(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 October 2013 (03.10.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/148728 A1

(51) International Patent Classification:
H04W 76/02 (2009.01) *H04W 72/12* (2009.01)
H04W 88/06 (2009.01) *H04L 1/00* (2006.01)

(21) International Application Number:
PCT/US2013/033939

(22) International Filing Date:
26 March 2013 (26.03.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/685,891 26 March 2012 (26.03.2012) US
13/851,016 26 March 2013 (26.03.2013) US

(71) Applicant: **APPLE, INC.** [US/US]; 1 Infinite Loop, Cupertino, CA 95014 (US).

(72) Inventors: **SHI, Jianxiong**; 1 Infinite Loop, Mail Stop 302-21OS, Cupertino, CA 95014 (US). **SEBENI, Johnson, O.**; 1 Infinite Loop, Mail Stop 302-1NS, Cupertino, CA 95014 (US). **SU, Li**; 1 Infinite Loop, Mail Stop 302-1SN, Cupertino, CA 95014 (US). **DAMJI, Navid**; 1 Infinite Loop, Mail Stop 302-3IOS, Cupertino, CA 95014 (US). **FLYNN, Paul, V.**; 1 Infinite Loop, Mail Stop 302-3IOS, Cupertino, CA 95014 (US). **VANGALA, Sarma, V.**; 1 Infinite Loop, Mail Stop 302-3IOS, Cupertino, CA 95014 (US). **VALLATH, Sreevalsan**; 1 Infinite Loop, Mail Stop 302-3IOS, Cupertino, CA 95014 (US). **ELANGOVAN, Thanigaivelu**; 1 Infinite Loop, Mail Stop 302-1NS, Cupertino, CA 95014 (US). **JI, Zhu**; 1 Infinite Loop, Mail Stop 302-1IOS, Cupertino, CA 95014 (US).

(74) Agent: **FERRAZANO, Michael, J.**; Womble Carlyle Sandridge & Rice LLP, 10050 North Wolfe Road, Suite 260, Cupertino, CA 95014-2519 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,

[Continued on next page]

(54) Title: NETWORK BASED DETECTION AND MITIGATION OF HYBRID CLIENT DEVICE RECEPTION OUTAGE EVENTS

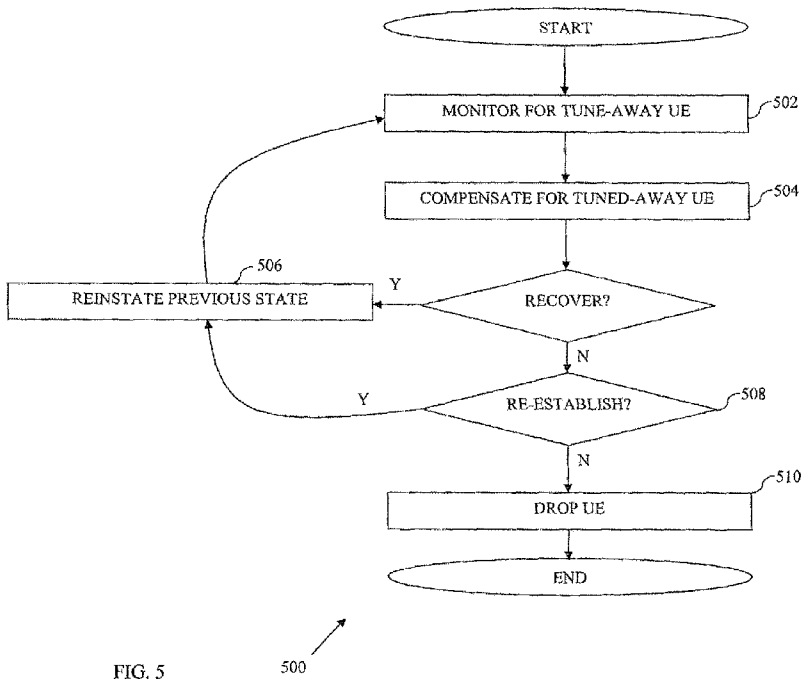


FIG. 5

(57) Abstract: Methods and apparatus for network-based detection and mitigation of hybrid client device reception outage events. For example, in one embodiment, a cellular device uses a single-radio solution to support circuit-switched calls on a CDMA IX network and packet- switched calls on LTE. Periodically, the cellular device tunes away from LTE and monitors CDMA I X activity, and vice versa. During these tuned-away periods, the network adjusts operation to mitigate adverse effects (e.g., underutilization of radio resources, synchronization loss, etc.).

WO 2013/148728 A1

UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

NETWORK BASED DETECTION AND MITIGATION OF HYBRID CLIENT DEVICE RECEPTION OUTAGE EVENTS

Priority

This application claims priority to co-owned and co-pending U.S. Patent Application Serial No. 13/851,016 filed contemporaneously herewith and entitled "APPARATUS AND METHODS FOR NETWORK DETECTION AND MITIGATION OF HYBRID CLIENT DEVICE OPERATION", which claims priority to U.S. Provisional Patent Application Serial No. 61/685,891, filed March 26, 2012 of the same title, each of the foregoing incorporated herein by reference in its entirety.

Related Applications

This application is related to co-owned, co-pending U.S. Patent Application Serial Nos. 13/475,482 filed on May 18, 2012, and entitled "APPARATUS AND METHODS FOR CLIENT SERVER INTERACTION IN HYBRID NETWORK ENVIRONMENTS", 13/475,655 filed on May 18, 2012, and entitled "APPARATUS AND METHODS FOR OPTIMIZING SCHEDULED OPERATIONS IN HYBRID NETWORK ENVIRONMENTS", 13/475,802 filed May 18, 2012, and entitled "APPARATUS AND METHODS FOR NETWORK ASSISTED HYBRID NETWORK OPERATION", 13/346,419 filed January 9, 2012, and entitled "DYNAMIC TRANSMIT CONFIGURATIONS IN DEVICES WITH MULTIPLE ANTENNAS", and 13/347,641 filed January 10, 2012, and entitled "MULTIMODE USER EQUIPMENT WITH DUAL CIRCUIT ARCHITECTURE", and 13/099,204 filed May 2, 2011, and entitled "SINGLE-RADIO DEVICE SUPPORTING COEXISTENCE BETWEEN MULTIPLE RADIO ACCESS TECHNOLOGIES". This case is also related to U.S. Provisional Patent Application Serial Nos. 61/_____ filed April 25, 2011, and entitled "DUAL NETWORK MOBILE DEVICE RADIO RESOURCE MANAGEMENT", 61/_____ filed April 6, 2011, and entitled "MULTIPLE NETWORK MOBILE DEVICE CONNECTION MANAGEMENT", each of the foregoing being incorporated herein by reference in its entirety.

Background

1. Technological Field

The present disclosure relates generally to operation within heterogeneous wireless systems such as, for example, hybrid network operation in which client devices can communicate using any one of several networks. More particularly, in one exemplary regard, the present disclosure introduces methods and apparatus for network-based detection and mitigation of hybrid client device reception outage events.

2. Description of Related Technology

A cellular network operator provides mobile telecommunications services to the public via a network infrastructure of e.g., cellular base stations (BS), base station controllers, infrastructure nodes, etc. There is a wide variety of cellular network technologies, and historically cellular devices have been specialized for operation within a single cellular network. However, as cellular technologies have become increasingly commoditized, devices are now able to offer so-called "multimode" operation; i.e., a single device that is capable of operation on two or more cellular networks. Multimode operation allows a device to operate on any one of several network technologies, but does not enable operation on multiple network technologies simultaneously.

Incipient research is directed to so-called "hybrid" network operation. During hybrid network operation, the client device operates simultaneously among multiple distinct networks having different technologies. In one exemplary case, a hybrid device can support both: (i) Long Term Evolution (LTE) and (ii) Code Division Multiple Access 1X (CDMA 1X) networks; i.e., the device can maintain a simultaneous connection between a first LTE network and a second CDMA 1X network. For example, a LTE/CDMA 1X hybrid device can conduct a voice call over the CDMA 1X network while the mobile device is in LTE mode. In another exemplary case, a hybrid device can support both: (i) CDMA 1X-EVDO (Evolution Data Optimized) and (ii) CDMA 1X networks.

Existing solutions for hybrid network operation rely on the client device to manage its own operation between networks. Specifically, the client device is responsible for maintaining its active connections to the various service networks; there are no required changes to existing network installations (i.e., hybrid network operation does not affect the legacy hardware and software of the network infrastructure). Client-centric hybrid operation has several benefits. For example, there is very little (if any) infrastructure cost for the network operator. Moreover, hardware costs can be incorporated into the price of consumer

devices. Additionally, hybrid network operation will not affect existing legacy devices. Similarly, devices capable of hybrid operation are also capable of normal operation.

