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(54) METHODS FOR D2D COMMUNICATION

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Description

TECHNICAL FIELD

[0001] The present invention relates to devices and methods for device to device (D2D) communication. More specifically, the present invention relates a method for D2D communication assisted by a cellular communication network.

BACKGROUND

[0002] In communication networks, communication resources used for communication, such as time slots, frequency channels, resource blocks and the like, usually have to be shared by a plurality of communication devices. In order to coordinate an access of the plurality of communication devices to the communication resources, medium access control (MAC) mechanisms can be applied. Common mechanisms for medium access control (MAC) are, for instance, carrier sense multiple access with collision avoidance (CSMA/CA) or carrier sense multiple access with collision detection (CSMA/CD). Data to be communicated can be embedded in a frame structure adapted to the chosen medium access control (MAC) mechanism.

[0003] In CSMA/CA, a carrier sensing scheme is used, wherein the plurality of communication devices can attempt to avoid collisions by transmitting only when the communication resource is sensed to be idle. In CSMA/CD, a carrier sensing scheme is used, wherein a device can detect collisions while transmitting data, can stop transmitting the data, and can wait for a time interval before resending the data.

[0004] Newly emerging applications, e.g. vehicle-to-X (V2X) communications using device-to-device (D2D) communications, can pose challenges with regard to providing a low latency and a high reliability within a communication network. Moreover, data having different priorities may have to be communicated within the communication network. Conventional medium access control (MAC) mechanisms in conjunction with conventional frame structures, however, are usually not capable of providing these functionalities concurrently and can suffer from a lack of flexibility and scalability.

[0005] In G. Fodor et al., "Design Aspects of Network Assisted Device-to-Device Communications", IEEE Communications Magazine, May 2011, a D2D communication network is described. Document ERICSSON, "On Metric and Procedures for In/Out of NW coverage detection for D2D", vol. RAN WG1, no. Shenzhen, China; 20140331 - 20140404, (20140321), 3GPP DRAFT; R1-141389 OUT OF COVERAGE PROCEDURES, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, discloses coverage detection metrics and procedures for D2D. In particular, a D2D-enabled UE that is out of coverage (OoC) of a cellular network and uses a set of preconfigured D2D resources can determine that it is approaching the edge of coverage, if it can reliably detect an "in-coverage" UE relaying broadcast control information. Upon receiving such control information, the UE will refrain from using the preconfigured resources and will start monitoring broadcast information about resources for D2D transmission.

[0006] US 2014/0133332 A1 discloses a method and apparatus for supporting UE relay functions. Particularly, a device in non-network assisted D2D radio communication with a second device, over a first frequency and with a first communication protocol, receives from the second device a coverage message indicting that the second device is within coverage of the cellular network. Upon receiving such message, the first device can prepare and initiate handover to a second frequency resource and communication protocol for the D2D communication.

SUMMARY

[0007] It is an object of the invention to provide a concept to improve the effectiveness and efficiency of a communication network.

[0008] The present invention is defined by a method of operating a communication device outside a coverage area of a cellular communication network configured to perform a D2D communication according to the independent claim 1.

[0009] Additional features of the invention are provided in the dependent claims. In the following, parts of the description and drawings referring to embodiments which are not covered by the claims are not presented as embodiments of the invention, but as examples useful for understanding the invention.

[0010] A first aspect relates to a communication device configured to perform a device to device communication with a plurality of further communication devices using a second (carrier) frequency band. The communication device is configured to receive using the second frequency band a control message from a further communication device of the plurality of communication devices, the control message indicating that the further communication device is within a coverage area of a cellular communication network (or in short cellular network). The communication device is further configured to, upon reception of said control message, start listening for messages from further communication devices of the plurality of communication devices using a first (carrier) frequency band, in particular by turning on a second receiver which is configured to receive in the first frequency band.

[0011] A communication device according to the first aspect moving into the coverage area of a cellular network can obtain information about communication resources used by other communication devices within the coverage area of the cellular network by monitoring messages within a further frequency band. Doing so allows

to efficiently share communication resources leading to fewer collisions of communication devices selecting interfering communication resources. Hence, the effectiveness and the efficiency of a communication network comprising such a communication device are improved.

[0012] In a first possible implementation form of the first aspect as such the communication device is configured to stop listening for messages using the first frequency band upon not receiving said control message from any of the plurality of communication devices for a predetermined amount of time, in particular by switching of the second receiver. By stopping to monitor messages from further communication devices over the further frequency band, once the communication device has left the coverage area of the cellular communication network, processing resources of the communication device are not unnecessarily wasted. Hence, the effectiveness and the efficiency of a communication network comprising such a communication device are improved.

[0013] In a second possible implementation form of the first aspect as such or the first implementation form thereof the communication device is configured to keep listening for messages using the first frequency band as long as it periodically receives the control message from at least one further communication device within the coverage area of the cellular communication network. It should be made clear that such control message does not need to be received periodically from one the same communication device. The control message could also be received from different communication devices. Doing so makes sure that, as long as the communication device is within the coverage area of the cellular network, the communication device is aware of the presence of the cellular network and the communication device can select communication resources on the basis of information received from the other communication devices over the further frequency band leading to fewer collisions of communication devices selecting interfering communication resources. Hence, the effectiveness and the efficiency of a communication network comprising such a communication device are improved.

[0014] In a third possible implementation form of the first aspect as such or the first or the second implementation form thereof the communication device is configured to determine itself to be within the coverage area of the cellular communication network, wherein the communication device is configured to, upon determining itself to be within the coverage area of the cellular communication network, stop receiving (e.g. stop listening for) said control message. Doing so reduces the processing overhead of the communication device, in case it can determine by other means (e.g. based on control signals received from a base station of the cellular communication network) to be within the coverage area of the cellular communication network. Hence, the effectiveness and the efficiency of a communication network comprising such a communication device are improved.

[0015] In a fourth possible implementation form of the first aspect as such or any one of the first to third implementation form thereof the communication device comprises a first receiver for the second frequency band and a second receiver for the first frequency band, wherein the communication device is configured to switch on the second receiver, upon reception of the control message, to start listening for messages from further communication devices of the plurality of communication devices using the first frequency band.

[0016] In a fifth possible implementation form of the first aspect as such or any one of the first to fourth implementation form thereof the communication device is configured to, as long as it does not receive said control message, communicate with the further communication devices using a communication frame having a first control channel format, the first control channel format offering only communication resources for an ad hoc communication mode, wherein the communication device is further configured to, upon reception of said control message, communicate with the further communication devices using a communication frame having a second control channel format, the second control channel format offering communication resources for an ad hoc communication mode and a network assisted communication mode.

