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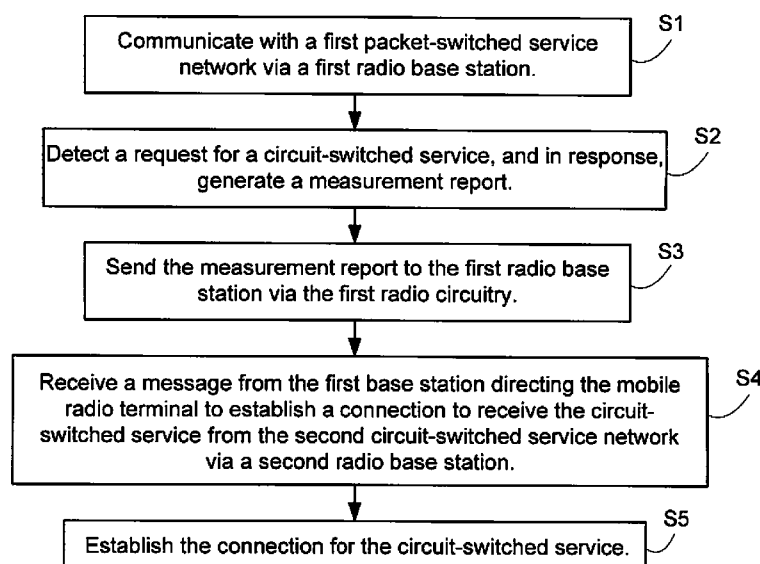


FIG. 3

(57) Abstract: A UE (10) that is in communication with a first packet-switched service network via a first radio base station (24) detects a request or a need for a circuit-switched service. In response, the UE generates a measurement report and sends it to the first radio base station. The first base station sends a message, e.g., a release message, directing the UE to establish a connection to receive the circuit-switched service from a second circuit-switched service network via a second radio base station, which the UE does. Advantageously, the (release) message is sent to initiate a circuit-switched fallback procedure without having to request permission from a core network node in the first packet-switched service network.

CIRCUIT-SWITCHED FALLBACK FOR A MOBILE RADIO

TECHNICAL FIELD

[0001] The technology relates to radio communications, and in particular, to mobile radios that can obtain services from both packet-switched and circuit-switched networks.

BACKGROUND

[0002] A mobile radio, referred to as a user equipment (UE) hereafter, that is equipped with dual radio receiver (RX) or a dual radio may at the same time be connected to two different cellular networks such as a Long-Term Evolution (LTE) network and a Code Division Multiple Access (CDMA) network. A LTE system supports packet-switched (PS) services, and the CDMA system is a CDMA system that supports circuit-switched (CS) services. One of the UE's receivers monitors the LTE system and the other of the UE's receivers monitors the CDMA system.

[0003] Normally, the UE is monitoring and operating with the LTE system. But there are situations where the UE may want to obtain a circuit-switched service from the CDMA system. One example circuit-switched service in the CDMA system is a circuit-switched voice call service. The UE can originate the circuit-switched service request, e.g., make a circuit-switched voice call, or receive the circuit-switched service, e.g., receive a page for an incoming circuit-switched voice call to the UE. The temporary change from the LTE system to the CDMA system for the circuit-switched service is termed "Circuit-Switched FallBack" (CSFB) in 3GPP.

[0004] If the UE is in an idle mode with respect to both the LTE and CDMA system, then the UE may perform idle mode cell reselection and page monitoring independently in both systems at the same time. When a UE is paged by the CDMA system, the UE may perform an LTE access to make the LTE system aware of this page and that the UE may be unreachable for a time period during which the UE connects to the CDMA system.

[0005] 3GPP TS 36.300 v10.3.0 ch 10.3, which may be accessed at http://www.3gpp.org/ftp/Specs/archive/36_series/36.300/36300-a40.zip, the disclosure of which is incorporated herein by reference, discloses that “CS fallback [from the LTE system] to 1xRTT [the CDMA system] enables the delivery of CS-domain services when a UE is being served by the E-UTRAN [analogous to LTE].” The UE initiates “1xCSFB (e.g. to perform a 1xCS call origination or accept a 1xCS call termination) by using non-access stratum (NAS) signaling to send a CSFB [circuit-switched fallback] indication to the MME [Mobility Management Entity]. The MME then indicates to the eNB that 1xCSFB is required.” This triggers the eNB (a base station in LTE) to execute one of the following circuit-switched fallback procedures depending on network support and UE capability:

- (1) a Rel-8 1xCSFB fallback procedure [e.g., from the LTE system to the CDMA system] characterized for example by a radio resource control (RRC) connection release with redirection to 1x Radio Transmission Technology (1xRTT). 1xRTT is the core CDMA2000 wireless air interface standard. The designation “1x”, meaning 1 times Radio Transmission Technology, indicates one carrier at the same radio frequency (RF) bandwidth as IS-95: a duplex pair of 1.25 MHz radio channels,
- (2) an enhanced 1xCSFB fallback procedure characterized for example by 1xRTT handover signaling tunnelled between the UE and 1xRTT network,
- (3) a dual receiver 1xCSFB fallback procedure characterized by RRC connection release without redirection information, or
- (4) a dual receiver/transmitter enhanced 1xCSFB fallback procedure characterized for example by either 1xRTT handover signaling tunnelled between the UE and 1xRTT network or redirection of the UE’s second radio to the 1xRTT network.

[0006] A problem with known CSFB procedure is that it requires signaling between a core network node, e.g., the MME in LTE, and the UE, which delays the delivery of the circuit-switched service to the point where it may be noticeable to end users—which is undesirable. Indeed, users operating in the packet-switched system

expect a fallback circuit-switched service to be delivered with no more delay than if the service were directly provided by the circuit-switched system.

SUMMARY

[0007] A mobile radio terminal (e.g., a UE) that is in communication with a first packet-switched service network via a first radio base station detects a request or a need for a circuit-switched service. In response, the mobile radio terminal generates a measurement report and sends it to the first radio base station. The first base station sends a message, e.g., a release message, directing the mobile radio terminal to establish a connection to receive the circuit-switched service from a second circuit-switched service network via a second radio base station, which the mobile radio terminal does. Advantageously, that message is sent to initiate a circuit-switched fallback procedure without having to request permission from a core network node in the first packet-switched service network thereby reducing service delay experienced by a user.

[0008] A first aspect of the technology includes a mobile radio terminal with first radio circuitry to communicate with a first packet-switched service network via a first radio base station and second radio circuitry to communicate with a second circuit-switched service network. Processing circuitry is configured to perform several tasks. First, a request for a circuit-switched service is detected, e.g., a voice call circuit-switched service, and in response, a measurement report is generated. The measurement report is sent to the first radio base station via the first radio circuitry. A message is returned from the first base station directing the mobile radio terminal to establish a connection to receive the circuit-switched service from the second circuit-switched service network via a second radio base station. One example of such a message is a release with redirection for circuit-switched fallback message. Thereafter, the second radio circuitry is activated to establish the connection for the circuit-switched service.

[0009] The measurement report includes information that the first radio base station interprets as a request for the circuit-switched service, and in a particular

example embodiment, the measurement report includes information indicating a circuit-switched fallback request. The measurement report information may also optionally include one or more of the following: a cell identifier of a cell associated with a second radio base station in the second circuit-switched service network, a carrier frequency, a measurement identifier, or a non-valid measurement value.

