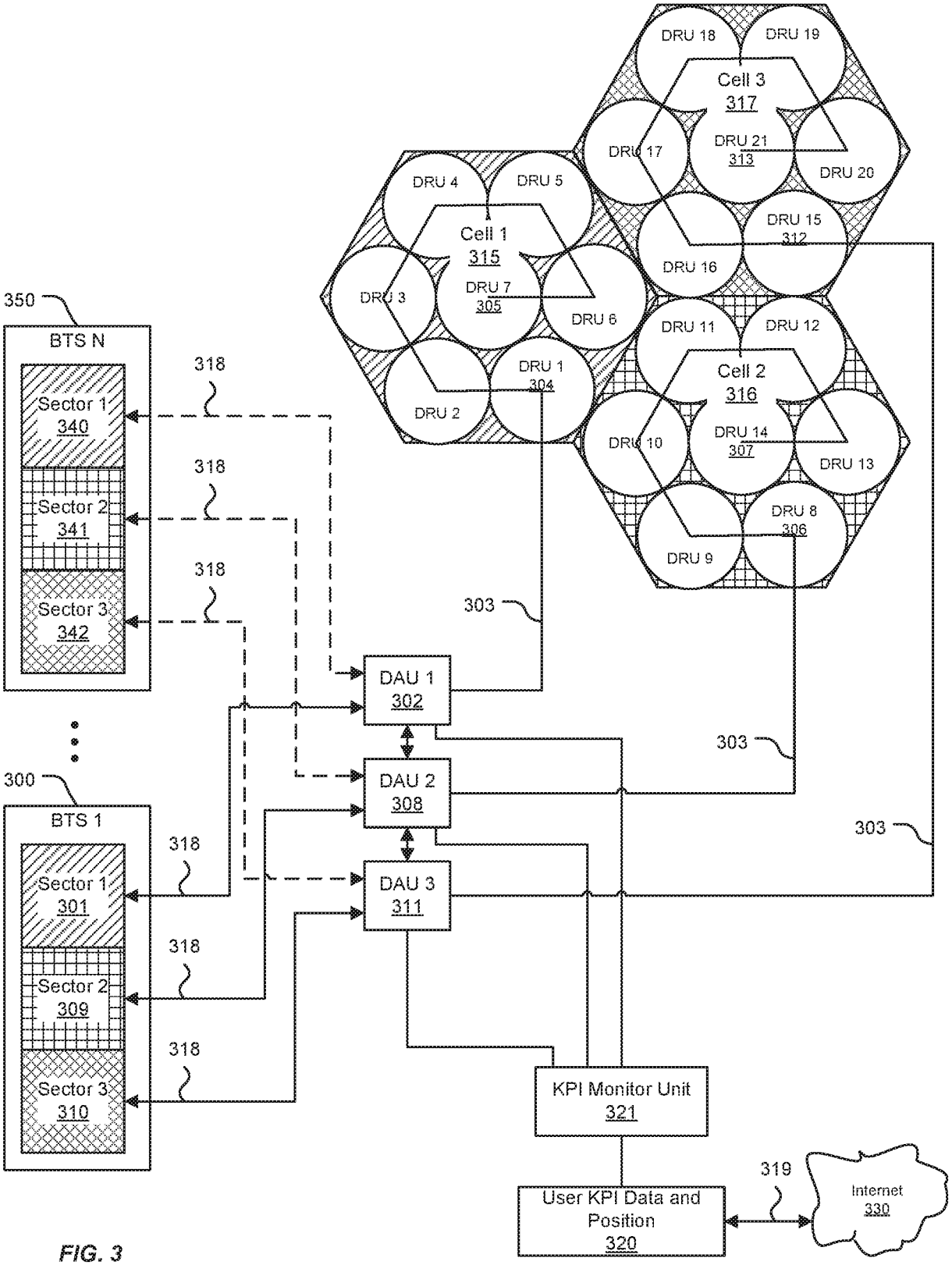

DRU 18
DRU 19
Cell 3
317
DRU 17
DRU 21
313
DRU 20
DRU 4
DRU 5
Cell 1
315
DRU 15
312
DRU 16
DRU 3
DRU 7
305
DRU 6
DRU 11
DRU 12
DRU 1
304
Cell 2
316
DRU 2
DRU 10
DRU 14
307
DRU 13
DRU 8
306
DRU 9
350
BTS N
Sector 1
340
Sector 2
341
Sector 3
342
318
318
318
303
303
303
DAU 1
302
DAU 2
308
DAU 3
311
300
BTS 1
Sector 1
301
Sector 2
309
Sector 3
310
318
318
318
KPI Monitor Unit
321
User KPI Data and
Position
320
319
Internet
330

FIG. 3

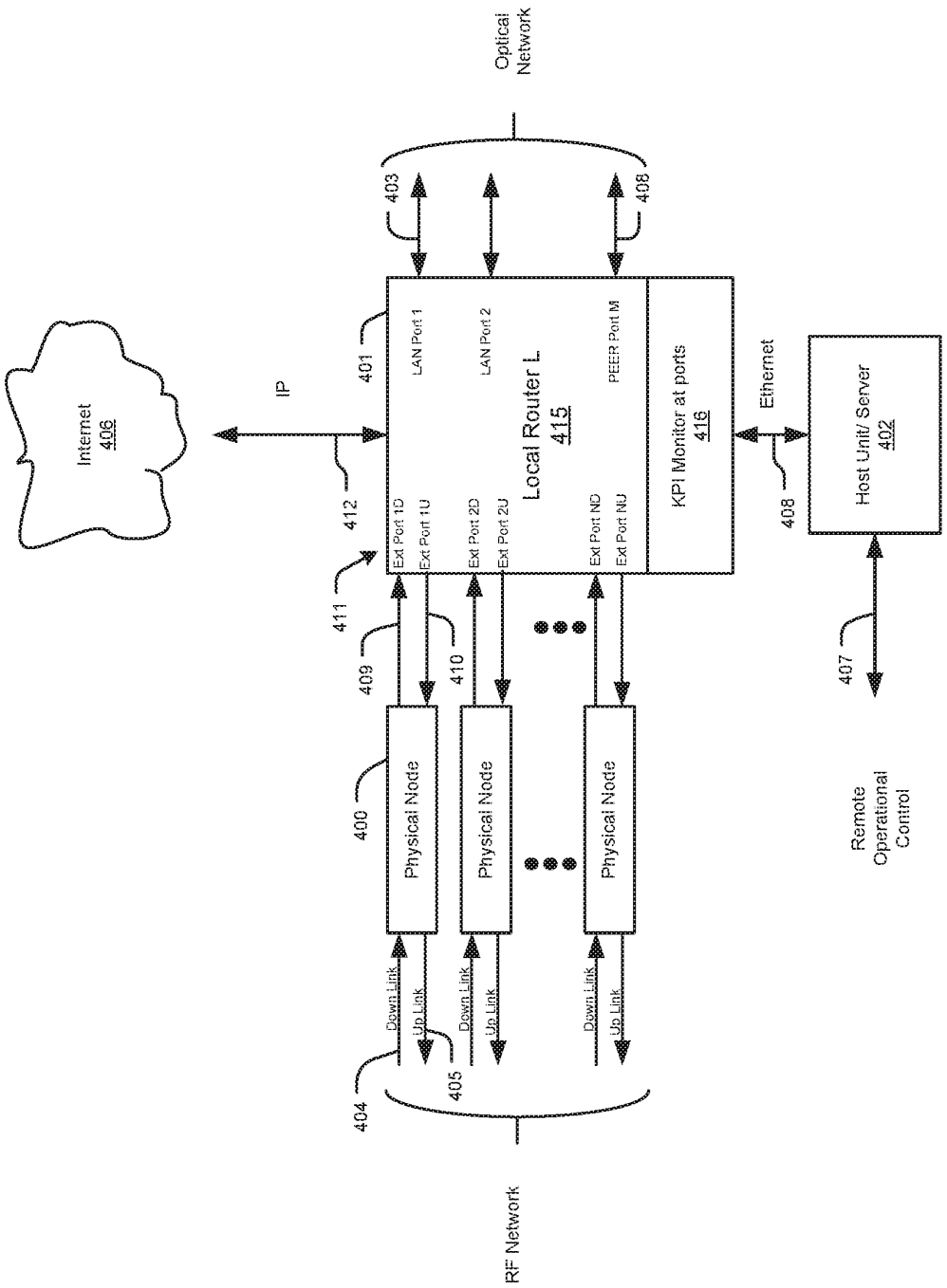

Optical Network
403
408
401
LAN Port 1
LAN Port 2
PEER Port M
Local Router L
415
KPI Monitor at ports
416
Ethernet
Host Unit/ Server
402
Internet
406
IP
412
Ext Port 1D
Ext Port 1U
Ext Port 2D
Ext Port 2U
Ext Port ND
Ext Port NU
411
409
410
408
407
Physical Node
400
Down Link
Up Link
404
405
RF Network
Remote Operational Control