However, since existing solutions for hybrid network operation do not require the constituent networks to coordinate with one another, the client device will inevitably experience certain scheduling collisions. For example, in the context of the foregoing example of LTE/CDMA operation, while a mobile device is attached to the first LTE network, it must periodically "tune out" the LTE network to perform CDMA 1X actions (such as decoding the Quick Paging Channel (QPCH) to determine if the device is being paged). If the mobile device is receiving data from the LTE network during the tune out period, this data is lost, which may negatively impact throughput and ultimately user experience. Furthermore, a tuned-out mobile device will miss any broadcasted updated network resource information or control data; this can result in the mobile device being barred from access to the LTE network (at least for a period of time).

Moreover, network resources which are assigned to a tuned-out client device are wasted and/or underutilized.

Thus, improved methods and apparatus are needed to, *inter alia*, minimize the impact of such tuned-out devices on the network.

Summary

The aforementioned needs are satisfied by providing, *inter alia*, improved apparatus and methods for detection and mitigation of hybrid client device reception outage events.

Firstly, a method for network-based detection and mitigation of hybrid client device reception outage events is disclosed. In one embodiment, the method includes: determining a reception loss event associated with a client-device; adjusting operation for the client device; monitoring for reception recovery; if reception is recovered, resuming normal operation; and otherwise disconnecting the client device.

An apparatus for network-based detection and mitigation of hybrid client device reception outage events is also disclosed herein. In one embodiment, the apparatus is a network-based entity (e.g., server). In another embodiment, the apparatus is a mobile device such as a smartphone or tablet computer.

In another embodiment, the apparatus includes at least one wireless interface configured for wireless communication via at least first and second wireless technologies, the first technology being different than the second technology; at least one processor in data communication with the at least one wireless interface; and logic in data communication with

the at least one processor. In one variant, the logic is configured to: identify the occurrence of a reception loss event associated with a wireless interface of a client device, the wireless interface of the client device being compliant with the second wireless technology; adjust at least one aspect of the operation for the client device (e.g., the adjustment comprising adjustment of at least one aspect which will result in reduced network resource utilization by the client device for at least a period of time in one variant); monitor for reception recovery by the client device; when reception is recovered, resume operation according to an established protocol; and disconnect the client device when reception is not recovered.

A computer-readable storage apparatus is further disclosed. In one embodiment, the apparatus includes a storage medium having at least one computer program stored thereon, the at least one program being configured to, when executed, cause a computerized device to determine a reception loss event associated with a client-device; adjust operation for the client device; monitor for reception recovery; if reception is recovered, resume normal operation; and otherwise disconnect the client device.

A hybrid network system is also disclosed. In one embodiment, the system includes at least two networks, and at least one network of the hybrid network system prioritizes one or more of its tasks based on high-priority tasks of one or more others of the at least two networks.

A client device capable of hybrid network operation is further disclosed herein. In one embodiment, the client device is a mobile wireless-enabled device one or more air interfaces for communication with multiple different wireless network infrastructures. A client device useful with in a wireless network is also disclosed. In one embodiment, the wireless network is configured to provide network-based detection and mitigation of client device reception outage events, and the client device includes: at least one wireless interface, the at least one interface configured for wireless communication via at least first and second wireless technologies, the first technology being different than the second technology; at least one processor in data communication with the at least one wireless interface; and logic in data communication with the at least one processor. in one variant, the logic is configured to: signal the occurrence or incipient occurrence of a reception loss event associated with the at least one wireless interface to a network entity; receive at least one adjustment of at least one aspect of the operation for the client device, the adjustment comprising adjustment of at least one aspect which will result in reduced network resource utilization by the client device for at least a period of time; and implement the received adjustment.

A method of operating a wireless network entity so as to mitigate wasting of network resources associated with at least one mobile device of the network is also disclosed. In one embodiment, the method includes: receiving one or more communications from the at least one mobile device; evaluating the received one or more communications; inferring from the evaluation that a loss of reception event is incipient for the at least one mobile device; and adjusting operation of at least one of (i) the network, and/or (ii) the at least one mobile device based at least in part on the inference, the adjusting providing the mitigation.

Other features and advantages will immediately be recognized by persons of ordinary skill in the art with reference to the attached drawings and detailed description of exemplary embodiments as given below.

Brief Description of the Drawings

FIG. 1 is a logical block diagram illustrating one exemplary hybrid network system useful in conjunction with various features of the present disclosure.

FIG. 2 is a functional block diagram of an exemplary embodiment of a user equipment (UE) apparatus.

FIG. 3 is a graphical representation of tune-away periods along an exemplary time line, in accordance with one embodiment.

FIG. 4 is a logical flow diagram detailing one embodiment of a method for network-based detection and mitigation of hybrid client device reception outage events.

FIG. 5 is a logical flow diagram detailing one exemplary implementation of the method of FIG. 4 in the context of Long Term Evolution network and a Code Division Multiple Access 1X networks.

FIG. 6 is a functional block diagram of an exemplary embodiment of a wireless network apparatus useful for implementing various of the methods of the disclosure.

All Figures © Copyright 2012-2013 Apple Inc. All rights reserved.

Detailed Description

Reference is now made to the drawings, wherein like numerals refer to like parts throughout.

Detailed Description of Exemplary Embodiments

Exemplary embodiments and aspects of the present disclosure are now described in detail. While these embodiments and aspects are primarily discussed in the context of Long

Term Evolution (LTE), Code Division Multiple Access 1X (CDMA 1X) cellular networks, and CDMA 1X EVDO (Evolution Data Optimized), it will be recognized by those of ordinary skill that the various features of the present disclosure are not so limited, and can be used with other cellular technologies such as TD-LTE (Time-Division Long-Term Evolution), TD-LTE-Advanced, TD-SCDMA (Time Division Synchronous Code Division Multiple Access) and Global System for Mobile Communications (GSM). In fact, the various features are useful in combination with any network (cellular, wireless, wireline, or otherwise) that can benefit from network-based detection and mitigation of hybrid client device reception outage events.

LTE/CDMA 1X Hybrid Network Operation –

FIG. 1 illustrates an exemplary hybrid network system 100. The exemplary hybrid network includes a first LTE RAN (radio access network) 102A and a second CDMA 1X RAN 102B in communication with a user equipment (UE) client device 200. As shown in FIG. 1, the LTE RAN and CDMA 1X RAN are unsynchronized, and entirely unaware of the other RAN's operation. In other scenarios, the RANs may have higher levels of coordination; e.g., the RANs may be loosely synchronized, or even tightly synchronized in certain aspects of their operation.

Referring now to FIG. 2, the exemplary user equipment (UE) apparatus 200 is illustrated in greater detail. The UE of FIG. 2 may be, for instance, a single-radio solution to support circuit-switched calls on a CDMA 1X network and packet-switched calls on LTE; specifically, the UE has a single Radio Frequency (RF) processing "chain" which is used alternately for CDMA 1X or LTE processing. Specifically, the single RF chain periodically tunes away from LTE and monitors CDMA 1X activity, and *vice versa*. The UE includes: (i) one or more Radio Frequency (RF) front-ends 202 (e.g., other RF front-ends may be present for other radio access technologies, etc.), (ii) one or more baseband processors 204, and (iii) at least one application processor 206 and associated memor(ies) 208. In various implementations, the RF front-ends and baseband processors may be further specialized to handle a single wireless technology, or generalized to encompass multiple wireless technologies.

As shown, the exemplary UE includes a first RF front-end that is coupled to both first and second baseband processors adapted to interface to a LTE network and CDMA 1X network, respectively. It is further appreciated that the foregoing configuration is purely illustrative, and various implementations may include other cellular technologies such as

GSM, GPRS, EDGE, WCDMA, CDMA2000, CDMA 1X EVDO, LTE-A (LTE Advanced), etc. in various combinations. Moreover, while only a single RF front-end is shown for simplicity, it is appreciated that a RF front-end can (and generally will) include multiple receive and/or transmit antennas and/or chains. For example, well known MIMO (Multiple In Multiple Out), SISO (Single In Single Out), MISO (Multiple In Single Out), and SIMO (Single In Multiple Out) antenna configurations are widely used within the related arts, and may be used consistent with the present disclosure.

Additionally, in one exemplary embodiment, the UE 200 further includes a switching fabric 210 that can connect any one (or more) of the baseband processors 204 to various one (or more) of the antennas 202. The illustrated switching fabric is adapted to connect either the LTE baseband or CDMA 1X baseband to the RF front-end. However, common embodiments may connect one baseband processor to one antenna ("one-to-one"), one-to-many, many-to-one, etc. This "switching" capability is desirable for a number of reasons, including *inter alia*: (i) power management, (ii) processing efficiency/flexibility, and (iii) antenna isolation constraints may require that only a subset of radios of a mobile device are active at any one time. In some small form factor designs, there is not enough space to completely isolate multiple antennas during operation; consequently, only one antenna (or a limited subset) can be active at any time. Similarly, certain form factor designs may reuse antennas for different wireless interfaces, such that only one wireless interface can use a common antenna at any given time. Yet other motivations will be appreciated by those of ordinary skill in the related arts, and are not discussed further herein (e.g., business or profit considerations, network utilization, etc.).

