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Soliman et al.

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(45) **Date of Patent: Feb. 23, 2016**

(54) **SYSTEM AND METHOD FOR TIMING AND FREQUENCY SYNCHRONIZATION BY A FEMTO ACCESS POINT**

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(73) Assignee: **QUALCOMM Incorporated**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1222 days.

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Related U.S. Application Data

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H04W 36/00 (2009.01)
H04W 56/00 (2009.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04W 56/0025*** (2013.01); *H04W 84/045* (2013.01); *H04W 92/10* (2013.01)

(58) **Field of Classification Search**
CPC ... H04W 84/045; H04W 84/18; H04W 24/10; H04W 36/08; H04W 52/247; H04W 8/26; H04W 36/04; H04W 52/283; H04W 8/005; H04W 52/288; H04W 52/367; H04W 12/08; H04W 28/18; H04W 4/206; H04W 52/244; H04W 12/06; H04W 60/00; H04W 4/22; H04W 64/003; H04W 36/14; H04W 48/16; H04W 48/18; H04W 52/0206; H04W 36/00; H04W 76/06; H04W 84/12; H04L 63/101; H04L 63/18; H04L 63/164; H04L 1/0026; H04L 67/306
USPC 455/456.1, 422.1, 436, 411, 41.2, 455/67.13, 1, 432.1, 437, 458, 522, 63.1, 455/67.11, 103, 404.2, 408, 444, 450, 455/456.6; 370/328, 252, 329, 331, 254, 370/310, 338, 401
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,872,774 A 2/1999 Wheatley, III
5,898,929 A 4/1999 Haartsen
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1398079 A 2/2003
CN 1875648 A 12/2006
(Continued)

OTHER PUBLICATIONS

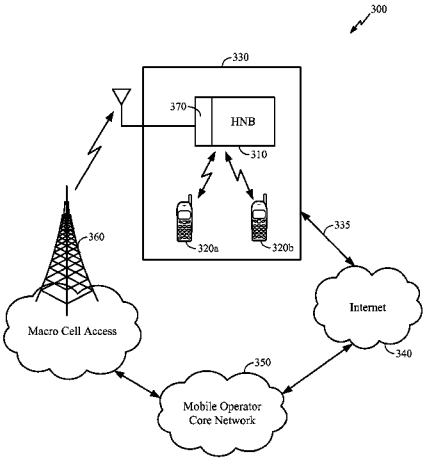
Yavuz M., et al., "Interference management and performance analysis of UMTS/HSPA+ femtocells", IEEE Communications Magazine, IEEE Service Center, Piscataway, US, vol. 47, No. 9, Sep. 1, 2009, pp. 102-109, XP011283371, ISSN: 0163-6804, DOI: 10.1109/MCOM.2009.5277462.
(Continued)

Primary Examiner — Fred Casca

(57) **ABSTRACT**

Techniques are provided for frequency and timing synchronization of a femto access point (FAP). In one example, the FAP may be configured to establish an out-of-band (OOB) link with at least user equipment (UE), and receive aiding parameters from the at least one UE via the OOB link. The FAP may be configured to extract frequency and timing information from at least one uplink packet of the at least one UE based at least in part on the aiding parameters. Extracting the frequency and timing information may involve sniffing the at least one uplink packet to a macro base station (e.g., eNB).

64 Claims, 28 Drawing Sheets



(51) **Int. Cl.**

H04W 84/04	(2009.01)
H04W 92/10	(2009.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,151,311	A	11/2000	Wheatley, III	
6,307,840	B1	10/2001	Wheatley, III	
6,433,739	B1	8/2002	Soliman	
6,590,881	B1	7/2003	Wallace et al.	
6,970,708	B1	11/2005	Raith	
6,983,031	B2	1/2006	Wheatley	
7,295,531	B2	11/2007	Wheatley, III	
7,391,759	B2	6/2008	Wallace et al.	
7,512,111	B2	3/2009	Kauhanen	
7,929,970	B1	4/2011	Gunasekara et al.	
8,226,340	B1	7/2012	Mahalingam	
8,244,257	B2	8/2012	Walldeen et al.	
8,355,713	B1	1/2013	Oh et al.	
2003/0114204	A1	6/2003	Allen et al.	
2003/0123666	A1	7/2003	Sambhwani et al.	
2003/0194992	A1	10/2003	Kim et al.	
2004/0043746	A1	3/2004	Hiramatsu	
2005/0058097	A1*	3/2005	Kang et al.	370/329
2005/0094589	A1	5/2005	Camp, Jr. et al.	
2005/0099972	A1	5/2005	Motegi et al.	
2005/0130672	A1	6/2005	Dean et al.	
2005/0186933	A1	8/2005	Trans	
2006/0293067	A1	12/2006	Leung et al.	
2007/0053340	A1	3/2007	Guilford	
2007/0093268	A1	4/2007	Hosono et al.	
2007/0230393	A1	10/2007	Sinha et al.	
2007/0254620	A1	11/2007	Lindqvist et al.	
2007/0286136	A1	12/2007	Rittle et al.	
2008/0002660	A1	1/2008	Jeong et al.	
2008/0176568	A1	7/2008	Palanki et al.	
2008/0181195	A1	7/2008	Cho et al.	
2008/0188266	A1	8/2008	Carter et al.	
2008/0254812	A1	10/2008	Kitazoe	
2008/0261596	A1*	10/2008	Khetawat et al.	455/436
2008/0268856	A1	10/2008	Francalanci et al.	
2008/0285529	A1	11/2008	Kwak et al.	
2008/0285539	A1	11/2008	Tiedemann, Jr. et al.	
2008/0311926	A1	12/2008	Fischer et al.	
2009/0067417	A1	3/2009	Kalavade et al.	
2009/0086691	A1	4/2009	Balasubramanian	
2009/0092122	A1	4/2009	Czaja et al.	
2009/0097452	A1	4/2009	Gogic	
2009/0131049	A1	5/2009	Osborn	
2009/0163216	A1	6/2009	Hoang et al.	
2009/0164547	A1	6/2009	Ch'ng et al.	
2009/0185632	A1	7/2009	Cai et al.	
2009/0196266	A1	8/2009	Wu et al.	
2009/0210888	A1	8/2009	Lee et al.	
2009/0219888	A1	9/2009	Chen et al.	
2009/0221303	A1	9/2009	Soliman	
2009/0247084	A1	10/2009	Palanki	
2009/0253421	A1	10/2009	Camp, Jr. et al.	
2009/0258672	A1	10/2009	Camp, Jr. et al.	
2009/0290555	A1	11/2009	Alpert et al.	
2009/0316591	A1*	12/2009	Reial et al.	370/252
2009/0316654	A1	12/2009	Prakash et al.	
2010/0027694	A1	2/2010	Touboul et al.	
2010/0035601	A1	2/2010	Chen et al.	
2010/0035629	A1	2/2010	Soliman	
2010/0041364	A1	2/2010	Lott et al.	
2010/0046494	A1	2/2010	Palanki et al.	
2010/0054237	A1	3/2010	Han et al.	
2010/0061356	A1	3/2010	Qvarfordt et al.	
2010/0067433	A1	3/2010	Cheng et al.	
2010/0067507	A1*	3/2010	Park	370/338
2010/0085913	A1	4/2010	Subrahmanya	
2010/0105377	A1	4/2010	Iwamura et al.	
2010/0111070	A1	5/2010	Hsu	
2010/0128694	A1*	5/2010	Choi-Grogan	370/331
2010/0135248	A1	6/2010	Aramaki et al.	
2010/0136997	A1	6/2010	Palanki et al.	
2010/0150109	A1	6/2010	Bradley et al.	
2010/0157906	A1	6/2010	Yang et al.	
2010/0173630	A1	7/2010	Han et al.	
2010/0197309	A1	8/2010	Fang et al.	
2010/0203891	A1	8/2010	Nagaraja et al.	
2010/0210239	A1	8/2010	Karaoguz et al.	
2010/0222068	A1	9/2010	Gaal et al.	
2010/0242103	A1	9/2010	Richardson et al.	
2010/0260168	A1	10/2010	Gheorghiu et al.	
2011/0002284	A1*	1/2011	Talwar et al.	370/329
2011/0019604	A1	1/2011	Chun et al.	
2011/0058503	A1	3/2011	Ono	
2011/0059739	A1	3/2011	Huang	
2011/0098042	A1	4/2011	Mach et al.	
2011/0128916	A1	6/2011	Kwon et al.	
2011/0158164	A1	6/2011	Palanki et al.	
2011/0182252	A1	7/2011	Liu et al.	
2011/0275402	A1	11/2011	Charipadi et al.	
2011/0281571	A1	11/2011	Patel et al.	
2011/0281574	A1	11/2011	Patel et al.	
2011/0300870	A1	12/2011	Chun et al.	
2011/0312317	A1	12/2011	Sahin et al.	
2012/0040659	A1	2/2012	Iwamura et al.	
2012/0044908	A1	2/2012	Spinelli et al.	
2012/0046025	A1	2/2012	Das et al.	
2012/0046026	A1	2/2012	Chande et al.	
2012/0046063	A1	2/2012	Chande et al.	
2012/0052793	A1	3/2012	Brisebois et al.	
2012/0069800	A1	3/2012	Soliman et al.	
2012/0094663	A1	4/2012	Awoniyi et al.	
2012/0115496	A1	5/2012	Soliman et al.	
2012/0142392	A1	6/2012	Patel et al.	
2012/0178482	A1	7/2012	Seo et al.	
2012/0184206	A1	7/2012	Kim et al.	
2013/0005326	A1	1/2013	Flanagan	
2013/0059592	A1	3/2013	Chakraborty et al.	
2013/0095789	A1	4/2013	Keevill et al.	
2013/0294425	A1	11/2013	Song et al.	
2014/0134997	A1	5/2014	Song et al.	

FOREIGN PATENT DOCUMENTS

CN	101155167	A	4/2008
CN	101330322		12/2008
EP	1089499	A2	4/2001
EP	1809056	A2	7/2007
EP	1871035	A1	12/2007
GB	2446192		8/2008
JP	6334593	A	12/1994
JP	2002505542	A	2/2002
JP	2004112225	A	4/2004
JP	2005184824	A	7/2005
JP	2007534221	A	11/2007
JP	2007536788	A	12/2007
JP	2008172380	A	7/2008
JP	4352281	B1	10/2009
JP	2009232434	A	10/2009
JP	2009239568	A	10/2009
JP	2010041537	A	2/2010
JP	2010512054	A	4/2010
JP	2010166163	A	7/2010
KR	20100034579	A	4/2010
TW	200926649		6/2009
WO	9809390	A1	3/1998
WO	WO-9937037		7/1999
WO	WO-9944306	A1	9/1999
WO	WO-2005048628	A1	5/2005
WO	WO-2005109767	A1	11/2005
WO	WO-2008066957	A2	6/2008
WO	2008094334	A1	8/2008
WO	2008139707	A1	11/2008
WO	WO-2008140225	A1	11/2008
WO	WO2009006041	A1	1/2009
WO	2009049207	A2	4/2009
WO	2010017226	A2	2/2010
WO	WO-2010022371		2/2010
WO	2010033438		3/2010
WO	WO-2010033413		3/2010

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO2010059750	5/2010
WO	WO2011011760 A2	1/2011
WO	WO2011063044 A1	5/2011

OTHER PUBLICATIONS

Co-pending U.S. Appl. No. 61/094,100, filed Sep. 4, 2008.

3GPP TR 36.922 version 9.0.0 Release 9; LTE; Evolved Universal Terrestrial Radio Access (E-UTRA);TDD Home eNode B (HeNB) Radio Frequency (RF) requirements analysis, ETSI TR 136 922 V9.0.0, pp. 1-77, Apr. 2010.

"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); TDD Home eNode B (HeNB) Radio Frequency (RF) requirements analysis (Release 9)", 3GPP Standard; 3GPP TR 36.922, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre ; 650, Route Des Lucioles ; F-06921 Sophia-Antipolis Cedex ; France, No. V9.1.0, Jun. 21, 2010, pp. 1-74, XP050441979, [retrieved on Jun. 21, 2010].

3rd Generation Partnership Project, Technical Specification Group Radio Access Networks, Home Node B Radio Frequency (RF) Requirements (FDD) (Release 9), 3GPP Standard, 3GPP TR 25.967, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre, 650, Route Des Lucioles, F-06921 Sophia-Antipolis Cedex, France, No. 9.0.0, May 1, 2009, pp. 1-55, XP050369580, paragraph [0007].

International Search Report and Written Opinion—PCT/US2011/026800—ISA/EPO—Jun. 16, 2011.

LG Electronics: "Methods to facilitate the inter-cell coordination in heterogeneous networks", 3GPP Draft; R1-105358 Coordinati0n_Method, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre ; 650, Route Des Lucioles ; F-06921 Sophia-Antipolis Cedex ; France, vol. RAN WG1, No. Xi'an; 20101011, Oct. 5, 2010, XP050450509, [retrieved on Oct. 5, 2010].

Mediatek Inc: "Further Discussion on HeNB Downlink Power Setting in HetNet", 3GPP Draft; R1-105238 Power Setting in HETNET, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre ; 650, Route Des Lucioles ; F-06921 Sophia-Antipolis Cedex; France, vol. RAN WG1, No. Xi 'an; 20101011, Oct. 5, 2010, XP050450424, [retrieved on Oct. 5, 2010].

Mitsubishi Electric: "Dynamic Setup of HNBs for Energy Savings and Interference Reduction", 3GPP Draft; R3-081949 (Dynamic Setup HNBS), 3rd Generation Partnership Project (3GPP), Mobile Competence Centre ; 650, Route Des Lucioles ; F-06921 Sophia-Antipolis Cedex ; France, vol . RAN WG3, no. Jeju Island; 20080813, Aug. 13, 2008, XP050165010, [retrieved on Aug. 13, 2008].

Qualcomm Europe et al., "TDD HeNB Synchronization Requirement for Large Propagation Distance Case", 3GPP Draft, R4-094985, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre, 650, Route Des Lucioles, F-06921 Sophia-Antipolis Cedex, France, no. Jeju, 20091109, Nov. 9, 2009, XP050394434, [retrieved on Nov. 17, 2009].

Qualcomm Europe: "HeNB Timing Requirements", 3GPP Draft, R4-091902 Timing Requirements, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre, 650, Route Des Lucioles, F-06921 Sophia-Antipolis Cedex, France, no. San Francisco, 20090427, Apr. 27, 2009, XP050342629, [retrieved on Apr. 27, 2009] paragraph [0002].

Qualcomm Europe: "Text Proposal on TDD HeNB Synchronization Requirement", 3GPP Draft, R4-093725 Text Proposal for HeNB Sync Requirements, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre, 650, Route Des Lucioles, F-06921 Sophia-Antipolis Cedex, France, no. Miyazaki, 20091012, Oct. 12, 2009, XP050393326, [retrieved on Oct. 6, 2009].

Qualcomm Europe: "Synchronization Requirements and Techniques", 3GPP Draft, R4-091336, 3rd Generation Partnership Project (3GPP), Mobile Competence Centre, 650, Route Des Lucioles, F-06921 Sophia-Antipolis Cedex, France, no. Seoul, Korea, 20090319, Mar. 19, 2009, XP050342103, [retrieved on Mar. 19, 2009].

Universal Mobile Telecommunications System (UMTS), Physical layer, Measurements (TDD) (3GPP TS 25.225 version 8.2.0 Release 8), ETSI TS 125 225, ETSI Standard, European Telecommunications Standards Institute (ETSI), Sophia Antipolis Cedex, France, vol. 3-R1, No. V8.2.0, Mar. 1, 2009, XP014043978, paragraph [0007].

Motorola: "PCID confusion", R2-092307, 3GPP TSG RAN WG2 #65bis Mar. 23-27, 2009, Seoul, Korea, pp. 1-3.

Qualcomm Europe: "Network support for inbound handover of pre-Rel-9 UMTS UEs", R3-091213, 3GPP TSG RAN WG 3 #64, May 4-8, 2009 San Francisco, USA, pp. 1-3.

Damnjanovic et al., "A Survey on 3GPP Heterogeneous Networks", IEEE Wireless Communications, pp. 10-21 (Jun. 2011).

Domenico A.D., et al., "A Survey on MAC Strategies for Cognitive Radio Networks", IEEE Communications Surveys, IEEE, New York, NY, US, vol. 14, No. 1, Jan. 1, 2012, pp. 21-44, XP011420410, ISSN: 1553-877X, DOI: 10.1109/SURV.2011.111510.00108.

* cited by examiner

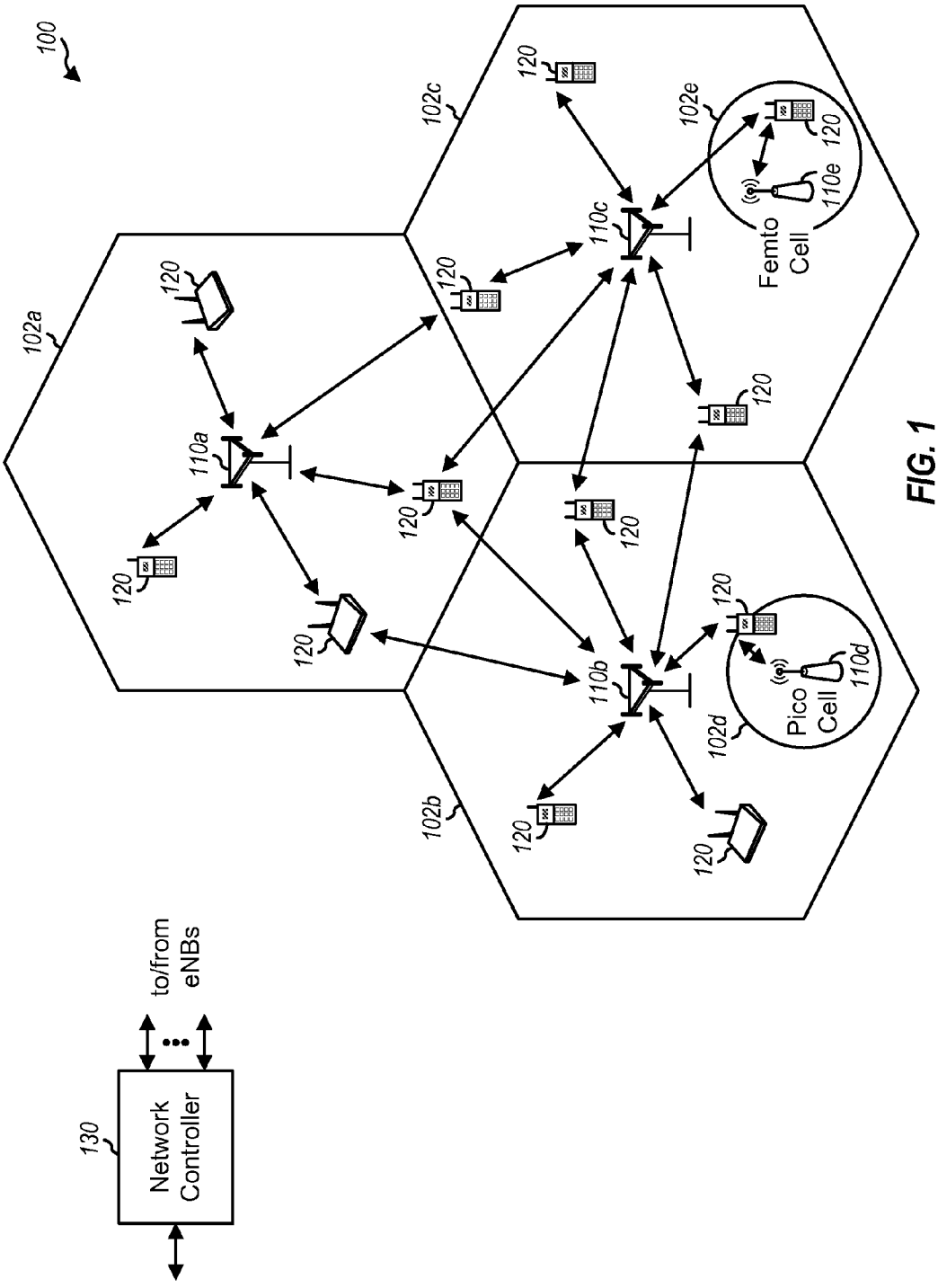

100
102a
102b
102c
102d
102e
110a
110b
110c
110d
110e
120
Femto Cell
Pico Cell
130
Network Controller
to/from eNBs

FIG. 1

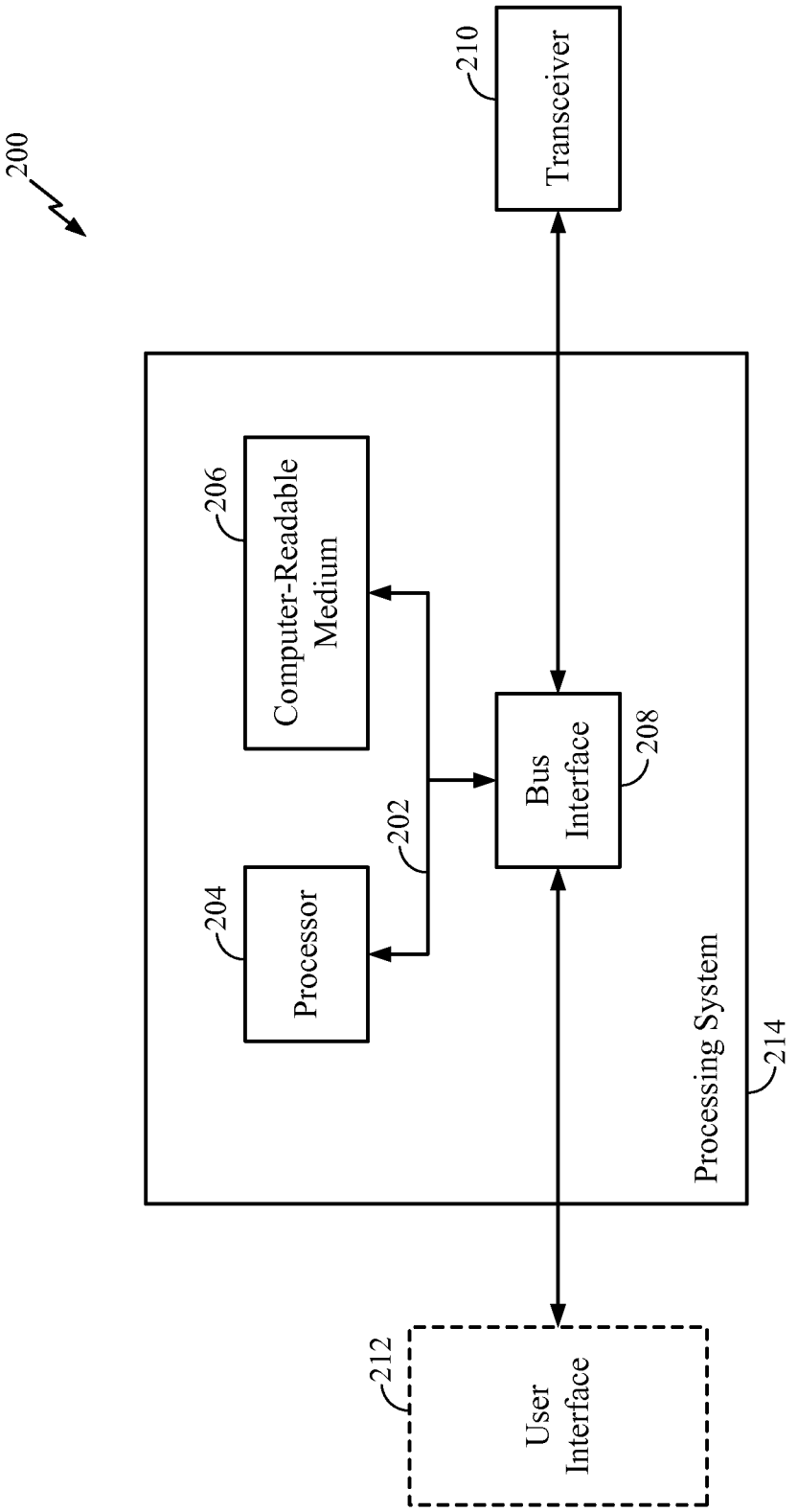

200
210
Transceiver
206
Computer-Readable Medium
208
Bus Interface
202
204
Processor
214
Processing System
212
User Interface