[0017] Such a communication frame allows supporting both the network assisted communication mode and the ad hoc communication mode of a plurality of communication devices within a communication network at the same time. By means of such a communication frame it is possible for a communication device to seamlessly switch from the network assisted communication mode to the ad hoc communication mode in case cellular network assistance is no longer available. Furthermore it can be achieved that even ad-hoc mode devices (which are currently not in a network assisted mode) don't interfere with network assisted mode devices and vice versa, as the communication frame can provide dedicated communication resources to be used by the devices depending on in what mode the devices currently are (network assisted mode or ad hoc mode). Hence, the effectiveness and efficiency of a communication network employing such a communication device are improved.

[0018] The communication frame can be embedded within a frequency division duplexing (FDD) uplink frequency band or a time division duplexing (TDD) uplink time frame of a LTE communication frame. In particular, the communication frame can be embedded within a physical uplink shared channel (PUSCH) and/or a physical uplink control channel (PUCCH).

[0019] In a sixth possible implementation form of the first aspect as such or any one of the first to fifth implementation form thereof the communication device is configured to, when it is within the coverage area of the cellular communication network, use the first frequency band for cellular communication and device to device communication and, when it is within an edge region of the coverage area, further use the second frequency

band for device to device communication only.

[0020] The communication device can be arranged within a vehicle or car, or can be carried by a pedestrian. Furthermore, the communication device can be arranged within a traffic infrastructure device.

[0021] The communication device can be configured to operate within a vehicle-to-X (V2X) communication network or a device-to-device (D2D) communication network. The vehicle-to-X (V2X) communication network or the device-to-device (D2D) communication network can be an IEEE 802.11p based communication network or a long term evolution (LTE) based communication network.

[0022] The invention relates to a method of operating a communication device configured to perform a device to device communication with a plurality of further communication devices using a second (carrier) frequency band. The method comprises the steps of: receiving using the second frequency band a control message from a further communication device of the plurality of communication devices, the control message indicating that the further communication device is within a coverage area of a cellular communication network; and upon reception of the control message, start listening for messages from further communication devices of the plurality of communication devices using a first (carrier) frequency band, in particular by activating a second receiver.

[0023] The method according to the invention can be performed, for instance, by the communication device according to the first aspect. Further features of the method according to the invention result directly from the functionality of the communication device according to the first aspect.

[0024] A further aspect relates to a computer program comprising a program code for performing the method according to the second aspect of the invention when executed on a computer.

[0025] The invention can be implemented in hardware and/or software.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Further embodiments of the invention will be described with respect to the following figures, wherein:

Fig. 1 shows a schematic diagram of a communication scenario including a plurality of communication devices operating in a network-assisted communication mode and in an ad-hoc communication mode according to an embodiment;

Fig. 2 shows a schematic diagram of a communication frame suitable in a communication device or method according to an embodiment;

Fig. 3 shows a schematic diagram of a communication scenario including a plurality of communication devices inside and outside of a coverage area of a cellular network according to an embodiment;

Fig. 4 shows a schematic diagram illustrating different frequency bands that can be used by a communication device according to an embodiment;

Fig. 5 shows a schematic diagram illustrating a communication process between different communication devices according to an embodiment;

Fig. 6 shows a schematic diagram illustrating a communication process between different communication devices according to an embodiment;

Fig. 7 shows a flow diagram illustrating a method of operating a communication device according to an embodiment; and

Fig. 8 shows a flow diagram illustrating a method of operating a communication device according to an embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0027] Figure 1 shows a schematic diagram of a communication scenario including a plurality of communication devices operating in an ad-hoc communication mode and a network-assisted communication mode according to an embodiment. The upper half of figure 1 shows three exemplary communication devices 101 a, 101b and 101c according to an embodiment operating in a network-assisted communication mode and configured to communicate with an exemplary base station 102 of a cellular network. The lower half of figure 1 shows four exemplary communication devices 101b, 103a, 103b and 103c according to an embodiment operating in the ad-hoc communication mode.

[0028] The communication devices 101a-c and 103a-c can be configured to operate within a vehicle-to-X (V2X) communication network or a device-to-device (D2D) communication network. The term vehicle-to-X (V2X) communications is used to cover vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and vehicle-to-X (V2X) communications. The vehicle-to-X (V2X) communication network or the device-to-device (D2D) communication network can be an IEEE 802.11p based communication network or a long term evolution (LTE) based communication network.

[0029] As indicated in figure 1, in the network-assisted communication mode the D2D control plane and data plane can be separated in that exchange of control data between the communication devices 100a-c can be done via the cellular network represented by the base station. In the ad-hoc communication mode the D2D control plane and data plane can be the same.

[0030] Figure 2 shows a schematic diagram of an embodiment of a communication frame 200 for network communication, in particular for device-to-device (D2D)

network communication that can be used by the communication devices 100a-c or 101a-c. The communication frame 200 comprises a control channel 201 and a data channel 207.

[0031] In an embodiment, the communication frame 200 can be a unified medium access control (MAC) frame. In an embodiment, the communication frame 200 can be embedded within a frequency division duplexing (FDD) uplink frequency band or a time division duplexing (TDD) uplink time frame of a LTE communication frame. In an embodiment, the communication frame 200 can be embedded within a physical uplink shared channel (PUSCH) and/or a physical uplink control channel (PUCCH) of a LTE communication frame.

[0032] Typically, control data provided by a communication resource within the control channel 201 of the communication frame 200 defines communication resources within the data channel 207 communicating specific payload data. In other words, the control data within the control channel 201 of the communication frame provides a mapping to the payload data within the data channel 207 of the communication frame 200.

[0033] The control channel 201 can enable a fine-tuned synchronization, a direct neighboring device discovery, a paging, a communication resource reservation for data and can be used for exchanging communication device context information, e.g. a geographic position of a communication device.

[0034] The control channel 201 can have a permanent set of communication resources, e.g. used for a L1/L2 control among communication devices. The control channel 201 length or size can be configurable, e.g. based on a communication device density. A multi-user control channel access protocol can be used.

[0035] The data channel 207 can comprise a high priority portion 207a (referred to in figure 2 as "Safety Data Channel" or short "SDC") and a low priority portion 207b (referred to in figure 2 as "Non-Safety Data Channel" or short "NDC").

[0036] The high priority portion 207a of the data channel 207, i.e. the SDC portion, can be reserved for high priority data, e.g. hard quality of service (QoS) safety vehicle-to-X (V2X) traffic data, with high priority. It can support mixed data or traffic types, e.g. semi-persistent communication resource patterns for cooperative awareness message (CAM) periodical messages, and/or an on-demand communication resource reservation for context-rich mission-critical data (CMD). A multi-user high priority data channel communication resource reservation protocol can be used.

[0037] The low priority portion 207b of the data channel 207, i.e. the NDC portion, can serve low priority data, e.g. soft quality of service (QoS) vehicle-to-X (V2X) traffic data, with low priority, e.g. traffic efficiency application data. It can give up priority for high priority data, e.g. hard quality of service (QoS) safety traffic data. A multi-user communication resource coordination in the low priority portion 207b, i.e. the NDC portion, can be based on an on-demand reservation scheme or a carrier sense multiple access (CSMA) type reservation scheme.