Moreover, it will be appreciated that other components are commonly incorporated within UE 200, but are not discussed further herein. For example, the UE may include user interface components (display screens, buttons, touch screens such as a multi-touch display, dials, etc.), memory components (e.g., RAM (Random Access Memory), Flash, hard disk drives (HDD), etc.), power management components (e.g., batteries, charger components, etc.), and external interfaces (e.g., *FireWire™, Universal Serial Bus™ (USB), Thunderbolt,* etc.).

Furthermore, it should be recognized that the UE depicted in FIG. 2 is merely illustrative of one exemplary embodiment. Still other variants useful with the various features disclosed herein are described with greater detail in co-owned and co-pending U.S. Provisional Patent Application Serial Nos. 61/_____ filed April 25, 2011, and entitled "DUAL NETWORK MOBILE DEVICE RADIO RESOURCE MANAGEMENT",

61/_____ filed April 6, 2011, and entitled "MULTIPLE NETWORK MOBILE DEVICE CONNECTION MANAGEMENT", and U.S Patent Application Serial Nos. 13/099,204 filed May 2, 2011, and entitled "SINGLE-RADIO DEVICE SUPPORTING COEXISTENCE BETWEEN MULTIPLE RADIO ACCESS TECHNOLOGIES", 13/346,419 filed January 9, 2012, and entitled "DYNAMIC TRANSMIT CONFIGURATIONS IN DEVICES WITH MULTIPLE ANTENNAS", and 13/347,641 filed January 10, 2012, and entitled "MULTIMODE USER EQUIPMENT WITH DUAL CIRCUIT ARCHITECTURE", each of the foregoing being incorporated herein by reference in its entirety.

The exemplary UE 200 of FIG. 2 is capable of LTE/CDMA 1X hybrid mode operation within, e.g., the hybrid network system of FIG. 1. Specifically, the UE 200 can place CDMA 1X voice calls while registered with the LTE network. During hybrid operation, the UE can be registered to both a LTE network 102A and a CDMA 1X network 102B. The UE is capable of receiving and responding to data and control messaging from either the LTE network or the CDMA 1X network; however, as previously discussed, the UE cannot respond simultaneously to both networks, and hence in the illustrated embodiment is configured to always prioritize CDMA 1X (voice call) traffic over LTE (data) traffic to ensure that user experience for voice calls is unaffected. Other implementations may have other prioritization schemes (e.g., where voice calls are lower priority, based on the type of traffic, historic device usage, QoS requirements, etc.)

Once the UE 200 has connected to the LTE network 102A, the UE will periodically "tune" its radio away from the LTE network to perform CDMA 1X maintenance actions such as acquiring a CDMA 1X cell, registering to the acquired CDMA 1X cell, and receiving CDMA 1X pages, etc. Depending on CDMA 1X network 102B radio conditions, these actions can range in one exemplary implementation from eighty milliseconds (80ms) up to several seconds (4s-6s). Moreover, when the UE receives or places a voice call on the CDMA 1X network, the LTE connection may be dropped. As used hereinafter, the terms "tune-away", "tune-out", etc. are interchangeably used, and similarly the reciprocal terms "tune-in", "tune-back", etc. are interchangeably used. More generally, "tune-away" operation is subsumed in a larger group of client device reception outage events. Specifically, these client device reception outage events are initiated by the client device (with or without network coordination) to intentionally or indirectly disable reception of the client device to achieve some other purpose or goal. Common examples include e.g., to perform measurements on other networks, to reduce power consumption, to reduce interference on other nearby devices, to preserve processing resources for other applications, etc.

Referring back to the exemplary UE 200 of FIG. 2, there are several events that can trigger a tune-away event. Common examples include (without limitation): (i) registration, (ii) location updates, (iii) paging, (iv) search operations, (v) cell measurements, (vi) voice call events (both mobile originated (MO) (i.e., placed by the mobile device), and mobile terminated (MT) (i.e., received by the mobile device)), (vii) out of service (OOS) procedures, etc. Tune-away events may be periodic in nature (or otherwise predictably scheduled), or may be entirely unpredictable, interrupting events, or variants or combinations thereof. The duration of tune-away events widely varies from a few milliseconds to several seconds.

For example, within this context, the UE may periodically tune-away from a LTE network to tune-in to the CDMA 1X network to detect a paging channel, and perform serving cell and neighbor cell measurements of the CDMA 1X network. More rarely, the tune-away event may require a substantially longer time interval to perform lengthy maintenance tasks. For example, one exemplary time line is shown in FIG. 3. As illustrated, over the course of normal operation, the mobile device periodically tunes to the CDMA 1X network for brief time intervals 302. Occasionally, the device must perform much lengthier tasks 304. Common examples of lengthier tasks include, without limitation, Location Area Updates (LAU) where the mobile device must actively exchange information with the CDMA 1X network, periods of poor reception (e.g., the mobile device may need additional time to decode messaging (e.g., paging channels, etc.)), etc.

While the foregoing scenario is discussed in relation to LTE/CDMA 1X capable client devices, it is further appreciated that similar (if not identical) complications arise in other hybrid client devices. For example, other mobile devices may be capable of Time-Division Long-Term Evolution (TD-LTE) and Time Division Synchronous Code Division Multiple Access (TD-SCDMA) technologies. In LTE (also referred to as Frequency Division Duplex LTE (FD-LTE)), the downlink and uplink are transmitted using different frequencies. In Time Division Duplex LTE (TD-LTE), the downlink and the uplink are on the same frequency and the separation occurs in the time domain, so that each direction in a call is assigned to specific timeslots.

Similarly, Time Division Synchronous Code Division Multiple Access (TD-SCDMA) allows traffic to be uplinked (from the mobile terminal to the base station) and downlinked (from the base station to the mobile terminal) using different time slots in the same frame.

Embodiments of the present disclosure contemplate the use of these technologies together and separately (in combination with other technologies) in a hybrid network, such as by implementing the methodology described herein with respect to FIG. 4 (except using one

or more different combinations of radio access technologies set forth herein). For example, in an exemplary embodiment relating to both TD-LTE and TD-SCDMA, a UE connected to the TD-LTE network will periodically (or on an event driven or other basis) tune its radio away from the TD-LTE network to perform TD-SCDMA actions such as cell selection, registration, and receiving pages.

Moreover, Global System for Mobile Communications (GSM) is a cellular technology standard that has evolved a number of advancements including General Packet Radio Service (GPRS), Enhanced Data rates for GSM Evolution (EDGE), and Universal Mobile Telecommunications System (UMTS) also known as 3G (Third Generation) UMTS. Various other common embodiments may further combine either LTE, or TD-LTE with any of GSM, GPRS, EDGE, UMTS, etc.

Unfortunately, during tune-away operation, the network (e.g., the evolved NodeB (eNB)) may not be aware that the UE is tuned out. This can have significant undesirable effects. For example, the eNB may grant either uplink (UL) resources to the UE (which will be unused), or downlink (DL) resources for transmissions (which will be missed). Similarly, the eNB will not receive Physical Uplink Control Channel (PUCCH) information (e.g., Hybrid Automatic Repeat Request (HARQ) Acknowledgment (ACK)/Non-acknowledgements (NACK); Channel Quality Indication (CQI), Rank Indication (RI), Precoding Matrix Information (PMI), etc.), which may result in unnecessary retransmissions, and/or incorrect or stale information.

More severe consequences may occur when the UE is improperly operating with "stale" information. For example, if the eNB does not receive Sounding Reference Signals (SRS), the eNB may improperly schedule the UE for UL scheduling. Similarly, where the Radio Resource Connection (RRC) inactivity timer expires during tuned away operation, the UE and eNB can lose synchronization. In either circumstance, the UE may transmit control signaling on stale resources (e.g., PUCCH transmissions, SRS transmissions, Physical Random Access Channel (PRACH), etc.) which contributes to overall network pollution.

In still other situations, the UE and the eNB may lose connectivity altogether. This can create a prolonged service blackout for the UE. For example, premature Radio Link Failure (RLF) may result in further synchronization problems, spotty reception, and excessive connection attempts.

Methods –

Referring now to FIG. 4, one embodiment of a method 400 for network-based detection and mitigation of hybrid client device reception outage events is illustrated. In one scenario, a client device is connected to a first network, where the first network is entirely unaware of the client device's connections to other networks. Alternatively, the first network may have limited information on nearby networks (e.g., timing information, registered devices, etc.) which may be periodically refreshed, but is not integrated within the operational decisions for the first network.

At step 402, the network determines a reception loss event associated with a client-device. In one variant, the reception loss is detected on the basis of one or more signaling exchanges or events which are incomplete and/or not received. In alternate variants, reception loss is detected on the basis of a length of time during which no signaling is received from the client device.