FIG. 2

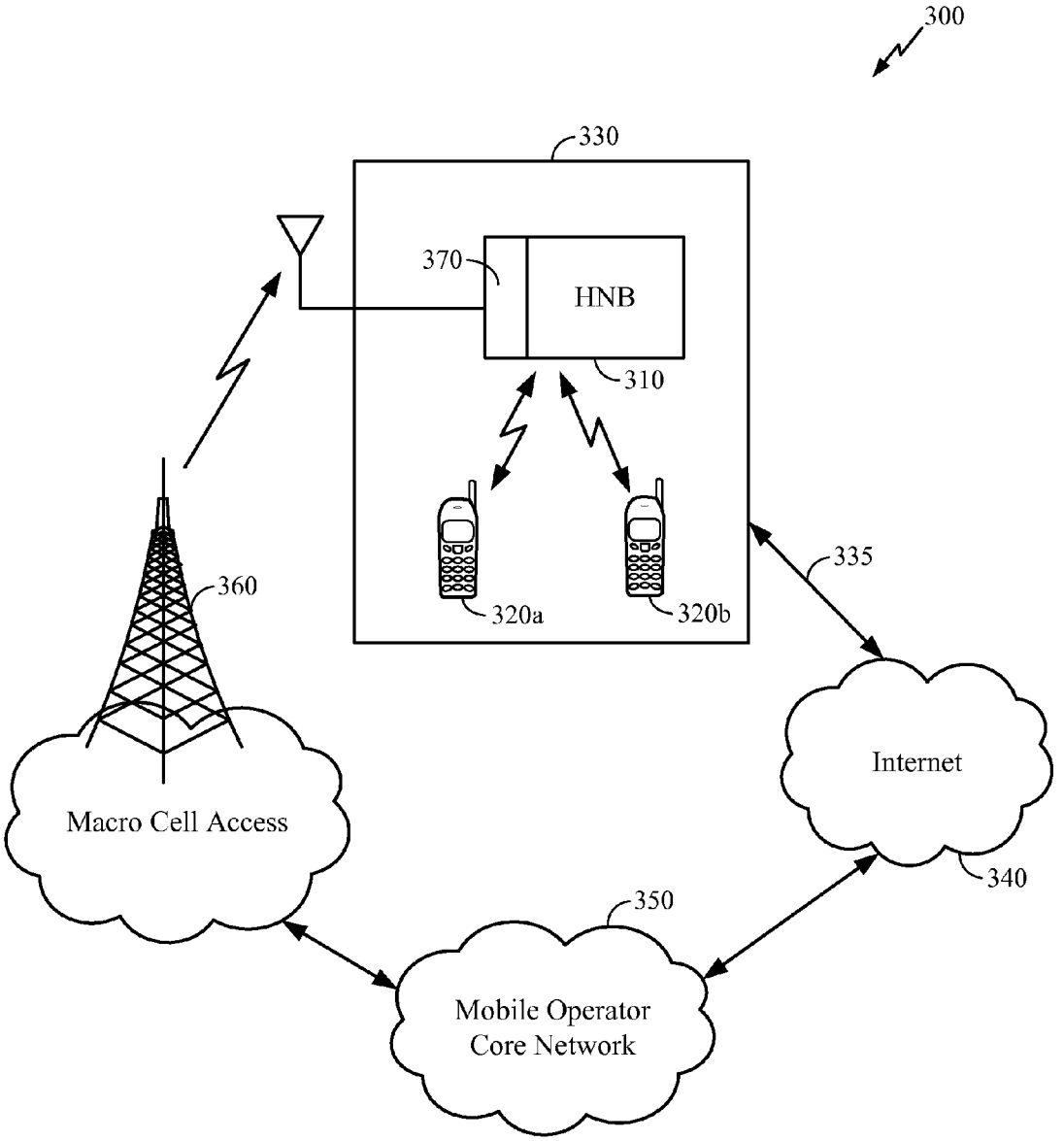

300
330
370
HNB
310
320a
320b
335
360
Macro Cell Access
Internet
340
350
Mobile Operator
Core Network

FIG. 3

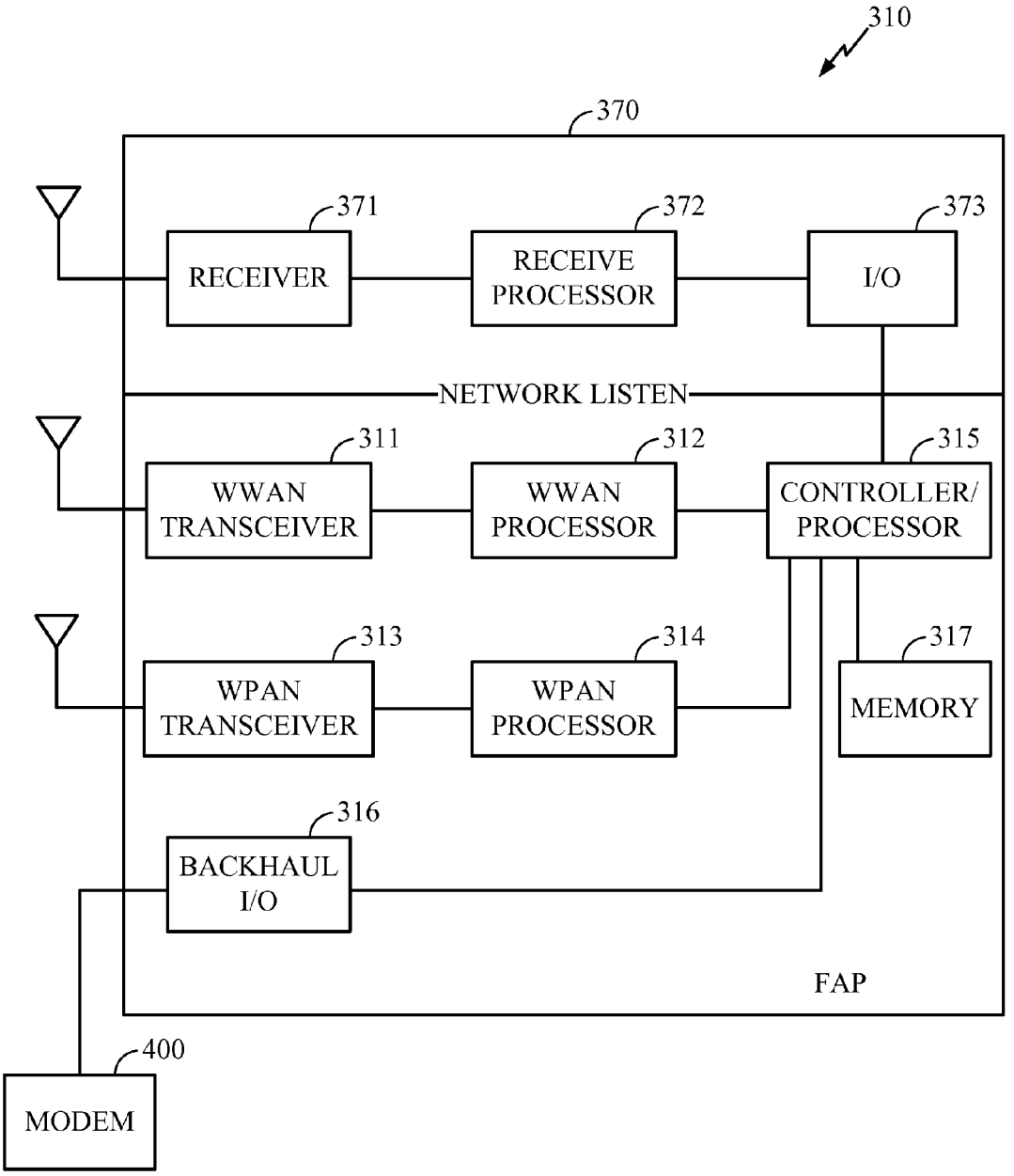

310
370
371
RECEIVER
372
RECEIVE PROCESSOR
373
I/O
NETWORK LISTEN
311
WWAN TRANSCEIVER
312
WWAN PROCESSOR
315
CONTROLLER/ PROCESSOR
313
WPAN TRANSCEIVER
314
WPAN PROCESSOR
317
MEMORY
316
BACKHAUL I/O
FAP
400
MODEM

FIG. 4A

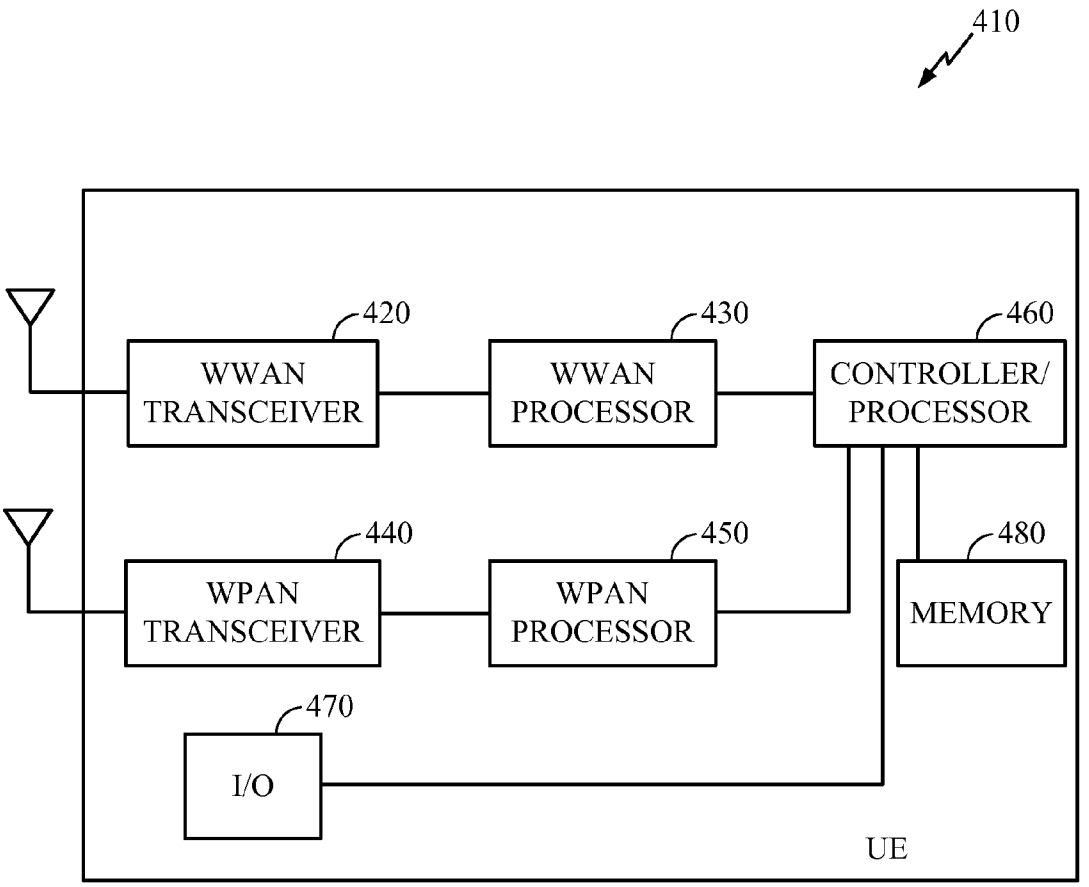

410
420
WWAN TRANSCEIVER
430
WWAN PROCESSOR
460
CONTROLLER/ PROCESSOR
440
WPAN TRANSCEIVER
450
WPAN PROCESSOR
480
MEMORY
470
I/O
UE

FIG. 4B

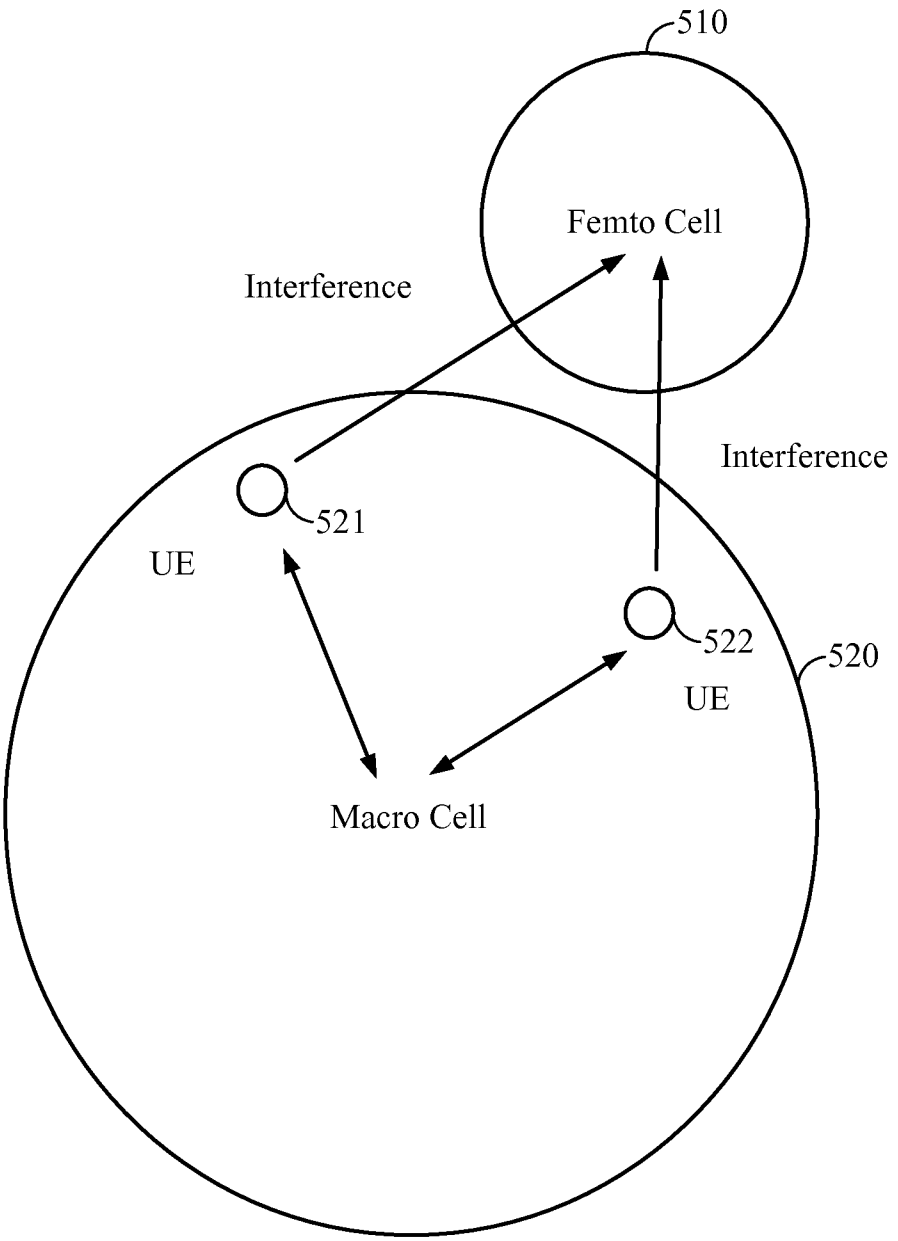

510
Femto Cell
Interference
Interference
521
UE
522
UE
520
Macro Cell

FIG. 5A

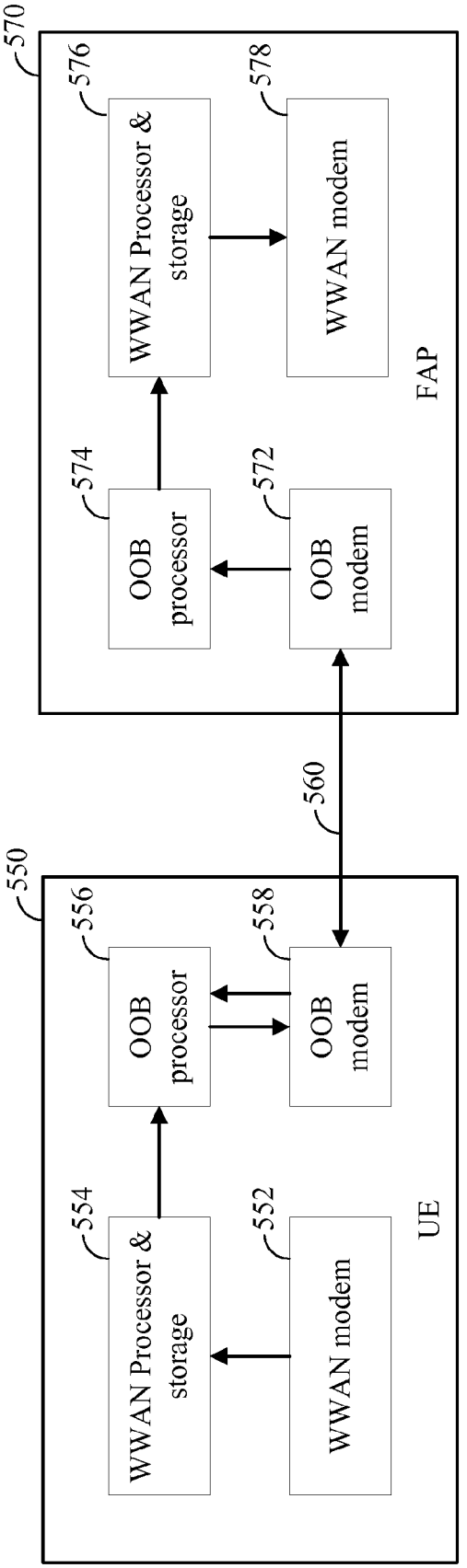

570
576
WWAN Processor & storage
578
WWAN modem
FAP
574
OOB processor
572
OOB modem
560
550
556
OOB processor
558
OOB modem
554
WWAN Processor & storage
552
WWAN modem
UE

FIG. 5B

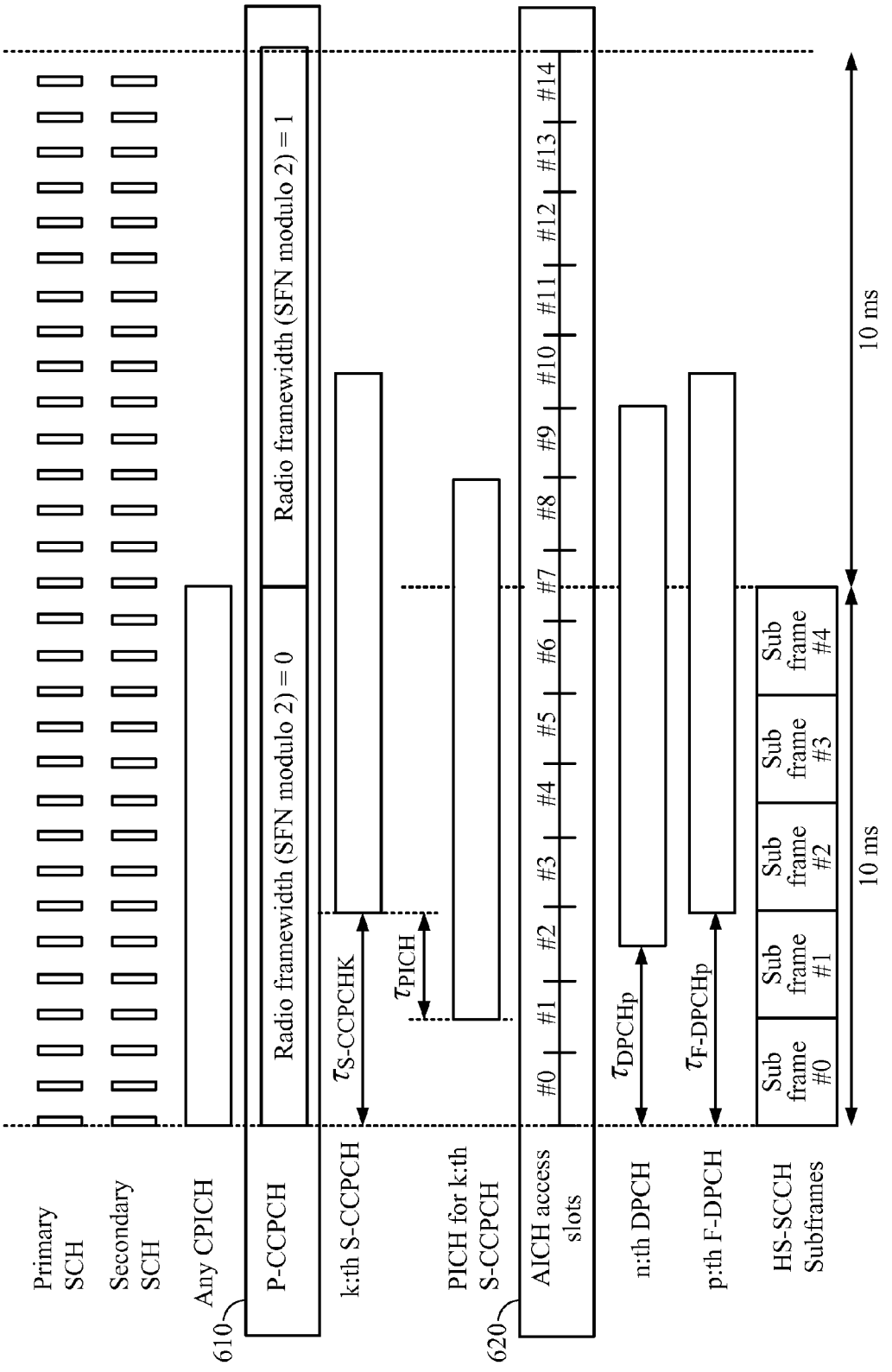

Primary SCH
Secondary SCH
Any CPICH
610
P-CCPCH
Radio framewidth (SFN modulo 2) = 0
Radio framewidth (SFN modulo 2) = 1
k:th S-CCPCH
$\tau_{S\text{-}CCPCHK}$
τ_{PICH}
PICH for k:th S-CCPCH
620
AICH access slots
#0 #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13 #14
n:th DPCH
τ_{DPCHp}
p:th F-DPCH
$\tau_{F\text{-}DPCHp}$
HS-SCCH Subframes
Sub frame #0
Sub frame #1
Sub frame #2
Sub frame #3
Sub frame #4
10 ms
10 ms

FIG. 6

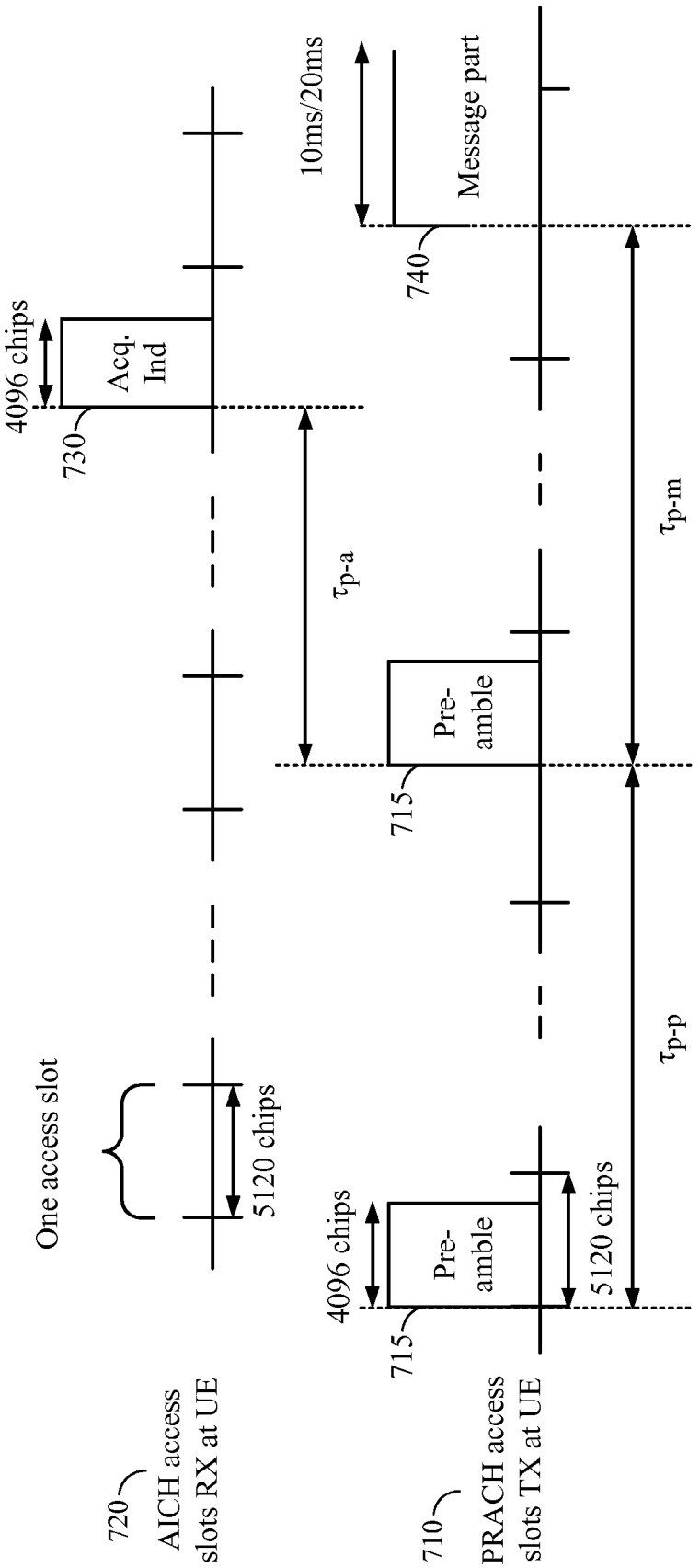

720
AICH access slots RX at UE
710
PRACH access slots TX at UE
One access slot
5120 chips
4096 chips
Acq. Ind
730
Pre-amble
715
4096 chips
Pre-amble
715
5120 chips
τp-a
τp-p
τp-m
10ms/20ms
Message part
740

