

KEEPING PACKET SWITCHED SESSION IN LTE WHILE CIRCUIT SWITCHED REGISTERED IN WCDMA

RELATED APPLICATIONS

- 5 This application claims the priority of and is related to the following United States Provisional Patent Applications, all of which are incorporated herein by reference in their entireties:

United States Provisional Patent Application 61/287,575 to Magnus Olsson et al., entitled "GSM and LTE Multiplexing Systems", filed on December 17, 2009.

- 10 United States Provisional Patent Application 61/287,623 to Magnus Olsson et al., entitled "Measurement Report Relay in Access Division Multiplexing Systems", filed on December 17, 2009.

United States Provisional Patent Application 61/287,438 to Magnus Olsson et al., entitled "WCDMA and LTE Multiplexing", filed on December 17, 2009.

- 15 United States Provisional Patent Application 61/287,627 to Magnus Olsson et al., entitled "Telecommunications Multiplexing", filed on December 17, 2009.

United States Provisional Patent Application 61/287,630 to Magnus Olsson et al., entitled "Access Division Multiplexing – Call Setup Performance Improvement", filed on December 17, 2009.

- 20 United States Provisional Patent Application 61/287,954 to Magnus Olsson et al., entitled "Scheduled Optimized for GSM and LTD Multiplexing", filed on December 17, 2009.

- 25 This application is related to the following United States Patent Applications, all of which are filed on same date herewith and incorporated herein by reference in their entireties:

United States Patent Application 12/943,801 to Magnus Olsson et al., entitled "GSM and LTE Multiplexing".

United States Patent Application 12/943,770 to Magnus Olsson et al., entitled “Link Report Relay in Access Division Multiplexing Systems”.

United States Patent Application 12/943,685 to Magnus Olsson et al., entitled
5 “Maintaining Packet Switched Session in LTE When Establishing GSM Circuit Switched Call”.

United States Patent Application 12/943,736 to Magnus Olsson et al., entitled “Call Setup For Access Division Multiplexing”.

United States Patent Application 12/943,504 to Magnus Olsson et al., entitled “Scheduling For Access Division Multiplexing”.

10 United States Patent Application 12/943,612 to Magnus Olsson et al., entitled “Keeping Packet Switched Session in LTE While Circuit Switched Registered in WCDMA”.

TECHNICAL FIELD

This technology pertains to wireless communications networks, and particularly to access division multiplexing (ADM).

15 BACKGROUND

In a typical cellular radio system, wireless terminals (also known as mobile stations and/or user equipment units (UEs)) communicate via a radio access network (RAN) to one or more core networks. The radio access network (RAN) covers a geographical area which is divided into cell areas, with each cell area being served by a
20 base station, e.g., a radio base station (RBS), which in some networks may also be called, for example, a “NodeB” (UMTS) or “eNodeB” (LTE). A cell is a geographical area where radio coverage is provided by the radio base station equipment at a base station site. Each cell is identified by an identity within the local radio area, which is broadcast in the cell. The base stations communicate over the air interface operating on
25 radio frequencies with the user equipment units (UE) within range of the base stations.

In some versions of the radio access network, several base stations are typically connected (e.g., by landlines or microwave) to a controller node (such as a radio network controller (RNC) or a base station controller (BSC)) which supervises and

coordinates various activities of the plural base stations connected thereto. The radio network controllers are typically connected to one or more core networks.

The Universal Mobile Telecommunications System (UMTS) is a third generation mobile communication system, which evolved from the second generation (2G) Global System for Mobile Communications (GSM). UTRAN is essentially a radio access network using wideband code division multiple access for user equipment units (UEs). In a forum known as the Third Generation Partnership Project (3GPP), telecommunications suppliers propose and agree upon standards for third generation networks and UTRAN specifically, and investigate enhanced data rate and radio capacity. Specifications for the Evolved Universal Terrestrial Radio Access Network (E-UTRAN) are ongoing within the 3rd Generation Partnership Project (3GPP). The Evolved Universal Terrestrial Radio Access Network (E-UTRAN) comprises the Long Term Evolution (LTE) and System Architecture Evolution (SAE). Long Term Evolution (LTE) is a variant of a 3GPP radio access technology wherein the radio base station nodes are connected to a core network (via Serving Gateways, or SGWs) rather than to radio network controller (RNC) nodes. In general, in LTE the functions of a radio network controller (RNC) node are distributed between the radio base stations nodes (eNodeB's in LTE) and SGWs. As such, the radio access network (RAN) of an LTE system has an essentially "flat" architecture comprising radio base station nodes without reporting to radio network controller (RNC) nodes.

