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(54) **INTER-SYSTEM HANDOVER USING LEGACY INTERFACE**

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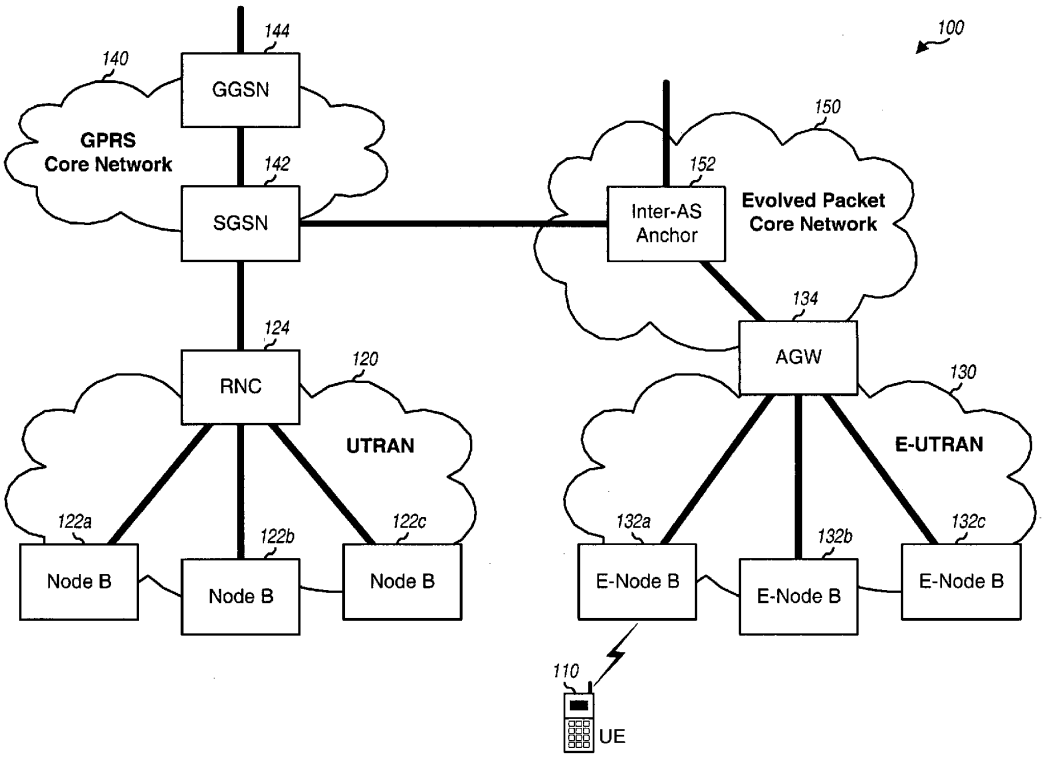
(52) **U.S. Cl.** **455/436**; 455/331

(57) **ABSTRACT**

Techniques for performing inter-system handover are described. An Access Gateway (AGW) sends a message requesting handover of a user equipment (UE) from a first radio access network (RAN) to a second RAN. The message is sent to an Inter Access System (inter-AS) Anchor for the first RAN communicating with an SGSN for the second RAN via a Gn interface. The Inter-AS Anchor and SGSN exchange messages via the Gn interface, and the Inter-AS Anchor forwards the messages to the AGW to handover the UE from the first RAN to the second RAN. The SGSN sees the Inter-AS Anchor as another SGSN for the handover and as a GGSN after the handover. This allows the inter-system handover to be achieved with an inter-SGSN SRNS relocation procedure used for handover between two SGSNs, which reduces impact on the SGSN to support the inter-system handover.



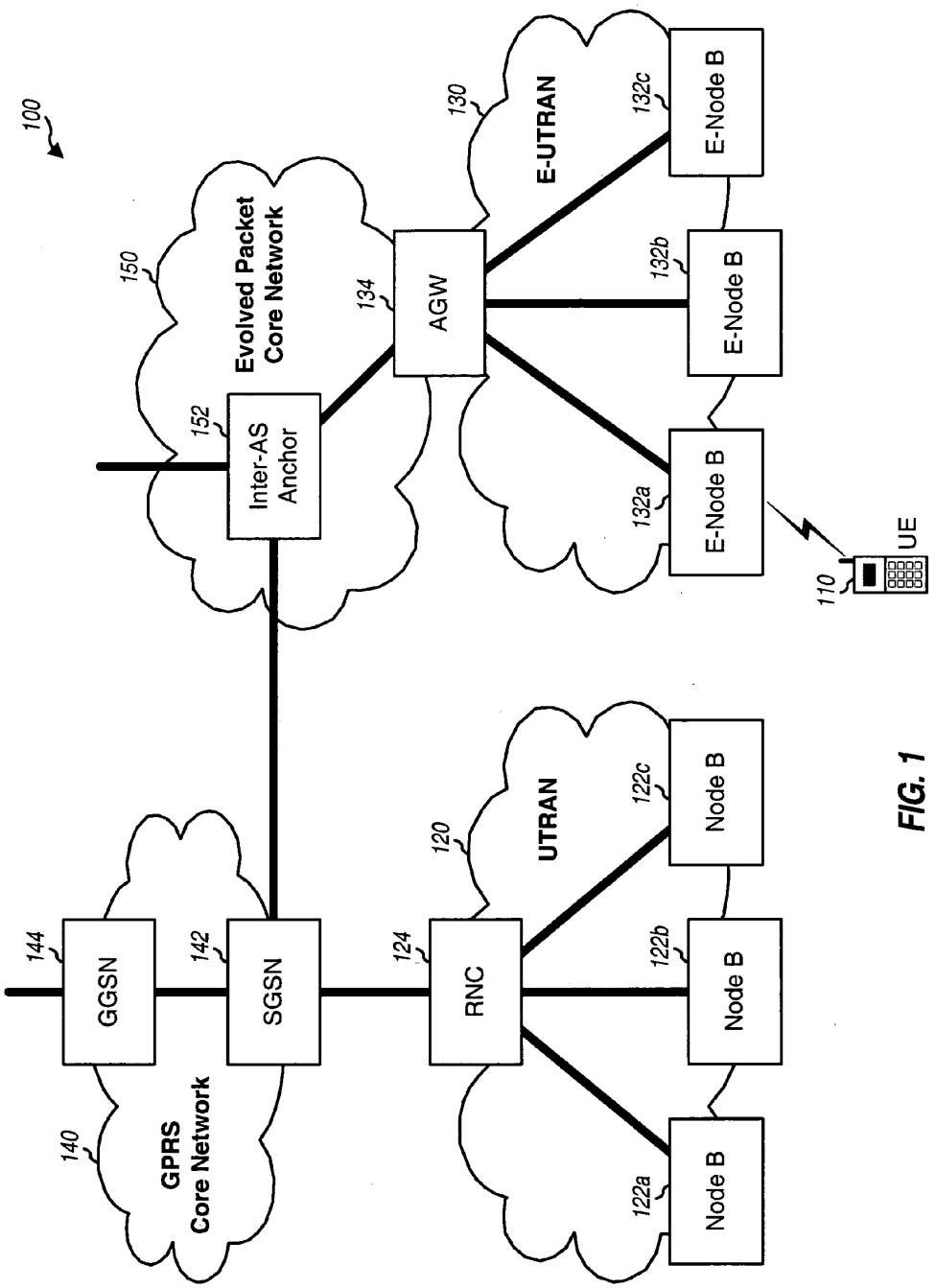

100
Evolved Packet Core Network
150
Inter-AS Anchor
152
AGW
134
E-UTRAN
130
E-Node B
132a
E-Node B
132b
E-Node B
132c
UE
110
GPRS Core Network
140
GGSN
144
SGSN
142
RNC
124
UTRAN
120
Node B
122a
Node B
122b
Node B
122c

