(12) UK Patent Application (19) GB (11) 2502581 (13) A

(43) Date of A Publication 04.12.2013

(21) Application No: 1209703.6

(22) Date of Filing: 31.05.2012

(71) Applicant(s):
Renesas Mobile Corporation
(Incorporated in Japan)
6-2, Otemachi 2-Chome, Chiyoda-Ku 100-0004, Tokyo, Japan

(72) Inventor(s):
Samuli Turtinen
Sami-Jukka Hakola
Timo Kalevi Koskela
Anna Pantelidou

(74) Agent and/or Address for Service:
EIP
Fairfax House, 15 Fulwood Place, LONDON, WC1V 6HU, United Kingdom

(51) INT CL:
H04W 84/18 (2009.01) ***H04W 52/02*** (2009.01)

(56) Documents Cited:
GB 2421153 A **WO 2009/158663 A1**
WO 2009/117472 A2

(58) Field of Search:
INT CL **H04W**
Other: **WPI, EPODOC & 3GPP**

(54) Title of the Invention: **Method, apparatus and computer program for communicating**
Abstract Title: **Device discovery signalling**

(57) At a radio link control (RLC) layer (520) only device discovery information (522) is compiled into a first protocol data unit PDU (532) associated with a first radio bearer that is established for device discovery, and service discovery information (526) is compiled into at least a second PDU (536) associated with a second radio bearer. At a medium access control MAC layer (530) the first PDU (532) is prioritised over the second PDU (536). In one embodiment the MAC layer (530) sets priority of the first bearer to infinity before giving the available resources to the RLC layer (520) to ensure that the device discovery gets resources allocated in the RLC layer (520). Prioritising device discovery information in the RLC layer reduces signal processing effort required and so preserves device battery power. The invention has particular benefit in ad-hoc device-to-device (D2D) communications networks (such as machine-to-machine (M2M)).

