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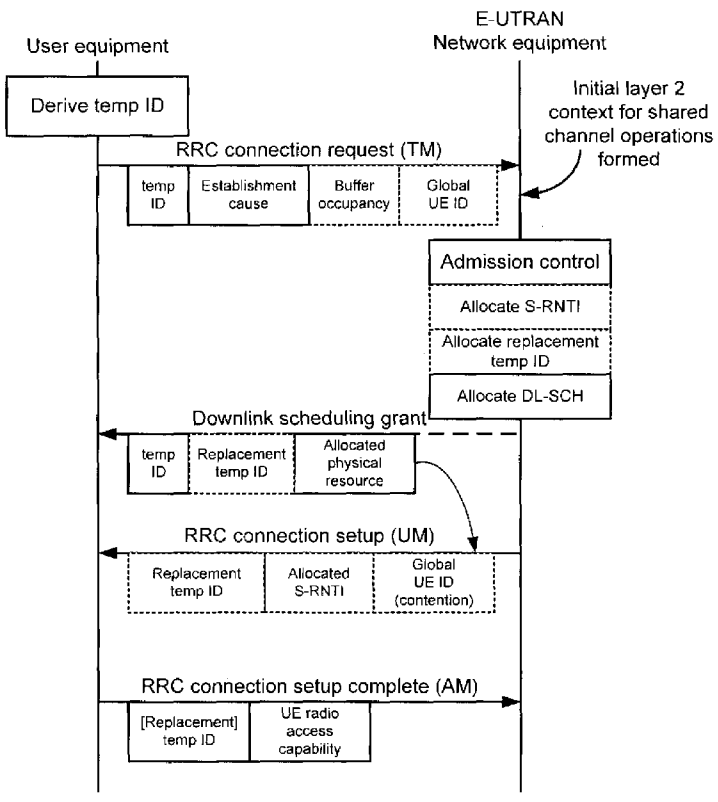
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(54) Title: INITIAL CONNECTION ESTABLISHMENT IN A WIRELESS COMMUNICATION SYSTEM




Scheduled downlink connection procedure

(57) Abstract: A method, user equipment, network equipment and a system for initiating a wireless connection and subsequent communication over a shared physical resource in a wireless communication system between user equipment and network equipment comprising: processing a UE-derived temporary identifier; communicating the temporary identifier as an identifier to the network equipment; communicating a downlink message conveying the temporary identifier and a description of a scheduled resource on a shared channel, the scheduled resource comprising a resource allocated to the user equipment by the network equipment; and communicating data on the scheduled resource in response to the downlink message.

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# INITIAL CONNECTION ESTABLISHMENT IN A WIRELESS COMMUNICATION SYSTEM

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates generally to wireless communication technology, and more particularly to an initial connection procedure between user equipment and network equipment in a wireless communication system.

### 2. Description of the Related Art.

In wireless communication systems there is the need for a logical connection between a mobile station (also referred to as user equipment (UE), a user terminal, a mobile terminal, a wireless data terminal and a cellular phone) and radio access network. The radio access network may comprise one or more base stations (also referred to as a Node B, for example in 3GPP nomenclature) together with one or more radio network controllers (RNCs). The logical connection provides a context for a particular network to UE communication link over which data may be transferred without miscommunication of the data to network elements or UEs in the system that are not intended to take part in the communication.

In the radio access network system defined by 3GPP, the logical connection between the user terminal and the radio access network is defined by radio resource control (RRC) connection states. Two of the main RRC connection states are defined as RRC connected and RRC idle.

If there is a logical connection between the user terminal and the radio access network, then the user terminal is said to be in RRC connected state. The existence of a user terminal in RRC connected state can be determined within a cell or multiple cells. Therefore, the radio resources for a particular user terminal can be managed efficiently by the wireless network. In contrast to RRC connected state, a user terminal in RRC idle state has no logical connection to the wireless access network. Thus, the user terminal in RRC idle state can only be determined within the core network or area that is larger than the cell, such as a location area or routing area.

When the user terminal is initially switched on by the user, a public land mobile network (PLMN) is selected and the user terminal searches for a suitable cell to be camped on to and remains in RRC idle state in the corresponding cell. An initial RRC connection may be initiated either by the network or by the user equipment. For example, in the case of a UE initiated connection for a UE in the RRC idle state, the UE requires an initial connection to the network and sends a RRC connection request message to the network. By means of a further example, in the case of a network initiated connection, an RRC connection request message may also be sent by the UE in response to receipt of a paging message from the network (the network having sent the paging message to the UE to illicit the commencement of an RRC connection procedure).

**[0007]** There are thus a number of reasons for RRC connection request by the UE. For example: (1) Initial cell access: when the UE attempts to make a call, the UE needs to establish an RRC connection; (2) Paging response: when transmitting a response message to a paging message; (3) Cell update: when the UE selects a suitable cell while in idle mode; (4) UTRAN Routing Area (URA) update: when the UE selects a suitable URA while in idle mode; and (5) Multimedia Broadcast and Multicast (MBMS) connection: in order to receive MBMS service and request for MBMS point-to-point connection.

**[0008]** In the conventional RRC connection procedure, the user terminal initiates the connection procedure by transmitting a RRC connection request message to the network using common uplink transport channels. The common uplink transport channels are shared by a plurality of UEs and are used for non-scheduled data transmission.

**[0009]** The network considers the connection request and may return on downlink either an RRC connection setup message (in the event of a successful admission) or an RRC connection reject message (in the event of an unsuccessful admission). In both cases the message is sent using common downlink transport channels which are (similar to the uplink common channels) shared by a plurality of UEs and used for non-scheduled data transmission.

The common transport channel over which messages from the user terminal to the network are transmitted during this initial RRC connection phase are termed random access channels. Random access transmission may similarly be referred to as unscheduled transmissions, as no

explicit scheduling or coordination of the transmissions is carried out. Due to this lack of explicit coordination, there exists a probability that one mobile will transmit using the same uplink transmission resources or uplink identity as another user. In this instance, the communication reliability of both transmissions may be compromised due to the mutual logical or actual interference the uplink messages generate at the receiving base station. These cases, in which more than one mobile transmits on a defined set of uplink resources, may be referred to as collisions.

A further description of collisions, unscheduled access and scheduled access may be found in U.S. Patent Application No. 11/263,044, filed on October 31, 2005, titled "FREQUENCY DOMAIN UNSCHEDULED TRANSMISSION IN A TDD WIRELESS COMMUNICATIONS SYSTEM" to inventor Nicholas W. ANDERSON, and which is hereby incorporated by reference.

The common downlink transport channels used to convey the corresponding messages from the network to the user terminal are termed forward access channels (FACH).

System resources are typically reserved for these uplink and downlink common transport channels. The radio resources used for common channels are typically separated from the radio resources used for other transport channels. Examples of other types of transport channel comprise dedicated transport channels and shared transport channels. In the case of dedicated transport channels the data is mapped to a sub-set of the total radio resources assigned on a long term basis to a particular user or connection. Conversely, in the case of shared channels, the data for each user is more dynamically mapped to a part of a pool of radio resources assigned within the set of total radio resources under control of a resource scheduler located typically within the MAC layer (layer 2) of the network. The radio resource in this instance is thus shared amongst users and is arbitrated by the scheduler. This is to be contrasted against the case for common channels in which the users share the radio resource but in a non-scheduled manned.

The use of shared channels only can provide benefits in terms of system capacity when compared to the use of multiple channel types within the system (such as mixtures of common, shared and dedicated types) wherein each is assigned for a particular traffic type. This is because, by

multiplexing all traffic types onto only shared channels, the scheduler can dynamically adapt the resources assigned to the varying instantaneous loads presented by each traffic type. In contrast, if for example we assign one traffic type exclusively to common channels and another traffic type exclusively to shared channels, then variations in the traffic loads offered by each traffic type cannot be accommodated without reconfiguring the respective portions of the total radio resource space assigned firstly to common and secondly to shared channels. This reconfiguration of radio resources is typically a slow process and the system is therefore unresponsive to fast variations in load. A consequence of this is that in current systems, the fraction of the total radio resource space assigned to common channels often has to be designed with a worst-case consideration in mind and radio resource usage efficiency is therefore suboptimum.

Following a conventional RRC connection establishment procedure, the existence of the UE is known by the network and a shared channel address or UE ID may then be assigned by the network only at the completion of the connection establishment procedure. Therefore, shared channels may only be used after the normal RRC connection procedure has been accomplished using the common channel procedures. A significant portion of the total radio resource space must therefore be pre-assigned to the common channels to carry the connection establishment traffic. The user terminal specific layer 2 connection context used for the shared channel operation can only be established at the completion of the RRC connection procedure.

In addition, known wireless communication systems expend a substantial amount of time and exchange a number of signaling messages on unshared and common channels to establish an initial layer 2 context for shared channel operations and this can contribute to communication delay. Furthermore, the existence of a plurality of channel types and associated protocols, procedures and attributes can significantly increase system implementation complexity.

For the abovementioned reasons, an improvement to the initial system access and RRC connection procedure is desirable in order to improve radio resource usage efficiency, to reduce communication delay and to simplify system implementation complexity.

## BRIEF SUMMARY OF THE INVENTION

Some embodiments of the present invention provide a prompt establishment of a layer 2 shared channel context by allowing the UE to derive its own layer 2 address as a temporary identifier until the network decides to replace the UE-derived temporary identifier with a network selected identifier. This enables the system to utilize shared channels in lieu of common channels at a very early stage of the connection establishment and thus minimizes the volume of traffic carried on common channels.

Furthermore, some embodiments of the present invention provide a method, an apparatus (such as user equipment or network equipment), a computer program product or a system for initiating a wireless connection and subsequent communication over a shared physical resource in a wireless communication system between user equipment and network equipment comprising: processing a UE-derived temporary identifier; communicating the temporary identifier to the network equipment; communicating a downlink message conveying the temporary identifier and a description of a scheduled resource on a shared channel, the scheduled resource comprising a resource allocated to the user equipment by the network equipment; and communicating data on the scheduled resource in response to the downlink message.

Some embodiments of the present invention provide for forming the temporary identifier from a portion of a network-known UE identifier such as from a temporary mobile subscriber identity (TMSI), an international mobile subscriber identity (IMSI), or an international mobile equipment identity (IMEI). Some embodiments of the present invention provide selecting the temporary identifier from a plurality of temporary identifiers. Some embodiments of the present invention provide for deriving the temporary identifier based on a time parameter. Some embodiments of the present invention provide communicating an indication of the plurality of temporary identifiers to the UE from the network equipment, for example, via a broadcast channel (BCH). Some embodiments of the present invention provide saving the plurality of temporary identifiers in non-volatile memory.

Some embodiments of the present invention provide for communicating the temporary identifier to the network equipment within a first uplink message containing the temporary identifier and,

for example, a request for an uplink or downlink scheduled resource as well as communicating the temporary identifier in subsequent communications between the UE and the network.

Some embodiments of the present invention provide for timing out after the transmitting the first uplink message and before the receiving of the downlink message; selecting a different temporary identifier; and retransmitting the first uplink message including the different temporary identifier in place of the originally-selected temporary identifier.

Some embodiments of the present invention provide communication of RRC connection signaling over shared channels.

Some embodiments of the present invention provide for communicating a replacement identifier from the network equipment; and using the replacement identifier in place of the temporary identifier to identify the user equipment on the shared channel resources.

Some embodiments of the present invention provide for incorporating, encoding or decoding a network-known UE identifier in the request such as a temporary mobile subscriber identity (TMSI), an international mobile subscriber identity (IMSI), or an international mobile equipment identity (IMEI). Some embodiments of the present invention provide for including the network-known UE identifier as a parameter in the request. Some embodiments of the present invention provide for computing a cyclic redundancy check (CRC) value using the network-known UE identifier.

Other features and aspects of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings which illustrate, by way of example, the features in accordance with embodiments of the invention. The summary is not intended to limit the scope of the invention, which is defined solely by the claims attached hereto.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIGURES 1A and 1B show a conventional sequence of messages for transitioning from an RRC idle state to an RRC connected state in a conventional UMTS system.

FIGURES 2, 3A and 3B compare a UTRAN network and an evolved UTRAN (E-UTRAN) network operating with user equipment (UEs) and a core network (CN).

FIGURES 3A and 3B illustrate an evolved UTRAN (E-UTRAN) network operating with user equipment and a core network in accordance with the present invention.

FIGURE 4 shows components of user equipment in accordance with the present invention.

FIGURES 5A and 5B show initial signaling sequences in accordance with the present invention.

FIGURES 6A and 6B show detailed signaling sequences using a scheduled downlink in accordance with the present invention.

FIGURES 7A and 7B show detailed signaling sequences using a scheduled downlink and both non-scheduled and scheduled uplink in accordance with the present invention.

FIGURES 8A and 8B show detailed signaling sequences using a scheduled downlink and a scheduled uplink in accordance with the present invention.

FIGURES 9 and 10 illustrate processes of contention resolution in accordance with the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

In the following description, reference is made to the accompanying drawings which illustrate several embodiments of the present invention. It is understood that other embodiments may be utilized and mechanical, compositional, structural, electrical, and operational changes may be made without departing from the spirit and scope of the present disclosure. The following detailed description is not to be taken in a limiting sense, and the scope of the embodiments of the present invention is defined only by the claims of the issued patent.

Some portions of the detailed description which follows are presented in terms of procedures, steps, logic blocks, processing, and other symbolic representations of operations on data bits that can be performed on computer memory. A procedure, computer executed step, logic block, process, etc., are here conceived to be a self-consistent sequence of steps or instructions leading

to a desired result. The steps are those utilizing physical manipulations of physical quantities. These quantities can take the form of electrical, magnetic, or radio signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a computer system. These signals may be referred to at times as bits, values, elements, symbols, characters, terms, numbers, or the like. Each step may be performed by hardware, software, firmware, or combinations thereof.

Though the following figures illustrate the invention with reference to a conventional Universal Mobile Telecommunications System (UMTS system), embodiments of the invention may apply to other wireless radio systems as well. A conventional UMTS system usually includes multiple user equipment (UE), which are sometimes referred to as user terminals, mobile stations, mobile terminals, wireless data terminals and cellular phones. The conventional UMTS system also includes network equipment including a Node B, also referred to as a base station, which provides a radio access connection between the UEs and the network, and also including a radio network controller (RNC).

FIGURES 1A and 1B show a conventional sequence of messages for transitioning from a radio resource connection (RRC) idle state to an RRC connected state in a conventional UMTS system. In a conventional UMTS system, a UE in an RRC idle state may initiate an RRC connection through a procedure as indicated in FIGURES 1A and 1B. The UE and network may exchange messages over logical control channels where each logical control channel is mapped to a common transport channel.