FIG. 4

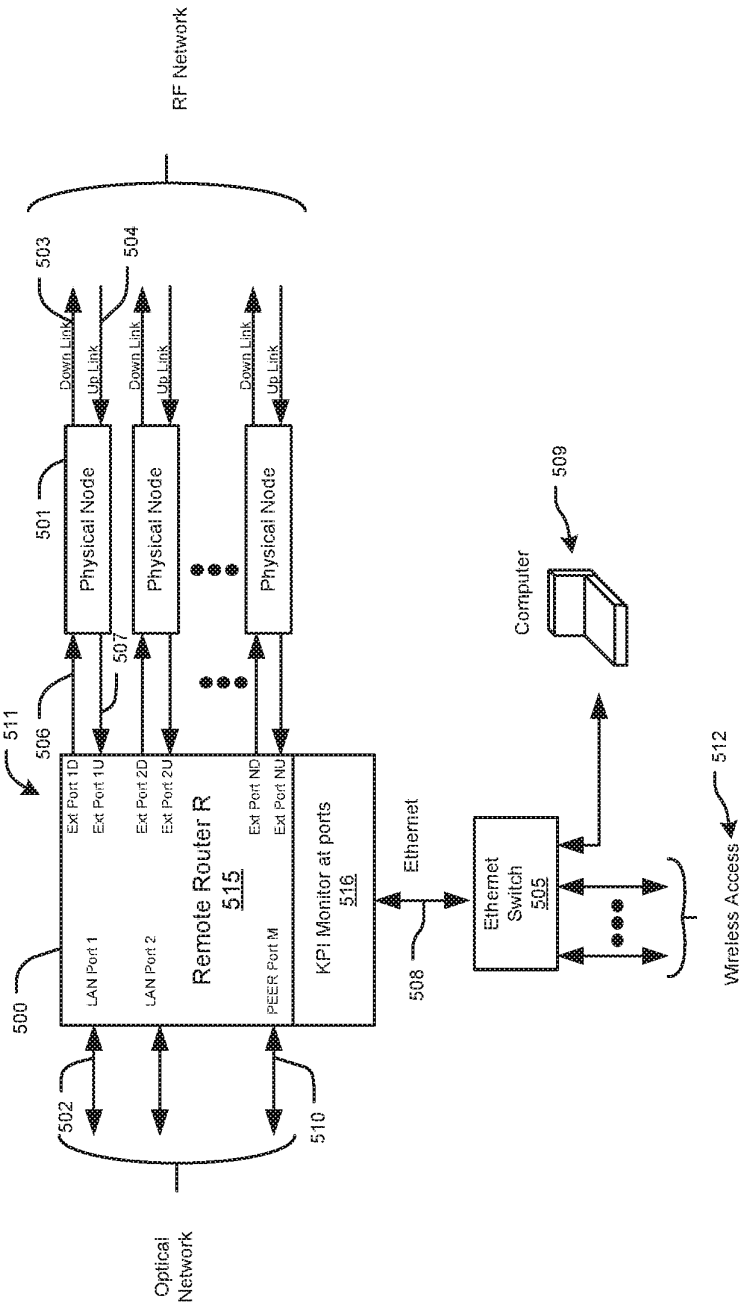

RF Network
503
504
Down Link
Up Link
Down Link
Up Link
Down Link
Up Link
501
Physical Node
Physical Node
Physical Node
507
511
506
Ext Port 1D
Ext Port 1U
Ext Port 2D
Ext Port 2U
Ext Port ND
Ext Port NU
LAN Port 1
LAN Port 2
Remote Router R
515
PEER Port M
KPI Monitor at ports
516
500
Ethernet
508
Ethernet
Switch
505
Computer
509
512
Wireless Access
Points
502
510
Optical
Network

FIG. 5

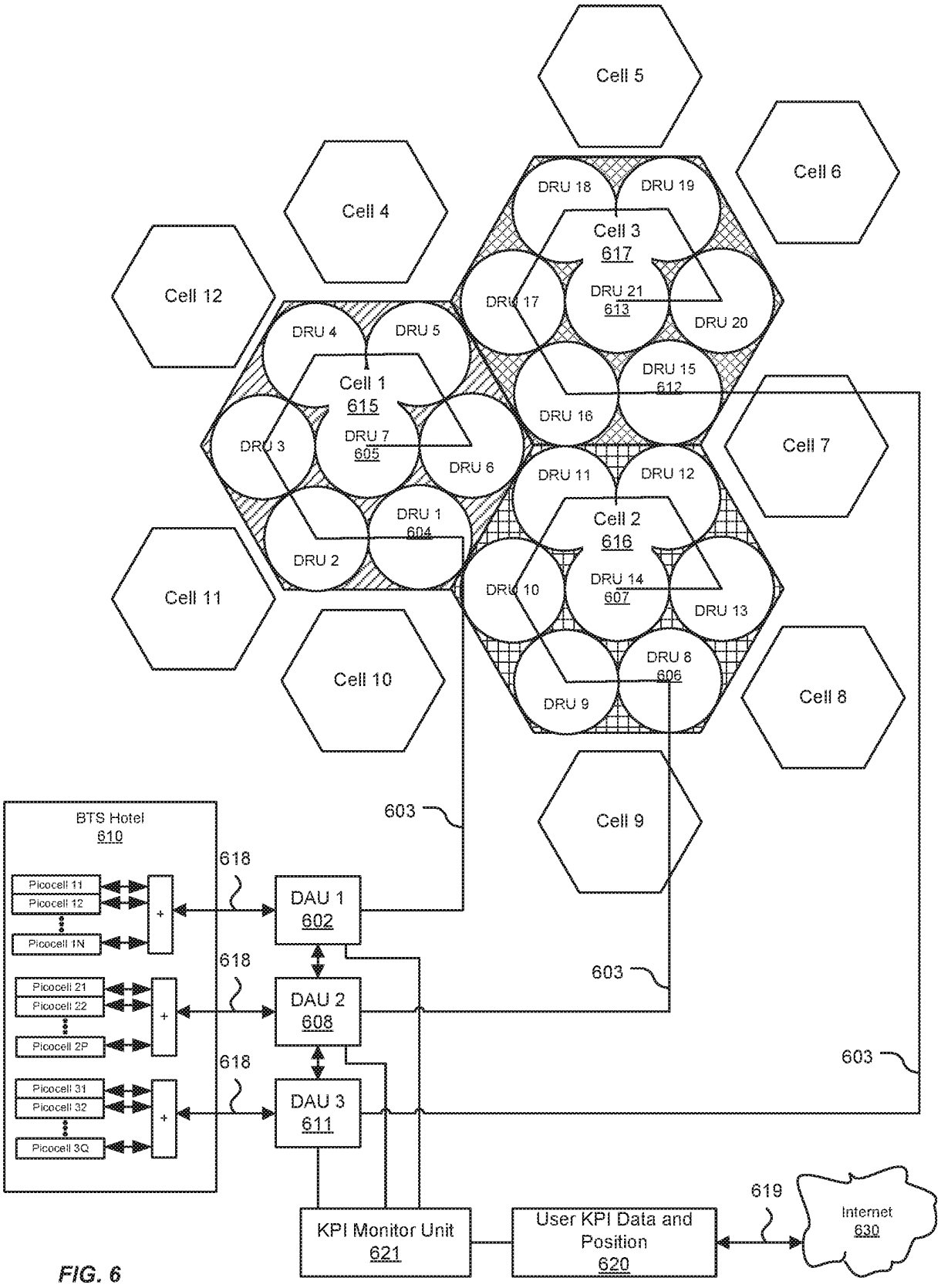

Cell 5
Cell 6
Cell 4
Cell 12
Cell 7
Cell 11
Cell 10
Cell 8
Cell 9
Cell 1
615
Cell 2
616
Cell 3
617
DRU 1
604
DRU 2
DRU 3
DRU 4
DRU 5
DRU 6
DRU 7
605
DRU 8
606
DRU 9
DRU 10
DRU 11
DRU 12
DRU 13
DRU 14
607
DRU 15
612
DRU 16
DRU 17
DRU 18
DRU 19
DRU 20
DRU 21
613
603
603
603
BTS Hotel
610
618
618
618
Picocell 11
Picocell 12
Picocell 1N
Picocell 21
Picocell 22
Picocell 2P
Picocell 31
Picocell 32
Picocell 3Q
DAU 1
602
DAU 2
608
DAU 3
611
KPI Monitor Unit
621
User KPI Data and Position
620
619
Internet
630