FIG. 1

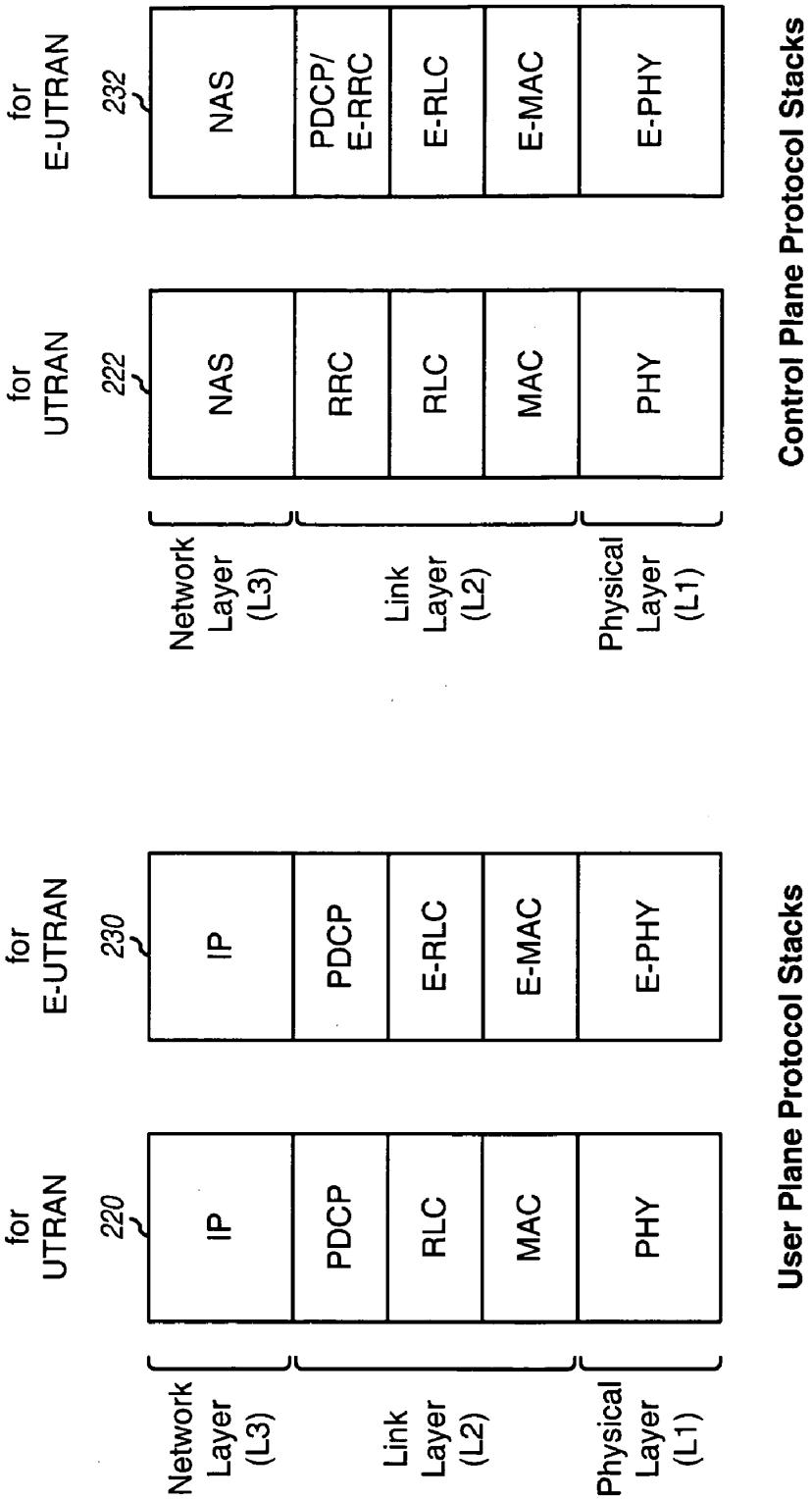
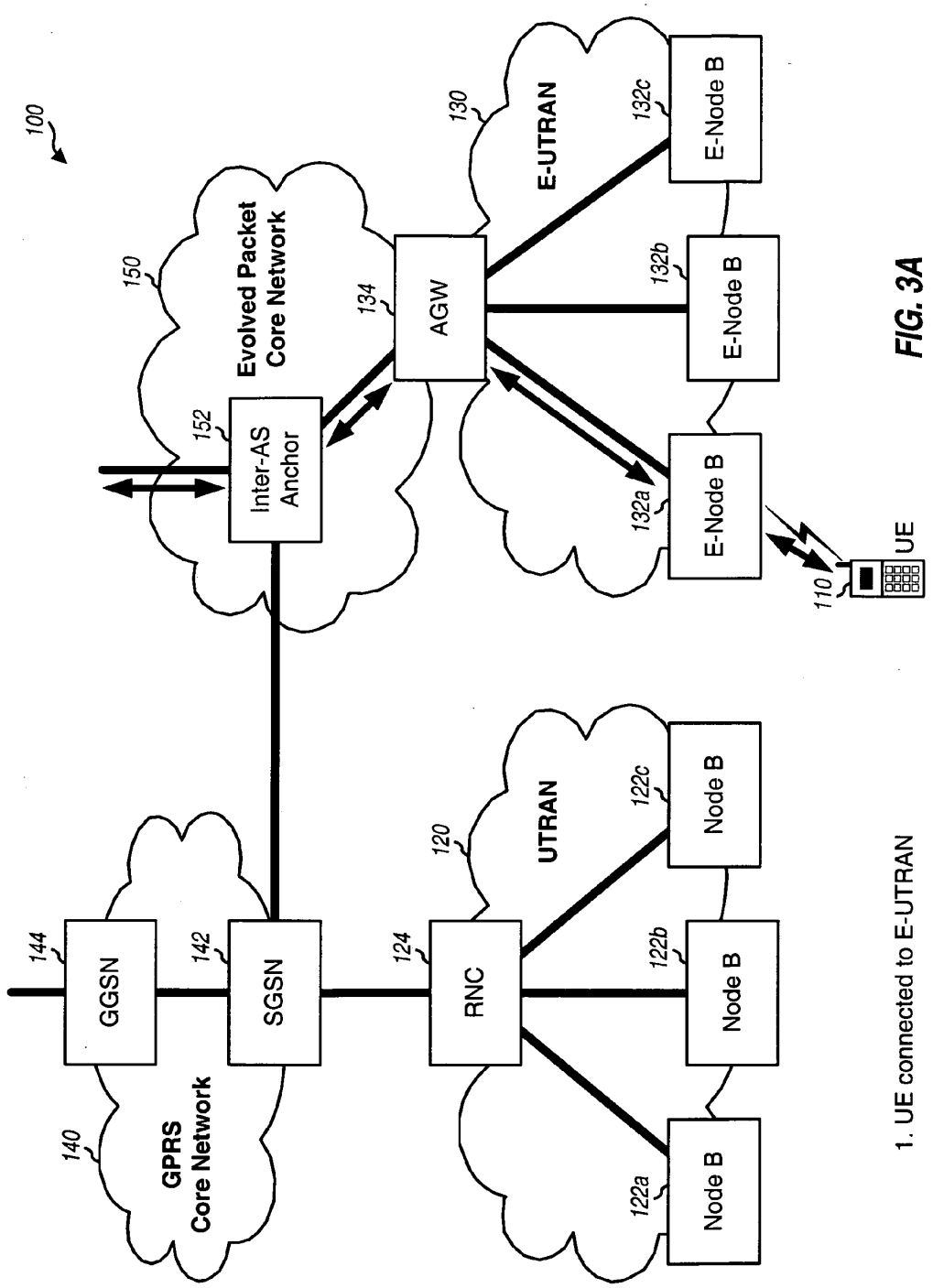

for UTRAN
220
for E-UTRAN
230
Network Layer (L3)
Link Layer (L2)
Physical Layer (L1)
IP
PDCP
RLC
MAC
PHY
IP
PDCP
E-RLC
E-MAC
E-PHY
User Plane Protocol Stacks
for UTRAN
222
for E-UTRAN
232
NAS
RRC
RLC
MAC
PHY
NAS
PDCP/ E-RRC
E-RLC
E-MAC
E-PHY
Control Plane Protocol Stacks