[0010] The mobile radio terminal may establish a connection with the first packet-switched service network via a first radio base station prior to detecting the request, and it may also send a capability message to the first radio base station to inform the first radio base station that the mobile radio terminal can support circuit-switched fallback. The terminal may at some point receive a measurement configuration message from the first radio base station that indicates that a circuit-switched service may be requested using a measurement report.

[0011] An example implementation includes an LTE system as the first packet-switched service network, an eNodeB as the first radio base station, a 1XRTT system as the second circuit-switched service network, and a CDMA-based second radio base station.

[0012] A second aspect of the technology includes a first radio base station that communicates with a mobile radio terminal over a radio interface. The base station also communicates with a network node in a first packet-switched service network that provides packet-switched services. The base station receives a measurement report from the mobile radio terminal that includes information indicating a request or need for a circuit-switched service. In response to the received measurement report, a redirect message is generated and sent to the mobile radio terminal directing the mobile radio terminal to a frequency associated with a second circuit-switched service network. A release message is generated and sent to the first packet-switched service network to cause the mobile radio terminal to be connected to a second radio base station to obtain the circuit-switched service.

[0013] In an example embodiment, the radio base station generates and sends to the mobile radio terminal a measurement configuration message that indicates the

information to be included in the measurement report associated with a request or need for a circuit-switched service.

[0014] In another example embodiment, the radio base station sends the release message to initiate a circuit-switched fallback procedure without having to request permission from a core network node in the first packet-switched service network.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Figure 1 illustrates a non-limiting example of a UE that may communicate with a network that supports packet-switched (PS) services and another network that supports circuit-switched (CS) services (and may or may not also support PS services);

[0016] Figure 2 is a signaling diagram that illustrates non-limiting examples of signaling to implement CSFB in accordance with one example embodiment;

[0017] Figure 3 is a flowchart illustrating example, non-limiting procedures implemented by a UE to request and obtain a CSFB service;

[0018] Figure 4 is a flowchart illustrating example, non-limiting procedures implemented by a base station involved in receiving a CSFB request and facilitating provision of a CSFB service;

[0019] Figure 5 is a non-limiting function block diagram of a UE;

[0020] Figure 6 is a non-limiting function block diagram of a base station;

[0021] Figure 7 is a non-limiting function block diagram of a core network node (such as an MME in an LTE network);

[0022] Figure 8 illustrates CSFB in a specific but still example context of an LTE PS network and a 1xRTT CS network; and

[0023] Figure 9 shows an example of a UE handover to the 1xRTT for a CSFB service in an example context like that shown in Figure 8.

DETAILED DESCRIPTION

[0024] The following description sets forth specific details, such as particular embodiments for purposes of explanation and not limitation. But it will be appreciated by one skilled in the art that other embodiments may be employed apart from these specific details. In some instances, detailed descriptions of well known methods, nodes, interfaces, circuits, and devices are omitted so as not obscure the description with unnecessary detail. Those skilled in the art will appreciate that the functions described may be implemented in one or more nodes using hardware circuitry (e.g., analog and/or discrete logic gates interconnected to perform a specialized function, ASICs, PLAs, etc.) and/or using software programs and data in conjunction with one or more digital microprocessors or general purpose computers. Nodes that communicate using the air interface also have suitable radio communications circuitry. Moreover, the technology can additionally be considered to be embodied entirely within any form of computer-readable memory, such as solid-state memory, magnetic disk, or optical disk containing an appropriate set of computer instructions that would cause a processor to carry out the techniques described herein.

[0025] Thus, for example, it will be appreciated by those skilled in the art that block diagrams herein can represent conceptual views of illustrative circuitry or other functional units embodying the principles of the technology. Similarly, it will be appreciated that any flow charts, state transition diagrams, pseudocode, and the like represent various processes which may be implemented by computer program instructions that may be stored in a non-transitory, computer-readable storage medium and which when executed by a computer or processor cause the processes to be performed, whether or not such computer or processor is explicitly shown.

[0026] Hardware implementation may include or encompass, without limitation, digital signal processor (DSP) hardware, a reduced instruction set processor, hardware (e.g., digital or analog) circuitry including but not limited to application specific integrated circuit(s) (ASIC) and/or field programmable gate array(s) (FPGA(s)), and (where appropriate) state machines capable of performing such functions.

[0027] In terms of computer implementation, a computer is generally understood to comprise one or more processors or one or more controllers, and the terms computer, processor, and controller may be employed interchangeably. When provided by a computer, processor, or controller, the functions may be provided by a single dedicated computer or processor or controller, by a single shared computer or processor or controller, or by a plurality of individual computers or processors or controllers, some of which may be shared or distributed. Moreover, the term “processor” or “controller” also refers to other hardware capable of performing such functions and/or executing software, such as the example hardware recited above.

[0028] The functions of the various elements including functional blocks, including but not limited to those labeled or described as a computer, processor, or controller, may be provided through the use of hardware such as circuit hardware and/or hardware capable of executing software in the form of coded instructions stored on non-transitory, computer-readable medium. Thus, such functions and illustrated functional blocks are to be understood as being either hardware-implemented and/or computer-implemented, and thus machine-implemented.

[0029] The term User Equipment (UE) is used to refer generally to an end terminal that attaches to a wireless communication network, and the term base station is used in its most general sense to refer to a wireless access point in a wireless communication network, and may refer to base stations that are controlled by a physically distinct radio network controller as well as to more autonomous access points such as the evolved Node Bs (eNBs) in LTE networks. A network node includes base stations and other network nodes.

[0030] Figure 1 illustrates a non-limiting example of a UE 10 that may communicate with a network that supports packet-switched (PS) services and another network that supports circuit-switched (CS) services (and may or may not also support PS services). To communicate with both networks, the UE 10 includes suitable radio circuitry 12. In this example, it is assumed that the network that supports packet-switched (PS) services and the other network that supports circuit-switched (CS) services each use a different radio access technology which means that the radio

circuitry 12 includes radio circuitry 14A for communicating with the PS services network and radio circuitry 14B for communicating with the CS services network. Although the UE 10 may typically obtain services from the network supporting PS services, there may be times when the UE 10 will need or want to “fallback” to the network supporting CS services to obtain a CS service, referred to herein as CS fallback (CSFB). Non-limiting examples of such CS services include voice and its supplementary services (e.g. call waiting, call forwarding), Unstructured Supplementary Service Data (USSD), LoCation Service (LCS), Short Message Service (SMS), E911, Lawful Interception (LI), and even CS DUI video, etc. The technology described here allows the UE 10 to perform CS fallback and provide CS services with more efficiency and with less delay.

[0031] A UE may request an action from the system by using a measurement report with network (NW)-coordinated and UE-coordinated specific content and can also be used for indicating a UE preference as in the example specified in 3GPP TS 43.318 v10.1.0 ch 9.14 described at http://www.3gpp.org/ftp/Specs/archive/43_series/43.318/43318-a10.zip, the disclosure of which is incorporated herein by reference. TS 43.318 indicates that:

1. The mobile station (MS) (another term for a UE) includes information about a generic access network (GAN) Iu mode cell in the Measurement Report message sent to the radio network controller (RNC). Reference is made to Annex B.2.1.