Cellular Circuit-Switched (CS) telephony was introduced in the first generation of mobile networks. Since then CS telephony has become the largest service in the world with approximately 4 billion subscriptions sold. Even today, the main part of the mobile operator's revenue comes from the CS telephony service (including Short Message Services (SMS)), and the 2G GSM networks still dominate the world in terms of subscriptions. 3G subscriptions are increasing in volume, but that increase is less in part because of users with handheld mobile terminals migrating from 2G to 3G and more as a result of mobile broadband implemented via dongles or embedded chipsets in laptops.

The long-term evolution (LTE) project within 3GPP aims to further improve the 3G standard to, among other things, provide even better mobile broadband to the end-users (higher throughput, lower round-trip-times, etc.).

A common view in the telecommunication industry is that the future networks will be all-IP networks. Based on this assumption, the CS domain in was removed in the LTE work. As a result, the telephony service cannot be used by a 3GPP Release 8 compliant LTE terminal, unless one of the following four things is done:

- 5 (1) Implement circuit switched (CS) fallback (CSFB), so that an LTE terminal falls back to 2G GSM when telephony service is used.
- (2) Implement 3GPP IP Multimedia Subsystem (IMS)/ Multimedia Telephony (MMTel), which is a simulated CS telephony service provided over IP and IMS that inter-works with the Public Switched Telephone Network (PSTN)/ Public Land Mobile
10 Network (PLMN).
- (3) Implement a tunneling solution with Unlicensed Mobile Access (UMA)/ Generic Access Network (GAN) over LTE where the CS service is encapsulated into an IP tunnel.
- (4) Implement a proprietary Voice over IP (VoIP) solution with PSTN/PLMN
15 interworking.

All of these four possibilities have drawbacks. In deployed GSM networks that do not have Dual Transfer Mode (DTM) capabilities; CS and Packet Switched (PS) services cannot be used in parallel. Hence, all PS services running prior to a call to or from a terminal using Circuit Switched Fallback (CSFB) are put on hold or are
20 terminated. If the GSM network has DTM, the PS performance will be greatly reduced (from 10's of Mbps to 10's to 100's of kbps). One drawback with the CS fallback approach is that when calling or being called and the terminal is falling back to GSM and the CS service from LTE. Circuit Switched Fallback (CSFB) also prolongs call set-up time.

25 The IMS/MMTel approach uses a completely new core/service layer that is IMS based. This provides new possibilities to enhance the service but also comes with the drawback of a financial hurdle for the operator to overcome. A new core network drives capital expenditures (CAPEX), and integration of that core network drives an initial operating expenditures (OPEX) increase. Further, the IMS/MMTel approach

needs features implemented in the terminals and the legacy CS network in order to handle voice handover to/from the 2G/3G CS telephony service.

Using UMA/GAN over LTE is not a standardized solution so a drawback is that it is a proprietary solution which may make terminal availability a problem. It also
5 adds additional functions to the core/service layer in both the network and terminal, e.g., a GAN controller in the network and GAN protocols in the UE terminal.

The proprietary VoIP approach, if operator controlled, comes with the same drawbacks as for the IMS/MMTel (new core/service layer) approach along with the difficulties associated with it being proprietary and handover to 2G/3G CS may not be
10 supported.

There is yet a further solution for using a legacy CS telephony service with a wireless terminal such as a 3GPP release 8-compliant LTE terminal. In that further solution, also known as a type of Access Division Multiplexing (ADM), transmissions of GSM CS voice are interleaved in between LTE transmissions. See, e.g.,
15 PCT/SE2007/000358, which is incorporated herein by reference. In one example implementation of such an ADM solution a wireless terminal simultaneously communicates with two TDMA-based radio systems, e.g., the wireless terminal can maintain communications paths to both systems by means of alternating in time its communication between the two systems. The toggling between the two systems is on
20 a time scale small enough to effectively yield a simultaneous communication between the two systems.

The ADM solution attempts to achieve a good PS connection in parallel with the telephony service when in LTE coverage but still reusing the legacy CS core and deployed GSM network for the telephony service to reduce costs but still maintain
25 good coverage for the telephony service.

The ADM solution may be implemented in several ways. A first example implementation, illustrated in Fig. 1A, is a fully UE centric solution where no coordination is needed between the GSM CS core and a LTE PS core. A second example implementation, illustrated by Fig. 1B, is a network assisted solution which
30 can either be based on circuit switched fallback (CSFB), or a solution that only reuses paging over LTE.