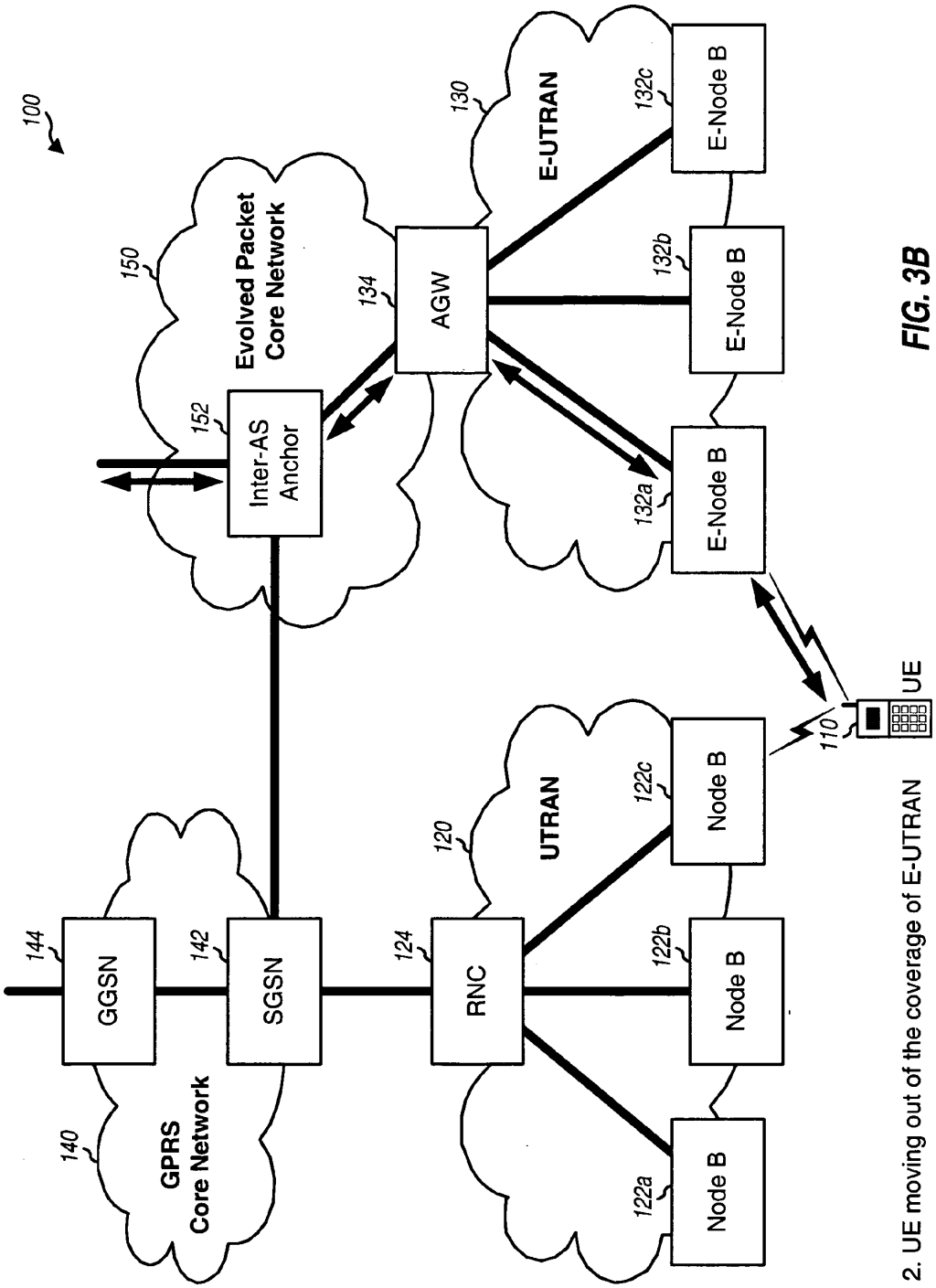
FIG. 2A

FIG. 2B



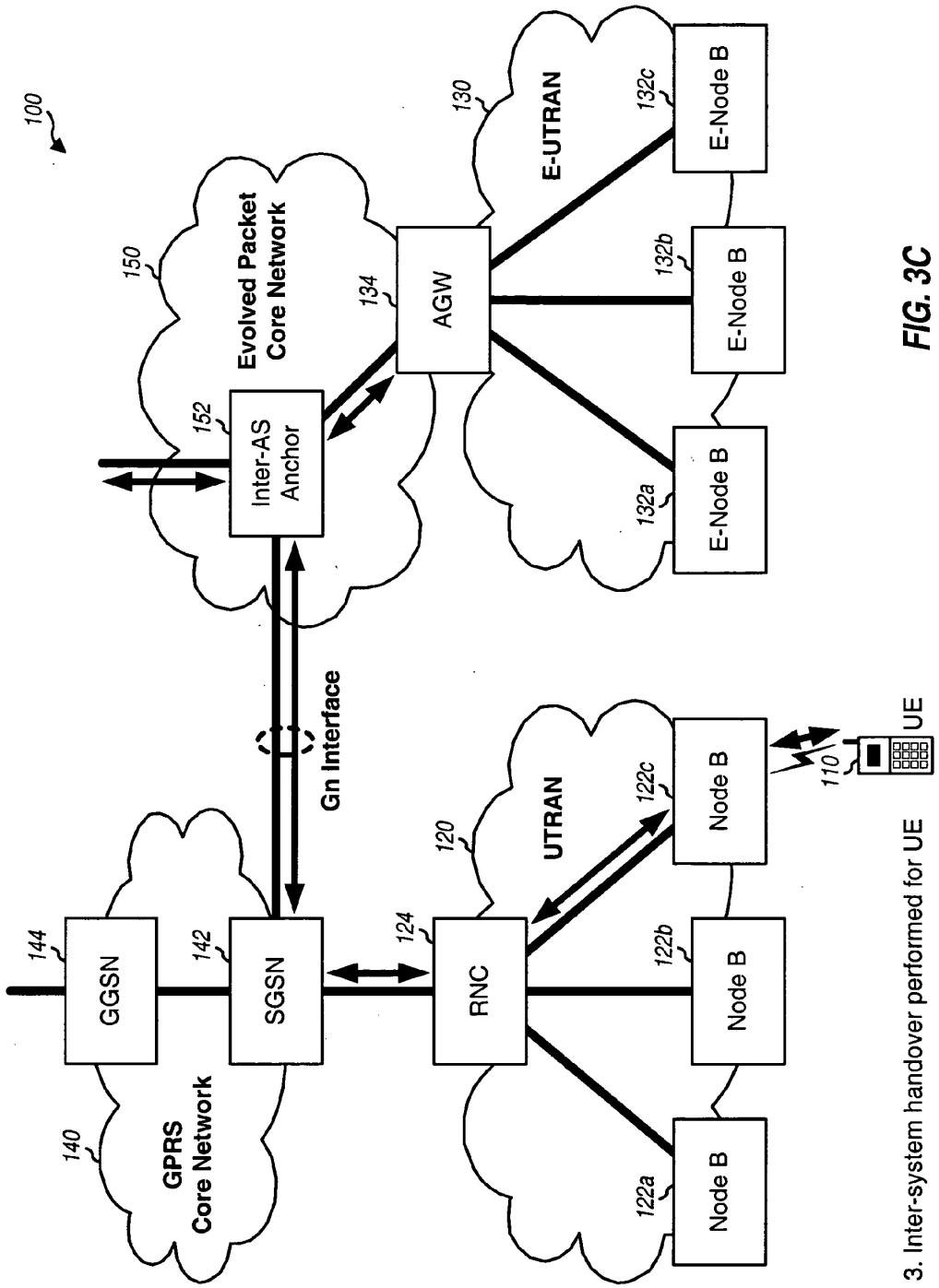
1. UE connected to E-UTRAN

FIG. 3A



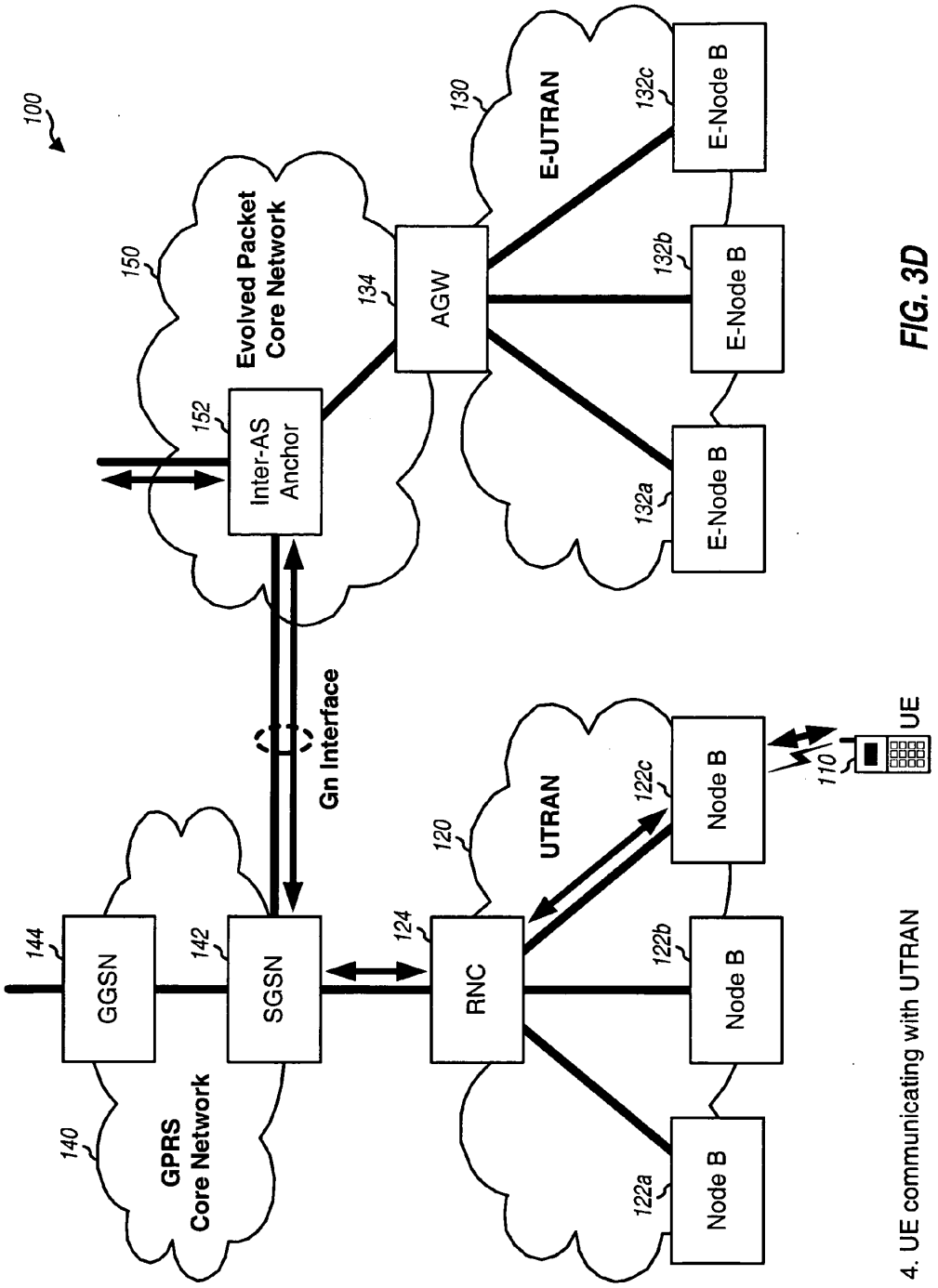
2. UE moving out of the coverage of E-UTRAN