2. Based on MS measurement reports and other internal algorithms, the RNC decides to initiate handover to the GAN Iu mode cell. The RNC starts the preparation phase of the Relocation procedure by sending a Relocation Required message to the mobile switching center (MSC), identifying the target GAN Iu mode cell.

- 3-6. Same as steps 3-6 for a circuit-switched CS handover from GERAN to GAN is described in clause 9.14.1.1.

7. The GAN controller (GANC) acknowledges the relocation request message, using a Relocation Request Acknowledge message, indicating it can support

the requested handover, and includes a Physical Channel Reconfiguration message to indicate the radio channel to which the MS should be directed.

8. The MSC sends the Relocation Command message to the RNC, completing the relocation preparation.

9. The RNC sends the Physical Channel Reconfiguration message to the MS to initiate handover to GAN Iu mode. The MS does not switch its audio path from UTRAN to GAN until handover completion (i.e., until it sends the GA-RRC HANDOVER COMPLETE message) to keep the audio interruption short.

10-13. Same as steps 10-13 for CS handover from GERAN to GAN in clause 9.14.1.1.

14. Finally, the MSC tears down the connection to the source RNC using an Iu Release Command.

15. The source RNC confirms the release of UTRAN resources allocated for this call using Iu Release Complete.

[0032] The 3GPP TS 43.318 specification describes in clause 9.14.2 (CS case) and clause 9.23.2 (PS case) that handover from UTRAN to GAN Iu mode requires that the MS include information corresponding to the registered GAN Iu mode cell in the Measurement Report message sent to the RNC. The MS reports the “highest signal quality” for the GAN Iu mode cell. This is not the actual measured signal level on the GAN, but rather is an artificial value allowing the MS to indicate its preference for the GAN.

[0033] The RNC may request that the MS report either the downlink E_c/N_0 (received energy per chip divided by the noise power spectral density in the band) or downlink RSCP (Received Signal Code Power) measurement quantities. The MS reports maximum values for the E_c/N_0 or RSCP quantities. The standard specifies a maximum value of E_c/N_0 is 63 and a maximum value of RSCP is 91.

[0034] The above text describes a process for setting of information elements in a UE measurement report (MR) as asked for by RNC. The inventor recognized that maximum values is set in such a measurement report need not be interpreted as actual measured values. In this way the RNC can re-use a legacy measurement report as a

vehicle for receiving a CSFB request from a UE by having the UE include, for example, maximum or invalid values set for information elements set in the already existing measurement report. But using a measurement report is one example indicating a request for CSFB. Other messages can be used. The measurement configuration primarily indicates whether the UE is allowed to ask for CSFB, and secondarily, the measurement configuration may also indicate how. The “how” part may be predefined for example in a standard specification.

[0035] Figure 2 is a signaling diagram that illustrates non-limiting examples of signaling to implement CSFB in accordance with one example embodiment. At some point, the UE provides UE information (or some other node provides the UE information) to a serving base station (BS) that indicates that the UE supports CSFB. Additional information may also be provided such as for example radio capabilities of the UE, e.g., a dual receiver/single transmitter UE, a dual receiver/dual transmitter UE, a multi-mode UE, etc. The base station responds with a measurement configuration message which informs the UE that the UE may request a CSFB service using a measurement report type message and provides some sort of information to indicate how the UE should indicate a CSFB request in the measurement report. For example, the base station may inform the UE that it may request a CSFB service by including a predetermined measurement value that will be interpreted by the BS as a CSFB request. Any suitable agreed upon value included in the report message may be used, even an invalid or unused measurement value. These two signals only need be exchanged at initial set up. Another option is to exchange this information each time there is a cell change. Additional information may be included in the configuration message such as a carrier frequency, a cell identifier, etc.

[0036] Thereafter, when the UE wants to request a CSFB service, it sends a measurement report message to the BS that includes the agreed upon or predefined information to request same. The measurement report is preferably of the type already sent by the UE to the BS, and indeed, preferably includes valid measurement information, e.g., signal quality measurements of signals received from other base stations.

[0037] Figure 3 is a flowchart illustrating example, non-limiting procedures implemented by a mobile radio terminal (also called a UE) to request and obtain a CSFB service. The UE is in some sort of communication with a first packet-switched service network via a first radio base station (S1), e.g., an active connection, a monitoring broadcasts, camping on a cell of the BS, etc. The UE detects a request or a need for a circuit-switched service, and in response, generates a measurement report (S2) and sends the measurement report to the first radio base station via the first radio circuitry (S3). A message from the first base station is then received directing the UE to establish a connection to receive the circuit-switched service from the second circuit-switched service network via a second radio base station (S4), which it then does (S5).

[0038] Figure 4 is a flowchart illustrating example, non-limiting procedures implemented by a base station involved in receiving a CSFB request and facilitating provision of a CSFB service. The base station (BS) includes radio circuitry to communicate with a UE over a radio interface and communications circuitry to communicate with a network node in a first packet-switched service network that provides packet-switched services. In this example, the BS optionally sends a measurement configuration message that indicates that a circuit-switched service may be requested using a measurement report (S10). Ultimately, the BS receives a measurement report from the UE that includes information associated with the measurement configuration message (S11). In response, the BS generates and sends to the UE a redirect message redirecting the mobile radio terminal to a frequency associated with a second circuit-switched service network (S12). Redirection is used by the base station to direct a UE to another frequency and/or radio access technology (RAT) to search for a best cell on that frequency/RAT and initiate a connection setup in that best cell. In this way, a source base station does not need to have detailed configured knowledge of cells on the target frequency/RAT. As shown in Figure 2, the BS also at the same time generates and sends to the first packet-switched service network a release message to cause the UE to be connected to a second radio base station to obtain the circuit-switched service (S13). The release may mean that the UE actually disconnects from or becomes in some way temporarily unavailable to the PS

services network. Alternatively, the UE radio circuitry is such that the release means that the UE carries on parallel connections with the network providing PS services and the network providing CS service. Release and redirect are general messages that may be accomplished using existing or to be developed messages. For example, a redirect message may be implemented, but need not be, using a handover mechanism.

[0039] Figure 5 is a non-limiting function block diagram of a UE 10. The UE 10 includes first radio circuitry 12 configured to communicate with a first packet-switched service network via a first radio base station and second radio circuitry 12 configured to communicate with a second circuit-switched service network. The radio circuitry communicates with processing circuitry 22 coupled to memory 20 that is configured to perform a number of functions including detecting a request during the connection for a circuit-switched service, and in response, generating a measurement report; sending the measurement report to the first radio base station via the first radio circuitry; receiving a message from the first base station directing the mobile radio terminal to establish a connection to receive the circuit-switched service from the second circuit-switched service network via a second radio base station; and activating the second radio circuitry to establish the connection for the circuit-switched service. Non-limiting examples of the measurement report information includes one or more of the following: a cell identifier of a cell associated with a second radio base station in the second circuit-switched service network, a carrier frequency, a measurement identifier, or a non-valid measurement value. Optionally, the first radio circuitry may receive a measurement configuration message from the first radio base station that indicates that a circuit-switched service may be requested using a measurement report. Alternatively, the UE may receive that information from another source.