[0038] The communication resources of the high priority portion 207a of the data channel 207, i.e. the SDC portion, and the low priority portion 207b of the data channel 207, i.e. the NDC portion, can be multiplexed, for instance, in the frequency domain and/or the time domain.

[0039] In the embodiment shown in figure 2 the communication frame 200 is embedded within an uplink LTE communication frame that can further comprise an uplink LTE communication frame portion 209. Thus, an allocation of connected communication resources within a long term evolution (LTE) structure is possible. In a downlink communication portion, communication resources may not be allocated connectedly since control frames may appear every 1 ms. A concurrent downlink (DL) receive can be achieved.

[0040] In an embodiment, when using a long term evolution (LTE) frequency division duplexing (FDD) carrier, communications can be performed within a physical uplink shared channel (PUSCH). Thus, after communication of the communication frame 200, normal long term evolution (LTE) communications can take place.

[0041] As can be taken from the more detailed view of the communication frame 200 shown on the bottom left hand side of figure 2, the control channel 201 of the communication frame 200 comprises in an embodiment a high priority control channel part ("SDC control") and a low priority control channel part ("NDC control"). In the embodiment shown in figure 2, the high priority part of the control channel 201 is divided into an ad-hoc communication mode control channel portion 203a and a network assisted communication mode control channel portion 203b. Likewise, in the embodiment shown in figure 2, the low priority part of the control channel 201 is divided into an ad-hoc communication mode control channel portion 205a and a network assisted communication mode control channel portion 205b.

[0042] Figure 2 shows two exemplary communication resources, in particular resource blocks, 201a and 201b within the ad-hoc communication mode control channel portion 203a of the high priority part of the control channel 201. As can be taken from the more detailed view shown on the bottom right hand side of figure 2, the exemplary communication resource, in particular resource block, 201a comprises a plurality of data fields, such as a synchronization sequence or signal (SS) 211, a device ID 213, a resource block ID 215, context data 217, such as information about the location of a device, a field for other data 219 and a guard interval (GI) 221.

[0043] The synchronization sequence or signal (SS) 211, for instance, allows synchronizing communication devices operating in the ad-hoc communication mode, such as the communication devices 101a-d shown in figure 1.

[0044] The top left hand side of figure 2 shows an embodiment of a control channel 201', which can be used

when no network assistance is available. In this case the control channel 201' can comprise only a high priority part (referred to as "SDC control" in figure 2) and a low priority part (referred to as "NDC control" in figure 2).

[0045] In an embodiment, the communication frame 200 can be structured depending on a mode from a set of modes, wherein the set of modes comprises the ad-hoc communication mode and the network-assisted communication mode. In an embodiment, the communication frame 200 can be switched between the ad-hoc communication mode and the network-assisted communication mode and vice versa, for instance, according to cellular network coverage and/or whether a communication device is in an idle mode or a connected mode with respect to a cellular network. Thus, a decision criterion for automatic mode switching can be provided.

[0046] Figure 3 shows a schematic diagram of a communication scenario including a plurality of communication devices inside and outside of a coverage area 301 of the cellular communication network 102 according to an embodiment. The cellular communication network is provided by means of base stations 102a. Although in the example in Fig. 3 only one base station 102a is shown, it is clear for a person skilled in the art that a cellular communication network is typically spanned by a plurality of base stations 102a. The coverage area 301 of the cellular communication network 102 is divided into a center region 301a in the vicinity of the base station 102a establishing the cellular communication network 102 and an edge region 301b outside of the center region 301a of the cellular communication network 102, i.e. in the vicinity of the edge of the coverage area 301. In the example shown in figure 3 the communication device 101a is within the center region 301a of the coverage area 301 of the cellular communication network 102, the communication devices 101b and 101c are within the edge region 301b of the coverage area 301 of the cellular communication network 102 and the communication devices 103a-c are outside of the coverage area 301 of the cellular communication network 102. In other words, the communication devices 103a-c cannot communicate directly with the base station 102a (or any other base station) of the cellular communication network 102. In an embodiment, the center region 301a and the edge 301b of the coverage area 301 of the cellular communication network 102 can be defined by using a signal strength threshold for the signal strength of the cellular communication network 102.

[0047] In an embodiment, the communication devices within the coverage area 301 of the cellular communication network 102, i.e. the exemplary communication devices 101a-c shown in figure 3, and the communication devices outside of the coverage area 301 of the cellular communication network 102, i.e. the exemplary communication devices 103a-c shown in figure 3, can operate using communication frames within different frequency bands. In an embodiment, the communication devices within the coverage area 301 of the cellular communication network 102, i.e. the exemplary communication devices 101a-c shown in figure 3, can use part of the cellular UL PUSCH communication resources as shown in figure 4. In this case, the communication frame can be embedded in the legacy LTE PUSCH communication frame, including a control channel 201 and a data channel 207 with a high priority portion 207a and a low priority portion 207b, as already described above in the context of figure 2.

[0048] In an alternative embodiment, both the communication devices within the coverage area 301 of the cellular communication network 102, i.e. the exemplary communication devices 101a-c shown in figure 3, and the communication devices outside of the coverage area 301 of the cellular communication network 102, i.e. the exemplary communication devices 103a-c shown in figure 3, can operate using the same frequency band for D2D communication. In other words, the D2D communication can take place in a dedicated band using a dedicated D2D communication frame, as shown also in figure 4. The cellular communication network 102, which can only be utilized by the communication devices within the coverage area 301 of the cellular communication network 102, i.e. the exemplary communication devices 101a-c shown in figure 3, can be deployed on Band 1, as schematically illustrated in figure 4.

[0049] Figure 5 shows a schematic diagram illustrating the communication flow 500 between a communication device within the coverage area 301 of the cellular communication network 102, e.g. the communication device 101b shown in figure 3, and a communication device approaching the coverage area 301 of the cellular communication network 102, e.g. the communication device 103a shown in figure 3, for the case described above that the communication devices within the coverage area 301 of the cellular communication network 102 and the communication devices outside of the coverage area 301 of the cellular communication network 102 perform D2D communications using different frequency bands e.g. Band 1 (first frequency band) and Band 2 (second frequency band) from the upper half of Fig. 4.

[0050] In a step 501 of the communication process 500 shown in figure 5 the communication device 101b determines itself to be within the edge region 301b of the coverage area 301 of the cellular communication network 102. In an embodiment, the communication device 101b is configured to make this determination on the basis of a (e.g. legacy LTE) signal strength provided by the cellular communication network 102 or on the basis of interacting with the network.

[0051] In a step 503 the communication device 101b activates a second receiver in order to start listening for communication messages over a second frequency band, while continuing to listen for communication messages from other communication devices within the coverage area 301 of the cellular communication network 102 over a first frequency band using a first receiver.