From a radio perspective, the ADM solution can be realized in any of three different ways: As a first example radio realized embodiment illustrated in Fig. 2A, the LTE transmissions could be multiplexed with the GSM transmissions on a GSM TDMA frame level. In Fig. 2A, frames for GSM transmissions and frames of LTE transmissions have different darkness shading. This first example solution requires that the GSM circuit switched (CS) telephony service only use the half rate codec. When GSM is running at half rate, then every second GSM TDMA frame is not used by the user.

As a second example radio-realized embodiment illustrated in Fig. 2B, the LTE transmissions could be multiplexed with the GSM transmissions on GSM burst level. GSM transmits speech using bursts, each with a duration of 0.577 ms. In speech operation, after having sent one burst, the Rx/Tx part sleeps for 7×0.577 ms until it wakes up again and do a new Rx/Tx process. In this second example this time gap could be used for LTE transmissions.

As a third example radio-realized embodiment illustrated in Fig. 2C, any of above can be used for transmission but by using dual receiver for simultaneous reception of GSM and LTE in the downlink for simplified operation.

The architecture and principles of the circuit switched fallback (CSFB) are defined in, e.g., 3GPP TS 23.272, Circuit Switched Fallback in Evolved Packet System, Stage 2 (Release 8), which is abbreviated herein as "23.272" and which is incorporated herein by reference in its entirety.

Long Term Evolution (LTE) access typically provides improved packet switched (PS) session performance as compared to WCDMA and GSM/GPRS. However, LTE is mainly available to PS-only devices, as shown in Fig. 3 in which the dashed line represents the user plane of the PS session.

The ADM solution such as that of PCT/SE2007/000358 targets, e.g., co-existence between Long Term Evolution (LTE) and Global System for Mobile communication (GSM). Fig. 4 shows what would occur if a circuit switched (CS) voice-centric device could register for CS services in GSM while keeping the PS session in LTE. In Fig. 4 the dashed line represents the user plane of the PS session and the solid line represents the CS registration (control plane).

However, in the case of co-existence with WCDMA, the ADM approach such as that of PCT/SE2007/000358 assumes that CS voice centric devices need to camp on WCDMA as shown in Fig. 5. In Fig. 5 the dashed line represents the user plane of the PS session and the green solid line represents the CS registration (control plane). This means that CS voice centric devices cannot benefit from the improved performance of the LTE access. (Typically, LTE provides increased bandwidth and reduced latency (round-trip delay)).

Moving to WCDMA includes additional steps as shown in Fig. 6 and Fig. 7. In Fig. 6 (Cell Re-selection to WCDMA where combined LA/RA Update is not used) the combined Location Area/ Registration Area (LA/RA) Update is not used; in Fig. 7 (Cell Re-selection to WCDMA where combined LA/RA Update is used) the combined LA/RA Update is used.

SUMMARY

In one of its aspects the technology disclosed herein concerns a wireless terminal configured, when already having a registration and/or session for a packet switched (PS) service with a Long Term Evolution (LTE) core network, to make a registration for a circuit switched (CS) service over a Wide Band Code Division Multiplexing (WCDMA) air interface with a circuit switched (CS) core network. The wireless terminal is configured, in conjunction with the registration for the circuit switched (CS) service, to maintain the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network. In an example embodiment, the wireless terminal is configured to refrain from making a registration for a packet switched (PS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with a packet switched (PS) core network in conjunction with making the registration for the circuit switched (CS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core network. For example, in an example implementation, the wireless terminal is configured, in conjunction with the registration for the circuit switched (CS) service, to refrain from performing a routing area update towards the Wide Band Code Division Multiplexing (WCDMA) packet switched (PS) core network.

In an example implementation, the wireless terminal is configured to maintain the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network until such time as a circuit switched (CS) connection is

established, but to perform a routing area update towards the Wide Band Code Division Multiplexing (WCDMA) packet switched (PS) core network when a circuit switched (CS) connection is established.

5 In an example embodiment the wireless terminal comprises a communication interface and a registration controller. The communication interface is arranged to communicate, over the air interface, a message configured to make the registration for the circuit switched (CS) service. The registration controller is configured to make the registration for the circuit switched (CS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core network
10 while maintaining the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network.

In another of its aspects the technology disclosed herein concerns a method of operating a wireless terminal. The method comprises the wireless terminal, when already having a registration and/or session for a packet switched (PS) service with a
15 Long Term Evolution (LTE) core network, making a registration for a circuit switched (CS) service over a Wide Band Code Division Multiplexing (WCDMA) air interface with a circuit switched (CS) core network. The method further comprises the wireless terminal maintaining the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network in conjunction with the registration
20 for the circuit switched (CS) service. In an example mode and embodiment the wireless terminal refrains from making a registration for a packet switched (PS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with a packet switched (PS) core network in conjunction with making the registration for the circuit switched (CS) service over the Wide Band Code Division Multiplexing (WCDMA) air
25 interface with the circuit switched (CS) core network. For example, in an example implementation the wireless terminal method comprises the wireless terminal refraining from performing a routing area update towards the Wide Band Code Division Multiplexing (WCDMA) packet switched (PS) core network in conjunction with the registration for the circuit switched (CS) service.