[0040] Figure 6 is a non-limiting function block diagram of a base station 24. The base station 24 includes radio circuitry 26 configured to communicate with a UE 10 over a radio interface and communications circuitry 32 configured to communicate with a network node in a first packet-switched service network that provides packet-switched services. The radio circuitry 26 communicates with processing circuitry 30 coupled to memory 28 that is configured to receive via the radio circuitry a

measurement report from the UE that includes information indicating a request or need for a circuit-switched service; in response to the received measurement report, generate and send to the UE via the radio circuitry a redirect message directing the mobile radio terminal to a frequency associated with a second circuit-switched service network; and generate and send to the first packet-switched service network via the communications circuitry a release message to cause the UE to be connected to a second radio base station to obtain the circuit-switched service. Advantageously, the processing circuitry sends the release message to initiate a circuit-switched fallback procedure without having to request permission from a core network node in the first packet-switched service network. The processing circuitry 30 may optionally also be configured to generate and send to the UE a measurement configuration message that indicates the information to be included in the measurement report associated with a request or need for a circuit-switched service.

[0041] Figure 7 is a non-limiting function block diagram of a core network node 34. One example of such a node is an MME in an LTE network. The core network node 34 includes a processing unit 38 coupled to a memory 38 and a communication unit 40 for communicating to base stations, among other nodes. The core network node 34 receives a UE context release request message from the base station and acknowledge a CSFB procedure by sending a acknowledgement back to eNB .

[0042] Figure 8 illustrates CSFB in a specific but still example context of an LTE PS network and a 1xRTT CS network. In this example context, the base station is an eNodeB (eNB) which agrees with the UE agree on a way of handling measurement configuration and measurement reports to allow the UE to request circuit-switched fallback (CSFB) and the eNB to grant the CSFB immediately without waiting for an MME response. The agreed measurement configuration sent by the eNB indicates to UE that the eNB is prepared to receive a measurement result that is understood by the eNB as a CSFB request from the UE. A similar method may be used for Universal Terrestrial Radio Access Network (UTRAN) to Generic Access Network (GAN) handover. Such a handover is described for example in TS 43.318 referenced in the background and incorporated by reference. The eNB answers the UE CSFB request

immediately—without involving the MME—by sending a release with redirection for CSFB message directly to the UE. Other messages may be used. One example is a handover command. At the same time or shortly thereafter, the eNB also sends a UE context release request message to the MME with a cause value, e.g., “CS Fallback Triggered.” The MME responds with a UE context release command, and the eNB answers with UE context release complete. See for example 3GPP TS36.413, v10.2.0, chapter 8.3.2, the disclosure of which is incorporated here by reference. Another way for the UE to indicate to MME that CSFB should be triggered and MME uses a UE context modification request with a CSFB indicator set. See for example 3GPP TS 36.413, v10.2.0, chapters 8.3.4 and 9.1.4.8.

[0043] An eNB in LTE recognizes a UE’s capabilities for example through one or more feature group indicators (FGIs) to determine whether the UE supports circuit-switched fallback (CSFB) to a circuit switched capable system like a CDMA2000 system. For example, the UE may signal that it has a dual receiver (RX) capability. In this non-limiting example context, the eNB configures the UE to measure on a CDMA2000 frequency and CDMA1XRTT cell id measurement object. The specific combination of carrier frequency and cell id in the circuit switched capable system informs to the UE that the UE may request CSFB to the circuit switched capable system, e.g., cdma1XRTT, directly from eNB using a measurement report.

[0044] Figure 9 is a non-limiting function block diagram showing an example CSFB from LTE to a 1xRTT circuit switched communications system in an example context like the 3GPP example shown in Figure 8. The eNB 24 sends a measurement configuration with specific content that indicates to the UE 10 that a CSFB request may be sent by using a measurement report based on this measurement configuration. One or more values on information elements in the measurement report message may be selected so that other UEs not supporting the CSFB technology described here may respond, for example, with a measurement configuration failure. The UE sends a measurement configuration acknowledgement. Example messages names used in the LTE standard for signaling measurement configuration and acknowledge are RRC connection reconfiguration and RRC connection reconfiguration acknowledge. The UE

acknowledgement also indicates to the eNB that the UE may later request a CSFB by sending a measurement report. The UE 10 requests a circuit-switched fallback (CSFB) to a circuit switched capable system like a CDMA2000 system, e.g., CSFB1XRTT, by sending a measurement report containing a specific measurement identifier (id) for the measurement configuration containing the specific and agreed (between the eNB and the UE) measurement object and also preferably an agreed cell global identify (CGI) information value (e.g., 47 bits in 3GPP) and specific, (e.g., extreme or invalid), measurement result values, e.g., 0.

[0045] The following pseudo-code is a non-limiting example implementation for the scenario in Figure 9.

```
MeasResultCDMA2000 ::= SEQUENCE {
    physCellId          PhysCellIdCDMA2000,
    cgi-Info            CellGlobalIdCDMA2000          OPTIONAL,
    measResult          SEQUENCE {
        pilotPnPhase    INTEGER (0..32767)            OPTIONAL,
        pilotStrength    INTEGER (0..63),
```

[0046] When the eNB station receives the UE's measurement report indicating a CSFB and verifies the report contains a valid CSFB request, the eNB sends an RRC Release message with redirection including a release cause, e.g., "cs-FallbackHighPriority," to the UE. The eNB then sends a UE context release request to the MME with a cause value "CS Fallback Triggered." Subsequently, the base station receives a UE context release command response from the MME and may remove the UE context from that eNB, and answer that UE context release is complete.

[0047] The technology in this application provides several example advantages. First, a circuit-switched fallback (CSFB) to a circuit switched capable system is not delayed by base station-core network node (e.g., eNB/MME) signaling procedures. Second, the CSFB technology supports and is consistent with legacy signaling procedures, which means that already-implemented functionality can be re-used. Third, measurement configuration and reporting are already standardized and do not require interface update. Fourth, backward compatibility, and to some extent forward compatibility, are supported because the base station and UE can select and agree upon

some information, e.g., non-used measurement id's, carrier frequency, physical cell id, CGI and measurement result values, etc., to allow and indicate a CSFB request from the UE. Fifth, using one or more specific values also allows one or more non-valid values to be used so that UE's that do not support this technology may still respond as defined in legacy RRC procedures, e.g., by a failure message to the eNB as a response to the measurement configuration message.

[0048] Further, the CSFB technology described may further take the form of a computer program product stored on a non-transitory computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purpose of this description, a computer readable medium includes any apparatus that can contain or store the program for use by or in connection with the instruction execution system, apparatus, or device. The medium can be for example an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device). Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a RAM, a ROM, a rigid magnetic disk and an optical disk. Current examples of optical disks include CD-read only memory ("CD-ROM"), CD-read/write ("CD-R/W"), and DVD.

[0049] Although the description above contains many specifics, these should not be construed as limiting the scope of the claims but as merely providing illustrations of example embodiments. It will be appreciated that the technology claimed fully encompasses other embodiments which may become apparent to those skilled in the art, and that the scope of the claims is accordingly not to be limited. Reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more." All structural and functional equivalents to the elements of the above-described embodiments that are known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed hereby. Moreover, it is not necessary for a device or method to address each and every problem sought to be solved for it to be encompassed hereby. No element, block, or instruction used in the present application should be construed as

critical or essential to the implementations described herein unless explicitly described as such. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise. Unclaimed subject matter is not dedicated to the public and Applicant reserves all rights in unclaimed subject matter including the right to claim such subject matter in this and other applications, e.g., continuations, continuations in part, divisions, etc.