FIG. 6

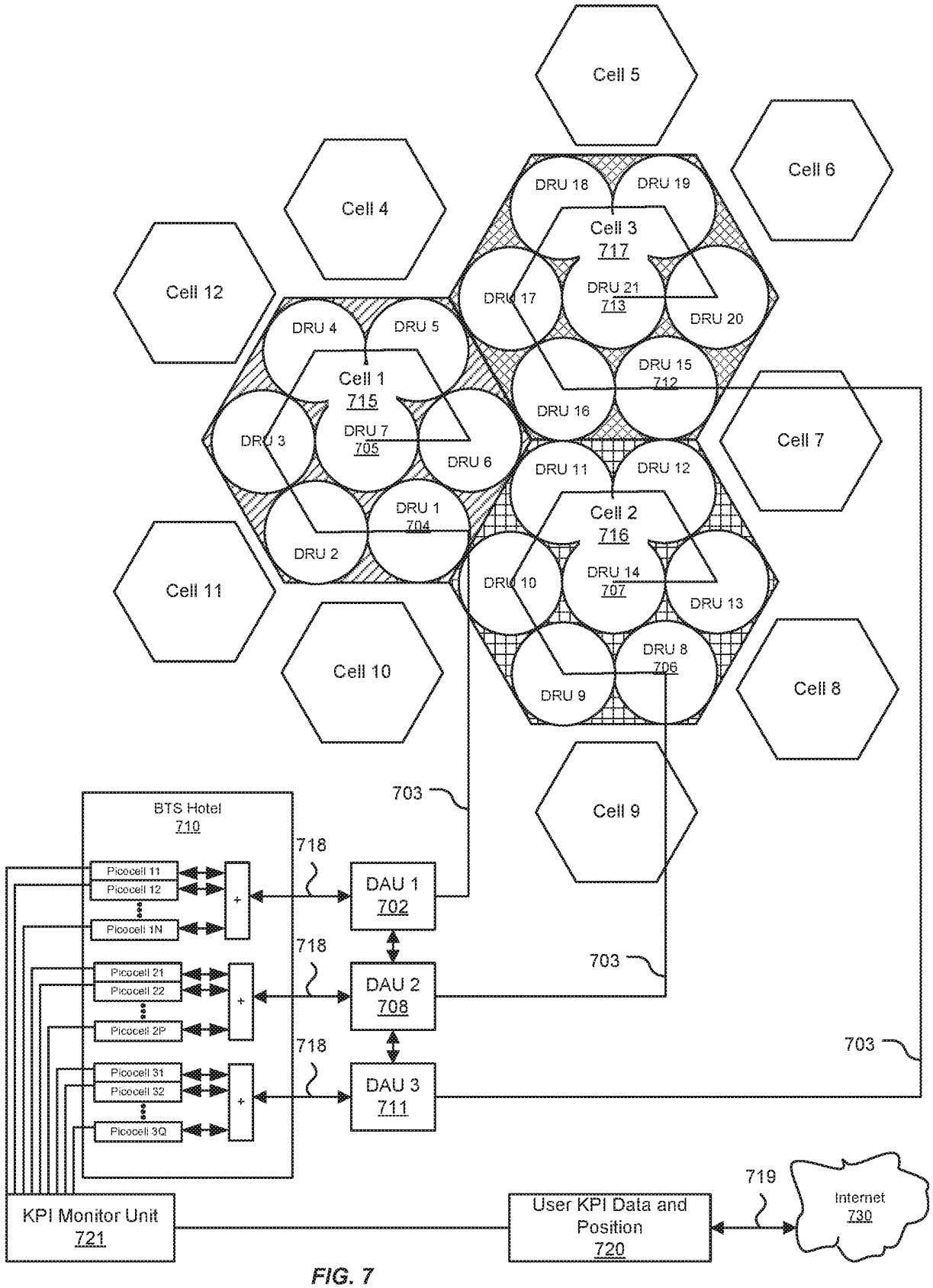

Cell 5
Cell 6
Cell 4
Cell 12
Cell 7
Cell 11
Cell 10
Cell 8
Cell 9
Cell 1
715
Cell 2
716
Cell 3
717
DRU 1
704
DRU 2
DRU 3
DRU 4
DRU 5
DRU 6
DRU 7
705
DRU 8
706
DRU 9
DRU 10
DRU 11
DRU 12
DRU 13
DRU 14
707
DRU 15
712
DRU 16
DRU 17
DRU 18
DRU 19
DRU 20
DRU 21
713
703
BTS Hotel
710
718
Picocell 11
Picocell 12
Picocell 1N
Picocell 21
Picocell 22
Picocell 2P
Picocell 31
Picocell 32
Picocell 3Q
DAU 1
702
DAU 2
708
DAU 3
711
KPI Monitor Unit
721
User KPI Data and
Position
720
719
Internet
730