FIG. 3B



3. Inter-system handover performed for UE

FIG. 3C



4. UE communicating with UTRAN

FIG. 3D

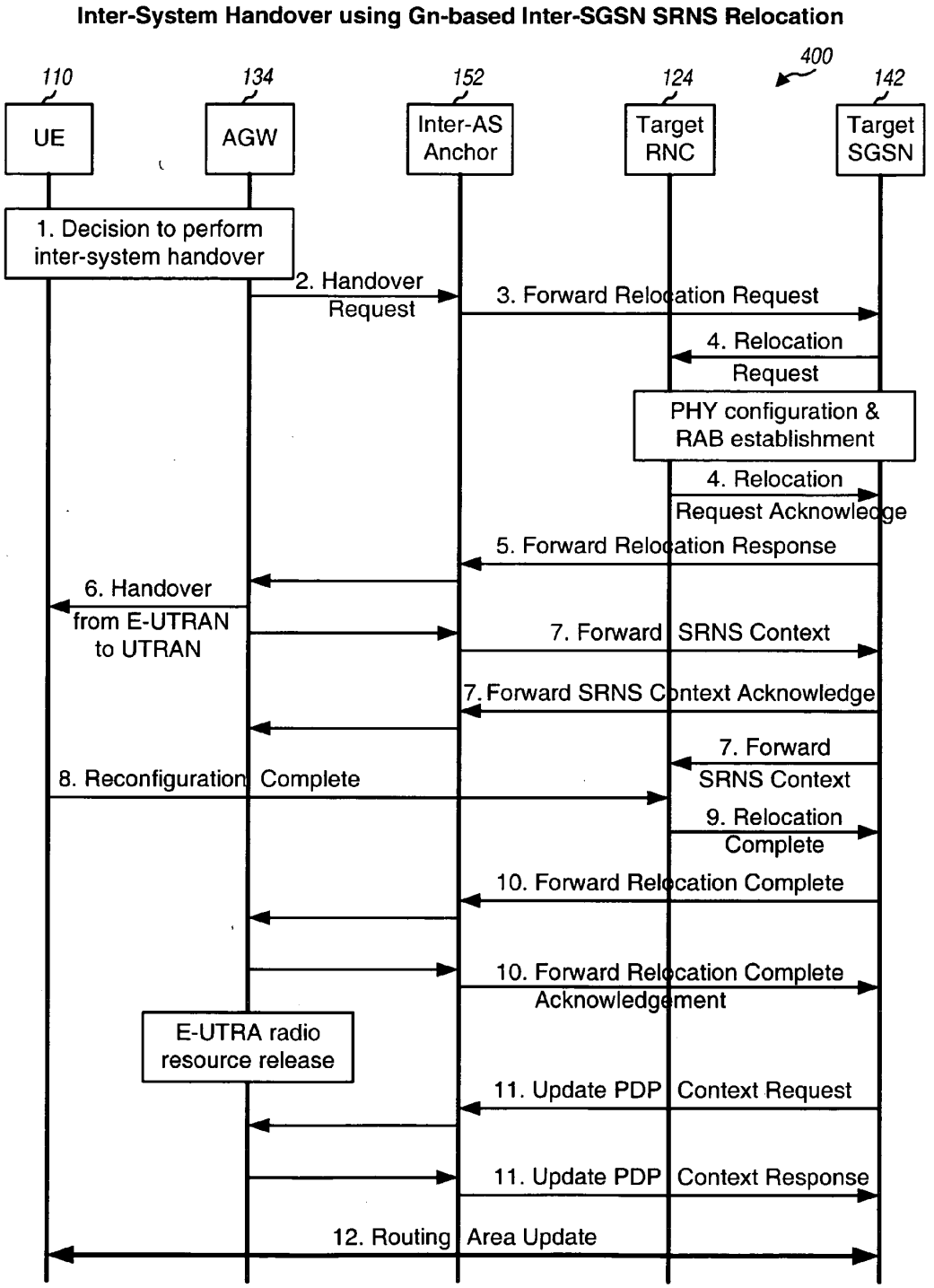

Inter-System Handover using Gn-based Inter-SGSN SRNS Relocation
400
110
134
152
124
142
UE
AGW
Inter-AS Anchor
Target RNC
Target SGSN
1. Decision to perform inter-system handover
2. Handover Request
3. Forward Relocation Request
4. Relocation Request
PHY configuration & RAB establishment
4. Relocation Request Acknowledge
5. Forward Relocation Response
6. Handover from E-UTRAN to UTRAN
7. Forward SRNS Context
7. Forward SRNS Context Acknowledge
7. Forward SRNS Context
8. Reconfiguration Complete
9. Relocation Complete
10. Forward Relocation Complete
10. Forward Relocation Complete Acknowledgement
E-UTRA radio resource release
11. Update PDP Context Request
11. Update PDP Context Response
12. Routing Area Update

FIG. 4

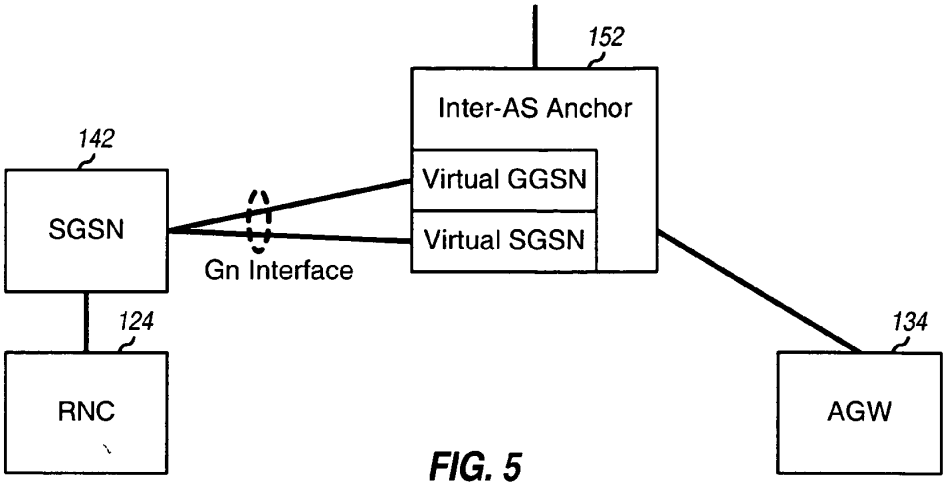

152
Inter-AS Anchor
Virtual GGSN
Virtual SGSN
142
SGSN
Gn Interface
124
RNC
134
AGW

FIG. 5

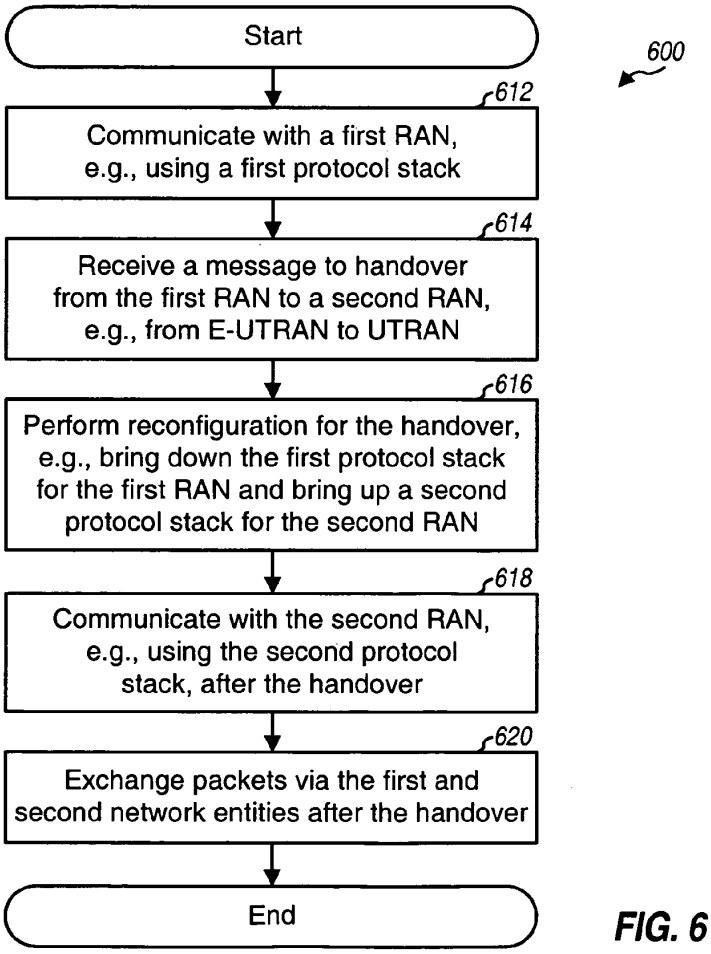

Start
600
612
Communicate with a first RAN, e.g., using a first protocol stack
614
Receive a message to handover from the first RAN to a second RAN, e.g., from E-UTRAN to UTRAN
616
Perform reconfiguration for the handover, e.g., bring down the first protocol stack for the first RAN and bring up a second protocol stack for the second RAN
618
Communicate with the second RAN, e.g., using the second protocol stack, after the handover
620
Exchange packets via the first and second network entities after the handover
End

FIG. 6

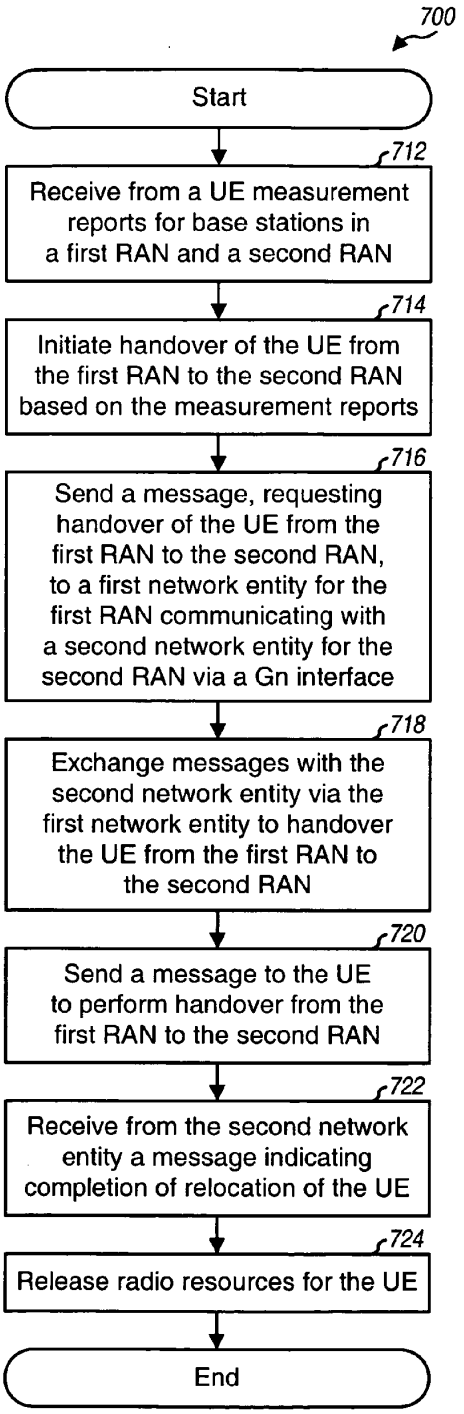

700
Start
712
Receive from a UE measurement reports for base stations in a first RAN and a second RAN
714
Initiate handover of the UE from the first RAN to the second RAN based on the measurement reports
716
Send a message, requesting handover of the UE from the first RAN to the second RAN, to a first network entity for the first RAN communicating with a second network entity for the second RAN via a Gn interface
718
Exchange messages with the second network entity via the first network entity to handover the UE from the first RAN to the second RAN
720
Send a message to the UE to perform handover from the first RAN to the second RAN
722
Receive from the second network entity a message indicating completion of relocation of the UE
724
Release radio resources for the UE
End

FIG. 7

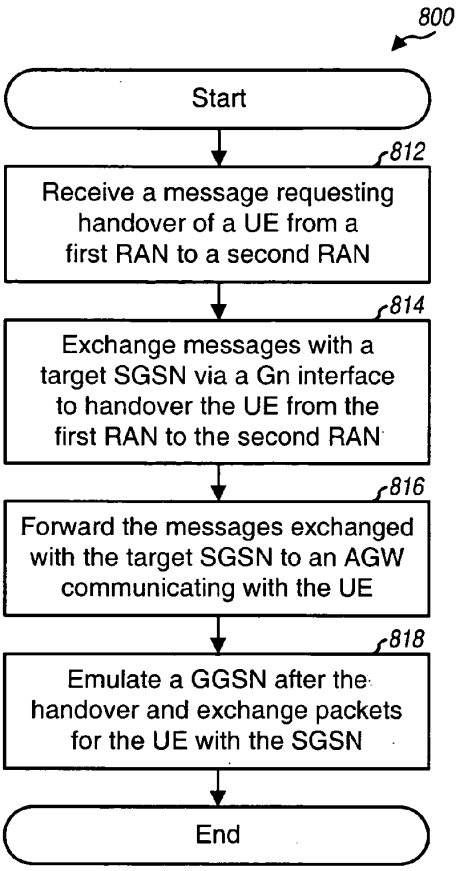

800
Start
812
Receive a message requesting handover of a UE from a first RAN to a second RAN
814
Exchange messages with a target SGSN via a Gn interface to handover the UE from the first RAN to the second RAN
816
Forward the messages exchanged with the target SGSN to an AGW communicating with the UE
818
Emulate a GGSN after the handover and exchange packets for the UE with the SGSN
End

