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(54) Title: MEASURES FOR COMMUNICATION

(57) Abstract: Measures for communication are provided. The measures comprise communicating with user equipment capable of device-to-device communication, deciding on the activation of a collision detection and reporting mechanism in discovery transmissions of device-to-device communication and transmitting a message to the user equipment, the message activating a collision detection and reporting mechanism and comprising parameters related to the mechanism.

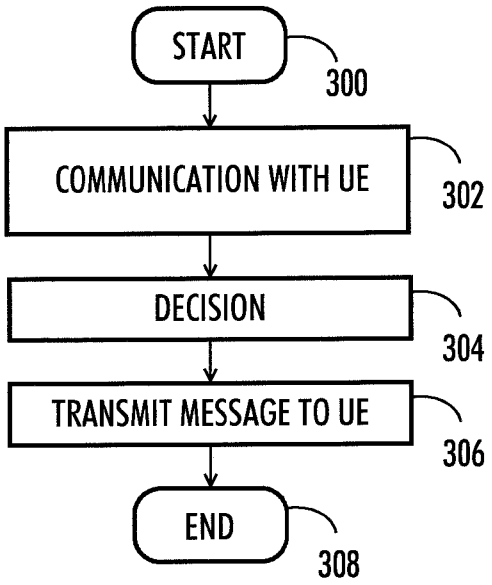

FIG. 3A

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Measures for communication

Technical Field

The present disclosure relates generally to communication systems. In particular, but not exclusively, the present disclosure relates to apparatus, methods, computer software and computer program products for use in collision detection and reporting in a communication system.

Background

Wireless communication systems are constantly under development. Developing systems provide a cost-effective support of high data rates and efficient resource utilization. One communication system under development is the 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE). An improved version of the Long Term Evolution radio access system is called LTE-Advanced (LTE-A). LTE is designed to support various services, such as high-speed data, multimedia unicast and multimedia broadcast services.

In addition to cellular operation, in many systems, direct device-to-device (D2D) communication is proposed. Device-to-device communication may be performed under network supervision or independently from the network. Device-to-device communication may improve resource usage efficiency of a communication system, reduce the power consumption at both the eNodeB and the user equipment side, offload traffic from cellular networks, and also potentially enable some new service types in the future.

For the devices to be able to communicate with each other they must be aware of each other. To this purpose, discovery procedures have been developed. In discovery procedures, devices inform their existence to other devices and detect other nearby devices with which direct communication might be possible.

Summary

In accordance with a first aspect of the present disclosure, there is provided apparatus for use in collision detection and reporting in a communication system, the apparatus comprising a processing system adapted to cause the apparatus to:

communicate with user equipment capable of device-to-device communication;

decide on the activation of a collision detection and reporting mechanism in discovery transmissions of device-to-device communication; and

transmit a first message to the user equipment, the first message activating the collision detection and reporting mechanism and comprising parameters related to the mechanism.

In accordance with a second aspect of the present disclosure, there is provided apparatus for use in collision detection and reporting in a communication system, the apparatus comprising a processing system adapted to cause the apparatus to:

transmit and receive discovery transmissions of device-to-device communication on given resources;

receive a first message from the communication system, the first message indicating the activation of a collision detection and reporting mechanism and comprising parameters related to the mechanism; and

in response to receipt of the first message, activate the collision detection and reporting mechanism using the received parameters.

In accordance with a third aspect of the present disclosure, there is provided a method for use in collision detection and reporting in a communication system, the method comprising:

communicating with user equipment capable of device-to-device communication;

deciding on the activation of a collision detection and reporting mechanism in discovery transmissions of device-to-device communication; and

transmitting a first message to the user equipment, the first message activating the collision detection and reporting mechanism and comprising parameters related to the mechanism.

In accordance with a fourth aspect of the present disclosure, there is provided a method for use in collision detection and reporting in a communication system, the method comprising:

transmitting and receiving discovery transmissions of device-to-device communication on given resources;

receiving a first message from the communication system, the first message indicating the activation of a collision detection and reporting mechanism and comprising parameters related to the mechanism; and

activating the collision detection and reporting mechanism using the received parameters.

In accordance with a fifth aspect of the present disclosure, there is provided computer software adapted to perform the method of the third aspect of the present disclosure.

In accordance with a sixth aspect of the present disclosure, there is provided computer software adapted to perform the method of the fourth aspect of the present disclosure.

In accordance with a seventh aspect of the present disclosure, there is provided a computer program product comprising a non-transitory computer-readable storage medium having computer readable instructions stored thereon, the computer readable instructions being executable by a computerized device to cause the computerized device to perform a method according to the third aspect of the present disclosure.

In accordance with a eighth aspect of the present disclosure, there is provided a computer program product comprising a non-transitory computer-readable storage medium having computer readable instructions stored thereon, the computer readable instructions being executable by a computerized device to cause the computerized device to perform a method according to the fourth aspect of the present disclosure.

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

Brief Description of the Drawings

Some embodiments of the present disclosure are described below, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 illustrates a communication environment;

Figure 2 illustrates apparatuses according to embodiments;

Figures 3A and 3B are flowcharts illustrating embodiments;

Figure 4 illustrates an example of resource allocation;

Figure 5 illustrates an example of frame structure; and

Figures 6 and 7 are flowcharts illustrating embodiments.

Detailed Description

Embodiments of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments are shown. Indeed, embodiments may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Although the specification may refer to "an", "one", or "some" embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments.

Some embodiments of the present disclosure are applicable to any user terminal, server, corresponding component, and/or to any communication system or any combination of different communication systems where device-to-device communication is supported. The communication system may be a wireless communication system or a communication system utilizing both fixed networks and wireless networks. The protocols used and the specifications of communication systems, servers and user terminals, especially in wireless communication, develop rapidly. Such development may require extra changes to an embodiment. Therefore, all words and expressions should be interpreted broadly and are intended to illustrate, not to restrict, the embodiment.