Figure 1A shows the messaging exchanged over the air interface (Uu). The first message shown is the RRC connection request message, which includes the network-known UE identifier, shown as a global UE identifier (ID) and an establishment cause. The network-known UE identifier may be one of the network assigned temporary mobile subscriber identity (TMSI), the UE's international mobile subscriber identity (IMSI), or the UE's international mobile equipment identity (IMEI). The establishment cause indicates the reason for the UE requesting a connection with the network. A UE may request a connection when transmitting a response message to a paging message (paging response), when selecting a suitable cell while in idle mode (cell

update), when selecting a suitable URA while in idle mode (URA update), and when receiving MBMS service or an MBMS point-to-point connection (MBMS connection).

Next, the network performs admission control and allocates Radio Network Temporary Identifier (RNTI) values. The network uses an admission control process to determine whether a requested service from the establishment cause can be supported by the network. Factors considered when performing admission control may include mobile access class for determining privileges, the Radio Resource Management status (RRM status) to determine availability of resources, details of the user's subscription, and equipment registers including lists of valid and stolen terminals.

The allocation of the RNTI values involves the network allocating a Serving Radio Network Controller (RNC) RNTI (S-RNTI), which is used by UE to identify itself to the serving RNC. The S-RNTI is also used by the SRNC to address the UE. An S-RNTI value is allocated by the Serving RNC to each UE having an RRC connection and is unique within the Serving RNC. The S-RNTI may be reallocated after the Serving RNC for the RRC connection has changed. The S-RNTI may be concatenated with an SRNC identifier (SRNC ID) received in a broadcast channel to form a unique RNTI (U-RNTI) within UTRAN. Optionally, the network may allocate a Cell Radio Network Temporary Identifier (C-RNTI). The C-RNTI may be allocated and used on common transport channels. The C-RNTI value may be used to identify the UE on a cell basis. In a conventional network, the decision to use the C-RNTI is made by the Controlling Radio Network Controller (CRNC).

After the network equipment performs a successful admission control process and allocation process, the network responds to the RRC connection request message with an RRC connection setup message including the global UE ID, the newly-allocated S-RNTI value, optionally a C-RNTI value, and a radio bearer configuration.

Once the RRC connection setup message is processed by the UE, the UE responds with an RRC connection setup complete message. The RRC connection setup complete message is accompanied by the C-RNTI value in a header field and includes the UE radio access capability. At this point, the UE enters an RRC connected state.

In response to receiving the RRC connection setup complete message, and if the high speed downlink shared channel (HS-DSCH) is to be used for downlink data transfer, the network may allocate an H-RNTI value to the UE within an RRC radio bearer setup message to the UE. The H-RNTI value is used to identify the UE on the high speed downlink shared channel. The RRC radio bearer setup message includes the allocated S-RNTI, the allocated H-RNTI and a shared channel radio bearer configuration. The UE completes the process by responding with an RRC radio bearer setup complete message. At this point, the UE and network have established a layer 2 context for shared channel operations.

FIGURE 1B shows elements of the UE and network equipment and the messaging between these elements. The UE includes a layer 3 comprising an RRC layer, a layer 2 comprising a Radio Link Control (RLC) layer and a medium access control (MAC) layer, and a layer 1 comprising a physical layer (L1). The Node B includes a layer 1 physical layer (L1). The RNC includes a layer 2 comprising a MAC layer and an RLC layer, and a layer 3 comprising an RRC layer and an RRM layer. Note additional layer 1 functions also exist in both the Node B and the RNC to provide physical connections between these entities (lub interface) although these are not shown for diagrammatical clarity. The RRC connection request message is initiated by the RRC layer in the UE. The RRC sends a message to the RLC layer which sends the RRC connection request message a common control channel (CCCH) mapped onto a random access channel (RACH) using an RLC transparent mode (TM). When using a transparent mode (TM) the message sender does not include a message sequence identifier unlike acknowledged mode (AM) and unacknowledged mode (UM), which both include a message sequence identifier that may be used for identifying/reordering out of sequence packets and for identifying missing packets. The acknowledged mode (AM) additionally provides for message retransmission. The CCCH is a common logical control channel between the RLC and MAC layers and the RACH is a common transport channel between the MAC and L1 layers. The RRC connection request message is transmitted over the air interface (Uu) to the network.

Upon receipt of the RRC connection request message, the Node B's layer 1 sends the message on a Random Access Channel (RACH) channel to the MAC layer of the RNC. The RACH channel is a common uplink transport channel used to carry control and data information from a UE over

random access physical resources which may be shared by a plurality of UEs and are used for unscheduled data transmission. The MAC layer sends the message to the RLC layer over a CCCH channel. In turn, the RLC layer sends the message to the RRC layer, which sends the message to the RRM layer for admission control, allocation of the S-RNTI value, and optional allocation of the C-RNTI value.

After successful admission control and allocation of the S-RNTI value, the RRM returns the allocated S-RNTI value to the RRC layer, which forms the RRC connection setup message to be sent in an unacknowledged mode (UM). A C-RNTI, which identifies the UE within the cell, is also typically allocated. However, if a dedicated physical channel connection is to be immediately configured, the C-RNTI may be omitted. The RRC sends the RRC connection setup message to the RLC layer. The RLC layer sends the message over a CCCH channel to the MAC layer. CCCH is used because a common RNTI context does not yet exist between the network and the UE. That is, the network knows the RNTI values but the UE does not know the RNTI values at this stage. The MAC layer sends the message over a Forward Access Channel (FACH). The FACH channel is a common downlink transport channel that may be used to carry control and data information to the UE when the network knows the location cell of the UE. The FACH may be shared by a plurality of UEs for unscheduled downlink data transmission. The Node B layer 1 transmits the message to the UE over the air interface (Uu).

Unfortunately, each UE monitoring the FACH channel decodes each and every RRC connection setup message and other messages in order to determine whether the enclosed message was addressed to it. Upon receipt of the RRC connection setup message by the UE, the UE's layer 1 sends the message over a FACH channel to its MAC layer, which sends the message over a CCCH channel to the RLC layer, which in turn sends the message to the RRC layer of the UE. The UE RRC layer may then inspect the global ID field contained within the connection setup message to determine whether or not it matches the UE's own global ID. If not, the message is discarded. If the IDs match, the message is decoded and the UE registers the assignment of the S-RNTI and possibly the C-RNTI values. At this point, the UE now has a dedicated control channel (DCCH) allocated to it.

Next, the UE responds using the RRC connection setup complete message, which is sent using an acknowledge mode (AM) to the network. The RRC layer sends a message to the RLC layer, which uses the DCCH channel to send the RRC connection setup complete message to the MAC layer. The MAC layer sends the message on a RACH (common transport) channel to the physical layer (L1), which transmits the message over the air interface (Uu) to the Node B. Data sent on DCCH on common transport channel resources is accompanied by a header field in which the C-RNTI is contained to distinguish the UE on a cell basis from the plurality of other UEs using the RACH (common transport) channel in that cell. For data sent on dedicated or shared transport channels, no C-RNTI is required in the header since user identification/addressing is accomplished at the physical resource level (the mapping between physical resource and user terminal is known at the physical layer). Once the UE has communicated the RRC connection setup complete message, the UE enters an RRC connected state.

Next, the Node B receives the RRC connection setup complete message over the air interface (Uu). Its layer 1 sends the message to the RNC's MAC layer using a RACH channel. The MAC layer reads the header (containing the C-RNTI) and sends the message to the appropriate RLC entity using the appropriate DCCH channel. The RLC sends the message to the RRC layer.

The network uses another value to identify a UE when the UE communicates over a high speed-downlink shared channel (HS-DSCH). This value is allocated by the RRC layer and is designated the HS-DSCH RNTI (H-RNTI) value. The H-RNTI value is used as a temporary identifier while the UE is has an established connection over the HS-DSCH channel. The network sends the allocated H-RNTI value to the UE within a Radio Bearer Setup message using a DCCH channel between the RLC and MAC layers, and a FACH channel between the MAC layer and the UE's layer 1. The Node B transmits the message over the air interface (Uu) to the UE. The UE's layer 1 sends the message over a FACH channel to its MAC layer, which sends the message to the RLC on a DCCH channel. The RLC sends the message to the RRC layer, which responds with an RRC radio bearer setup complete message sent to the network using an RLC acknowledged mode (AM). The channel path between the UE's RRC layer and the RNC's

RRC layer replicates the channel path described above for signaling the RRC connection complete message.

Upon being allocated an H-RNTI, the UE may subsequently utilize the high speed (hs) downlink shared (transport) channel for downlink communication. Resource allocations for this channel are granted by a scheduler located in a MAC-hs entity in Node-B. The MAC-hs entity can address the UE within the cell when making high speed downlink shared channel allocations by using the H-RNTI as a UE identifier.

The MAC-hs entity is not shown in the figure as it does not take part in the connection setup procedure and associated messaging. Messaging used to establish the RRC connection is not conveyed on shared transport channels.

At this point, the UE and the network have established and formed a layer 2 shared channel context and the network has allocated a shared channel identifier to the UE. In forming this layer 2 context, the network allocated the identifier and exchanged three uplink messages and two downlink messages.

According to embodiments of the present invention, a UE derives a temporary identifier (temp ID) to promptly establish a layer 2 context for more immediate communication over shared transport channels. This more immediate layer 2 context can obviate the need for extensive communication over common transport channels and can avoid a need to reserve significant portions of the total available radio resources for common channels. Such an assignment is typically slow to reconfigure and hence is not responsive to rapid changes in traffic loads. If the UE derived temporary identifier is unique in the network during the duration of use, the UE may be uniquely identified on the shared channel and data may be communicated via dynamic assignment of shared channel resources rather than via statically-assigned common resources as is the case in conventional systems. Additionally, the network may update the UE derived temporary identifier during or subsequent to the RRC connection process.

FIGURES 2, 3A and 3B compare a UTRAN network to an evolved UTRAN (E-UTRAN) network operating with user equipment (UEs) and a core network (CN) in accordance with the present invention.

FIGURE 2 shows multiple UEs and UTRAN network equipment. The UTRAN network equipment provides a link for the UE to the core network. The UTRAN network equipment, also referred to as a Radio Access Network (RAN), includes one or more Radio Network Subsystem (RNS). Each RNS includes a Radio Network Controller (RNC) and one or more Node Bs. For RRC signaling, the RNC provides RRM, RRC, RLC and MAC signaling layers and the Node B provides layer 1.

FIGURE 3A shows an architecture to implement the invention in accordance with some embodiments of the present invention. An evolved UTRAN (E-UTRAN) network provides a long term evolution (LTE) platform to simply the UTRAN architecture and reduce the number of interfaces between components. The "evolved" and "E-" designation may be used to distinguish conventional components or elements that may be similar to the corresponding components or elements of the present invention. The E-UTRAN network provides a link for the UE to communicate with the core network (CN). The E-UTRAN includes an LTE gateway (LTE GW) coupled to one or more evolved Node Bs (E-Node Bs), which perform functions of both the Node B and the RNC of FIGURE 2. The LTE gateway provides an interface between the core network and the E-Node Bs. For RRC signaling, the E-Node B provides RRM, RRC, RLC, MAC and L1 signaling layers. Here, the "evolved" and "E-" designations have been omitted from some labeled components within the E-UTRAN network for brevity purposes.

FIGURE 3B shows an alternate architecture for an E-UTRAN network. The LTE gateway provides an interface between the core network and the E-Node Bs and also provides RRM and RRC layers for RRC signaling. In this architecture, the E-Node B provides RLC, MAC and L1 signaling layers.

The embodiments of FIGURES 3A and 3B provide a MAC layer and an RLC layer collocated with the layer 1 processing, which aides in reducing signaling latencies. FIGURE 3A shows the collection of each of the layers used during the RRC connection establishment procedure, which further assists with reducing signal latencies.

FIGURE 4 shows components of user equipment in accordance with the present invention. User equipment comprises a memory for holding the UE-derived temporary identifier, a processor,

program code executable to derive the UE-derived temporary identifier and store the identifier into the memory, and a transceiver to communicate with the E-UTRAN network equipment. The memory may be volatile memory such as RAM or non-volatile memory such as flash (EEPROM). The memory may be a component of the UE's circuitry or may be on a smart card installed in the UE's housing. The processor may be a reduced instruction set computer (RISC), a general processor, a specialized processor, a gate-logic implemented processor, or the like. The program code may be executable machine code, object code, scripts or other computer interpreted or compiled code. The program code may be compressed or uncompressed and may be encoded or not coded. The transceiver may be a code division multiple access (CDMA) transmitter/receiver pair operating in either a time division duplex (TDD) scheme or frequency division duplex (FDD) scheme.

FIGURES 5A and 5B show initial signaling sequences in accordance with the present invention. In each figure, the UE first derives a temporary identifier (temp ID). The process of deriving a temporary identifier may vary among different implementations of the present invention. Derivation of a temporary identifier provides an immediate layer 2 context for layer 2 messaging over shared transport channels which are scheduled by the E-MAC entity in E-Node B. Derivation of a temporary identifier preferably occurs in a manner to minimize the probability to an acceptable level of two UEs deriving the same temporary identifier. If two UEs derive the same temporary identifier within a cell and attempt to use these during an overlapping period of time, additional collision detection and recovery procedures may be implemented.

In some embodiments of the present invention, a UE derives a temporary identifier by forming the temporary identifier from a portion of a network-known UE identifier. The network-known UE identifier may be one of the network assigned temporary mobile subscriber identity (TMSI), the UE's international mobile subscriber identity (IMSI), or the UE's international mobile equipment identity (IMEI). The UE may use a predetermined number of the lower significant bits of the TMSI, IMSI or IMEI. For example, if the TMSI is available, a UE may derive the temp ID by using the lower 16 bits of a 32-bit TMSI. If the TMSI is not available, the UE may use the lower 16 bits of its 32-bit IMSI. If neither the TMSI nor IMSI is available, the UE may use the lower 16 bits of its 32-bit IMEI.

In some embodiments of the present invention, a UE derives a temporary identifier by selecting the temporary identifier from a plurality of temporary identifiers. The plurality of temporary identifiers may comprise a subset of possible values of common bit length. For example, the plurality of temporary identifiers may include $1/8^{th}$ of the possible permutations of 16 bits. A network may re-allocate a temporary identifier by selection of a value from the remaining $7/8^{th}$ possible permutations in order to eliminate a possibility of potential conflict with future UE-derived values. The plurality of temporary identifiers may be in the form of a table stored in RAM or ROM. In some embodiments, the plurality of temporary identifiers is generated by the UE. In some embodiments, the plurality of temporary identifiers is signaled from the network to the UE. In some embodiments, an indication of the plurality of temporary identifiers is broadcast over a broadcast channel (BCH) from the network to the UE. In some embodiments, the plurality of temporary identifiers is saved in non-volatile memory.