CLAIMS

1. A mobile radio terminal (10), comprising:
first radio circuitry (12, 14A) configured to communicate with a first packet-switched service network via a first radio base station (24);
second radio circuitry (12, 14B) configured to communicate with a second circuit-switched service network;
processing circuitry (22, 20) configured to:
detect a request for a circuit-switched service, and in response, generate a measurement report;
send the measurement report to the first radio base station via the first radio circuitry;
receive a message from the first base station directing the mobile radio terminal to establish a connection to receive the circuit-switched service from the second circuit-switched service network via a second radio base station; and
activate the second radio circuitry to establish the connection for the circuit-switched service.
2. The mobile radio terminal in claim 1, wherein the measurement report includes information that the first radio base station interprets as a request for the circuit-switched service.
3. The mobile radio terminal in any of the above claims, wherein the measurement report includes information indicating a circuit-switched fallback request.
4. The mobile radio terminal in claim 3, wherein the measurement report information includes one or more of the following: a cell identifier of a cell associated with a second radio base station in the second circuit-switched service network, a carrier frequency, a measurement identifier, or a non-valid measurement value.

5. The mobile radio terminal in any of the above claims, wherein the processing circuitry is configured to establish a connection with the first packet-switched service network via a first radio base station prior to detecting the request.

6. The mobile radio terminal in any of the above claims, wherein the processing circuitry is configured to send a capability message to the first radio base station to inform the first radio base station that the mobile radio terminal can support circuit-switched fallback.

7. The mobile radio terminal in any of the above claims, wherein the first radio circuitry is configured to receive a measurement configuration message from the first radio base station that indicates that a circuit-switched service may be requested using a measurement report.

8. The mobile radio terminal in any of the above claims, wherein the circuit-switched service is a voice call circuit-switched service.

9. The mobile radio terminal in any of the above claims, wherein the received message is a release with redirection for circuit-switched fallback message.

10. The mobile radio terminal in any of the above claims, wherein the first packet-switched service network is an LTE-based network, the first radio base station is an eNodeB, the second circuit-switched service network is a 1XRTT system, and the second radio base station is CDMA-based.

11. A first radio base station (24), comprising:
radio circuitry (26) configured to communicate with a mobile radio terminal (10) over a radio interface;

communications circuitry (32) configured to communicate with a network node (34) in a first packet-switched service network that provides packet-switched services; and

processing circuitry (30, 28) configured to:

receive via the radio circuitry a measurement report from the mobile radio terminal that includes information indicating a request or need for a circuit-switched service;

in response to the received measurement report, generate and send to the mobile radio terminal via the radio circuitry a redirect message directing the mobile radio terminal to a frequency associated with a second circuit-switched service network; and

generate and send to the first packet-switched service network via the communications circuitry a release message to cause the mobile radio terminal to be connected to a second radio base station to obtain the circuit-switched service.

12. The radio base station in claim 11, wherein the processing circuitry is configured to generate and send to the mobile radio terminal a measurement configuration message that indicates the information to be included in the measurement report associated with a request or need for a circuit-switched service.

13. The radio base station in any of the above claims, wherein the processing circuitry is configured to send the release message to initiate a circuit-switched fallback procedure without having to request permission from a core network node in the first packet-switched service network.

14. The radio base station in any of the above claims, wherein the measurement report includes information indicating a circuit-switched fallback request.

15. The radio base station in claim 14, wherein the measurement report information includes one or more of the following: a cell identifier of a cell associated with a second radio base station in the second circuit-switched service network, a carrier frequency, a measurement identifier, or a non-valid measurement value.

16. The radio base station in any of the above claims, wherein the circuit-switched service is a voice call circuit-switched service.

17. The radio base station in any of the above claims, wherein the release message is a release with redirection to a circuit-switched network.

18. The radio base station in any of the above claims, wherein the first packet-switched service network is an LTE-based network, the first radio base station is an eNodeB, the second circuit-switched service network is a 1XRTT system, and the second radio base station is CDMA-based.

19. A method implemented in a mobile radio terminal (10), comprising:
communicating with a first packet-switched service network via a first radio base station (24) (S1);

detecting a request for a circuit-switched service, and in response, generating a measurement report (S2);

sending the measurement report to the first radio base station (S3);

receiving a message from the first base station directing the mobile radio terminal to establish a connection to receive the circuit-switched service from the second circuit-switched service network via a second radio base station (S4); and

establishing the connection for the circuit-switched service (S5).

20. The method in claim 19, wherein the measurement report includes information that the first radio base station interprets as a request for the circuit-switched service.

21. The method in any of the above claims, wherein the measurement report includes information indicating a circuit-switched fallback request.

22. The method in claim 21, wherein the measurement report information includes one or more of the following: a cell identifier of a cell associated with a second radio base station in the second circuit-switched service network, a carrier frequency, a measurement identifier, or a non-valid measurement value.

23. The method in any of the above claims, wherein first radio circuitry in the mobile radio terminal (12, 14A) is configured to receive a measurement configuration message from the first radio base station that indicates that a circuit-switched service may be requested using a measurement report.

24. The method in any of the above claims, wherein the received message is a release with redirection for circuit-switched fallback message.

25. A method implemented in a radio base station (24) including radio circuitry (26) to communicate with a mobile radio terminal (10) over a radio interface and communications circuitry (32) to communicate with a network node (34) in a first packet-switched service network that provides packet-switched services, the method comprising:

receiving a measurement report from the mobile radio terminal that includes information indicating a request or need for a circuit-switched service (S11);

generating and sending to the mobile radio terminal a redirect message directing the mobile radio terminal to a frequency associated with a second circuit-switched service network (S12); and

generating and sending to the first packet-switched service network a release message to cause the mobile radio terminal to be connected to a second radio base station to obtain the circuit-switched service (S13).

26. The method in claim 25, further comprising generating and sending to the mobile radio terminal a measurement configuration message that indicates the information to be included in the measurement report associated with a request or need for a circuit-switched service (S10).

27. The method in any of the above claims, wherein the release message is sent to initiate a circuit-switched fallback procedure without having to request permission from a core network node in the first packet-switched service network.

28. The method in any of the above claims, wherein the measurement report includes information indicating a circuit-switched fallback request.

29. The method in claim 28, wherein the information includes one or more of the following: a cell identifier of a cell associated with a second radio base station in the second circuit-switched service network, a carrier frequency, a measurement identifier, or a non-valid measurement value.

30. The method in any of the above claims, wherein the release message is a release with redirection to a circuit-switched network.