[0052] In a step 505 the communication device 101b

periodically broadcasts a control message to communication devices outside of the coverage area 301 of the cellular communication network 102 using the second frequency band, in particular using the control channel of a communication frame operating in the second frequency band. In an embodiment, the control message broadcasted by the communication device 101b can comprise at least one of the following data elements: an identifier of the communication device 101b, an indicator indicating that the communication device 101b is within the coverage area 301 of the cellular communication network 102, a communication resource identifier identifying the communication resource(s) selected by the communication device 101b, a synchronization signal from the communication device 101b, and/or location information about the communication device 101b.

[0053] When in step 505 the communication device 103a outside of the coverage area 301 of the cellular communication network 102, but within the broadcasting region of the communication device 101b receives such a control message from the communication device 101b the communications device 103a determines itself to be in the vicinity of the outer edge of the coverage area 301 of the cellular communication network 102. In response thereto, in a step 507 the communication device 103a starts listening for communication messages within the first frequency band (schematically indicated as step 509 in figure 5), in particular by activating its second receiver, while continuing to listen for communication messages over the second frequency band. The communication device 103a is now also aware about D2D communications performed on the first frequency band (e.g. by communications devices within in the coverage range of the cellular communication network 102).

[0054] Figure 6 shows a schematic diagram illustrating the communication flow 600 between a communication device within the coverage area 301 of the cellular communication network 102, e.g. the communication device 101b shown in figure 3, and a communication device approaching the coverage area 301 of the cellular communication network 102, e.g. the communication device 103a shown in figure 3, for the case described above that the communication devices within the coverage area 301 of the cellular communication network 102 and the communication devices outside of the coverage area 301 of the cellular communication network 102 perform D2D communications using the same frequency band e.g. Band 2 (the second frequency band) from the lower half of Fig. 4.

[0055] In a step 601 of the communication process 600 shown in figure 6 the communication device 101b determines itself to be within the edge region 301b of the coverage area 301 of the cellular communication network 102. In an embodiment, the communication device 101b is configured to make this determination on the basis of a (e.g. legacy LTE) signal strength provided by the cellular communication network 102 or on the basis of interacting with the network.

[0056] In a step 603 the communication device 101b periodically broadcasts a control message to communication devices outside of the coverage area 301 of the cellular communication network 102 using the second frequency band, in particular using the control channel of a communication frame operating in the second frequency band. In an embodiment, the control message broadcasted by the communication device 101b can comprise at least one of the following data elements: an identifier of the communication device 101b, an indicator indicating that the communication device 101b is within the coverage area 301 of the cellular communication network 102, a communication resource identifier identifying the communication resource(s) selected by the communication device 101b, a synchronization signal from the communication device 101b, and/or location information about the communication device 101b.

[0057] When in step 603 the communication device 103a outside of the coverage area 301 of the cellular communication network 102, but within the broadcasting region of the communication device 101b receives such a control message from the communication device 101b and, the communication device 103a determines itself to be in the vicinity of the outer edge of the coverage area 301 of the cellular communication network 102. In response thereto, in steps 605 and 607 the communication device 103a only uses the ad-hoc communication mode control channel portion of the control channel of the communication frame, such as the ad-hoc communication mode control channel portion 205a of the control channel 201 of the communication frame 200 shown in figure 2, defined by the control message received from the communication device 101b within the edge region 301b of the coverage area 301 of the cellular communication network 102. In an embodiment, the communication device 103a continues to receive over the entire control channel of the communication frame, including the ad-hoc communication mode control channel portion 205a and the network assisted communication mode control channel portion 205b. Hence, the communication device 103a is now aware of D2D communications of devices in the ad-hoc communication mode and the network-assisted communication mode. Hence, resource collision between communication devices in different communications modes can be avoided.

[0058] Figure 7 shows a flow diagram illustrating a method 700 of operating a communication device, such as one of the communication devices 103a-c, configured to perform a D2D communication with a plurality of further communication devices, such as the communication devices 101a-c, 103a-c, using a second frequency band. The method 700 comprises the following steps.

[0059] A first step 701 of receiving a control message from a further communication device of the plurality of communication devices, such as one of the communication devices 101a-c, the control message indicating that the further communication device, such as one of the communication devices 101a-c, is within a coverage area

301 of a cellular communication network (represented by the base station 102). A second step 703, in response to the reception of the control message, of starting to listen for messages from further communication devices of the plurality of communication devices, such as the communication devices 101a-c, 103a-c, using a first frequency band.

[0060] Figure 8 shows a flow diagram illustrating a method 800 of operating a communication device, such as one of the communication devices 101a-c, configured to perform a D2D communication with a plurality of further communication devices. The method 800 comprises the following steps.

[0061] A first step 801 of determining itself (i.e. the communication device) to be within a coverage area 301 of a cellular communication network (provided by at least one base station 102a). A second step 803 of broadcasting a control message to the further communication devices, the control message indicating that the communication device is within the coverage area 301 of the cellular communication network 102.

[0062] Embodiments of the invention may be implemented in a computer program for running on a computer system, at least including code portions for performing steps of a method according to the invention when run on a programmable apparatus, such as a computer system or enabling a programmable apparatus to perform functions of a device or system according to the invention. A computer program is a list of instructions such as a particular application program and/or an operating system. The computer program may for instance include one or more of: a subroutine, a function, a procedure, an object method, an object implementation, an executable application, an applet, a servlet, a source code, an object code, a shared library/dynamic load library and/or other sequence of instructions designed for execution on a computer system.

[0063] Although the invention is described with reference to specific features, implementation forms, and embodiments, it is evident that various modifications and combinations can be made thereto without departing from the scope of the invention, as defined by the appended claims. The description and the figures are, accordingly, to be regarded simply as an illustration of the invention, and are contemplated to cover any and all modifications, variations, or combinations that fall within the scope of the invention, as defined by the appended claims.

Claims

1. A method (700) performed by a communication device (103a-c) outside a coverage area (301) of a cellular communication network (102), wherein the communication device (103a-c) is configured to perform a device to device communication with a plurality of further communication devices (101a-c, 103a-c) using a second frequency band, the method (700) comprising the steps of:

   receiving (701), by using the second frequency band, a control message from a further communication device (101a-c) of the plurality of communication devices (101a-c, 103a-c), the control message indicating that the further communication device (101a-c) is within the coverage area (301) of the cellular communication network (102); and
   upon reception of the control message, starting (703) to listen for messages from further communication devices of the plurality of communication devices (101a-c, 103a-c) using a first frequency band,
   wherein the method (700) further comprises:

      as long as the communication device (103a-c) does not receive said control message, communicating with the further communication devices using a communication frame (200) having a first control channel format (201'), the first control channel format (201') offering only communication resources for an ad-hoc communication mode; and
      upon reception of said control message, communicating with the further communication devices using a communication frame (200) having a second control channel format (201), the second control channel format (201) offering communication resources for an ad-hoc communication mode and a network assisted communication mode.