FIG. 7

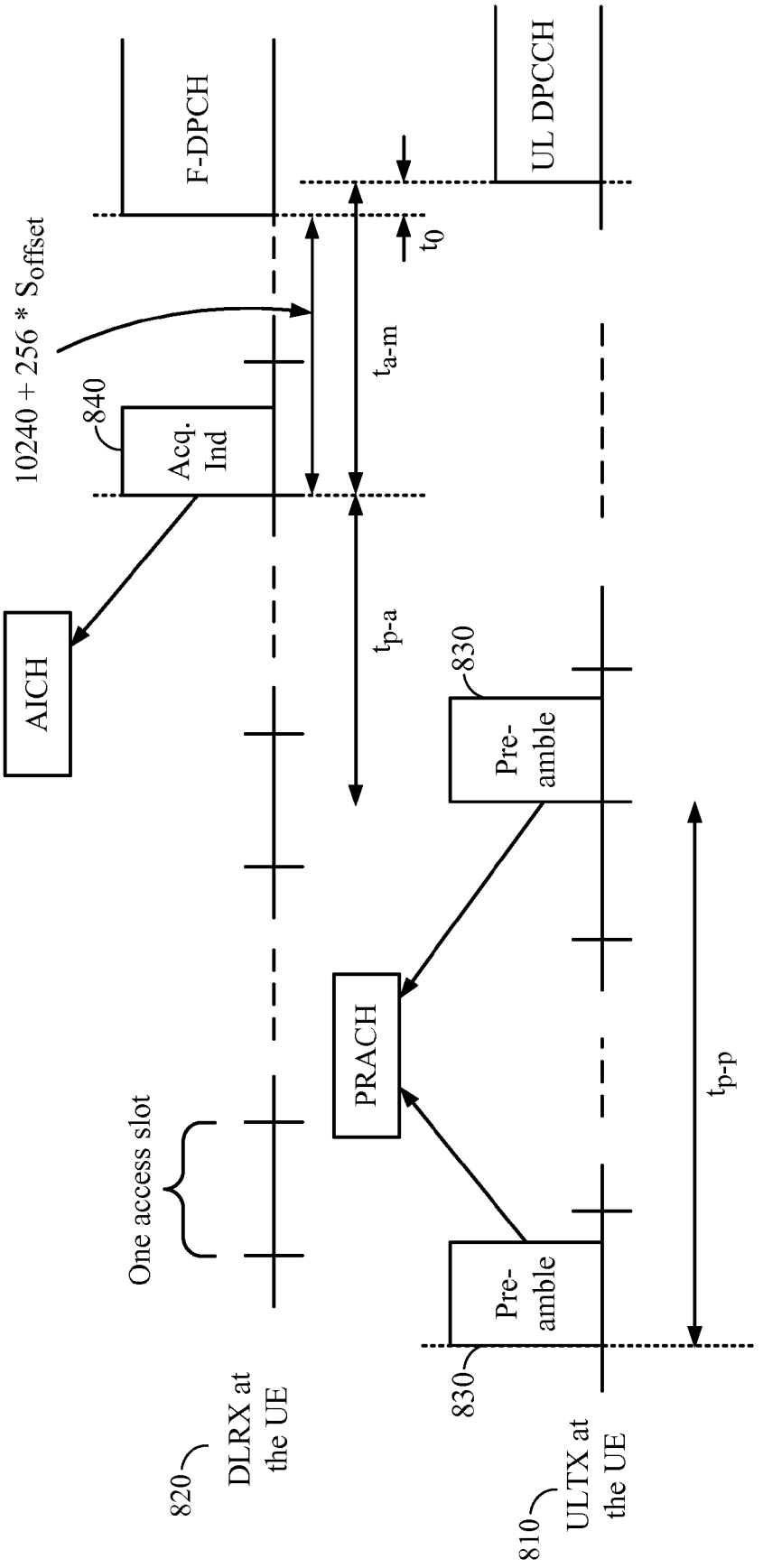

F-DPCH
UL DPCCH
t_0
$10240 + 256 * S_{offset}$
t_{a-m}
840
Acq. Ind
AICH
t_{p-a}
830
Pre-amble
PRACH
t_{p-p}
One access slot
830
Pre-amble
820
DLRX at the UE
810
ULTX at the UE

FIG. 8

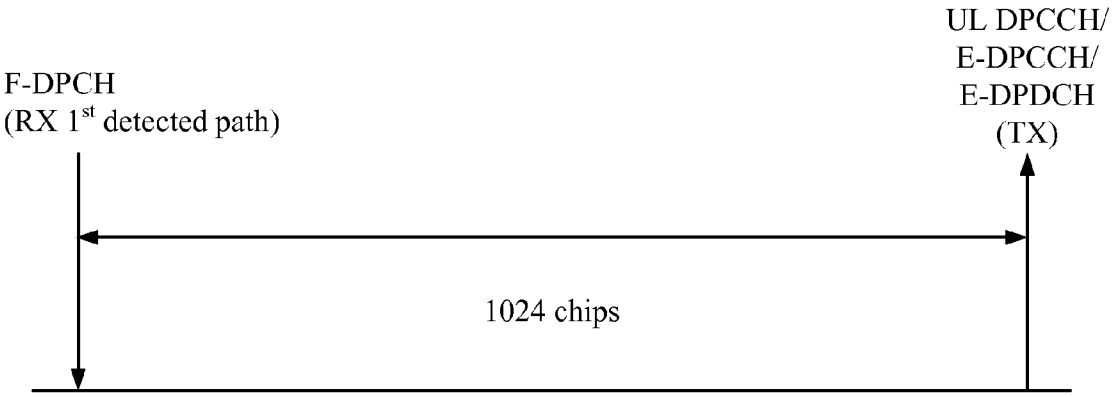

F-DPCH
(RX 1st detected path)
UL DPCCH/
E-DPCCH/
E-DPDCH
(TX)
1024 chips

FIG. 9

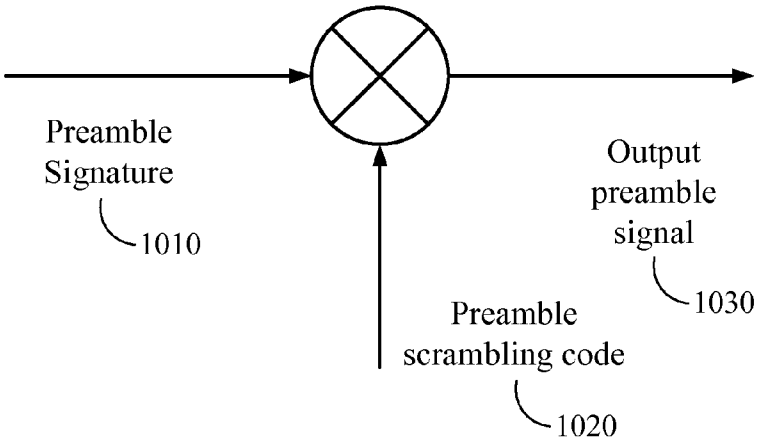

Preamble
Signature
1010
Output
preamble
signal
1030
Preamble
scrambling code
1020

FIG. 10

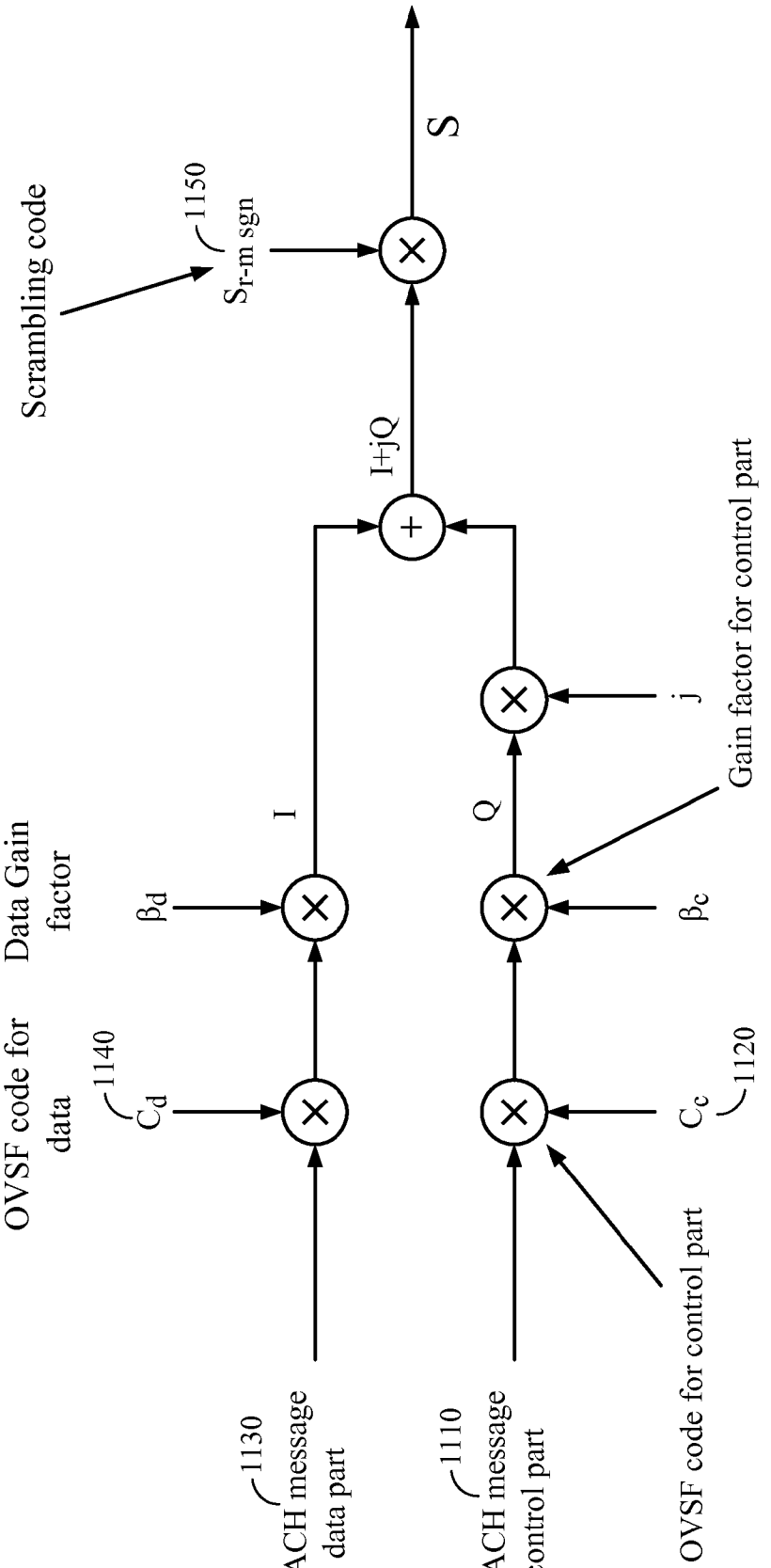

Scrambling code
1150
$S_{r-m\ sgn}$
S
I+jQ
+
Data Gain factor
β_d
β_c
I
Q
j
Gain factor for control part
OVSF code for data
1140
C_d
C_c
1120
1130
PRACH message data part
1110
PRACH message control part
OVSF code for control part

FIG. 11

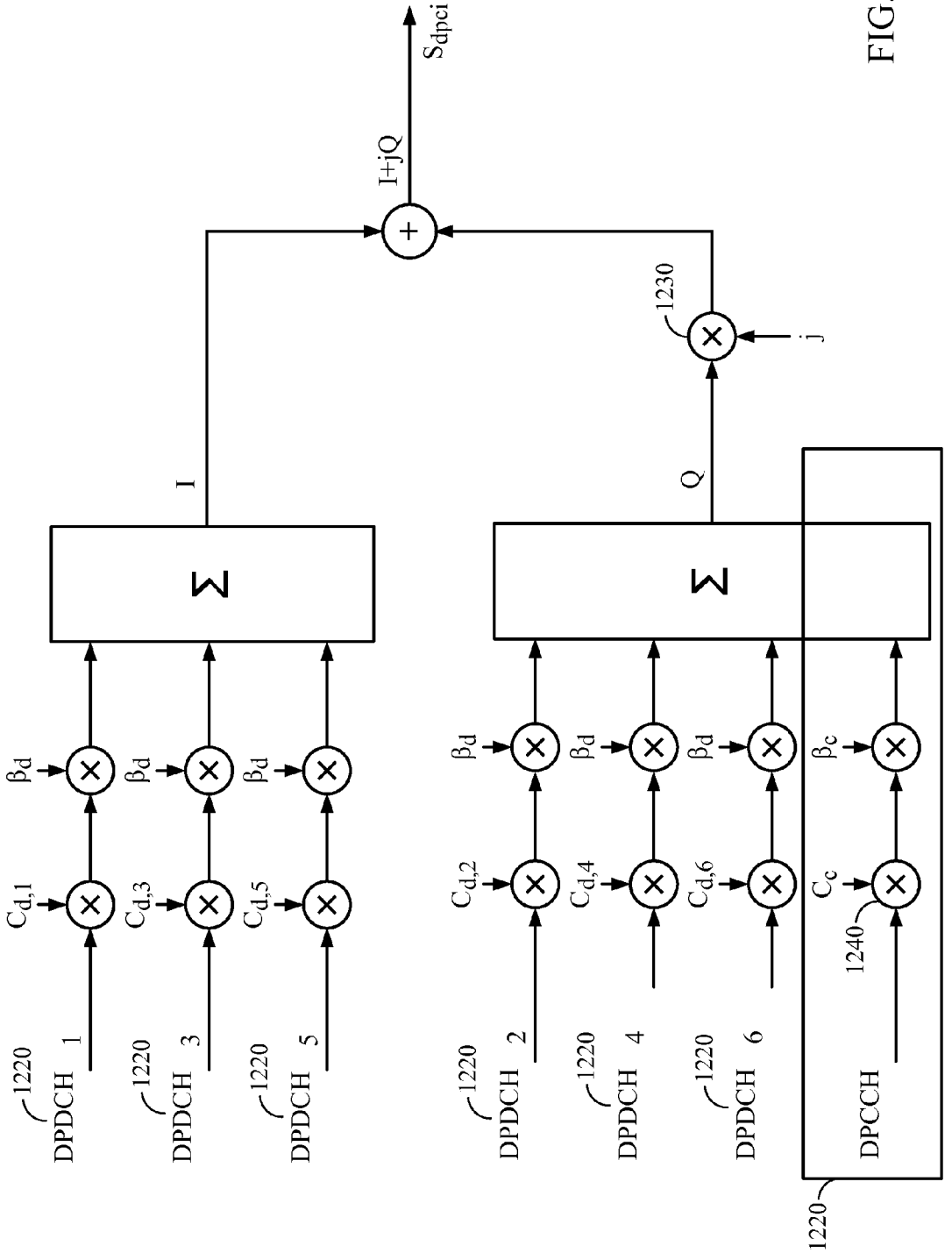

1220
DPDCH 1
1220
DPDCH 3
1220
DPDCH 5
1220
DPDCH 2
1220
DPDCH 4
1220
DPDCH 6
DPCCH
1220
$C_{d,1}$
$C_{d,3}$
$C_{d,5}$
$C_{d,2}$
$C_{d,4}$
$C_{d,6}$
C_c
1240
β_d
β_d
β_d
β_d
β_d
β_d
β_c
Σ
Σ
I
Q
1230
j
I+jQ
+
S_{dpci}

FIG. 12

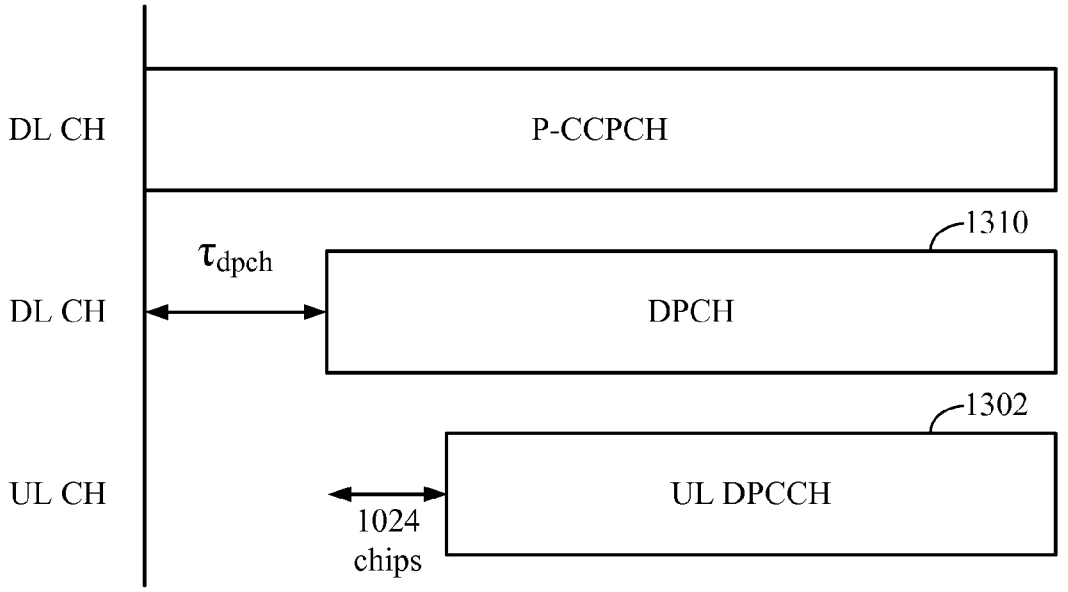


FIG. 13A

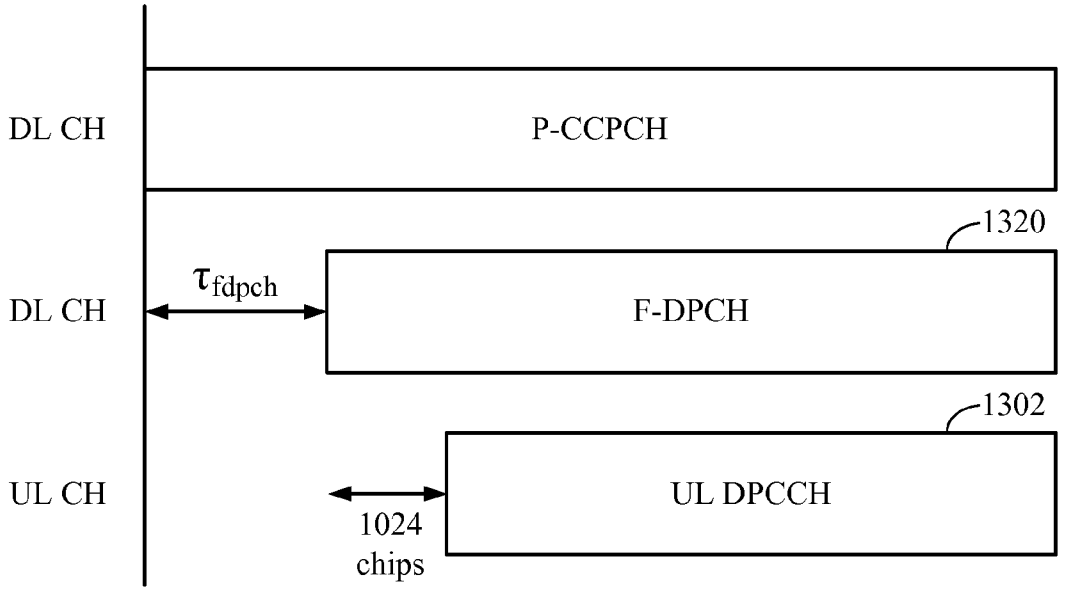


FIG. 13B

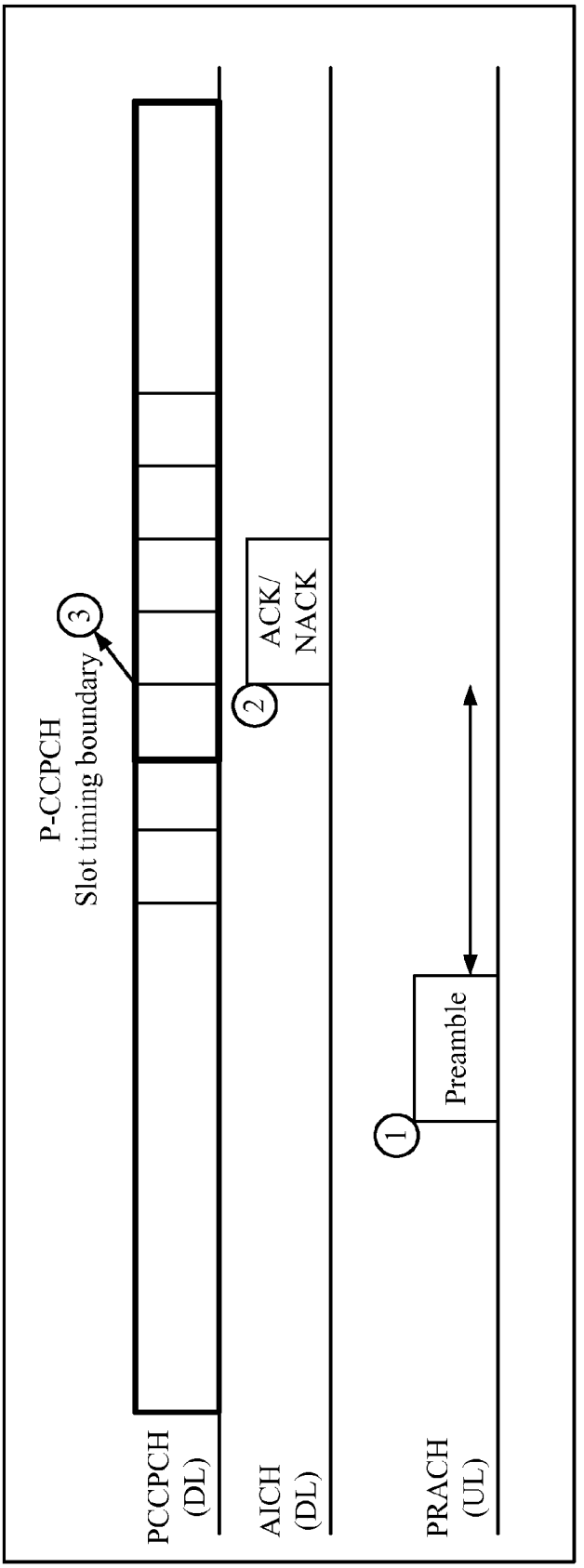

PCCPCH
(DL)
AICH
(DL)
PRACH
(UL)
P-CCPCH
Slot timing boundary
3
ACK/
NACK
2
Preamble
1