30 In an example implementation the wireless terminal method further comprises the wireless terminal refraining from performing a routing area update towards the Wide Band Code Division Multiplexing (WCDMA) packet switched (PS) core network in conjunction with the registration for the circuit switched (CS) service. In an example

implementation the wireless terminal method further comprises the wireless terminal performing a routing area update towards the Wide Band Code Division Multiplexing (WCDMA) packet switched (PS) core network when a circuit switched (CS) connection is established.

5 In another of its aspects the technology disclosed herein concerns a communications network comprising a Long Term Evolution (LTE) core network; a circuit switched (CS) core network such as a WCDMA network; and a wireless terminal. The wireless terminal is configured, when already having a registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE)
10 core network, to make a registration for a circuit switched (CS) service over a Wide Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core network. The wireless terminal is further configured to maintain the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network in conjunction with the registration for the circuit
15 switched (CS) service.

In another of its aspects the technology disclosed herein concerns a method of operating such a communications network.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will
20 be apparent from the following more particular description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Fig. 1A is a diagrammatic view illustrating a fully UE centric solution ADM
25 solution where no coordination is needed between a GSM CS core and a LTE PS core.

Fig. 1B is a diagrammatic view illustrating a network assisted ADM solution which can either be based on CS fallback (CSFB), or a solution that only reuses paging over LTE.

Fig. 2A, Fig. 2B, and Fig. 2C are differing example radio-realized embodiments
30 illustrated of ADM solutions, with Fig. 2A showing an embodiment comprising a

single receiver/transmitter with GSM at half rate and multiplexing on a TDMA frame level; Fig. 2B showing an embodiment comprising a single receiver/transmitter with multiplexing on a burst period level; and Fig. 2C showing an embodiment comprising a dual receiver/single transmitter.

5 Fig. 3 is a diagrammatic view showing a packet switched-only device in a Long Term Evolution (LTE) packet switched session.

Fig. 4 is a diagrammatic view showing a voice centric device being registered in GSM with a Long Term Evolution (LTE) packet switched session.

10 Fig. 5 is a diagrammatic view showing movement of a packet switched session to WCDMA when being circuit switch registered in WCDMA.

Fig. 6 is a diagrammatic view depicting basic acts or steps involved in cell re-selection to WCDMA without use of a combined location area and routing area update.

Fig. 7 is a diagrammatic view depicting basic acts or steps involved in cell re-selection to WCDMA with use of a combined location area and routing area update.

15 Fig. 8 is a diagrammatic view depicting a wireless terminal participating in access division multiplexing (ADM) with a LTE network and a WCDMA network.

Fig. 9 shows basic, representative acts or steps comprising a method of operating wireless terminal according to an example mode and embodiment.

20 Fig. 10 shows basic, representative acts or steps comprising a method of operating wireless terminal according to a specific implementation of the example mode and embodiment of Fig. 9.

Fig. 11 is a schematic view of an example embodiment of a wireless terminal.

Fig. 12 is a more detailed schematic view of an example embodiment of a wireless terminal showing a platform implementation

Fig. 13 is a diagrammatic view depicting basic acts or steps involved in cell re-selection to WCDMA without use of a combined location area and routing area update and while maintaining a packet switched registration and/or packet switched session in LTE.

5 Fig. 14 is a diagrammatic view depicting basic acts or steps involved in cell re-selection to WCDMA with use of a combined location area and routing area update and while maintaining registration and/or session for a packet switched service with the Long Term Evolution (LTE) core network.

10 Fig. 15 is a diagrammatic view showing maintenance of a packet switched (PS) registration and/or session in Long Term Evolution (LTE) while being CS registered in WCDMA.

DETAILED DESCRIPTION

In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular architectures, interfaces, techniques, etc.
15 in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. That is, those skilled in the art will be able to devise various arrangements which, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope. In some instances, detailed descriptions of well-known devices, circuits, and methods are omitted so as not to obscure the description of the present invention with unnecessary detail. All statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is
20 intended that such equivalents include both currently known equivalents as well as equivalents developed in the future, i.e., any elements developed that perform the same function, regardless of structure.