Many different radio protocols to be used in communications systems exist. Some examples of different communication systems are the universal mobile telecommunications system (UMTS) radio access network (UTRAN), long term evolution (LTE, known also as evolved UMTS Terrestrial Radio Access Network E-UTRAN), long term evolution advanced (LTE-A), Wireless Local Area Network

(WLAN) based on IEEE 802.11stardard, worldwide interoperability for microwave access (WiMAX), Bluetooth®, personal communications services (PCS) and systems using ultra-wideband (UWB) technology. IEEE refers to the Institute of Electrical and Electronics Engineers. LTE and LTE-A are developed by the Third Generation Partnership Project 3GPP.

Figure 1 depicts an example of a radio system to which embodiments can be applied. In this example, the radio system is based on LTE network elements. However, the embodiments described in these examples is not limited to LTE radio systems but can also be implemented in other radio systems, such as UMTS. In an embodiment, the presented solution may be applied between user equipment belonging to different but compatible systems such as LTE and UMTS.

A general architecture of a communication system is illustrated in Figure 1. Figure 1 is a simplified system architecture only showing some elements and functional entities, all being logical units whose implementation may differ from what is shown. The connections shown in Figure 1 are logical connections; the actual physical connections may be different. It will be apparent to a person skilled in the art that the systems also comprise other functions and structures. It should be appreciated that the functions, structures, elements, and protocols used in or for group communication are irrelevant and need not be discussed in more detail here.

The radio system of Figure 1 comprises an operator service core including the following elements: an MME (Mobility Management Entity) 108 and an SAE GW (System Architecture Evolution Gateway) 104.

Base stations that may also be called eNodeBs (Enhanced node Bs) 100, 102 of the radio system host the functions for Radio Resource Management: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic Resource Allocation (scheduling). The MME 108 is responsible for distributing paging messages to the eNodeBs 100, 102. The eNBs are connected to the SAE GW by an S1_U interface and to MME 108 by an S1_MME interface. The eNodeBs may be connected to each other by an X2 interface. The SAE GW 104 and MME 108 may be connected to each other by an S11 interface.

Figure 1 shows user equipment 110 and 114 located in the service area of eNodeB 100 and user equipment 116 located in the service area of eNodeB 102. The

user equipment refers to a portable computing device. Such computing devices may include wireless mobile communication devices operating with or without a subscriber identification module (SIM), including, but not limited to, the following types of devices: mobile phone, mobile station (MS), smartphone, personal digital assistant (PDA), handset, laptop computer.

Figure 1 illustrates a simplified example. In practice, the network may include more base stations and radio network controllers, and more cells may be formed by the base stations. The networks of two or more operators may overlap and the sizes and form of the cells may vary from what is depicted in Figure 1, etc.

The physical layer of LTE includes orthogonal frequency division multiple access (OFDMA) and multiple-input and multiple-output (MIMO) data transmission. For example, LTE deploys the OFDMA for the downlink transmission and single carrier frequency division multiple access (SC-FDMA) for the uplink transmission. In OFDMA, the transmission frequency band is divided into multiple sub-carriers orthogonal to each other. Each sub-carrier may transmit data to a specific UE. Thus, multiple access is achieved by assigning subsets of sub-carriers to any individual UE. SC-FDMA utilizes single carrier modulation, orthogonal frequency domain multiplexing and frequency domain equalization. Embodiments are not limited to any particular multiple access method.

In the uplink direction, LTE-A provides a Physical Uplink Shared Channel (PUSCH) for transmitting user data. The resources of PUSCH are allocated by the network and signalled on a control channel to user equipment.

It should be appreciated that the communication system may also comprise other core network elements besides SAE GW 104 and MME 108. Direct communication between different eNodeBs over an air interface is also possible by implementing a relay node concept, wherein a relay node may be considered as a special eNodeB having wireless backhauls or, for instance, X2 and S1 interfaces relayed over the air interface by another eNodeB. The communication system is also able to communicate with other networks, such as a public switched telephone network or Internet 106.

Embodiments are not, however, restricted to the network given above which is given as an example, but a person skilled in the art may apply the solution to other

communication networks provided with the necessary properties. For example, the connections between different network elements may be realized with Internet Protocol (IP) connections.

Figure 2 illustrates examples of apparatuses according to embodiments. It should be understood that the apparatuses are depicted herein as examples illustrating some embodiments. It will be apparent to a person skilled in the art that the devices may also comprise other functions and/or structures and not all described functions and structures are required. Although the devices have been depicted as single entities, different modules and memories may be implemented in one or more physical or logical entities.

Figure 2 shows user equipment 110 located in the area of base station or eNodeB 100. The user equipment is configured to be in connection with base station 100. User equipment 110 comprises a controller (CONT) 200 operationally connected to a memory (MEM) 202 and a transceiver (TRX) 204. Controller 200 controls the operation of user equipment 110. Controller 200 may comprise a processing system, a processor, a processing circuitry or any device capable of processing data and executing programmed commands or software. Memory 202 is configured to store software and data. Transceiver 204 is configured to set up and maintain a wireless connection to base station 100. Transceiver 204 is operationally connected to a set of antenna ports 206 connected to an antenna arrangement 208. Antenna arrangement 208 may comprise a set of antennas. The number of antennas may be one to four, for example. The number of antennas is not limited to any particular number.

The user equipment may also comprise various other components, such as a user interface, camera, and media player (not shown).

Base station or eNodeB 100 comprises a controller (CONT) 210 operationally connected to a memory (MEM) 212 and a transceiver (TRX) 214. Controller 210 controls the operation of base station 100. The controller may comprise a processing system, a processor, a processing circuitry or any device capable of processing data and executing programmed commands or software. Memory 212 is configured to store software and data. Transceiver 214 is configured to set up and maintain a wireless connection to user equipment within the service area of the base station. Transceiver 214 is operationally connected to an antenna

arrangement 216. Antenna arrangement 216 may comprise a set of antennas. The number of antennas may be two to four, for example. The number of antennas is not limited to any particular number.

Base station 100 may be operationally connected to another network element 218 of the communication system. Network element (NE) 218 may comprise an MME (Mobility Management Entity), an SAE GW (SAE Gateway), a radio network controller (RNC), another base station, a gateway, or a server, for example. The base station may be connected to more than one network element. Base station 100 may comprise an interface (IF) 220 configured to set up and maintain connections with the network elements.