In some embodiments the UE-derived temporary identifier may also be a function of time or radio frame number. The function may vary in accordance with a pre-determined pattern or one signaled to the UE for example over a broadcast channel (BCH). Alternatively the variation pattern may contain a random element in its derivation. The use of a time-varying component or a time parameter (such as the system clock, super frame number, radio frame number, sub-frame number, time slot number) by the user equipment when deriving the temporary identifier may advantageously assist in reducing the probability of two or more users selecting the same temporary identifier within a given time-frame.

After deriving the temporary identifier, the UE transmits this UE-derived temporary identifier to the E-UTRAN network in a first uplink message. An initial L2 shared channel context is formed as soon as the network has received the initial temporary identifier; at this stage both the UE and the network know the value of the temporary identifier. However, this connection may be subject to collision, and a more permanent connection (without possibility for collision) may be formed once the network has reassigned a replacement temporary identifier.

Upon receipt of the temp ID, the network allocates a physical resource. An allocated physical resource describes the resources allocated to the UE such as would allow for the UE to correctly encode and transmit or receive and decode the data message. The description may include

attributes such as: (1) an explicit or relational time of transmission; (2) description of a physical channel resources, such as codes, frequencies, sub-carriers, time/freq codes, and/or the like; (3) a formatting type of the data on the resources; and/or (4) FEC encoding type, block size, modulation format and/or the like.

This physical resource may be either an uplink resource (as shown in FIGURE 5A) or a downlink resource (as shown in FIGURE 5B). The network transmits a first downlink message to the UE including the UE-derived temporary identifier as a destination address and also including a description of the allocated physical resource. Next, the UE and network communicate user traffic data or signaling data (data) over the allocated physical resource.

FIGURE 5A shows data being communicated on an uplink scheduled, shared resource allocated by the network and described in the first downlink message. For uplink data, the UE can only transmit the data after the UE has received and processed the first downlink message containing the description of the allocated physical resource. The UE may initiate this sequence of deriving a temp ID and acquiring an uplink physical resource when the UE intends to send user traffic data or signaling data to the network.

FIGURE 5B shows data being communicated on a downlink scheduled, shared resource allocated by the network and described in the first downlink message. For downlink data, the UE can only receive and process the data after the UE has received and processed the first downlink message containing the description of the allocated physical resource. In some embodiments, the first downlink message is carried and received in a burst also containing the second downlink message. In this case, the UE processes the received burst to obtain the allocated physical resource. If the allocation indicates that the user traffic data or signaling data is contained in the same burst as the first downlink message containing the allocation, the UE may re-process the received burst to obtain the second downlink message.

A conventional system configures both common and shared channels. The segmentation of resources limits the efficient use of the combined resources. For example, if most traffic at a particular time uses common channels, then the shared channels are left idle. Conversely, if most traffic is using the configured shared channels, then the common channels are left under utilized.

In accordance with some embodiments of the present invention, a minimal set of resources may be assigned for unscheduled messages such as the first uplink message of FIGURES 5A and 5B. Uplink messages on this channel may be limited to short messages containing only the temp ID or alternatively containing the temp ID and an indication of what type of resource is being requested. Unscheduled downlink channels (e.g., FACH) may be removed from the configured channels since each UE initiates contact with the network using a layer 2 addressable temp ID. The remainder of the resources may be dynamically allocated between control channel message (e.g., the first downlink message) and user traffic data or signaling data (i.e., second downlink or uplink message). Such an allocation of resources provides a higher bandwidth system due to the more efficient use of resources.

As shown in FIGURES 6A and 6B, some embodiments of the present invention utilize a random access channel (RACH) for a first uplink message, a scheduled channel for downlink messages, and a common channel for subsequent uplink messages. As shown in FIGURES 7A and 7B, some embodiments of the present invention utilize a random access channel (RACH) for a first uplink message and scheduled channels for subsequent downlink and uplink messages. As shown in FIGURES 8A and 8B, some embodiments of the present invention utilize a random access channel (RACH) for an abbreviated initial uplink message and scheduled channels for subsequent downlink and uplink messages.

FIGURES 6A and 6B show detailed signaling sequences using a scheduled downlink in accordance with the present invention. A UE derives a temporary identifier and sends the temporary identifier in a first uplink message to the network. In addition to the temp ID, the first uplink message contains an establishment cause parameter and two optional parameters: buffer occupancy and a global UE ID. The establishment cause and the global UE ID may be the same or similar to the corresponding parameters described above with reference to FIGURE 1A.

The buffer occupancy may be used as an indication of the current pending data volume for transmission in the UE's transmission buffer and may be used by a scheduler at Node B to determine the extent of resources to grant for uplink transmission. The buffer occupancy could be a single bit, a range of quantized values, an absolute value in bytes, or a list of values, for example, one for each of a number of transmission flows, types or priority streams.

The UE may transmit the RRC connection request message using transparent mode (TM). Upon receipt of the RRC connection request message by the network equipment, the network performs admission control (described above with reference to FIGURE 1A) and allocates a physical resource: either an uplink shared channel (UL-SCH) or a downlink shared channel (DL-SCH) as indicated by the establishment cause parameter. Optionally, the network may also allocate an S-RNTI and a replacement temp ID.

The network transmits a first downlink message containing a downlink scheduling grant indication including the temp ID to address the particular UE and a description of the allocated physical resource. The first downlink message may be transmitted on a shared physical control channel (SPCCH) monitored my UEs expecting or waiting for possible scheduling messages. A network may also send a replacement temporary identifier. The network may select the replacement temporary identifier from a list or table of unique identifiers not selectable by UEs. Such replacement temporary identifier insures that a message containing a UE-derived temporary identifier from a first UE will not collide with a message containing the same temporary identifier derived by a second UE. In effect, the UE-derived temporary identifier provides a limited duration hopefully-unique identifier that may be replaced by a more certain network selected unique identifier. The replacement temporary identifier may be sent in an RRC connection setup message, or may also be contained within the SPCCH grant message.

Upon receipt of the downlink scheduling grant message, UEs decode the short scheduling message and inspect the temp ID. Only the UE address by the temp ID needs to decode the longer message sent or to be sent on a downlink shared channel (DL-SCH). Other UEs not addressed by the scheduling grant message need not spend CPU cycles or battery resources to decode an RRC connection setup or other long messages to determine if the message is directed to it.

The UE identified by the temp ID receives and decodes the message transmitted in the allocated physical resource described in the downlink scheduling grant message. This second downlink message to the UE may contain a RRC connection setup message transmitted by the network using unacknowledged mode (UM). The RRC connection setup message may optionally contain a replacement temp ID, an allocated S-RNTI value, and/or a global UE ID. If the UE receives a

replacement temp ID, it uses this replacement temp ID as its temporary identifier when signaling messages with the network. Additionally, the global UE ID may be included in this first downlink message if received by the network from the RRC connection request message and if a conflict between overlapping temp IDs is detected by the network. In some embodiments, the global UE ID is incorporated explicitly in the message. In other embodiments, the global UE ID is used for encoding the downlink message (e.g., CRC).

The contention resolution process of handling conflicts is further described below with reference to FIGURES 9 and 10. Furthermore, in some embodiments, a radio bearer configuration may be transmitted to multiple UEs using a broadcast channel (BCH).

**[0082]** Next, the UE responds to receiving and processing the RRC connection setup message by preparing and transmitting a RRC connection setup complete message using acknowledge mode (AM). If a replacement temp ID was provided by the network, the UE uses this new value as its temporary identifier. The RRC connection setup complete message may also contain UE radio access capability parameters indicating various capabilities of the UE.

In accordance with the present invention, information contained within the conventional RRC radio bearer setup message (FIGURE 1A) may be broadcast on a BCH rather than signaled individually to each UE since the information describing a shared channel may be used by multiple UEs in a cell.

**[0084]** FIGURE 6B shows elements of the UE and network equipment and the messaging between these elements. The UE includes a layer 3 comprising an evolved RRC (E-RRC) layer, a layer 2 comprising an evolved Radio Link Control (E-RLC) layer and an evolved MAC (E-MAC) layer, and a layer 1 comprising a physical layer (L1). The E-UTRAN network includes a layer 1 physical layer (L1), a layer 2 comprising an evolved MAC (E-MAC) layer and an evolved RLC (E-RLC) layer, and a layer 3 comprising an evolved RRC (E-RRC) layer and an evolved RRM (E-RRM) layer.

The RRC connection request message is initiated by the E-RRC layer in the UE. The E-RRC sends a message to the E-RLC layer which sends the RRC connection request message a common control channel (CCCH) mapped onto a random access channel (RACH) using a

transparent mode (TM). The CCCH is a logical control channel between the E-RLC and E-MAC layers and the RACH is a common transport channel between the E-MAC and L1 layers. The RRC connection request message is transmitted over the air interface (Uu) to the network.

Upon receipt of the RRC connection request message, the network equipment's layer 1 sends the message on a Random Access Channel (RACH) channel to the MAC layer. The MAC layer sends the message to the E-RLC layer over a CCCH channel. In turn, the E-RLC layer sends the message to the E-RRC layer, which sends the message to the E-RRM layer for admission control and allocation of the replacement temporary identifier and optionally the replacement S-RNTI value.

After admission control and optional replacement of the temporary ID and optional allocation of the S-RNTI value, the E-RRM returns the allocated values to the E-RRC layer, which forms the RRC connection setup message to be sent in an unacknowledged mode (UM). The E-RLC sends the RRC connection setup message to the E-RLC layer. The E-RLC layer sends the message over a DCCH or a CCCH channel to the E-MAC layer.

Instead of simply forwarding the RRC connection setup message, the E-MAC layer sends a scheduling grant message over a shared physical control channel (SPCCH) to layer 1 for transmission to the UE. The UE's layer 1 receives the scheduling grant, which indicates the physical resource that will carry the RRC connection setup message. The E-MAC layer also transmits, either concurrently or subsequently, the RRC connection setup message to layer 1 on the allocated physical resource on the downlink shared channel (DL-SCH). Layer 1 transmits the RRC connection setup message over the air interface (Uu) to the UE. Fortunately, each UE monitoring the air interface decodes only the short scheduling messages in order to determine whether the enclosed message was addressed to it rather than the longer RRC connection setup message and other messages.

Upon receipt of the RRC connection setup message by the UE, the UE's layer 1 sends the message over a DL-SCH channel to its E-MAC layer, which sends the message over a DCCH or CCCH channel to the E-RLC layer, which in turn sends the message to the E-RRC layer of the UE.

Next, the UE responds using the RRC connection setup complete message, which is sent using an acknowledge mode (AM) to the network. The E-RRC layer sends a message to the E-RLC layer, which uses the DCCH channel to send the RRC connection setup complete message to the E-MAC layer. The E-MAC layer sends the message on a RACH channel to the physical layer (L1), which transmits the message over the air interface (Uu) to the network. Once the UE has communicated the RRC connection setup complete message, the UE enters an RRC connected state.

Next, the network receives the RRC connection setup complete message over the air interface (Uu). Its layer 1 sends the message to the E-MAC layer using a RACH channel. The E-MAC layer sends the message to the E-RLC using a DCCH channel. The E-RLC sends the message to the E-RRC layer.

FIGURES 7A and 7B show detailed signaling sequences using a scheduled downlink and both non-scheduled and scheduled uplink in accordance with the present invention. The scheduling and exchange of the RRC connection request message and the RRC connection setup message, as well as admission control and allocation of resources are as described above with reference to FIGURES 6A and 6B. FIGURES 7A and 7B depart from the previous embodiment by sending subsequent uplink messages on shared resources.

Specifically, when the UE's E-MAC layer receives the RRC connection setup complete message from its E-RLC layer, the UE's E-MAC layer first sends a scheduling request message on a RACH channel or an evolved RACH (E-RACH) channel. The short scheduling request message requests allocation of an uplink physical resource from the network. The scheduling request message is transmitted over the air interface (Uu) to the network. Upon receipt of the scheduling request message by the network's layer 1, the scheduling request message is forwarded on the RACH channel to the network's E-MAC layer. The E-MAC layer allocates an uplink shared channel (UL-SCH) to the UE and describes the uplink allocation in a scheduling grant message sent on a shared physical control channel (SPCCH) from the E-MAC layer to layer 1, then over the air interface (Uu) to the UE's layer 1, which forwards the scheduling grant message on an SPCCH channel to the E-MAC layer. The E-MAC layer forwards the RRC connection setup complete message to layer 1 on the allocated UL-SCH resource for transmission to the network.

By using a shared, scheduled uplink and/or downlink scheme in accordance with some embodiments of the present invention, one or more advantages may be realized. For example, in some embodiments, shorter messages on the initial uplink resource may reduce the number collisions at the physical layer over the air interface. In some embodiments, logical collisions (occurring due to a common temporary identifier independently derived by two UEs during an overlapping time period) may be overcome by collision recovery procedures at the UE and/or by collision recovery procedures in the network. In some embodiments, resources that would otherwise be dedicated to RACH and/or FACH common channels may be either reduced or possibly eliminated; thus these resources are available for allocation to other channel traffic types. Thus a more efficient usage of radio resources may be realized when compared to the case in which multiple traffic types are not allowed to share the same shared channel resources and instead need to be assigned separate resources. This is because, by multiplexing all traffic types onto only shared channels, the scheduler can dynamically adapt the resources assigned to the varying instantaneous loads presented by each traffic type. In contrast, if separate radio resources are statically assigned to each traffic type then variations in the traffic loads offered by each traffic type cannot be accommodated without reconfiguring the respective portions of the total radio resource space assigned firstly to common and secondly to shared channels. In some embodiments, signaling latency and response time as viewed by the UE may be reduced. In some embodiments, the use of scheduled channels means that a UE decodes short scheduling messages and no longer needs to monitor and decode each common channel message address to other UEs, which may lead to more efficient use of the UE's battery life. Furthermore, in some embodiments, the connection setup signaling exchange over a high speed channel may occur faster than over a conventional common channel.