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
30 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 substantially represented in computer

readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

5 The functions of the various elements including functional blocks, including but not limited to those labeled or described as “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 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.

10 In terms of hardware implementation, the functional blocks may include or encompass, without limitation, digital signal processor (DSP) hardware, reduced instruction set processor, hardware (e.g., digital or analog) circuitry including but not limited to application specific integrated circuit(s) [ASIC], and (where appropriate) state machines capable of performing such functions.

15 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 and processor and controller may be employed interchangeably herein. When provided by a computer or processor or controller, the functions may be provided by a single dedicated computer or processor or controller, by a single shared computer or processor
20 or controller, or by a plurality of individual computers or processors or controllers, some of which may be shared or distributed. Moreover, use of the term “processor” or “controller” shall also be construed to refer to other hardware capable of performing such functions and/or executing software, such as the example hardware recited above.

25 In accordance with one aspect of the technology disclosed herein illustrated by way of example in Fig. 8, a user equipment unit (UE) or wireless terminal 30 can participate in access division multiplexing (ADM) with two radio access technology networks in parallel. Fig. 8 shows a cell of Long Term Evolution (LTE) network 22-1 and a cell of WCDMA network 22-2 (a 3G network). The LTE network 22-1 comprises a base station or eNodeB 28-1 while the 3G network 22-2 comprises base
30 station 28-2. As mentioned above, the LTE network 22-1 does not provide circuit switched (CS) services, so that a wireless terminal 30 participating in packet switched

(PS) services offered by LTE network 22-1 must turn to another network, e.g., WCDMA network 22-2 for circuit switched (CS) services.

The technology disclosed herein enables circuit switched (CS) voice centric devices to benefit from the improved performance of the Long Term Evolution (LTE) access as long as there is no CS voice call ongoing. The solution is UE-centric which means that the wireless terminal (e.g., user equipment unit [UE]) is registered for CS services in WCDMA (in case WCDMA is the preferred access, based on 3GPP compliant idle mode behavior). However, the wireless terminal does not register for packet switched (PS) services in WCDMA while being registered for CS services in WCDMA. This is done by registering for CS services, while keeping the PS registration/session in LTE.

The term “session” is used herein to indicate an active packet switched (PS) connection, while the term “registration” is used for a terminal which is known to the network, and thus a terminal ready to have a “session” but not yet engaged in or participating in a session. In Long Term Evolution (LTE) a “registration” is performed initially as an “Attach” and maintained (in Idle Mode) by “Tracking Area Updates”. In Connected Mode, e.g. while having a “session”, the “registration” is maintained by “being connected to the network”. In WCDMA (and GSM) it is possible to make a clearer distinction between “registration” and “session”. A “session” in WCDMA requires a PDP Context Activation to establish the means of communication. On the other hand, in WCDMA a registration can be made and maintained without a PDP Context being activated.

Fig. 9 shows basic, representative acts or steps comprising a method of operating wireless terminal 30 according to an example mode and embodiment. Act 9-1 comprises the wireless terminal, when already having a registration and/or session for a packet switched (PS) service with a Long Term Evolution (LTE) core network, making a registration for a circuit switched (CS) service over a Wide Band Code Division Multiplexing (WCDMA) air interface with a circuit switched (CS) core network. Act 9-2 comprises the wireless terminal maintaining the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network in conjunction with the registration for the circuit switched (CS) service. Fig. 10 shows a more specific mode and embodiment wherein act 9-2 takes the form of act 9-2(10). Act 9-2(10) comprises the wireless terminal refraining from making a

registration for a packet switched (PS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with a packet switched (PS) core network in conjunction with making the registration for the circuit switched (CS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core network. For example, in an example implementation below illustrated with reference to Fig. 13 and Fig. 14, act 9-2(10) comprises the wireless terminal refraining from performing a routing area update towards the Wide Band Code Division Multiplexing (WCDMA) packet switched (PS) core network in conjunction with the registration for the circuit switched (CS) service.

Fig. 11 shows an example, generic, and basic embodiment of wireless terminal 30. As shown in Fig. 11, wireless terminal 30 comprises communication interface 40 and service registration controller 42. The communication interface 40 is arranged to engage in communications over an air interface, such communications including a message configured to make the registration for the circuit switched (CS) service. The service registration controller 42 is configured to make the registration for the circuit switched (CS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core network while maintaining the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network 22-1. In the particular example embodiment illustrated in Fig. 11, service registration controller 42 comprises routing area update inhibitor 44.