2. The method (700) according to claim 1, wherein the method (700) further comprises: stopping listening for messages using the first frequency band upon not receiving said control message from any of the plurality of communication devices (101a-c, 103a-c) for a predetermined amount of time.

3. The method (700) according to claim 1 or 2, wherein the starting (703) to listen comprises: keeping listening for messages using the first frequency band as long as the communication device (103a-c) periodically receives said control message from at least one further communication device (101a-c, 103a-c) within the coverage area (301) of the cellular communication network (102).

4. The method (700) according to any of claims 1-3, wherein the method (700) further comprises: switching on a second receiver, upon reception of the control message, to start listening for messages from further communication devices of the plurality of

communication devices (101a-c, 103a-c) using the first frequency band, wherein the communication device (103a-c) comprises a first receiver for the first frequency band and a second receiver for the second frequency band.

5. The method (700) according to any of claims 1-4, wherein the method (700) further comprises: when the communication device (103a-c) is within the coverage area (301) of the cellular communication network (102), using the first frequency band for cellular communication and device to device communication and when the communication device (103a-c) is within an edge region (301b) of the coverage area (301) further using the second frequency band for device to device communication only.

Patentansprüche

1. Verfahren (700), das durch eine Kommunikationsvorrichtung (103a-c) außerhalb eines Abdeckungsbereichs (301) eines zellulären Kommunikationsnetzwerks (102) durchgeführt wird, wobei die Kommunikationsvorrichtung (103a-c) dazu ausgelegt ist, eine Vorrichtung-zu-Vorrichtung-Kommunikation mit mehreren weiteren Kommunikationsvorrichtungen (101a-c, 103a-c) unter Verwendung eines zweiten Frequenzbands durchzuführen, wobei das Verfahren (700) die folgenden Schritte umfasst:

Empfangen (701) einer Steuernachricht aus einer weiteren Kommunikationsvorrichtung (101a-c) der mehreren Kommunikationsvorrichtungen (101a-c, 103a-c) unter Verwendung des zweiten Frequenzbands, wobei die Steuernachricht anzeigt, dass sich die weitere Kommunikationsvorrichtung (101a-c) innerhalb des Abdeckungsbereichs (301) des zellulären Kommunikationsnetzwerks (102) befindet; und
bei Empfang der Steuernachricht Beginnen (703) mit Lauschen nach Nachrichten aus weiteren Kommunikationsvorrichtungen der mehreren Kommunikationsvorrichtungen (101a-c, 103a-c) unter Verwendung eines ersten Frequenzbands,
wobei das Verfahren (700) ferner umfasst:

solange die Kommunikationsvorrichtung (103a-c) die Steuernachricht nicht empfängt, Kommunizieren mit den weiteren Kommunikationsvorrichtungen unter Verwendung eines Kommunikationsrahmens (200) mit einem ersten Steuerkanalformat (201'), wobei das erste Steuerkanalformat (201') nur Kommunikationsressourcen für einen Ad-hoc-Kommunikationsmodus bietet; und
bei Empfang der Steuernachricht Kommunizieren mit den weiteren Kommunikationsvorrichtungen unter Verwendung eines Kommunikationsrahmens (200) mit einem zweiten Steuerkanalformat (201), wobei das zweite Steuerkanalformat (201) Kommunikationsressourcen für einen Ad-hoc-Kommunikationsmodus und einen netzwerkgestützten Kommunikationsmodus bietet.

2. Verfahren (700) gemäß Anspruch 1, wobei das Verfahren (700) ferner umfasst:
Beenden des Lauschens nach Nachrichten unter Verwendung des ersten Frequenzbands, wenn für eine vorbestimmte Zeitspanne aus keinem der mehreren Kommunikationsvorrichtungen (101a-c, 103a-c) die Steuernachricht empfangen wird.

3. Verfahren (700) gemäß Anspruch 1 oder 2, wobei das Beginnen (703) mit Lauschen umfasst:
fortgesetztes Lauschen nach Nachrichten unter Verwendung des ersten Frequenzbands, solange die Kommunikationsvorrichtung (103a-c) regelmäßig die Steuernachricht aus mindestens einer weiteren Kommunikationsvorrichtung (101a-c, 103a-c) innerhalb des Abdeckungsbereichs (301) des zellulären Kommunikationsnetzwerks (102) empfängt.

4. Verfahren (700) gemäß einem der Ansprüche 1-3, wobei das Verfahren (700) ferner umfasst:
Einschalten eines zweiten Empfängers bei Empfang der Steuernachricht, um zu beginnen, auf Nachrichten aus weiteren Kommunikationsvorrichtungen der mehreren Kommunikationsvorrichtungen (101a-c, 103a-c), die das erste Frequenzband verwenden, zu lauschen, wobei die Kommunikationsvorrichtung (103a-c) einen ersten Empfänger für das erste Frequenzband und einen zweiten Empfänger für das zweite Frequenzband umfasst.

5. Verfahren (700) gemäß einem der Ansprüche 1-4, wobei das Verfahren (700) ferner umfasst:
wenn sich die Kommunikationsvorrichtung (103a-c) innerhalb des Abdeckungsbereichs (301) des zellulären Kommunikationsnetzwerks (102) befindet, Verwenden des ersten Frequenzbands für zelluläre Kommunikation und Vorrichtung-zu-Vorrichtung-Kommunikation und wenn sich die Kommunikationsvorrichtung (103a-c) innerhalb eines Randbereichs (301b) des Abdeckungsbereichs (301) befindet, weiteres Verwenden des zweiten Frequenzbands nur für Vorrichtung-zu-Vorrichtung-Kommunikation.

Revendications

1. Procédé (700) réalisé par un dispositif de communi-

cation (103a-c) en dehors d'une zone de couverture (301) d'un réseau de communication cellulaire (102), le dispositif de communication (103a-c) étant configuré pour réaliser une communication de dispositif à dispositif avec une pluralité d'autres dispositifs de communication (101a-c, 103a-c) en utilisant une deuxième bande de fréquences, le procédé (700) comprenant les étapes consistant à :

recevoir (701), en utilisant la deuxième bande de fréquences, un message de commande provenant d'un autre dispositif de communication (101a-c) de la pluralité de dispositifs de communication (101a-c, 103a-c), le message de commande indiquant que l'autre dispositif de communication (101a-c) est dans la zone de couverture (301) du réseau de communication cellulaire (102) ; et
lors de la réception du message de commande, commencer (703) à écouter s'il y a des messages provenant d'autres dispositifs de communication de la pluralité de dispositifs de communication (101a-c, 103a-c) en utilisant une première bande de fréquences,
le procédé (700) consistant en outre à :

tant que le dispositif de communication (103a-c) ne reçoit pas ledit message de commande, communiquer avec les autres dispositifs de communication en utilisant une trame de communication (200) ayant un premier format de canal de commande (201'), le premier format de canal de commande (201') offrant uniquement des ressources de communication pour un mode de communication ad hoc ; et
lors de la réception dudit message de commande, communiquer avec les autres dispositifs de communication en utilisant une trame de communication (200) ayant un deuxième format de canal de commande (201), le deuxième format de canal de commande (201) offrant des ressources de communication pour un mode de communication ad hoc et un mode de communication assisté par un réseau.