FIGURES 8A and 8B show detailed signaling sequences using a scheduled downlink and a scheduled uplink in accordance with the present invention. In the embodiment shown, the initial uplink communication is scheduled as well as subsequent communications. Rather than transmitting an initial message containing the RRC connection request, the UE first sends a short scheduling request message to request the network allocate an uplink physical resource. The UE derives and includes a temporary identifier in the short uplink message. The message may optionally include a buffer occupancy parameter (described above) and a cause parameter. The

cause parameter may indicate the reason for the request (e.g., uplink physical resource requested). The network allocates an uplink shared channel (UL-SCH) and transmits a scheduling grant on a shared physical control channel (SPCCH) including the UE-derived temporary identity and a description of the UL-SCH. The E-MAC layer of the UE receives the uplink scheduling grant message on the SPCCH channel and responds by sending the RRC connection request on the allocated UL-SCH physical channel. The RRC connection request message is received by the network which performs admission control and additional resource allocation as describe above with reference to FIGURES 7A and 7B. Furthermore, FIGURE 8A shows some embodiments may use acknowledged mode (AM) while other embodiments may use unacknowledged mode (UM) when communicating either or both of the RRC connection request and RRC connection setup messages.

FIGURES 9 and 10 illustrate processes of contention resolution in accordance with the present invention. This contention scenario occurs when two UEs derive and are using a common temporary identifier. Each UE transmits an RRC connection request message as described with reference to FIGURES 5A, 5B, 6A-B, 7A-B or 8A-B. Derivation of a temporary identifier preferably occurs in a manner to minimize the probability to an acceptable level of two UEs deriving the same temporary identifier. However, in some embodiments two UEs might derive the same temporary identifier within a cell. Therefore, additional collision detection and recovery procedures may be implemented.

FIGURE 9 illustrates a remedy primarily instigated by the UEs. Two UEs each transmit an uplink message to the network using an identical temporary identifier ($1^{st}$ temp ID). The uplink message may be a message transmitted on a RACH channel or an E-RACH. The message may be a scheduling request message (as shown) or some other message. The network may detect the duplicate identical temporary identifier in the two uplink messages. The network may elect to perform no following processing and will allow each UE to time out. After not receiving the expected downlink response, each UE discards the initially derived temporary identifier and derives another temporary identifier ($2^{nd}$ temp ID and $3^{rd}$ temp ID, respectively). Each UE then retransmits the original uplink message using the newly derived temporary identifier. Upon receipt of the newer temporary identifier, an initial layer 2 context is established between the

respective UE and the network for shared channel operations. The network then responds to each UE having a unique temp ID as described above.

FIGURE 10 illustrates a remedy primarily instigated by the network. Again, two UEs each transmit an uplink message to the network using an identical temporary identifier (temp ID). The uplink message may be a message transmitted on a RACH channel or an E-RACH. The message may be an RRC connection request message (as shown) or some other message. The network may detect an identical temporary identifier in the two uplink messages. In this case, two UEs have derived the same temp ID and may each may expect downlink signaling including this temp ID to be address to it. In such a case, the network may determine that a conflict or collision has occurred. However, if one or both of the uplink messages includes a global UE ID, the UEs may be distinguished from one another. At this point, an initial layer 2 context is established between the respective UE and the network for shared channel operations.

The network may transmit, on a control channel, a scheduling grant message allocated a downlink resource. The network may also transmit, on a traffic channel described in the scheduling grant message, a message incorporating a global UE ID. For example, the network may transmit an RRC connection setup complete message incorporating addressed to the UEs using the conflicting UE-derived temporary identification. In some embodiments, the network explicitly incorporates the global UE ID in the downlink message by including the global UE ID as a parameter. Alternatively, the network may incorporate the global UE ID by using the global UE ID to encode the downlink message. For example, the incorporating may comprise computing a cyclic redundancy check (CRC) value using the network-known UE identifier. When decoding the downlink message, each UE may use its global UE ID to determine whether the global UE ID was incorporated explicitly as a parameter or alternatively to decode the message to determine whether the previously-transmitted global UE ID was used by the network to encode the message. Additionally, the network may respond by allocating a replacement temp ID to the UE that transmitted its global UE ID. Once one of the UEs receives a replacement temp ID, a unique layer 2 context is formed for both UEs for shared channel operation. The first UE will receive and properly decode the RRC connection setup message, which is encoded with its UE. The second UE will attempt to decode the RRC connection setup message but will fail

because the message is encoded with an unknown global UE ID causing the second UE to discard the message and return to the downlink scheduling channel (SPCCH). The second UE will then receive a second downlink scheduling grant message sent by the network. The second UE will then properly receive and decode the RRC connection setup message addressed to it. Both UEs may complete the process by responding with an RRC connection setup complete message.

While the invention has been described in terms of particular embodiments and illustrative figures, those of ordinary skill in the art will recognize that the invention is not limited to the embodiments or figures described. For example, many of the embodiments described above are referenced to 3GPP systems and evolved UMTS Terrestrial Radio Access Network (E-UTRAN) nomenclature. More generally, some embodiments may include a transceiver using a code division multiple access (CDMA) transmitter/receiver pair operating in either a time division duplex (TDD) scheme or frequency division duplex (FDD) scheme. Alternatively, the transceiver may be a non-code division transceiver, such as used in a TDMA system, an FDMA system, an OFDM system or hybrids thereof (e.g. TMDA/FDMA, TDMA/CDMA, TDMA/OFDM, and TDMA/OFDM/CDMA). The transceiver may operate on bursts or may operate on a signal stream.

The figures provided are merely representational and may not be drawn to scale. Certain proportions thereof may be exaggerated, while others may be minimized. The figures are intended to illustrate various implementations of the invention that can be understood and appropriately carried out by those of ordinary skill in the art. Therefore, it should be understood that the invention can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is not intended to be exhaustive or to limit the invention to the precise form disclosed. It should be understood that the invention can be practiced with modification and alteration and that the invention be limited only by the claims and the equivalents thereof.

# CLAIMS

What is claimed is:

1. A method of initiating a wireless connection and subsequent communication over a shared physical resource in a wireless communication system between user equipment and network equipment, the method, by the user equipment, comprising:

deriving a temporary identifier;

transmitting the temporary identifier to the network equipment;

receiving a downlink message conveying the temporary identifier and a description of a scheduled resource on a shared channel, the scheduled resource comprising a resource allocated to the user equipment by the network equipment; and

communicating data on the scheduled resource in response to the downlink message.

2. The method of claim 1, wherein the deriving of the temporary identifier includes forming the temporary identifier from a portion of a network-known UE identifier.

3. The method of claim 2, wherein the network-known UE identifier comprises a temporary mobile subscriber identity (TMSI).

4. The method of claim 2, wherein the network-known UE identifier comprises an international mobile subscriber identity (IMSI).

5. The method of claim 2, wherein the network-known UE identifier comprises an international mobile equipment identity (IMEI).

6. The method of claim 1, wherein the deriving of the temporary identifier includes selecting the temporary identifier from a plurality of temporary identifiers.

7. The method of claim 1, wherein the deriving of the temporary identifier includes deriving the temporary identifier based on a time parameter.

8. The method of claim 6, wherein the plurality of temporary identifiers comprises a table.

9. The method of claim 6, further comprising receiving an indication of the plurality of temporary identifiers from the network equipment.

10. The method of claim 9, wherein the received indication comprises receiving the indication on a broadcast channel (BCH).

11. The method of claim 6, further comprising saving the plurality of temporary identifiers in non-volatile memory.

12. The method of claim 1, wherein the transmitting of the temporary identifier to the network equipment includes transmitting the temporary identifier within a first uplink message containing the temporary identifier and a request for the scheduled resource.

13. The method of claim 12, wherein the scheduled resource includes an uplink scheduled resource.

14. The method of claim 12, wherein the scheduled resource includes a downlink scheduled resource.

15. The method of claim 1, wherein:

the transmitting of the temporary identifier includes transmitting a first uplink message;

the receiving of the downlink message includes receiving a first downlink message; and

the communicating of the data on the scheduled resource includes transmitting a connection request in a second uplink message.

16. The method of claim 15, further comprising:

receiving a second downlink message sent in response to the second uplink message, the second downlink message conveying the temporary identifier and a description of a scheduled downlink resource on a shared downlink channel, the scheduled downlink resource comprising a downlink resource allocated to the user equipment by the network equipment; and

receiving a third downlink message on the scheduled downlink resource, the third downlink message including a connection setup message.

17. The method of claim 1, wherein the transmitting of the temporary identifier includes transmitting a first uplink message, the method further comprising:

timing out after the transmitting the first uplink message and before the receiving of the downlink message;

selecting a different temporary identifier; and

retransmitting the first uplink message including the different temporary identifier in place of the temporary identifier.

18. The method of claim 1, wherein the transmitting of the temporary identifier includes transmitting the temporary identifier in a first uplink message including an RRC connection request.

19. The method of claim 1, wherein the transmitting of the temporary identifier includes transmitting the temporary identifier in a first uplink message,

the method further comprising transmitting a second uplink message including an RRC connection request, wherein the second uplink message is separate from the first uplink message.

20. The method of claim 1, wherein the communicating of the data includes a RRC connection request message.

21. The method of claim 1, further comprising:

transmitting a RRC connection request; and

receiving an RRC connection setup message.

22. The method of claim 1, further comprising:

receiving a replacement identifier from the network equipment; and

using the replacement identifier in place of the temporary identifier.

23. The method of claim 1, further comprising incorporating a network-known UE identifier in the request.

24. The method of claim 23, wherein the network-known UE identifier comprises a temporary mobile subscriber identity (TMSI).

25. The method of claim 23, wherein the network-known UE identifier comprises an international mobile subscriber identity (IMSI).

26. The method of claim 23, wherein the network-known UE identifier comprises an international mobile equipment identity (IMEI).

27. The method of claim 23, wherein the incorporating comprises including the network-known UE identifier as a parameter in the request.

28. The method of claim 23, wherein the incorporating comprises computing a cyclic redundancy check (CRC) value using the network-known UE identifier.

29. The method of claim 1, further comprising decoding a message from the network equipment using a network-known UE identifier.

30. The method of claim 1, wherein the wireless communication system comprises an evolved UMTS Terrestrial Radio Access Network (E-UTRAN).

31. User equipment used in initiating a wireless connection and subsequent communication over a shared physical resource in a wireless communication system between the user equipment and network equipment, the user equipment comprising:

a memory;

a processor coupled to the memory; and

program code executable on the processor, the program code operable for:

deriving a temporary identifier;

transmitting the temporary identifier to the network equipment;

receiving a downlink message conveying the temporary identifier and a description of a scheduled resource on a shared channel, the scheduled resource comprising a resource allocated to the user equipment by the network equipment; and

communicating data on the scheduled resource in response to the downlink message.

32. The user equipment of claim 31, wherein the deriving of the temporary identifier includes forming the temporary identifier from a portion of a network-known UE identifier.

33. The user equipment of claim 31, wherein the deriving of the temporary identifier includes selecting the temporary identifier from a plurality of temporary identifiers.

34. The user equipment of claim 33, wherein the program code is further operable for receiving an indication of the plurality of temporary identifiers from the network equipment.

35. The user equipment of claim 33, wherein the program code is further operable for saving the plurality of temporary identifiers in non-volatile memory.

36. The user equipment of claim 31, wherein the transmitting of the temporary identifier to the network equipment includes transmitting the temporary identifier within a first uplink message containing the temporary identifier and a request for the scheduled resource.

37. The user equipment of claim 31, wherein:

the transmitting of the temporary identifier includes transmitting a first uplink message;

the receiving of the downlink message includes receiving a first downlink message; and

the communicating of the data on the scheduled resource includes transmitting a connection request in a second uplink message.

38. The user equipment of claim 37, wherein the program code is further operable for:

receiving a second downlink message sent in response to the second uplink message, the second downlink message conveying the temporary identifier and a description of a scheduled downlink resource on a shared downlink channel, the

scheduled downlink resource comprising a downlink resource allocated to the user equipment by the network equipment; and

receiving a third downlink message on the scheduled downlink resource, the third downlink message including a connection setup message.

39. The user equipment of claim 31, wherein the transmitting of the temporary identifier includes transmitting a first uplink message, and wherein the program code is further operable for:

timing out after the transmitting the first uplink message and before the receiving of the downlink message;

selecting a different temporary identifier; and

retransmitting the first uplink message including the different temporary identifier in place of the temporary identifier.

40. Network equipment used in initiating a wireless connection and subsequent communication over a shared physical resource in a wireless communication system between user equipment and the network equipment, the network equipment comprising:

a memory;

a processor coupled to the memory; and

program code executable on the processor, the program code operable for:

receiving a temporary identifier derived by the user equipment;

allocating a scheduled resource to the user equipment, the scheduled resource comprising a resource on a shared channel;

transmitting a downlink message conveying the temporary identifier and a description of the scheduled resource; and

communicating data on the scheduled resource in response to the downlink message.

41. The network equipment of claim 40, wherein the program code is further operable for transmitting an indication of a plurality of temporary identifiers to the user equipment.

42. The network equipment of claim 41, wherein the transmitting of the indication includes transmitting the indication on a broadcast channel (BCH).

43. The network equipment of claim 40, wherein the receiving of the temporary identifier from the user equipment includes receiving the temporary identifier within a first uplink message containing the temporary identifier and a request for the scheduled resource.

44. The network equipment of claim 40, wherein:

the receiving of the temporary identifier includes receiving a first uplink message;

the transmitting of the downlink message includes transmitting a first downlink message; and

the communicating of the data on the scheduled resource includes receiving a connection request in a second uplink message.

45. The network equipment of claim 40, wherein the program code is further operable for:

allocating a scheduled downlink resource to the user equipment, the scheduled downlink resource comprising a resource on a shared channel;

transmitting a second downlink message sent in response to the second uplink message, the second downlink message conveying the temporary identifier and a description of the scheduled downlink; and

transmitting a third downlink message on the scheduled downlink resource, the third downlink message including a connection setup message.

46. The network equipment of claim 40, wherein the program code is further operable for:

allocating a replacement identifier from a plurality of identifiers; and

transmitting the replacement identifier to the user equipment.

47. The network equipment of claim 40, wherein the program code is further operable for:

incorporating a network-known UE identifier in a message; and

transmitting the message to the user equipment.

48. The network equipment of claim 47, wherein the incorporating comprises computing a cyclic redundancy check (CRC) value using the network-known UE identifier.

49. A computer program product comprising program code for initiating a wireless connection and subsequent communication over a shared physical resource in a wireless communication system between user equipment and network equipment, the computer program product comprising program code for:

deriving a temporary identifier;

transmitting the temporary identifier to the network equipment;

receiving a downlink message conveying the temporary identifier and a description of a scheduled resource on a shared channel, the scheduled resource comprising a resource allocated to the user equipment by the network equipment; and

communicating data on the scheduled resource in response to the downlink message.