Fig. 12 shows a more detailed example embodiment of wireless terminal 30(12) comprising a first controller 58-1 configured to handle administration and transmissions of LTE network 22-1 and second controller 58-2 configured to handle administration and transmissions of the WCDMA network 22-2. First controller 58-1 and second controller 58-2 can be realized or implemented by a same processor or controller (or processor system), and in such case may constitute separate sets of non-transitory executable signals (e.g., programs or routines stored on tangible media).

Fig. 12 further shows that certain functionalities of the example wireless terminal 30(12) can be realized by and/or provided on a platform 60. The terminology “platform” is a way of describing how the functional units of a communications unit or node can be implemented or realized by machine. One example platform is a computer implementation wherein one or more of the elements framed by line 60, including but not limited to service registration controller 42.

In one example implementation, the functionalities shown as framed by platform 60 and even other functionalities can be realized by one or more processors which execute coded instructions stored in memory (e.g., non-transitory signals) in order to perform the various acts described herein. In such a computer implementation
5 the wireless terminal can comprise, in addition to a processor(s), a memory section 62 (which in turn can comprise random access memory 64; read only memory 66; application memory 68 (which stores, e.g., coded instructions which can be executed by the processor to perform acts described herein); and any other memory such as cache memory, for example).

10 Whether or not specifically illustrated, typically the wireless terminal of each of the embodiments discussed herein can also comprise certain input/output units or functionalities, the representative input/output units for wireless terminal being illustrated in Fig. 12 as keypad 70; audio input device (e.g. microphone) 72; visual input device (e.g., camera) 74; visual output device (e.g., display 76); and audio output
15 device (e.g., speaker) 78. Other types of input/output devices can also be connected to or comprise wireless terminal 30.

In the example of Fig. 12 the platform 60 has been illustrated as computer-implemented or computer-based platform. Another example platform 60 for wireless terminal can be that of a hardware circuit, e.g., an application specific integrated circuit
20 (ASIC) wherein circuit elements are structured and operated to perform the various acts described herein.

Furthermore, it will be appreciated that, as used herein, “wireless terminal(s)” or “UE” can be mobile stations or user equipment units (UE) such as but not limited to mobile telephones (“cellular” telephones) and laptops with wireless capability), e.g.,
25 mobile termination), and thus can be, for example, portable, pocket, hand-held, computer-included, or car-mounted mobile devices which communicate voice and/or data with radio access network.

A method of keeping the PS registration/session in LTE while registering for CS services is shown in Fig. 13 and Fig. 14. Fig. 13 shows Cell Re-selection to
30 WCDMA where combined LA/RA Update is not used and modifications are required; Fig. 14 shows Cell Re-selection to WCDMA with combined LA/RA Update used and modifications are required.

As shown in Fig. 13 and Fig. 14, the changes to the Cell Re-selection to WCDMA include that there is no RA Update (or combined LA/RA Update) towards the packet switched (PS) domain. Refraining from a RA Update (or combined LA/RA Update) towards the WCDMA packet switched (PS) domain enable the existing packet switched (PS) session to be maintained in LTE while being CS registered in WCDMA as shown in Fig. 15 (PS Session maintained in LTE while being CS registered in WCDMA).

Once a circuit switched (CS) call is established, the wireless terminal can perform a routing area update towards the WCDMA PS Domain in conjunction with the CS call establishment. The Registration Area (RA) Update can be sent before, after, or in parallel with the CS call establishment. In other words, the technology disclosed herein keeps the PS session in LTE while CS-registered with WCDMA, but once a CS connection is established the PS session in LTE is terminated.

As stated above, the RA Update can be sent before, after, or in parallel with the CS call establishment. Preferably the RA Update is sent as soon as possible after the CS call establishment. The WCDMA packet switched (PS) service starts essentially immediately after the routing area (RA) update.

An advantage of the technology disclosed herein is retaining the better packet switched (PS) session via LTE (rather than switching to WCDMA PS) during the period from WCDMA CS registration to establishment of a CS call. This period from WCDMA CS registration to establishment of a CS call can be a significant time period, and thus the advantage can be considerable.

In the above regard, most people having a mobile phone are engaged in calls only a small portion of the total connected time. However, when considering smart phones like the iPhone, HTC Hero, SonyEricsson Xperia X10, and the like, such phones are more or less constantly connected in a packet switched (PS) session but rarely in voice calls. A benefit of the technology disclosed herein is thus that most of the time the better PS access will be retained while being accessible for voice.