In yet other alternate variants, reception loss events are signaled to the network. In one implementation, the signaling is implicit in one or more existing protocols (that is, by mere invocation of the protocol, a loss event can be inferred). Alternatively, the signaling may be explicit (e.g., using a dedicated message protocol implemented for that purpose, or alternatively an existing message protocol that has been "repurposed" or upon which the necessary signaling is "piggybacked"), or may use a "mixed" approach of implicit and explicit techniques, such as where one of the two is more appropriate to one operating circumstance, and the other technique to another circumstance.

In still other variants, reception loss is based on one or more failed access attempts initiated by the network.

It will also be appreciated that combinations of the foregoing may be used either simultaneously (e.g., two of three implicit/explicit criteria must be met before a "loss" is established), or alternatively in different circumstances (e.g., one criterion or set of criteria in one circumstance, and another in a second circumstance).

At step 404 of the method 400, the network adjusts operation for the client device. In one embodiment, the network adjusts by reserving fewer resources for the client device. Alternatively the network may not reserve any resources for the client device. These actions accomplish reduction in "wasted" network resources; i.e., freeing up resources that would otherwise be allocated to the client but not used.

In one embodiment, the network may deactivate one or more layers of device context. In one exemplary implementation, the one or more layers of device context include state information for one or more communication protocol stack software elements or layers. For

example, in one such scenario, the network may deactivate one or more of: a physical software layer, a radio link layer, a medium access (e.g., MAC) layer, etc.

At step 406, the network monitors for reception recovery; if reception is recovered, the network resumes normal operation (which may occur immediately, or after a "wait" or other period to endure that reception has been in fact reliably recovered, so as to e.g., prevent the device from cycling modes repeatedly). In one embodiment, the network and client device negotiate resources for the connected operation. In alternate embodiments, the network and client device resume or re-negotiate one or more layers of device context information. For example, in one such example, the network may reactivate one or more of: a physical software layer, a radio link layer, a medium access layer, etc.

In another variant, the network simply defaults to the allocation that was associated with the client immediately before the loss event; this approach advantageously obviates further negotiation between the network and client device.

In one variant, the choice of which of the foregoing techniques to apply is determined based on one or more criteria; e.g., time duration of the loss event. For example, if the loss event duration is comparatively short (say, 100ms in the example context discussed *supra*), then the network will choose to reinstitute the prior resource allocation without negotiation. However, when a prescribed threshold is exceeded (say, e.g., 1000ms or 1s), then the renegotiation is invoked.

Otherwise, if reception is not recovered (e.g., within a prescribed time window, number of events, cycles, etc., as described with respect to the exemplary embodiments *infra*), the network disconnects the client device at step 408.

Example Operation -

Referring now to FIG. 5, one exemplary implementation of the method 400 of FIG. 4 is shown and described. Specifically, one exemplary embodiment of a method 500 for network-based detection and mitigation of hybrid client device reception outage events is illustrated.

In one scenario, the hybrid client device is a single-radio solution capable of communicating with a Long Term Evolution (LTE) network and Code Division Multiple Access 1X (CDMA 1X) network. While the following operation is described with reference to the evolved Node B (eNB) of the LTE network, it is readily appreciated that various aspects of the present invention are widely applicable to base stations (regardless of

technology), and more generally wireless server devices of any type (e.g., *ad hoc* networks, etc.)

As a brief aside, during normal operation, the eNB configures the UE with a dedicated Physical Uplink Control Channel (PUCCH) and/or Sounding Reference Signal (SRS) resources during Radio Resource Connection (RRC) setup. The dedicated PUCCH resources enable the UE to transmit one or more of: Scheduling Requests (SR), Channel Quality Indications (CQI), Rank Indications (RI), and/or Precoding Matrix Indexes (PMI). Each PUCCH resource is identified according to, *inter alia*: location (e.g., time slot, subcarrier), periodicity, and offset of the dedicated resource. Dedicated SRS resources are specified according to a bandwidth, location, periodicity and offset of the dedicated resource.

Existing eNBs can determine if a PUCCH and/or SRS has not been recovered from a UE. Generally, this capability is broadly categorized under Discontinuous Transmission (DTX) detection. Common solutions for DTX detection exhibit various degrees of success according to, *inter alia*: implementation algorithms, channel conditions, and neighbor cell interference.

Referring to FIG. 5, at step 502, the eNB monitors for a UE tune-away event. In one exemplary embodiment, the eNB monitors for one or more missed PUCCH and/or SRS signals e.g., via DTX detection.

In some variants, the eNB monitors for multiple missed PUCCH and/or SRS (e.g., one or more DTX occurrences). Checking for multiple DTX occurrences can ensure that the UE is actually tuned away (as opposed to just a momentary loss of reception caused by e.g., a deep fade). The number of consecutive DTX may be selected on the basis of a tradeoff between the time to detect a true tune-away with no UL transmission, and the probability of a false alarm (based on the eNB PUCCH/SRS DTX). In some embodiments, the tradeoff may be dynamically adjusted to optimize according to e.g., the probability of success, the probability of misdetection, overall detection time, etc. In one such variant, once the eNB has detected a DTX event, the eNB starts a timer function (e.g., *DTX_Monitoring_Timer*). In one implementation, the length of the *DTX_Monitoring_Timer* has a maximal upper limit (e.g., such that Radio Link Failure (RLF) is not declared during the DTX monitoring timeout).

In some implementations, the UE can explicitly or implicitly communicate with the eNB to provide information on an upcoming tune-away period. For example, in one such case, the eNB is implicitly signaled via existing messaging schemes. The eNB may infer an upcoming tune-away period if, for instance, the UE transmits a number of consecutive CQI measurements with a pre-determined value on PUCCH/PUSCH resources (e.g., a null value

or zero value CQI is currently reserved and indicates that no defined Modulation and Coding Scheme (MCS) can be supported given the spectral efficiency estimation).

In another such example, the eNB may infer an upcoming tune-away period when the UE transmits a number of consecutive Buffer State Reports (BSR) with a null (or zero) value on the available UL grant.

In still other examples, the eNB may infer an upcoming tune-away period based on a number of consecutive Power Headroom (PHR) reports with a specified value (e.g., LTE has a lowest PHR value of -23dBm). It is appreciated that detection of a tune-away event may also be based on any combinations of the foregoing.

In one implementation, if the *DTX_Monitoring_Timer* expires before receiving UE activity, then the eNB treats the UE as a tuned-away UE, and proceeds to step 504. Alternately, if the *DTX_Monitoring_Timer* does not expire (e.g., UE activity occurs before timer expiration), then the eNB considers the UE as momentarily interrupted (i.e., no corrective action is necessary).

Referring to step 504, the eNB can compensate for the tuned-away UE by implementing one or more corrective actions.

In one exemplary embodiment, the eNB starts a timer function (e.g., *Tune-away_Release_Timer*). The *Tune-away_Release_Timer* is selected in one exemplary implementation on the basis of a tradeoff between the time to detect a UE recovery, and the probability of a complete disconnection. In some embodiments, this tradeoff may be dynamically adjusted to optimize according to e.g., maximize the tune-away time, minimize reconnection time, minimize time for reconnection in the event of actual reception loss, etc. In one such variant, once the eNB has detected a tune-away event, the eNB starts another timer (e.g., *Tune-away_Release_Timer*).

Common examples of corrective actions include e.g. and without limitation: (i) suspending the scheduling of the UE, (ii) suspending the *RRC_Inactivity_Timer* (if running), (iii) suspending the *C-DRX_Inactivity_Timer* (Connected DRX operation) (if running), (iv) suspending RRC procedures (e.g., handover operation, radio link monitoring, re-establishment, etc.) (if running), (v) suspending various software stack components (e.g., Medium Access Control (MAC), Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP) layers) (if running), and/or (vi) releasing any (or a portion of) physical layer dedicated resources (e.g., time slots, subcarriers, resource blocks, etc.).

At decision point 505 of the method 500, the eNB monitors for UE recovery. If the UE recovers, then the eNB proceeds to step 506. Alternately, if the *Tune-*

away_Release_Timer expires without activity, then the eNB proceeds to step 508 for eNB initiated recovery. Alternately, if the *Tune-away_Release_Timer* expires without activity, then the eNB may proceed directly to step 510 (and hence dropping the UE).

In one variant, the eNB monitors for Random Access Channel (RACH) operation. If the UE initiates a RACH attempt, then the eNB will service the UE reinstate the UE via the procedure of step 506; otherwise, the eNB proceeds to step 508.

In another variant, the eNB monitors for PUCCH and/or SRS accesses from the UE, alternately or additionally, the eNB may also monitor RACH procedures from the tuned-away UE. In one exemplary embodiment, if a minimum threshold of consecutive PUCCH and/or SRS are detected, then the eNB can consider the UE to be tuned back to the LTE network. For RACH type embodiments, if the UE initiates a RACH procedure which is successful, then the eNB will consider the UE to be tuned back to the LTE network.