50. The computer program product of claim 49, wherein the deriving of the temporary identifier includes forming the temporary identifier from a portion of a network-known UE identifier.

51. The computer program product of claim 49, wherein the deriving of the temporary identifier includes selecting the temporary identifier from a plurality of temporary identifiers.

52. The computer program product of claim 51, wherein the program code is further operable for receiving an indication of the plurality of temporary identifiers from the network equipment.

53. The computer program product of claim 51, wherein the program code is further operable for saving the plurality of temporary identifiers in non-volatile memory.

54. The computer program product of claim 49, wherein the transmitting of the temporary identifier to the network equipment includes transmitting the temporary identifier within a first uplink message containing the temporary identifier and a request for the scheduled resource.

55. The computer program product of claim 49, wherein:

the transmitting of the temporary identifier includes transmitting a first uplink message;

the receiving of the downlink message includes receiving a first downlink message; and

the communicating of the data on the scheduled resource includes transmitting a connection request in a second uplink message.

56. The computer program product of claim 55, wherein the program code is further operable for:

receiving a second downlink message sent in response to the second uplink message, the second downlink message conveying the temporary identifier and a description of a scheduled downlink resource on a shared downlink channel, the scheduled downlink resource comprising a downlink resource allocated to the user equipment by the network equipment; and

receiving a third downlink message on the scheduled downlink resource, the third downlink message including a connection setup message.

57. The computer program product of claim 49, wherein the transmitting of the temporary identifier includes transmitting a first uplink message, and wherein the program code is further operable for:

timing out after the transmitting the first uplink message and before the receiving of the downlink message;

selecting a different temporary identifier; and

retransmitting the first uplink message including the different temporary identifier in place of the temporary identifier.

58. A wireless communication system for initiating a wireless connection and subsequent communication over a shared physical resource, the wireless communication system comprising:

one or more user equipment, wherein each user equipment includes:

a user equipment memory;

a user equipment processor coupled to the user equipment memory; and

user equipment program code executable on the user equipment processor, the user equipment program code operable for:

deriving a temporary identifier;

transmitting the temporary identifier to the network equipment;

receiving a downlink message conveying the temporary identifier and a description of a scheduled resource on a shared channel, the scheduled resource comprising a resource allocated to the user equipment by the network equipment; and

communicating data on the scheduled resource in response to the downlink message; and

network equipment including:

a network equipment memory;

a network equipment processor coupled to the network equipment memory; and

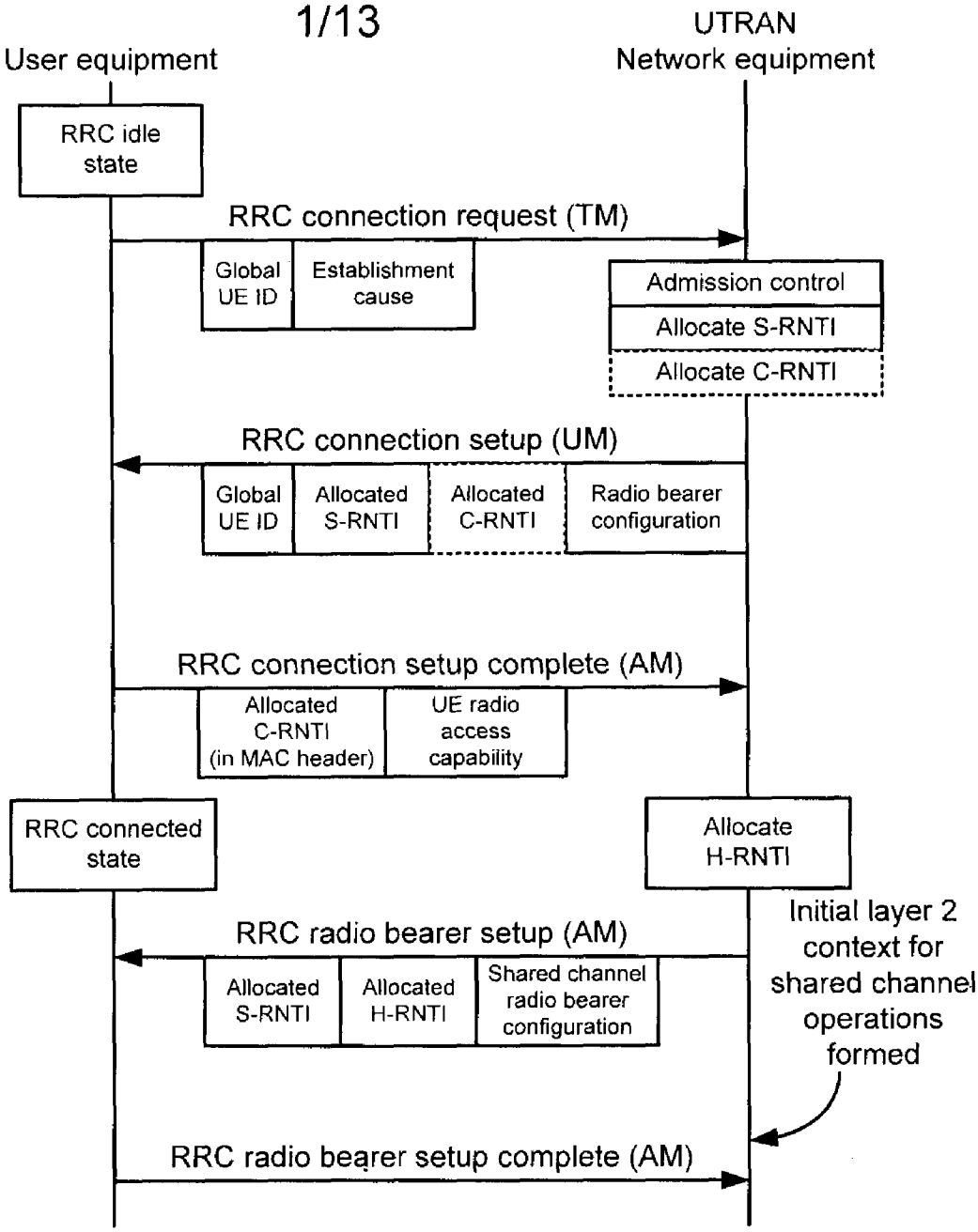
network equipment program code executable on the network equipment processor, the network equipment program code operable for:

receiving the temporary identifier derived by the user equipment;

allocating the scheduled resource to the user equipment, the scheduled resource comprising a resource on a shared channel;

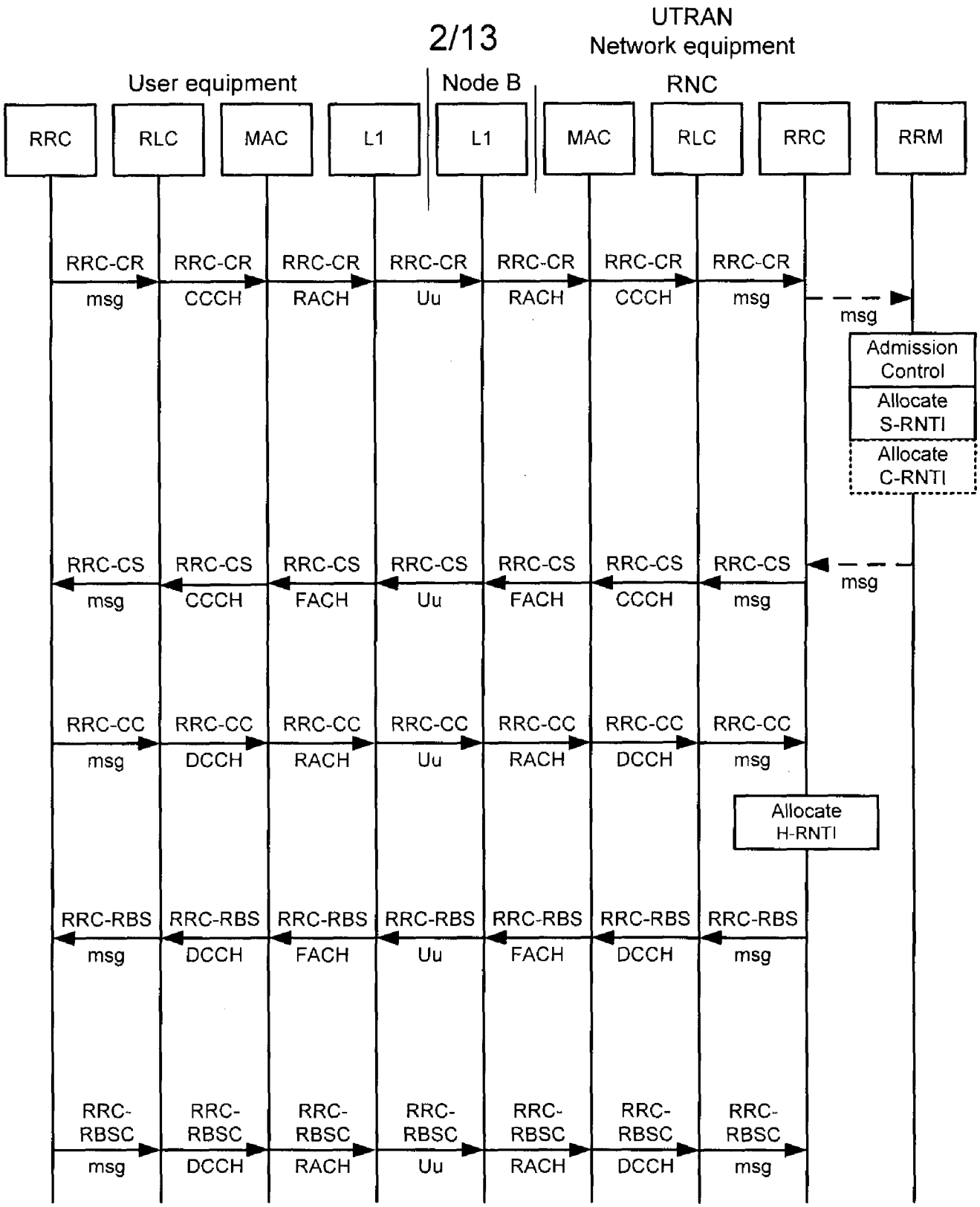
transmitting the downlink message conveying the temporary identifier and the description of the scheduled resource; and

communicating the data on the scheduled resource in response to the downlink message.




Conventional RRC connection procedure
using common channel signalling
in a UTMS system
(PRIOR ART)

FIGURE 1A




Conventional RRC connection procedure
using common channel signalling
in a UTMS system
(PRIOR ART)