FIG. 14

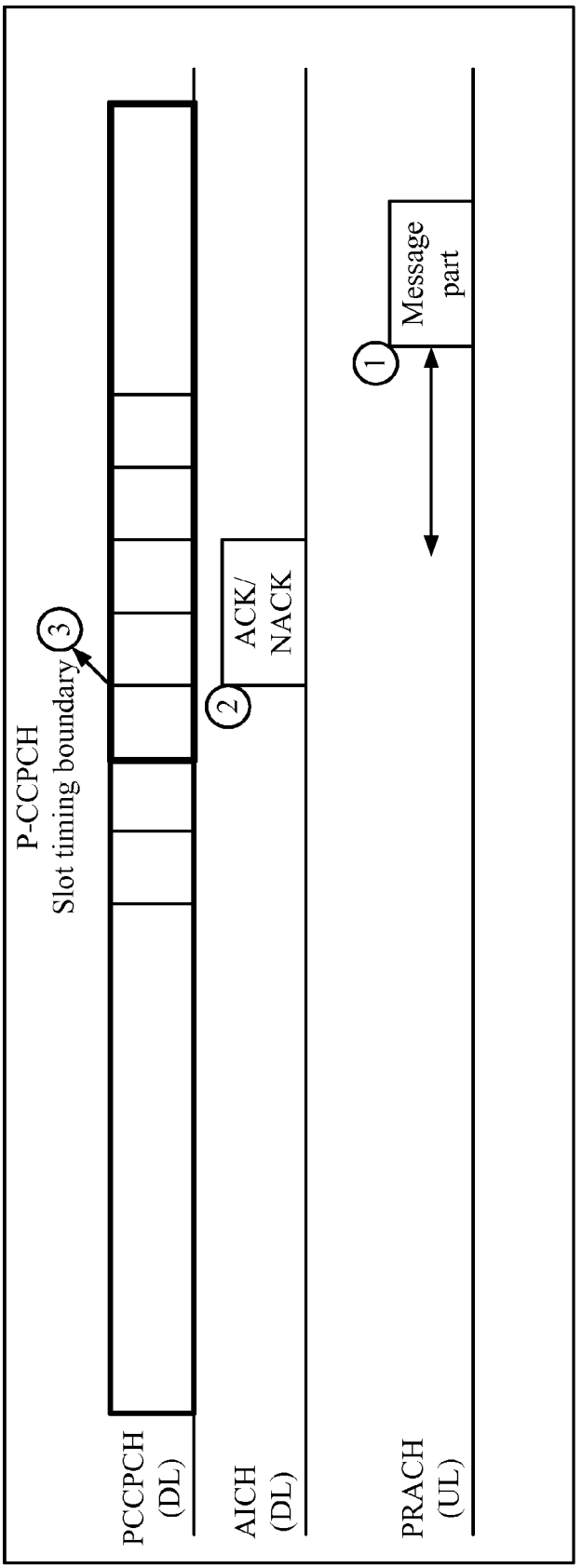

P-CCPCH
Slot timing boundary
3
ACK/
NACK
2
1
Message
part
PCCPCH
(DL)
AICH
(DL)
PRACH
(UL)

FIG. 15

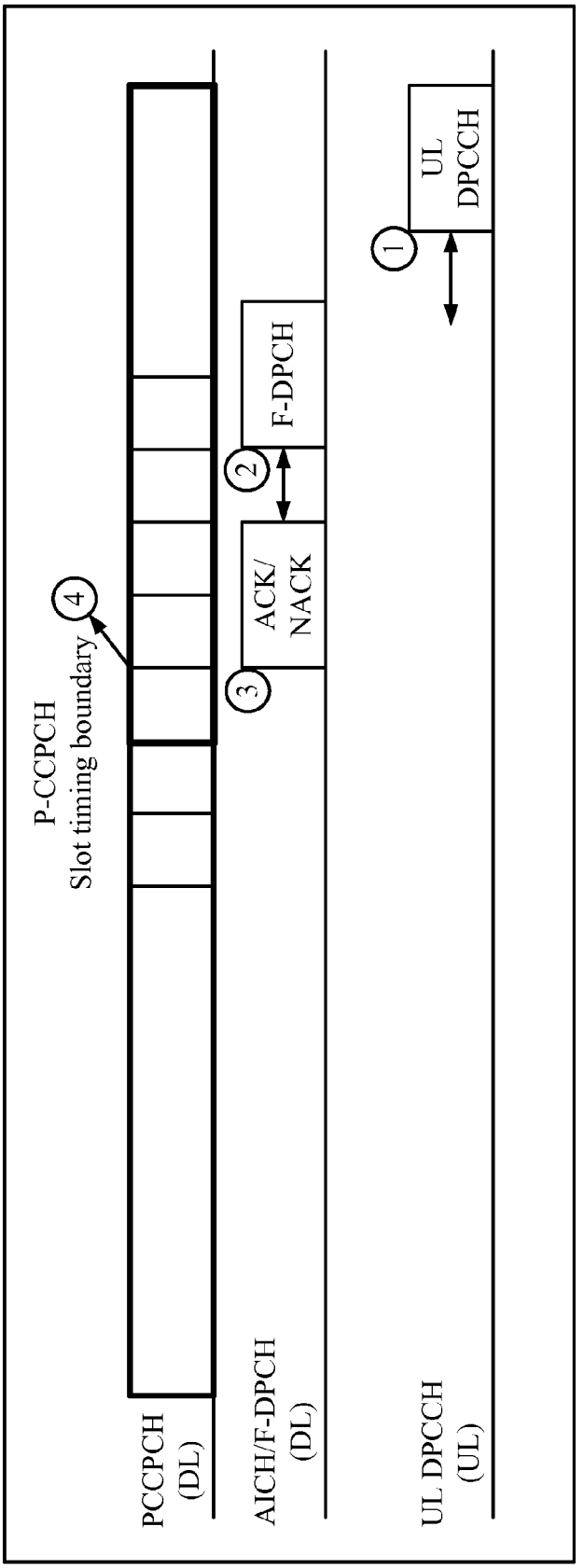

PCCPCH
(DL)
AICH/F-DPCH
(DL)
UL DPCCH
(UL)
P-CCPCH
Slot timing boundary
4
ACK/
NACK
3
F-DPCH
2
UL
DPCCH
1

FIG. 16

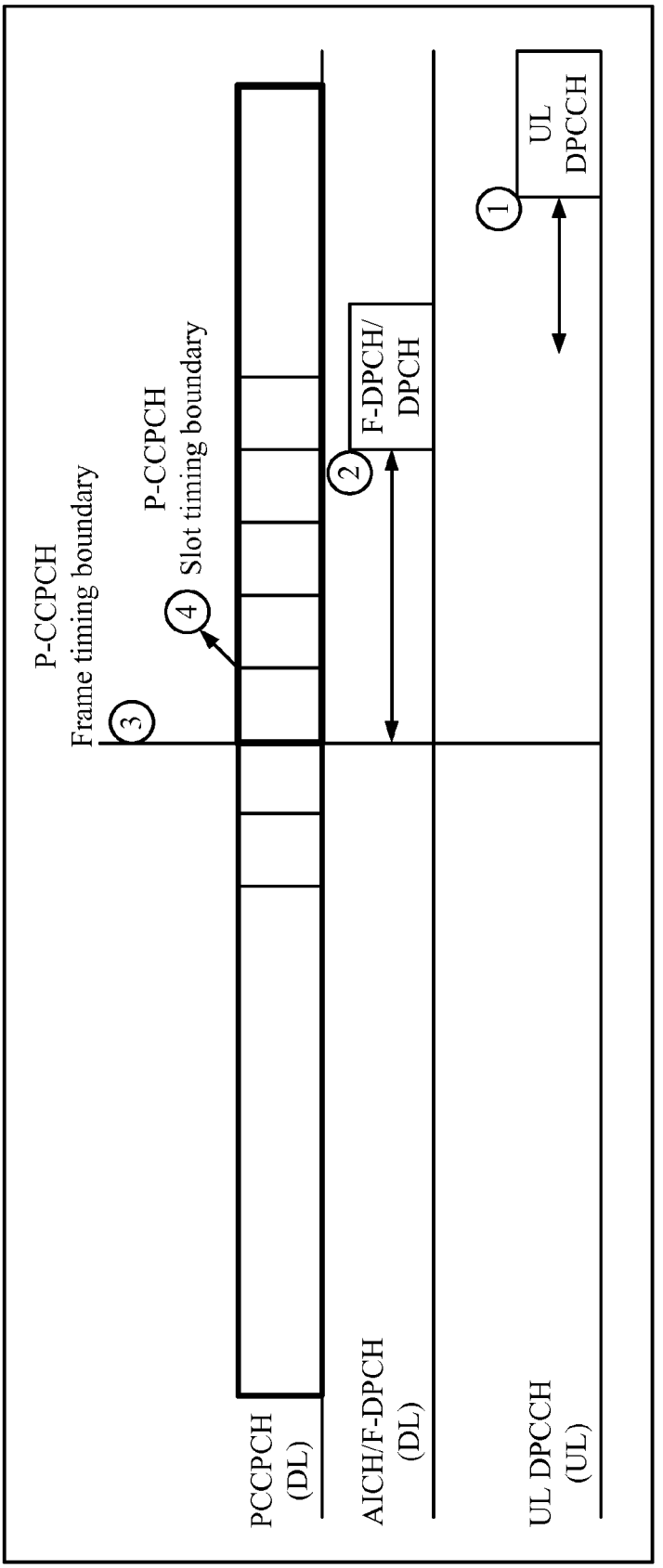

P-CCPCH
Frame timing boundary
3
P-CCPCH
Slot timing boundary
4
F-DPCH/
DPCH
2
UL
DPCCH
1
PCCPCH
(DL)
AICH/F-DPCH
(DL)
UL DPCCH
(UL)

FIG. 17

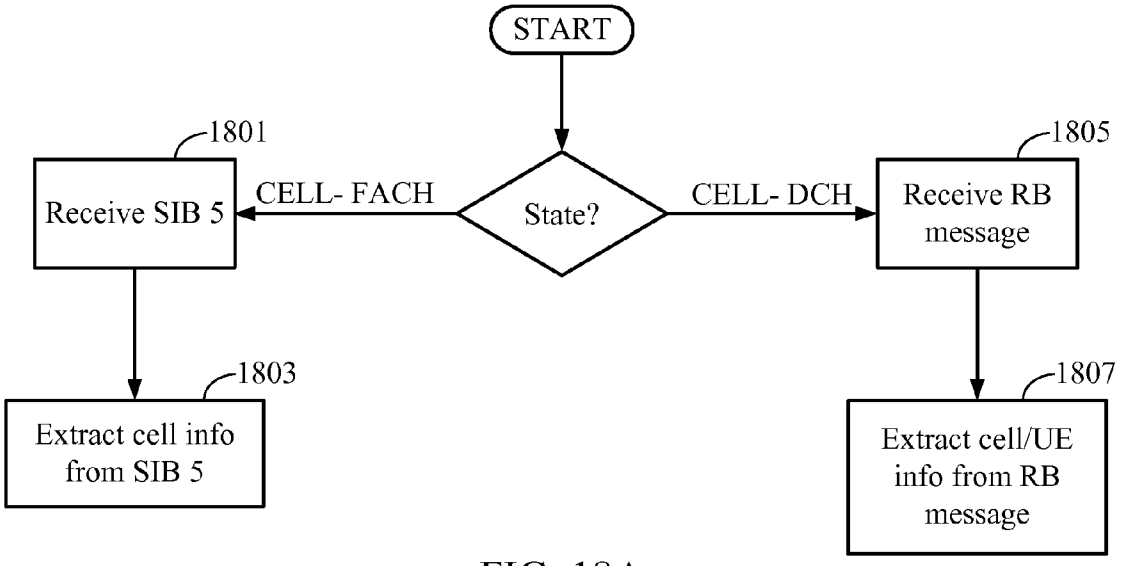

START
State?
CELL- FACH
CELL- DCH
1801
Receive SIB 5
1803
Extract cell info from SIB 5
1805
Receive RB message
1807
Extract cell/UE info from RB message

FIG. 18A

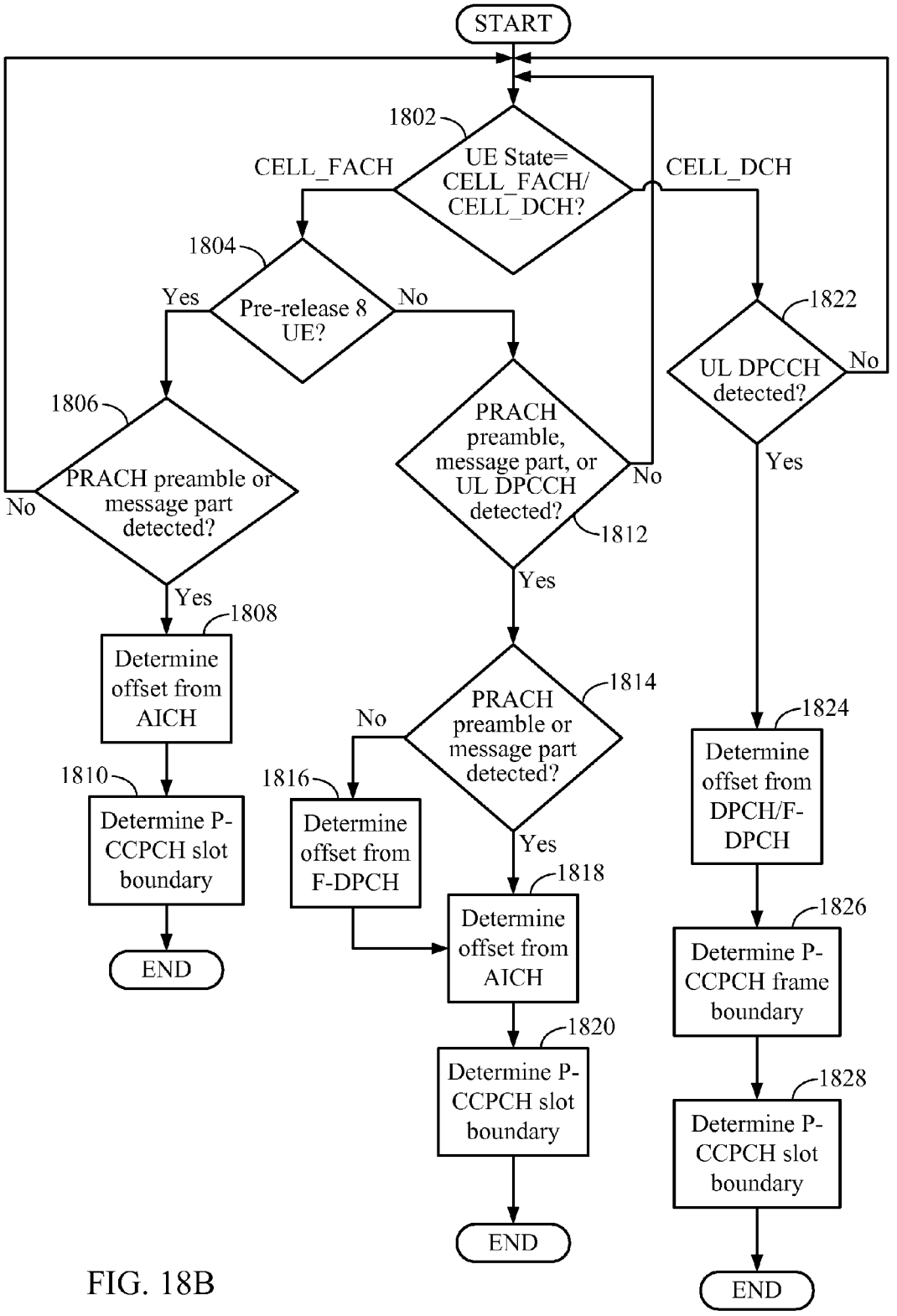

START
1802
UE State= CELL_FACH/ CELL_DCH?
CELL_FACH
CELL_DCH
1804
Pre-release 8 UE?
Yes
No
1806
PRACH preamble or message part detected?
No
Yes
1808
Determine offset from AICH
1810
Determine P-CCPCH slot boundary
END
PRACH preamble, message part, or UL DPCCH detected?
No
1812
Yes
1814
PRACH preamble or message part detected?
No
1816
Determine offset from F-DPCH
Yes
1818
Determine offset from AICH
1820
Determine P-CCPCH slot boundary
END
1822
UL DPCCH detected?
No
Yes
1824
Determine offset from DPCH/F-DPCH
1826
Determine P-CCPCH frame boundary
1828
Determine P-CCPCH slot boundary
END

FIG. 18B

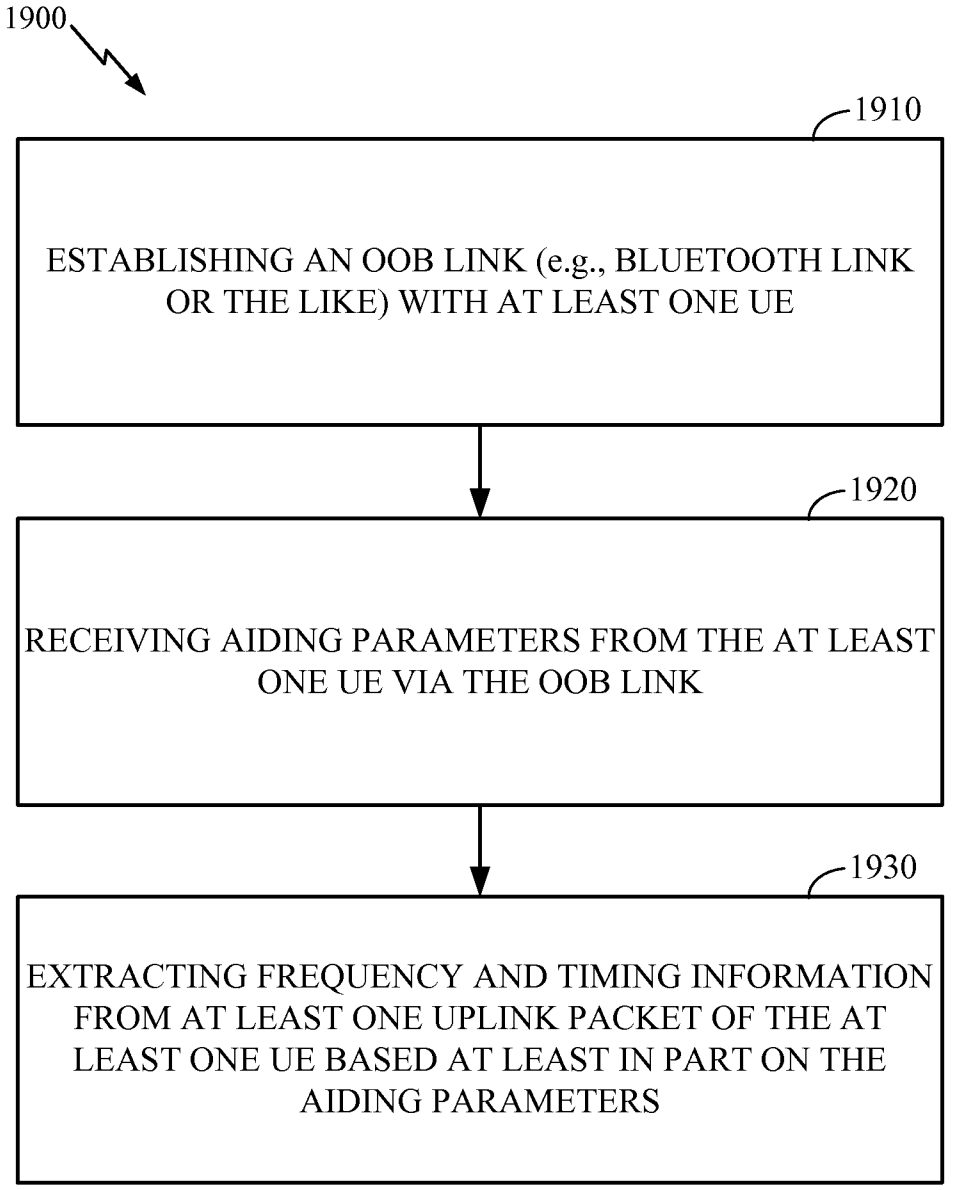

1900
1910
ESTABLISHING AN OOB LINK (e.g., BLUETOOTH LINK OR THE LIKE) WITH AT LEAST ONE UE
1920
RECEIVING AIDING PARAMETERS FROM THE AT LEAST ONE UE VIA THE OOB LINK
1930
EXTRACTING FREQUENCY AND TIMING INFORMATION FROM AT LEAST ONE UPLINK PACKET OF THE AT LEAST ONE UE BASED AT LEAST IN PART ON THE AIDING PARAMETERS

FIG. 19

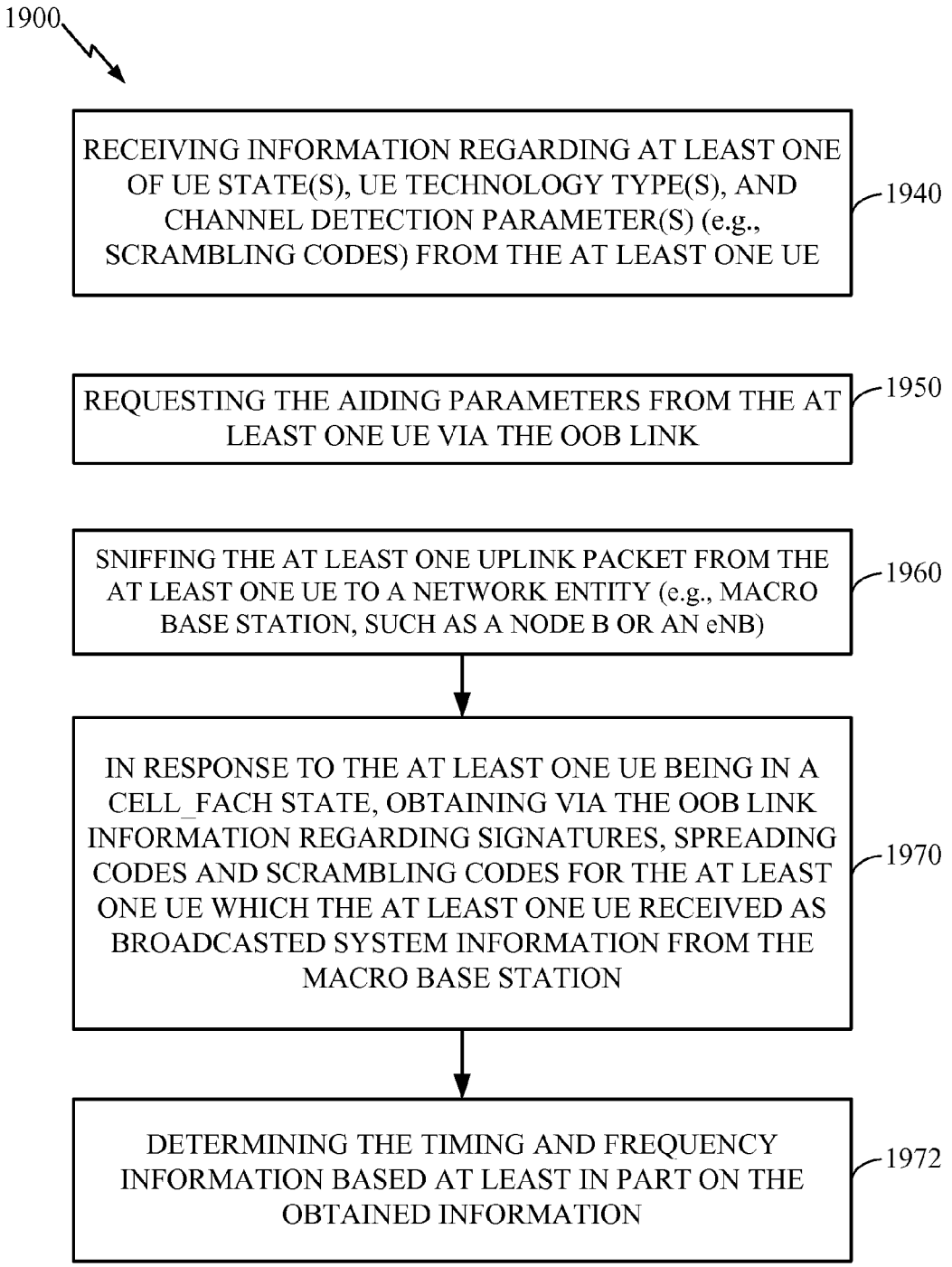

1900
RECEIVING INFORMATION REGARDING AT LEAST ONE OF UE STATE(S), UE TECHNOLOGY TYPE(S), AND CHANNEL DETECTION PARAMETER(S) (e.g., SCRAMBLING CODES) FROM THE AT LEAST ONE UE
1940
REQUESTING THE AIDING PARAMETERS FROM THE AT LEAST ONE UE VIA THE OOB LINK
1950
SNIFFING THE AT LEAST ONE UPLINK PACKET FROM THE AT LEAST ONE UE TO A NETWORK ENTITY (e.g., MACRO BASE STATION, SUCH AS A NODE B OR AN eNB)
1960
IN RESPONSE TO THE AT LEAST ONE UE BEING IN A CELL_FACH STATE, OBTAINING VIA THE OOB LINK INFORMATION REGARDING SIGNATURES, SPREADING CODES AND SCRAMBLING CODES FOR THE AT LEAST ONE UE WHICH THE AT LEAST ONE UE RECEIVED AS BROADCASTED SYSTEM INFORMATION FROM THE MACRO BASE STATION
1970
DETERMINING THE TIMING AND FREQUENCY INFORMATION BASED AT LEAST IN PART ON THE OBTAINED INFORMATION
1972