User equipment and eNodeB have been described above as examples of apparatuses where embodiments may be applied. In an embodiment, the apparatuses need not be complete user equipment or eNodeBs. Embodiments may also be realized in circuitries or processing systems that form a part or parts of user equipment or an eNodeB.

Figure 3A is a flowchart illustrating an embodiment, for example illustrating the operation of an apparatus such as an eNodeB of a communication system. In an embodiment, the apparatus comprises a part of an eNodeB, such as a controller. The process starts at step 300.

In step 302, the apparatus causes communication with user equipment (UE) capable of device-to-device communication. The communication may comprise reception and/or transmission of control signalling, for example. In an embodiment, the apparatus may monitor the discovery process of device-to-device communication of the user equipment.

In step 304, the apparatus causes a decision to be made on the activation of a collision detection and reporting mechanism in discovery transmissions of device-to-device communication.

In step 306, the apparatus causes transmission of a first message to the user equipment, the message activating a collision detection and reporting mechanism and comprising parameters related to the mechanism. The parameters may comprise threshold values, for example. In an embodiment, the apparatus is configured to

update discovery specific System Information Block (SIB) and inform the UE about the SIB change including relevant parameters.

The process ends in step 308.

Figure 3B is a flowchart illustrating another embodiment, for example illustrating the operation of an apparatus such as user equipment of a communication system. In an embodiment, the apparatus comprises a part of user equipment, such as a controller. The process starts at step 310.

In step 312, the apparatus causes transmission and reception of discovery transmissions of device-to-device communication on given resources.

In step 314, the apparatus causes reception of a first message from the communication system, the message indicating the activation of a collision detection and reporting mechanism and comprising parameters related to the mechanism.

In step 316, the apparatus causes activation of the collision detection and reporting mechanism using the received parameters. The parameters may comprise threshold values, for example.

The process ends in step 318.

In an embodiment, the decision to activate the collision detection and reporting mechanism is based on the observed location of user equipment. An eNodeB may detect that several UEs are near each other, for example, and thus the probability of collisions may be higher and a collision detection mechanism may be more useful. As a result of the activated mechanism and related reporting, discovery resources may be reallocated between the UEs. The reallocation may utilise information obtained using the mechanism and location information related to the UEs.

In an embodiment, the user equipment 110, 114 and 116 of Figures 1 and 2 may be configured to communicate not only with the base station but also directly with other user equipment using device-to-device communication 118, 120 on given resources. For the device-to-device communication to succeed, the participating devices must be aware of each other. To this purpose, discovery procedures have been developed.

Discovery procedures can take place both in network controlled mode and in ad hoc mode (without network involvement). In the former, devices are under

network coverage, whilst in the latter option the devices are assumed not to have cellular coverage, or at least some of the devices are assumed as not having cellular coverage. In the network controlled case, resources for the discovery function may be allocated both in downlink and uplink.

In an embodiment, discovery transmission methods have similarities to Multimedia Broadcast Multicast Service (MBMS) in which a transmitter either broadcasts or multicasts data. The former can be considered as a public mode of operation (open mode) and the latter as a private mode of operation (restricted mode) in which the transmitter UE is desired to be discovered only by certain enabled UEs.

As an example of the resource allocation for the discovery transmissions, a discovery period consisting of k time-frequency resource chunks can be defined where each resource chunk has n transmission resources, and one device is allowed to send once in m such chunks. Thus, a device would select one channel (the selection can be performed autonomously by the device, assisted by the network or fully provided by the network) and thus there would be n x m orthogonal channels and one device would have k / m transmission opportunities within a discovery period.

Figure 4 illustrates an example when k equal 6, n equal 3 and m equal 3. Each chunk has three (n) transmission resources and thus three (m) successive chunks have nine resources in total. The placement of resources in the chunks may follow a pseudorandom pattern. Assuming a device uses resource #3 of the first group 400 of chunks. It may use the same #3 resource in the following group 402 of chucks but the actual time/frequency placement is different.

The transmission range of the discovery message may vary based on the service and operator policies. However, in general it can be assumed that the transmission ranges will be shorter than cell radius which makes it possible to reuse the same channel within a cell by multiple discovery transmitters. Allocation of the specific discovery channel to the device can be assigned by the network (eNodeB) or allocated autonomously by the device according to observed local utilization of the channels. In the former option, the device shall first observe the local utilization of the virtual channels and select the least interfered channel for its transmissions whilst in the latter option the eNodeB would take care of the virtual channel allocation based

on measurement reports by the devices. Furthermore, in the network based resource allocation, the eNodeB could utilize the location information of the devices.

Due to inaccuracy of resource allocation methods in practice and mobility of user equipment, collisions may occur on discovery channels and thus the system should have mechanisms to detect possible collisions i.e. the situation where two or more transmitters are using the same radio resources in the same area.

In an embodiment, discovery transmissions of device-to-device communication utilise a modular frame structure which consists of a specific part 500 and a common part 502. Figure 5 illustrates an example of such a structure. In the example, the specific part 500 is realized as a prefix transmitted before the common part 502. In an embodiment, discovery transmission on downlink is transmitted on a MBSFN (Multicast-Broadcast Single Frequency Network) sub frame. In cellular, the first two symbols of the frame are omitted to allow normal PDCCH (Physical Downlink Control Channel) transmission by the eNodeB. The length of the prefix may correspond to the length of the first two symbols.

In an embodiment, the specific part in uplink is used for collision detection by the receivers. The devices may receive from the network a sequence from a set of mutually orthogonal sequences and apply the sequence when transmitting the specific part of a discovery transmission of device-to-device communication.

In an embodiment, the sequences may be Zadoff-Chu sequences. Furthermore, each channel could be configured for instance with a root sequence with a given number (for example n) of different cyclic shifts. The use of mutually orthogonal sequences enhances the collision detection mechanism as a receiver may detect the sequences. When the collision detection mechanism is activated by the network, a device shall randomly select one of the given cyclic shifts for the sequence to be transmitted in the prefix. In some embodiments, given cyclic shifts may be partly determined based on the resource used for discovery transmission.