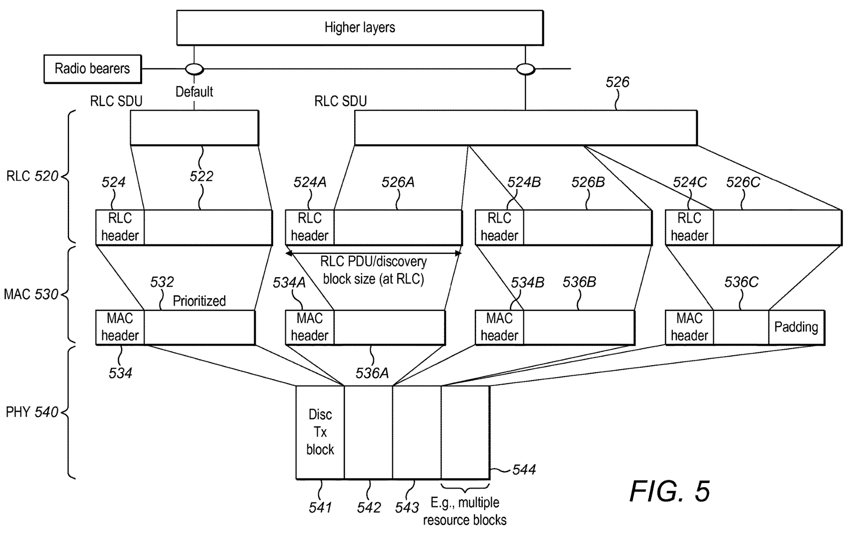

FIG. 5

GB 2502581 A

31 07 13

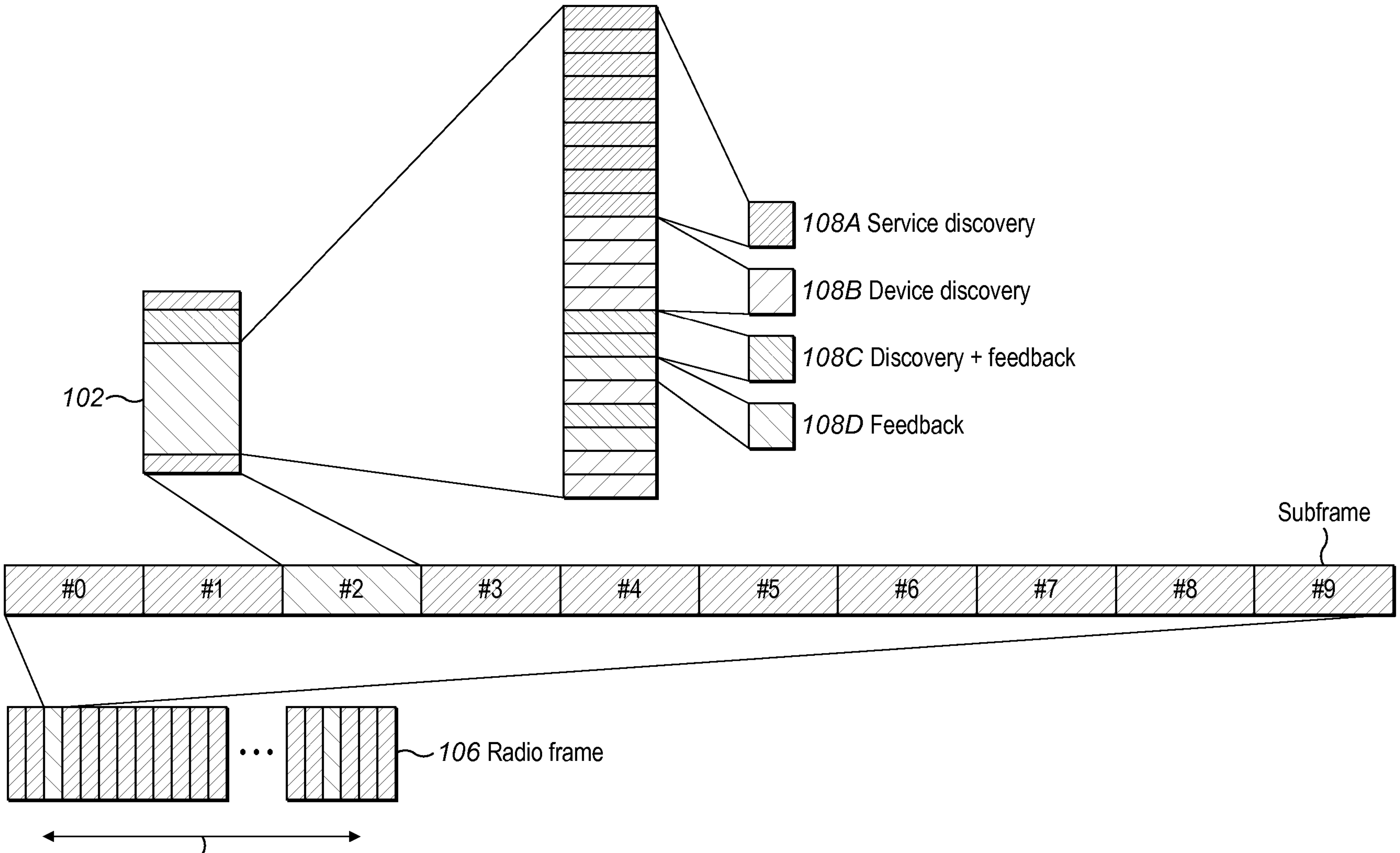

FIG. 1A

31 07 13

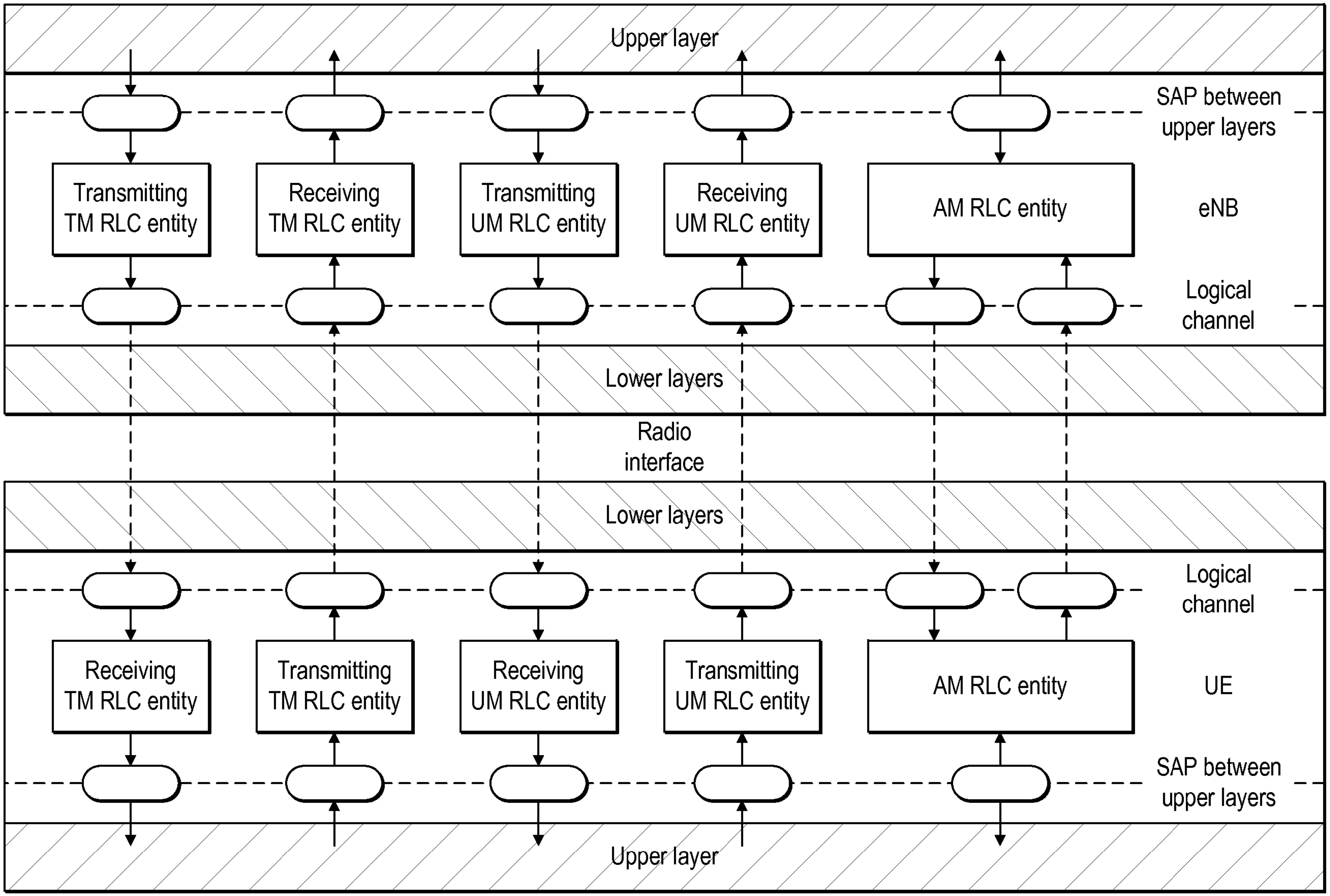

FIG. 1B
Prior Art

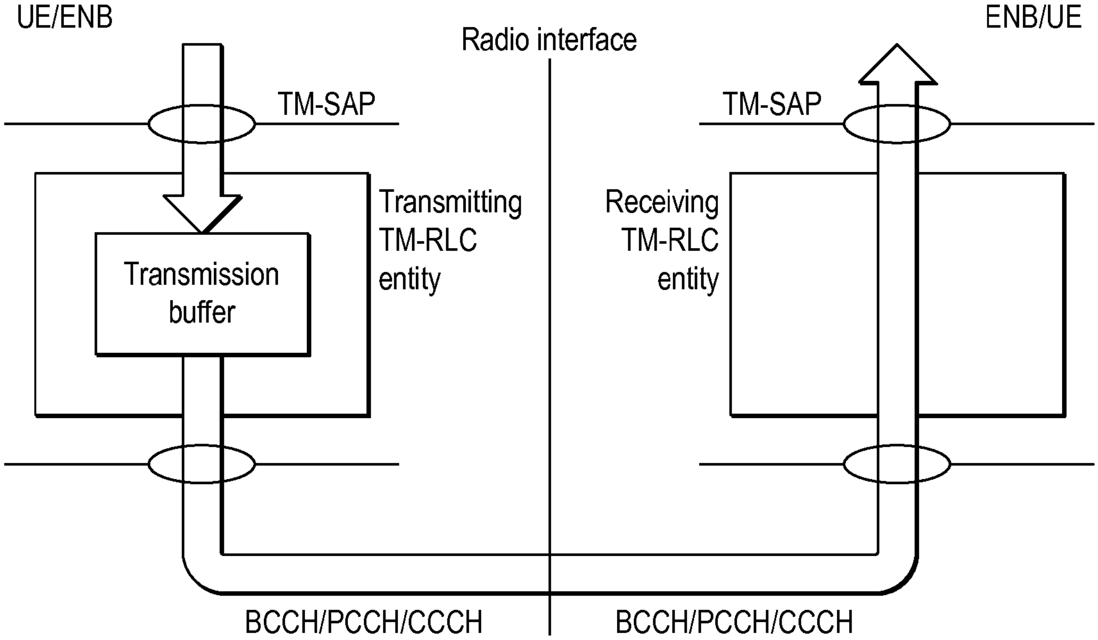

FIG. 1C
Prior Art

31 07 13

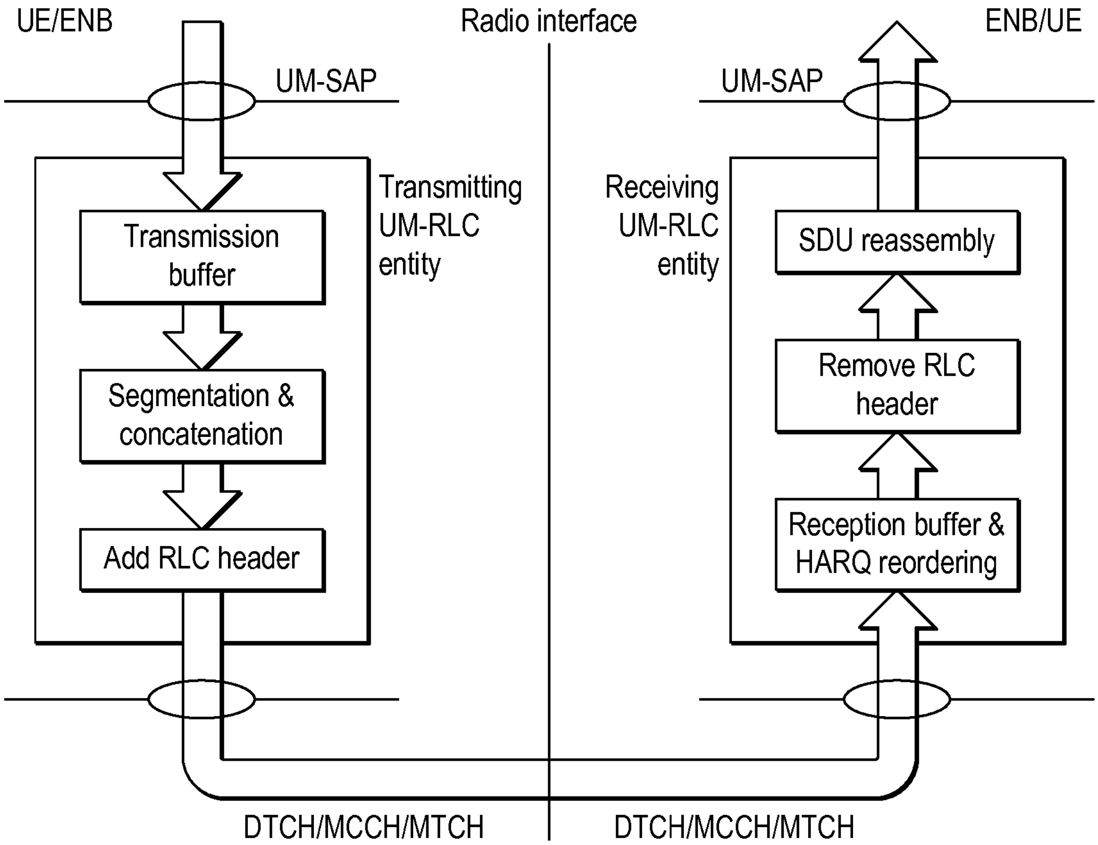

FIG. 1D
Prior Art

31 07 13

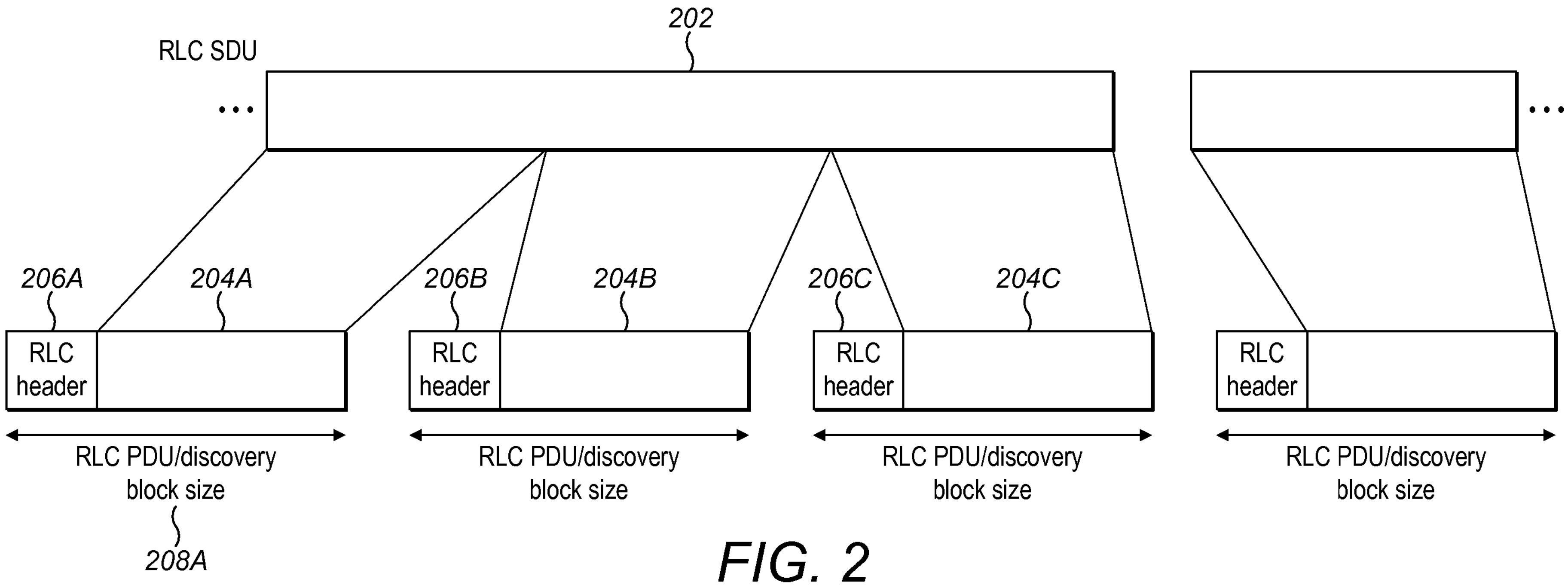
202
RLC SDU
206A
204A
206B
204B
206C
204C
RLC header
RLC header
RLC header
RLC header
RLC PDU/discovery block size
RLC PDU/discovery block size
RLC PDU/discovery block size
RLC PDU/discovery block size
208A

FIG. 2

31 07 13

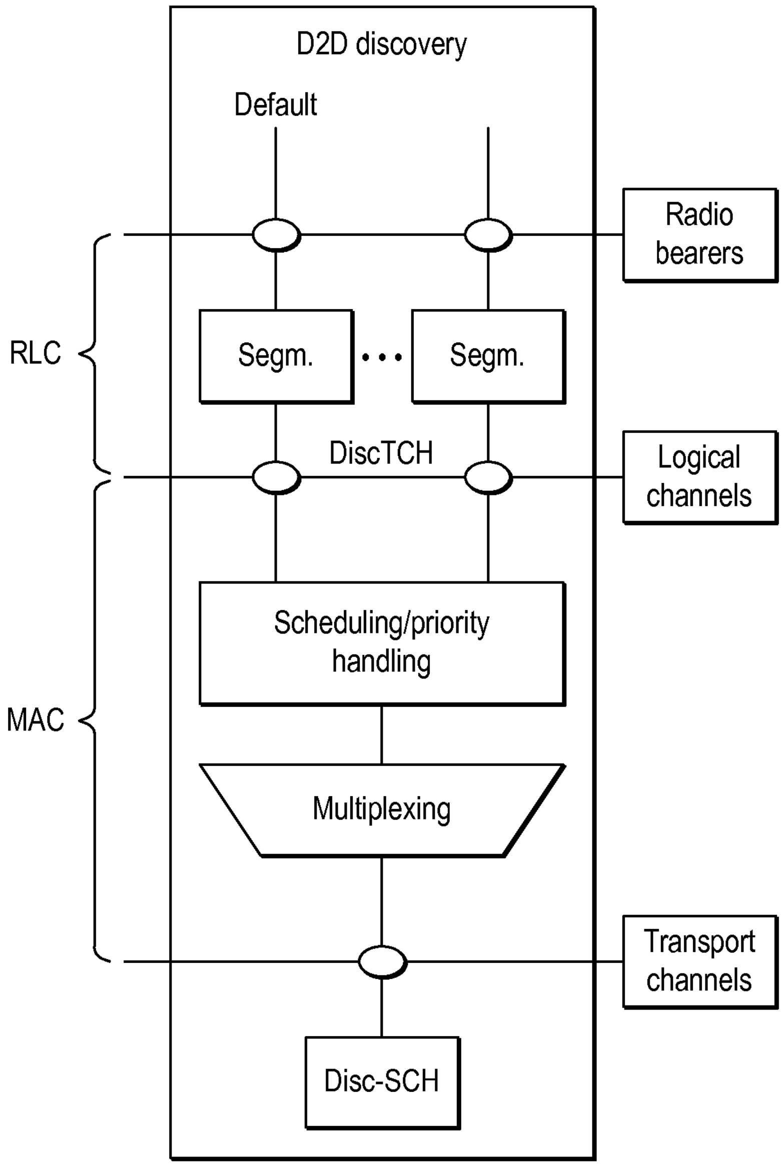
D2D discovery
Default
Radio bearers
RLC
Segm.
Segm.
DiscTCH
Logical channels
Scheduling/priority handling
MAC
Multiplexing
Transport channels
Disc-SCH