For wireless terminals camping on WCDMA where LTE coverage is detected, the wireless terminal performs Tracking Area Update in LTE, as defined in 3GPP TS 23.401, General Packet Radio Service (GPRS) enhancements for Evolved Universal

- Terrestrial Radio Access Network (E-UTRAN) access (Release 8) (chapter 5.3.3 for “S4-SGSN” to MME and Annex D.3.6 for “Gn/Gp SGSN to MME” Tracking Area Update) (the contents of which are incorporated herein by reference) but continues to listen for CS voice Paging in WCDMA since it is still CS registered in WCDMA.
- 5 When being connected in WCDMA and detecting LTE coverage, the mobility management entity (MME) is the network node that handles the Tracking Area Update, as described in 3GPP TS 23.401.

Thus, with the technology disclosed herein, CS voice-enabled devices can advantageously continue to use the packet switched (PS) services over the LTE access while being circuit switched (CS) registered in WCDMA.

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Although the description above contains many specificities, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention. Therefore, it will be appreciated that the scope of the present invention fully encompasses other

15 embodiments which may become obvious to those skilled in the art, and that the scope of the present invention is accordingly to be unduly 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, chemical, and functional equivalents to the elements of the above-described preferred embodiments that are known to those of

20 ordinary skill in the art are expressly incorporated 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 by the present invention, for it to be encompassed hereby.

WHAT IS CLAIMED IS:

1 1. A wireless terminal (30) configured, when already having a registration and/or
2 session for a packet switched (PS) service with a Long Term Evolution (LTE) core network, to
3 make a registration for a circuit switched (CS) service over a Wide Band Code Division
4 Multiplexing (WCDMA) air interface with a circuit switched (CS) core network, the wireless
5 terminal being characterized in that, in conjunction with the registration for the circuit switched
6 (CS) service, the wireless terminal is configured to maintain the registration and/or session for
7 a packet switched (PS) service with the Long Term Evolution (LTE) core network.

1 2. The wireless terminal of claim 1, wherein the wireless terminal (30) is configured to
2 refrain from making a registration for a packet switched (PS) service over the Wide Band Code
3 Division Multiplexing (WCDMA) air interface with a packet switched (PS) core network in
4 conjunction with making the registration for the circuit switched (CS) service over the Wide
5 Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core
6 network.

1 3. The wireless terminal of claim 1, wherein the wireless terminal (30) is configured, in
2 conjunction with the registration for the circuit switched (CS) service, to refrain from
3 performing a routing area update towards a Wide Band Code Division Multiplexing
4 (WCDMA) packet switched (PS) core network.

1 4. The wireless terminal of claim 1, wherein the wireless terminal (30) is configured to
2 maintain the registration and/or session for a packet switched (PS) service with the Long Term
3 Evolution (LTE) core network until such time as a circuit switched (CS) is established.

1 5. The wireless terminal of claim 1, wherein the wireless terminal (30) is configured to
2 perform a routing area update towards a Wide Band Code Division Multiplexing (WCDMA)
3 packet switched (PS) core network when a circuit switched (CS) is established.

6. The wireless terminal of claim 1, wherein the wireless terminal (30) comprises:
a communication interface (40) arranged to communicate over the air interface a message configured to make the registration for the circuit switched (CS) service;
a mobility management unit configured to make the registration for the circuit switched (CS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core network while maintaining the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network.

7. A method of operating a wireless terminal (30) comprising:
when already having a registration and/or session for a packet switched (PS) service with a Long Term Evolution (LTE) core network, making a registration for a circuit switched (CS) service over a Wide Band Code Division Multiplexing (WCDMA) air interface with a circuit switched (CS) core network;
the method characterized by:
maintaining the registration and/or session for a packet switched (PS) service with the Long Term Evolution (LTE) core network in conjunction with the registration for the circuit switched (CS) service.

8. The method of claim 7, further comprising the wireless terminal (30) refraining from making a registration for a packet switched (PS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with a packet switched (PS) core network in conjunction with making the registration for the circuit switched (CS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core network.

9. The method of claim 7, further comprising the wireless terminal (30) refraining from performing a routing area update towards a Wide Band Code Division Multiplexing (WCDMA) packet switched (PS) core network in conjunction with the registration for the circuit switched (CS) service.

1 10. The method of claim 7, further comprising the wireless terminal (30) refraining
2 from performing a combined Location Area (LA)/routing area (RA) update towards a Wide
3 Band Code Division Multiplexing (WCDMA) packet switched (PS) core network in
4 conjunction with the registration for the circuit switched (CS) service, and instead performing a
5 Location Area (LA) update toward the Wide Band Code Division Multiplexing (WCDMA)
6 packet switched (PS) core network.

1 11. The method of claim 7, further comprising the wireless terminal (30) maintaining
2 the registration and/or session for a packet switched (PS) service with the Long Term
3 Evolution (LTE) core network until such time as a circuit switched (CS) is established.