Referring now to step 506, the eNB reinstates the UE's previous state. Reinstatement of operation may include, without limitation: (i) resuming scheduling of the UE, (ii) resuming the *RRC_Inactivity_Timer* (if suspended), (iii) resuming the *C-DRX_Inactivity_Timer* (if suspended), (iv) resuming RRC procedures (e.g., handover operation, radio link monitoring, re-establishment, etc.) (if suspended), (v) resuming any halted software stack components (e.g., Medium Access Control (MAC), Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP) layers), and/or (vi) setting up any physical layer dedicated resources (e.g., time slots, subcarriers, resource blocks, etc.).

Finally, at step 508, the eNB may attempt to re-establish connection to the UE. If the UE responds to the eNB's re-establishment attempt, then the eNB can reinstate the UE at step 506. If the re-establishment attempt fails, then the eNB can drop the UE altogether (step 510). For example, in one exemplary embodiment, the eNB sends a Physical Downlink Control Channel (PDCCH) message, if the UE is "tuned in", then the UE will responsively initiate a RACH attempt and the eNB can proceed to step 506. If the eNB does not receive the RACH, then the eNB proceeds to step 510. It will also be appreciated that the eNB may be configured to apply various retry and/or timeout logic to the foregoing process; e.g., *n* number of retries and/or expiration of a timer before proceeding to step 510.

At step 510, the eNB drops the UE (when the connection cannot be re-established). In one embodiment, this includes: releasing any dedicated radio resources, removing the UE from the eNB active UE database, transitioning the UE to *RRC_IDLE* operation, and releasing any signaling and data radio bearers.

Apparatus –

FIG. 6 illustrates one exemplary embodiment of a network entity 600 configured in accordance with the present disclosure. The network entity may be a stand-alone entity, or be incorporated with other network entities (e.g., a base station, a base station controller, a radio access network controller, etc.). In one exemplary embodiment, the network entity includes a Long Term Evolution (LTE) evolved Node B (eNB).

As shown in FIG. 6, the network entity 600 generally includes a wireless (e.g., cellular) interface 602 for interfacing with cellular devices, a processor 604, and a storage apparatus 606. The cellular interface is shown as a wireless cellular interface configured for communication with one or more mobile devices, although other configurations and functionalities may be substituted. For example, in alternate embodiments, the cellular interface may be a wireline communication to a base station, where the base station is in communication with the mobile device.

The cellular interface 602 of the apparatus 600 shown in FIG. 6 at a high level includes one or more radio transceiver circuits configured to transmit and receive data via radio frequency transmissions (RF). Common embodiments of a radio transceiver generally include a modem processor, and one or more antennas. In one exemplary embodiment of the present invention, the radio transceiver is configured in accordance with Long Term Evolution (LTE) radio access technologies. It is recognized that various other implementations of the present invention may be configured for other cellular and/or wireless standards. Common examples of such technologies include: GSM, GPRS, EDGE, WCDMA, CDMA2000, CDMA 1X, CDMA 1X-EVDO, LTE-A, etc. and various combinations thereof.

During normal operation, the aforementioned cellular interface 602 adjusts detects and mitigates hybrid client device reception outage events.

The processor 604 includes one or more processors (or multi-core processor(s)). Additionally, the processor is coupled to processing memory and/or the storage apparatus. Common implementations of the processing subsystem are implemented within signal processors, general processors, network processors, field programmable gate arrays (FPGAs), digital signal processors (DSPs), and any combination of the foregoing. Typical implementations of memory and storage apparatus include Random Access Memory (RAM) and variations thereof (Dynamic RAM, Static RAM, Synchronous RAM, etc.), Flash memory, and Hard Disk Drives (HDD). Moreover, it is further appreciated that one or more memory apparatus may further be configured in various redundancy schemes (e.g., Redundant Arrays of Inexpensive Drives (RAID)), etc.

In one exemplary embodiment, the network entity 600 is further coupled to a wired network infrastructure via a network interface 612. The network interface is generally adapted for use with Ethernet networks, although other suitable network variations include Synchronous Optical Networking (SONET), Asynchronous Transfer Mode (ATM), MoCA, etc. Various forms of physical interface are widely used within the related arts, including for example Ethernet cable (e.g., CAT5), coaxial, fiber optics, etc.

It will be recognized that while certain features of the disclosure are described in terms of a specific sequence of steps of a method, these descriptions are only illustrative of the broader methods, and may be modified as required by the particular application. Certain steps may be rendered unnecessary or optional under certain circumstances. Additionally, certain steps or functionality may be added to the disclosed embodiments, or the order of performance of two or more steps permuted. All such variations are considered to be encompassed within the disclosure.

While the above detailed description has shown, described, and pointed out novel features as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the device or process illustrated may be made by those skilled in the art. The foregoing description is of the best mode presently contemplated. This description is in no way meant to be limiting, but rather should be taken as illustrative of the general principles of the disclosure.

WHAT IS CLAIMED IS:

1. Wireless network apparatus configured for network-based detection and mitigation of hybrid client device reception outage events, the apparatus comprising:

at least one wireless interface, the at least one wireless interface configured for wireless communication via at least first and second wireless technologies, the first wireless technology being different than the second wireless technology;

at least one processor in data communication with the at least one wireless interface; and

logic in data communication with the at least one processor, the logic configured to cause the apparatus to:

identify an occurrence of a reception loss event associated with a wireless interface of a client device, the wireless interface of the client device being compliant with the second wireless technology;

adjust at least one aspect of the operation for the client device;

monitor for reception recovery by the client device;

when reception is recovered, resume operation according to an established protocol; and

disconnect the client device when reception is not recovered.

2. The apparatus of Claim 1, wherein the comprises allocating no resources to the client device for the at least period of time.

3. The apparatus of Claim 1, wherein the adjustment comprises a change in an allocation of at least one of a Physical Uplink Control Channel (PUCCH) and/or Sounding Reference Signal (SRS) resource to the client device.

4. The apparatus of Claim 1, wherein the adjustment comprises deactivation of one or more layers of client device context.

5. The apparatus of Claim 4, wherein the deactivated one or more layers of device context comprise state information for one or more communication protocol stack software elements or layers.

6. The apparatus of Claim 4, wherein the deactivation of one or more of layers comprises deactivation of at least one of: (i) a physical software layer, (ii) a radio link layer, and/or (iii) a medium access control (MAC) layer.

7. The apparatus of Claim 1, wherein the first wireless technology comprises a code division multiple access (CDMA) - based technology, and the second wireless

technology comprises an orthogonal frequency division multiplexing (OFDM) based technology.

8. The apparatus of Claim 7, wherein:

the OFDM-based technology comprises a Long Term Evolution (LTE) compliant technology,

the wireless network apparatus is associated with an enhanced Node B (eNB) of the LTE network, and

the logic configured to monitor for reception recovery by the client device is configured to monitor for recovery of at least one of (i) a Physical Uplink Control Channel (PUCCH) data element, and/or (ii) a Sounding Reference Signal (SRS) data element, from the client device.

9. A method for network-based detection and mitigation of hybrid client device reception outage events, comprising:

determining a reception loss event associated with a client device;

adjusting at least one aspect of the operation for the client device;

monitoring for reception recovery;

when reception is recovered, resuming normal operation; and

otherwise disconnecting the client device.

10. The method of Claim 9, wherein the reception loss event comprises a reception loss event associated with a high-speed wireless data interface of the client device that is a result of a tune-away event performed by the client device.

11. The method of Claim 10, wherein the tune-away event is performed pursuant to a prescribed protocol within a Long Term Evolution (LTE) technology standard with which the client device is compliant.

12. A client device useful within a wireless network, the wireless network configured to provide network-based detection and mitigation of client device reception outage events, the client device comprising:

at least one wireless interface, the at least one wireless interface configured for wireless communication via at least first and second wireless technologies, the first wireless technology being different than the second wireless technology;

at least one processor in data communication with the at least one wireless interface; and

logic in data communication with the at least one processor, the logic configured to:

signal the occurrence or incipient occurrence of a reception loss event associated with the at least one wireless interface to a network entity;

receive at least one adjustment of at least one aspect of the operation for the client device, the adjustment comprising adjustment of at least one aspect which will result in reduced network resource utilization by the client device for at least a period of time; and

implement the received adjustment.

13. The device of Claim 12, wherein the signaling of the occurrence or incipient occurrence comprises signaling via an existing message protocol which has been re-purposed for the signaling.

14. The device of Claim 12, wherein the logic configured to receive at least one adjustment message comprises logic configured to receive at least one adjustment message that has been generated based at least in part on an evaluation of the signal of the occurrence or incipient occurrence sent by the client device.