If receiving devices detect two different cyclic shifts using the same resource they may assume that a collision has occurred. After detecting the collision, the receiving device may inform the network or inform the collision locally in its own discovery signal transmission by indicating e.g. the channel identification ID on which the collision occurred. When the collision detection mechanism is switched off

by the network, the first cyclic shift in configuration order could be transmitted by default.

In an embodiment, when the collision detection mechanism is switched off, the common part 502 may have a longer length than in the case when collision detection mechanism is applied. The specific part 500 may be shorter or omitted altogether.

In an embodiment, the signal strengths of the detected sequences in the same resource have to be at a certain level compared to other detected sequences of other resources or channels or the average or maximum received signal strength of the sequences should be within a certain range of each other before detecting a collision. This would avoid detecting a collision when the receiving device is between and far away from the transmitting devices that are using the same resources. Thus, embodiments utilise two threshold values: a first threshold value to indicate the allowed difference to the average or maximum detected prefix strength to detect a potential collision and a second threshold value to indicate the allowed difference between two detected prefixes in the same channel.

Figure 6 is a flowchart illustrating an embodiment and the use of thresholds in receiving devices, such as user equipment or part of user equipment. The embodiment starts at step 600.

In step 602, the receiving device detects the specific part such as the prefix 500.

In step 604, the receiving device is configured to determine whether more than one sequence is detected in the specific part.

If not, the receiving device is configured to determine in step 606 that there is no collision.

If more than one sequence is detected, the receiving device is configured to determine whether the difference between the strength of the detected sequences and the average or maximum detected sequence strength on any resource within a given time window is above a given first threshold value, in step 608.

If the determination of step 608 is negative, the receiving device is configured to determine in step 606 that there is no collision.

If the determination of step 608 is positive, the receiving device is configured to determine in step 610 whether the difference between the strengths of the detected sequences is below a given second threshold value.

If the determination of step 610 is negative, the receiving device is configured to determine in step 606 that there is no collision.

If the determination of step 610 is positive, the receiving device is configured to determine in step 612 that a collision has occurred.

The process ends in step 614.

Figure 7 is a flowchart illustrating an embodiment, for example illustrating the operation of an apparatus such as an eNodeB of a communication system. In an embodiment, the apparatus comprises a part of an eNodeB, such as a controller. The process starts at step 700.

In step 702, the apparatus is configured to decide on whether to deactivate the collision detection and reporting mechanism in discovery transmissions of device-to-device communication.

In step 704, the apparatus is configured to transmit a second message to user equipment, the message indicating the deactivation of the collision detection and reporting mechanism. In an embodiment, the apparatus is configured to update specific System Information Block (SIB) and inform the UE about the SIB change.

The process ends in step 706.

The mechanism may be deactivated to reduce signalling load in the system. In addition, the mechanism may increase signalling and thus the deactivation may decrease battery consumption of the UEs.

In an embodiment, discovery transmissions may be further controlled. For example, it may be specified that the device transmitting discovery messages shall omit every rth transmission opportunity within a discovery period, where r is a parameter provided by the network and signalled to the device at Radio Resource Control (RRC) level. For instance, system information block (SIB) or the like designated for the D2D/discovery function may be used.

In an embodiment, a device transmitting discovery messages could randomly or according to a specified algorithm select the transmission opportunity to be omitted in the beginning of the discovery period to avoid always omitting the same

transmission opportunity with the same other devices. After the first omitted transmission occasion, the next omitted occasion would be r occasions later. During the omitted occasion, the device is able to detect whether some other device within its radio proximity is using the same discovery resources which could further trigger an autonomous channel re-selection method. The network could enable and disable this collision detection mechanism via SIB signalling or the like.

The steps and related functions described in the above and attached figures are in no absolute chronological order, and some of the steps may be performed simultaneously or in an order differing from that given. Other functions can also be executed between the steps or within the steps. Some of the steps can also be left out or replaced with a corresponding step.

The apparatuses or controllers able to perform the above-described steps may be implemented as an electronic digital computer, processing system or a circuitry which may comprise a working memory (RAM), a central processing unit (CPU), and a system clock. The CPU may comprise a set of registers, an arithmetic logic unit, and a controller. The processing system, controller or the circuitry is controlled by a sequence of program instructions transferred to the CPU from the RAM. The controller may contain a number of microinstructions for basic operations. The implementation of microinstructions may vary depending on the CPU design. The program instructions may be coded by a programming language, which may be a high-level programming language, such as C, Java, etc., or a low-level programming language, such as a machine language, or an assembler. The electronic digital computer may also have an operating system, which may provide system services to a computer program written with the program instructions.

As used in this application, the term 'circuitry' refers to any or all of the following: (a) hardware-only circuit implementations, such as implementations in only analogue and/or digital circuitry, and (b) combinations of circuits and software (and/or firmware), such as (as applicable): (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 to perform various functions, 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.

The above definition of 'circuitry' applies to all uses of this term in this application. As a further example, as used in this application, the term 'circuitry' also covers an implementation of merely a processor (or multiple processors) or a portion of a processor and its (or their) accompanying software and/or firmware. The term 'circuitry' also covers, for example and if applicable to the particular element, a baseband integrated circuit or applications processor integrated circuit for a mobile phone or a similar integrated circuit in a server, a cellular network device, or another network device.

An embodiment provides a computer program embodied on a distribution medium, comprising program instructions which, when loaded into an electronic apparatus, are configured to control the apparatus to execute the embodiments described above.

The computer program may be in source code form, object code form, or in some intermediate form, and it may be stored in some sort of carrier, which may be any entity or device capable of carrying the program. Such carriers include a record medium, computer memory, read-only memory, and a software distribution package, for example. Depending on the processing power needed, the computer program may be executed in a single electronic digital computer or it may be distributed amongst a number of computers.

The apparatus may also be implemented as one or more integrated circuits, such as application-specific integrated circuits (ASICs). Other hardware embodiments are also feasible, such as a circuit built of separate logic components. A hybrid of these different implementations is also feasible. When selecting the method of implementation, a person skilled in the art will consider the requirements set for the size and power consumption of the apparatus, the necessary processing capacity, production costs, and production volumes, for example.