FIG. 8

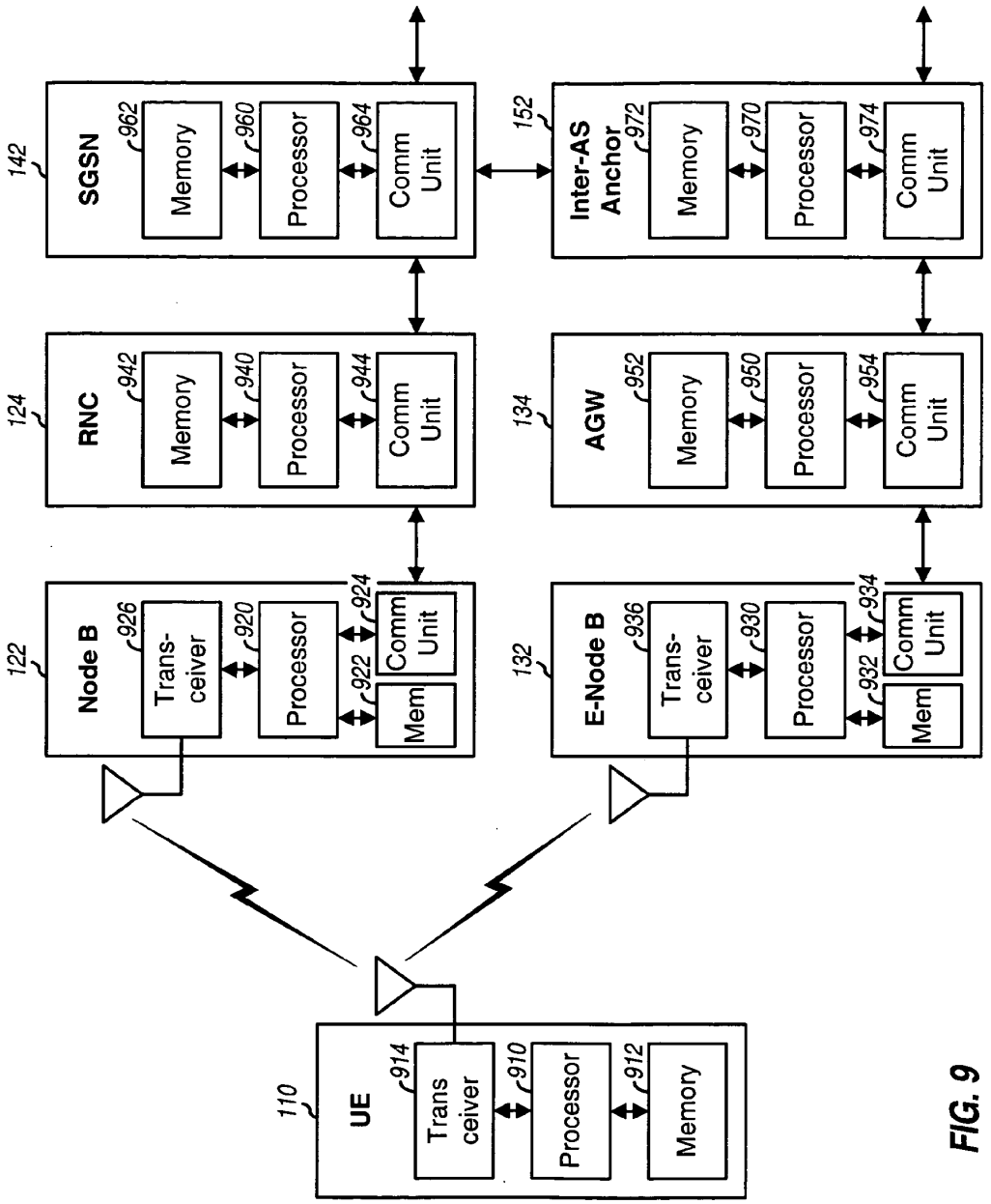

142
SGSN
962
Memory
960
Processor
964
Comm Unit
152
Inter-AS Anchor
972
Memory
970
Processor
974
Comm Unit
124
RNC
942
Memory
940
Processor
944
Comm Unit
134
AGW
952
Memory
950
Processor
954
Comm Unit
122
Node B
926
Trans-ceiver
920
Processor
924
Comm Unit
922
Mem
132
E-Node B
936
Trans-ceiver
930
Processor
934
Comm Unit
932
Mem
110
UE
914
Trans ceiver
910
Processor
912
Memory

FIG. 9

INTER-SYSTEM HANDOVER USING LEGACY INTERFACE

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

[0001] The present Application for Patent claims priority to Provisional Application Ser. No. 60/701,240, entitled "Gn-Based Handover between a New Access System and the UMTS," filed Jul. 19, 2005, assigned to the assignee hereof, and expressly incorporated herein by reference.

BACKGROUND

[0002] I. Field

[0003] The present disclosure relates generally to communication, and more specifically to techniques for performing handover between wireless communication networks using different radio access technologies.

[0004] II. Background

[0005] Wireless communication networks are widely deployed to provide various communication services such as voice, video, packet data, messaging, broadcast, and so on. These networks may be multiple-access networks capable of supporting communication for multiple users by sharing the available network resources. Examples of such multiple-access networks include Code Division Multiple Access (CDMA) networks, Time Division Multiple Access (TDMA) networks, and Frequency Division Multiple Access (FDMA) networks. A CDMA network may implement a radio access technology (RAT) such as cdma2000 or Wideband-CDMA (W-CDMA). cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA network may implement a RAT such as Global System for Mobile Communications (GSM). W-CDMA and GSM are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). cdma2000 is described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). These various RATs and standards are known in the art.

[0006] Data usage for wireless communication networks continually grows due to increasing number of users as well as emergence of new applications with higher data requirements. Consequently, new wireless networks with enhanced performance are continually developed and deployed. Second-generation (2G) wireless networks such as GSM and IS-95 networks can provide voice and low rate data services. Third-generation (3G) wireless networks such as Universal Mobile Telecommunication System (UMTS) networks (which implement W-CDMA) and CDMA2000 1X networks (which implement IS-2000) can support concurrent voice and data services, higher data rates, and other enhanced features. Next generation wireless networks will likely provide higher performance and more features than existing 2G and 3G wireless networks.

[0007] A major challenge in development and deployment of a new wireless network is interoperability with existing wireless networks. It is desirable for a wireless user to be able to roam seamlessly between the new wireless network and existing wireless networks. This would allow the user to enjoy the performance advantages of the new wireless network and the coverage benefits of the existing wireless networks.

SUMMARY

[0008] Techniques for performing inter-system handover of a user equipment (UE) from a first radio access network (RAN) to a second RAN are described herein. The second RAN may be a Universal Terrestrial Radio Access Network (UTRAN), and the first RAN may be an Evolved UTRAN (E-UTRAN), or vice versa. The E-UTRAN is a new RAN with enhanced performance. The first and second RANs may also be RANs of other radio access technologies.

[0009] According to an embodiment of the invention, an apparatus (e.g., a UE) is described which includes at least one processor and a memory. The processor(s) communicate with the first RAN, receive a message to handover from the first RAN to the second RAN, and perform reconfiguration for handover from the first RAN to the second RAN, e.g., bring down a first protocol stack for the first RAN and bring up a second protocol stack for the second RAN. The processor(s) communicate with the second RAN after the handover. The handover is achieved by exchanging messages between a first network entity for the first RAN and a second network entity for the second RAN. The first network entity may be an Inter Access System (Inter-AS) Anchor, and the second network entity may be a Serving GPRS Support Node (SGSN). The first and second network entities communicate via a legacy Gn interface.

[0010] According to another embodiment, an apparatus (e.g., an Access Gateway (AGW)) is described which includes at least one processor and a memory. The processor(s) send to the first network entity a message requesting handover of the UE from the first RAN to the second RAN. The processor(s) exchange messages with the second network entity via the first network entity to handover the UE from the first RAN to the second RAN. The processor(s) also send a message to the UE to perform handover from the first RAN to the second RAN.

[0011] According to yet another embodiment, an apparatus (e.g., an Inter-AS Anchor) is described which includes at least one processor and a memory. The processor(s) receive a message requesting handover of the UE from the first RAN to the second RAN and exchange messages with the SGSN via the Gn interface to handover the UE from the first RAN to the second RAN.

[0012] Various aspects and embodiments of the invention are described in further detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** shows a deployment with a UTRAN and an E-UTRAN.

[0014] FIG. **2**A shows protocol stacks for a user plane.

[0015] FIG. **2**B shows protocol stacks for a control plane.

[0016] FIGS. **3**A to **3**D illustrate handover of a UE from the E-UTRAN to the UTRAN.

[0017] FIG. **4** shows an inter-SGSN SRNS relocation procedure.

[0018] FIG. **5** shows the interface between an SGSN and an Inter-AS Anchor.

[0019] FIG. **6** shows a process performed by the UE for inter-system handover.

[0020] FIG. **7** shows a process performed by an AGW for inter-system handover.

[0021] FIG. **8** shows a process performed by an Inter-AS Anchor for inter-system handover.

[0022] FIG. **9** shows a block diagram of the UE and various network entities.

DETAILED DESCRIPTION

[0023] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments.

[0024] The inter-system handover techniques described herein may be used for various wireless communication networks such as CDMA, TDMA, FDMA, and Orthogonal FDMA (OFDMA) networks. The terms "network" and "system" are often used interchangeably. For clarity, the techniques are described below for 3GPP-based networks.

[0025] FIG. **1** shows an exemplary deployment **100** with a UTRAN **120**, an E-UTRAN **130**, a General Packet Radio Service (GPRS) core network **140**, and an Evolved Packet Core (EPC) network **150**.

[0026] UTRAN **120** includes Node Bs coupled to Radio Network Controllers (RNCs). For simplicity, only three Node Bs **122***a*, **122***b* and **122***c* and one RNC **124** are shown in FIG. **1**. A Node B may also be referred to as a base station, an access point, or some other terminology. Node Bs **122** provide radio communication for UEs within their coverage. RNC **124** provides control for Node Bs **122** and perform radio resource management, some mobility management functions, and other functions to support communication between the UEs and the UTRAN.