FIGURE 1B

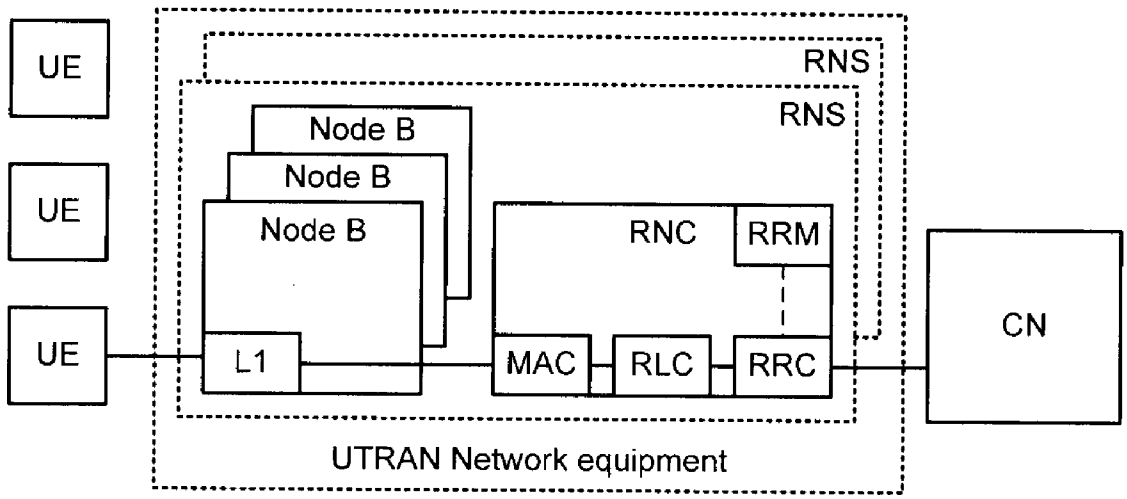



FIGURE 2

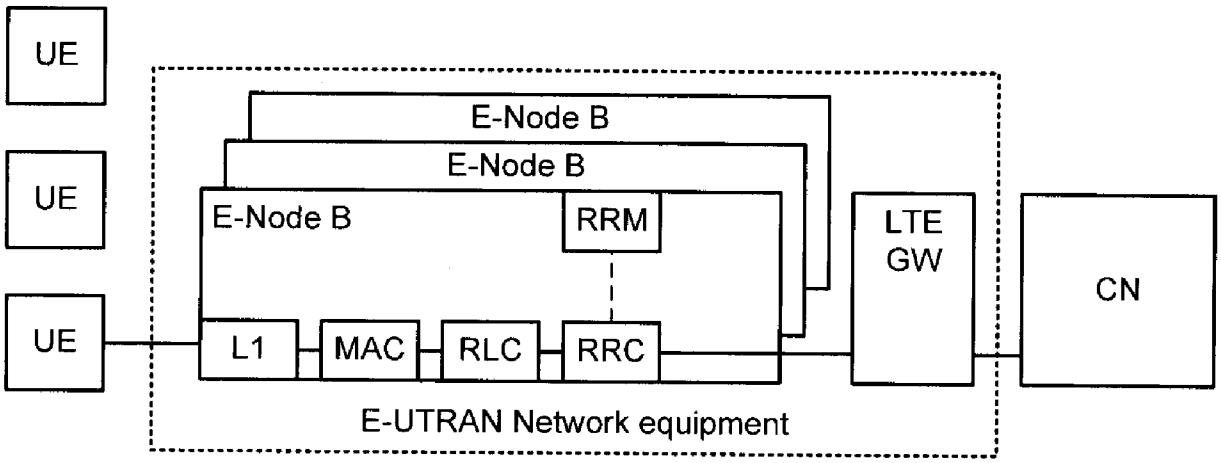



FIGURE 3A

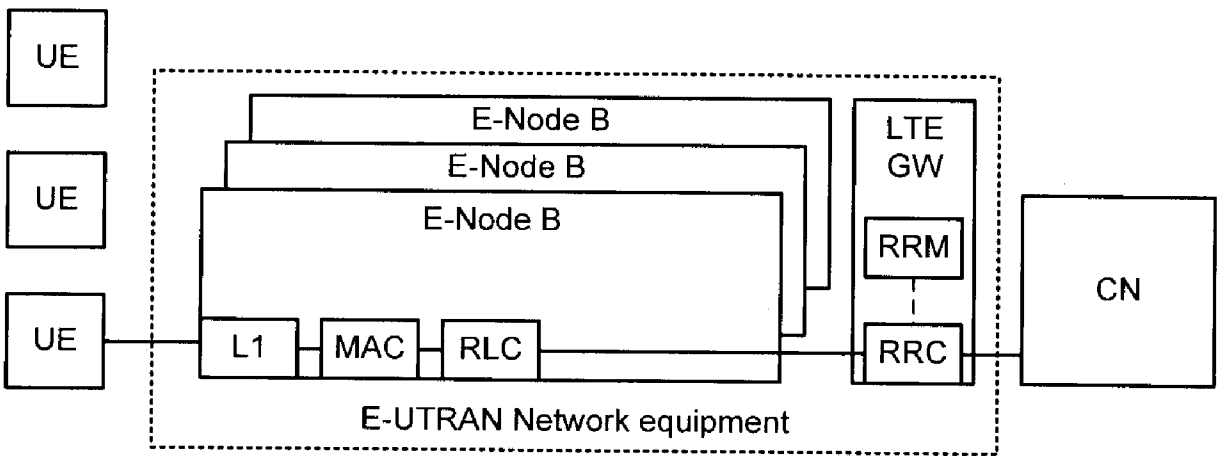



FIGURE 3B

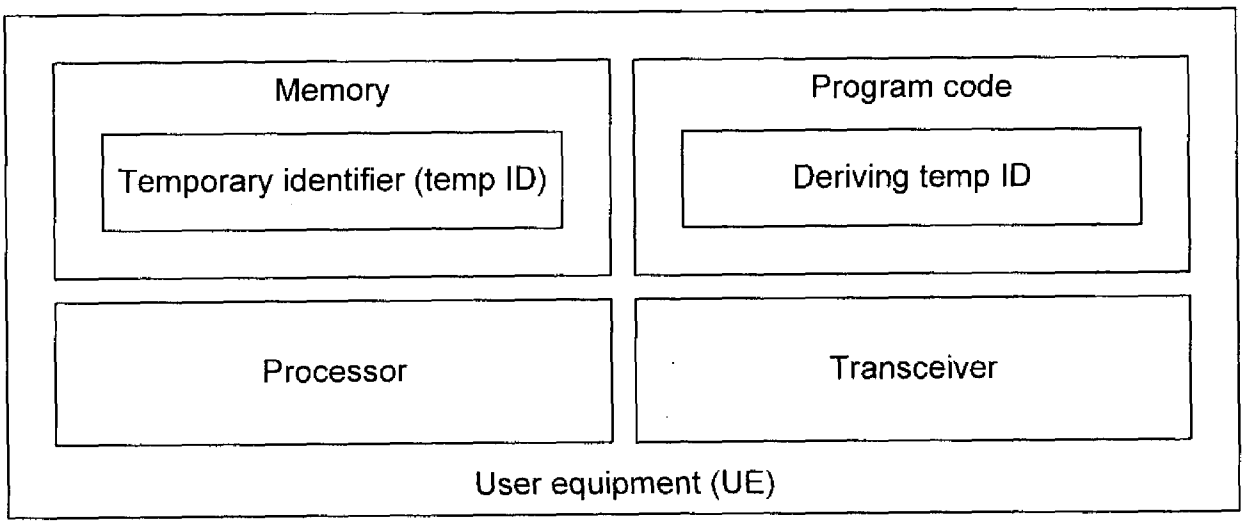

Memory
Temporary identifier (temp ID)
Program code
Deriving temp ID
Processor
Transceiver
User equipment (UE)

FIGURE 4

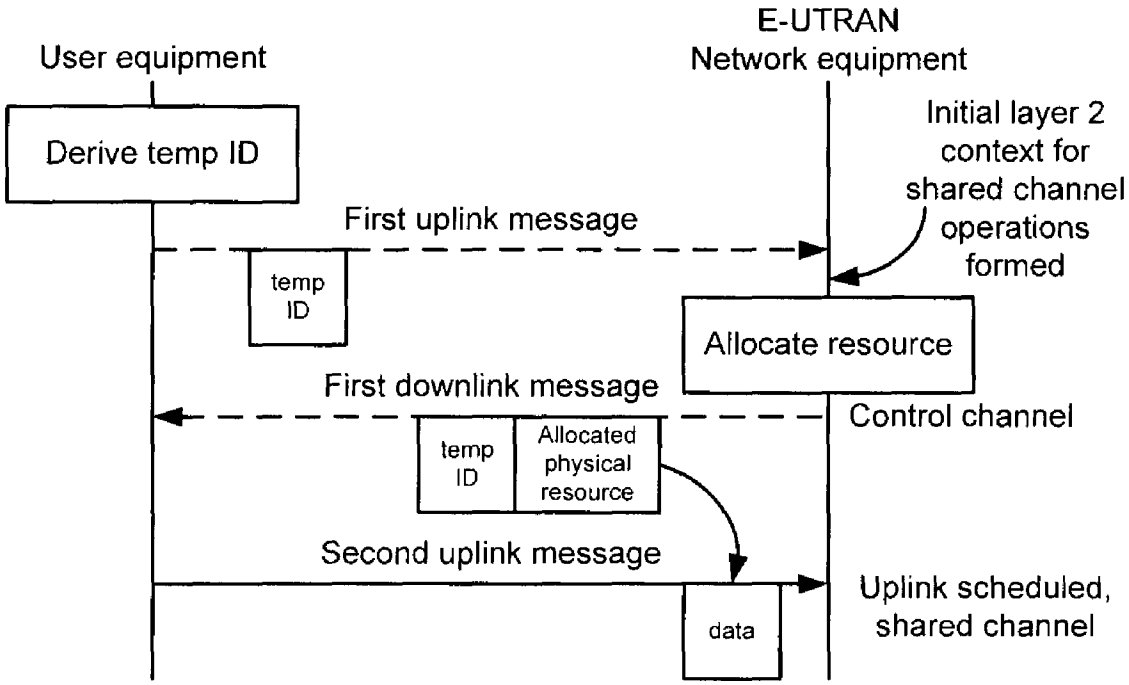



FIGURE 5A

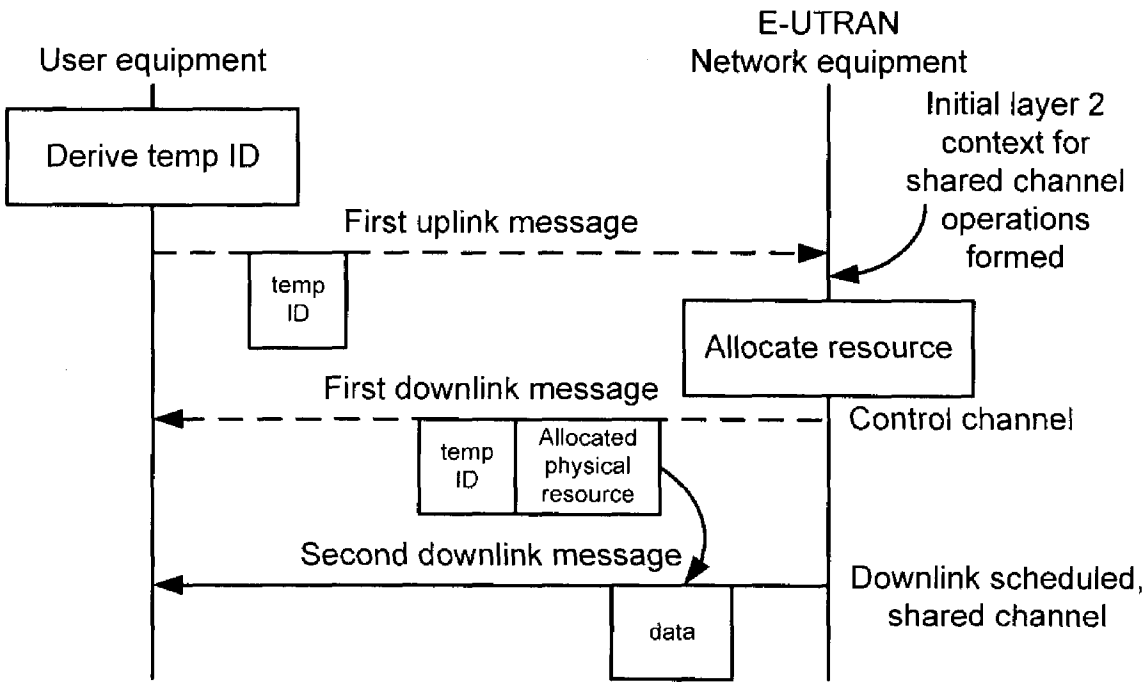
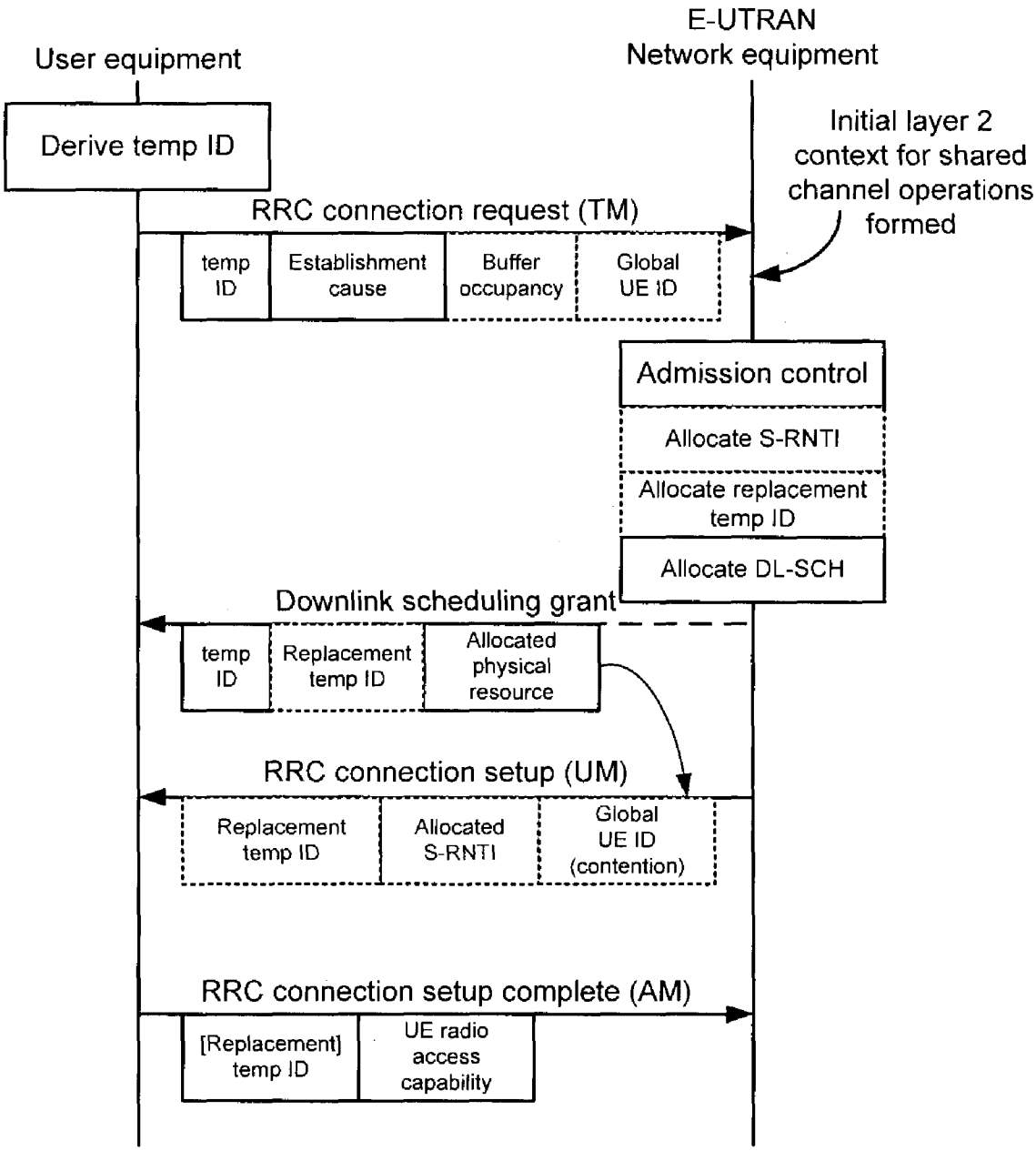