15. A method of operating a wireless network entity so as to mitigate wasting of network resources associated with at least one mobile device of the network, the method comprising:

receiving one or more communications from the at least one mobile device;

evaluating the received one or more communications;

inferring from the evaluation that a loss of reception event is incipient for the at least one mobile device; and

adjusting operation of at least one of (i) the network, and/or (ii) the at least one mobile device based at least in part on the inference, the adjusting providing the mitigation.

16. The method of Claim 15, wherein the one or more communications comprise a plurality of consecutive channel quality index (CQI) measurements comprising an uplink control or shared channel value.

17. The method of Claim 16, wherein the value comprises at least one of a null value and/or zero value CQI.

18. The method of Claim 15, wherein the one or more communications comprise a plurality of consecutive Buffer State Reports (BSR) with a null (or zero) value on an available uplink grant.

19. The method of Claim 15, wherein the one or more communications comprise the a plurality of consecutive Power Headroom (PHR) reports with a prescribed value.

20. Computer readable apparatus comprising a storage medium, the storage medium comprising at least one computer program comprised of a plurality of instructions that, when executed on a processor, cause a client device to:

signal an occurrence or incipient occurrence of a reception loss event associated with at least one wireless interface to a network entity;

receive at least one adjustment of at least one aspect of the operation for the client device, the adjustment comprising adjustment of at least one aspect which will result in reduced network resource utilization by the client device for at least a period of time; and

implement the received adjustment.

21. A wireless network apparatus configured for network-based detection and mitigation of hybrid client device reception outage events, the wireless network apparatus comprising:

means for determining a reception loss event associated with a client device;

means for adjusting at least one aspect of the operation for the client device;

means for monitoring for reception recovery;

means configured to, when reception is recovered, resume normal operation, otherwise the means are configured to disconnect the client device.

22. The wireless network apparatus of Claim 21, wherein the reception loss event comprises a reception loss event associated with a high-speed wireless data interface of the client device that is a result of a tune-away event performed by the client device.

23. The wireless network apparatus of Claim 21, wherein the tune-away event is performed pursuant to a prescribed protocol within a Long Term Evolution (LTE) technology standard with which the client device is compliant.

24. A wireless network apparatus configured to mitigate wasting of network resources associated with at least one mobile device of the network, the wireless network apparatus comprising:

means for receiving one or more communications from the at least one mobile device;

means for evaluating the received one or more communications;

means for inferring from the evaluation that a loss of reception event is incipient for the at least one mobile device; and

means for adjusting operation of at least one of (i) the network, and/or (ii) the at least one mobile device based at least in part on the inference, the adjusting providing the mitigation.

25. The wireless network apparatus of Claim 24, wherein the one or more communications comprise a plurality of consecutive channel quality index (CQI) measurements comprising an uplink control or shared channel value.

26. The wireless network apparatus of Claim 25, wherein the value comprises at least one of a null value and/or zero value CQI.

27. The wireless network apparatus of Claim 24, wherein the one or more communications comprise a plurality of consecutive Buffer State Reports (BSR) with a null (or zero) value on an available uplink grant.

28. The wireless network apparatus of Claim 24, wherein the one or more communications comprise a plurality of consecutive Power Headroom (PHR) reports with a prescribed value.

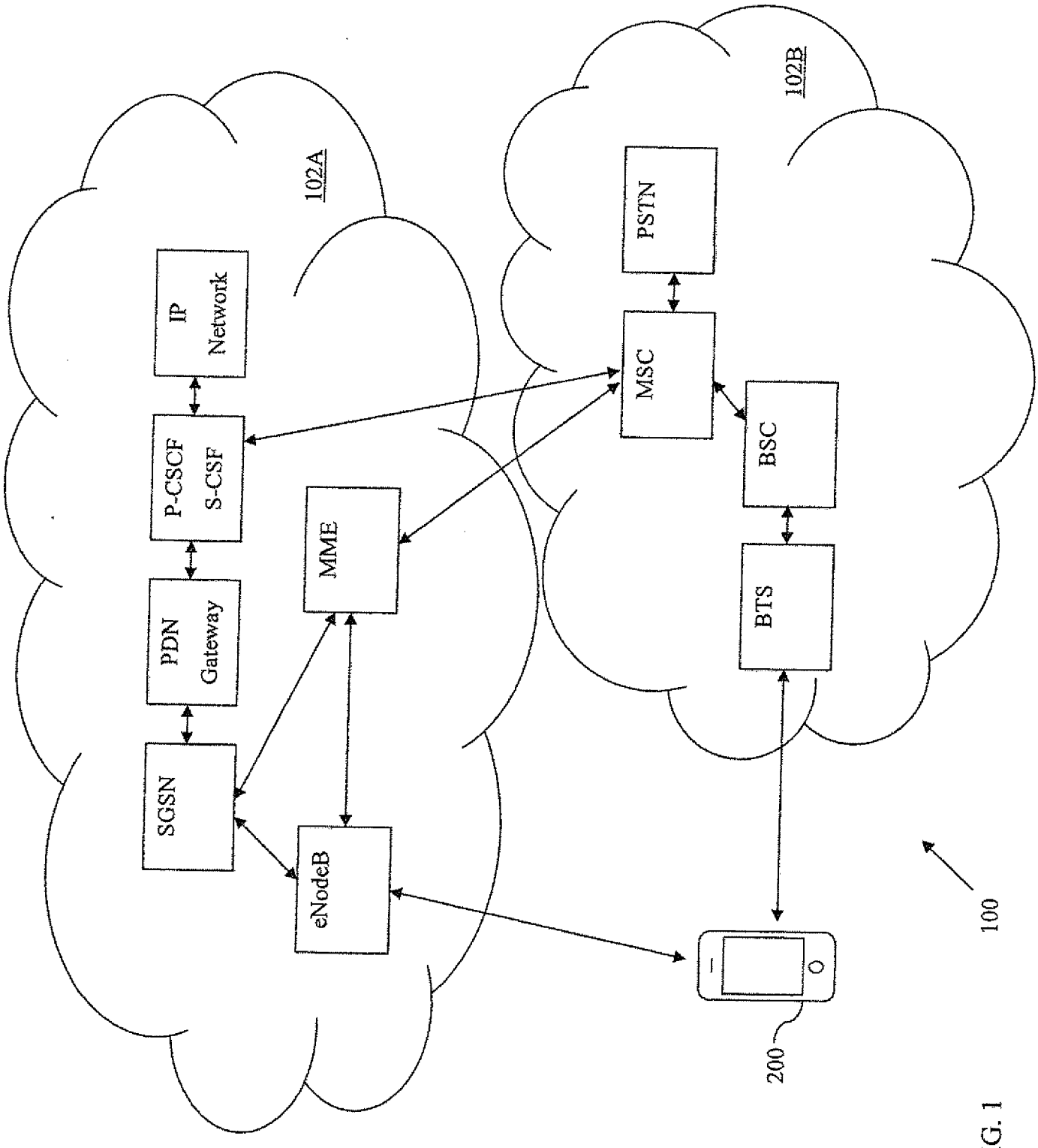

102A
IP Network
P-CSCF S-CSF
PDN Gateway
SGSN
MME
eNodeB
102B
PSTN
MSC
BSC
BTS
200
100