FIG. 3

31 07 13

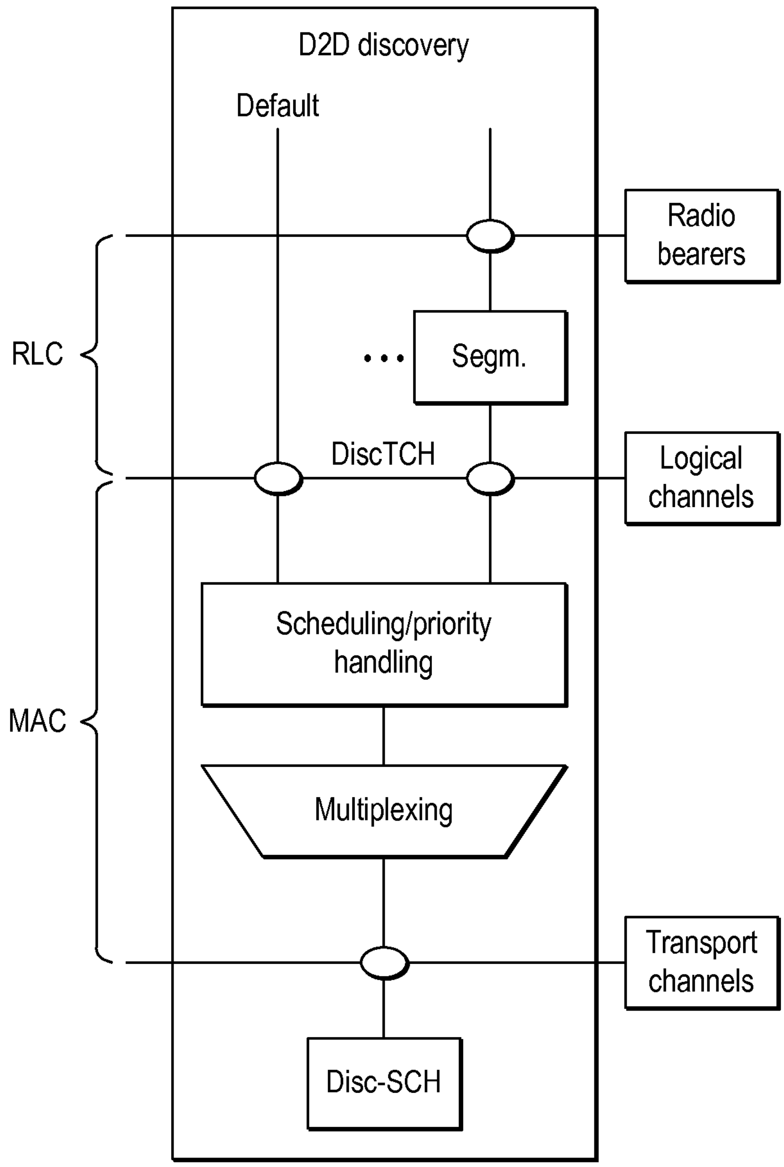
D2D discovery
Default
Radio bearers
RLC
Segm.
DiscTCH
Logical channels
Scheduling/priority handling
MAC
Multiplexing
Transport channels
Disc-SCH

FIG. 4

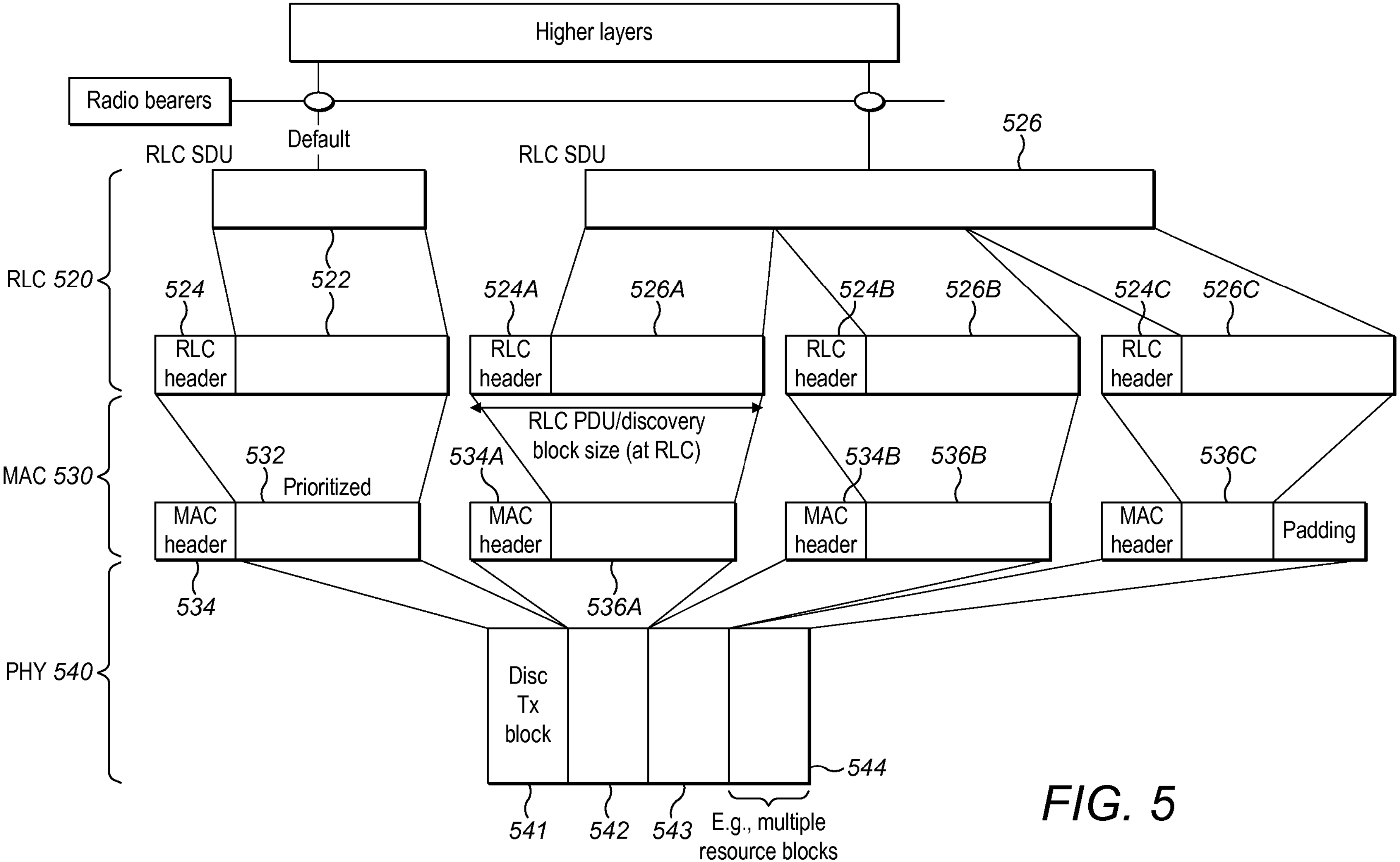
Higher layers
Radio bearers
Default
RLC SDU
RLC SDU
526
RLC 520
MAC 530
PHY 540
524
522
524A
526A
524B
526B
524C
526C
RLC header
RLC header
RLC header
RLC header
RLC PDU/discovery block size (at RLC)
532
Prioritized
534A
534B
536B
536C
MAC header
MAC header
MAC header
MAC header
Padding
534
536A
Disc Tx block
544
541
542
543
E.g., multiple resource blocks

FIG. 5

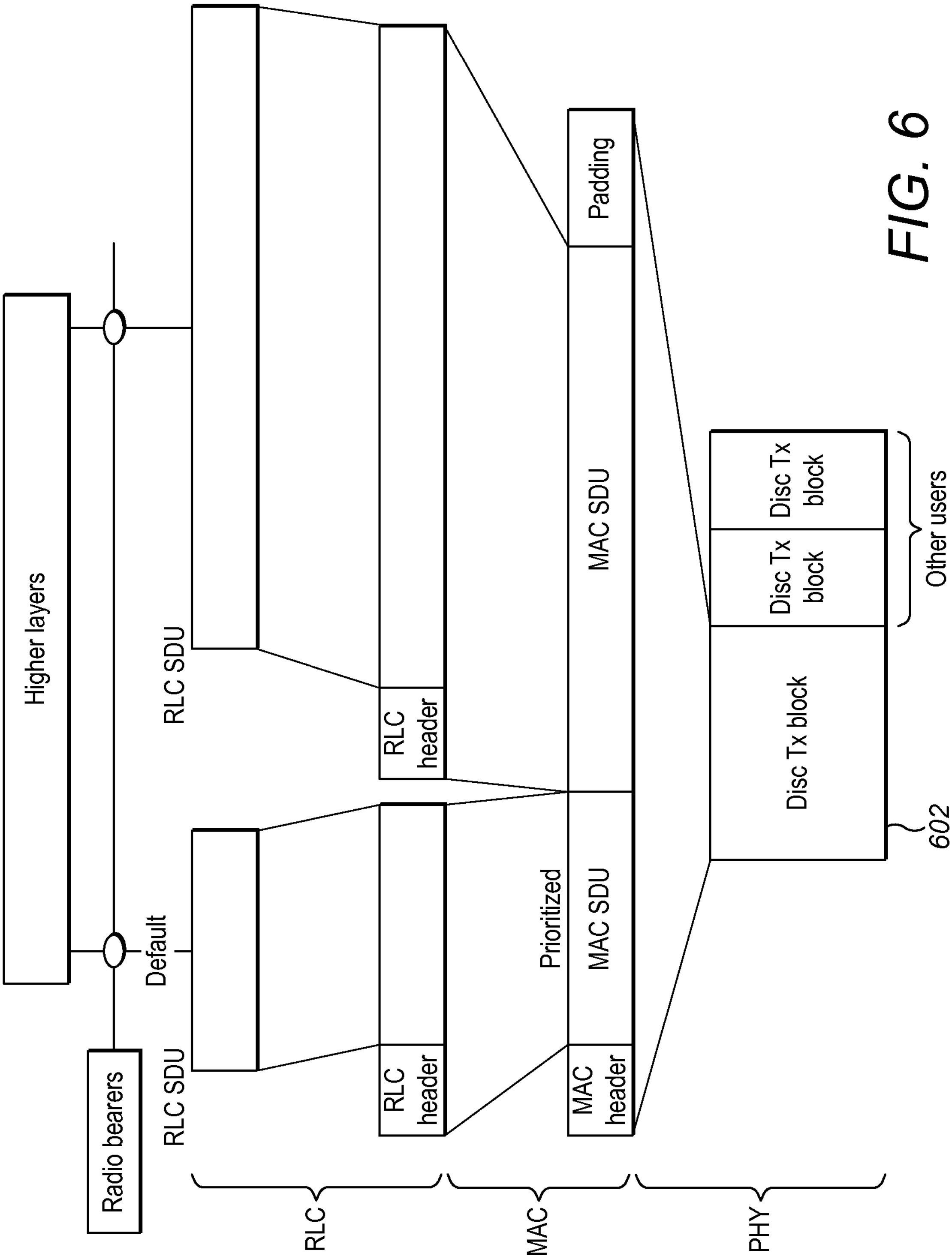
Higher layers
Radio bearers
Default
RLC SDU
RLC SDU
RLC header
RLC header
MAC header
Prioritized MAC SDU
MAC SDU
Padding
Disc Tx block
Disc Tx block
Disc Tx block
Other users
602
RLC
MAC
PHY