FIG. 7

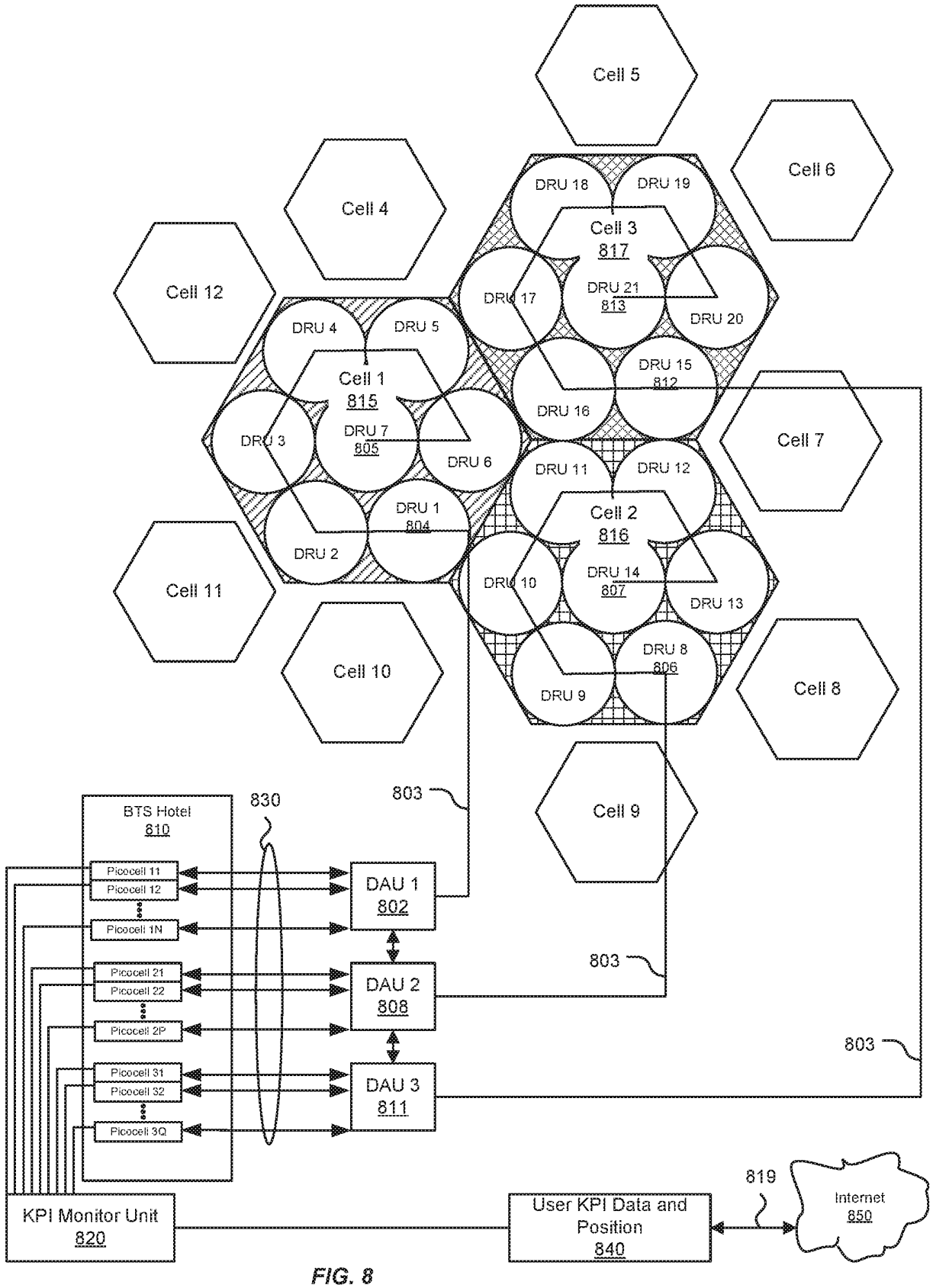

Cell 5
Cell 6
Cell 4
Cell 12
Cell 7
Cell 11
Cell 10
Cell 8
Cell 9
Cell 1
815
Cell 2
816
Cell 3
817
DRU 1
804
DRU 2
DRU 3
DRU 4
DRU 5
DRU 6
DRU 7
805
DRU 8
806
DRU 9
DRU 10
DRU 11
DRU 12
DRU 13
DRU 14
807
DRU 15
812
DRU 16
DRU 17
DRU 18
DRU 19
DRU 20
DRU 21
813
803
803
803
830
BTS Hotel
810
Picocell 11
Picocell 12
Picocell 1N
Picocell 21
Picocell 22
Picocell 2P
Picocell 31
Picocell 32
Picocell 3Q
DAU 1
802
DAU 2
808
DAU 3
811
KPI Monitor Unit
820
User KPI Data and Position
840
819
Internet
850

FIG. 8

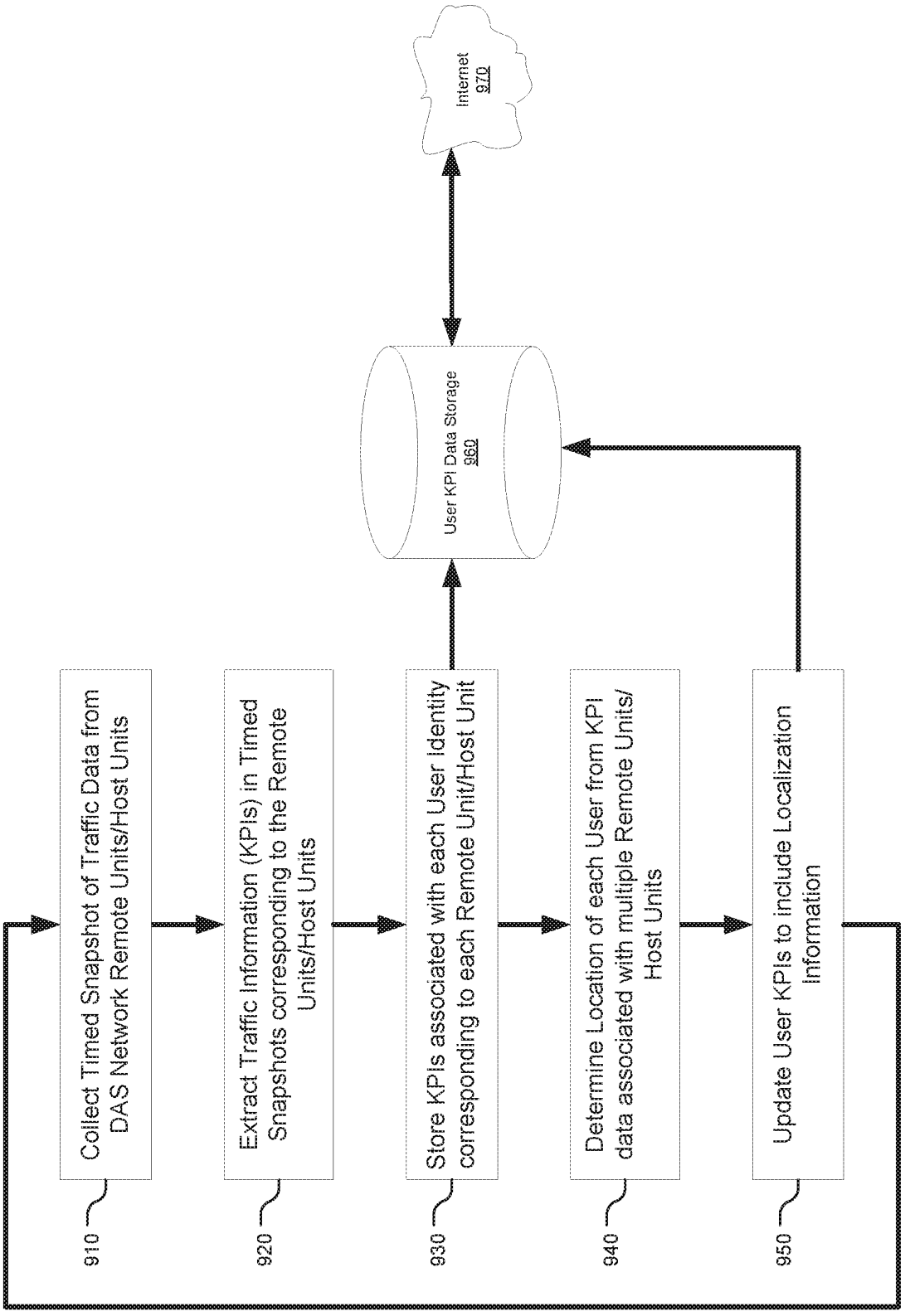

Internet
970
User KPI Data Storage
960
Collect Timed Snapshot of Traffic Data from DAS Network Remote Units/Host Units
910
Extract Traffic Information (KPIs) in Timed Snapshots corresponding to the Remote Units/Host Units
920
Store KPIs associated with each User Identity corresponding to each Remote Unit/Host Unit
930
Determine Location of each User from KPI data associated with multiple Remote Units/ Host Units
940
Update User KPIs to include Localization Information
950