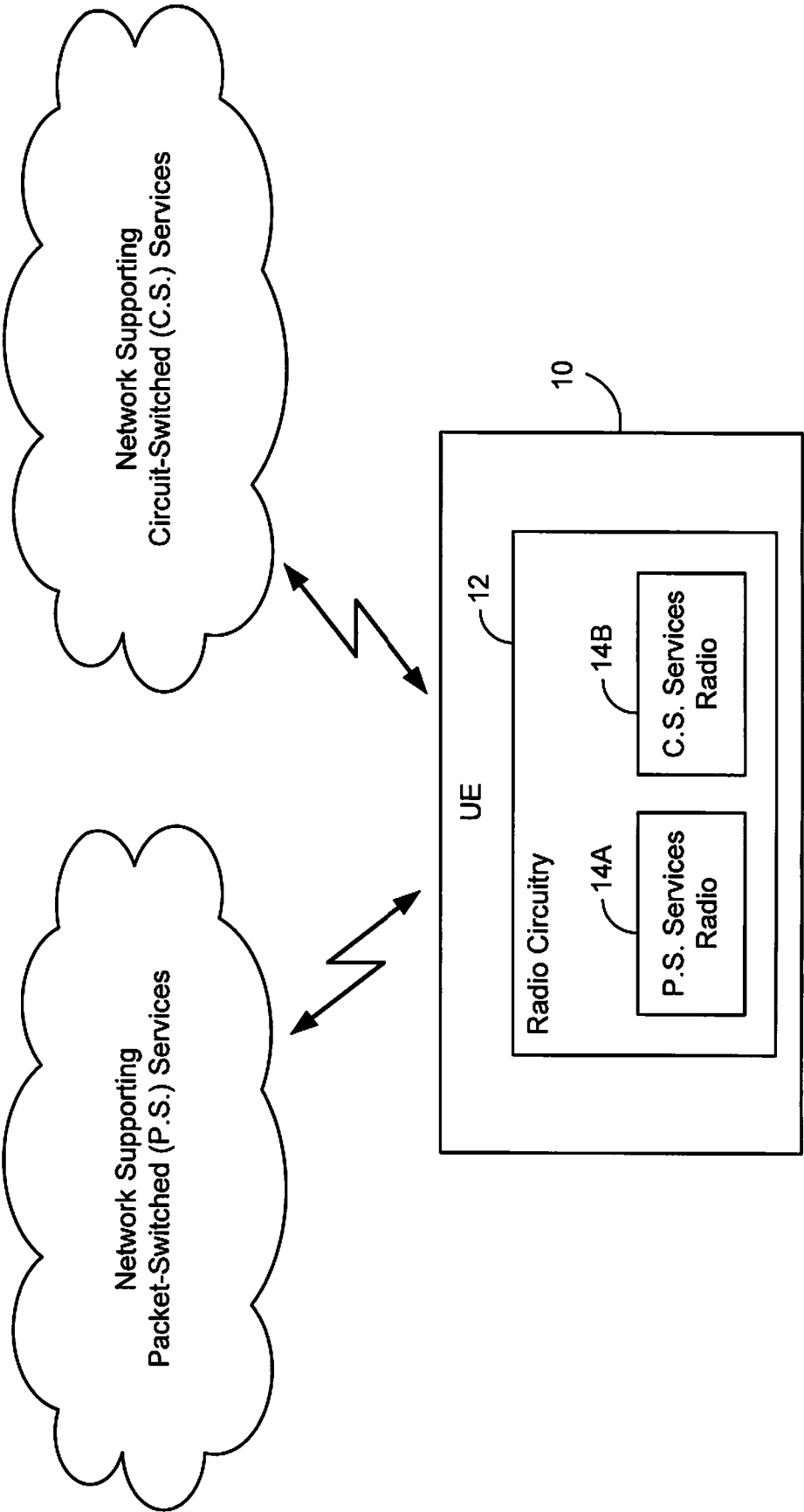


FIG. 1

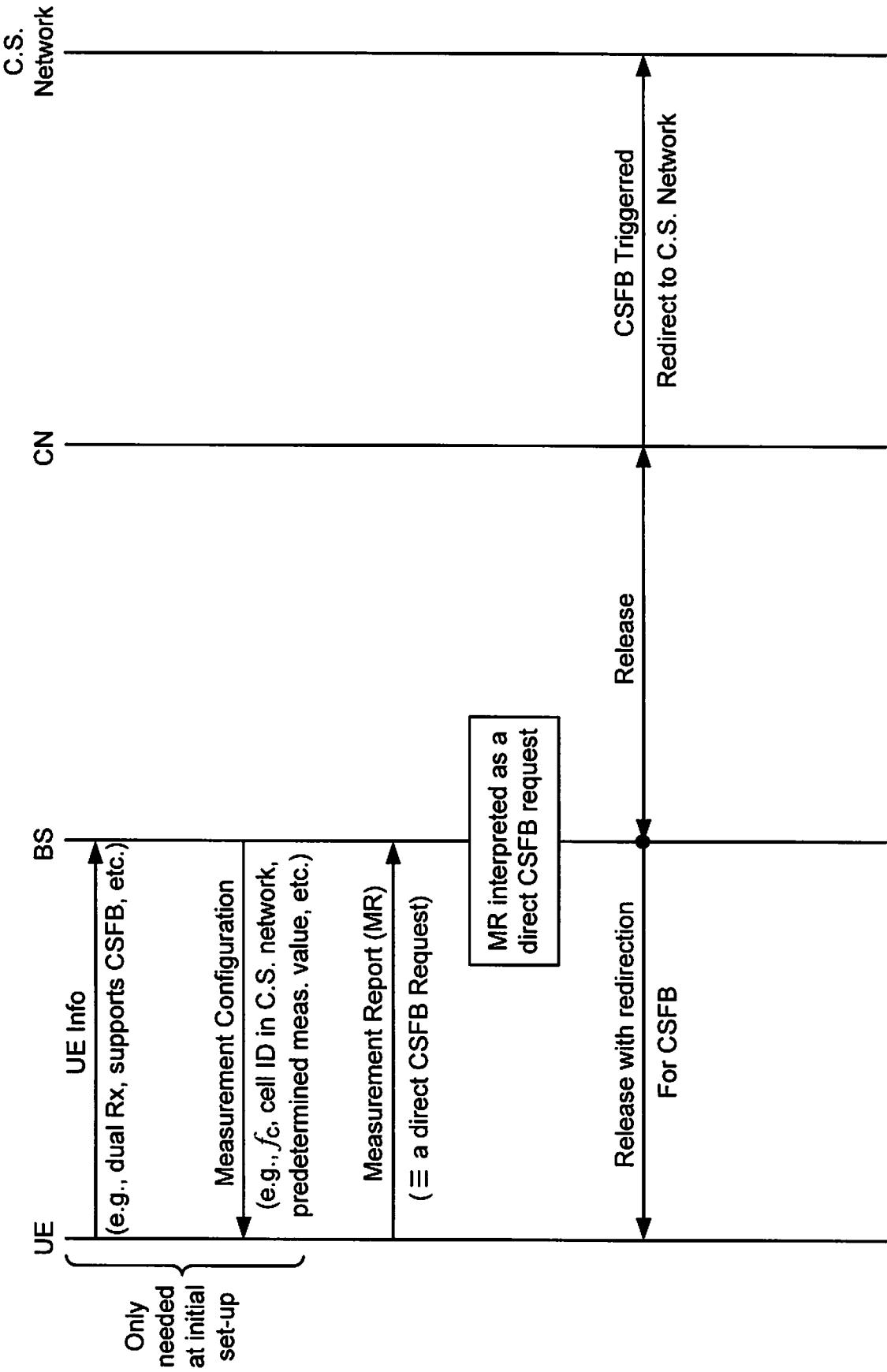


FIG. 2

3/6

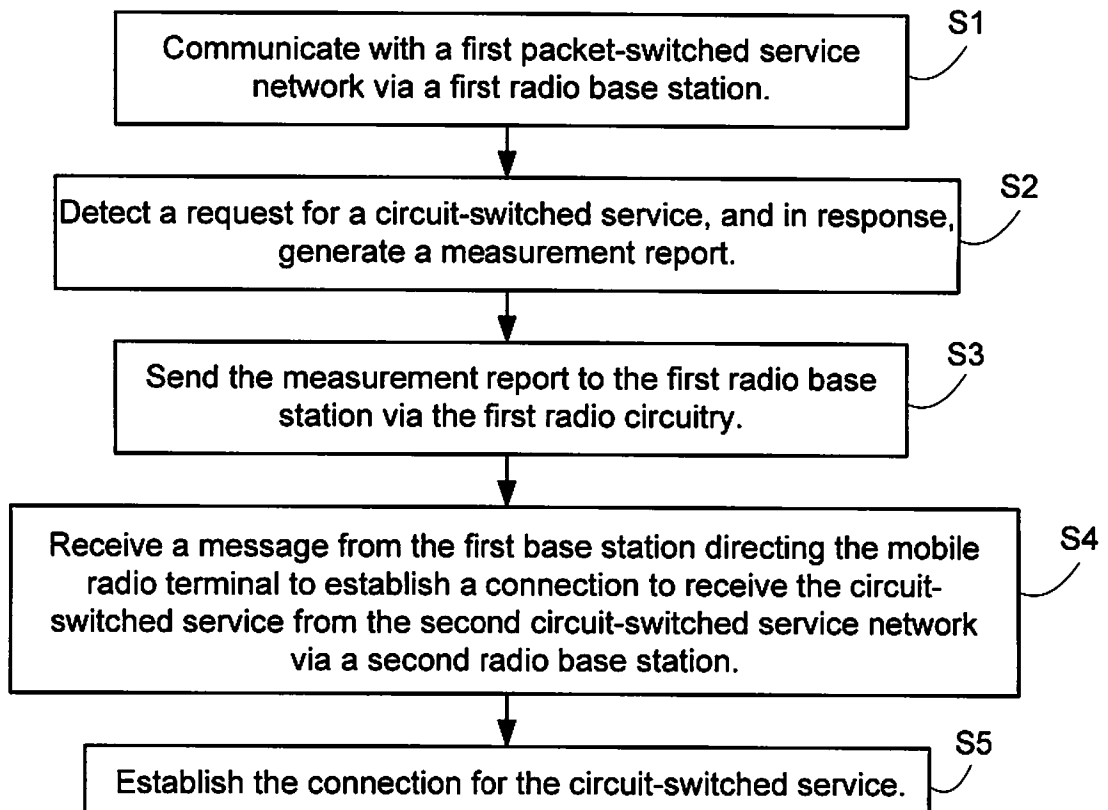


FIG. 3

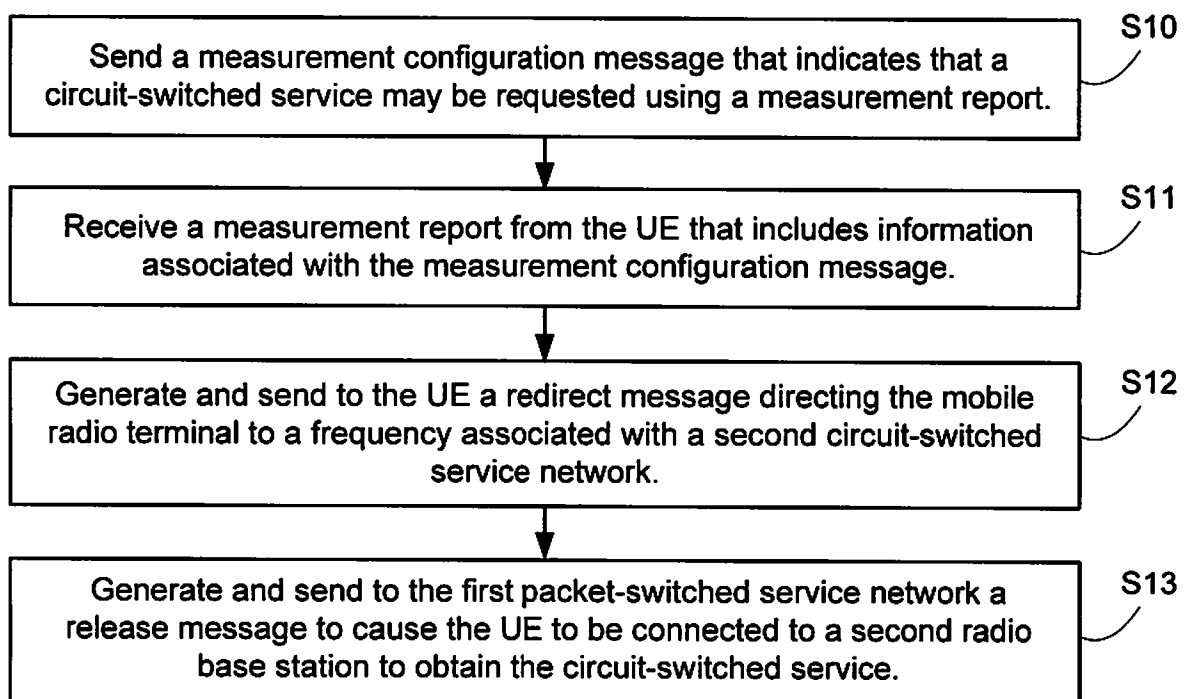


FIG. 4

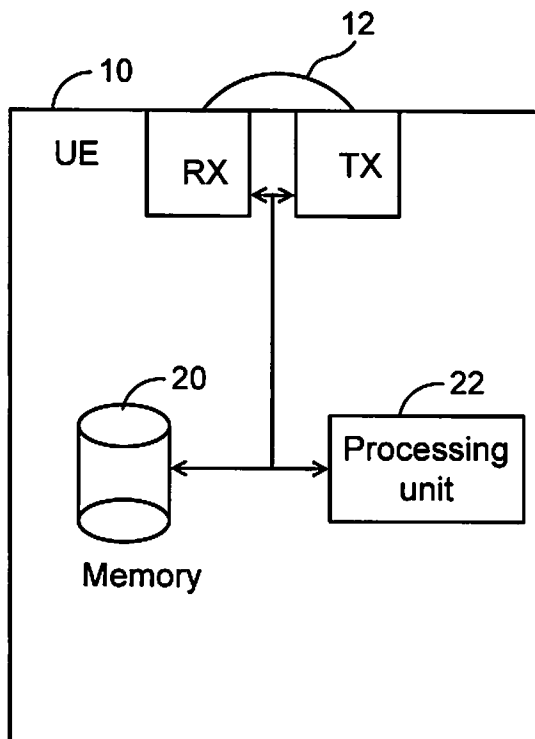


FIG. 5

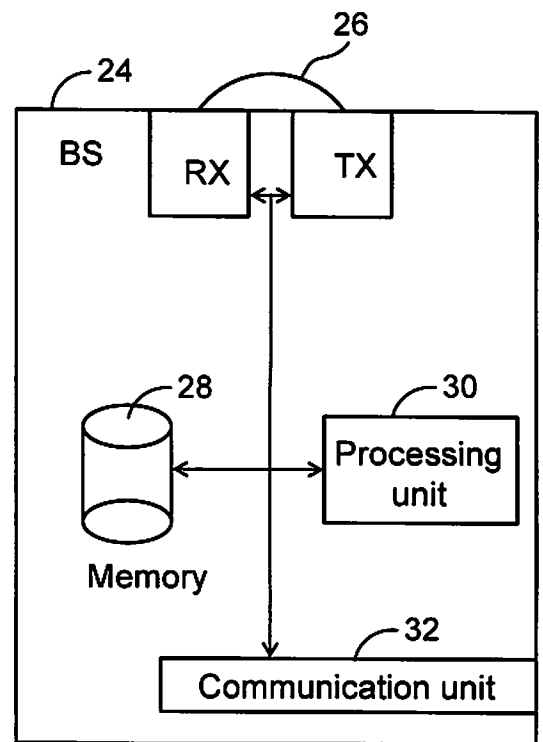


FIG. 6

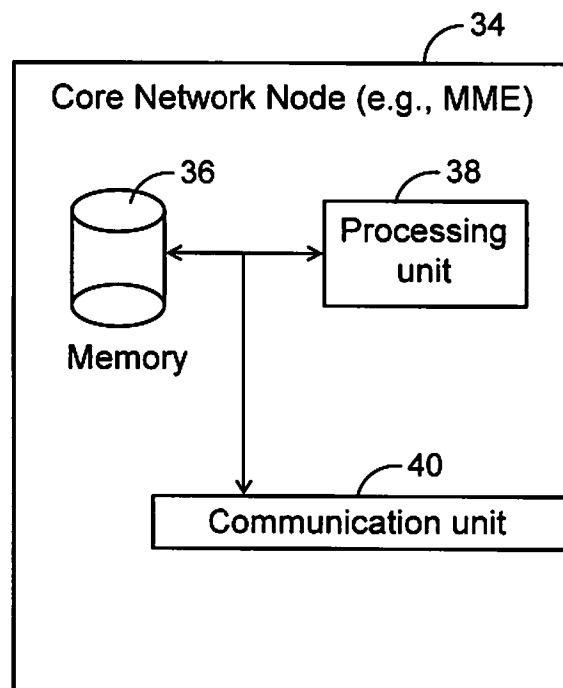


FIG. 7

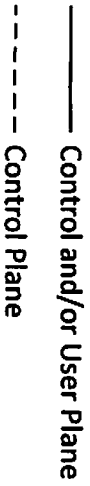


FIG. 8

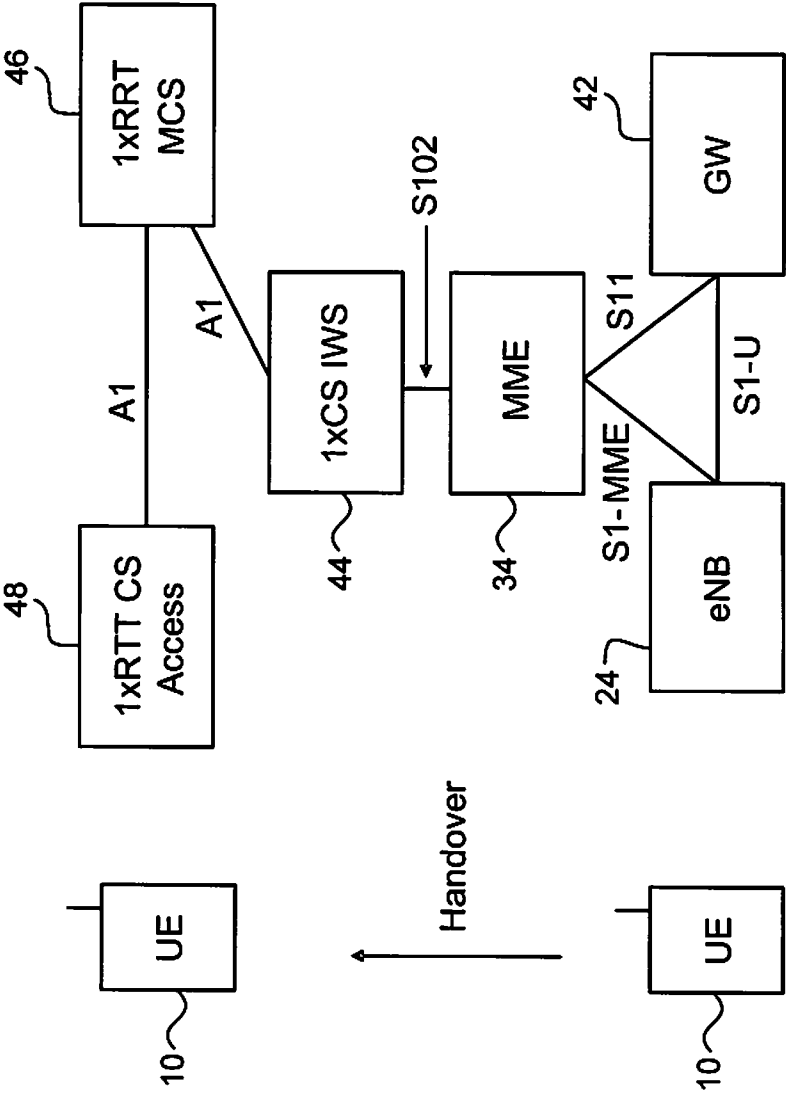


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2012/050696A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W36/00
ADD.

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

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, INSPEC, 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	US 2010/316000 A1 (BURBIDGE RICHARD CHARLES [GB] ET AL) 16 December 2010 (2010-12-16) paragraph [0007] - paragraph [0013]; figures 1,2 paragraph [0040] - paragraph [0048]; figure 3 paragraph [0062] - paragraph [0066]; figure 4 paragraph [0090] - paragraph [0097]; figure 6 paragraph [0117] - paragraph [0137]; figures 11-14 ----- -/--	1-30



Further documents are listed in the continuation of Box C.



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

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"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

4 October 2012

Date of mailing of the international search report

12/10/2012

Name and mailing address of the ISA/

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Authorized officer

Lastoria, Gianluca

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2012/050696

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/155314 A1 (ERICSSON TELEFON AB L M [SE]; SAELLBERG KRISTER [SE]; PALM HAAKAN [SE]) 24 December 2008 (2008-12-24) page 3, line 12 - page 6, line 4; figures 1,2 -----	1-30
T	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Circuit Switched (CS) fallback in Evolved Packet System (EPS); Stage 2 (Release 10)", 3GPP STANDARD; 3GPP TS 23.272, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. SA WG2, no. V10.4.0, 10 June 2011 (2011-06-10), pages 1-78, XP050552987, [retrieved on 2011-06-10] Annex B (normative): CS Fallback to 1xRTT 55; page 55 - page 77 -----	1-30

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/SE2012/050696

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010316000	A1	16-12-2010	CA 2765535 A1 23-12-2010
			EP 2443873 A1 25-04-2012
			US 2010316000 A1 16-12-2010
			WO 2010146464 A1 23-12-2010

WO 2008155314	A1	24-12-2008	AT 522113 T 15-09-2011
			AU 2008265241 A1 24-12-2008
			CA 2689344 A1 24-12-2008
			CN 101690329 A 31-03-2010
			EP 2156682 A1 24-02-2010
			JP 2010530689 A 09-09-2010
			KR 20100036325 A 07-04-2010
			MA 31522 B1 01-07-2010
			PL 2156682 T3 31-01-2012
			PT 2156682 E 30-11-2011
			US 2009036130 A1 05-02-2009
			WO 2008155314 A1 24-12-2008