The above embodiments are to be understood as illustrative examples. Further embodiments 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. Apparatus for use in collision detection and reporting in a communication system, the apparatus comprising a processing system adapted to cause the apparatus to:

communicate with user equipment capable of device-to-device communication;

decide on the activation of a collision detection and reporting mechanism in discovery transmissions of device-to-device communication; and

transmit a first message to the user equipment, the first message activating the collision detection and reporting mechanism and comprising parameters related to the mechanism.

2. Apparatus according to claim 1, wherein the first message comprises a first threshold related to an allowed difference between signal strength detected on a given channel and a given reference signal strength value and a second threshold related to an allowed difference between the signal strengths detected on a given channel.

3. Apparatus according to claim 2, wherein the given reference signal strength value comprises an average or maximum detected signal strength value of discovery transmissions.

4. Apparatus according to claim 1, wherein the first message comprises a parameter defining the number of transmission opportunities to be skipped when transmitting discovery transmissions.

5. Apparatus according to any preceding claim, the processing system being adapted to cause the apparatus to:

decide on the deactivation of the collision detection and reporting mechanism in discovery transmissions of device-to-device communication; and

transmit a second message to the user equipment, the second message being operable to deactivate the collision detection and reporting mechanism.

6. Apparatus according to any preceding claim, the processing system being adapted to cause the apparatus to select transmission resources of the user equipment for discovery transmissions of device-to-device communication.

7. Apparatus according to any preceding claim, the processing system being adapted to cause the apparatus to receive from user equipment a message indicating a collision on discovery transmissions of device-to-device communication.

8. Apparatus according to claim 7, the processing system being adapted to cause the apparatus to reselect transmission resources of the user equipment for discovery transmissions of device-to-device communication on the basis of messages indicating collisions on discovery transmissions of device-to-device communication.

9. Apparatus according to any preceding claim, wherein the processing system is adapted to cause the apparatus to operate in a Universal Mobile Telecommunication System Long-Term Evolution network and/or in a Universal Mobile Telecommunication System Long-Term Evolution Advanced network.

10. Apparatus according to any preceding claim, wherein the apparatus comprises a base station.

11. Apparatus for use in collision detection and reporting in a communication system, the apparatus comprising a processing system adapted to cause the apparatus to:

transmit and receive discovery transmissions of device-to-device communication on given resources;

receive a first message from the communication system, the first message indicating the activation of a collision detection and reporting mechanism and comprising parameters related to the mechanism; and

in response to receipt of the first message, activate the collision detection and reporting mechanism using the received parameters.

12. Apparatus according to claim 11, wherein the first message comprises a first threshold related to the allowed difference between signal strength detected on a given channel and a given reference signal strength value and a second threshold related to an allowed difference between the signal strengths detected on a given channel.

13. Apparatus according to claim 12, wherein the given reference signal strength value comprises an average or maximum detected signal strength value of discovery transmissions.

14. Apparatus according to claim 11, wherein the first message comprises a parameter defining the number of transmission opportunities to be skipped when transmitting discovery transmissions.

15. Apparatus according to any of claims 11 to 14, the processing system being adapted to cause the apparatus to utilise in the transmission and reception of discovery transmissions of device-to-device communication a transmission resource comprising a specific part and a common part, the specific part being utilised in collision detection.

16. Apparatus according to claim 15, the processing system being adapted to cause the apparatus to:

receive from the communication system a sequence from a set of mutually orthogonal sequences; and

apply the sequence when transmitting the specific part of the discovery transmission of device-to-device communication.

17. Apparatus according to claim 15, the processing system being adapted to cause the apparatus to:

detect the specific part of a discovery transmission of device-to-device communication;

determine whether the specific part comprises more than one sequence;

and if so, determine whether the signal strengths of the detected sequences are above the first threshold;

and if so, determine whether the difference of the signal strengths of the detected sequences is below the second threshold;

and if so, determine that a collision has occurred.

18. Apparatus according to claim 17, the processing system being adapted to cause the apparatus to inform a base station of the communication system of the collision.

19. Apparatus according to claim 14, the processing system being adapted to cause the apparatus to, when transmitting discovery transmissions, skip every rth transmission opportunity, where r is a parameter provided by the communication system.

20. Apparatus according to claim 14, the processing system being adapted to cause the apparatus to, when beginning transmitting discovery transmissions, skip r first transmission opportunities according to a given criteria, where r is a parameter provided by the communication system.

21. Apparatus according to claim 15, wherein the specific part comprises a prefix of a sub frame.

22. Apparatus according to any of claims 11 to 21, wherein the processing system is adapted to cause the apparatus to operate in a Universal Mobile Telecommunication System Long-Term Evolution network and/or in a Universal Mobile Telecommunication System Long-Term Evolution Advanced network.

23. Apparatus according to any of claims 11 to 22, wherein the apparatus comprises a mobile phone or user equipment.

24. A method for use in collision detection and reporting in a communication system, the method comprising:

communicating with user equipment capable of device-to-device communication;

deciding on the activation of a collision detection and reporting mechanism in discovery transmissions of device-to-device communication; and

transmitting a first message to the user equipment, the first message activating the collision detection and reporting mechanism and comprising parameters related to the mechanism.

25. A method according to claim 24, wherein the first message comprises a first threshold related to an allowed difference between signal strength detected on a given channel and a given reference signal strength value and a second threshold related to an allowed difference between the signal strengths detected on a given channel.

26. A method according to claim 25, wherein the given reference signal strength value comprises an average or maximum detected signal strength value of discovery transmissions.

27. A method according to claim 24, comprising transmitting the first message comprising a parameter defining the number of transmission opportunities to be skipped when transmitting discovery transmissions.

28. A method according to any of claims 24 to 27, comprising:

deciding on the deactivation of the collision detection and reporting mechanism in discovery transmissions of device-to-device communication; and

transmitting a second message to the user equipment, the message deactivating the collision detection and reporting mechanism.

29. A method according to any of claims 24 to 28, comprising selecting transmission resources of the user equipment for discovery transmissions of device-to-device communication.

30. A method according to any of claims 24 to 29, comprising receiving from user equipment a message indicating a collision on discovery transmissions of device-to-device communication.