FIG. 6

31 07 13

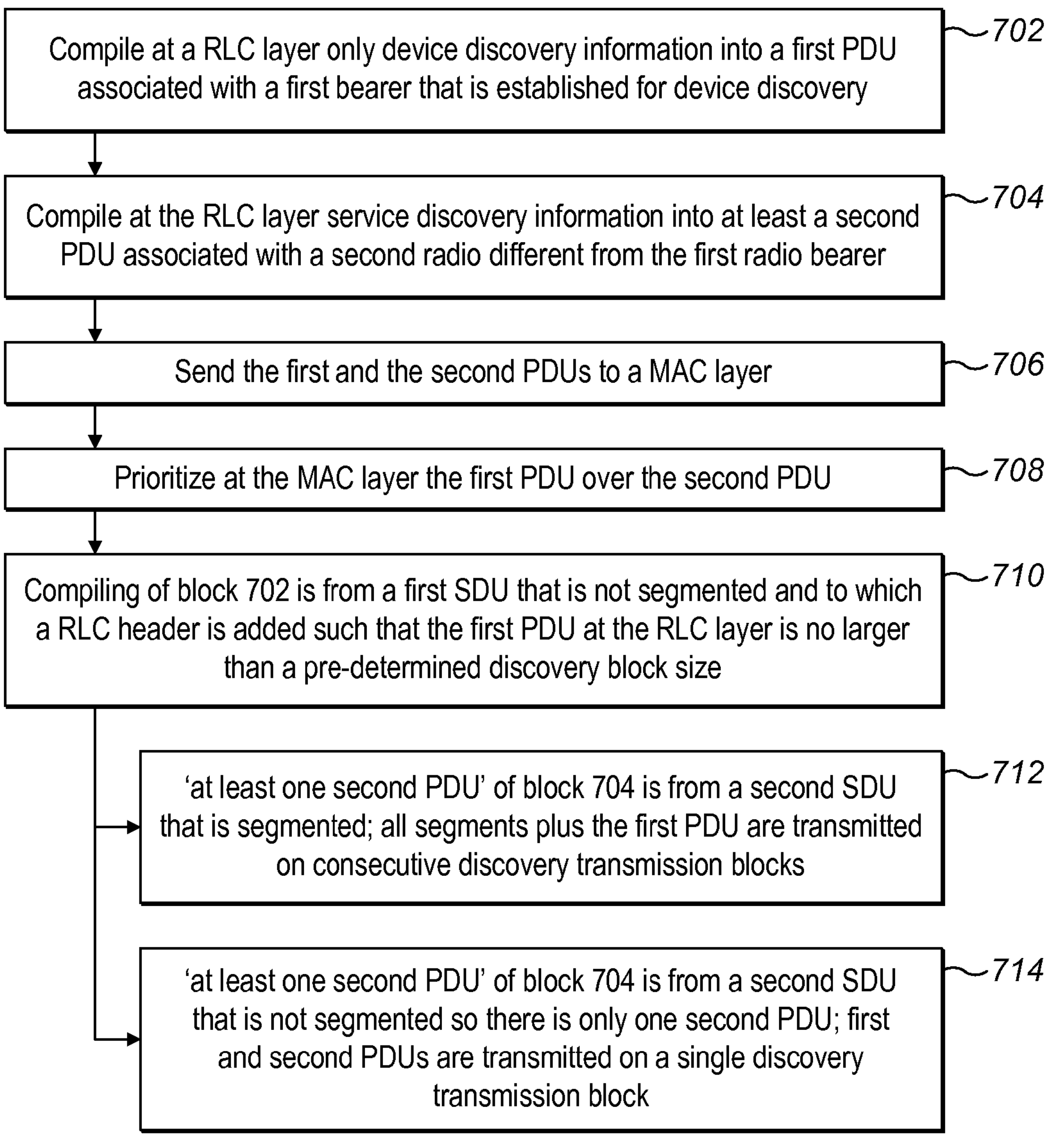
Compile at a RLC layer only device discovery information into a first PDU associated with a first bearer that is established for device discovery
702
Compile at the RLC layer service discovery information into at least a second PDU associated with a second radio different from the first radio bearer
704
Send the first and the second PDUs to a MAC layer
706
Prioritize at the MAC layer the first PDU over the second PDU
708
Compiling of block 702 is from a first SDU that is not segmented and to which a RLC header is added such that the first PDU at the RLC layer is no larger than a pre-determined discovery block size
710
'at least one second PDU' of block 704 is from a second SDU that is segmented; all segments plus the first PDU are transmitted on consecutive discovery transmission blocks
712
'at least one second PDU' of block 704 is from a second SDU that is not segmented so there is only one second PDU; first and second PDUs are transmitted on a single discovery transmission block
714

FIG. 7

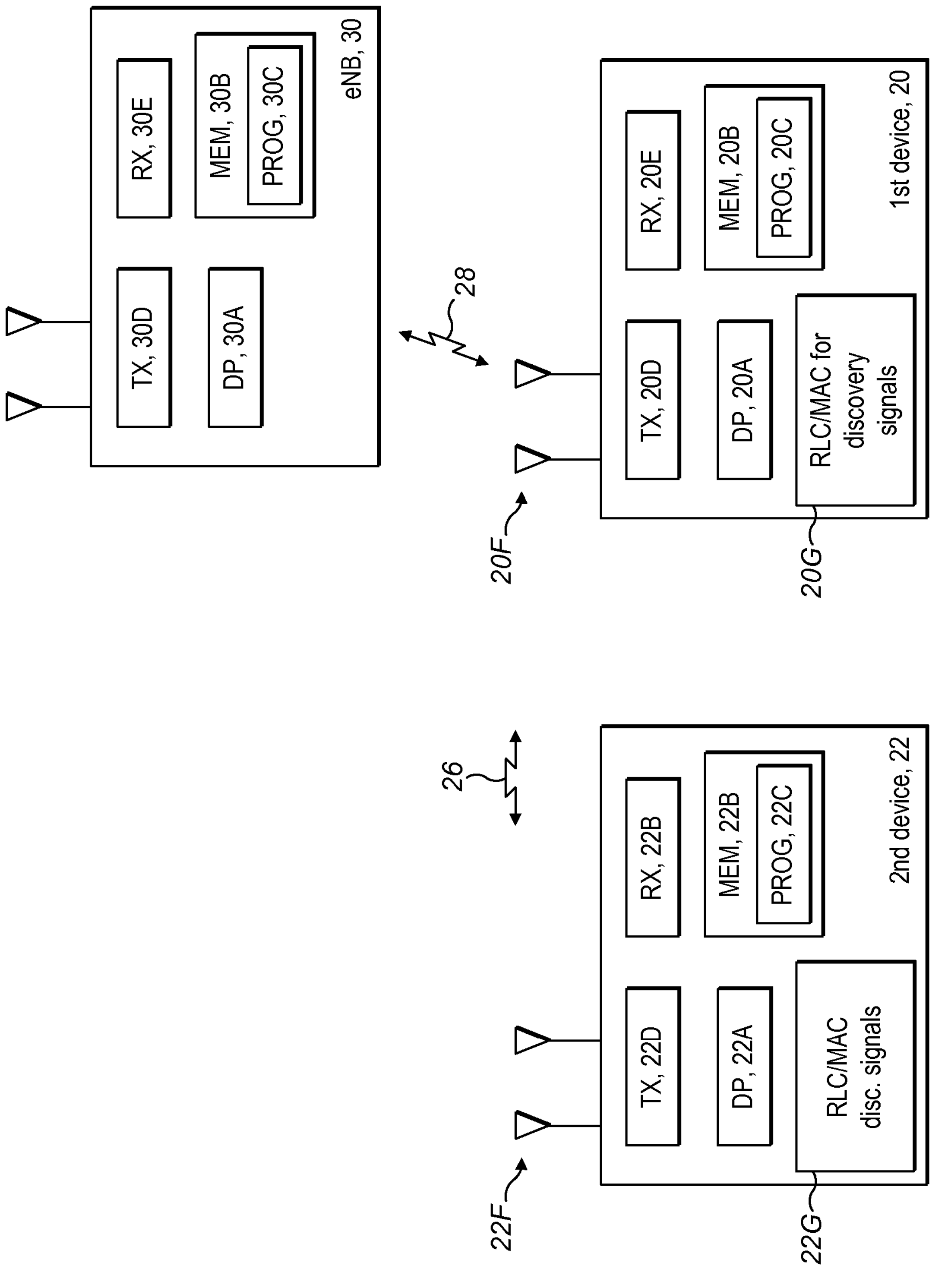
eNB, 30
TX, 30D
DP, 30A
RX, 30E
MEM, 30B
PROG, 30C
28
1st device, 20
TX, 20D
DP, 20A
RLC/MAC for discovery signals
RX, 20E
MEM, 20B
PROG, 20C
20F
20G
26
2nd device, 22
TX, 22D
DP, 22A
RLC/MAC disc. signals
RX, 22B
MEM, 22B
PROG, 22C
22F
22G

FIG. 8

METHOD, APPARATUS AND COMPUTER PROGRAM FOR COMMUNICATING

Technical Field

The present invention relates to a method, apparatus and a computer program for communicating. The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods, devices and computer programs, and in specific embodiments relate to discovery signalling in ad hoc device-to-device D2D communications.

Background

Device to device (D2D) communications have been the subject of increasing research in recent years. D2D encompasses direct communication among portable devices without utilising nodes/base stations of an infrastructure-based wireless network (typically a cellular network such as Global System for Mobile Communications GSM, Wideband Code Division Multiple Access WCDMA, Long Term Evolution LTE or the like). There is a subset of D2D commonly termed machine to machine (M2M) communications which refer to automated communications from and to portable radio devices that are not user controlled, such as for example smart meters, traffic monitors and the like. Typically M2M communications are infrequent and carry only small amounts of data as compared to cellular and D2D communications that are not M2M. To keep costs low, given their more focused purposes many M2M devices have quite limited capabilities as compared to conventional user equipment (UEs).

Specific to LTE and LTE-Advanced systems there has been proposed a study item to evolve the LTE platform in order to intercept the demand of proximity-based applications by studying enhancements to the LTE radio layers that allow devices to discover each other directly over the air, and potentially communicate directly, when viable considering system management and network supervision. See for example documents Tdoc-RP-110706 entitled "On the need for a 3GPP study on LTE device-to-device discovery and communication"; Tdoc RP-110707 entitled "Study on LTE Device to Device Discovery and Communication – Radio Aspects"; and Tdoc-RP-110708 entitled "Study on LTE Device to Device Discovery and Communication – Service and System Aspects" (each by Qualcomm, Inc; TSG RAN#52; Bratislava, Slovakia; May 31-June 3, 2011). Document RP-110706 describes one of the main targets is that the "radio-based discovery process needs also to be coupled with a system architecture and a security architecture that allow the 3GPP operators to retain control of the device behaviour, for example who can emit discovery signals, when and where, what information do they carry, and what devices should do once they discover each other."