FIG. 20A

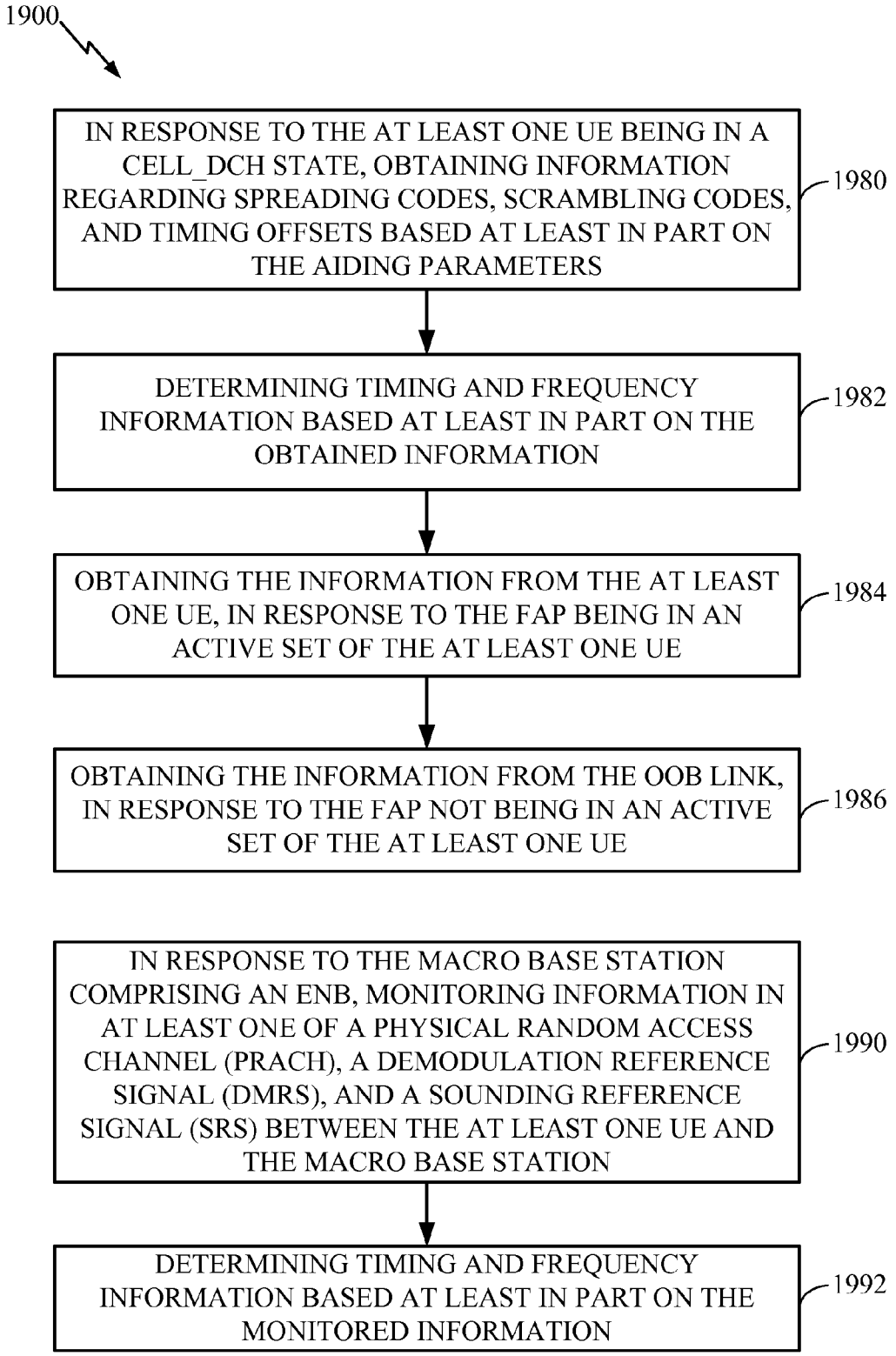

1900
IN RESPONSE TO THE AT LEAST ONE UE BEING IN A CELL_DCH STATE, OBTAINING INFORMATION REGARDING SPREADING CODES, SCRAMBLING CODES, AND TIMING OFFSETS BASED AT LEAST IN PART ON THE AIDING PARAMETERS
1980
DETERMINING TIMING AND FREQUENCY INFORMATION BASED AT LEAST IN PART ON THE OBTAINED INFORMATION
1982
OBTAINING THE INFORMATION FROM THE AT LEAST ONE UE, IN RESPONSE TO THE FAP BEING IN AN ACTIVE SET OF THE AT LEAST ONE UE
1984
OBTAINING THE INFORMATION FROM THE OOB LINK, IN RESPONSE TO THE FAP NOT BEING IN AN ACTIVE SET OF THE AT LEAST ONE UE
1986
IN RESPONSE TO THE MACRO BASE STATION COMPRISING AN ENB, MONITORING INFORMATION IN AT LEAST ONE OF A PHYSICAL RANDOM ACCESS CHANNEL (PRACH), A DEMODULATION REFERENCE SIGNAL (DMRS), AND A SOUNDING REFERENCE SIGNAL (SRS) BETWEEN THE AT LEAST ONE UE AND THE MACRO BASE STATION
1990
DETERMINING TIMING AND FREQUENCY INFORMATION BASED AT LEAST IN PART ON THE MONITORED INFORMATION
1992

FIG. 20B

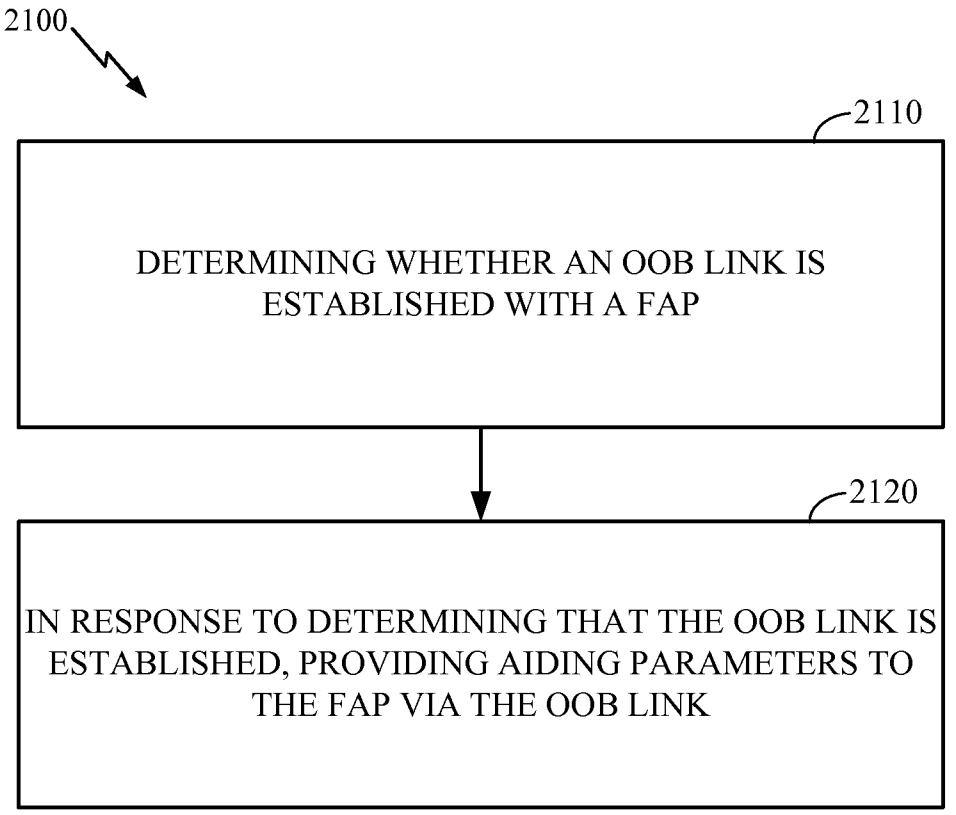

2100
2110
DETERMINING WHETHER AN OOB LINK IS ESTABLISHED WITH A FAP
2120
IN RESPONSE TO DETERMINING THAT THE OOB LINK IS ESTABLISHED, PROVIDING AIDING PARAMETERS TO THE FAP VIA THE OOB LINK

FIG. 21

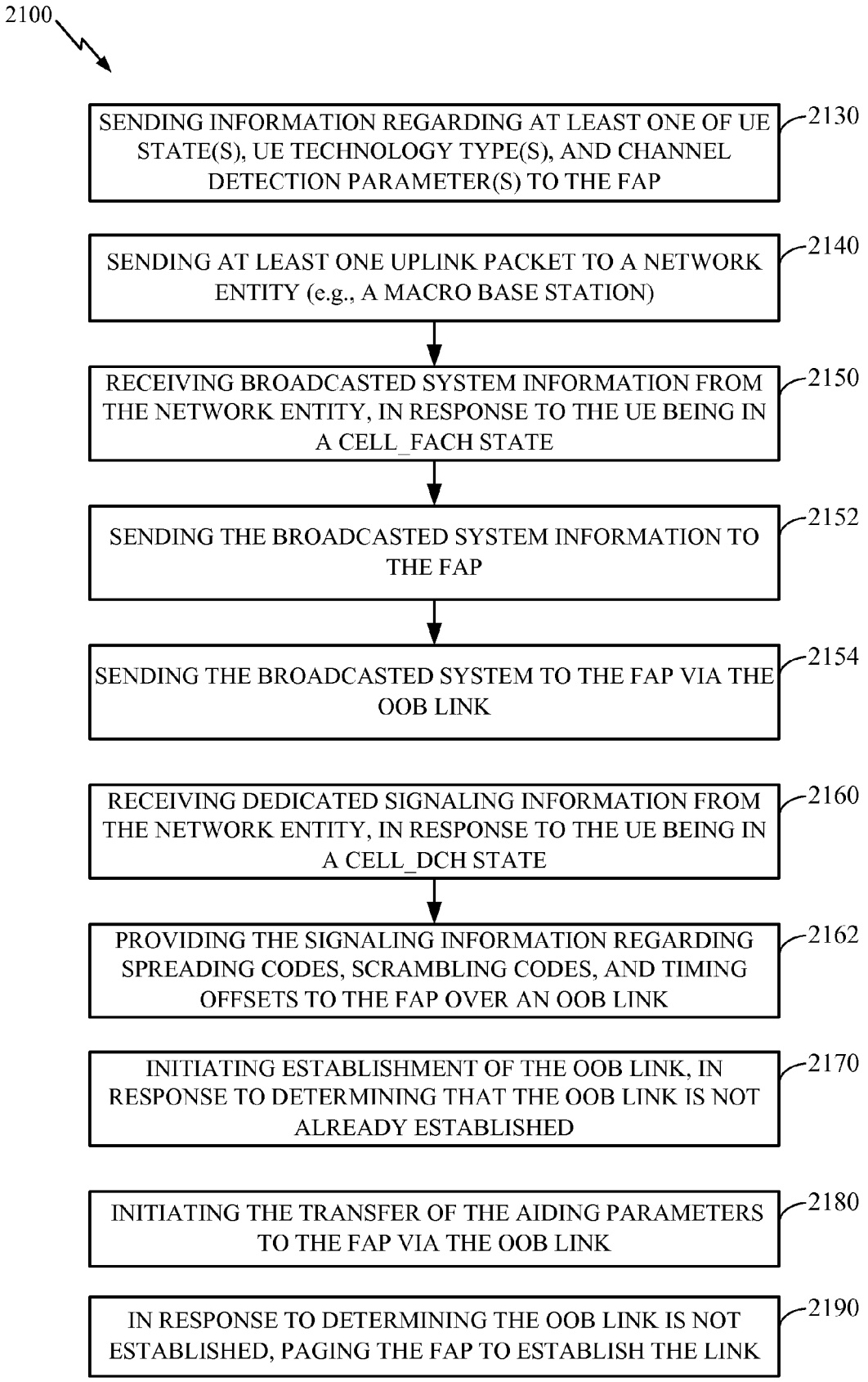

2100
SENDING INFORMATION REGARDING AT LEAST ONE OF UE STATE(S), UE TECHNOLOGY TYPE(S), AND CHANNEL DETECTION PARAMETER(S) TO THE FAP
2130
SENDING AT LEAST ONE UPLINK PACKET TO A NETWORK ENTITY (e.g., A MACRO BASE STATION)
2140
RECEIVING BROADCASTED SYSTEM INFORMATION FROM THE NETWORK ENTITY, IN RESPONSE TO THE UE BEING IN A CELL_FACH STATE
2150
SENDING THE BROADCASTED SYSTEM INFORMATION TO THE FAP
2152
SENDING THE BROADCASTED SYSTEM TO THE FAP VIA THE OOB LINK
2154
RECEIVING DEDICATED SIGNALING INFORMATION FROM THE NETWORK ENTITY, IN RESPONSE TO THE UE BEING IN A CELL_DCH STATE
2160
PROVIDING THE SIGNALING INFORMATION REGARDING SPREADING CODES, SCRAMBLING CODES, AND TIMING OFFSETS TO THE FAP OVER AN OOB LINK
2162
INITIATING ESTABLISHMENT OF THE OOB LINK, IN RESPONSE TO DETERMINING THAT THE OOB LINK IS NOT ALREADY ESTABLISHED
2170
INITIATING THE TRANSFER OF THE AIDING PARAMETERS TO THE FAP VIA THE OOB LINK
2180
IN RESPONSE TO DETERMINING THE OOB LINK IS NOT ESTABLISHED, PAGING THE FAP TO ESTABLISH THE LINK
2190

FIG. 22A

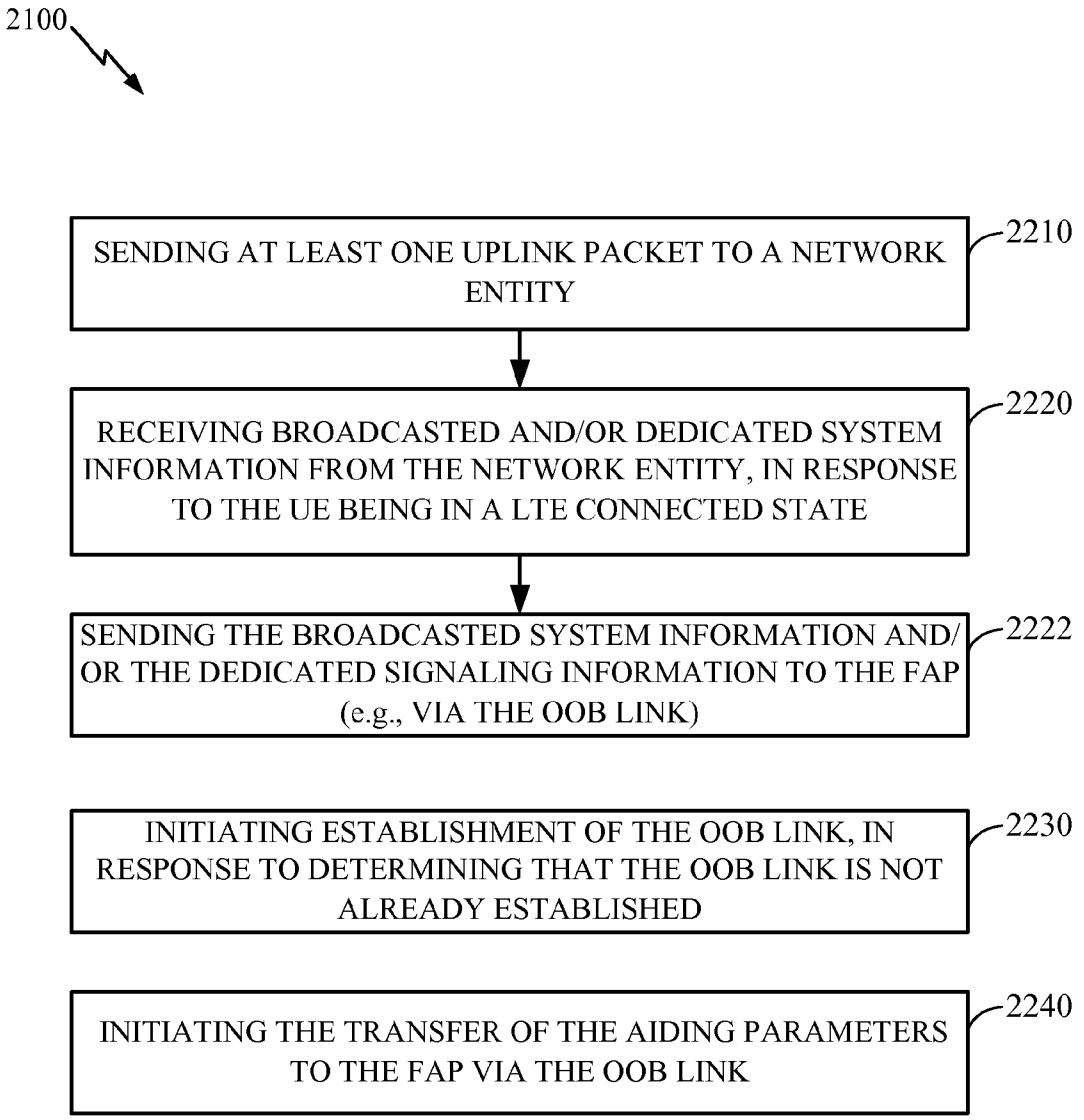

2100
SENDING AT LEAST ONE UPLINK PACKET TO A NETWORK ENTITY
2210
RECEIVING BROADCASTED AND/OR DEDICATED SYSTEM INFORMATION FROM THE NETWORK ENTITY, IN RESPONSE TO THE UE BEING IN A LTE CONNECTED STATE
2220
SENDING THE BROADCASTED SYSTEM INFORMATION AND/OR THE DEDICATED SIGNALING INFORMATION TO THE FAP (e.g., VIA THE OOB LINK)
2222
INITIATING ESTABLISHMENT OF THE OOB LINK, IN RESPONSE TO DETERMINING THAT THE OOB LINK IS NOT ALREADY ESTABLISHED
2230
INITIATING THE TRANSFER OF THE AIDING PARAMETERS TO THE FAP VIA THE OOB LINK
2240

FIG. 22B

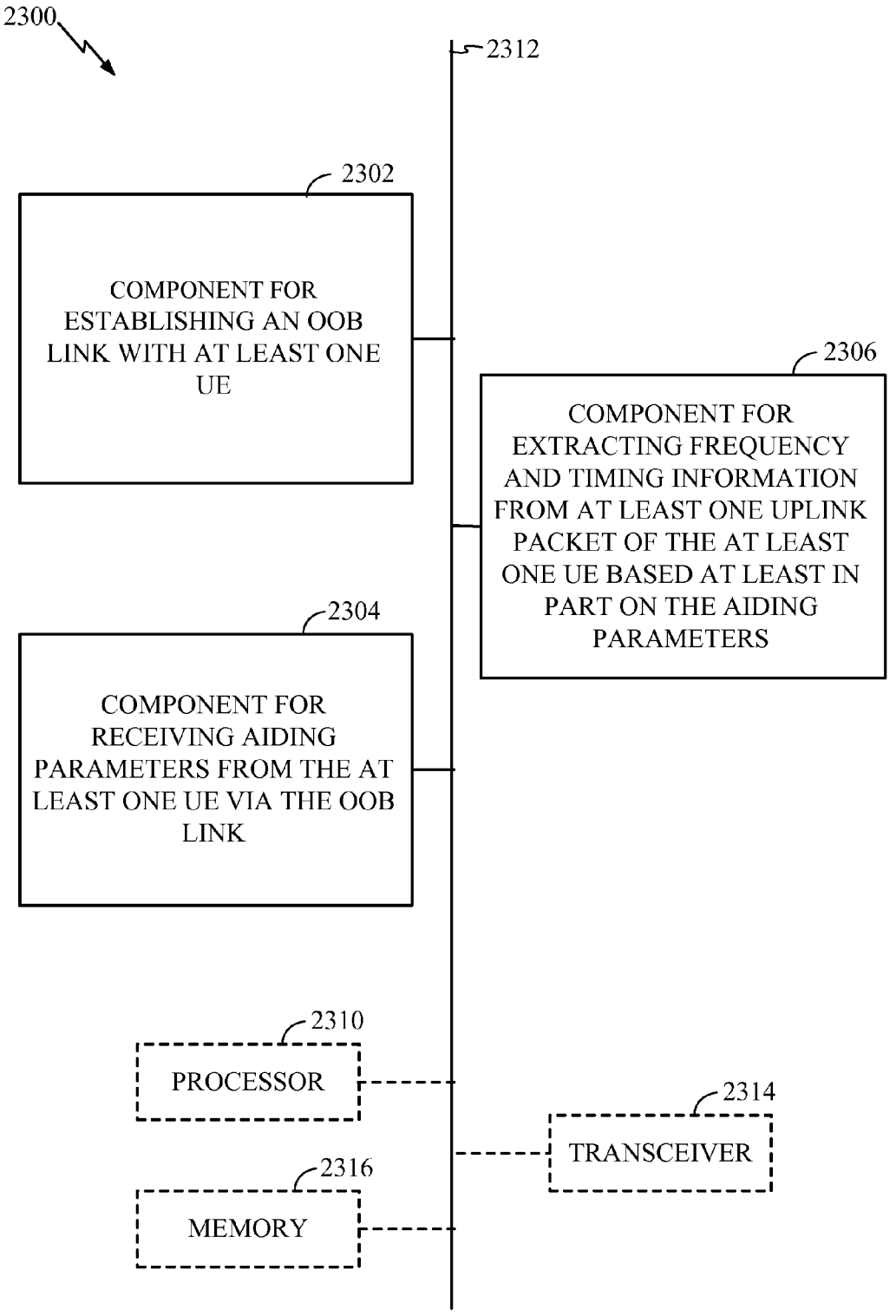

2300
2312
2302
COMPONENT FOR ESTABLISHING AN OOB LINK WITH AT LEAST ONE UE
2306
COMPONENT FOR EXTRACTING FREQUENCY AND TIMING INFORMATION FROM AT LEAST ONE UPLINK PACKET OF THE AT LEAST ONE UE BASED AT LEAST IN PART ON THE AIDING PARAMETERS
2304
COMPONENT FOR RECEIVING AIDING PARAMETERS FROM THE AT LEAST ONE UE VIA THE OOB LINK
2310
PROCESSOR
2314
TRANSCEIVER
2316
MEMORY