31. A method according to claim 30, comprising reselecting transmission resources of the user equipment for discovery transmissions of device-to-device communication on the basis of messages indicating collisions on discovery transmissions of device-to-device communication.

32. A method for use in collision detection and reporting in a communication system, the method comprising:

transmitting and receiving discovery transmissions of device-to-device communication on given resources;

receiving a first message from the communication system, the first message indicating the activation of a collision detection and reporting mechanism and comprising parameters related to the mechanism; and

activating the collision detection and reporting mechanism using the received parameters.

33. A method according to claim 32, wherein the first message comprises a first threshold related to the allowed difference between signal strength detected on a given channel and a given reference signal strength value and a second threshold related to an allowed difference between the signal strengths detected on a given channel.

34. A method according to claim 33, wherein the given reference signal strength value comprises an average or maximum detected signal strength value of discovery transmissions.

35. A method according to claim 32, comprising receiving the first message comprising a parameter defining the number of transmission opportunities to be skipped when transmitting discovery transmissions.

36. A method according to any of claims 32 to 35, comprising utilising in the transmission and reception of discovery transmissions of device-to-device communication a transmission resource comprising a specific part and a common part, the specific part being utilised in collision detection.

37. A method according to claim 36, comprising:

receiving from the communication system a sequence from a set of mutually orthogonal sequences; and

applying the sequence when transmitting the specific part of the discovery transmission of device-to-device communication.

38. A method according to claim 36, comprising:

detecting the specific part of a discovery transmission of device-to-device communication;

determining whether the specific part comprises more than one sequence;

and if so, determining whether the signal strengths of the detected sequences are above the first threshold;

and if so, determining whether the signal strengths of the detected sequences are below the second threshold;

and if so, determining that a collision has occurred.

39. A method according to claim 38, comprising informing a base station of the communication system of the collision.

40. A method according to claim 35, comprising, when transmitting discovery transmissions, to skip every rth transmission opportunity, where r is a parameter provided by the communication system.

41. A method according to claim 35, comprising, when beginning transmitting discovery transmissions, to skip r first transmission opportunities according to a given criteria, where r is a parameter provided by the communication system.

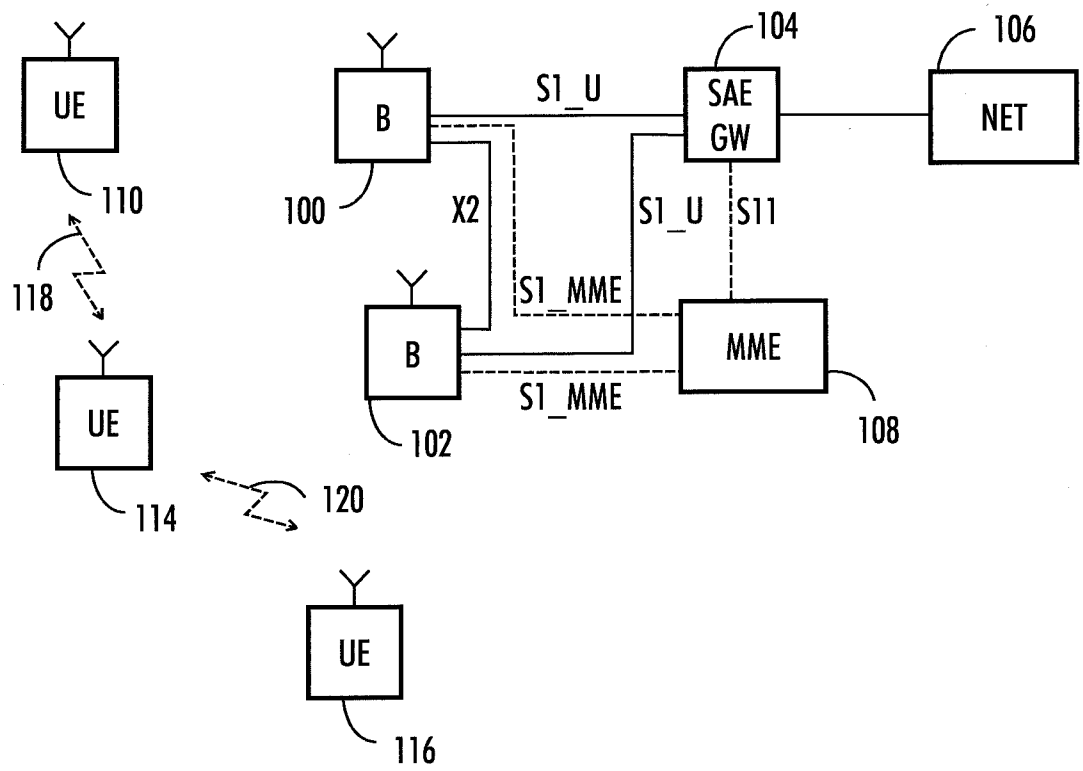
42. A method according to claim 36, wherein the specific part comprises a prefix of a sub frame.

43. Computer software adapted to perform the method of any of claims 24 to 31.

44. Computer software adapted to perform the method of any of claims 32 to 42.

45. A computer program product comprising a non-transitory computer-readable storage medium having computer readable instructions stored thereon, the computer readable instructions being executable by a computerized device to cause the computerized device to perform a method for use in collision detection and reporting in a communication system according to any of claims 24 to 31.