2. Procédé (700) selon la revendication 1, le procédé (700) consistant en outre à : arrêter d'écouter s'il y a des messages en utilisant la première bande de fréquences lorsque ledit message de commande n'est pas reçu de l'un quelconque de la pluralité de dispositifs de communication (101a-c, 103a-c) pendant une durée prédéterminée.

3. Procédé (700) selon la revendication 1 ou 2, le fait de commencer (703) à écouter consistant à : continuer à écouter s'il y a des messages en utilisant la première bande de fréquences tant que le dispositif de communication (103a-c) reçoit périodiquement ledit message de commande d'au moins un autre dispositif de communication (101a-c, 103a-c) dans la zone de couverture (301) du réseau de communication cellulaire (102).

4. Procédé (700) selon l'une quelconque des revendications 1 à 3, le procédé (700) consistant en outre à : basculer sur un deuxième récepteur, lors de la réception du message de commande, pour commencer à écouter s'il y a des messages provenant d'autres dispositifs de communication de la pluralité de dispositifs de communication (101a-c, 103a-c) en utilisant la première bande de fréquences, le dispositif de communication (103a-c) comprenant un premier récepteur pour la première bande de fréquences et un deuxième récepteur pour la deuxième bande de de fréquences.

5. Procédé (700) selon l'une quelconque des revendications 1 à 4, le procédé (700) consistant en outre à : lorsque le dispositif de communication (103a-c) est dans la zone de couverture (301) du réseau de communication cellulaire (102), utiliser la première bande de de fréquences pour la communication cellulaire et pour la communication de dispositif à dispositif, et lorsque le dispositif de communication (103a-c) est dans une région périphérique (301b) de la zone de couverture (301), utiliser en outre la deuxième bande de fréquences pour la communication de dispositif à dispositif uniquement.

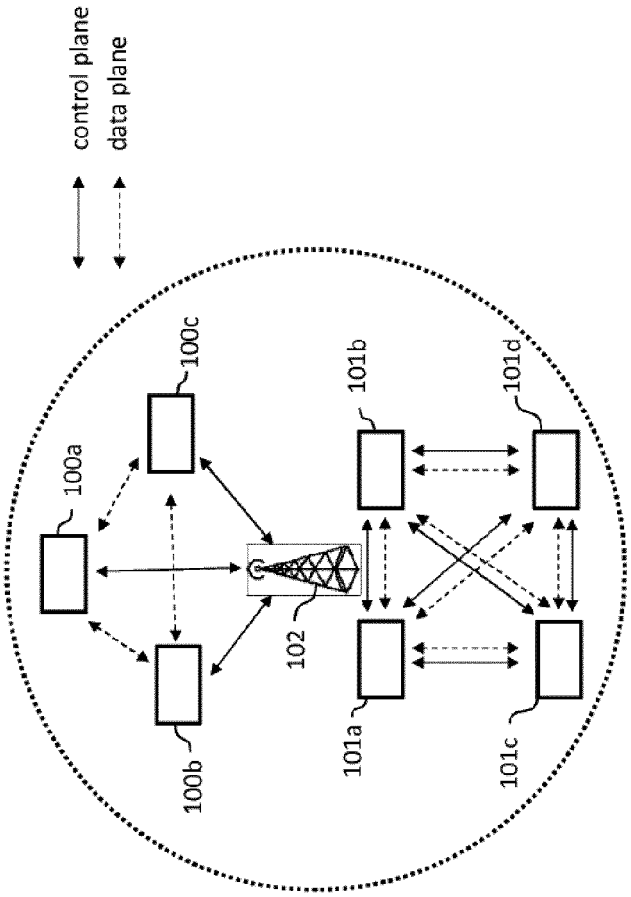
control plane
data plane
100a
100b
100c
101a
101b
101c
101d
102

Fig. 1

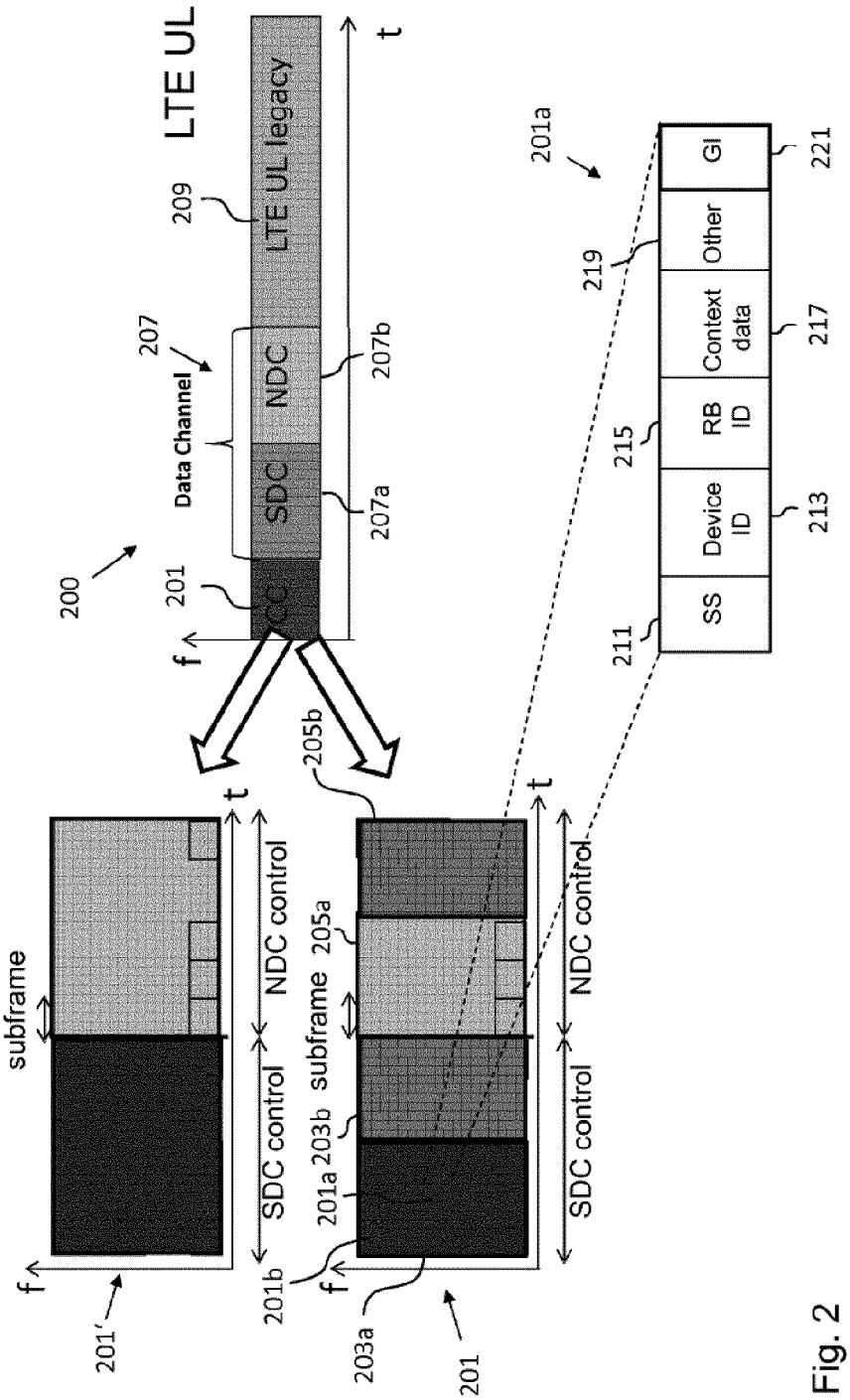
LTE UL
LTE UL legacy
209
t
207
Data Channel
NDC
207b
SDC
207a
200
201
CC
f
205b
201a
219
Other
GI
221
Context data
217
RB ID
215
Device ID
213
SS
211
t
NDC control
SDC control
subframe
205a
201a 203b
201b
f
203a
201
t
NDC control
SDC control
subframe
201'
f