FIG. 9

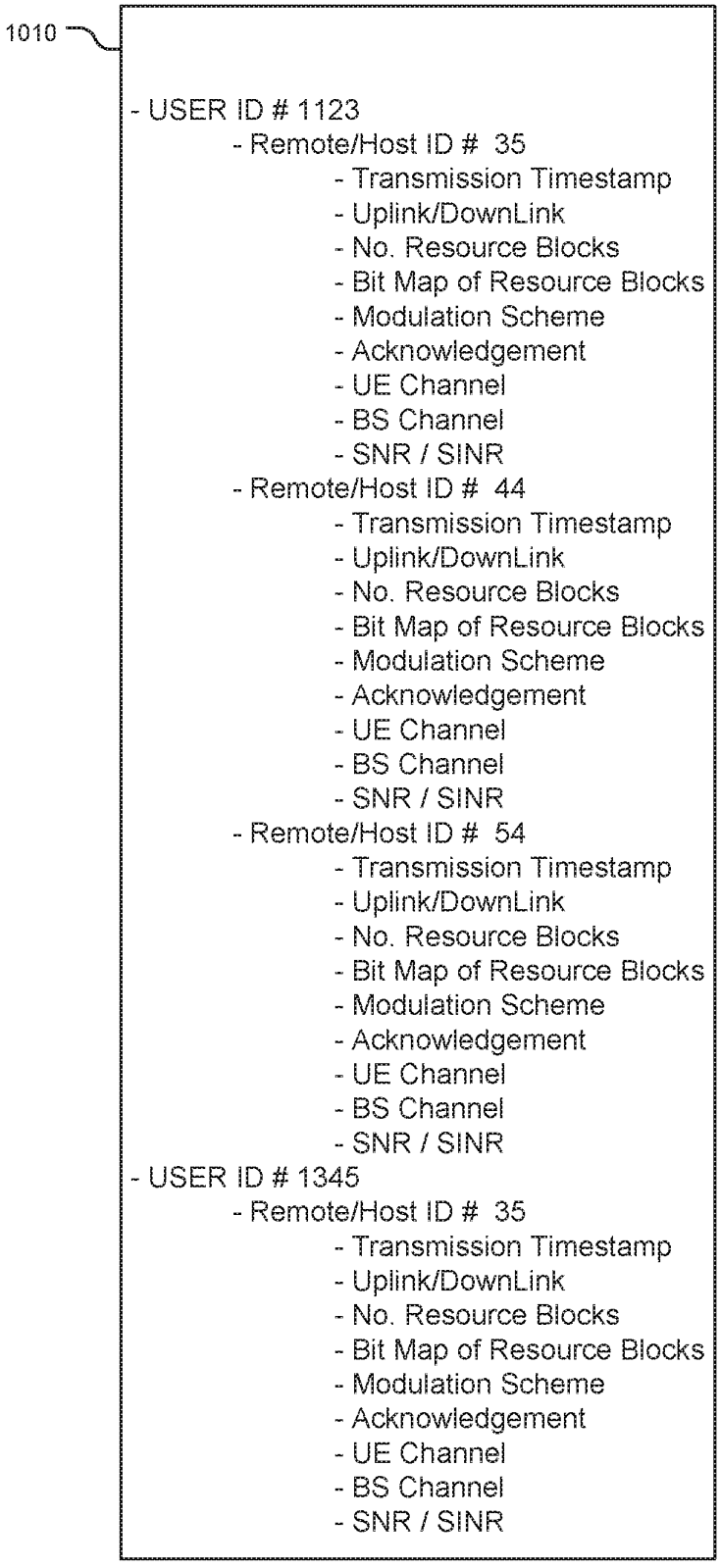

1010
- USER ID # 1123
- Remote/Host ID # 35
- Transmission Timestamp
- Uplink/DownLink
- No. Resource Blocks
- Bit Map of Resource Blocks
- Modulation Scheme
- Acknowledgement
- UE Channel
- BS Channel
- SNR / SINR
- Remote/Host ID # 44
- Transmission Timestamp
- Uplink/DownLink
- No. Resource Blocks
- Bit Map of Resource Blocks
- Modulation Scheme
- Acknowledgement
- UE Channel
- BS Channel
- SNR / SINR
- Remote/Host ID # 54
- Transmission Timestamp
- Uplink/DownLink
- No. Resource Blocks
- Bit Map of Resource Blocks
- Modulation Scheme
- Acknowledgement
- UE Channel
- BS Channel
- SNR / SINR
- USER ID # 1345
- Remote/Host ID # 35
- Transmission Timestamp
- Uplink/DownLink
- No. Resource Blocks
- Bit Map of Resource Blocks
- Modulation Scheme
- Acknowledgement
- UE Channel
- BS Channel
- SNR / SINR

FIG. 10

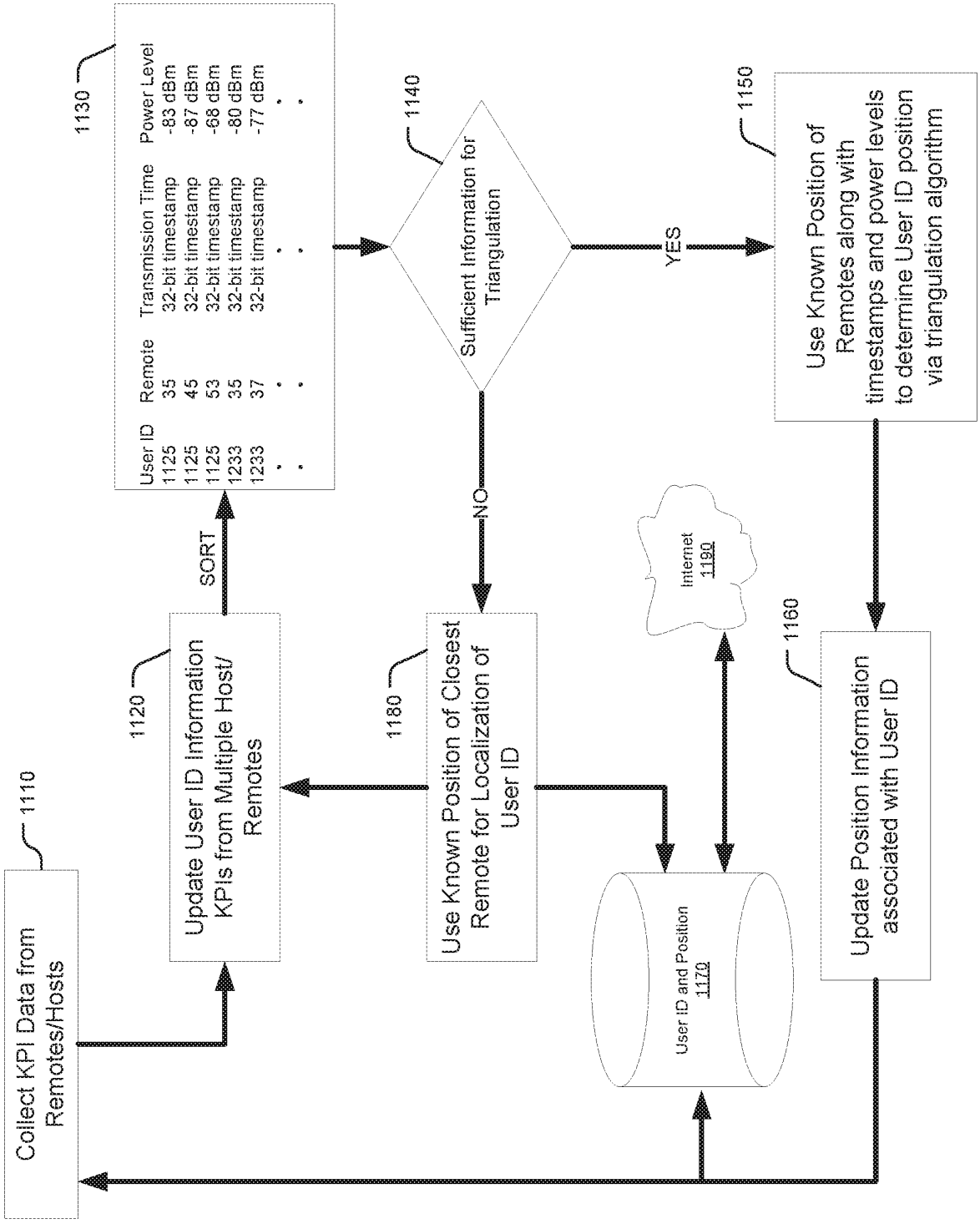

Collect KPI Data from Remotes/Hosts
1110
Update User ID Information KPIs from Multiple Host/ Remotes
1120
SORT
1130
User ID | Remote | Transmission Time | Power Level
1125 | 35 | 32-bit timestamp | -83 dBm
1125 | 45 | 32-bit timestamp | -87 dBm
1125 | 53 | 32-bit timestamp | -68 dBm
1233 | 35 | 32-bit timestamp | -80 dBm
1233 | 37 | 32-bit timestamp | -77 dBm
Sufficient Information for Triangulation
1140
NO
YES
Use Known Position of Closest Remote for Localization of User ID
1180
Use Known Position of Remotes along with timestamps and power levels to determine User ID position via triangulation algorithm
1150
Internet 1190
User ID and Position 1170
Update Position Information associated with User ID
1160