46. A computer program product comprising a non-transitory computer-readable storage medium having computer readable instructions stored thereon, the computer readable instructions being executable by a computerized device to cause the computerized device to perform a method for use in collision detection and reporting in a communication system according to any of claims 32 to 42.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118
UE
114
120
UE
116
B
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S1_U
SAE
GW
104
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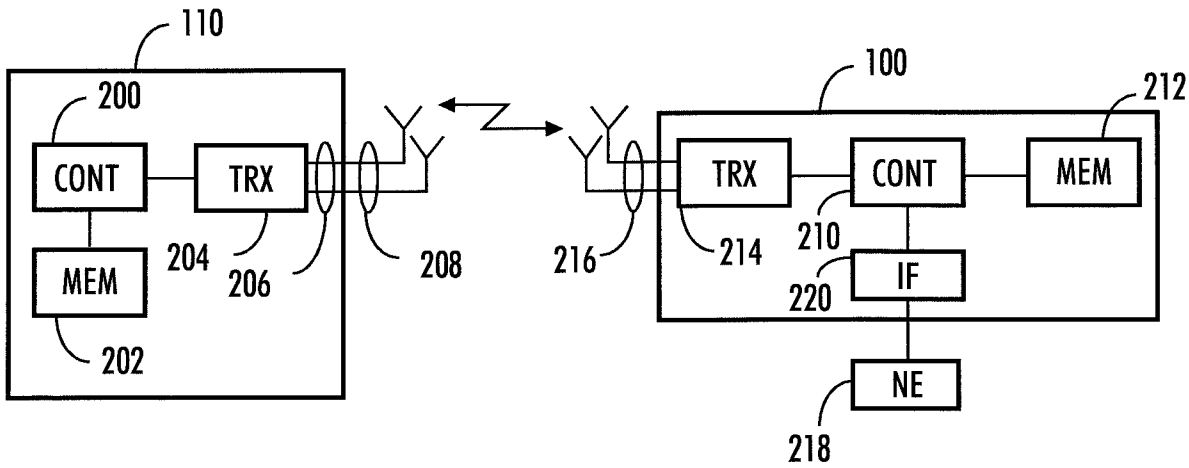
106
X2
S1_U
S11
S1_MME
B
102
MME
S1_MME
108

FIG. 1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CONT
TRX
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204
206
208
216
100
212
TRX
CONT
MEM
214
210
IF
220
NE
218

FIG. 2

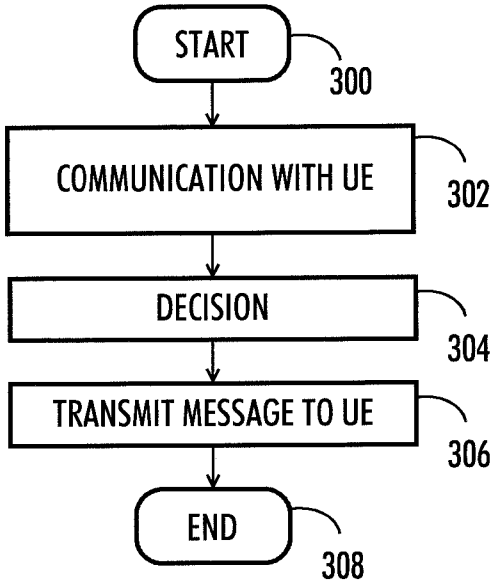
START
300
COMMUNICATION WITH UE
302
DECISION
304
TRANSMIT MESSAGE TO UE
306
END
308

FIG. 3A

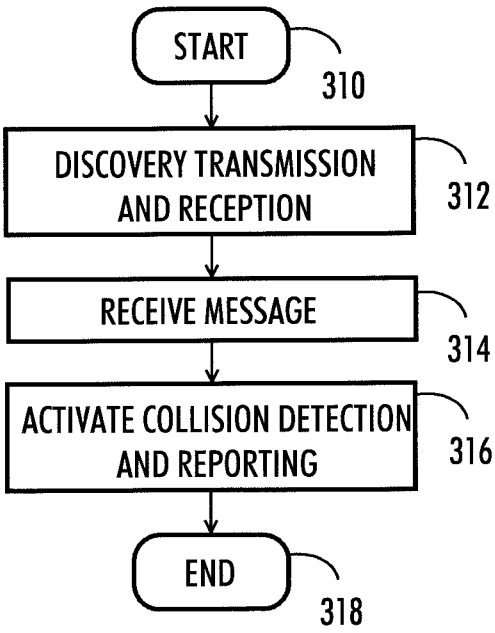
START
310
DISCOVERY TRANSMISSION AND RECEPTION
312
RECEIVE MESSAGE
314
ACTIVATE COLLISION DETECTION AND REPORTING
316
END
318