One 3GPP working group is currently discussing and defining use cases and service requirements for the D2D. Such use cases include social applications, local advertising, network offloading, smart meters and public safety. Specifically, social applications can use D2D for the exchange of files, photos, text messages, etc, VoIP conversations, one-way streaming video and two-way video conferencing. Multiplayer gaming can use D2D for exchanging high resolution media (voice & video) interactively either with all participants or only with team members within a game environment. In this gaming use case, the control inputs are expected to be received by all game participants with an ability to maintain causality. Network offloading can utilise D2D when an opportunistic proximity offload potential exists. For example, Device 1 can initiate transfer of a media flow from the macro network to a proximity communications session with Device 2, thereby conserving macro network resources while maintaining the quality of the user experience for the media session. Smart meters can use D2D communication among low capability MTC devices, for vehicular communication (safety and non-safety purposes), and possibly also general M2M communication among different capability devices/machines. In the public safety regime, D2D can be made to have TETRA like functionality, and can be either network controlled D2D or a pure ad hoc D2D which does not utilise any network infrastructure for setting up or maintaining the D2D links.

These are the two main realisations of a D2D network, the network-controlled type likely to take place on licensed spectrum under tight operator and (cellular) network control and the other type being ad hoc D2D which needs to be able to work autonomously without network coverage. For the ad hoc type at least, there is the problem of how the various devices discover one another. Proximity peer discovery consists of discovering other peers in proximity where a peer may be another device, a service provided on a device, or an application running on a device. Discovery of different types of peers can be considered to happen in different layers. Device discovery may happen on the radio layer whereas service and application discovery may happen in higher layers. But the typical D2D device is expected to operate on a portable power supply, and so the signal processing effort these devices go through to discover one another should be limited so as to preserve battery power. For this reason, blind detection and searching across wideband spectrum is not a viable solution for devices to learn whether and what peers are in range.

Summary

According to a first aspect of the present invention, there is provided a method for communicating, the method comprising: compiling at a radio link control layer only device discovery information into a first protocol data unit associated with a first radio bearer that is established for device discovery; compiling at the radio link control layer service discovery information into at least a second protocol data unit associated with a second radio bearer different from the first radio bearer; sending the first and the second protocol data units to a medium access control layer; and prioritising at a medium access control layer the first protocol data unit over the second protocol data unit.

According to a second aspect of the present invention, there is provided apparatus comprising a processing system configured to cause the apparatus to perform at least: compiling at a radio link control layer only device discovery information into a first protocol data unit associated with a first radio bearer that is established for device discovery; compiling at the radio link control layer service discovery information into at least a second protocol data unit associated with a second radio bearer different from the first radio bearer; sending the first and the second protocol data units to a medium access control layer; and prioritising at a medium access control layer the first protocol data unit over the second protocol data unit.

The processing system described above may comprise at least one processor and at least one memory storing a computer program, the processing system being configured to cause the apparatus to perform at least as described above.

According to a third aspect of the present invention, there is provided a computer program comprising a set of instructions which, when executed on a first device causes the first device to perform at least: compiling at a radio link control layer only device discovery information into a first protocol data unit associated with a first radio bearer that is established for device discovery; compiling at the radio link control layer service discovery information into at least a second protocol data unit associated with a second radio bearer different from the first radio bearer; sending the first and the second protocol data units to a medium access control layer; and prioritising at a medium access control layer the first protocol data unit over the second protocol data unit.

There may be provided a computer readable memory tangibly storing a set of instructions as described above.

Examples of embodiments of the present invention provide an efficient way for D2D peers to discover one another.

Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1A shows schematically a high level frame structure showing different discovery signals being multiplexed in a discovery occasion within cellular communication resources;

Figure 1B shows schematically a prior art overview model of the RLC sub layer, reproduced from Figure 4.2.1-1 of 3GPP TS 36.322 V10.0.0;

Figure 1C shows schematically a prior art model of two transparent mode peer entities reproduced from Figure 4.2.1.1.1-1 of 3GPP TS 36.322 V10.0.0;

Figure 1D shows schematically a prior art model of two unacknowledged mode peer entities reproduced from Figure 4.2.1.2.1-1 of 3GPP TS 36.322 V10.0.0;

Figure 2 shows an exemplary schematic illustration of the segmentation of discovery data at the RLC layer done by RLC entity for a discovery message according to an exemplary embodiment of these teachings;

Figure 3 shows an exemplary schematic diagram showing implementation of RLC and MAC layers for D2D discovery with the device discovery bearer going through the RLC entity in TM mode according to an exemplary embodiment of these teachings;

Figure 4 is similar to Figure 3 but illustrating another exemplary implementation of RLC and MAC layers for the D2D discovery according to another exemplary embodiment of these teachings;

Figure 5 shows an exemplary schematic diagram illustrating the information flow of D2D discovery at radio stack in which the contiguous allocation in the physical layer is constructed of multiple components which at the MAC layer are the size of the discovery block and which are segmented at the RLC layer according to an exemplary embodiment of these teachings;

Figure 6 is similar to Figure 5 but illustrating another exemplary implementation of the information flow according to another exemplary embodiment of these teachings;

Figure 7 shows a logic flow diagram that illustrates from the perspective of a D2D device the operation of a method, and a result of execution of computer program instructions embodied on a computer readable memory, in accordance with an exemplary embodiment of these teachings; and

Figure 8 shows a simplified block diagram of two D2D devices, which are exemplary electronic devices suitable for use in practising the exemplary embodiments of this invention.

Detailed Description

Embodiments of these teachings consider how discovery signals are formed and where they may be found by other devices in an ad hoc D2D network. To conserve power it is convenient that all the participating D2D devices in a local area transmit their own discovery signals within a given time period, sometimes termed a discovery transmission occasion 102 which is shown as subframe #2 at Figure 1A. These discovery transmission occasions are spaced from one another at regular intervals termed the discovery cycle 104, also shown at Figure 1A as spanning multiple radio frames 106. This arrangement allows any individual device to transmit its own discovery signal and to listen for such signals from other D2D devices without having to continuously listen to the channel on which discovery signals are transmitted. Timing for when this discovery transmission occasion 104 is to occur may be based on a timing signal from an infrastructure/cellular network, or it may be self-organised by the D2D devices themselves according to a pre-arranged organising protocol, or it may be pre-arranged and static such as by being published in a D2D radio standard along with the length of the discovery cycle 104.

For the various D2D devices to efficiently communicate it is convenient to use an existing radio access technology and adapt it as necessary. The solution below uses the Evolved Universal Terrestrial Radio Access Technology (E-UTRAN, or LTE) as a non-limiting example. Figure 1 uses the LTE frame structure with subframe #2 once per discovery cycle 104 for the discovery signalling.

The discovery transmission occasion 102 may consist of different kinds of signals carrying different kinds of information. For example, device discovery 108A is different from service discovery 108B; the latter would typically require much more data to be transmitted over the actual physical link, in order to convey for example application layer data for relevance detection or advertisement broadcasts. While the relevance detection happens in the radio layer, in some embodiments the application level data could be transmitted in a discovery message. It is assumed that a UE device needs to blindly decode the discovery signals transmitted within one discovery occasion without any more accurate scheduling information than knowing the frequency region used for discovery signal transmissions. Isolating the discovery signals from all devices to only the discovery transmission occasions 102 improves system efficiency from a signalling overhead perspective, since the detailed discovery signal scheduling information does not need to be provided for all the devices, other than perhaps the transmitter of the discovery signal. It also saves power in the listening devices since it limits the search space in which they need to blindly detect.

To improve the blind decoding performance at the receiver of the discovery signals, it is helpful to have as few a number of different transport block sizes as possible, and also to use a fixed modulation and coding scheme (MCS) for the discovery signals at the physical layer as much as possible. A similar technique is used in the LTE system for the message sizes of the physical downlink control channel downlink control information (PDCCH DCI). But since it is unknown in advance what will be transmitted in any given discovery transmission occasion 102, without further refinement the only way to ensure that there is sufficient space in the physical layer for data signals having a high volume of data is to over-allocate the resources set aside for discovery signals and fill in any unused portion with padding bits whenever the discovery signals have a lower data volume.

According to a first embodiment of these teachings, there is one logical channel, and thus one radio bearer, reserved only for the device discovery 108A separate from the other discovery related data such as service discovery 108B and feedback 108C-D. In one implementation this logical channel is a default bearer of the D2D discovery, so that every D2D device knows in advance the bearer on which they should listen to see if any other D2D devices are nearby and transmitting discovery to indicate their presence. Whether a default bearer or not, in another implementation the medium access control (MAC) layer prioritises this device discovery 108A logical channel over the other logical channels conveying discovery data, such as service discovery 108B and discovery with feedback 108C. In this manner, when the block size constraints detailed below are imposed, at least the device discovery message can always be conveyed in any discovery transmission and the transmitter of each discovery message can be identified at the communication layer of the receiver when the receiver is decoding the discovery data it received.

In a further implementation of this first embodiment, the cellular network configures, commonly within a certain D2D discovery area, the logical channel identifiers (IDs) which are used for bearers conveying the different discovery data 108A, 108B, 108C, 108D. For example, this configuration may be done by a D2D control entity which may be located in the radio access network (RAN) or in the core network (CN); in the RAN the D2D control entity may be a network access node such as for example the eNB, or a multi-cell coordination entity (MCE) defined for D2D purposes, and in the CN it may be a D2D server or similar.

Before detailing other aspects of these teachings, following is a review of some salient aspects of the different logical layers in the LTE system. Figure 1B shows an overview model of the radio link control (RLC) sub layer, reproduced from Figure 4.2.1-1 of 3GPP TS 36.322 V10.0.0. The RLC sublayer consists of three RLC entities: a Transparent Mode (TM) entity, an Unacknowledged Mode (UM) entity, and an Acknowledged Mode (AM) entity. All three types support RLC service data units (SDUs) of variable sizes which are byte aligned (i.e. multiple of 8 bits). And in all three types, the RLC protocol data units (PDUs) are formed only when a transmission opportunity has been notified by some lower layer (i.e. by MAC) and are then delivered to a lower layer.

A TM RLC entity can be configured to deliver/receive RLC PDUs through the following logical channels: broadcast control channel (BCCH), downlink or uplink common control channels (DL/UL CCCH) and the paging control channel (PCCH). This is shown schematically at Figure 1C, which is reproduced from Figure 4.2.1.1.1-1 of 3GPP TS 36.322 V10.0.0 and which shows the model for two transparent mode peer entities. These TM RLC entities shown at Figure 1C deliver and receive TM data PDUs (abbreviated as TMD PDUs). When a transmitting TM RLC entity forms TMD PDUs from RLC SDUs, it is prohibited from segmenting or concatenating the RLC SDUs, and from including any RLC headers in the TMD PDUs. When a receiving TM RLC entity receives TMD PDUs, it is required to deliver the TMD PDUs (which are just RLC SDUs) to the next upper layer.

Figure 1D shows schematically a prior art model of two unacknowledged mode peer entities reproduced from Figure 4.2.1.2.1-1 of 3GPP TS 36.322 V10.0.0. An UM RLC entity can be configured to deliver/receive RLC PDUs through the following logical channels: DL/UL dedicated channel (DTCH), multimedia broadcast multicast service control channel (MCCH) or multicast transport channel (MTCH). These UM RLC entities shown at Figure 1D deliver and receive UM data PDUs (abbreviated as UMD PDUs). Hybrid automatic repeat request (HARQ) reordering is not applicable for MCCH or MTCH reception.

When a transmitting UM RLC entity forms UMD PDUs from RLC SDUs, it is required to segment and/or concatenate the RLC SDUs so that the UMD PDUs fit within the total size of RLC PDU(s) indicated by the lower layer at the particular transmission opportunity notified by the lower layer. The UM RLC entity is also required to include relevant RLC headers in the UMD PDU.