[0027] E-UTRAN **130** includes Evolved Node Bs coupled to Access Gateways. An Evolved Node B may also be referred to as a base station, an E-Node B, an eNode B, an eNB, and so on. An Access Gateway may also be referred to as an AGW, an aGW, an anchor, and so on. For simplicity, only three E-Node Bs **132***a*, **132***b* and **132***c* and one AGW **134** are shown in FIG. **1**. E-Node Bs **132** provide radio communication for UEs within their coverage and may perform radio resource management. AGW **134** provides control for E-Node Bs **132**. AGW **134** may include a Mobility Management Entity (MME) and a User Plane Entity (UPE). The MME may perform mobility management functions, e.g., distribution of paging messages to the E-Node Bs. The UPE may perform functions to support data exchanges on a user plane.

[0028] GPRS core network **140** includes a Serving GPRS Support Node (SGSN) **142** coupled to a Gateway GPRS Support Node (GGSN) **144**. SGSN **142** facilitates exchanges of packets between RANs and GGSN **144** and also performs mobility management for UEs. GGSN **144** performs routing function and exchanges packets with external data networks. SGSN **142** interfaces with RNC **124** in UTRAN **120** and supports packet-switched services for the UEs communicating with the UTRAN.

[0029] Evolved Packet Core network **150** includes an Inter Access System Anchor (IASA) **152**, which may also be referred to as an Inter-AS Anchor or some other terminology. AGW **134** may perform some functions for E-UTRAN **130** and some functions for Evolved Packet Core network **150** and is shown as part of both networks in FIG. **1**. Inter-AS Anchor **152** interfaces with AGW **134** and also with SGSN **142** in GPRS core network **140**. Inter-AS Anchor **152** provides interoperability between E-UTRAN **130** and UTRAN **120** and GPRS core network **140**. Inter-AS Anchor **152** may communicate with SGSN **142** via a Gn interface, which is a legacy interface between SGSNs and GGSNs within a GPRS core network. The use of the Gn interface allows SGSN **142** to communicate with Inter-AS Anchor **152** in the same manner as with another SGSN, which minimizes impact to legacy networks **120** and **140** to interoperate with new networks **130** and **150**.

[0030] The network entities in UTRAN **120** and GPRS core network **140** are described in 3GPP TS 23.002, entitled "Network architecture," March 2006. The network entities in E-UTRAN **130** and Evolved Packet Core network **150** are described in 3GPP TR 25.912, entitled "Feasibility Study for Evolved UTRA and UTRAN," June 2006. These documents are publicly available.

[0031] A UE **110** may be capable of communicating with UTRAN **120** and E-UTRAN **130**. UE **110** may also be referred to as a mobile station, an access terminal, or some other terminology. UE **110** may be a cellular phone, a personal digital assistant (PDA), a subscriber unit, a wireless modem, a wireless device, a terminal, and so on.

[0032] UE **110** may communicate with UTRAN **120** or E-UTRAN **130** via a control plane and a user plane. A control plane is a mechanism for carrying signaling for higher-layer applications and may be implemented with network-specific protocols and signaling messages. A user plane is a mechanism for carrying data for higher-layer applications and employs a user-plane bearer, which is typically implemented with protocols such as User Datagram Protocol (UDP), Transmission Control Protocol (TCP), and Internet Protocol (IP). UE **110** utilizes different protocols for the control plane and user plane.

[0033] FIG. **2**A shows exemplary protocol stacks **220** and **230** at UE **110** for communication with UTRAN **120** and E-UTRAN **130**, respectively, on the user plane. Protocol stacks **220** and **230** include a network layer, a link layer, and a physical layer. For protocol stack **220**, the network layer includes IP. The link layer includes Packet Data Convergence Protocol (PDCP), Radio Link Control (RLC), and Medium Access Control (MAC). The physical layer is W-CDMA air-interface (PHY). For protocol stack **230**, the network layer includes IP. The link layer includes PDCP, Evolved RLC (E-RLC), and Evolved MAC (E-MAC). The physical layer is an evolved air-interface (E-PHY). UE **110** exchanges IP packets with SGSN **142** or AGW **134** via IP and PDCP. UE **110** communicates via RLC, MAC, and PHY with a Node B in UTRAN **120** to exchange the IP packets. UE **110** communicates via E-RLC, E-MAC, and E-PHY with an E-Node B in E-UTRAN **130** to exchange the IP packets. UE **110** uses protocol stack **220** when communicating with UTRAN **120** and uses protocol stack **230** when communicating with E-UTRAN **130**.

[0034] FIG. **2**B shows exemplary protocol stacks **222** and **232** at UE **110** for communication with UTRAN **120** and E-UTRAN **130**, respectively, on the control plane. For protocol stack **222**, the network layer includes Non Access

Stratum (NAS). The link layer includes Radio Resource Control (RRC), RLC, and MAC. The physical layer is PHY. For protocol stack **232**, the network layer includes NAS. The link layer may include PDCP, Evolved RRC (E-RRC), E-RLC, and E-MAC (as shown in FIG. **2**B) or may include E-RRC, E-RLC, and E-MAC (not shown in FIG. **2**B). The physical layer is E-PHY. UE **110** exchanges signaling with RRC **124** via NAS. UE **110** communicates via RLC, MAC, and PHY with a Node B in UTRAN **120** to exchange the signaling. UE **110** may exchange signaling with AGW **134** via NAS and possibly PDCP. UE **110** communicates via E-RLC, E-MAC, and E-PHY with an E-Node B in E-UTRAN **130** to exchange the signaling. UE **110** uses protocol stack **222** when communicating with UTRAN **120** and uses protocol stack **232** when communicating with E-UTRAN **130**.

[**0035**] The protocols for UTRAN **120** are described in a book from Harri Holma et al., entitled "W-CDMA for UMTS," Section 7, 2001. The protocols for E-UTRAN are described in the aforementioned 3GPP TR 25.912.

[**0036**] FIG. **3**A shows communication between UE **110** and E-UTRAN **130**. UE **110** communicates with E-Node B **132***c* via E-RLC, E-MAC, and E-PHY. UE **110** exchanges data with AGW **134** via IP and PDCP and further exchanges signaling with AGW **134** via NAS and PDCP. E-Node B **132** communicates with AGW **134** via an S1 interface. AGW **134** may route data for UE **110** to other devices located outside of E-UTRAN **130**.

[**0037**] FIG. **3**B shows UE **110** moving out of the coverage of E-UTRAN **130**. While in communication with E-Node B **132***a* in E-UTRAN **130**, UE **110** may periodically search for signals from nearby Node Bs and E-Node Bs in order to detect for any Node Bs and E-Node Bs that are better than the current serving E-Node B **132***a*. UE **110** may send measurement reports to AGW **134**. In this example, UE **110** detects the signal from Node B **122***c* to be stronger than the signal from E-Node B **132***a* by a sufficient amount to merit handover from E-Node B **132***a* to Node B **122***c*.

[**0038**] FIG. **3**C shows inter-system handover of UE **110** from E-UTRAN **130** to UTRAN **120**. The inter-system handover may be triggered based on received signal strength measurements made by UE **110** for Node Bs in UTRAN **120** and E-Node Bs in E-UTRAN **130**. The inter-system handover may be performed as described below.

[**0039**] FIG. **3**D shows UE **110** communicating with UTRAN **120** after completing the inter-system handover. User data is exchanged between UE **110** and SGSN **142**, which forwards the data to via Inter-AS Anchor **152** acting as the GGSN.

[**0040**] In an embodiment, an inter-SGSN Serving Radio Network Subsystem (SRNS) relocation procedure is performed for the inter-system handover of UE **110** from E-UTRAN **130** to UTRAN **120**. For this procedure, Inter-AS Anchor **152** facilitates message exchanges between SGSN **142** and AGW **134** in order to perform the handover. Inter-AS Anchor **152** communicates with SGSN **142** via the Gn interface and emulates (or appears as) another SGSN to SGSN **142**. This emulation allows SGSN **142** to treat the inter-system handover as an inter-SGSN handover, which is handover of a UE from one SGSN to another SGSN in the UTRAN. SGSN **142** may then support inter-system handover using the same messages and internal procedures used for inter-SGSN handover. This minimizes the impact to SGSN **142** and other network entities in UTRAN **120** to support inter-system handover.

[**0041**] FIG. **4** shows an embodiment of an inter-SGSN SRNS relocation procedure **400** for handover of UE **110** from E-UTRAN **130** to UTRAN **120**. In procedure **400**, AGW **134** is considered as a source RNC, Inter-AS Anchor **152** behaves as a source SGSN, RNC **142** is a target RNC, and SGSN **142** is a target SGSN of the handover.

[**0042**] Initially, AGW **134** makes a decision to perform inter-system handover of UE **110** based on measurement reports collected from the UE (step 1). AGW **134** sends a handover request message to Inter-AS Anchor **152** (step 2), which forwards the request in a Forward Relocation Request message to SGSN **142** (step 3). The Forward Relocation Request message contains the ID of target RNC **124** and identifies Inter-AS Anchor **152** as the source SGSN and the GGSN for the handover. SGSN **142** then sends a Relocation Request message to RNC **124** (step 4). RNC **124** and SGSN **142** thereafter exchange messages to configure the physical layer and establish Radio Access Bearers (RABs) for UE **110**. RNC **124** establishes and configures RLC and PDCP for UE **110**. After completing the PHY configuration and RAB establishment, RNC **124** sends a Relocation Request Acknowledge message to SGSN **142** (also step 4).

[**0043**] SGSN **142** then sends a Forward Relocation Response message to Inter-AS Anchor **152**, which forwards the information in the message to AGW **134** (step 5). The Forward Relocation Response message indicates that resources for UE **110** have been assigned between SGSN **142** and RNC **124** in the legacy system, that RNC **124** is ready to receive data, and that SGSN **142** is ready for relocation of SRNS. AGW **134** then sends a message to UE **110** to handover from E-UTRAN **130** to UTRAN **120** (step 6).