FIG. 1

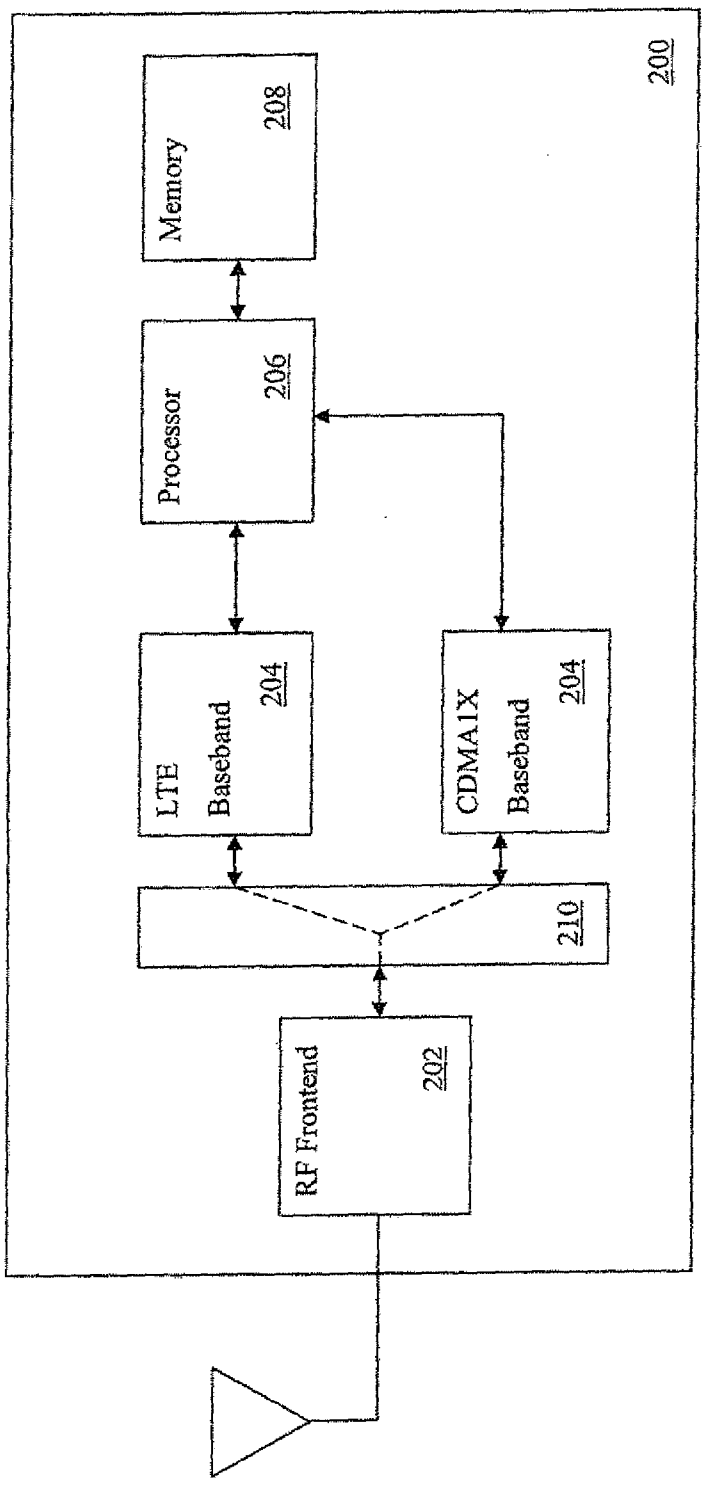

200
Memory
208
Processor
206
LTE
Baseband
204
CDMA1X
Baseband
204
210
RF Frontend
202

FIG. 2

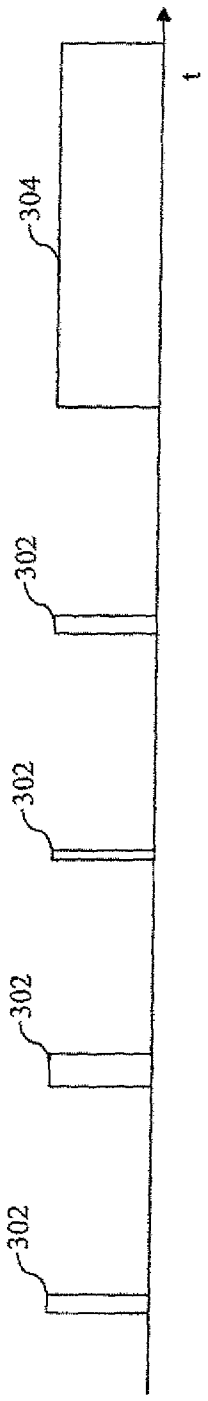


FIG. 3

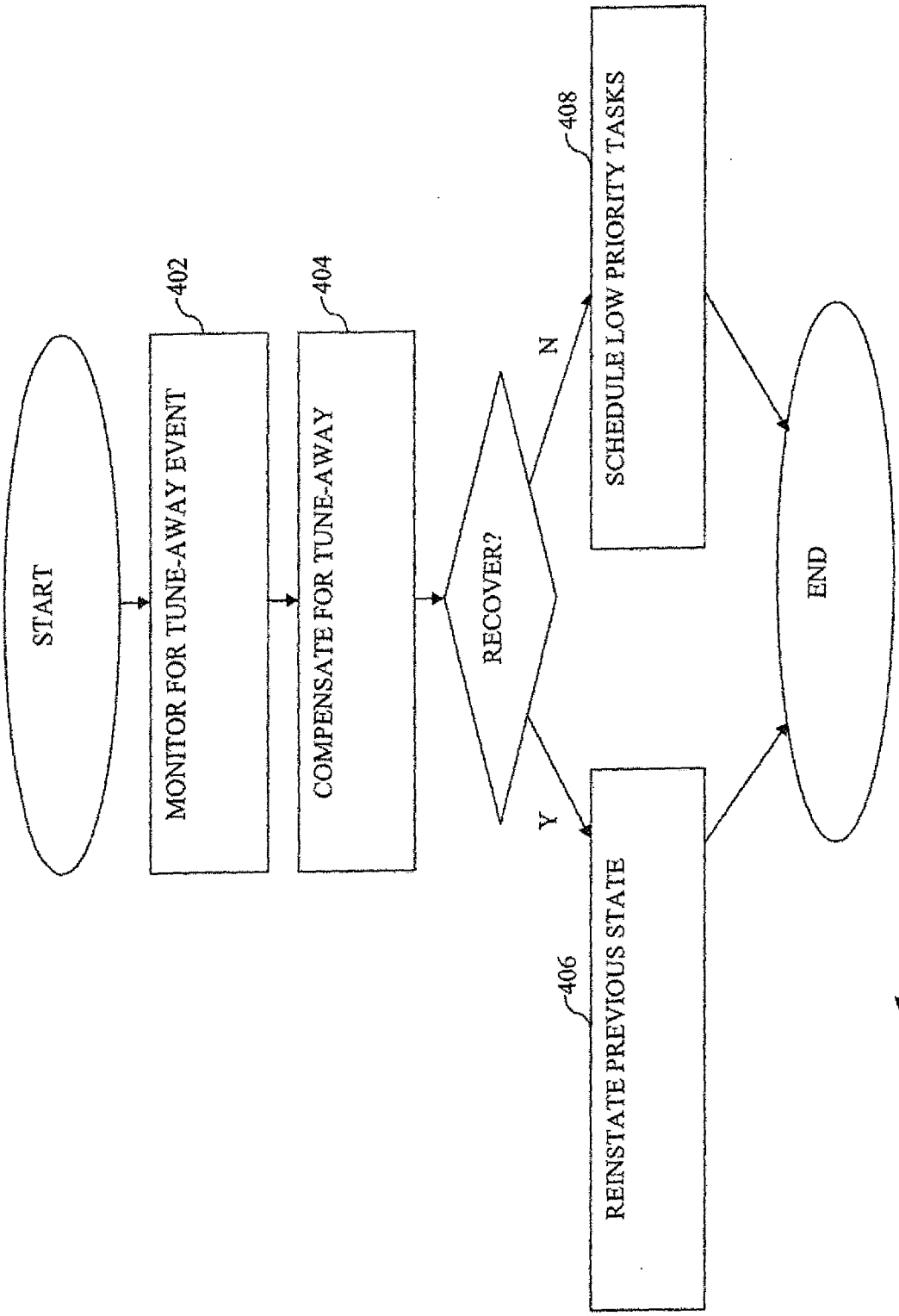

START
402
MONITOR FOR TUNE-AWAY EVENT
404
COMPENSATE FOR TUNE-AWAY
RECOVER?
N
408
SCHEDULE LOW PRIORITY TASKS
Y
406
REINSTATE PREVIOUS STATE
END
400