When a receiving UM RLC entity receives UMD PDUs, it is required to:

- detect whether or not the UMD PDUs have been received in duplication, and discard duplicated UMD PDUs;
- reorder the UMD PDUs if they are received out of sequence;
- detect the loss of UMD PDUs at lower layers and avoid excessive reordering delays;
- reassemble RLC SDUs from the reordered UMD PDUs (not accounting for RLC PDUs for which losses have been detected) and deliver the RLC SDUs to the upper layer in ascending order of the RLC SN; and
- discard received UMD PDUs that cannot be re-assembled into a RLC SDU due to loss at lower layers of an UMD PDU which belonged to the particular RLC SDU.

At the time of RLC re-establishment, the receiving UM RLC entity is required to:

- if possible, reassemble RLC SDUs from the UMD PDUs that are received out of sequence and deliver them to the upper layer;
- discard any remaining UMD PDUs that could not be reassembled into RLC SDUs; and
- initialise relevant state variables and stop relevant timers.

For the following examples the discovery data is integrity protected and ciphered by upper layers (e.g. the packet data convergence protocol (PDCP) layer) and thereafter is delivered to the peer RLC entity on logical channels dedicated to

D2D discovery. The RLC entity is assumed to be in UM mode. In other embodiments at least the integrity protection is not required for D2D discovery signals.

As an overview of these different protocol layers, a protocol stack consists of many different individual protocols, which may be considered as a set of rules that allow communication between peer entities (or to facilitate horizontal communication). These protocols are arranged in layers as can be seen in Figure 1B and also Figure 2. In the transmitter side, a layer N receives data in the form of an SDU from layer N+1. This layer N modifies the data and converts it into a PDU. The peer entity in the receiver is only able to understand this PDU.

In simplest form, this modification by layer N of the layer N+1 SDU contains encapsulation. In encapsulation, the SDU is preserved as it is and an additional header is added by the layer N protocol. The modification can also perform concatenation (where more than one SDU is combined in a single PDU), segmentation (where a SDU can be split so that different parts of it end up in different PDUs) and padding (where a SDU is so small that filler bits are added in the end to complete the PDU).

At the receiver side, the peer entity receives the PDU from layer N-1 (actually layer N-1 SDU) and converts it back into SDU(s) and passes it to layer N+1. As can be seen generally at Figure 2, the SDUs are received from a higher layer (RLC) and need to be converted to PDUs so they undergo segmentation (or in another example concatenation) and suitable RLC headers are added to form the RLC PDUs.

The above review of peer entities and protocol layers is context for the other aspects of these teachings presented below. In a second embodiment of these teachings the RLC segmentation/concatenation for D2D discovery signals is done according to the transport block size that corresponds to a used discovery block size at the MAC/physical layer, as is shown at Figure 2 for the case of segmentation done by an RLC entity for a discovery message. In this example the SDU 202 having the discovery signals is too large to be put into one PDU that is restricted in size to a discovery block 208A, and so the PDU 202 is divided into segments 204A, 204B, 204C of such a size that when a RLC header 206A, 206B 206C is added to each segment the segment plus header is no larger than the size of a discovery block 208A. In an embodiment the discovery block 208A is given by the MAC entity after taking into account the headers and control elements which are to be included in the eventual discovery signal, and based on the MAC elements the size of the discovery block may be different at the RLC layer for the different discovery bearers. The discovery block size 208A may be configured by the network at the radio resource control (RRC) level so that at the physical layer all the block sizes for a given bearer are the same. Additionally or alternatively, a default discovery block size may be defined. The block size information is conveyed to the RLC entity by the MAC layer.

Figure 3 illustrates an exemplary implementation of RLC and MAC layers for the D2D discovery. The MAC layer conveys to the RLC entity the discovery block size. The RLC entity in the UM mode then segments the SDU(s) 202 and adds RLC headers 206A-C to the segments 204A-C to form PDUs 208 as shown in Figure 2.

In one implementation of this second embodiment, the MAC layer indicates to the RLC entities, which handle the current discovery logical channels, the amount/number of available discovery blocks in the next discovery occasion.

In another implementation of either the first and/or second embodiments, the data of the device discovery logical channel is conveyed through the RLC layer via an RLC entity in TM mode. This is a departure from the prior art in that 3GPP TS 36.322 v10.0.0 specifies at section 4.2.1.1.2, as summarised in the review above, that a transmitting TM RLC entity shall not segment or concatenate the RLC SDUs. With that in mind, this implementation could be used for example when the discovery block size is specified such that the data of the basic device discovery signal always fits into that block, and so segmentation would not be required for device discovery.

Furthermore, this would also enable a more compact device discovery message since it would lack any RLC header (in the summary above the TM RLC entity is also not to include RLC headers in TM data PDUs).

This is shown for example at Figure 4, which is a schematic diagram of how the RLC and MAC layers may be implemented for the device discovery going through the RLC TM entity. In this example, the device discovery bearer is delivered through the RLC entity in TM mode and so there is no segmentation (or concatenation) between the RLC and the MAC layers on that default bearer.

Figure 5 is an exemplary illustration of the data flow of D2D discovery signals through the radio protocol stack proposed in various embodiments of these teachings. Though the allocation is contiguous in the physical layer, it can be seen in Figure 5 that the signal is constructed of multiple components the size of a discovery block at the MAC layer and segmented at the RLC layer. Specifically, there are higher layers 510 which establish the radio bearers including one default radio bearer.

Below those higher layers 510 is a RLC layer 520 in which are two SDUs. One SDU 522 is sized, after a RLC header 524 is attached, to fit into a discovery signal PDU 532. This carries the device discovery signalling shown at Figure 1 and is associated with the default bearer for device discovery. Since there is no segmentation required for this device discovery SDU 522 it may be processed by a TM-mode RLC entity. The other SDU 526 carries the service discovery signalling and possibly also the discovery feedback shown at Figure 1, and so is too large for a single discovery block size so the RLC layer 520 segments it into three portions 526A-C. This will be associated with radio bearers other than the default bearer. The RLC layer 520 adds to each portion or segment 526A-C a RLC header 524A-C so each fits into one discovery block size 208A as shown at Figure 2.

The MAC layer 530 takes these RLC PDUs which are each the size of one discovery block and appends headers 534, 534A-C as shown, and padding bits 538 as necessary to fill out the MAC PDUs. Additionally, the MAC layer 530 prioritises the PDU on the default bearer since by these teachings that PDU carries only the device discovery signalling. In an embodiment, the MAC layer prioritises the logical channels before indicating the available resources to the RLC entity. In an embodiment, the MAC layer sets the prioritised bit rate for the logical channel carrying the device discovery information to infinity. This ensures that the MAC layer will have sufficient resources to allocate for the device discovery logical channel and the whole device discovery message, and only then would resources be allocated for other logical channels.

The physical layer 540, sometimes referred to as the radio layer, then maps these MAC PDUs to discovery transmission blocks, each of those physical layer blocks representing one or multiple resource blocks. These resource blocks are contiguous and also the discovery transmission blocks themselves are contiguous as is shown at the physical layer 540 of Figure 5 and also at Figure 1.

In one embodiment of these teachings, a MAC control element as well as a corresponding MAC subheader is implemented in at least one of the transport blocks of a certain discovery signal wherein the number of consecutive discovery blocks 541-544 used for the whole discovery signal transmission is specified. In one implementation of this embodiment, the MAC layer includes this control element into the transport block of the device discovery message, and Figure 5 shows these MAC control elements as 532 and 532A-C. In another embodiment, a MAC control element 532, 532A-C as well as a corresponding MAC subheader 534, 534A-C is implemented into the transport block 541-544 of the said device discovery message that indicates the discovery signal to contain also at least a part of another discovery message.

If the physical resources of one discovery occasion available for discovery signal transmission are not sufficient for the SDU received by the RLC, a RLC sequence number is maintained for at least the next discovery occasion. The RLC sequence number is restarted for each SDU received by higher layers 510. In one example implementation, the MAC layer 530 prioritises the data of the logical channels having segments of a certain discovery message which have not yet been transmitted, to enable these discovery messages to be transmitted one after another sequentially.

The Figure 6 embodiment is similar to Figure 5 but with a larger discovery data packet which for example might be scheduled by the network base station/eNB if the discovery signalling is done under cellular network scheduling. The eNB does this scheduling so that every device receiving discovery packets may decode the discovery signals during their discontinuous reception awake times. This enables a larger transport block size to be used for greater discovery packet transmission without the need of segmenting the packet according to the discovery block size. Furthermore, since every device is able to decode the scheduling grant from the eNB, there is no need to blindly decode different transport block sizes.

The discovery transmission block sizes at Figure 6 are not all identical; one of them 602 is large enough to contain both SDUs described above with reference to Figure 5. Therefore in Figure 6 the larger SDU carrying the service discovery signalling and possibly also discovery feedback is not segmented so as to fit into a different same-size discovery blocks but instead goes into a larger PDU. But still the device discovery SDU and the resulting RLC PDU with the added RLC header is constrained to the predetermined discovery block size. Due to the nature of the device discovery information as opposed to service discovery information, this prioritised block will not need to be segmented.

Now are detailed with reference to Figure 7 further particular exemplary embodiments from the perspective of the portable communicating device which sends the discovery signalling. Figure 7 may be performed by the whole first or second device 20, 22 shown at Figure 8, or by one or several components thereof such as a modem. The logic flow diagram of Figure 7 may be considered to illustrate the operation of a method, and a result of execution of a computer program stored in a computer readable memory, and a specific manner in which components of an electronic device are configured to cause that electronic device to operate. The various blocks shown in Figure 7 may also be considered as a plurality of coupled logic circuit elements constructed to carry out the associated function(s), or specific result of strings of computer program code stored in a memory.

Such blocks and the functions they represent are non-limiting examples, and may be practised in various components such as integrated circuit chips and modules, and the exemplary embodiments of this invention may be realised in an apparatus that is embodied as an integrated circuit. The integrated circuit, or circuits, may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or data processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry that are configurable so as to operate in accordance with the exemplary embodiments of this invention.

Such circuit/circuitry embodiments include any of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and (b) combinations of circuits and software (and/or firmware), such as: (i) a combination of processor(s) or (ii) portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone/UE, to perform the various functions summarised at Figure 3) and (c) circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present. This definition of "circuitry" applies to all uses of this term in this specification, including in any claims. As a further example, as used in this specification, the term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" also covers, for example, a baseband integrated circuit or application-specific integrated circuit for a mobile phone/UE or a similar integrated circuit in a server, a cellular network device, or other network device which compiles the discovery signals as detailed by example above, and which transmits them on the radio layer whether scheduled by an eNB or otherwise as detailed further above and according to these teachings.

At block 702 the first device 20 compiles at a RLC layer only device discovery information into a first PDU associated with a first radio bearer that is established for device discovery. At block 704 it compiles at the RLC layer service discovery information into at least a second PDU associated with a second radio bearer different from the first radio bearer. Then at block 706 it sends the first and the second PDUs to a MAC layer, which at block 708 prioritises the first PDU over the second PDU. All these are shown clearly at Figures 5and 6.

Further portions of Figure 7 represent some of the specific but non-limiting embodiments detailed above. Block 710 adds in that the compiling of block 702 is from a first SDU that is not segmented and to which a RLC header is added such that the first PDU at the RLC layer is no larger than a pre-determined discovery block size. As noted in more detail above, in some embodiments the MAC layer communicates to the RLC layer the pre-determined discovery block size, which may be a default discovery block size or may be configured by a cellular network node/eNB.