[**0044**] AGW **134** continues the execution of the SRNS relocation by sending radio context to Inter-AS Anchor **152**, which forwards the information in a Forward SRNS Context message to SGSN **142**, which further forwards the information to RNC **124** (step 7). The radio context may include pertinent information used for radio communication, e.g., protocol state, quality of service (QoS) parameters, and so on. SGSN **142** returns a Forward SRNS Context Acknowledge message to Inter-AS Anchor **152**, which forwards the acknowledgement to AGW **134** (also step 7). Lossless SRNS relocation may be performed, and AGW **134** may continue to forward packets for UE **110** to RNC **124** to avoid losing packets during SRNS switching (not shown in FIG. **4**).

[**0045**] Upon receiving the handover message in step 6, UE **110** performs reconfiguration for the handover, e.g., brings down the protocol stacks for E-UTRAN **130** and brings up the protocol stacks for UTRAN **120**. After UE **110** has reconfigured itself, the UE sends a Reconfiguration Complete message to RNC **124** (step 8). Upon receiving this message, RNC **124** sends a Relocation Complete message to SGSN **142** (step 9). SGSN **142** sends a Forward Relocation Complete message to Inter-AS Anchor **152**, which forwards the information to AGW **134** (step 10). This message informs AGW **134** of the completion of the SRNS relocation procedure. AGW **134** returns an acknowledgement to Inter-AS Anchor **152**, which forwards the acknowledgement in a

Forward Relocation Complete Acknowledgement message to SGSN **142** (also step 10). AGW **134** then releases the radio resources for UE **110**.

[**0046**] After receiving the Relocation Complete message in step 9, SGSN **142** sends an Update PDP Context Request message to Inter-AS Anchor **152**, which forwards the request to AGW **134** (step 11). UE **110** may have established a call with E-UTRAN **130** by activating a Packet Data Protocol (PDP) context, which contains various parameters such as routing information for IP packets (e.g., the IP addresses of UE **110** and Inter-AS Anchor **152**), QoS profiles, and so on. AGW **134** stores the PDP context for UE **110** during the call and, in response to the request from SGSN **142**, forwards the PDP context to Inter-AS Anchor **152**, which forwards the information in an Update PDP Context Response message to SGSN **142** (also step 11). Inter-AS Anchor **152** updates its PDP context fields for UE **110** so that future packets for the UE are forwarded to SGSN **142** instead of AGW **134**. Step 11 switches the user plane from AGW **134** to RNC **124**. In the first phase of the handover procedure and until the PDP context is updated in step 11, SGSN **142** communicates with Inter-AS Anchor **152**, which acts as a source SGSN to SGSN **142**. After the PDP context is updated, Inter-AS Anchor **152** acts as a GGSN to SGSN **142**.

[**0047**] After completing SRNS relocation, UE **110** performs a routing area update procedure that involves Inter-AS Anchor **152** and SGSN **142** (step 12). Different radio access technologies may have different registration areas. UE **110** registers with UTRAN **120** via SGSN **142** so that the UTRAN can locate the UE later, if necessary.

[**0048**] Inter-AS Anchor **152** exchanges messages with AGW **134** and SGSN **142** for the inter-system handover. Inter-AS Anchor **152** communicates with SGSN **142** via the Gn interface and using messages described in 3GPP TS 29.060, entitled "GPRS Tunnelling Protocol (GTP) across Gn and Gp interface," June 2006. Inter-AS Anchor **152** may communicate with AGW **134** via a suitable interface, e.g., an S5a interface being defined by 3GPP. The messages exchanged between Inter-AS Anchor **152** and AGW **134** are currently not defined by 3GPP and are not shown in FIG. **4**. In general, the messages exchanged between Inter-AS Anchor **152** and AGW **134** may be any suitable messages and may be sent directly to SGSN **142** or may be encapsulated in some other messages prior to forwarding to SGSN **142**. The handover message in step **6** may be defined to include pertinent information for the inter-system handover.

[**0049**] With procedure **400**, UE **110** operates with new protocol stacks **230** and **232** prior to step 8 and with legacy protocol stacks **220** and **222** for step 8 and beyond. UE **110** may operate only one set of protocol stacks at any given moment and does not need to support both new and legacy protocol stacks at the same time, which may simplify UE operation.

[**0050**] FIG. **5** shows the interface between SGSN **142** and Inter-AS Anchor **152**. Inter-AS Anchor **152** emulates a virtual SGSN and a virtual GGSN and communicates with SGSN **142** via the Gn interface. Inter-AS Anchor **152** behaves as the source SGSN prior to updating the PDP context for UE **110** and behaves as a GGSN after updating the PDP context. The messages exchanged between SGSN **142** and Inter-AS Anchor **152** for procedure **400** are similar (or may be identical) to the messages exchanged between a new SGSN and an old SGSN for an inter-SGSN SRNS relocation procedure in UTRAN **120**. Hence, SGSN **142** can support inter-system handover with existing messages and procedures.

[**0051**] FIG. **4** shows an exemplary procedure **400** for inter-system handover of UE **110** from E-UTRAN **130** to UTRAN **120**. The inter-system handover may also be performed with other procedures and/or other message flows. Furthermore, the messages may be sent in various orders. In general, Inter-AS Anchor **152** may emulate any network entity that is recognized by SGSN **142**, which may then allow SGSN **142** to use an existing procedure to support inter-system handover. If Inter-AS Anchor **152** emulates an SGSN and communicates with SGSN **142** via the Gn interface, then inter-system handover complexity may be reduced for Inter-AS Anchor **152**, AGW **134** and UE **110**. The Gn interface is IP based and operates at higher layer. Hence, Inter-AS Anchor **152** and AGW **134** can terminate the messages from SGSN **142** at IP layer. Inter-AS Anchor **152** may also emulate an RNC and communicates with SGSN **142** via an Iu interface, which operates at RRC, RLC, and MAC. However, the complexity of Inter-AS Anchor **152** would increase to terminate RRC, RLC, and MAC, the complexity of AGW **134** would increase to support two data tunnels during handover, and the complexity of UE **110** would also increase to concurrently support new and legacy protocol stacks during handover.

[**0052**] The inter-system handover techniques may be used for handover from an E-UTRAN to a UTRAN, as described above. UTRANs may be more extensively deployed than E-UTRANs, particularly during early deployment phase of E-UTRANs. The techniques allow UEs to be handed over from E-UTRANs to UTRANs and continue to receive communication services upon moving outside the coverage of the E-UTRANs.

[**0053**] The inter-system handover techniques may also be used for handover from a UTRAN to an E-UTRAN. In this case, Inter-AS Anchor **152** may behave as a target SGSN and exchange messages with a source SGSN to achieve handover. The message flow in FIG. **4** may be used for handover from the UTRAN to the E-UTRAN, albeit with AGW **134** in procedure **400** being replaced with a source RNC in the UTRAN, Inter-AS Anchor **152** being replaced by the old SGSN, target RNC **124** being replaced by AGW **134**, and target SGSN **142** being replaced by Inter-AS Anchor **152**. The source RNC may send an RRC message to UE **110** step 6, and UE **110** may send another RRC message to AGW **134** in step 8.

[**0054**] The inter-system handover techniques may also be used for handover from an E-UTRAN to other RANs such as a GSM/EDGE RAN (GERAN). A message flow similar to the one shown in FIG. **4** may be used, albeit with different network entities and messages.

[**0055**] The inter-system handover techniques may allow for smooth inter-operability between E-UTRANs and UTRANs with little or no impact on the legacy system. The techniques may also reduce impact on the new system and the UEs. The techniques may also be able to perform handover with small interruption time.

[**0056**] FIG. **6** shows an embodiment of a process **600** performed by a UE for inter-system handover. The UE

initially communicates with a first RAN, e.g., using a first protocol stack (block **612**). The UE receives a message to handover from the first RAN to a second RAN (block **614**). The first RAN may be an E-UTRAN, and the second RAN may be a UTRAN. The first and second RANs may also be other RANs. The handover is achieved by messages exchanged between a first network entity (e.g., an Inter-AS Anchor) for the first RAN and a second network entity (e.g., an SGSN) for the second RAN via a Gn interface. The UE performs reconfiguration for the handover, e.g., brings down the first protocol stack for the first RAN and brings up a second protocol stack for the second RAN (block **616**). The UE may break communication with the first RAN before making communication with the second RAN. The UE communicates with the second RAN after the handover, e.g., using the second protocol stack (block **618**). The UE may exchange packets via the first and second network entities (e.g., the Inter-AS Anchor and SGSN) after the handover to the second RAN (block **620**).

[**0057**] FIG. **7** shows an embodiment of a process **700** performed by an AGW to support inter-system handover. Measurement reports are received from a UE for base stations in a first RAN and a second RAN (block **712**). The first RAN may be an E-UTRAN, and the second RAN may be a UTRAN. The first and second RANs may also be other RANs. Handover of the UE from the first RAN to the second RAN is initiated based on the measurement reports (block **714**). A message requesting handover of the UE from the first RAN to the second RAN is then sent to a first network entity (e.g., an Inter-AS Anchor) for the first RAN communicating with a second network entity (e.g., an SGSN) for the second RAN via a Gn interface (block **716**).

[**0058**] Messages are exchanged with the second network entity via the first network entity to handover the UE from the first RAN to the second RAN (block **718**). Radio context and PDP context for the UE may be forwarded to the second network entity. The radio context may be used to establish radio access bearers for the UE. The PDP context may be used to route data for the UE. A message is sent to the UE to perform handover from the first RAN to the second RAN (block **720**). A message indicating completion of relocation of the UE is received from the second network entity (block **722**). Radio resources for the UE are then released (block **724**).

[**0059**] FIG. **8** shows an embodiment of a process **800** performed by an Inter-AS Anchor to support inter-system handover. A message requesting handover of a UE from a first RAN to a second RAN is received (block **812**). The first RAN may be an E-UTRAN, and the second RAN may be a UTRAN. The first and second RANs may also be other RANs. Messages are exchanged with a target SGSN via a Gn interface to handover the UE from the first RAN to the second RAN (block **814**). The messages exchanged with the target SGSN are forwarded to an AGW for the first RAN and communicating with the UE (block **816**). The exchanged messages may be for an inter-SGSN SRNS relocation procedure that treats the handover from the first RAN to the second RAN as a handover between two SGSNs.

[**0060**] The Inter-AS Anchor may emulate a source SGSN for the messages exchanged with the target SGSN. The Inter-AS Anchor may emulate a GGSN after the handover to the second RAN and may exchange packets for the UE with the SGSN (block **818**). The Inter-AS Anchor may store PDP context for the UE and forward packets for the UE in accordance with the PDP context.