FIGURE 5B




Scheduled downlink connection procedure

FIGURE 6A

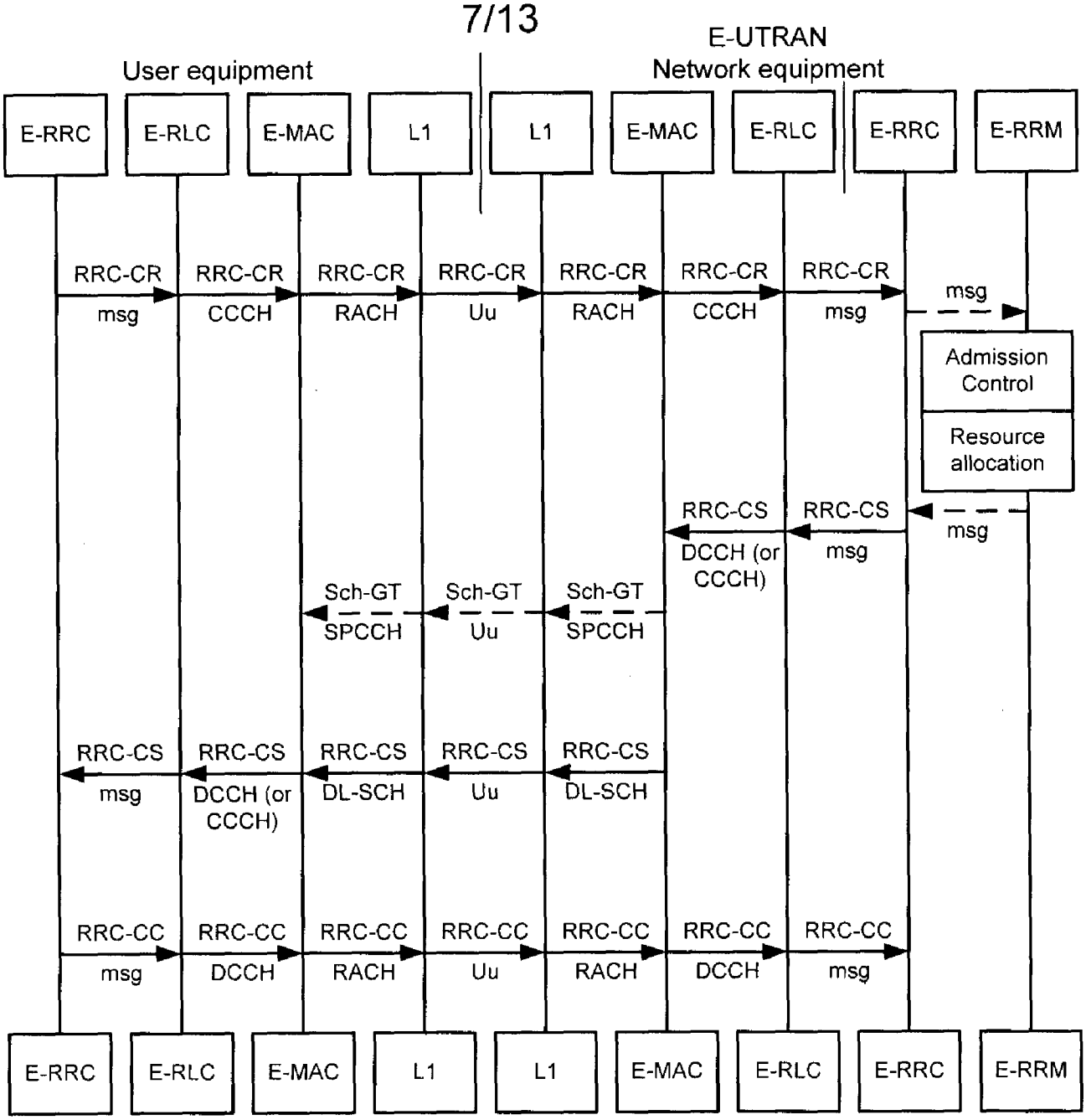
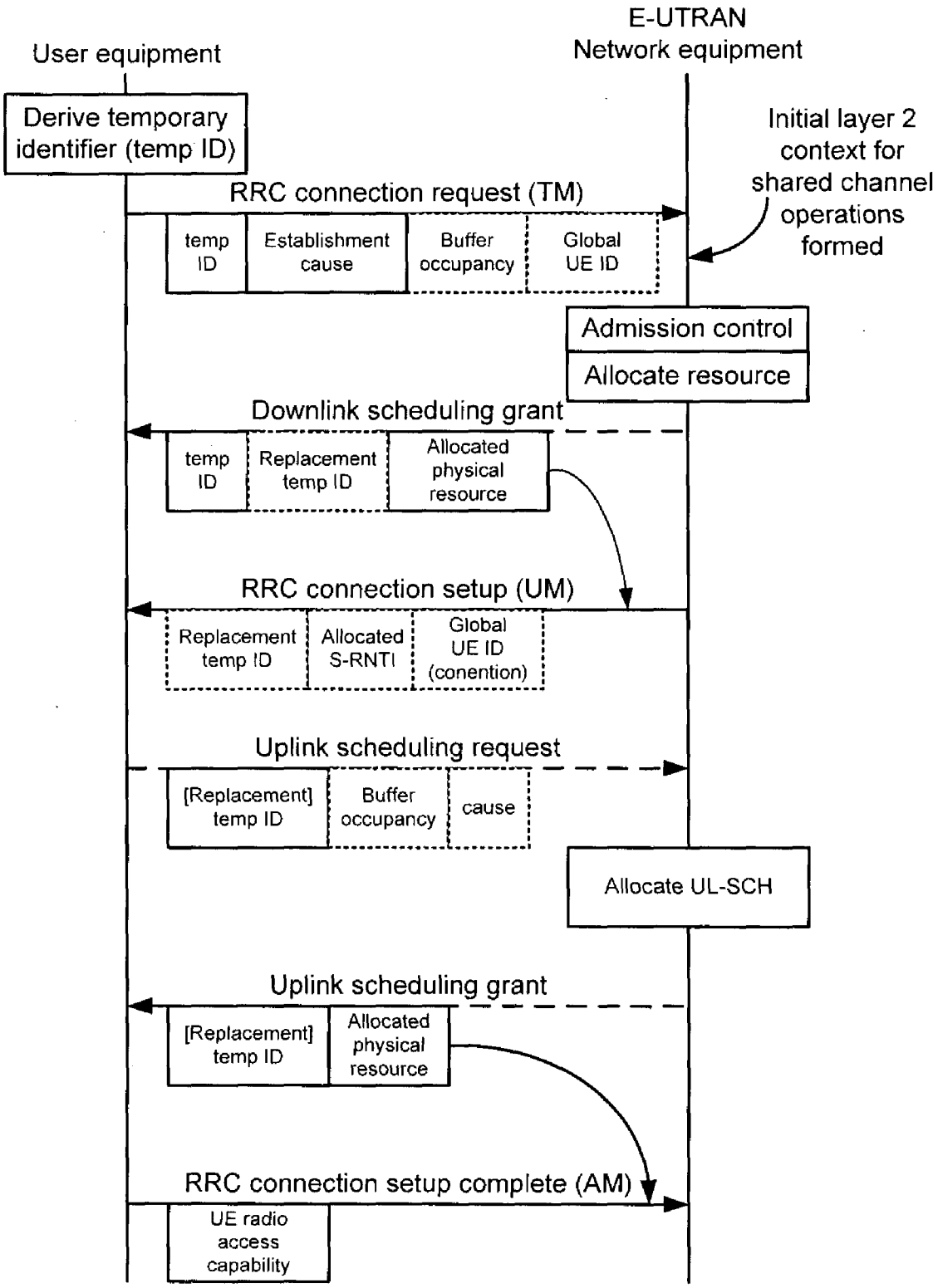

User equipment
E-UTRAN
Network equipment
E-RRC
E-RLC
E-MAC
L1
L1
E-MAC
E-RLC
E-RRC
E-RRM
RRC-CR
msg
RRC-CR
CCCH
RRC-CR
RACH
RRC-CR
Uu
RRC-CR
RACH
RRC-CR
CCCH
RRC-CR
msg
msg
Admission Control
Resource allocation
RRC-CS
DCCH (or CCCH)
RRC-CS
msg
msg
Sch-GT
SPCCH
Sch-GT
Uu
Sch-GT
SPCCH
RRC-CS
msg
RRC-CS
DCCH (or CCCH)
RRC-CS
DL-SCH
RRC-CS
Uu
RRC-CS
DL-SCH
RRC-CC
msg
RRC-CC
DCCH
RRC-CC
RACH
RRC-CC
Uu
RRC-CC
RACH
RRC-CC
DCCH
RRC-CC
msg
E-RRC
E-RLC
E-MAC
L1
L1
E-MAC
E-RLC
E-RRC
E-RRM

FIGURE 6B




Non-scheduled & scheduled uplink, scheduled downlink

FIGURE 7A

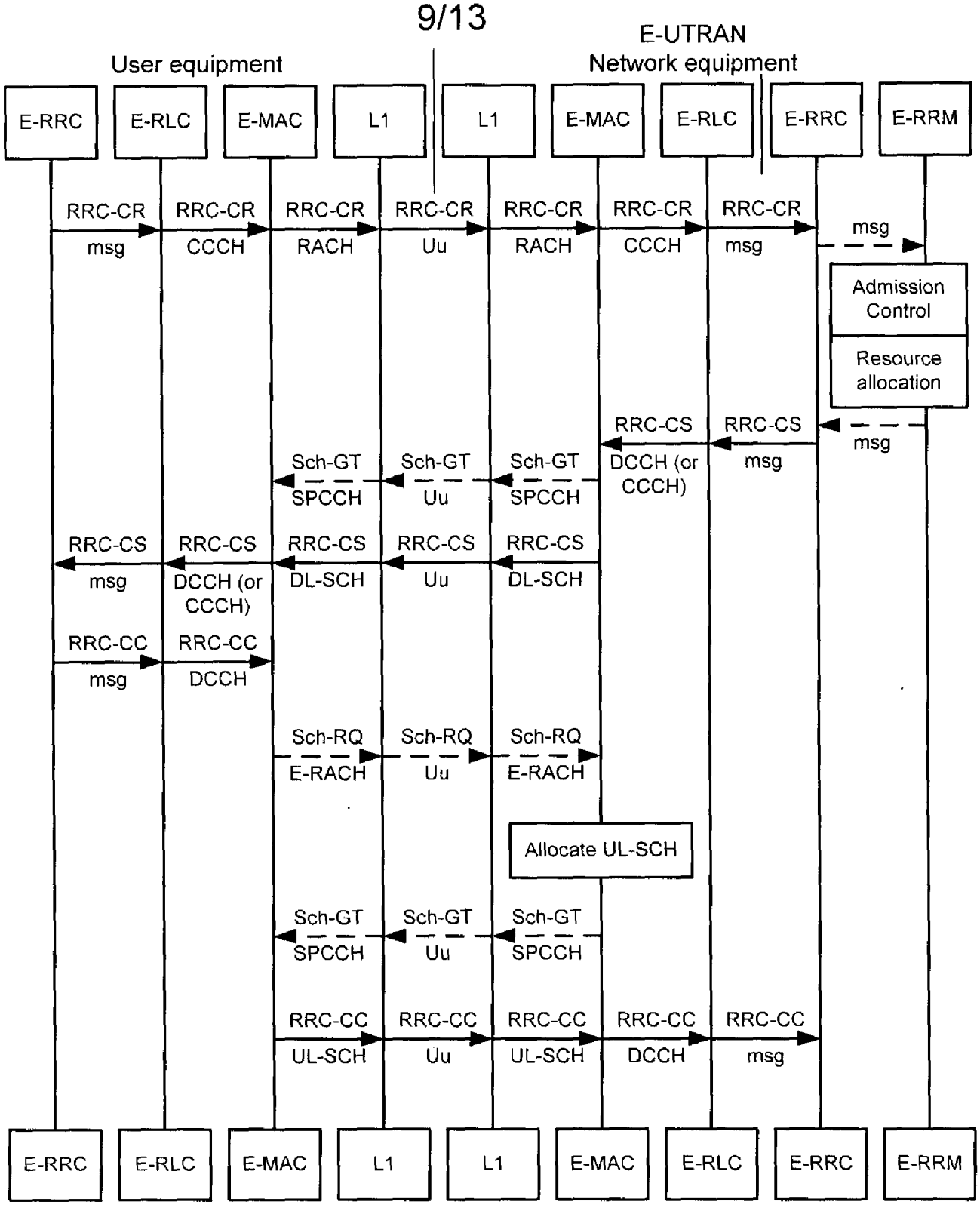
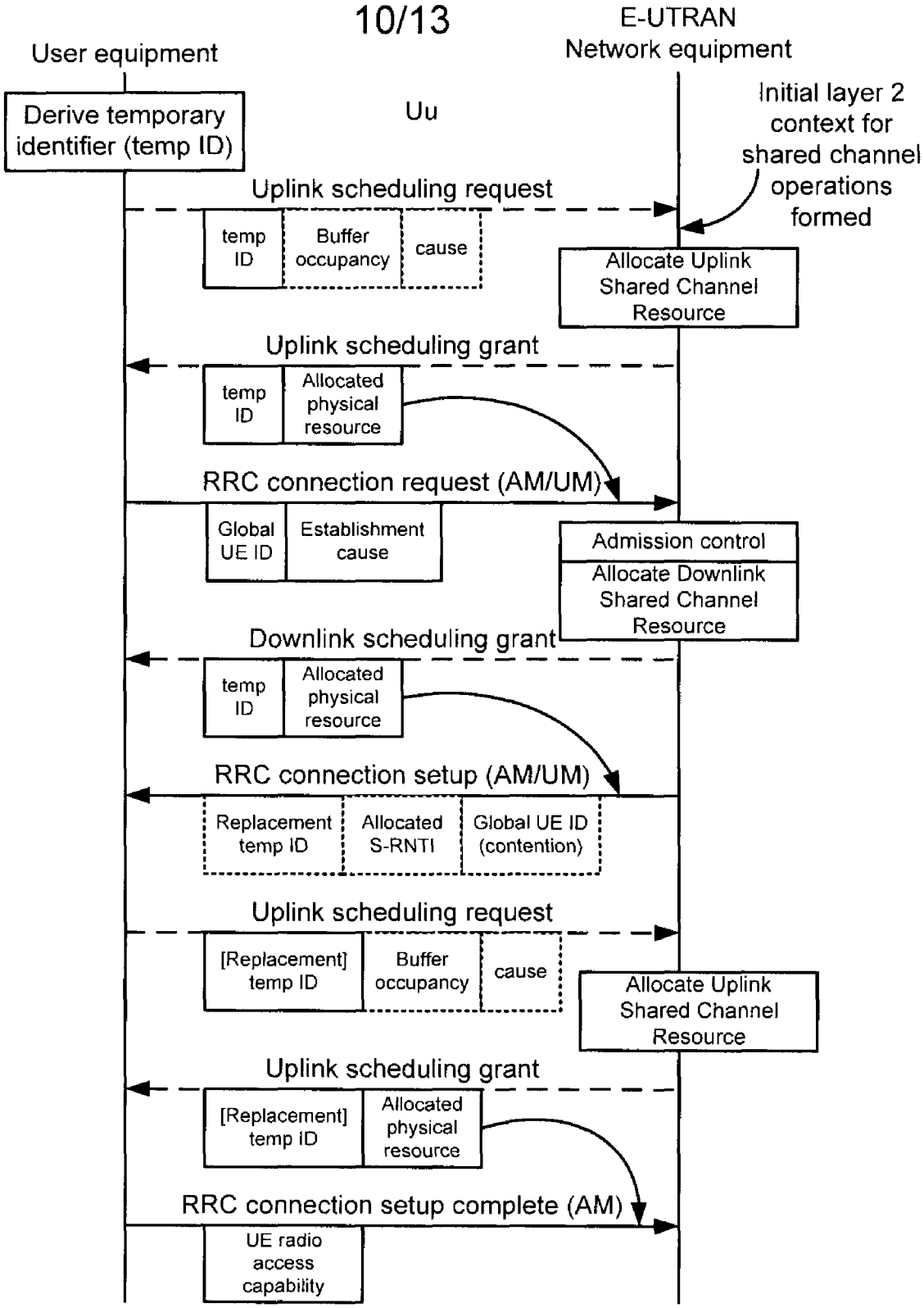