Block 712 summarises the embodiment illustrated at Figure 5 where the second SDU is segmented. In this case, compiling the service discovery information at the RLC layer into at least the second PDU includes segmenting that second SDU and adding to each segment a RLC header such that each segment with the added header is no larger than the pre-determined discovery block size. Then as shown at Figure 5 there is also a mapping at the physical layer of the first PDU with the added header and each segment with their added headers to consecutive discovery transmission blocks.

Block 714 summarises the embodiment illustrated at Figure 6 where the second SDU is not segmented. In this case, the second PDU is from a second SDU and compiling the service discovery information at the RLC layer into (only) the second PDU includes adding to the second PDU a radio link control header such that the second PDU with the added header is larger than the pre-determined discovery block size. Then as shown at Figure 6 there is a mapping at the physical layer of the first PDU with the added header and the second PDU with the added header to a single discovery transmission block.

Other of the detailed embodiments not summarised at Figure 7 include the MAC layer adding to at least one of the headers an indication that the discovery transmission block (Figure 6) or blocks (Figure 5) contains also a part of a previous discovery message, and also the RLC layer which compiles only the device discovery information into the first PDU is performed by a RLC entity in a transmit mode. Also not shown at Figure 7 is the MAC layer prioritisation, which occurs before the RLC layer processing which Figure 7 begins with at block 702. In one example embodiment above the MAC layer sets the prioritised bit rate for the logical channel carrying the device discovery information to infinity, before it indicates the available radio resources to the RLC layer, to ensure that the RLC layer will allocate sufficient resources for the device discovery message.

Reference is now made to Figure 8 for illustrating a simplified block diagram of various electronic devices and apparatus that are suitable for use in practising the exemplary embodiments of this invention. In Figure 8 there is a first D2D device 20 and a second D2D device 22 operating proximate to an eNB 30 and in wireless contact with it via wireless link 28, and also the first 20 and second 22 devices are in direct wireless communication with one another via D2D wireless link 26. The eNB 30 may in some embodiments schedule the resources used for D2D discovery as detailed above for some embodiments. Not shown are higher network nodes for the LTE/E-UTRAN system but which provide connectivity with further networks such as for example a publicly switched telephone network PSTN and/or a data communications network/Internet. There may also be a data and/or control path (not shown) coupling the eNB 30 with other eNBs (not shown).

The first device 20 includes processing means such as at least one data processor (DP) 20A, storing means such as at least one computer-readable memory (MEM) 20B storing at least one computer program (PROG) 20C, and communicating means such as a transmitter TX 20D and a receiver RX 20E for bidirectional wireless communications with the eNB 30 and with the second device 22 via one or more antennas 20F. While only one transmitter and receiver are shown, it is understood there may be more than one. Inherent in the first device (for example, in the DP 20A) is also a clock from which various software-defined timers are run, such as for example to align transmissions and receptions with the discovery opportunities and discovery cycles shown at Figure 1. Also stored in the MEM 20B at reference number 20G is the rules or algorithm for compiling, transmitting, receiving and decoding those discovery messages according to the different processes in the various protocol layers as detailed above for the various embodiments and as shown in the PROG at 20G for implementing these teachings. The second device 22 is functionally similar with blocks 22A, 22B, 22C, 22D, 22E, 22F and 22G. The first and second devices 20, 22 communicate with one another directly using discovery signals formulated according to the above embodiments which are sent on the direct wireless link 26.

The eNB 30, or more generally the network access node, also includes processing means such as at least one data processor (DP) 30A, storing means such as at least one computer-readable memory (MEM) 30B storing at least one computer program (PROG) 30C, and communicating means such as a transmitter TX 30D and a receiver RX 30E for bidirectional wireless communications with the UE 20 via one or more antennas 30F, at least for sending to the UEs the resource allocations for when they can send their discovery signalling.

While not particularly illustrated for the devices 20, 22 or the network access nodes 30, those apparatus are also assumed to include as part of their wireless communicating means a modem which may be inbuilt on an RF front end chip within those devices 20, 22, 30 and which may in some embodiments also carry the TX 20D/22D/30D and the RX 20E/22E/30E.

At least one of the PROGs 20C/20G/22C/22G in the first and second devices 20, 22 is assumed to include program instructions that, when executed by the associated DP 20A/22A, enable the device to operate in accordance with the exemplary embodiments of this invention, as was discussed above in detail. In this regard, the exemplary embodiments of this invention may be implemented at least in part by computer software stored on the MEM 20B, 22B which is executable by the DP 20A/22A of the communicating devices 20, 22, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware). Electronic devices implementing these aspects of the invention need not be the entire apparatus/device 20, 22 as shown, but exemplary embodiments may be implemented by one or more components of same such as the above described tangibly stored software, hardware, firmware and DP, or a system on a chip SOC or an application specific integrated circuit ASIC or a digital signal processor DSP.

In general, the various embodiments of the first and/or second device 20, 22 can include, but are not limited to: data cards, USB dongles, user equipments, cellular telephones, personal portable digital devices having wireless communication capabilities including but not limited to laptop/palmtop/tablet computers, digital cameras and music devices, Internet appliances, remotely operated robotic devices or machine-to-machine communication devices.

Various embodiments of the computer readable MEMs 20B/22B include any data storage technology type which is suitable to the local technical environment, including but not limited to semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory, removable memory, disc memory, flash memory, DRAM, SRAM, EEPROM and the like. Various embodiments of the DPs 20A/22A include but are not limited to general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and multi-core processors.

Various modifications and adaptations to the foregoing exemplary embodiments of this invention may become apparent to those skilled in the relevant arts in view of the foregoing description. While the exemplary embodiments have been described above in the context of a nearby access node of a E-UTRAN (LTE/LTE-Advanced) system, it should be appreciated that the exemplary embodiments of this invention are not limited for use with only this one particular type of wireless communication system, and that they may be used to advantage in other wireless communication systems/RATs such as for example GERAN, UTRAN and others.

The above embodiments are to be understood as illustrative examples of the invention. Further embodiments of the invention are envisaged. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

CLAIMS

1. A method for communicating, the method comprising:

compiling at a radio link control layer only device discovery information into a first protocol data unit associated with a first radio bearer that is established for device discovery;

compiling at the radio link control layer service discovery information into at least a second protocol data unit associated with a second radio bearer different from the first radio bearer;

sending the first and the second protocol data units to a medium access control layer; and

prioritising at the medium access control layer the first protocol data unit over the second protocol data unit.

2. A method according to claim 1, in which compiling at the radio link control layer only the device discovery information into the first protocol data unit is from a first service data unit that is not segmented and to which a radio link control header is added such that the first protocol data unit at the radio link control layer is no larger than a pre-determined discovery block size.

3. A method according to claim 2, in which compiling at the radio link control layer the service discovery information into at least the second protocol data unit comprises segmenting a second service data unit and adding to each segment a radio link control header such that each segment with the added header is no larger than the pre-determined discovery block size;

the method comprising mapping at a physical layer the first protocol data unit with the added header and each segment with the added header to consecutive discovery transmission blocks.

4. A method according to claim 3, in which the medium access control layer adds to at least one of the first protocol data units or segments or headers a number of the

contiguous discovery transmission blocks used for transmitting the device discovery information and the service discovery information.

5. A method according to any of claims 2 to 4, in which the second protocol data unit is from a second service data unit and compiling at the radio link control layer the service discovery information into the second protocol data unit comprises adding to the second protocol data unit a radio link control header such that the second protocol data unit with the added header is larger than the pre-determined discovery block size;

the method comprising mapping at a physical layer the first protocol data unit with the added header and the second protocol data unit with the added header to a single discovery transmission block.

6. A method according to any of claims 2 to 5, the method comprising the medium access control layer communicating to the radio link control layer the pre-determined discovery block size.

7. A method according to any of claims 2 to 6, in which the pre-determined discovery block size is a default discovery block size or is configured by a cellular network node.

8. A method according to any of claims 2 to 7, in which the medium access control layer adds to at least one of the headers an indication that the discovery transmission block or blocks contains also a part of a previous discovery message.

9. A method according to any of claims 1 to 8, in which compiling at the radio link control layer only the device discovery information into the first protocol data unit is performed by a radio link control entity in a transmit mode.

10. A method according to any of claims 1 to 9, comprising an initial step of the medium access control layer setting a priority of the first radio bearer to infinity prior

to informing the radio link control layer of radio resources that are available for sending the device and the service discovery information.

11. Apparatus for communicating, the apparatus comprising a processing system configured to cause the apparatus to perform at least:

compiling at a radio link control layer only device discovery information into a first protocol data unit associated with a first radio bearer that is established for device discovery;

compiling at the radio link control layer service discovery information into at least a second protocol data unit associated with a second radio bearer different from the first radio bearer;

sending the first and the second protocol data units to a medium access control layer; and

prioritising at the medium access control layer the first protocol data unit over the second protocol data unit.

12. Apparatus according to claim 11, in which compiling at the radio link control layer only the device discovery information into the first protocol data unit is from a first service data unit that is not segmented and to which a radio link control header is added such that the first protocol data unit at the radio link control layer is no larger than a pre-determined discovery block size.

13. Apparatus according to claim 12, in which compiling at the radio link control layer the service discovery information into at least the second protocol data unit comprises segmenting a second service data unit and adding to each segment a radio link control header such that each segment with the added header is no larger than the pre-determined discovery block size;

the processing system being configured to cause the apparatus to perform mapping at a physical layer the first protocol data unit with the added header and each segment with the added header to consecutive discovery transmission blocks.

14. Apparatus according to claim 13, in which the medium access control layer adds to at least one of the first protocol data units or segments or headers a number of the contiguous discovery transmission blocks used for transmitting the device discovery information and the service discovery information.

15. Apparatus according to any of claims 12 to 14, in which the second protocol data unit is from a second service data unit and compiling at the radio link control layer the service discovery information into the second protocol data unit comprises adding to the second protocol data unit a radio link control header such that the second protocol data unit with the added header is larger than the pre-determined discovery block size;

the processing system being configured to cause the apparatus to perform mapping at a physical layer the first protocol data unit with the added header and the second protocol data unit with the added header to a single discovery transmission block.

16. Apparatus according to any of claims 12 to 15, the processing system being configured to cause the apparatus to perform communicating from the medium access control layer to the radio link control layer the pre-determined discovery block size.

17. Apparatus according to any of claims 12 to 16, in which the pre-determined discovery block size is a default discovery block size or is configured by a cellular network node.

18. Apparatus according to any of claims 12 to 17, in which the medium access control layer adds to at least one of the headers an indication that the discovery transmission block or blocks contains also a part of a previous discovery message.

19. Apparatus according to any of claims 11 to 18, in which compiling at the radio link control layer only the device discovery information into the first protocol data unit is performed by a radio link control entity in a transmit mode.

20. Apparatus according to any of claims 11 to 19, in which the apparatus comprises a user equipment configured to send the first protocol data unit with the device discovery information and the second protocol data unit comprising the service discovery information over one of a Long Term Evolution LTE network and a LTE-Advanced network.

21. A computer program comprising a set of instructions which when executed on a first device causes the first device to perform at least:

compiling at a radio link control layer only device discovery information into a first protocol data unit associated with a first radio bearer that is established for device discovery;

compiling at the radio link control layer service discovery information into at least a second protocol data unit associated with a second radio bearer different from the first radio bearer;

sending the first and the second protocol data units to a medium access control layer; and

prioritising at the medium access control layer the first protocol data unit over the second protocol data unit.