1 12. The method of claim 7, further comprising the wireless terminal (30) performing a
2 routing area update a Wide Band Code Division Multiplexing (WCDMA) packet switched
3 (PS) core network when a circuit switched (CS) is established.

1 13. A communications network comprising:
2 a Long Term Evolution (LTE) core network;
3 a circuit switched (CS) core network;
4 a wireless terminal (30) configured, when already having a registration and/or session
5 for a packet switched (PS) service with the Long Term Evolution (LTE) core network, to make
6 a registration for a circuit switched (CS) service over a Wide Band Code Division Multiplexing
7 (WCDMA) air interface with the circuit switched (CS) core network;
8 characterized in that the wireless terminal, in conjunction with the registration for the
9 circuit switched (CS) service, is configured to maintain the registration and/or session for a
10 packet switched (PS) service with the Long Term Evolution (LTE) core network.

1 14. The network of claim 13, wherein the wireless terminal (30) is configured to
2 refrain from making a registration for a packet switched (PS) service over the Wide Band Code
3 Division Multiplexing (WCDMA) air interface with a packet switched (PS) core network in
4 conjunction with making the registration for the circuit switched (CS) service over the Wide
5 Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core
6 network.

1 15. The network of claim 13, wherein the wireless terminal (30) is configured, in
2 conjunction with the registration for the circuit switched (CS) service, to refrain from
3 performing a routing area update towards a Wide Band Code Division Multiplexing
4 (WCDMA) packet switched (PS) core network.

1 16. The network of claim 13, wherein the wireless terminal (30) is configured, in
2 conjunction with the registration for the circuit switched (CS) service, to refrain from
3 performing a combined Location Area (LA)/routing area (RA) update towards a Wide Band
4 Code Division Multiplexing (WCDMA) packet switched (PS) core network and instead

5 performing a Location Area (LA) update toward the Wide Band Code Division Multiplexing
6 (WCDMA) packet switched (PS) core network.

1 17. The network of claim 13, wherein the wireless terminal (30) is configured to
2 maintain the registration and/or session for a packet switched (PS) service with the Long Term
3 Evolution (LTE) core network until such time as a circuit switched (CS) is established.

1 18. The network of claim 13, wherein the wireless terminal (30) is configured to
2 perform a routing area update a Wide Band Code Division Multiplexing (WCDMA) packet
3 switched (PS) core network when a circuit switched (CS) is established.

1 19. The network of claim 13, wherein the wireless terminal (30) comprises:
2 a communication interface (40) arranged to communicate over the air interface a
3 message configured to make the registration for the circuit switched (CS) service;
1 a mobility management unit configured to make the registration for the circuit switched
2 (CS) service over the Wide Band Code Division Multiplexing (WCDMA) air interface with the
3 circuit switched (CS) core network while maintaining the registration and/or session for a
4 packet switched (PS) service with the Long Term Evolution (LTE) core network.

1 20. A method of operating a communications network comprising a Long Term
2 Evolution (LTE) core network; a circuit switched (CS) core network; and a wireless terminal
3 (30); the method comprising:
4 when already having a registration and/or session for a packet switched (PS) service
5 with a Long Term Evolution (LTE) core network, making a registration for a circuit switched
6 (CS) service over a Wide Band Code Division Multiplexing (WCDMA) air interface with a
7 circuit switched (CS) core network;
8 the method characterized by:
9 maintaining the registration and/or session for a packet switched (PS) service with the
10 Long Term Evolution (LTE) core network in conjunction with the registration for the circuit
11 switched (CS) service.

1 21. The method of claim 20, further comprising the wireless terminal (30) refraining
2 from making a registration for a packet switched (PS) service over the Wide Band Code
3 Division Multiplexing (WCDMA) air interface with a packet switched (PS) core network in
4 conjunction with making the registration for the circuit switched (CS) service over the Wide
5 Band Code Division Multiplexing (WCDMA) air interface with the circuit switched (CS) core
6 network.

1 22. The method of claim 20, further comprising the wireless terminal (30) refraining
2 from performing a routing area update towards a Wide Band Code Division Multiplexing
3 (WCDMA) packet switched (PS) core network in conjunction with the registration for the
4 circuit switched (CS) service.

1 23. The method of claim 20, further comprising the wireless terminal (30) maintaining
2 the registration and/or session for a packet switched (PS) service with the Long Term
3 Evolution (LTE) core network until such time as a circuit switched (CS) is established.

1 24. The method of claim 20, further comprising the wireless terminal (30) performing
2 a routing area update towards a Wide Band Code Division Multiplexing (WCDMA) packet
3 switched (PS) core network when a circuit switched (CS) is established.