FIG. 11

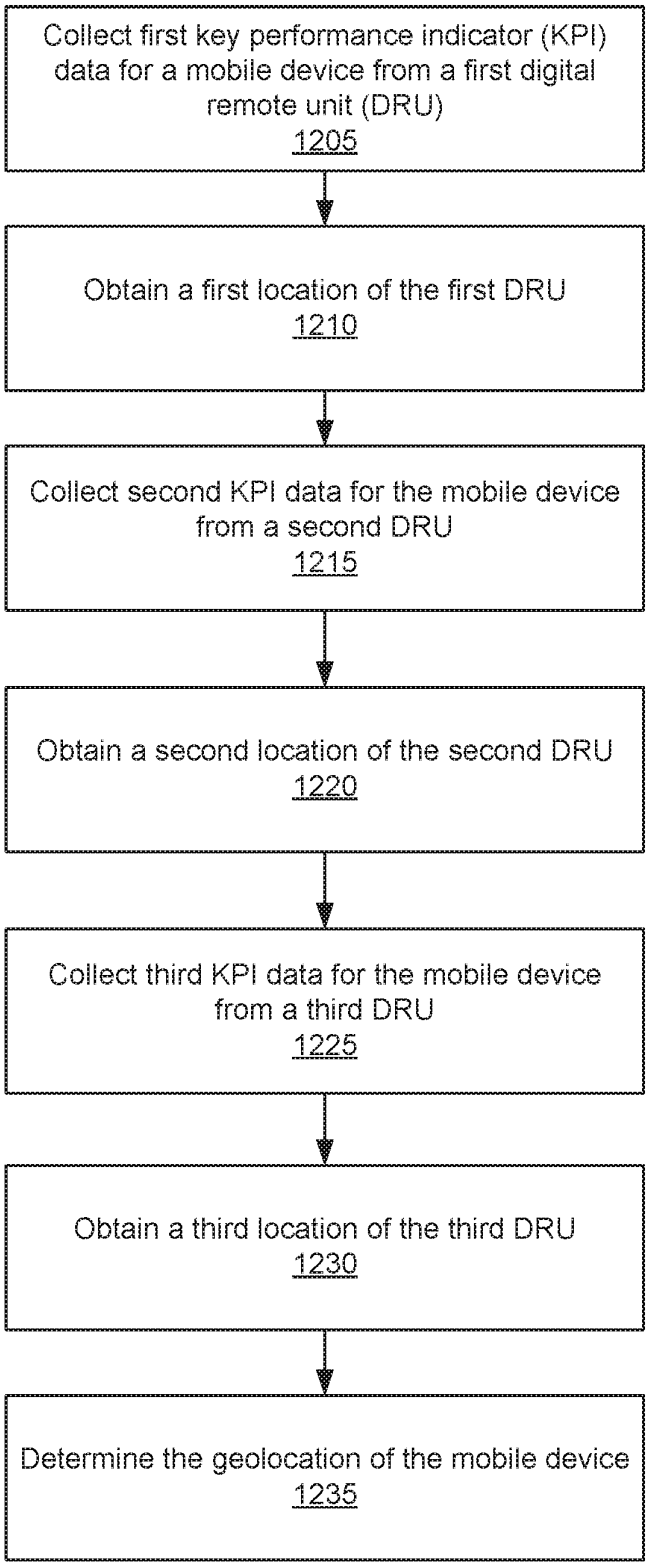

Collect first key performance indicator (KPI) data for a mobile device from a first digital remote unit (DRU)
1205
Obtain a first location of the first DRU
1210
Collect second KPI data for the mobile device from a second DRU
1215
Obtain a second location of the second DRU
1220
Collect third KPI data for the mobile device from a third DRU
1225
Obtain a third location of the third DRU
1230
Determine the geolocation of the mobile device
1235

FIG. 12

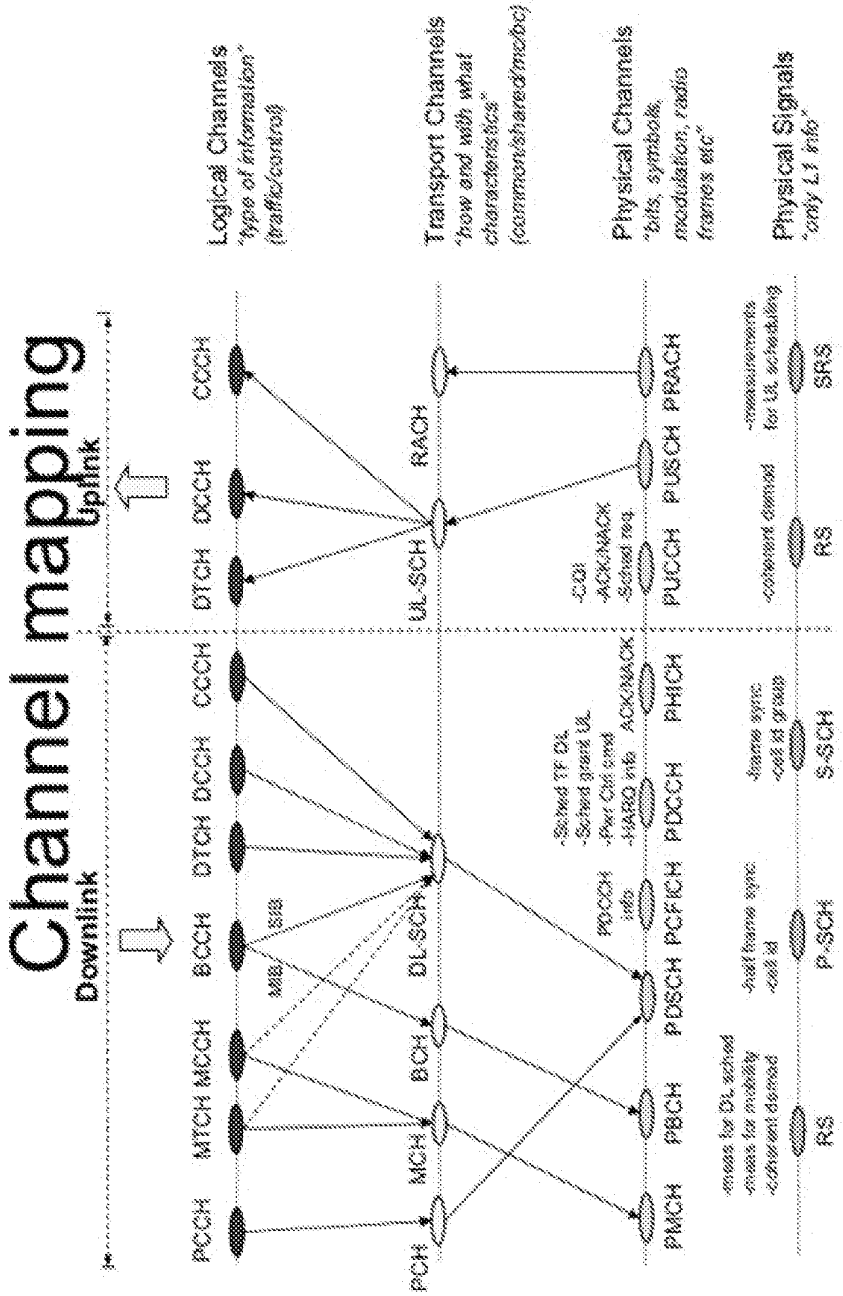

Channel mapping
Downlink
Uplink
Logical Channels
"type of information"
(traffic/control)
Transport Channels
"how and with what
characteristics"
(common/shared/mc/bc)
Physical Channels
"bits, symbols,
modulation, radio
frames etc"
Physical Signals
"only L1 info"
PCCH
MTCH
MCCH
BCCH
DTCH
DCCH
CCCH
DTCH
DCCH
CCCH
PCH
MCH
BCH
DL-SCH
UL-SCH
RACH
MIB
SIB
PMCH
PBCH
PDSCH
PCFICH
PDCCH
PHICH
PUCCH
PUSCH
PRACH
RS
P-SCH
S-SCH
RS
SRS
-Sched TF DL
-Sched grant UL
-Pwr Ctrl cmd
-HARQ info
ACK/NACK
-CQI
-ACK/NACK
-Sched req
PDCCH
info
-meas for DL sched
-meas for mobility
-Coherent demod
-Add frame sync
-cell id
-frame sync
-cell id groups
-coherent demod
-measurements
for UL scheduling