Fig. 2

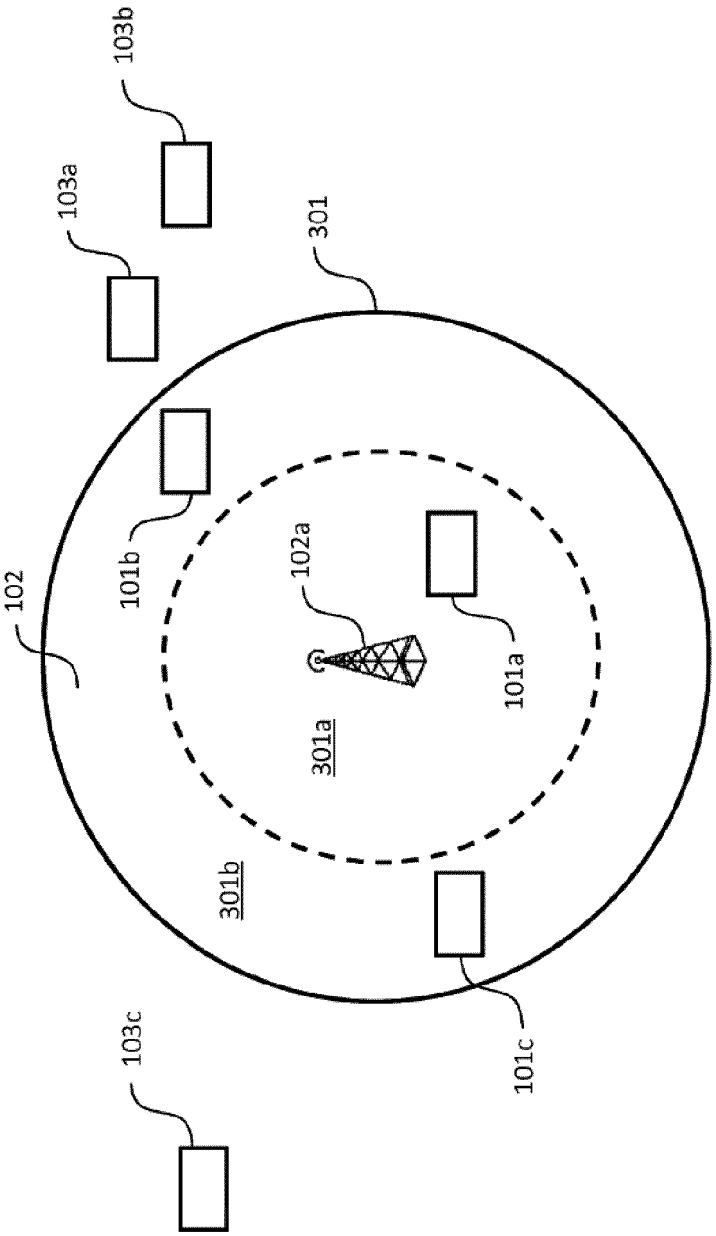

Fig. 3

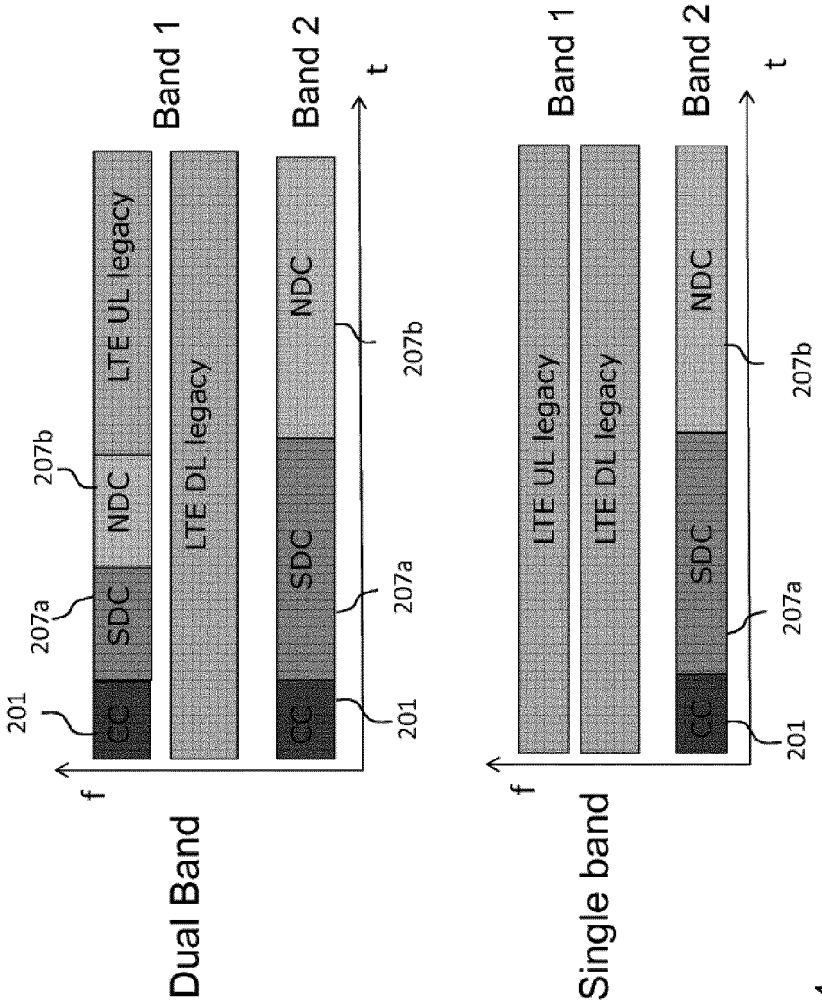
Band 1
Band 2
t
f
LTE UL legacy
LTE DL legacy
NDC
SDC
CC
201
207a
207b
Dual Band
Single band