FIG. 3B

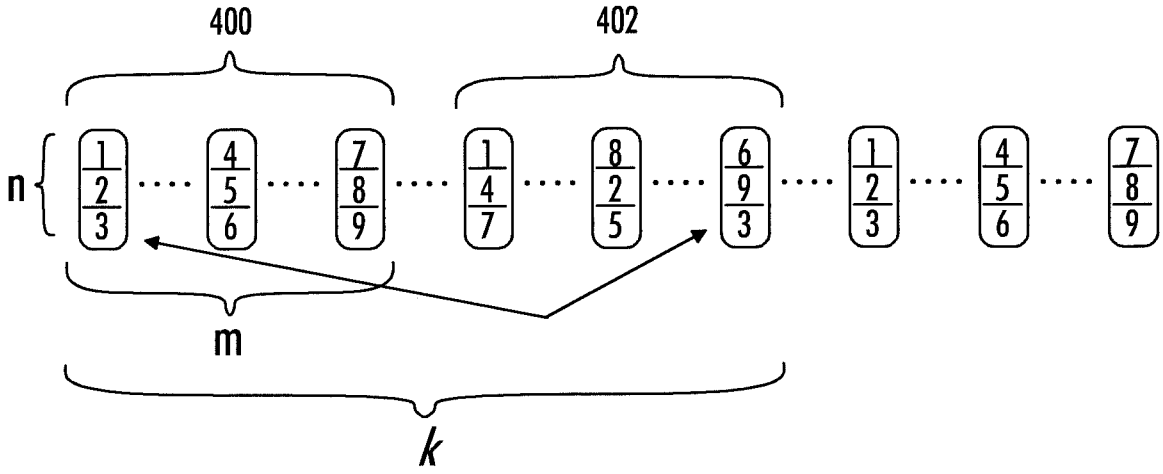

FIG. 4

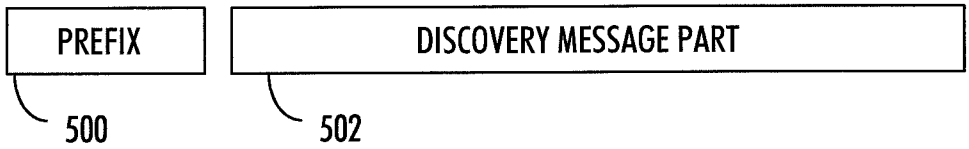

FIG. 5

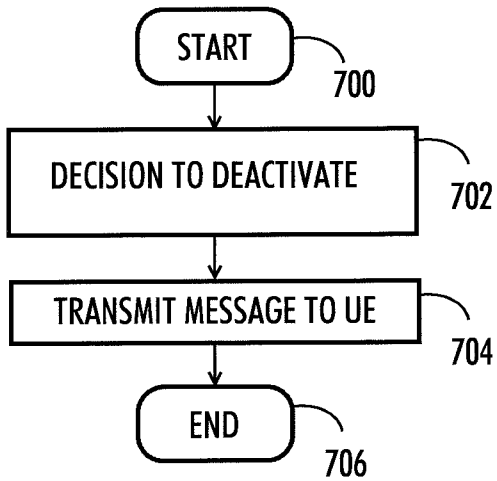

FIG. 7

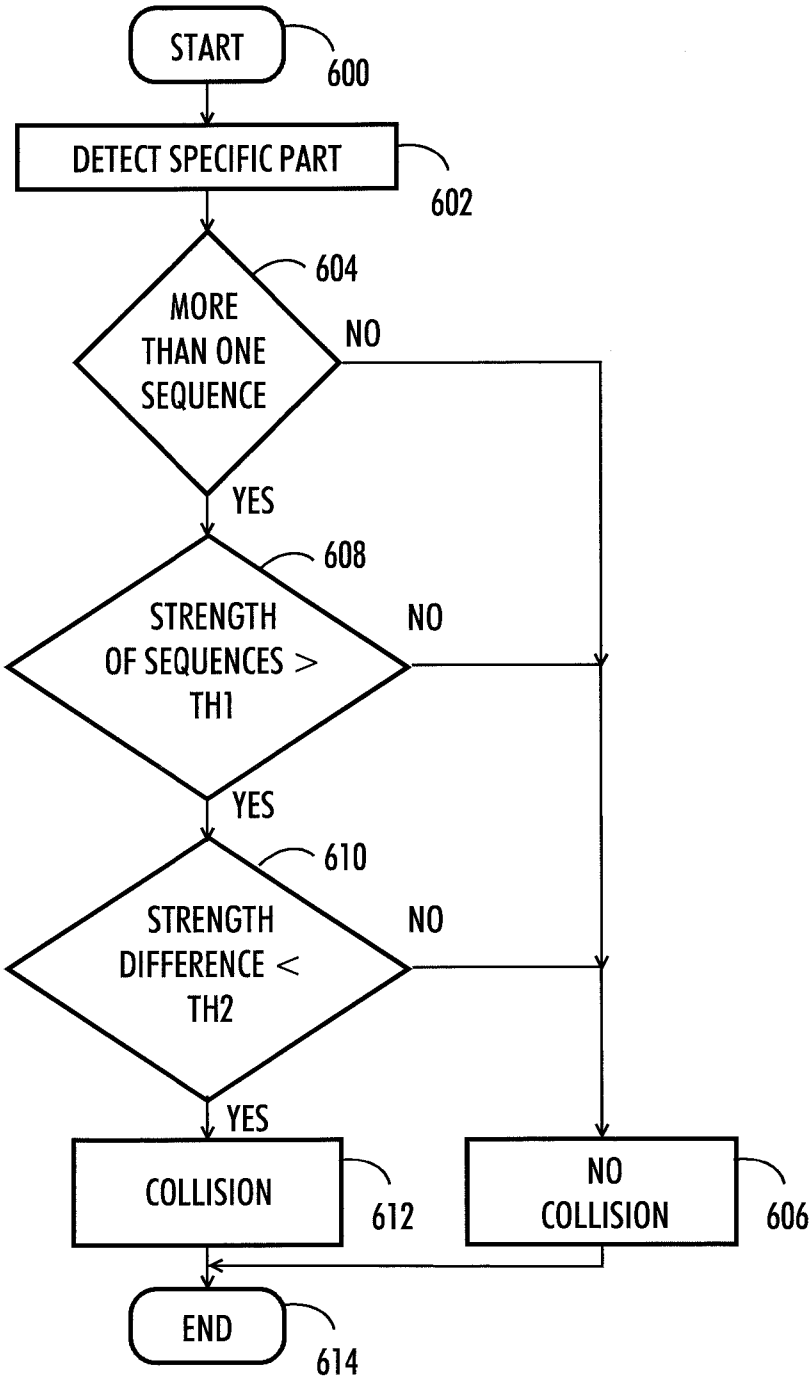
START
600
DETECT SPECIFIC PART
602
604
MORE THAN ONE SEQUENCE
NO
YES
608
STRENGTH OF SEQUENCES > TH1
NO
YES
610
STRENGTH DIFFERENCE < TH2
NO
YES
COLLISION
612
NO COLLISION
606
END
614

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/052988

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W8/00
ADD. H04W76/02 H04W74/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/069295 A1 (NOKIA CORP [FI]; CHEN TAO [FI]; WANG HAIMING [CN]; PENG TAO [CN]) 16 June 2011 (2011-06-16) abstract paragraphs [0001] - [0003], [0006], [0035] - [0048], [0051], [0055] - [0063]	1-46
A	US 2011/312330 A1 (SADEK AHMED K [US] ET AL) 22 December 2011 (2011-12-22) paragraphs [0048] - [0051]	1-46
A	US 2011/258313 A1 (MALLIK SIDDHARTHA [US] ET AL) 20 October 2011 (2011-10-20) abstract paragraphs [0007], [0008], [0024] - [0029], [0036] - [0043]	1-46

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 August 2013	16/08/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Isopescu, Ciprian

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2013/052988

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011069295 A1	16-06-2011	CN 102792745 A	21-11-2012
		EP 2510733 A1	17-10-2012
		US 2012243431 A1	27-09-2012
		WO 2011069295 A1	16-06-2011
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US 2011258313 A1	20-10-2011	CN 102972050 A	13-03-2013
		EP 2559271 A2	20-02-2013
		JP 2013526157 A	20-06-2013
		KR 20130010083 A	25-01-2013
		US 2011258313 A1	20-10-2011
		WO 2011130623 A2	20-10-2011