FIG. 23

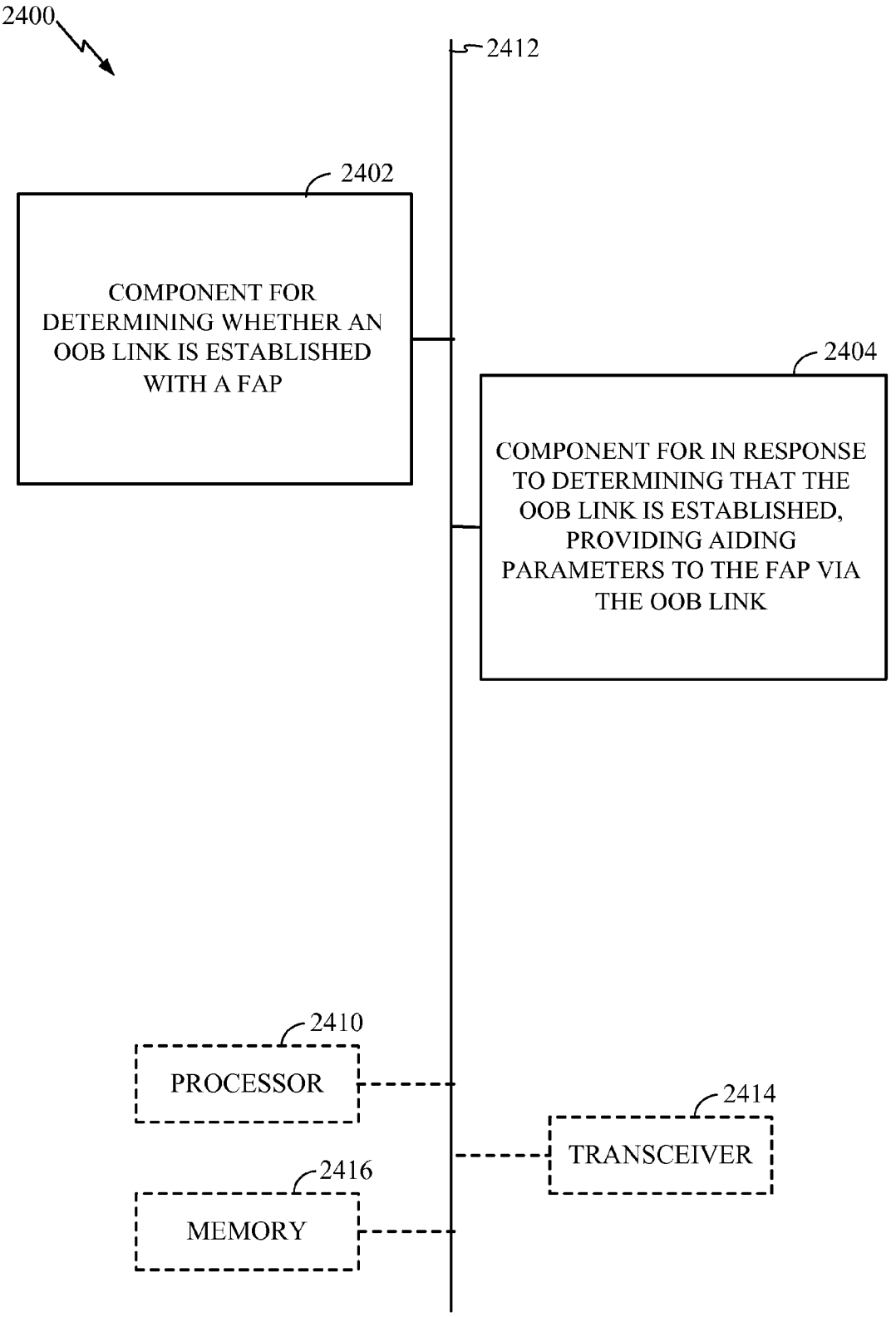

2400
2412
2402
COMPONENT FOR DETERMINING WHETHER AN OOB LINK IS ESTABLISHED WITH A FAP
2404
COMPONENT FOR IN RESPONSE TO DETERMINING THAT THE OOB LINK IS ESTABLISHED, PROVIDING AIDING PARAMETERS TO THE FAP VIA THE OOB LINK
2410
PROCESSOR
2414
TRANSCEIVER
2416
MEMORY

FIG. 24

SYSTEM AND METHOD FOR TIMING AND FREQUENCY SYNCHRONIZATION BY A FEMTO ACCESS POINT

CLAIM OF PRIORITY UNDER 35 U.S.C. §119

The present Application for patent claims priority to Provisional Application No. 61/309,730, entitled "METHOD AND APPARATUS TO ENABLE TIMING AND FREQUENCY SYNCHRONIZATION BASED ON INTERFERENCE FROM WIRELESS DEVICES," filed Mar. 2, 2010, and is assigned to the assignee hereof, and is hereby expressly incorporated in its entirety by reference herein.

BACKGROUND

1. Field

The present application relates generally to wireless communications, and more specifically to techniques for synchronizing a femto cell to a macro cell in a wireless communication network.

2. Background

Wireless communication networks are widely deployed to provide various communication content such as voice, video, packet data, messaging, broadcast, etc. These wireless networks may be multiple-access networks capable of supporting multiple users by sharing the available network resources. Examples of such multiple-access networks include Code Division Multiple Access (CDMA) networks, Time Division Multiple Access (TDMA) networks, Frequency Division Multiple Access (FDMA) networks, Orthogonal FDMA (OFDMA) networks, and Single-Carrier FDMA (SC-FDMA) networks.

In recent years, users have started to replace fixed line broadband communications with mobile broadband communications and have increasingly demanded great voice quality, reliable service, and low prices, especially at their home or office locations. In order to provide indoor services, network operators may deploy different solutions. For networks with moderate traffic, operators may rely on macro cellular base stations to transmit the signal into buildings. However, in areas where building penetration loss is high, it may be difficult to maintain acceptable signal quality, and thus other solutions are desired. New solutions are frequently desired to make the best of the limited radio resources such as space and spectrum. Some of these solutions include intelligent repeaters, remote radio heads, pico cells, and femto cells.

The Femto Forum, a non-profit membership organization focused on standardization and promotion of femto cell solutions, defines femto access points (FAPs), also referred to as femto cell units, to be low-powered wireless access points that operate in licensed spectrum and are controlled by the network operator, can be connected with existing handsets, and use a residential digital subscriber line (DSL) or cable connection for backhaul. In various standards or contexts, a FAP may be referred to as a home node B (HNB), home e-node B (HeNB), access point base station, etc.

In order to keep the expenses low, it is desired for FAPs to require very little for installation and setup. This means that a FAP may be designed to auto-configure itself such that the user only needs to plug in the cables for the internet connection and electricity, and the timing and frequency synchronization of the FAP with the macro cell is taken care of automatically.

SUMMARY

The following presents a simplified summary of one or more embodiments in order to provide a basic understanding of such embodiments. This summary is not an extensive overview of all contemplated embodiments, and is intended to neither identify key or critical elements of all embodiments nor delineate the scope of any or all embodiments. Its sole purpose is to present some concepts of one or more embodiments in a simplified form as a prelude to the more detailed description that is presented later.

In accordance with one or more embodiments and corresponding disclosure thereof, various aspects are described in connection with methods for frequency and timing synchronization by a femto access point (FAP). The method may involve establishing an out-of-band (OOB) link with at least one user equipment (UE). The method may involve receiving aiding parameters from the at least one UE via the OOB link. The method may involve extracting frequency and timing information from at least one uplink packet of the at least one UE based at least in part on the aiding parameters. In further related aspects, an electronic device may be configured to execute the above described methodology.

In accordance with one or more embodiments and corresponding disclosure thereof, various aspects are described in connection with a FAP synchronization method that may be performed by a mobile entity, such as a UE. In one embodiment, the method may involve determining whether an OOB link is established with a FAP. The method may involve, in response to determining that the OOB link is established, providing aiding parameters to the FAP via the OOB link. In further related aspects, an electronic device may be configured to execute the above described methodology.

To the accomplishment of the foregoing and related ends, the one or more embodiments comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative aspects of the one or more embodiments. These aspects are indicative, however, of but a few of the various ways in which the principles of various embodiments may be employed and the described embodiments are intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a wireless communication network.

FIG. **2** is a conceptual diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

FIG. **3** illustrates an exemplary communication system to enable deployment of FAPs within a network environment.

FIGS. **4**A-B are a block diagrams illustrating a FAP and a UE according to an aspect of the disclosure.

FIG. **5**A is a conceptual diagram illustrating the utilization of interference from UEs by a neighboring FAP according to an aspect of the disclosure.

FIG. **5**B shows an embodiment of a system for communicating aiding parameters over an OOB link.

FIG. **6** is a timing diagram illustrating timing relationships between transmissions on the P-CCPCH and AICH channels.

FIG. **7** is a timing diagram illustrating timing relationships between transmissions on the PRACH and AICH channels.

FIG. **8** is a timing diagram illustrating timing relationships between the PRACH, AICH, F-DPCH, and DPCCH transmissions.

FIG. **9** is a timing diagram illustrating a timing relationship at the UE between the F-DPCH and the UL DPCCH transmissions.

FIG. **10** is a conceptual diagram illustrating the generation of a preamble signal.

FIG. **11** is a conceptual diagram illustrating PRACH physical layer processing.

FIG. **12** is a conceptual diagram illustrating UL DPCCH and UL DPDCH physical layer processing.

FIGS. **13**A-B are timing diagrams illustrating timing relationships between UL DPCCH, P-CCPCH and DPCH or F-DPCH transmissions.

FIG. **14** is a timing diagram illustrating the determination of the slot timing of the P-CCPCH using the PRACH preamble and PRACH message part in the CELL_FACH state in accordance with an aspect of the disclosure.

FIG. **15** is a timing diagram illustrating the determination of the slot timing of the P-CCPCH using the PRACH message part in the CELL_FACH state in accordance with an aspect of the disclosure.

FIG. **16** is a timing diagram illustrating the determination of the slot timing of the P-CCPCH using the UL DPCCH in the CELL_FACH state in accordance with an aspect of the disclosure.

FIG. **17** is a timing diagram illustrating the determination of the slot and frame timing of the P-CCPCH using the UL DPCCH in the CELL_DCH state in accordance with an aspect of the disclosure.

FIGS. **18**A-B are flow charts illustrating a process for determining the slot timing of the P-CCPCH as shown in the timing diagrams of FIGS. **14-17** in accordance with an aspect of the disclosure.

FIG. **19** illustrates an example methodology for frequency and timing synchronization by a FAP.

FIGS. **20**A-B illustrate further aspects of the methodology of FIG. **19**.

FIG. **21** illustrates an example methodology for FAP synchronization by a mobile entity.

FIGS. **22**A-B illustrate further aspects of the methodology of FIG. **21**.

FIG. **23** shows an example apparatus for FAP synchronization, in accordance with the methodology of FIGS. **19-20**B.

FIG. **24** shows an example apparatus for FAP synchronization, in accordance with the methodology of FIGS. **21-22**B.

DETAILED DESCRIPTION

The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. The techniques described herein may be used for various wireless communication networks such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA and other wireless networks. The terms "network" and "system" are often used interchangeably. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000, etc. UTRA includes Wideband CDMA (WCDMA), Time Division Synchronous CDMA (TD-SCDMA), and other variants of CDMA. cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA network may implement a radio technology such as Evolved UTRA (E-UTRA), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, etc. UTRA and E-UTRA are part of Universal Mobile Telecommunication System (UMTS). 3GPP Long Term Evolution (LTE) and LTE-Advanced (LTE-A), in both FDD and TDD, are new releases of UMTS that use E-UTRA, which employs OFDMA on the downlink and SC-FDMA on the uplink. UTRA, E-UTRA, UMTS, LTE, LTE-A and GSM are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). cdma2000 and UMB are described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). The techniques described herein may be used for the wireless networks and radio technologies mentioned above as well as other wireless networks and radio technologies. For clarity, certain aspects of the techniques are described below for LTE, and LTE terminology is used in much of the description below.

FIG. **1** shows a wireless communication network **100**, which may be an LTE network or some other wireless network. Wireless network **100** may include a number of evolved Node Bs (eNBs) **110** and other network entities. An eNB may be an entity that communicates with the UEs and may also be referred to as a base station, a Node B, an access point, etc. Although the eNB typically has more functionalities than a base station, the terms "eNB" and "base station" are used interchangeably herein. Each eNB **110** may provide communication coverage for a particular geographic area and may support communication for mobile entities (MEs), such as, for example, user equipment (UEs) located within the coverage area. To improve network capacity, the overall coverage area of an eNB may be partitioned into multiple (e.g., three) smaller areas. Each smaller area may be served by a respective eNB subsystem. In 3GPP, the term "cell" can refer to the smallest coverage area of an eNB and/or an eNB subsystem serving this coverage area, depending on the context in which the term is used.

An eNB may provide communication coverage for a macro cell, a pico cell, a femto cell, and/or other types of cell. A macro cell may cover a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by UEs with service subscription. A pico cell may cover a relatively small geographic area and may allow unrestricted access by UEs with service subscription. A femto cell may cover a relatively small geographic area (e.g., a home) and may allow restricted access by UEs having association with the femto cell (e.g., UEs in a Closed Subscriber Group (CSG)). In the example shown in FIG. **1**, eNBs **110***a*, **110***b*, and **110***c* may be macro eNBs for macro cell groups **102***a*, **102***b*, and **102***c*, respectively. Each of the cell groups **102***a*, **102***b*, and **102***c* may include a plurality (e.g., three) of cells or sectors. An eNB **110***d* may be a pico eNB for a pico cell **102***d*. An eNB **110***e* may be a femto eNB or femto access point (FAP) for a femto cell **102***e*.

Wireless network **100** may also include relays (not shown in FIG. **1**). A relay may be an entity that can receive a transmission of data from an upstream station (e.g., an eNB or a UE) and send a transmission of the data to a downstream station (e.g., a UE or an eNB). A relay may also be a UE that can relay transmissions for other UEs.

A network controller **130** may couple to a set of eNBs and may provide coordination and control for these eNBs. Network controller **130** may comprise a single network entity or a collection of network entities. Network controller **130** may communicate with the eNBs via a backhaul. The eNBs may also communicate with one another, e.g., directly or indirectly via a wireless or wireline backhaul.

UEs **120** may be dispersed throughout wireless network **100**, and each UE may be stationary or mobile. A UE may also be referred to as a mobile station, a terminal, an access terminal, a subscriber unit, a station, etc. A UE may be a cellular phone, a personal digital assistant (PDA), a wireless modem, a wireless communication device, a handheld device, a laptop computer, a cordless phone, a wireless local loop (WLL) station, a smart phone, a netbook, a smartbook, etc. A UE may

be able to communicate with eNBs, relays, etc. A UE may also be able to communicate peer-to-peer (P2P) with other UEs.

Wireless network **100** may support operation on a single carrier or multiple carriers for each of the downlink and uplink. A carrier may refer to a range of frequencies used for communication and may be associated with certain characteristics. Operation on multiple carriers may also be referred to as multi-carrier operation or carrier aggregation. A UE may operate on one or more carriers for the downlink (or downlink carriers) and one or more carriers for the uplink (or uplink carriers) for communication with an eNB. The eNB may send data and control information on one or more downlink carriers to the UE. The UE may send data and control information on one or more uplink carriers to the eNB. In one design, the downlink carriers may be paired with the uplink carriers. In this design, control information to support data transmission on a given downlink carrier may be sent on that downlink carrier and an associated uplink carrier. Similarly, control information to support data transmission on a given uplink carrier may be sent on that uplink carrier and an associated downlink carrier. In another design, cross-carrier control may be supported. In this design, control information to support data transmission on a given downlink carrier may be sent on another downlink carrier (e.g., a base carrier) instead of the downlink carrier.

Wireless network **100** may support carrier extension for a given carrier. For carrier extension, different system bandwidths may be supported for different UEs on a carrier. For example, the wireless network may support (i) a first system bandwidth on a downlink carrier for first UEs (e.g., UEs supporting LTE Release 8 or 9 or some other release) and (ii) a second system bandwidth on the downlink carrier for second UEs (e.g., UEs supporting a later LTE release). The second system bandwidth may completely or partially overlap the first system bandwidth. For example, the second system bandwidth may include the first system bandwidth and additional bandwidth at one or both ends of the first system bandwidth. The additional system bandwidth may be used to send data and possibly control information to the second UEs.

Wireless network **100** may support data transmission via single-input single-output (SISO), single-input multiple-output (SIMO), multiple-input single-output (MISO), and/or multiple-input multiple-output (MIMO). For MIMO, a transmitter (e.g., an eNB) may transmit data from multiple transmit antennas to multiple receive antennas at a receiver (e.g., a UE). MIMO may be used to improve reliability (e.g., by transmitting the same data from different antennas) and/or to improve throughput (e.g., by transmitting different data from different antennas).

Wireless network **100** may support single-user MIMO, multi-user MIMO, Coordinated Multi-Point (CoMP), etc. For SU-MIMO, a cell may transmit multiple data streams to a single UE on a given time-frequency resource with or without precoding. For MU-MIMO, a cell may transmit multiple data streams to multiple UEs (e.g., one data stream to each UE) on the same time-frequency resource with or without precoding. CoMP may include cooperative transmission and/or joint processing. For cooperative transmission, multiple cells may transmit one or more data streams to a single UE on a given time-frequency resource such that the data transmission is steered toward the intended UE and/or away from one or more interfered UEs. For joint processing, multiple cells may transmit multiple data streams to multiple UEs (e.g., one data stream to each UE) on the same time-frequency resource with or without precoding.

Wireless network **100** may support hybrid automatic retransmission (HARQ) in order to improve reliability of data transmission. For HARQ, a transmitter (e.g., an eNB) may send a transmission of a data packet (or transport block) and may send one or more additional transmissions, if needed, until the packet is decoded correctly by a receiver (e.g., a UE), or the maximum number of transmissions has been sent, or some other termination condition is encountered. The transmitter may thus send a variable number of transmissions of the packet. For synchronous HARQ, all transmissions of the packet may be sent in subframes of a single HARQ interlace, which may include every Q-th subframes, where Q may be equal to 4, 6, 8, 10, or some other value. For asynchronous HARQ, each transmission of the packet may be sent in any subframe.

Wireless network **100** may support synchronous or asynchronous operation. For synchronous operation, the eNBs may have similar frame timing, and transmissions from different eNBs may be approximately aligned in time. For asynchronous operation, the eNBs may have different frame timing, and transmissions from different eNBs may not be aligned in time.

Wireless network **100** may utilize FDD or TDD. For FDD, the downlink and uplink may be allocated separate frequency channels, and downlink transmissions and uplink transmissions may be sent concurrently on the two frequency channels. For TDD, the downlink and uplink may share the same frequency channel, and downlink and uplink transmissions may be sent on the same frequency channel in different time periods. In related aspects, the FAP synchronization algorithm described in further detail below may be applied to the FAPs using FDD or TDD duplexing.

FIG. **2** is a conceptual diagram illustrating an example of a hardware implementation for an apparatus **200** employing a processing system **214**. For example, the apparatus **200** may comprise a mobile entity, such as a UE or the like, or a network entity, such as a macro base station (e.g., an eNB), a FAP, or the like. In this example, the processing system **214** may be implemented with a bus architecture, represented generally by the bus **202**. The bus **202** may include any number of interconnecting buses and bridges depending on the specific application of the processing system **214** and the overall design constraints. The bus **202** links together various circuits including one or more processors, represented generally by the processor **204**, and computer-readable media, represented generally by the computer-readable medium **206**. The bus **202** may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not be described any further. A bus interface **208** provides an interface between the bus **202** and a transceiver **210**. The transceiver **210** provides a means for communicating with various other apparatus over a transmission medium. Depending upon the nature of the apparatus, a user interface **212** (e.g., keypad, display, speaker, microphone, and/or joystick) may also be provided.

The processor **204** may be responsible for managing the bus **202** and general processing, including the execution of software stored on the computer-readable medium **206**. The software, when executed by the processor **204**, causes the processing system **214** to perform the various functions described infra for any particular apparatus. The computer-readable medium **206** may also be used for storing data that is manipulated by the processor **204** when executing software.

FIG. **3** illustrates an exemplary communication system to enable deployment of femto cells within a network environment. As shown in FIG. **3**, the system **300** includes a FAP **310**

installed in a corresponding small scale network environment, such as, for example, in one or more user residences **330**, and being configured to serve associated, as well as alien, mobile stations **320***a* and **320***b*. The FAP **310** may be coupled to the Internet **340** by way of a backhaul connection **335**, for example, a cable or digital subscriber line (DSL) connection. The FAP **310** is further communicatively coupled to a mobile operator core network **350** via the Internet **340** utilizing suitable communication hardware and software. Further, the FAP **310** may be communicatively coupled to one or more macro cell base stations **360** utilizing a network listen component **370** for sniffing the air interface broadcasted by one or more of the macro cell base stations **360** and/or for sniffing uplink packets from mobile entities (e.g., UEs).

FIG. **4**A is a conceptual block diagram that illustrates one example of the FAP **310** shown in FIG. **3**. In the figure, a number of blocks are labeled as processors or controllers. Those skilled in the art will comprehend that each of these processors may be implemented as hardware processors such as the processor **204** or the processing system **214** illustrated in FIG. **2**, or alternatively, the functions performed by any number of the illustrated processors may be combined into and implemented by a single hardware processor. Further, the illustrated processors in FIG. **4**A may represent functions to be implemented by processors, software, or the like.

As noted above, the FAP **310** may include a network listen component **370**. The network listen component **370** generally functions like the eyes and ears of the FAP **310** to configure the FAP **310** and retrieve timing and frequency information for synchronization. The network listen component **370** may include a downlink receiver **371** and a receive processor **372** for receiving and measuring signal and interference levels on various available channels. The network listen component **370** may further utilize the receiver **371** and receive processor **372** to acquire timing and frequency information from neighboring cells and decode broadcast messages from those cells for mobility and interference management purposes. For example, the network listen component **370** may achieve this by periodically scanning the surrounding cells. The FAP **310** may further include wireless wide area network (WWAN) components including a WWAN transceiver **311** and WWAN processor **312**, and wireless personal area network (WPAN) components including a WPAN transceiver **313** and WPAN processor **314**. Here, the WPAN components are optional, and may be utilized for out-of-band (OOB) communication with UEs in proximity to the FAP **310**. The FAP **310** may further include a backhaul I/O unit **316** for facilitating communication with a modem **400**, which may be internal or external to the FAP **310**, a controller/processor **315** for controlling and coordinating the various functionalities of the FAP **310**, and a memory **317** for storing information for utilization by the controller/processor **315**. In related aspects, the transmission functions of the FAP's WWAN transceiver **311** and WPAN transceiver **313** may be turned off to facilitate operation of the network listen component **370**.

FIG. **4**B is a block diagram illustrating an embodiment of a UE **410** according to an exemplary aspect of the disclosure. In FIG. **4**B, a number of blocks are labeled as processors or controllers. Those skilled in the art will comprehend that each of these processors may be implemented as hardware processors such as the processor **204** or the processing system **214** illustrated in FIG. **2**, or alternatively, the functions performed by any number of the illustrated processors may be combined into and implemented by a single hardware processor. Further, the illustrated processors in FIG. **4**B may represent functions to be implemented by processors, software, or the like. Here, the UE **410** may include a WWAN transceiver **420** and WWAN processor **430**, as well as a WPAN transceiver **440** and a WPAN processor **450**. Accordingly, the UE **410** may be configured to establish a WWAN link and/or a WPAN link with the FAP **310**. Further, the UE **410** may include an I/O for accepting user input, for example, from a keypad (not illustrated) and providing output, for example, to a display (not illustrated). Further, the UE **410** may include a controller/processor **460** for controlling the various functions of the UE **410**, and a memory **480** for storing information for use by the controller/processor **460**.

FIG. **5**A is a conceptual diagram illustrating an exemplary system in which aspects of the present disclosure may be implemented. Here, a femto cell **510** is located in the general vicinity of a neighboring macro cell **520**. To illustrate the example, two UEs **521**, **522** are camped on the macro cell **520**, which concomitantly acts as their serving cell. The UEs **521**, **522** may be configured to receive downlink transmissions in accordance with scheduling resources provided by the macro cell **520**, and to send uplink transmissions intended to be received and decoded by the macro cell **520**. Since the antennas of the UEs **521** and **522** may not be directional in nature, if the UEs **521**, **522** are located proximally to the femto cell **510**, the uplink transmissions may be received at the femto cell **510**. Ordinarily, uplink transmissions from the UEs **521**, **522** would be considered to be undesirable interference from the perspective of the WWAN transceiver and the network listen module of the FAP servicing the femto cell **510**. However, in accordance with some aspects of the present disclosure, the femto cell may sniff these uplink transmissions to obtain aiding information, such as to synchronize timing and frequency of the femto cell. In related aspects, as described in further detail below, the aiding information may be obtained by a FAP based as least upon aiding parameters obtained from the UEs **521** and/or **522** via an OOB link (e.g., a Bluetooth link).