22. A computer program according to claim 21, in which compiling at the radio link control layer only the device discovery information into the first protocol data unit is from a first service data unit that is not segmented and to which a radio link control header is added such that the first protocol data unit at the radio link control layer is no larger than a pre-determined discovery block size.

23. A computer program according to claim 22, in which compiling at the radio link control layer the service discovery information into at least the second protocol data unit comprises segmenting a second service data unit and adding to each segment a radio link control header such that each segment with the added header is no larger than the pre-determined discovery block size;

and the executed set of instructions causes the first device to perform mapping at a physical layer the first protocol data unit with the added header and each segment with the added header to consecutive discovery transmission blocks.

24. A computer program according to claim 23, in which the medium access control layer adds to at least one of the first protocol data units or segments or headers a number of the contiguous discovery transmission blocks used for transmitting the device discovery information and the service discovery information.

25. A computer program according to any of claims 22 to 24, in which the second protocol data unit is from a second service data unit and compiling at the radio link control layer the service discovery information into the second protocol data unit comprises adding to the second protocol data unit a radio link control header such that the second protocol data unit with the added header is larger than the pre-determined discovery block size;

and the executed set of instructions causes the first device to perform mapping at a physical layer the first protocol data unit with the added header and the second protocol data unit with the added header to a single discovery transmission block.

26. A computer program according to any of claims 22 to 25, wherein the executed set of instructions further causes the medium access control layer to communicate to the radio link control layer the pre-determined discovery block size.

27. A computer program according to any of claims 22 to 26, in which the pre-determined discovery block size is a default discovery block size or is configured by a cellular network node.

28. A computer program according to any of claims 22 to 27, in which the medium access control layer adds to at least one of the headers an indication that the discovery transmission block or blocks contains also a part of a previous discovery message.

29. A computer program according to any of claims 21 to 28, in which compiling at the radio link control layer only the device discovery information into the first protocol data unit is performed by a radio link control entity in a transmit mode.

30. A computer program according to any of claims 21 to 29, in which the executed set of instructions causes the first device to perform an initial step of the medium access control layer setting a priority of the first radio bearer to infinity prior to informing the radio link control layer of radio resources that are available for sending the device and the service discovery information.

31. A method of communicating, substantially in accordance with any of the examples as described herein with reference to and illustrated by Figures 2 to 8 of the accompanying drawings.

32. Apparatus for communicating, substantially in accordance with any of the examples as described herein with reference to and illustrated by Figures 2 to 8 of the accompanying drawings.

AMENDMENTS TO THE CLAIMS HAVE BEEN FILED AS FOLLOWS:

CLAIMS

1. A method for communicating, the method comprising:

compiling, at a radio link control layer, only device discovery information into a first protocol data unit, the first protocol data unit being associated with a first radio bearer which is established for device discovery;

compiling, at the radio link control layer, service discovery information into at least a second protocol data unit, the second protocol data unit being associated with a second radio bearer which is different from the first radio bearer;

sending the first and the second protocol data units to a medium access control layer; and

prioritising at the medium access control layer the first protocol data unit over the second protocol data unit.

2. A method according to claim 1, in which compiling, at the radio link control layer, only the device discovery information into the first protocol data unit is from a first service data unit that is not segmented and to which a radio link control header is added such that the first protocol data unit at the radio link control layer is no larger than a pre-determined discovery block size.

3. A method according to claim 2, in which compiling, at the radio link control layer, the service discovery information into at least the second protocol data unit comprises segmenting a second service data unit and adding to each segment a radio link control header such that each segment with the added header is no larger than the pre-determined discovery block size;

the method comprising mapping, at a physical layer, the first protocol data unit with the added header and each segment with the added header to consecutive discovery transmission blocks.

4. A method according to claim 3, in which the medium access control layer adds to at least one of the first protocol data units or segments or headers a number of the

contiguous discovery transmission blocks used for transmitting the device discovery information and the service discovery information.

5. A method according to any of claims 2 to 4, in which the second protocol data unit is from a second service data unit and in which compiling, at the radio link control layer, the service discovery information into the second protocol data unit comprises adding to the second protocol data unit a radio link control header such that the second protocol data unit with the added header is larger than the pre-determined discovery block size;

the method comprising mapping, at a physical layer, the first protocol data unit with the added header and the second protocol data unit with the added header to a single discovery transmission block.

6. A method according to any of claims 2 to 5, the method comprising the medium access control layer communicating to the radio link control layer the pre-determined discovery block size.

7. A method according to any of claims 2 to 6, in which the pre-determined discovery block size is a default discovery block size or is configured by a cellular network node.

8. A method according to any of claims 2 to 7, in which the medium access control layer adds to at least one of the headers an indication that the discovery transmission block or blocks contains also a part of a previous discovery message.

9. A method according to any of claims 1 to 8, in which compiling, at the radio link control layer, only the device discovery information into the first protocol data unit is performed by a radio link control entity in a transmit mode.

10. A method according to any of claims 1 to 9, comprising an initial step of the medium access control layer setting a priority of the first radio bearer to infinity prior

to informing the radio link control layer of radio resources that are available for sending the device and the service discovery information.

11. Apparatus for communicating, the apparatus comprising a processing system configured to cause the apparatus to perform at least:

compiling, at a radio link control layer, only device discovery information into a first protocol data unit, the first protocol data unit being associated with a first radio bearer which is established for device discovery;

compiling, at the radio link control layer, service discovery information into at least a second protocol data unit, the second protocol data unit being associated with a second radio bearer which is different from the first radio bearer;

sending the first and the second protocol data units to a medium access control layer; and

prioritising at the medium access control layer the first protocol data unit over the second protocol data unit.

12. Apparatus according to claim 11, in which compiling, at the radio link control layer, only the device discovery information into the first protocol data unit is from a first service data unit that is not segmented and to which a radio link control header is added such that the first protocol data unit at the radio link control layer is no larger than a pre-determined discovery block size.

13. Apparatus according to claim 12, in which compiling, at the radio link control layer, the service discovery information into at least the second protocol data unit comprises segmenting a second service data unit and adding to each segment a radio link control header such that each segment with the added header is no larger than the pre-determined discovery block size;

the processing system being configured to cause the apparatus to perform mapping, at a physical layer, the first protocol data unit with the added header and each segment with the added header to consecutive discovery transmission blocks.

14. Apparatus according to claim 13, in which the medium access control layer adds to at least one of the first protocol data units or segments or headers a number of the contiguous discovery transmission blocks used for transmitting the device discovery information and the service discovery information.

15. Apparatus according to any of claims 12 to 14, in which the second protocol data unit is from a second service data unit and in which compiling, at the radio link control layer, the service discovery information into the second protocol data unit comprises adding to the second protocol data unit a radio link control header such that the second protocol data unit with the added header is larger than the pre-determined discovery block size;

the processing system being configured to cause the apparatus to perform mapping at a physical layer the first protocol data unit with the added header and the second protocol data unit with the added header to a single discovery transmission block.

16. Apparatus according to any of claims 12 to 15, the processing system being configured to cause the apparatus to perform communicating from the medium access control layer to the radio link control layer the pre-determined discovery block size.

17. Apparatus according to any of claims 12 to 16, in which the pre-determined discovery block size is a default discovery block size or is configured by a cellular network node.

18. Apparatus according to any of claims 12 to 17, in which the medium access control layer adds to at least one of the headers an indication that the discovery transmission block or blocks contains also a part of a previous discovery message.

19. Apparatus according to any of claims 11 to 18, in which compiling, at the radio link control layer, only the device discovery information into the first protocol data unit is performed by a radio link control entity in a transmit mode.

20. Apparatus according to any of claims 11 to 19, in which the apparatus comprises a user equipment configured to send the first protocol data unit with the device discovery information and the second protocol data unit comprising the service discovery information over one of a Long Term Evolution LTE network and a LTE-Advanced network.

21. A computer program comprising a set of instructions which when executed on a first device causes the first device to perform at least:

compiling, at a radio link control layer, only device discovery information into a first protocol data unit, the first protocol data unit being associated with a first radio bearer which is established for device discovery;

compiling, at the radio link control layer, service discovery information into at least a second protocol data unit, the second protocol data unit being associated with a second radio bearer which is different from the first radio bearer;

sending the first and the second protocol data units to a medium access control layer; and

prioritising at the medium access control layer the first protocol data unit over the second protocol data unit.

22. A computer program according to claim 21, in which compiling, at the radio link control layer, only the device discovery information into the first protocol data unit is from a first service data unit that is not segmented and to which a radio link control header is added such that the first protocol data unit at the radio link control layer is no larger than a pre-determined discovery block size.

23. A computer program according to claim 22, in which compiling, at the radio link control layer, the service discovery information into at least the second protocol data unit comprises segmenting a second service data unit and adding to each segment a radio link control header such that each segment with the added header is no larger than the pre-determined discovery block size;

and the executed set of instructions causes the first device to perform mapping, at a physical layer, the first protocol data unit with the added header and each segment with the added header to consecutive discovery transmission blocks.

24. A computer program according to claim 23, in which the medium access control layer adds to at least one of the first protocol data units or segments or headers a number of the contiguous discovery transmission blocks used for transmitting the device discovery information and the service discovery information.

25. A computer program according to any of claims 22 to 24, in which the second protocol data unit is from a second service data unit and in which compiling, at the radio link control layer, the service discovery information into the second protocol data unit comprises adding to the second protocol data unit a radio link control header such that the second protocol data unit with the added header is larger than the pre-determined discovery block size;

and the executed set of instructions causes the first device to perform mapping, at a physical layer, the first protocol data unit with the added header and the second protocol data unit with the added header to a single discovery transmission block.

26. A computer program according to any of claims 22 to 25, wherein the executed set of instructions further causes the medium access control layer to communicate to the radio link control layer the pre-determined discovery block size.

27. A computer program according to any of claims 22 to 26, in which the pre-determined discovery block size is a default discovery block size or is configured by a cellular network node.

28. A computer program according to any of claims 22 to 27, in which the medium access control layer adds to at least one of the headers an indication that the discovery transmission block or blocks contains also a part of a previous discovery message.

29. A computer program according to any of claims 21 to 28, in which compiling, at the radio link control layer, only the device discovery information into the first protocol data unit is performed by a radio link control entity in a transmit mode.

30. A computer program according to any of claims 21 to 29, in which the executed set of instructions causes the first device to perform an initial step of the medium access control layer setting a priority of the first radio bearer to infinity prior to informing the radio link control layer of radio resources that are available for sending the device and the service discovery information.

31. A method of communicating, substantially in accordance with any of the examples as described herein with reference to and illustrated by Figures 2 to 8 of the accompanying drawings.

32. Apparatus for communicating, substantially in accordance with any of the examples as described herein with reference to and illustrated by Figures 2 to 8 of the accompanying drawings.

Application No:	GB1209703.6	**Examiner:**	Daniel Voisey
Claims searched:	1 to 32	**Date of search:**	27 September 2012

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	WO 2009/158663 A1 (QUALCOMM) see particularly the abstract, paragraphs [0002] to [0004], and figure 1.
A	-	WO 2009/117472 A2 (INTEL) see particularly the abstract, page 1 lines 4 to 12, page 3 lines 3 to 10, and figure 1.
A	-	GB 2421153 A (ITT) see particularly the abstract and figure 1.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

H04W

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC & 3GPP

International Classification:

Subclass	Subgroup	Valid From
H04W	0084/18	01/01/2009
H04W	0052/02	01/01/2009