FIG. 13

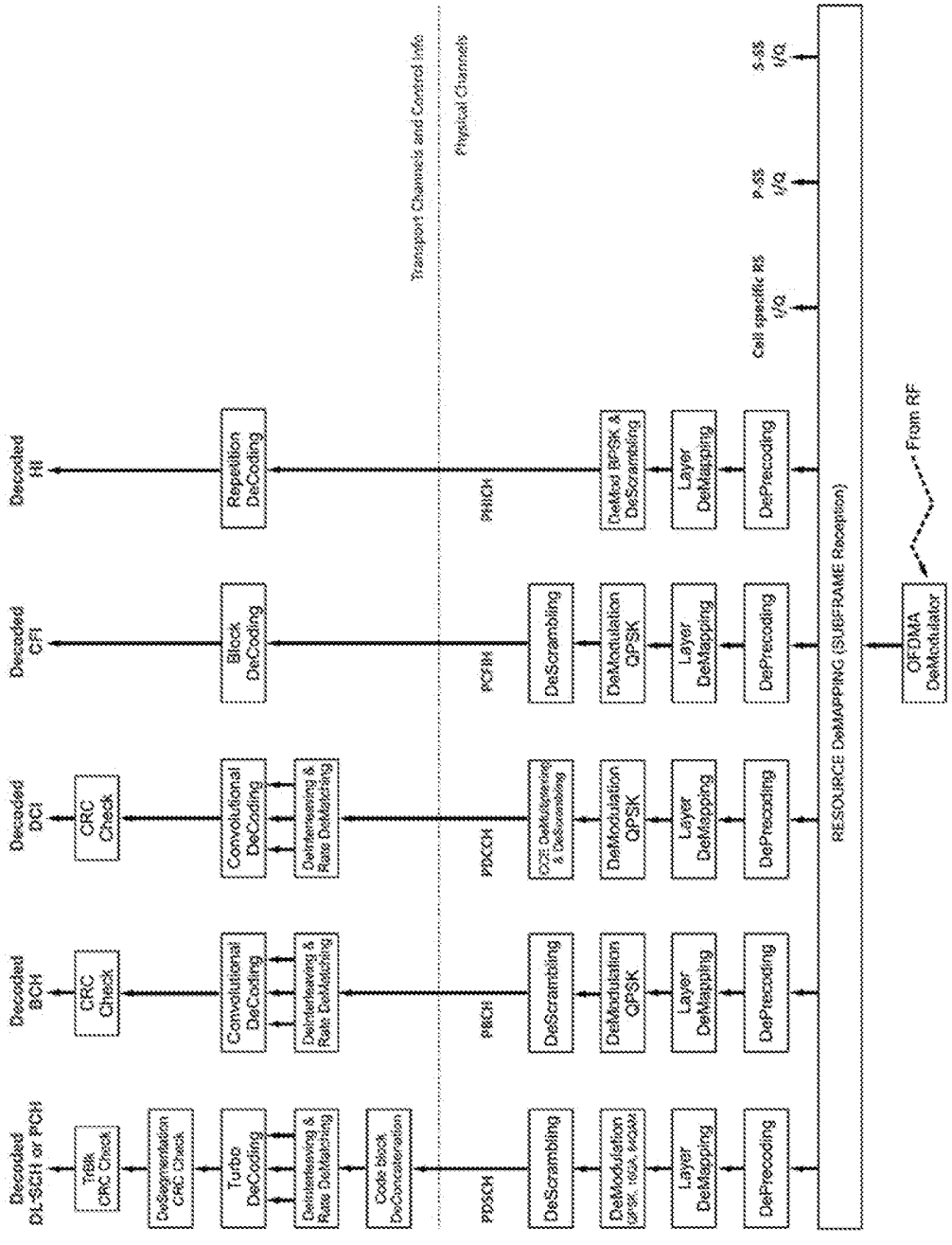

Decoded DL-SCH or PCH
Decoded BCH
Decoded DCI
Decoded CFI
Decoded HI
Transport Channels and Control Info
Physical Channels
TrBk CRC Check
DeSegmentation CRC Check
Turbo DeCoding
Deinterleaving & Rate DeMatching
Code block DeConcatenation
CRC Check
Convolutional DeCoding
Deinterleaving & Rate DeMatching
CRC Check
Convolutional DeCoding
Deinterleaving & Rate DeMatching
Block DeCoding
Repetition DeCoding
PDSCH
PBCH
PDCCH
PCFICH
PHICH
DeScrambling
DeModulation (QPSK, 16QA, 64QAM)
DeScrambling
DeModulation QPSK
DCI DeMultiplexing & DeScrambling
DeModulation QPSK
DeScrambling
DeModulation QPSK
DeMod BPSK & DeScrambling
Layer DeMapping
DePrecoding
Cell specific RS 1/3
P-SS 1/3
S-SS 1/3
RESOURCE DeMAPPING (SUBFRAME Reception)
OFDMA DeModulator
From RF

FIG. 14

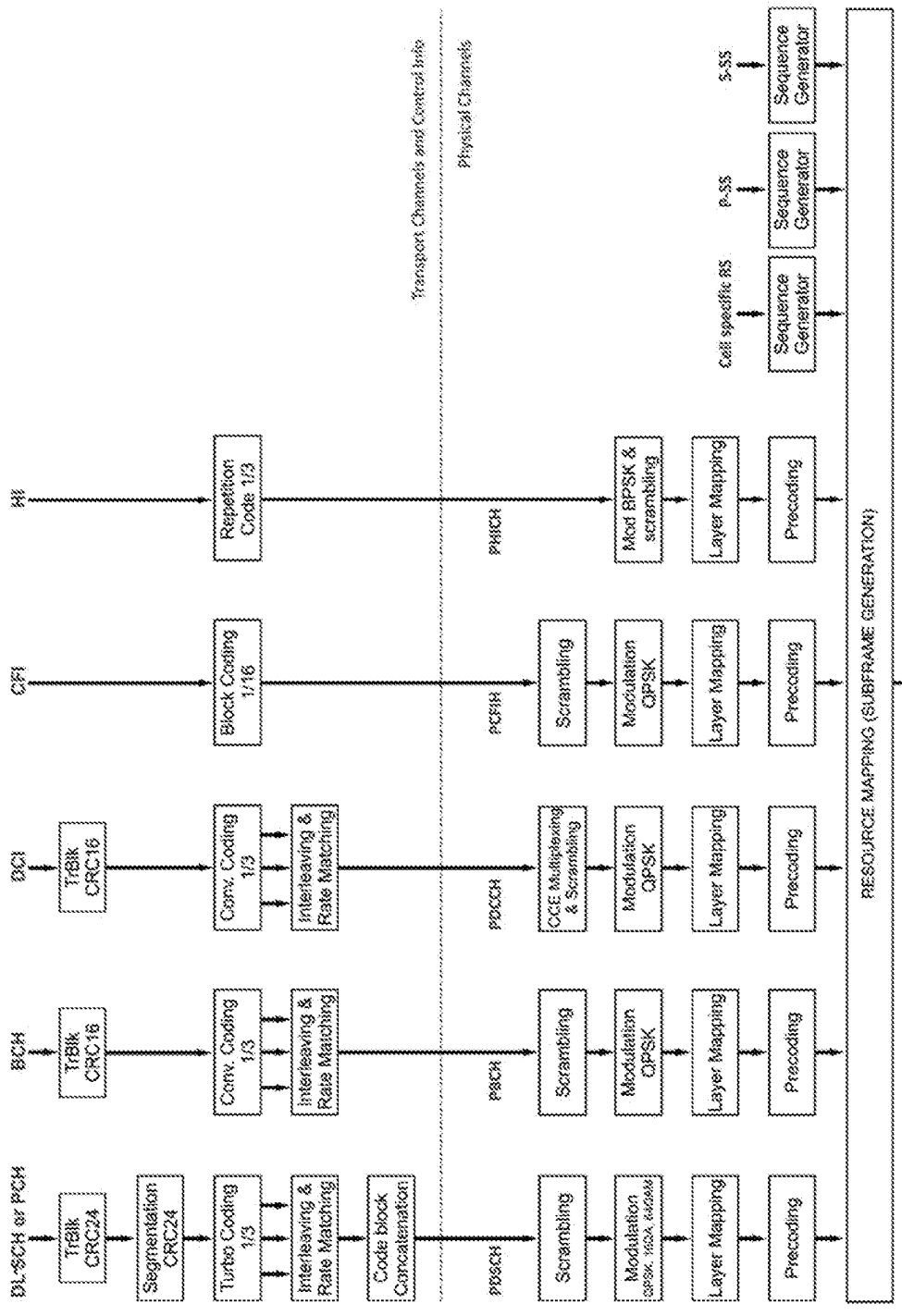

BCH or PCH
BCH
CFI
HI
TrBlk CRC24
TrBlk CRC16
Block Coding 1/16
Repetion Code 1/3
Segmentation CRC24
Conv. Coding 1/3
Turbo Coding 1/3
Interleaving & Rate Matching
Code block Concatenation
Transport Channels and Control Info
Physical Channels
PBCH
PDCCH
PCFICH
PHICH
Scrambling
CCE Multiplexing & Scrambling
Modulation QPSK
Mod BPSK & scrambling
Layer Mapping
Precoding
Cell specific RS
P-SS
S-SS
Sequence Generator
RESOURCE MAPPING (SUBFRAME GENERATION)
OFDMA Modulator
Towards RF