FIG. 4

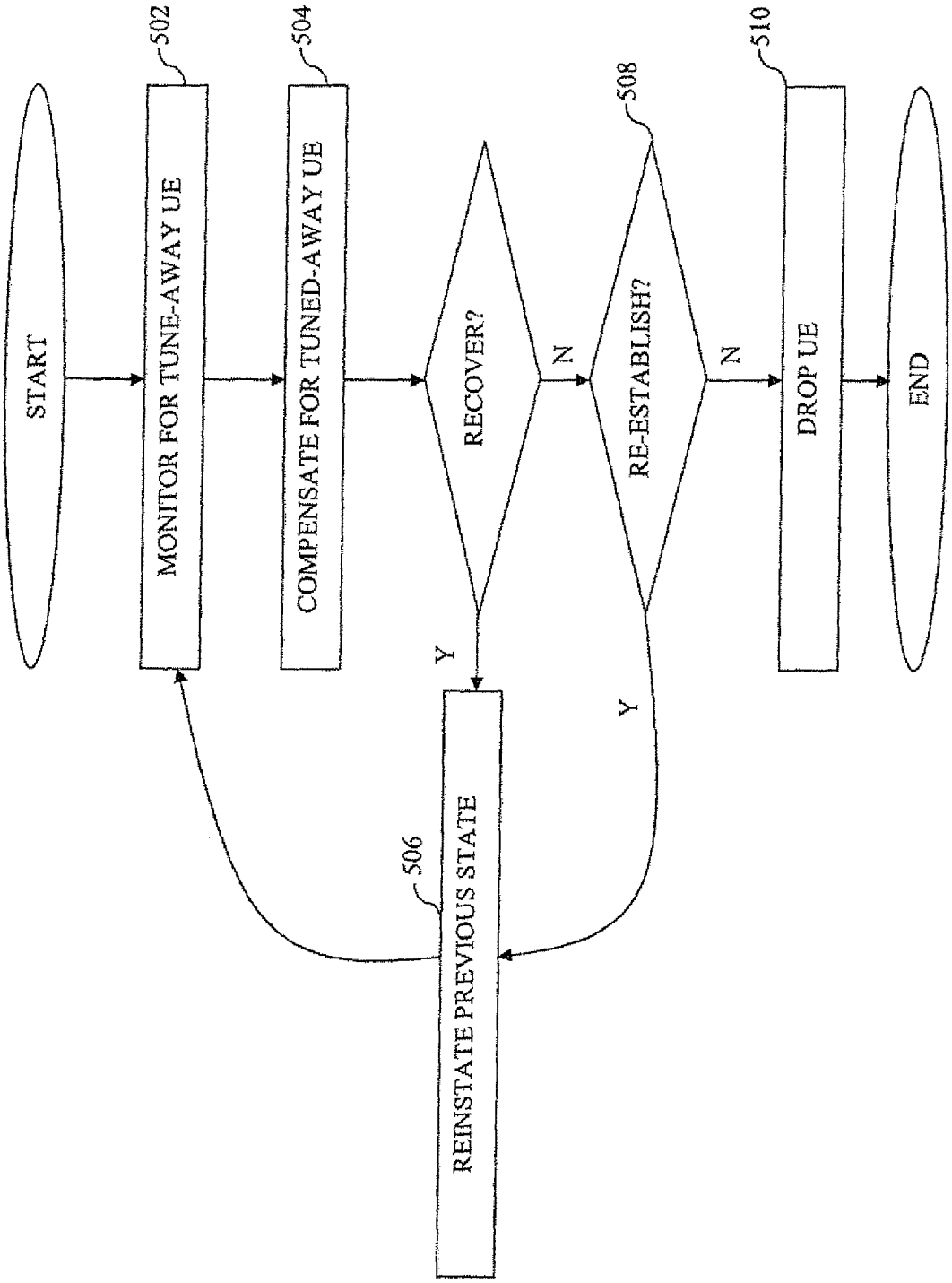

START
502
MONITOR FOR TUNE-AWAY UE
504
COMPENSATE FOR TUNED-AWAY UE
RECOVER?
N
508
RE-ESTABLISH?
N
510
DROP UE
END
Y
Y
506
REINSTATE PREVIOUS STATE
500

FIG. 5

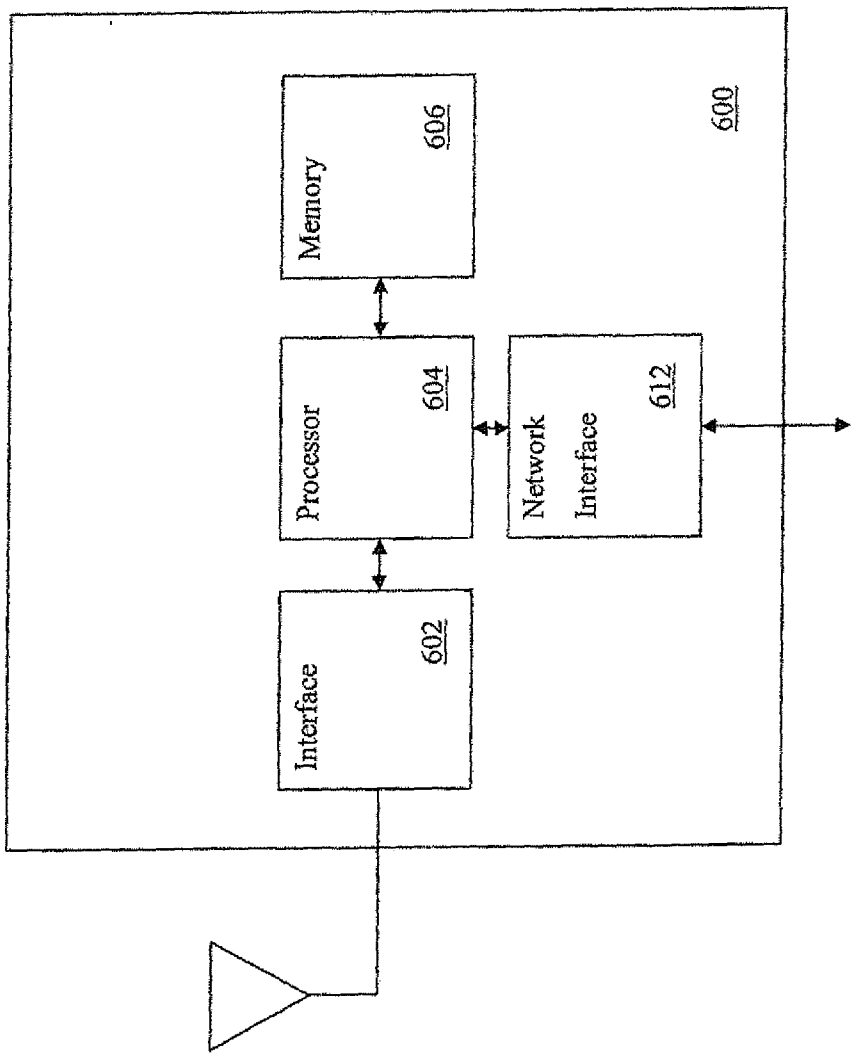

600
Memory
606
Processor
604
Network
Interface
612
Interface
602

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/033939

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W76/02
ADD. H04W88/06 H04W72/12 H04L1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2012/071185 A1 (DAYAL PRANAV [US] ET AL) 22 March 2012 (2012-03-22) figures 6,11-13 paragraphs [0006], [0007] paragraph [0011] - paragraph [0013] paragraphs [0060], [0061] paragraph [0071] - paragraph [0073] paragraph [0077] - paragraph [0090] paragraph [0095] -----	12-20, 24-28 1-11, 21-23
X A	US 2012/071103 A1 (KADOUS TAMER ADEL [US] ET AL) 22 March 2012 (2012-03-22) figure 11 paragraphs [0011], [0012], [0035] paragraphs [0065], [0066], [0070] paragraphs [0076], [0077] paragraph [0083] - paragraph [0068] paragraph [0102] - paragraph [0105] -----	12-20, 24-28 1-11, 21-23

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 August 2013	19/08/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bösch, Michael

2

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	TURNER S ET AL: "cdma2000 Hybrid Access Terminal Operation", ANNOUNCEMENT QUALCOMM CDMA TECHNOLOGIES, QUALCOMM, SAN DIEGO, CA, US, 9 April 2001 (2001-04-09), pages 1-25, XP002422171, paragraph [02.1] - paragraph [2.2.3]	1-11, 21-23
A	WO 2008/085952 A1 (INTERDIGITAL TECH CORP [US]; WANG JIN [US]; WANG PETER S [US]) 17 July 2008 (2008-07-17) paragraph [0010] - paragraph [0018] paragraph [0044] - paragraph [0049] paragraph [0056] - paragraph [0068] figures 2,3	1-28
X,P	WO 2012/162190 A1 (APPLE INC [US]; SU LI [US]; SHI JIANXIONG [US]; CHAUDHARY MADHUSUDAN []) 29 November 2012 (2012-11-29) page 14, line 1 - page 21, line 9 figures 2,2a	12-20, 24-28
E	WO 2013/112848 A2 (QUALCOMM INC [US]) 1 August 2013 (2013-08-01) paragraphs [0057], [0058] paragraphs [0062], [0065], [0075] paragraph [0077] - paragraph [0082] figures 6,9, 12	15-17, 24-26

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/033939

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012071185 A1	22-03-2012	CN 103141145 A	05-06-2013
		EP 2620030 A1	31-07-2013
		KR 20130058067 A	03-06-2013
		TW 201218795 A	01-05-2012
		US 2012071185 A1	22-03-2012
		WO 2012040265 A1	29-03-2012
US 2012071103 A1	22-03-2012	CN 103120012 A	22-05-2013
		EP 2620031 A1	31-07-2013
		KR 20130058068 A	03-06-2013
		US 2012071103 A1	22-03-2012
		WO 2012040435 A1	29-03-2012
WO 2008085952 A1	17-07-2008	AU 2008205368 A1	17-07-2008
		BR PI0806190 A2	30-08-2011
		CA 2674697 A1	17-07-2008
		CN 101682852 A	24-03-2010
		EP 2119272 A1	18-11-2009
		JP 2010516185 A	13-05-2010
		KR 20090099086 A	21-09-2009
		KR 20090122272 A	26-11-2009
		RU 2009130406 A	20-02-2011
		TW 200830750 A	16-07-2008
		US 2008189970 A1	14-08-2008
		WO 2008085952 A1	17-07-2008
WO 2012162190 A1	29-11-2012	CN 102802192 A	28-11-2012
		CN 202889646 U	17-04-2013
		WO 2012162190 A1	29-11-2012
WO 2013112848 A2	01-08-2013	US 2013194947 A1	01-08-2013
		WO 2013112848 A2	01-08-2013