[**0061**] FIG. **9** shows a block diagram an embodiment of UE **110** and various network entities in FIG. **1**. On the uplink, UE **110** may transmit data and signaling to one or more Node Bs in UTRAN **120** and/or one or more E-Node Bs in E-UTRAN **130**. The data and signaling are processed by a processor **910** and conditioned by a transceiver **914** to generate an uplink signal, which is transmitted. At Node B **122** and/or E-Node B **132**, the uplink signals from UE **110** and other UEs are received and conditioned by transceivers **926** and **936**, respectively, and further processed by processors **920** and **930**, respectively, to recover the uplink data and signaling sent by the UEs.

[**0062**] On the downlink, Node B **122** and E-Node B **132** transmit data and signaling to the UEs within their coverage area. At Node B **122**, the data and signaling are processed by processor **920** and conditioned by transceiver **926** to generate a downlink signal, which is transmitted to the UEs. At E-Node B **132**, the data and signaling are processed by processor **930** and conditioned by transceiver **936** to generate a downlink signal, which is transmitted to the UEs. At UE **110**, the downlink signals from the Node Bs and E-Node Bs are received and conditioned by transceiver **914** and further processed by processor **910** to recover the downlink data and signaling.

[**0063**] Memories **912**, **922** and **932** store program codes and data for UE **110**, Node B **122** and E-Node B **132**, respectively. Communication (Comm) unit **924** and **934** allow Node B **122** and E-Node B **132** to communicate with RNC **124** and AGW **134**, respectively. For inter-system handover, processor **910** at UE **110** may perform process **600** in FIG. **6** and the processing for UE **110** in FIG. **4**.

[**0064**] RNC **124** includes a processor **940**, a memory **942**, and a Comm unit **944**. AGW **134** includes a processor **950**, a memory **952**, and a Comm unit **954**. SGSN **142** includes a processor **960**, a memory **962**, and a Comm unit **964**. Inter-AS Anchor **152** includes a processor **970**, a memory **972**, and a Comm unit **974**. For each network entity, the processor performs pertinent processing for that network entity, the memory stores program codes and data, and the Comm unit supports communication with other network entities via appropriate interfaces. Processor **950** at AGW **134** may perform process **700** in FIG. **7** and the processing for AGW **134** in FIG. **4** for inter-system handover. Processor **970** may perform process **800** in FIG. **8** and the processing for Inter-AS Anchor **152** in FIG. **4** for inter-system handover. Processor **960** may perform the processing for SGSN **142** in FIG. **4** for inter-system handover. Comm unit **974** may communicate with SGSN **142** via a Gn interface and may communicate with AGW **134** and external network via other interfaces.

[**0065**] In general, each entity may include any number of processors, memories, communication units, transceivers, controllers, and so on.

[**0066**] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced

throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0067] Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[0068] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0069] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[0070] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

1. An apparatus comprising:

at least one processor to communicate with a first radio access network (RAN), to receive a message to handover from the first RAN to a second RAN, the handover being performed by messages exchanged between a first network entity for the first RAN and a second network entity for the second RAN via a Gn interface, and to communicate with the second RAN after the handover; and

a memory coupled to the at least one processor.

2. The apparatus of claim 1, wherein the at least one processor communicates with the first RAN using a first protocol stack and communicates with the second RAN using a second protocol stack.

3. The apparatus of claim 1, wherein the at least one processor breaks communication with the first RAN and then makes communication with the second RAN.

4. The apparatus of claim 1, wherein the first network entity is an Inter Access System Anchor and the second network entity is a Serving GPRS Support Node (SGSN).

5. The apparatus of claim 4, wherein the at least one processor exchanges packets via the Inter-AS Anchor and the SGSN after the handover to the second RAN.

6. The apparatus of claim 1, wherein the second RAN is a Universal Terrestrial Radio Access Network (UTRAN) and the first RAN is an Evolved UTRAN (E-UTRAN).

7. A method comprising:

communicating with a first radio access network (RAN);

receiving a message to handover from the first RAN to a second RAN, the handover being performed by messages exchanged between a first network entity for the first RAN and a second network entity for the second RAN via a Gn interface; and

communicating with the second RAN after the handover.

8. The method of claim 7, wherein the communicating with the first RAN comprises communicating with the first RAN using a first protocol stack, and wherein the communicating with the second RAN comprises communicating with the second RAN using a second protocol stack.

9. The method of claim 7, further comprising:

exchanging packets via the first and second network entities after the handover to the second RAN.

10. An apparatus comprising:

means for communicating with a first radio access network (RAN);

means for receiving a message to handover from the first RAN to a second RAN, the handover being performed by messages exchanged between a first network entity for the first RAN and a second network entity for the second RAN via a Gn interface; and

means for communicating with the second RAN after the handover.

11. The apparatus of claim 10, wherein the means for communicating with the first RAN comprises means for communicating with the first RAN using a first protocol stack, and wherein the means for communicating with the second RAN comprises means for communicating with the second RAN using a second protocol stack.

12. The apparatus of claim 10, further comprising:

means for exchanging packets via the first and second network entities after the handover to the second RAN.

13. An apparatus comprising:

at least one processor to send a message requesting handover of a user equipment (UE) from a first radio access network (RAN) to a second RAN, the message being sent to a first network entity for the first RAN communicating with a second network entity for the second RAN via a Gn interface, to exchange messages with the second network entity via the first network entity to handover the UE from the first RAN to the second RAN, and to send a message to the UE to perform handover from the first RAN to the second RAN; and

a memory coupled to the at least one processor.

14. The apparatus of claim 13, wherein the at least one processor receives measurement reports from the UE for base stations in the first RAN and the second RAN, and initiates handover of the UE from the first RAN to the second RAN based on the measurement reports.

15. The apparatus of claim 13, wherein the first network entity is an Inter-AS Anchor and the second network entity is a Serving GPRS Support Node (SGSN).

16. The apparatus of claim 13, wherein the at least one processor receives from the second network entity a message indicating completion of relocation of the UE, and releases radio resources for the UE.

17. The apparatus of claim 13, wherein the at least one processor forwards radio context for the UE to the second network entity via the first network entity.

18. The apparatus of claim 13, wherein the at least one processor forwards Packet Data Protocol (PDP) context for the UE to the second network entity via the first network entity.

19. A method comprising:

sending a message requesting handover of a user equipment (UE) from a first radio access network (RAN) to a second RAN, the message being sent to a first network entity for the first RAN communicating with a second network entity for the second RAN via a Gn interface;

exchanging messages with the second network entity via the first network entity to handover the UE from the first RAN to the second RAN; and

sending a message to the UE to perform handover from the first RAN to the second RAN.

20. The method of claim 19, further comprising:

forwarding radio context for the UE to the second network entity via the first network entity.

21. The method of claim 19, further comprising:

forwarding Packet Data Protocol (PDP) context for the UE to the second network entity via the first network entity.

22. An apparatus comprising:

means for sending a message requesting handover of a user equipment (UE) from a first radio access network (RAN) to a second RAN, the message being sent to a first network entity for the first RAN communicating with a second network entity for the second RAN via a Gn interface;

means for exchanging messages with the second network entity via the first network entity to handover the UE from the first RAN to the second RAN; and

means for sending a message to the UE to perform handover from the first RAN to the second RAN.

23. The apparatus of claim 22, further comprising:

means for forwarding radio context for the UE to the second network entity via the first network entity.

24. The apparatus of claim 22, further comprising:

means for forwarding Packet Data Protocol (PDP) context for the UE to the second network entity via the first network entity.

25. An apparatus comprising:

at least one processor to receive a message requesting handover of a user equipment (UE) from a first radio access network (RAN) to a second RAN, and to exchange messages with a target Serving GPRS Support Node (SGSN) via a Gn interface to handover the UE from the first RAN to the second RAN; and

a memory coupled to the at least one processor.

26. The apparatus of claim 25, wherein the at least one processor emulates a source SGSN for the exchange of messages with the target SGSN.

27. The apparatus of claim 25, wherein the at least one processor participates in an inter-SGSN Serving Radio Network Subsystem (SRNS) relocation procedure that treats the handover from the first RAN to the second RAN as a handover between two SGSNs.

28. The apparatus of claim 25, wherein the at least one processor forwards the messages exchanged with the target SGSN to an Access Gateway (AGW) for the first RAN and communicating with the UE.

29. The apparatus of claim 25, wherein the at least one processor emulates a Gateway GPRS Support Node (GGSN) after the handover to the second RAN, and exchanges packets for the UE with the target SGSN.

30. The apparatus of claim 25, wherein the memory stores Packet Data Protocol (PDP) context for the UE, and wherein the at least one processor forwards packets for the UE in accordance with the PDP context.

31. The apparatus of claim 25, wherein the second RAN is a Universal Terrestrial Radio Access Network (UTRAN) and the first RAN is an Evolved UTRAN (E-UTRAN).

32. The apparatus of claim 25, wherein the first RAN is a Universal Terrestrial Radio Access Network (UTRAN) and the second RAN is an Evolved UTRAN (E-UTRAN).

33. A method comprising:

receiving a message requesting handover of a user equipment (UE) from a first radio access network (RAN) to a second RAN; and

exchanging messages with a target Serving GPRS Support Node (SGSN) via a Gn interface to handover the UE from the first RAN to the second RAN.

34. The method of claim 33, further comprising:

emulating a source SGSN for the exchange of messages with the target SGSN.

35. The method of claim 33, further comprising:

emulating a Gateway GPRS Support Node (GGSN) after the handover to the second RAN; and

exchanging packets for the UE with the target SGSN.

36. An apparatus comprising:

means for receiving a message requesting handover of a user equipment (UE) from a first radio access network (RAN) to a second RAN; and

means for exchanging messages with a target Serving GPRS Support Node (SGSN) via a Gn interface to handover the UE from the first RAN to the second RAN.

37. The apparatus of claim 36, further comprising:

means for emulating a source SGSN for the exchange of messages with the target SGSN.

38. The apparatus of claim 36, further comprising:

means for emulating a Gateway GPRS Support Node (GGSN) after the handover to the second RAN; and

means for exchanging packets for the UE with the target SGSN.

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