User equipment
E-UTRAN
Network equipment
E-RRC
E-RLC
E-MAC
L1
L1
E-MAC
E-RLC
E-RRC
E-RRM
RRC-CR
msg
RRC-CR
CCCH
RRC-CR
RACH
RRC-CR
Uu
RRC-CR
RACH
RRC-CR
CCCH
RRC-CR
msg
msg
Admission Control
Resource allocation
RRC-CS
DCCH (or CCCH)
RRC-CS
msg
msg
Sch-GT
SPCCH
Sch-GT
Uu
Sch-GT
SPCCH
RRC-CS
msg
RRC-CS
DCCH (or CCCH)
RRC-CS
DL-SCH
RRC-CS
Uu
RRC-CS
DL-SCH
RRC-CC
msg
RRC-CC
DCCH
Sch-RQ
E-RACH
Sch-RQ
Uu
Sch-RQ
E-RACH
Allocate UL-SCH
Sch-GT
SPCCH
Sch-GT
Uu
Sch-GT
SPCCH
RRC-CC
UL-SCH
RRC-CC
Uu
RRC-CC
UL-SCH
RRC-CC
DCCH
RRC-CC
msg
E-RRC
E-RLC
E-MAC
L1
L1
E-MAC
E-RLC
E-RRC
E-RRM

FIGURE 7B




RRC connection procedure
using a shared physical control channel (SPCCH) and
shared transport channels (DL-SCH & UL-SCH)

FIGURE 8A

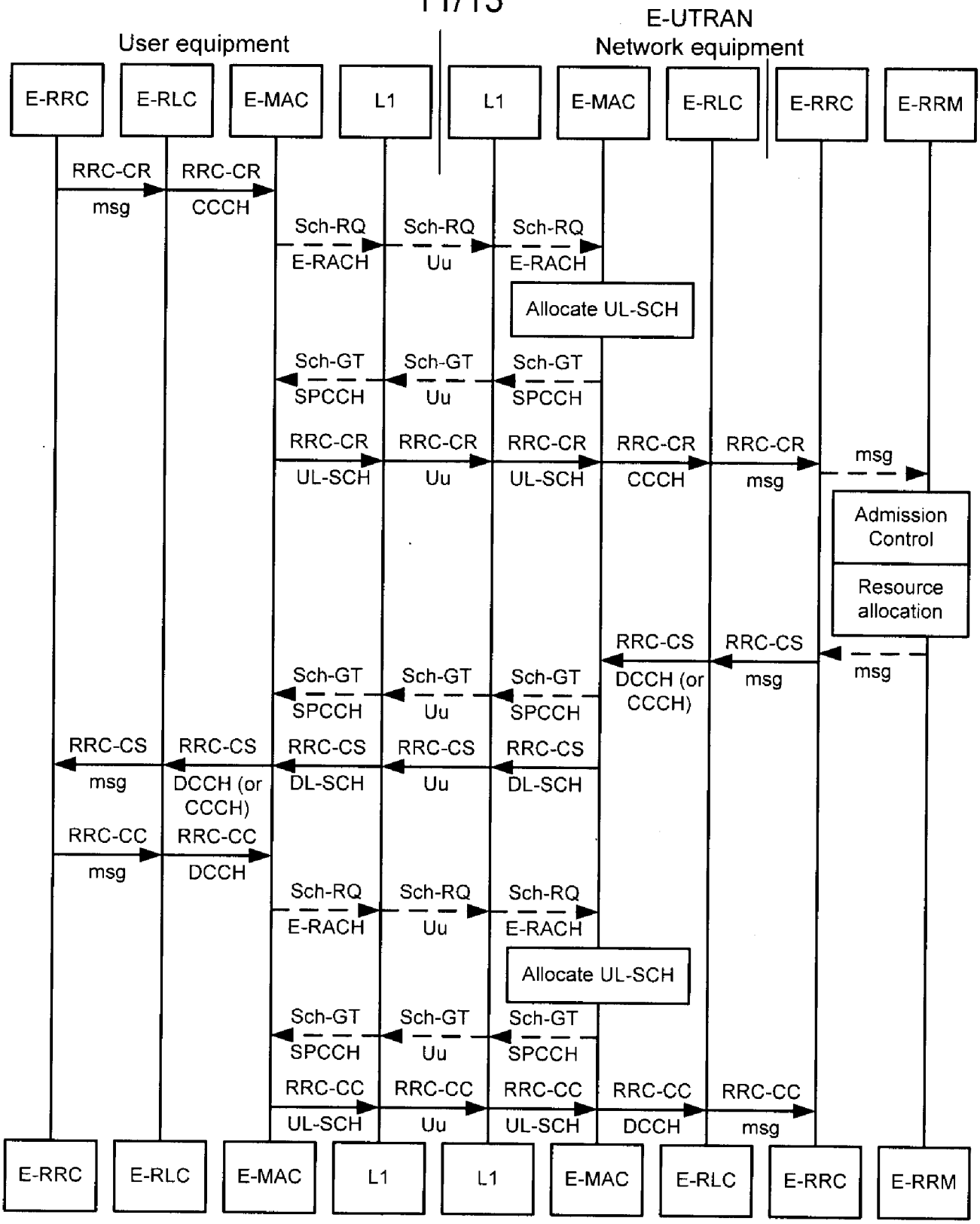
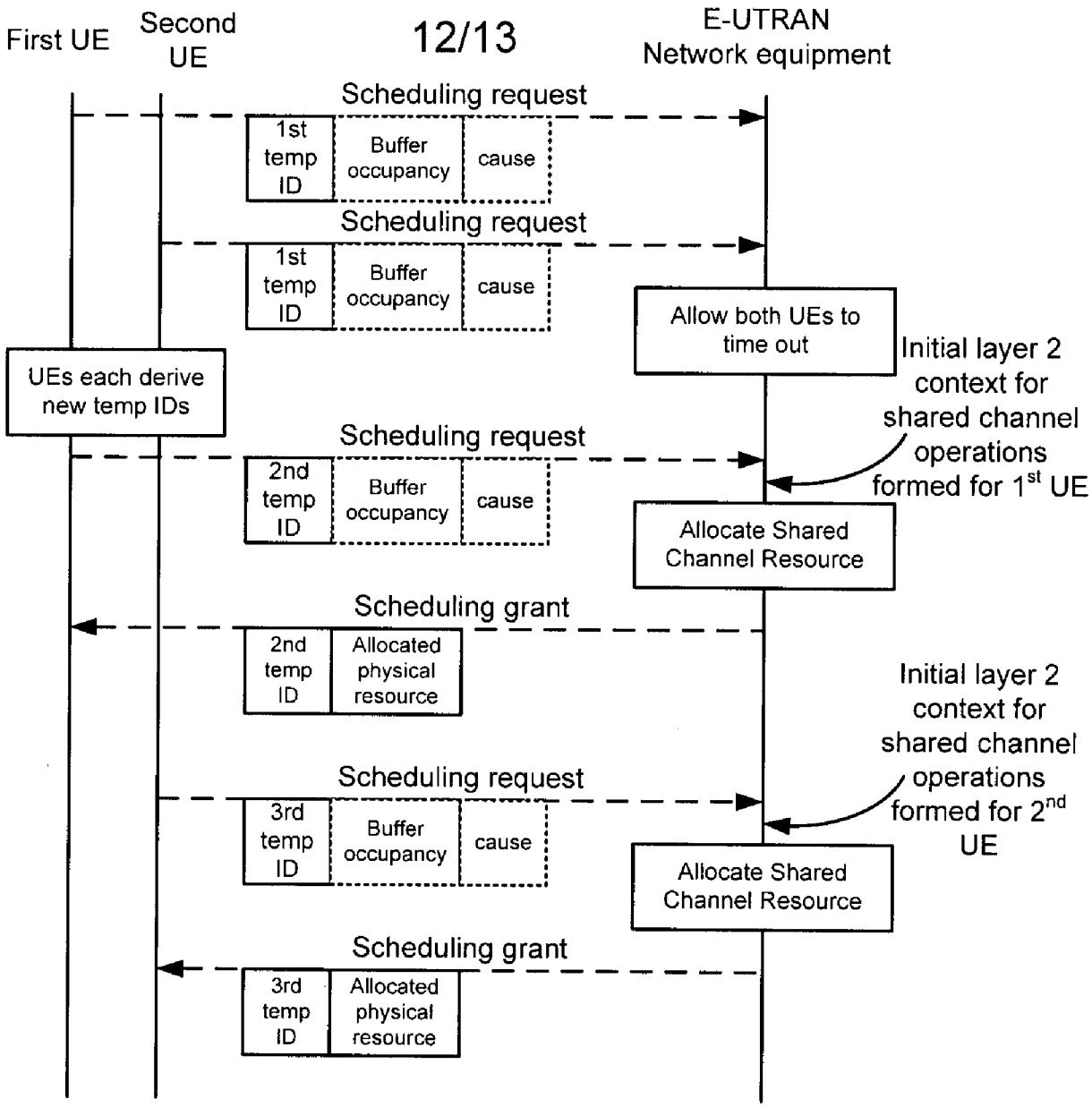
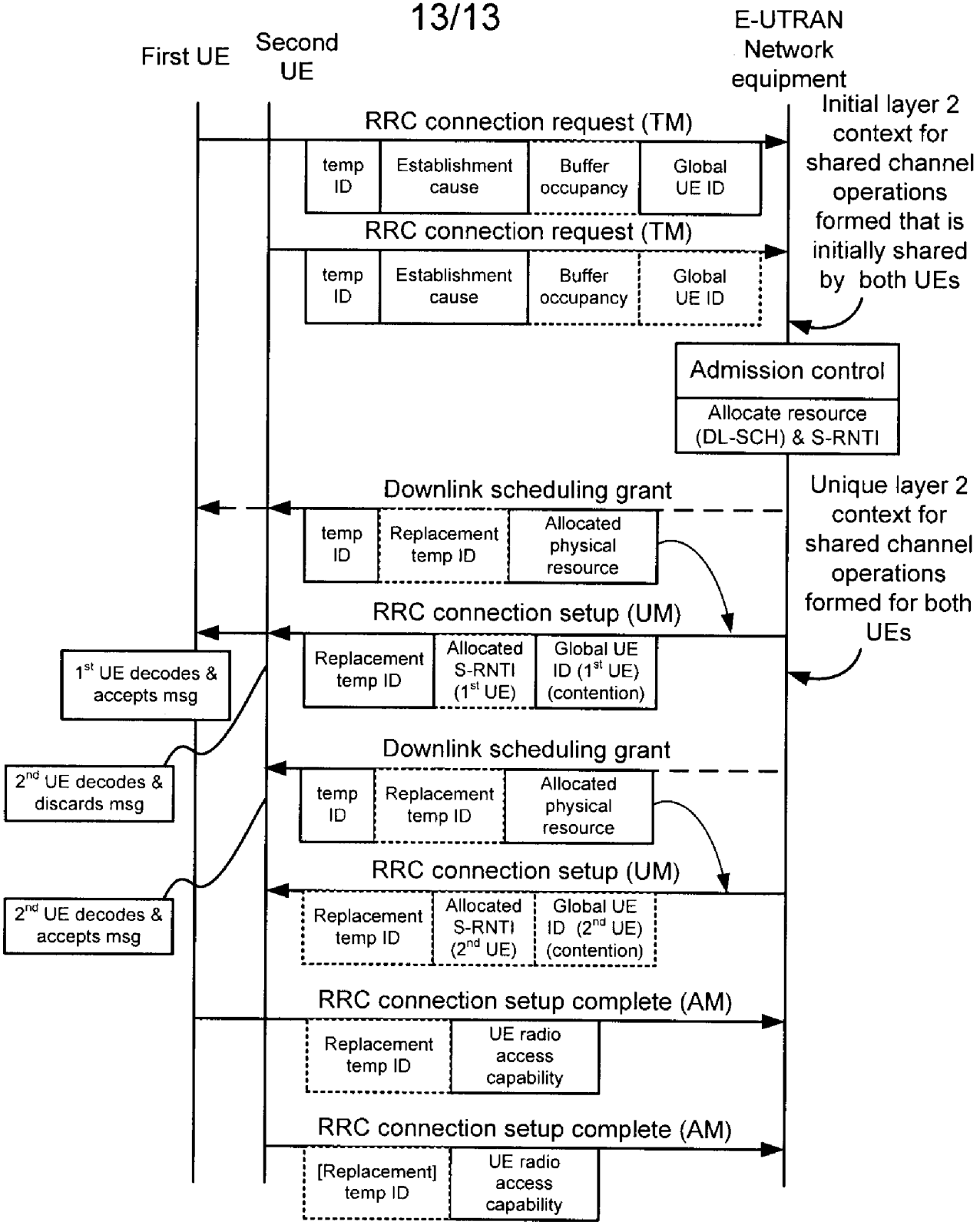

User equipment
E-UTRAN
Network equipment
E-RRC
E-RLC
E-MAC
L1
L1
E-MAC
E-RLC
E-RRC
E-RRM
RRC-CR
msg
RRC-CR
CCCH
Sch-RQ
E-RACH
Sch-RQ
Uu
Sch-RQ
E-RACH
Allocate UL-SCH
Sch-GT
SPCCH
Sch-GT
Uu
Sch-GT
SPCCH
RRC-CR
UL-SCH
RRC-CR
Uu
RRC-CR
UL-SCH
RRC-CR
CCCH
RRC-CR
msg
msg
Admission Control
Resource allocation
RRC-CS
DCCH (or CCCH)
RRC-CS
msg
msg
Sch-GT
SPCCH
Sch-GT
Uu
Sch-GT
SPCCH
RRC-CS
msg
RRC-CS
DCCH (or CCCH)
RRC-CS
DL-SCH
RRC-CS
Uu
RRC-CS
DL-SCH
RRC-CC
msg
RRC-CC
DCCH
Sch-RQ
E-RACH
Sch-RQ
Uu
Sch-RQ
E-RACH
Allocate UL-SCH
Sch-GT
SPCCH
Sch-GT
Uu
Sch-GT
SPCCH
RRC-CC
UL-SCH
RRC-CC
Uu
RRC-CC
UL-SCH
RRC-CC
DCCH
RRC-CC
msg
E-RRC
E-RLC
E-MAC
L1
L1
E-MAC
E-RLC
E-RRC
E-RRM

FIGURE 8B




Contention based RRC connection procedure using a shared physical control channel (SPCCH) and shared transport channels (DL-SCH & UL-SCH)

FIGURE 9




Scheduled downlink connection & conflict resolution procedure

FIGURE 10