In accordance with aspects of the embodiments described herein, a FAP of the femto cell **510** may sniff uplink packets transmitted by UE(s) **521** and/or **522** (e.g., packets directed to the macro cell **520**), and may retrieve aiding information, such as, for example, timing and frequency synchronization information of the particular macro cell **520** serving the respective UEs **521** and/or **522**. That is, packets transmitted by the UEs **521** and/or **522** directed to neighboring cells, which otherwise are considered as interference by a FAP, may be utilized by the FAP to improve the timing and/or frequency synchronization of the FAP.

In related aspects, the aiding information retrieved by sniffing the uplink transmissions from UEs may be utilized for refining coarse timing estimates obtained by other approaches, for example, utilizing the backhaul I/O module **316**, the network listen component **370**, or the like, shown in the embodiment of FIG. **3**.

In further related aspects, a FAP may sniff packets from UEs that are transmitting packets. In UMTS, UEs that are transmitting packets may be in the CELL_FACH or CELL_DCH mode. In other connected modes, such as the URA_PCH or the CELL_PCH states, the UEs are not transmitting packets on the uplink. Similarly, in idle mode, the UEs are also not transmitting packets on the uplink, and the FAP cannot sniff packets from the UEs in those states.

In order to sniff an uplink packet transmitted by a UE in the CELL_FACH state, the FAP may utilize scrambling code(s), spreading code(s), and signature(s) used by the UE in its uplink transmission(s). For example, the signatures and code numbers may be included in broadcasted system information (e.g., a given system information block (SIB)) in a macro cell, and may be obtained by a network listen entity of the FAP.

That is, to sniff packets from a UE in the CELL_FACH state, the network listen entity of the FAP may obtain broadcasted system information (e.g., SIB-5) from the macro cell. With this information, the FAP may extract signatures (e.g., a signature index), spreading codes (e.g., orthogonal variable spreading factor (OVSF) codes), and scrambling codes for the UEs in CELL_FACH from the broadcasted system information. The FAP may utilize such information to obtain timing and frequency information from uplink packets transmitted by the UE(s).

In order to sniff an uplink packet transmitted by an UE in the CELL_DCH state, the FAP may similarly utilize scrambling code(s), spreading code(s), and timing offset information used by the UE in its uplink transmissions. A FAP in the UE's active set will generally have access to such information, and may utilize this information to sniff the packets and obtain the timing and frequency information.

In accordance with aspects of the embodiments described herein, there are provided techniques for parameter communication for OOB-based uplink sniffing. As mentioned above, aiding information for synchronizing the timing and frequency of the FAP may be obtained by the FAP based as least upon aiding parameters obtained via an OOB link with UE(s). With reference to the embodiment of FIG. **5**B, there is shown a UE **550** in communication with a FAP **570** via an OOB link **560**, which may be a Bluetooth link or the like. The UE **550** may comprise a WWAN modem **552**, a WWAN processor and storage **554**, an OOB processor **556**, and an OOB modem **558** in operative communication with each other. The FAP **570** may comprise an OOB modem **572**, an OOB processor **574**, a WWAN processor and storage **576**, and a WWAN modem **578** in operative communication with each other.

At the UE **550**, WWAN aiding parameters may be extracted from the WWAN modem **552** and sent to the WWAN processor and storage **554** to be stored in registers. The WWAN aiding parameters may be read from the registers and passed to the OOB processor **556**. The OOB aiding parameters may also optionally be sent to the OOB processor **556** from OOB modem **558**. The combined aiding parameters may be sent to the OOB modem **558**. The aiding parameters may be then sent over the OOB link **560** to the femto OOB modem **572** of the FAP **570**. The aiding parameters may be sent from the femto OOB modem **572** to the OOB processor **574**, which in turn may send the aiding parameters to the WWAN processor and storage **576**. The femto WWAN modem **578** may be configured to use these aiding parameters in sniffing UE packets (e.g., uplink packets from the UE to a macro base station).

CELL_FACH: In the CELL_FACH state, the UE may be transmitting a preamble to gain access to the channel, or transmitting data to the network. If transmitting a preamble, the UE uses the physical random access channel (PRACH). UEs in the CELL_FACH state, which support Release 7 of the 3GPP family of standards and earlier releases of UMTS, may transmit data only on the PRACH, however, for later releases the UE may use the enhanced uplink dedicated channel dedicated physical control channel (E-DPDCH) for transmitting high data rate uplink messages.

FIG. **6** is a timing diagram that conceptually illustrates some of the channels discussed herein. In UMTS, the primary common control physical channel (P-CCPCH) **610** is the timing reference for all physical channels in a particular cell, directly for the downlink and indirectly for the uplink. Therefore, in order to obtain the timing reference of the macro cell, the timing relationship between the PRACH or the E-DPDCH the UE is using for uplink transmissions and the P-CCPCH of the macro cell is derived. This timing relationship is derived from the acquisition indicator channel (AICH) **620**, i.e., the downlink channel carrying the macro cell's ACK/NAK response to preambles. The AICH **620** has 15 slots labeled #0-#14, which overlap two P-CCPCH frames including 30 regular slots. The start of the AICH access slot #0 aligns with the start of P-CCPCH subframe number (SFN) modulo 2=0.

For each preamble transmitted in an uplink access slot there is a corresponding access slot from which the UE expects to receive an ACK/NAK from the network. In the event that an ACK was received, the timing of the UE's uplink data transmission (called the message part) is tied to the PRACH and AICH channel timing as shown in FIG. **6**. FIG. **7** shows the PRACH **710**, the AICH **720**, and the access slot the UE uses for transmission. Here, preambles **715** are 4096 chips long in slots that are 5120 chips wide. The time difference between the transmitted preamble and an expected ACK/NAK on the AICH is depicted as in FIG. **7**.

If an ACK **730** is received on the AICH channel **720**, then a message **740** of length 10 or 20 ms (data) is transmitted with a time difference of $\tau_{p\text{-}m}$ from when the original preamble was sent. If a NAK is received, then another preamble **715** is transmitted $\tau_{p\text{-}p}$ seconds after the previous preamble **715** was sent. The values for $\tau_{p\text{-}p}$, $\tau_{p\text{-}m}$, and $\tau_{p\text{-}a}$ depend on a parameter called the AICH Transmission Timing (ATT), which may takes on a value of 0 or 1. The value of the ATT parameter is derived from the cell broadcast information and the UE's access service class (ASC). The typical values for $\tau_{p\text{-}p}$, $\tau_{p\text{-}m}$, and $\tau_{p\text{-}a}$ are presented in Table 1 below.

TABLE 1

	AICH Trans. Timing = 0 (chips)	AICH Trans. Timing = 1 (chips)
$\tau_{p\text{-}p,\,min}$	15360	20480
$\tau_{p\text{-}a}$	7680	12800
$\tau_{p\text{-}m}$	15360	20480

As mentioned above, UEs in the CELL_FACH state supporting Release 8 and beyond are allowed to transmit data with a high data rate on the E-DPDCH, which may be 2 ms or 10 ms long. The transmission of E-DPDCH on the uplink **810** relies on the transmission of dedicated physical control channels, i.e., E-DPCCH and UL DPCCH. When UEs transmit on the E-DPDCH, the E-DPDCH and E-DPCCH are frame aligned with UL DPCCH. The UL DPCCH timing is tied to the timing of downlink channels **820** received during the preamble transmission and acknowledgement. These timing relationships are illustrated in FIG. **8**. Further, the values of the timing parameters illustrated in FIG. **8** are shown in Table 2 below.

The timing relationship between an UE's preamble transmission **830** on the PRACH and acknowledgement **840** on the AICH is the same as discussed previously, the difference here being when data can be transmitted after the reception of the ACK **840**. After an ACK **840** is transmitted on the AICH, the Node B transmits control information to the UE using the fractional dedicated physical channel (F-DPCH). The F-DPCH is transmitted $10240+256\times S_{offset}$ chips from the start of the AICH channel. Here, S_{offset} is an UE-dependent offset chosen by the network and used in staggering F-DPCH transmissions to multiple UEs so as to prevent overlaps. The range of S_{offset} is shown in Table 2.

TABLE 2

	AICH Trans. Timing = 0 (chips)	AICH Trans. Timing = 1 (chips)
$\tau_{p\text{-}p,\,min}$	15360	20480
$\tau_{p\text{-}a}$	7680	12800
$\tau_{p\text{-}m}$	15360	20480
$\tau_{a\text{-}m}$	$10240 + 256 \times S_{offset} + \tau_0$ chips	
τ_0	1024	
S_{offset}	0, 1, . . . , 9	

Once the UE receives the F-DPCH, the UE sends its corresponding uplink transmission in the UL DPCCH τ_0 (1024) chips afterward, as shown in FIG. **9**.

While sniffing the UEs' uplink packets in the CELL_FACH state, the network may determine whether the packet is a PRACH preamble, a PRACH message, or UL DPCCH (for release 8 and beyond UEs). The FAP may determine the type of transmission based on the packet structure of each of the transmissions. The PRACH preamble, PRACH message, and UL DPCCH structure are discussed below. In related aspects, the PRACH preambles **1030** are generated by the multiplication of a preamble signature **1010** with a scrambling code sequence **1020** as illustrated in FIG. **10**.

For example, there may be sixteen possible preamble signatures available in a particular cell. Each signature is made up of a 16-chip sequence repeated 256 times. While the indices of the available signatures are typically broadcasted in SIB-5, the subset available to a particular UE is derived based on the UE's ASC. In event that the ASC information is not available to the femto sniffing uplink packets, the femto would have to search through all sixteen signatures to find the particular signature that was used by the UE in generating the preamble signal.

The scrambling code used for the PRACH preamble is selected from a group of 8192 sequences divided into 512 code groups with 16 codes per group. Hence, the preamble scrambling code can be expressed as a code with index n, where n=m×16+k, where m is the index identifying the code group with values within the range 0, 1, . . . , 511 and k, and the specific code number within each group value is in the range of 0, 1, . . . , 15. The code group index has a one-to-one relationship with the primary scrambling code used by the cell (the macro cell in this case). Further information regarding these codes may be found in 3GPP TS25.213 section 4.3.3.2, incorporated herein by reference. The code number k is broadcasted in SIB 5.

The PRACH message is made of data and control information masked with the OVSF spreading and scrambling codes as shown in FIG. **11**.

The control part **1110** carries an 8-bit pilot pattern used for channel estimation at the Node B. There are 14 such patterns defined 3GPP TS25.211 section 5.2.2.1.3, incorporated herein by reference. The pilot pattern used in each slot can vary from slot to slot.

The OVSF code **1120** used for the control part has a fixed spreading factor of 256 given as $C_{256,m}$, where m=16×s+15, and s is the index of the preamble signature, discussed above, which values ranging from 0, 1, . . . , 15. The OVSF code **1140** for the data part **1130** is based on the spreading factor (SF) used for transmission, i.e., 256, 128, 64 and 32. The OVSF code **1140** can be expressed as $C_{SF,m}$, where m=SF×s/16. Further information about OVSF codes may be found in 3GPP TS25.213, section 4.3.1.3, incorporated herein by reference.

The scrambling code **1150** used for the PRACH message part may have a direct one to one mapping with the scrambling code used in scrambling the PRACH preamble.

Given that the search space for the data part is higher than the data, it is recommended that the OVSF code **1120** for the control part be used in the femto cell search during sniffing. The pilot sequence could also be employed in the search but since the pilot sequence can change every slot, it is therefore not efficient to use the pilot sequences.

FIG. **12** is a block diagram that illustrates UL DPCCH and UL DPDCH physical layer processing during transmission. It is noteworthy that although the gain factors are applied during transmissions as shown in FIG. **12**, the FAP may not be required to know the gain factors during detection.

The UL DPCCH contains control bits such as pilot sequences used for channel estimation and synchronization. There are six possible pilot patterns used in the UL DPCCH. The specific pattern used for transmission is typically signaled to the UE from the network.

The UL DPCCH may be transmitted alone or with other channels such as the E-DPDCH, E-DPCCH, and UL DPDCH. The transmission of UL DPCCH **1210** with the UL DPDCH **1220** is shown in FIG. **12**. The UL DPCCH **1210** may be transmitted on the quadrature component **1230** and spread using a known OVSF code **1240** with SF **256** and index 0, $C_{256,0}$. After data scaling with the beta factor and combining with the in-phase component (if transmitted with other channels), the UL DPCCH **1210** is scrambled using a UE specific scrambling code.

CELL_DCH: In the CELL_DCH state, the UE is actively exchanging data with the network. Similar to the CELL_FACH state described above, the timing reference for uplink transmission is the UL DPCCH **1302**. The timing of the UL DPCCH **1302** is derived from the timing of the DPCH **1310** or the F-DPCH **1320** as shown in FIGS. **13**A and **13**B, respectively. Here, the DPCH **1310** and F-DPCH **1320** have τ_{DPCH} and $\tau_{F\text{-}DPCH}$ timing offsets from the cell P-CCPCH, respectively. Further, the $\tau_{DPCH,n}$=T_n×256 chips, and the $\tau_{F\text{-}DPCH,p}$=T_p×256 chips, where T_n, T_p is in the range {0, 1, . . . , 149}.

The scrambling code index, beta factors, and τ_{DPCH} and $\tau_{F\text{-}DPCH}$ offsets corresponding to the UL DPCCH are typically signaled to the UE from the Node B through the Radio Bearer Configuration (RB Config.) or the Radio Bearer Reconfiguration (RB Re-config.) message.

Detection Parameters Used for Sniffing: A FAP may sniff uplink transmissions from UEs to obtain aiding information. The parameters utilized by the FAP for detection of the uplink transmissions, possible values of those parameters, and the sources of those values are presented in Table 3.

TABLE 3

Detection Parameter	Possible Values	UE source of Information
UE state	CELL_FACH/CELL_DCH	Signaled to UE in the RRC Connection set-up, RB configuration or RB re-configuration message

TABLE 3-continued

Detection Parameter	Possible Values	UE source of Information
UE Type	Pre-release 5, Release 5, 6, 7, 8, 9	Information is internal to UE but communicated to the network during UE capability information exchange
	PRACH Detection	
ATT Parameter	0, 1	Obtained from SIB 5/5 bis
ASC Parameter	0, 1, . . . , 7	Determined by UE based information from SIB 5 or 5 bis and USIM information
Preamble signature	s = 0, 1, . . . , 15	Available set is signaled through in SIB 5/5 bis but UE randomly selects a sequence
Preamble Scrambling code group	0, 1, . . . , 511	Tied to PSC on serving cell signaled. PSC is derived during UE synchronization
Preamble code Number	k = 0, 1, . . . , 15	Obtained from SIB 5/5 bis
Pilot bit pattern for the PRACH message control Part	14 possible bit patterns	Value is signaled from the network to UE
OVSF code for the PRACH message control part	$C_{256,m}$, where m = 16 × s + 15, and s = 0, 1, . . . , 15	Depends on the selected preamble signature
OVSF codes for the PRACH message data part	$C_{SF,m}$ = SF × s/16, where s = 0, 1, . . . , 15, and SF = 32, 64, 128, 256	SF is chosen by UE based on data rate. s is based on selected preamble signature
	UL DPCCH Detection	
Pilot bit pattern for the UL DPCCH	6 possible bit patterns	Signaled to UE in the RB configuration or RB re-configuration message
OVSF code for UL DPCCH	One option - $C_{256,0}$	Fixed
Scrambling code for UL DPCCH	2^{24} options	Signaled to UE in the RB configuration or RB re-configuration message
Time offsets - τ_{DPCH} and $\tau_{F\text{-}DPCH}$	$\tau_{DPCH,n} = T_n \times 256$ chip $\tau_{F\text{-}DPCH,p} = T_p \times 256$ T_n, T_p is in the range {0, 1, . . . , 149}	Signaled to UE in the RB configuration or RB re-configuration message
S_{offset}	{0, 1, . . . , 9}	Value is signaled from the network to UE

Almost all the parameters presented in Table 3 are provided from the macro cell to the UE in a broadcast or dedicated message, with the exception of the preamble signature, which is randomly selected by the UE. Therefore, the FAP would need to obtain this information from the UE over the OOB link.

If only a subset of the information is available, then the FAP may perform an exhaustive search of the possibilities of the unknown parameters to retrieve the macro cell timing information. Since the search space of the UL DPCCH scrambling code for the UE is very large (i.e., 2^{24}), a system may benefit if the UL DPCCH detection is used when the UL DPCCH scrambling code of the UE is known.

Slot and Frame Timing Determination: The detection of the slot or the frame timing of the P-CCPCH using the PRACH preamble and PRACH message part in CELL_FACH, UL DPCCH in CELL_FACH and UL DPCCH in CELL_DCH are illustrated in FIGS. **14-17**. In each figure, the order of the steps used for the determination of the slot timing of the P-CCPCH is also noted. A flow chart illustrating each of these detection processes is presented in FIG. **18**B. FIG. **18**A illustrates a general process illustrating details of a preliminary procedure prior to the determination of the slot or the frame timing.

In FIG. **18**A, the process depends on the state in which the UE exists. If the UE is in the CELL_FACH state, then in block **1801**, the process receives detection parameters, for example, utilizing a backhaul connection to retrieve the information from a network node such as a neighboring Node B or an RNC. In block **1803**, the process extracts information about the cell from the SIB information retrieved in block **1801**, to be utilized for the reception of uplink information from the UE as illustrated in FIG. **18**B. If the UE is in the CELL_DCH state, then in block **1805**, the process receives detection parameters, for example, utilizing a backhaul connection to retrieve the information from a network node such as a neighboring Node B or an RNC. In block **1807**, the process extracts information about the cell and the UE from the radio bearer message retrieved in block **1805**, to be utilized for the reception of uplink information from the UE as illustrated in FIG. **18**B.

FIG. **14** illustrates the determination of the slot timing of the P-CCPCH using the PRACH preamble in the CELL_FACH state. FIG. **15** illustrates the determination of the slot timing of the P-CCPCH using the PRACH message part in the CELL_FACH state. As shown in FIG. **18**B, in block **1802**, the process determines whether the cell is in a CELL_FACH state or a CELL_DCH state. If the process determines that the UE state is the CELL_FACH state, then the process branches to block **1804**. In block **1804**, the process determines whether the UE is a pre-release-8 UE. If the UE is a pre-release-8 UE, the process branches to block **1806**. In block **1806**, the process determines whether the PRACH preamble or the message part is detected. If the PRACH preamble or message part is not detected, the process returns to the start. If the PRACH preamble or message part is detected, as shown at ① in FIG. **14** or at ① in FIG. **15**; respectively, then the process branches to block **1808**. In

block **1808**, the process determines the offset from the AICH, which carries the macro cell's ACK/NAK response to preambles, as shown at ② in FIG. **14** for the PRACH preamble and at ② in FIG. **15** for the message part. In block **1810**, the process determines the P-CCPCH slot boundary, utilizing the relationship between the start of the AICH access slot #0 and the P-CCPCH slots, as shown at ③ in FIG. **14** for the PRACH preamble and at ③ in FIG. **15** for the message part.

As shown in FIG. **18**B, in block **1802**, if the UE state is determined to be the CELL_FACH state, the process branches to block **1804**. In block **1804**, if the UE is determined not to be a pre-release-8 UE, the process branches to block **1812**. In block **1812**, the process determines whether the PRACH preamble, message part, or UL DPCCH are detected. If the PRACH preamble, message part, or UL DPCCH are not detected, the process returns to the start. If the PRACH preamble, message part, or UL DPCCH are detected, the process branches to block **1814**. In block **1814**, the process determines whether the PRACH preamble or message part are detected. If the PRACH preamble or message part are detected, the process branches to block **1818**. In block **1818**, the process determines the offset from AICH, which carries the macro cell's ACK/NAK response to preambles, as shown at ② in FIG. **14** for the PRACH preamble and at ② in FIG. **15** for the message part. In block **1820**, the process determines the P-CCPCH slot boundary, utilizing the relationship between the start of the AICH access slot #0 and the P-CCPCH slots, as shown at ③ in FIG. **14** for the PRACH preamble and at ③ in FIG. **15** for the message part.

FIG. **16** illustrates the determination of the slot timing of the P-CCPCH using the UL DPCCH in the CELL_FACH state. As shown in FIG. **18**B, in block **1802**, if the UE state is determined to be the CELL_FACH state, the process branches to block **1804**. In block **1804**, if the UE is determined not to be a pre-release-8 UE, the process branches to block **1812**. In block **1812**, the process determines whether the PRACH preamble, message part, or UL DPCCH are detected. If the PRACH preamble, message part, or UL DPCCH are not detected, the process returns to the start. If the PRACH preamble, message part, or UL DPCCH are detected, the process branches to block **1814**. In block **1814**, the process determines whether the PRACH preamble or message part are detected. If the PRACH preamble and message part are not detected, the process branches to block **1816**. In block **1816**, the process determines the offset from F-DPCH, utilizing the relationship between UL-DPCCH and the F-DPCH, as shown at ② in FIG. **16**. In block **1818**, the process determines the offset from AICH, which carries the macro cell's ACK/NAK response to preambles, as shown at ③ in FIG. **16**. In block **1820**, the process determines the P-CCPCH slot boundary, utilizing the relationship between the start of the AICH access slot #0 and the P-CCPCH slots, as shown at ④ in FIG. **16**.

FIG. **17** illustrates the determination of the slot and frame timing of the P-CCPCH using the UL DPCCH in the CELL_DCH state. As shown in FIG. **18**, in block **1802**, if the UE state is determined to be the CELL_DCH state, the process branches to block **1822**. In block **1822**, the process determines whether the UL DPCCH is detected, as shown at ①. If UL DPCCH is not detected, the process returns to the start. If the UL DPCCH is detected on the downlink, then in block **1824**, as shown at ② in FIG. **17**, the process determines the offset of the DPCH **1310** or the F-DPCH **1320** (see FIGS. **13**A and **13**B). In block **1826**, the process determines the P-CCPCH frame boundary, as shown at ③ in FIG. **17**. In block **1828**, the process determines the P-CCPCH slot boundary, as shown at ④ in FIG. **17**.

In view of exemplary systems shown and described herein, methodologies that may be implemented in accordance with the disclosed subject matter, will be better appreciated with reference to various flow charts. While, for purposes of simplicity of explanation, methodologies are shown and described as a series of acts/blocks, it is to be understood and appreciated that the claimed subject matter is not limited by the number or order of blocks, as some blocks may occur in different orders and/or at substantially the same time with other blocks from what is depicted and described herein. Moreover, not all illustrated blocks may be required to implement methodologies described herein. It is to be appreciated that functionality associated with blocks may be implemented by software, hardware, a combination thereof or any other suitable means (e.g., device, system, process, or component). Additionally, it should be further appreciated that methodologies disclosed throughout this specification are capable of being stored on an article of manufacture to facilitate transporting and transferring such methodologies to various devices. Those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states or events, such as in a state diagram.

In accordance with one or more aspects of the subject of this disclosure, there are provided methods for frequency and timing synchronization of a FAP. With reference to FIG. **19**, illustrated is a methodology **1900** that may be performed by a FAP, or component(s) thereof. The method **1900** may involve, at **1910**, establishing an OOB link (e.g., Bluetooth link or the like) with at least one UE. The method **1900** may involve, at **1920**, receiving aiding parameters from the at least one UE via the OOB link. The method **1900** may involve, at **1930**, extracting frequency and timing information from at least one uplink packet of the at least one UE based at least in part on the aiding parameters.

With reference to FIG. **20**A, there are shown further operations or aspects of method **1900** that are optional and may be performed by a FAP for frequency and timing synchronization. It is noted that the blocks shown in FIGS. **20**A-B are not required to perform the method **1900**. If the method **1900** includes at least one block of FIGS. **20**A-B, then the method **1900** may terminate after the at least one block, without necessarily having to include any subsequent downstream block(s) that may be illustrated. It is further noted that numbers of the blocks do not imply a particular order in which the blocks may be performed according to the method **1900**. For example, receiving the aiding parameters may involve, at **1940**, receiving information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) (e.g., scrambling codes) from the at least one UE. In the alternative, or in addition, receiving the aiding parameters may involve, at **1950**, requesting the aiding parameters from the at least one UE via the OOB link. Extracting the frequency and timing information may involve, at **1960**, sniffing the at least one uplink packet from the at least one UE to a network entity (e.g., Node B or eNB).