FIG. 15

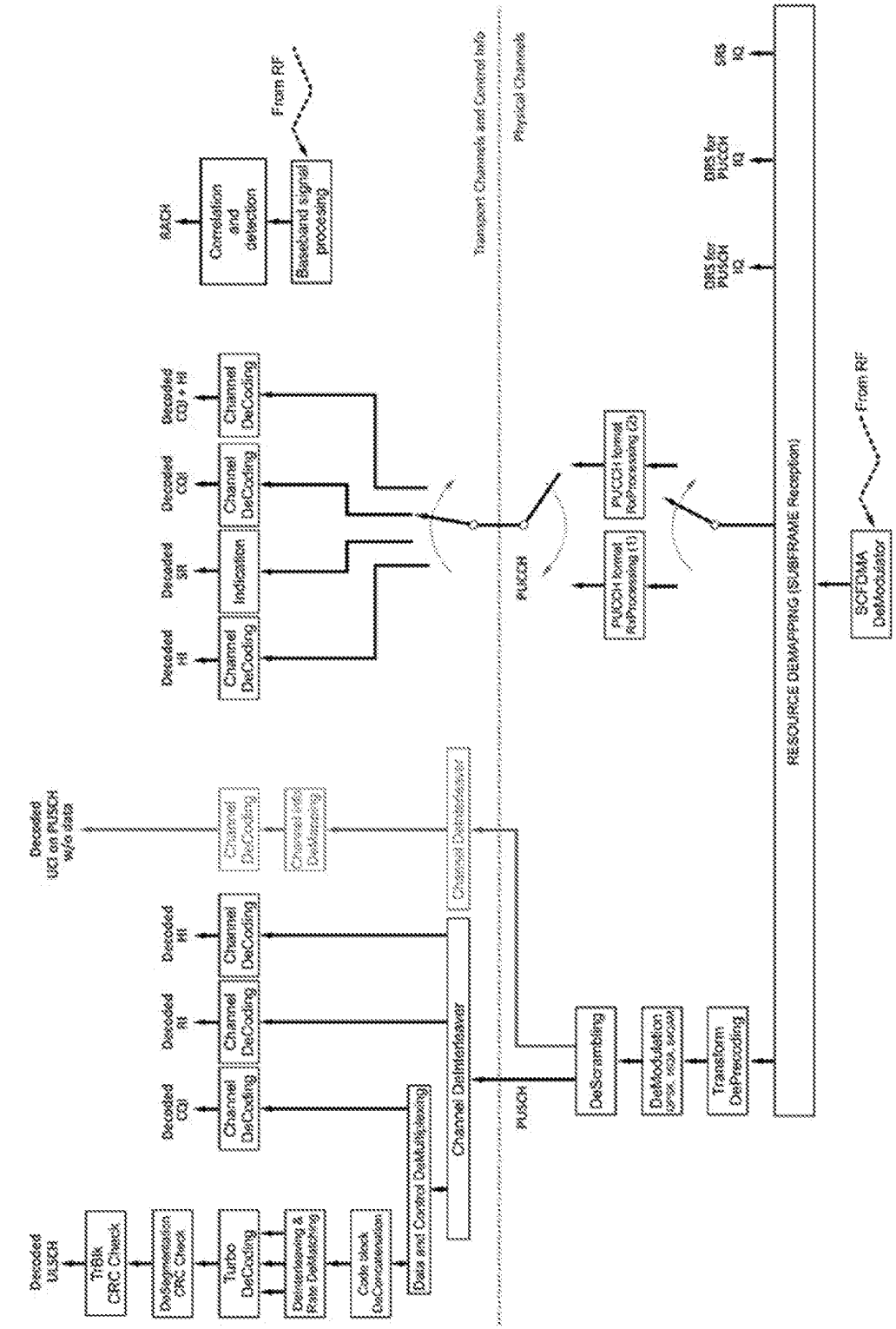

Decoded UL-SCH
TBlk CRC Check
DeSegmentation CRC Check
Turbo DeCoding
DeInterleaving & Rate DeMatching
Code block DeConcatenation
Data and Control DeMultiplexing
Channel DeInterleaver
Decoded CQI
Decoded RI
Decoded HI
Channel DeCoding
Decoded UCI on PUSCH w/o data
Channel DeCoding
Channel Info DeMapping
PUSCH
DeScrambling
DeModulation (QPSK, 16QAM, 64QAM)
Transform DePrecoding
Decoded CQI + HI
Decoded SR
Decoded HI
Channel DeCoding
Indication
Channel DeCoding
Channel DeCoding
RACH
Correlation and detection
Baseband signal processing
From RF
Transport Channels and Control Info
Physical Channels
PUCCH
PUCCH format 1a/1b/processing (1)
PUCCH format 2a/2b/processing (2)
RESOURCE DEMAPPING (SUBFRAME Reception)
DMRS for PUSCH #0
DMRS for PUSCH #1
SRS #0
SC-FDMA DeModulator
From RF

FIG. 16

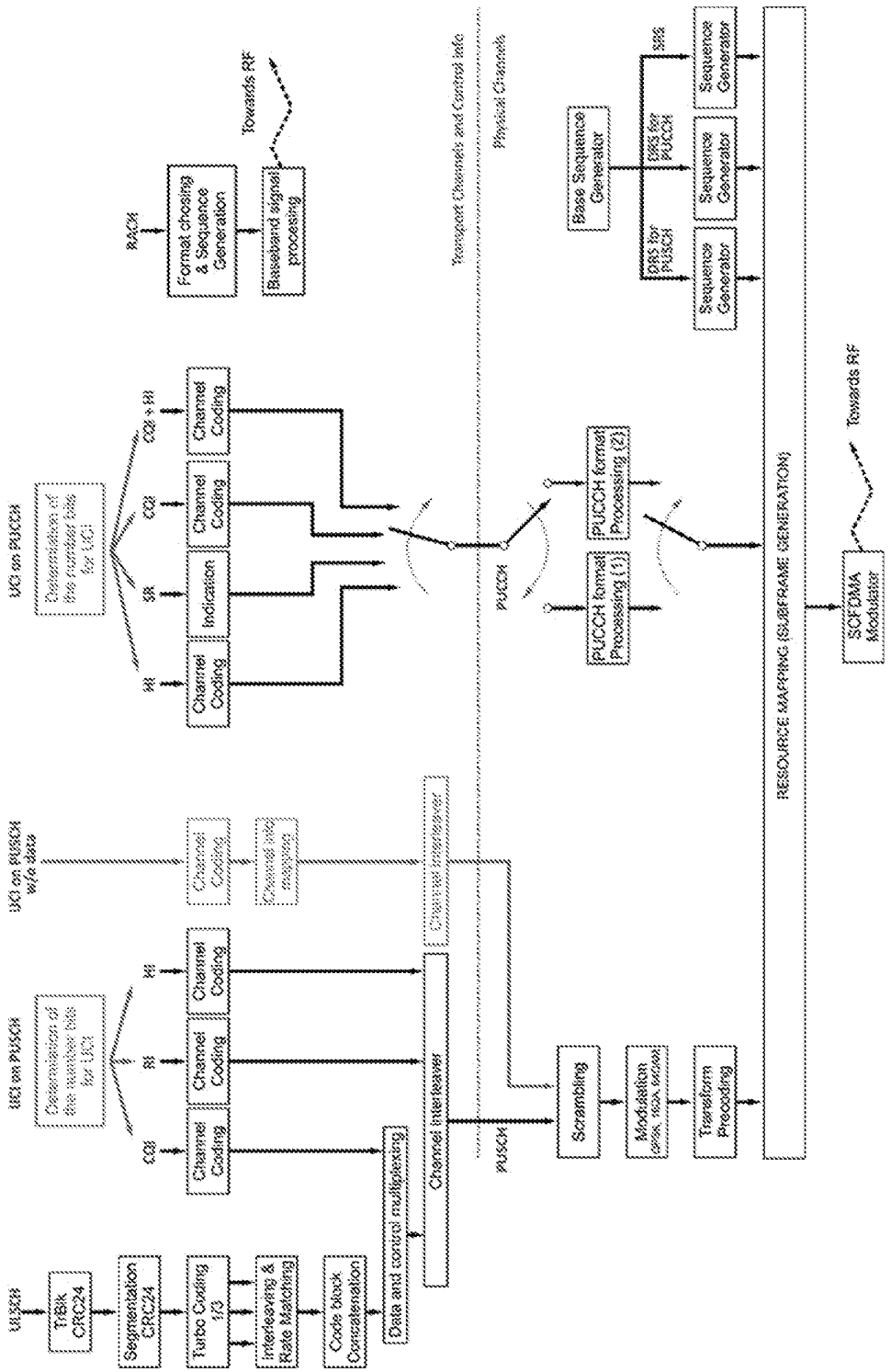

UL-SCH
TrBlk CRC24
Segmentation CRC24
Turbo Coding 1/3
Interleaving & Rate Matching
Code block Concatenation
Data and control multiplexing
Channel Interleaver
PUSCH
UCI on PUSCH
Determination of the number bits for UCI
CQI
RI
Channel Coding
UCI on PUSCH w/o data
Channel Coding
Channel Interleaver
Scrambling
Modulation QPSK, 16QAM, 64QAM
Transform Precoding
UCI on PUCCH
Determination of the number bits for UCI
CQI
SR
RI
CQI + RI
Channel Coding
Indication
RACH
Format chosing & Sequence Generation
Baseband signal processing
Towards RF
Transport Channels and Control info
Physical Channels
PUCCH
PUCCH format Processing (1)
PUCCH format Processing (2)
Base Sequence Generator
DRS for PUCCH
DRS for PUSCH
Sequence Generator
SRS
RESOURCE MAPPING (SUBFRAME GENERATION)
SC-FDMA Modulator
Towards RF

FIG. 17