In related aspects, extracting the frequency and timing information may involve, at **1970**, in response to the at least one UE being in a CELL_FACH state, obtaining via the OOB link information regarding signatures, spreading codes and scrambling codes for the at least one UE which the at least one UE received as broadcasted system information from the macro base station. Extracting may further involve, at **1972**, determining the timing and frequency information based at least in part on the obtained information.

With reference to FIG. **20**B, in further related aspects, extracting the frequency and timing information may involve,

at **1980**, in response to the at least one UE being in a CELL_DCH state, obtaining information regarding spreading codes, scrambling codes, and timing offsets based at least in part on the aiding parameters. Extracting may further involve, at **1982**, determining timing and frequency information based at least in part on the obtained information. Obtaining may involve, at **1984**, obtaining the information from the at least one UE, in response to the FAP being in an active set of the at least one UE. In the alternative, obtaining may involve, at **1986**, obtaining the information from the OOB link, in response to the FAP not being in an active set of the at least one UE.

In yet further related aspects, sniffing may involve, at **1990**, in response to the macro base station comprising an eNB and the UE being in a LTE connected mode, monitoring information in at least one of the LTE channels used by a connected mode LTE UE, a physical random access channel (PRACH), a demodulation reference signal (DMRS), and a sounding reference signal (SRS) between the at least one UE and the macro base station. Sniffing may further involve, at **1992**, determining timing and frequency information based at least in part on the monitored information.

In related aspects, the PRACH parameters may include: (a) PRACH_Config; (b) PRACH_Mapping; (c) PRACH_PrmbleIndex; (d) PRACH_RBOffset; (e) PRACH_u; (f) PRACH_Ncs; and/or (g) PRACH_PwrOffset. Analogously, the PRACH parameters for LTE uplink signals may include: (a) PRACH configuration index; (b) PRACH mapping patterns (in FDD, it indicates the subframe number where the preamble starts; in TDD, it indicates the index of preamble mapping pattern in time and frequency); (c) preamble indexes (e.g., used to select preamble sequences from 64 preambles available in a given cell); (d) PRACH frequency offset (e.g., the first RB available for PRACH); (e) logical index of root Zadoff-Chu (ZC) sequence (u); (f) cyclic shifts of ZC sequence; and/or (g) the power offset in dB for PRACH.

In further related aspects, the DMRS parameters may include: (a) physical uplink shared channel (PUSCH) parameters; (b) physical uplink control channel (PUCCH) parameters; (c) GroupHop_Enable; and/or (d) SeqHop_Enable. Analogously, the DMRS parameters for LTE uplink signals may include: (a) PUSCH parameters for LTE uplink signals; (b) PUCCH parameters for LTE uplink signals; (c) whether or not to enable group hopping for DMRS on PUCCH and PUSCH; and/or (d) whether or not to enable sequence hopping for DMRS on PUSCH. It is noted that not all PUSCH and PUCCH parameters are required for DMRS. The FAP may try to determine location of DMRS within these channels by using the difference in correlation properties of DMRS patterns versus quadrature phase shift keying (QPSK) patterns.

In yet related aspects, the SRS parameters may include: (a) SRS_BW; (b) SRS_SC Start; (c) SRS_SF_Config; (d) SRS_CS; and/or (e) SRS_PwrOffset. Analogously, the SRS parameters for LTE uplink signals may include: (a) the SRS bandwidth in RB; (b) the start subcarrier of the SRS; (c) SRS subframe configuration; (d) used in computing the cyclic shift of SRS; and/or (e) the power offset in dB for SRS.

In accordance with one or more aspects of the subject of this disclosure, FIG. **21** illustrates a methodology **2100** for FAP synchronization by a mobile entity (e.g., UE), or component(s) thereof. The method **2100** may involve, at **2110**, determining whether an OOB link is established with a FAP. The method **2100** may involve, at **2120**, in response to determining that the OOB link is established, providing aiding parameters to the FAP via the OOB link. In related aspects, if the UE determines that the OOB link is not established, the UE may choose to establish that connection by paging the FAP.

With reference to FIG. **22**A, there are shown further operations or aspects of method **2100** that are optional and may be performed by a UE for FAP synchronization. It is noted that the blocks shown in FIGS. **22**A-B are not required to perform the method **2100**. If the method **2100** includes at least one block of FIGS. **22**A-B, then the method **2100** may terminate after the at least one block, without necessarily having to include any subsequent downstream block(s) that may be illustrated. It is further noted that numbers of the blocks do not imply a particular order in which the blocks may be performed according to the method **2100**. For example, with reference to FIG. **22**A, providing the aiding parameters may involve, at **2130**, sending information regarding at least one of UE state(s), UE technology type(s) (e.g., UMTS, LTE, etc.), and channel detection parameter(s) to the FAP. The method **2100** may further involve, at **2140**, sending at least one uplink packet to a network entity.

In related aspects, the method **2100** may further involve, at **2150**, receiving broadcasted system information from the network entity, in response to the UE being in a CELL_FACH state. The method **2100** may further involve, at **2152**, sending the broadcasted system information to the FAP. Sending may involve, at **2154**, sending the broadcasted system information to the FAP via the OOB link.

In further related aspects, the method **2100** may further involve, at **2160**, receiving dedicated signaling information from the network entity, in response to the UE being in a CELL_DCH state. The method **2100** may further involve, at **2162**, providing the signaling information regarding spreading codes, scrambling codes, and timing offsets to the FAP over an OOB link.

In yet further related aspects, the method **2100** may further involve, at **2170**, initiating establishment of the OOB link, in response to determining that the OOB link is not already established. Providing may involve, at **2180**, initiating the transfer of the aiding parameters to the FAP via the OOB link. In still further related aspects, the method **2100** may involve, at **2190**, in response to determining that the OOB link is not established, paging the FAP to establish the OOB link.

It is noted that the blocks in FIG. **22**A are applicable to UMTS or LTE. With reference to FIG. **22**B, there are provided blocks that are specific to LTE. For example, the method **2100** may further involve, at **2210**, sending at least one uplink packet to a network entity. In related aspects, the method **2100** may further involve, at **2220**, receiving broadcasted and/or dedicated system information from the network entity, in response to the UE being in a LTE connected state. The method **2100** may further involve, at **2222**, sending the broadcasted system information and/or dedicated signaling information to the FAP. Sending may involve sending the broadcasted system information and/or the dedicated signaling information to the FAP via the OOB link or the like. In further related aspects, the method **2100** may further involve, at **2230**, initiating establishment of the OOB link, in response to determining that the OOB link is not already established. Providing may involve, at **2240**, initiating the transfer of the aiding parameters to the FAP via the OOB link.

In accordance with one or more aspects of the embodiments described herein, there are provided devices and apparatuses for frequency and timing synchronization of a FAP, as described above with reference to FIGS. **19**-**20**B. With reference to FIG. **23**, there is provided an exemplary apparatus **2300** that may be configured as a FAP, or as a processor or similar device for use within the FAP. The apparatus **2300**

may include functional blocks that can represent functions implemented by a processor, software, or combination thereof (e.g., firmware).

For example, the apparatus **2300** of FIG. **23** may comprise an electrical component or module **2302** for establishing an OOB link with at least one UE. The apparatus **2300** may comprise an electrical component **2304** for receiving aiding parameters from the at least one UE via the OOB link. The apparatus **2300** may comprise an electrical component **2306** for extracting frequency and timing information from at least one uplink packet of the at least one UE based at least in part on the aiding parameters.

In related aspects, the apparatus **2300** may optionally include a processor component **2310** having at least one processor, in the case of the apparatus **2300** configured as a network entity, rather than as a processor. The processor **2310**, in such case, may be in operative communication with the components **2302-2306** via a bus **2312** or similar communication coupling. The processor **2310** may effect initiation and scheduling of the processes or functions performed by electrical components **2302-2306**.

In further related aspects, the apparatus **2300** may include a radio transceiver component **2314**. A stand alone receiver and/or stand alone transmitter may be used in lieu of or in conjunction with the transceiver **2314**. The apparatus **2300** may optionally include a component for storing information, such as, for example, a memory device/component **2316**. The computer readable medium or the memory component **2316** may be operatively coupled to the other components of the apparatus **2300** via the bus **2312** or the like. The memory component **2316** may be adapted to store computer readable instructions and data for effecting the processes and behavior of the components **2302-2306**, and subcomponents thereof, or the processor **2310**, or the methods disclosed herein. The memory component **2316** may retain instructions for executing functions associated with the components **2302-2306**. While shown as being external to the processor **2310**, the transceiver **2314**, and the memory **2316**, it is to be understood that one or more of the components **2302-2306** can exist within the processor **2310**, the transceiver **2314**, and/or the memory **2316**.

In accordance with one or more aspects of the embodiments described herein, there are provided devices and apparatuses (e.g., mobile entities) configured to facilitate synchronization of a FAP, as described above with reference to FIGS. **21-22**B. With reference to FIG. **24**, the apparatus **2400** may comprise an electrical component or module **2402** for determining whether an OOB link is established with a FAP. The apparatus **2400** may comprise an electrical component **2404** for, in response to determining that the OOB link is established, providing aiding parameters to the FAP via the OOB link. For the sake of conciseness, the rest of the details regarding apparatus **2400** are not further elaborated on; however, it is to be understood that the remaining features and aspects of the apparatus **2400** are substantially similar to those described above with respect to apparatus **2300** of FIG. **23**.

Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the disclosure herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

The various illustrative logical blocks, modules, and circuits described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

The steps of a method or algorithm described in connection with the disclosure herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

In one or more exemplary designs, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage media may be any available media that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code means in the form of instructions or data structures and that can be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or non-transitory wireless technologies, then the coaxial cable, fiber optic cable, twisted pair, DSL, or the non-transitory

wireless technologies are included in the definition of medium. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

The previous description of the disclosure is provided to enable any person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the spirit or scope of the disclosure. Thus, the disclosure is not intended to be limited to the examples and designs described herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

1. A method for frequency and timing synchronization by a femto access point (FAP), comprising:

establishing, by a processor of the FAP, an out-of-band (OOB) link between the FAP and at least one user equipment (UE), wherein the at least one UE is being serviced by a network entity macro base station other than the FAP;

receiving aiding parameters from the at least one UE via the OOB link; and

in response to the at least one UE being in a CELL_DCH state or a CELL_FACH state, sniffing, by the FAP, at least one uplink packet directed from the at least one UE to the network entity macro base station at least by extracting frequency and timing information from the at least one uplink packet of the at least one UE based at least in part on the aiding parameters.

2. The method of claim **1**, wherein receiving the aiding parameters comprises receiving information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) from the at least one UE.

3. The method of claim **2**, wherein the channel detection parameter(s) comprise scrambling code(s).

4. The method of claim **1**, wherein receiving the aiding parameters comprises requesting the aiding parameters from the at least one UE via the OOB link.

5. The method of claim **1**, wherein the macro base station comprises one of a Node B and an evolved Node B (eNB).

6. The method of claim **5**, wherein sniffing further comprises:

in response to the network entity macro base station comprising an eNB, monitoring information in at least one of a physical random access channel (PRACH), a demodulation reference signal (DMRS), and a sounding reference signal (SRS) between the at least one UE and the eNB.

7. The method of claim **1**, wherein the aiding parameters comprise information regarding:

signatures, spreading codes and scrambling codes for the at least one UE which the at least one UE received as broadcasted system information from the network entity macro base station

determining the timing and frequency information based at least in part on the obtained information.

8. The method of claim **1**, wherein, the extracting is in response to the FAP being in an active set of the at least one UE.

9. The method of claim **1**, wherein, the extracting is in response to the FAP not being in an active set of the at least one UE.

10. The method of claim **1**, wherein the OOB link comprises a Bluetooth link.

11. An apparatus for frequency and timing synchronization of a femto access point (FAP), comprising:

at least one processor configured to: establish, by the FAP, an out-of-band (OOB) link between the FAP and at least one user equipment (UE), wherein the at least one UE is being serviced by a network entity macro base station other than the FAP; receive aiding parameters from the at least one UE via the OOB link; and in response to the at least one UE being in a CELL_DCH state or a CELL_FACH state, sniff, by the FAP, at least one uplink packet directed from the at least one UE to the network entity macro base station at least by extracting frequency and timing information from the at least one uplink packet of the at least one UE based at least in part on the aiding parameters; and

a memory coupled to the at least one processor for storing data.

12. The apparatus of claim **11**, wherein the at least one processor receives the aiding parameters by receiving information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) from the at least one UE.

13. The apparatus of claim **11**, wherein the at least one processor requests the aiding parameters from the at least one UE via the OOB link.

14. The apparatus of claim **11**, wherein the aiding parameters comprise information regarding:

signatures, spreading codes and scrambling codes for the at least one UE which the at least one UE received as broadcasted system information from the network entity macro base station.

15. The apparatus of claim **11**, wherein the at least one processor sniffs by:

in response to the network entity macro base station comprising an evolved Node B (eNB), monitoring information in at least one of a physical random access channel (PRACH), a demodulation reference signal (DMRS), and a sounding reference signal (SRS) between the at least one UE and the eNB.

16. An apparatus, comprising:

means for establishing an out-of-band (OOB) link between the apparatus and at least one user equipment (UE), wherein the at least one UE is being serviced by a network entity serving macro base station other than the apparatus;

means for receiving aiding parameters from the at least one UE via the OOB link; and

means for, in response to the at least one UE being in a CELL_DCH state or a CELL_FACH state, sniffing, by the FAP, at least one uplink packet directed from the at least one UE to the network entity macro base station at least by extracting frequency and timing information from the at least one uplink packet of the at least one UE based at least in part on the aiding parameters.

17. The apparatus of claim **16**, further comprising means for receiving information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) from the at least one UE.

18. The apparatus of claim **16**, further comprising means for requesting the aiding parameters from the at least one UE via the OOB link.

19. The apparatus of claim **16**, wherein the aiding parameters comprise information regarding:

signatures, spreading codes and scrambling codes for the at least one UE which the at least one UE received as

broadcasted system information from the network entity macro base station, in response to the at least one UE being in a CELL_FACH state; and

means for determining the timing and frequency information based at least in part on the obtained information.

20. The apparatus of claim **16**, wherein the at least one processor further sniffs by:

means for monitoring information in at least one of a physical random access channel (PRACH), a demodulation reference signal (DMRS), and a sounding reference signal (SRS) between the at least one UE and the network entity macro base station, in response to the network entity macro base station comprising an eNB.

21. A non-transitory computer-readable medium having computer-readable instructions stored therein that when executed cause a computing device to:

establish, by a processor of a femto access point (FAP), an out-of-band (OOB) link between the computing device and at least one user equipment (UE), wherein the at least one UE is being serviced by a network entity macro base station other than the computing device;

receive aiding parameters from the at least one UE via the OOB link; and

in response to the at least one UE being in a CELL_DCH state or a CELL_FACH state, sniff, by the FAP, at least one uplink packet directed from the at least one UE to the network entity macro base station at least by extracting frequency and timing information from the at least one uplink packet of the at least one UE based at least in part on the aiding parameters.

22. The computer readable medium of claim **21**, wherein the computer-readable instructions, when executed, further cause the computing device to receive information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) from the at least one UE.

23. The computer readable medium of claim **21**, wherein the computer-readable instructions, when executed, further cause the computing device to request the aiding parameters from the at least one UE via the OOB link.

24. The computer readable medium of claim **21**, wherein the aiding parameters comprise information regarding:

signatures, spreading codes and scrambling codes for the at least one UE which the at least one UE received as broadcasted system information from the network entity macro base station.

25. The computer readable medium of claim **21**, wherein the computer-readable instructions, when executed, further cause the computing device to:

monitor information in at least one of a physical random access channel (PRACH), a demodulation reference signal (DMRS), and a sounding reference signal (SRS) between the at least one UE and the network entity macro base station, in response to the network entity macro base station comprising an eNB.

26. A method for femto access point (FAP) synchronization by a user equipment (UE), comprising:

determining whether an out-of-band (OOB) link is established, by a processor of a FAP, between the UE and the FAP, wherein the UE is being serviced by a network entity macro base station other than the FAP; and

in response to determining that the OOB link is established, providing aiding parameters to the FAP via the OOB link, wherein, in response to the UE being in a CELL_DCH state or a CELL_FACH state, frequency and timing information from at least one uplink packet directed from the UE to the network entity macro base station is extracted, by sniffing of the at least one uplink packet by the FAP, based at least in part on the aiding parameters.

27. The method of claim **26**, wherein providing the aiding parameters comprises sending information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) to the FAP.

28. The method of claim **27**, wherein the channel detection parameter(s) comprise scrambling codes.

29. The method of claim **26**, wherein the network entity macro base station comprises one of a Node B and an evolved Node B (eNB).

30. The method of claim **26**, further comprising:

receiving broadcasted system information from the network entity macro base station, in response to the UE being in a CELL_FACH state; and

sending the broadcasted system information to the FAP.

31. The method of claim **30**, wherein sending comprises sending the broadcasted system to the FAP via the OOB link.

32. The method of claim **26**, wherein the aiding parameters comprise information regarding:

spreading codes, scrambling codes, and timing offsets to the FAP over an OOB link.

33. The method of claim **26**, further comprising initiating establishment of the OOB link, in response to determining that the OOB link is not already established.

34. The method of claim **26**, wherein providing comprises initiating the transfer of the aiding parameters to the FAP via the OOB link.

35. The method of claim **26**, further comprising, in response to determining that the OOB link is not established, paging the FAP to establish the OOB link.

36. The method of claim **26**, further comprising:

receiving at least one of broadcasted system information and dedicated system information from the network entity macro base station, in response to the UE being in a LTE connected state; and

sending the at least one the broadcasted system information and the dedicated signaling information to the FAP over an OOB link.

37. An apparatus for femto access point (FAP) synchronization by a user equipment (UE), comprising:

at least one processor configured to: determine whether an out-of-band (OOB) link is established between the UE and a FAP, wherein the UE is being serviced by a network entity macro base station other than the FAP; and provide aiding parameters to the FAP via the OOB link, in response to determining that the OOB link is established, wherein, in response to the UE being in a CELL_DCH state or a CELL_FACH state, frequency and timing information from at least one uplink packet directed from the UE to the network entity macro base station is extracted, by sniffing of the at least one uplink packet by the FAP, based at least in part on the aiding parameters; and

a memory coupled to the at least one processor for storing data.

38. The apparatus of claim **37**, wherein the at least one processor provides the aiding parameters by sending information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) to the FAP.

39. The apparatus of claim **37**, wherein the at least one processor:

receives broadcasted system information from the network entity macro base station, in response to the UE being in a CELL_FACH state; and

sends the broadcasted system information to the FAP.

40. The apparatus of claim 39, wherein the at least one processor sends the broadcasted system to the FAP via the OOB link.

41. The apparatus of claim 37, wherein the aiding parameters comprise information regarding:

spreading codes, scrambling codes, and timing offsets to the FAP over an OOB link.

42. The apparatus of claim 37, wherein the at least one processor initiates establishment of the OOB link, in response to determining that the OOB link is not already established.

43. The apparatus of claim 37, wherein the at least one processor initiates the transfer of the aiding parameters to the FAP via the OOB link.

44. The apparatus of claim 37, wherein the at least one processor pages the FAP to establish the OOB link, in response to determining that the OOB link is not established.

45. The apparatus of claim 37, wherein the at least one processor:

receives at least one of broadcasted system information and dedicated system information from the network entity macro base station, in response to the UE being in a LTE connected state; and

sends the at least one the broadcasted system information and the dedicated signaling information to the FAP over an OOB link.

46. User equipment (UE), comprising:

means for determining whether an out-of-band (OOB) link is established between the UE and a FAP, wherein the UE is being serviced by a network entity macro base station other than the FAP; and

means for providing aiding parameters to the FAP via the OOB link, in response to determining that the OOB link is established, wherein, in response to the UE being in a CELL_DCH state or a CELL_FACH state, frequency and timing information from at least one uplink packet directed from the UE to the network entity macro base station is extracted, by sniffing of the at least one uplink packet by the FAP, based at least in part on the aiding parameters.

47. The UE of claim 46, further comprising means for sending information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) to the FAP.

48. The UE of claim 46, further comprising:

means for receiving broadcasted system information from the network entity macro base station, in response to the UE being in a CELL_FACH state; and

means for sending the broadcasted system information to the FAP.

49. The UE of claim 48, further comprising means for sending the broadcasted system to the FAP via the OOB link.

50. The UE of claim 46, wherein the aiding parameters comprise information regarding:

spreading codes, scrambling codes, and timing offsets to the FAP over an OOB link.

51. The UE of claim 46, further comprising means for initiating establishment of the OOB link, in response to determining that the OOB link is not already established.

52. The UE of claim 46, further comprising means for initiating the transfer of the aiding parameters to the FAP via the OOB link.

53. The UE of claim 46, further comprising means for paging the FAP to establish the OOB link, in response to determining that the OOB link is not established.

54. The UE of claim 46, further comprising:

means for receiving at least one of broadcasted system information and dedicated system information from the network entity macro base station, in response to the UE being in a LTE connected state; and

means for sending the at least one the broadcasted system information and the dedicated signaling information to the FAP over an OOB link.

55. A non-transitory computer-readable medium having computer-readable instructions stored therein that when executed cause user equipment (UE) to:

determine whether an out-of-band (OOB) link is established between the UE and a FAP, wherein the UE is being serviced by a network entity macro base station other than the FAP; and

in response to determining that the OOB link is established, provide aiding parameters to the FAP via the OOB link, wherein, in response to the UE being in a CELL_DCH state or a CELL_FACH state, frequency and timing information from at least one uplink packet directed from the UE to the network entity macro base station is extracted, by sniffing of the at least one uplink packet by the FAP, based at least in part on the aiding parameters.

56. The computer readable medium of claim 55, wherein the computer-readable instructions, when executed, further cause the computing device to send information regarding at least one of UE state(s), UE technology type(s), and channel detection parameter(s) to the FAP.

57. The computer readable medium of claim 55, wherein the computer-readable instructions, when executed, further cause the computing device to:

receive broadcasted system information from the network entity macro base station, in response to the UE being in a CELL_FACH state; and

send the broadcasted system information to the FAP.

58. The computer readable medium of claim 57, further comprising means for sending the broadcasted system to the FAP via the OOB link.

59. The computer readable medium of claim 55, wherein the aiding parameters comprise information regarding:

spreading codes, scrambling codes, and timing offsets to the FAP over an OOB link.

60. The computer readable medium of claim 55, wherein the computer-readable instructions, when executed, further cause the computing device to initiate establishment of the OOB link, in response to determining that the OOB link is not already established.

61. The computer readable medium of claim 55, wherein the computer-readable instructions, when executed, further cause the computing device to initiate the transfer of the aiding parameters to the FAP via the OOB link.

62. The computer readable medium of claim 55, wherein the computer-readable instructions, when executed, further cause the computing device to page the FAP to establish the OOB link, in response to determining that the OOB link is not established.

63. The computer readable medium of claim 55, wherein the computer-readable instructions, when executed, further cause the computing device to:

receive at least one of broadcasted system information and dedicated system information from the network entity macro base station, in response to the UE being in a LTE connected state; and

send the at least one the broadcasted system information and the dedicated signaling information to the FAP over an OOB link.

64. A method for frequency and timing synchronization by a femto access point (FAP) and a user equipment (UE), comprising:

establishing, by a processor of the FAP, an out-of-band (OOB) link with the UE, wherein the UE is being serviced by a network entity macro base station other than the FAP;

determining, by the UE, whether the out-of-band (OOB) link is established with the FAP;

in response to determining that the OOB link is established, providing aiding parameters to the FAP via the OOB link;

receiving the aiding parameters from the UE via the OOB link; and

in response to the at least one UE being in a CELL_DCH state or a CELL_FACH state, sniffing, by the FAP, at least one uplink packet directed from the at least one UE to the network entity macro base station at least by extracting frequency and timing information from at least one uplink packet of the UE based at least in part on the aiding parameters.

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