Fig. 4

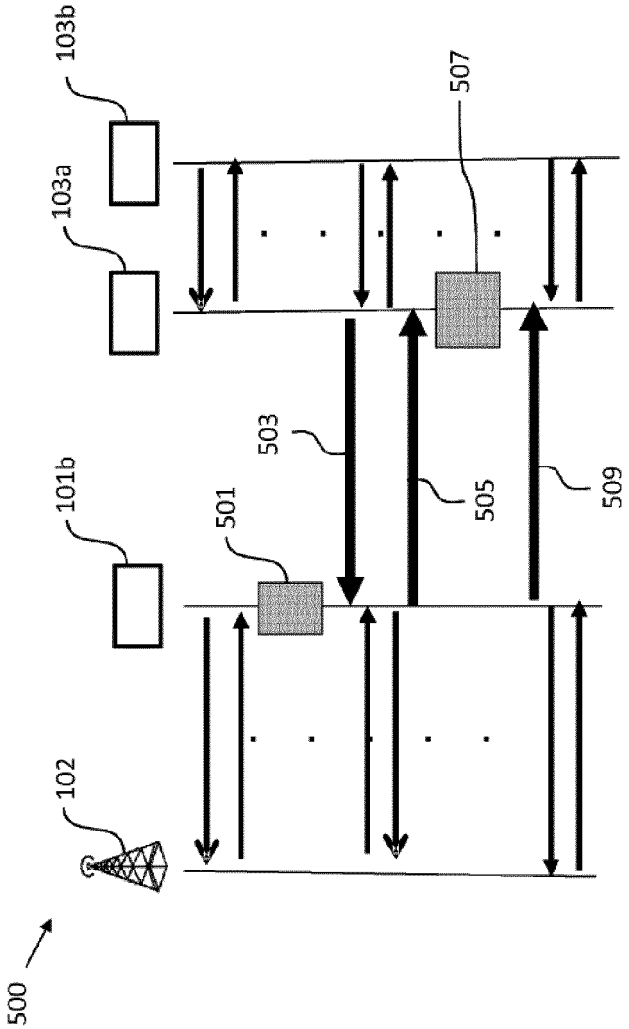

Fig. 5

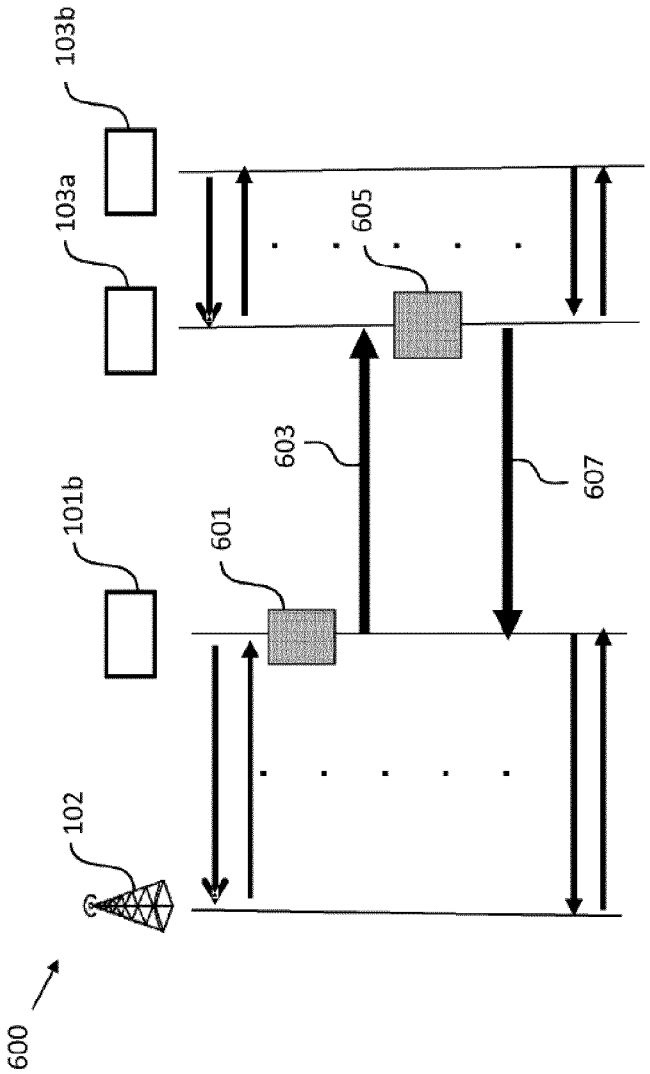

Fig. 6

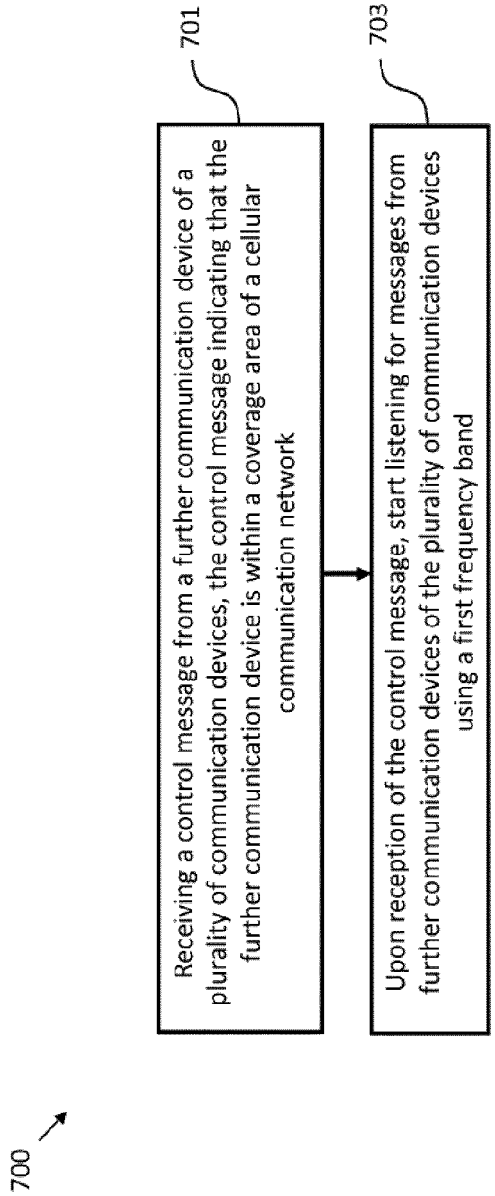
700
701
Receiving a control message from a further communication device of a plurality of communication devices, the control message indicating that the further communication device is within a coverage area of a cellular communication network
703
Upon reception of the control message, start listening for messages from further communication devices of the plurality of communication devices using a first frequency band

Fig. 7

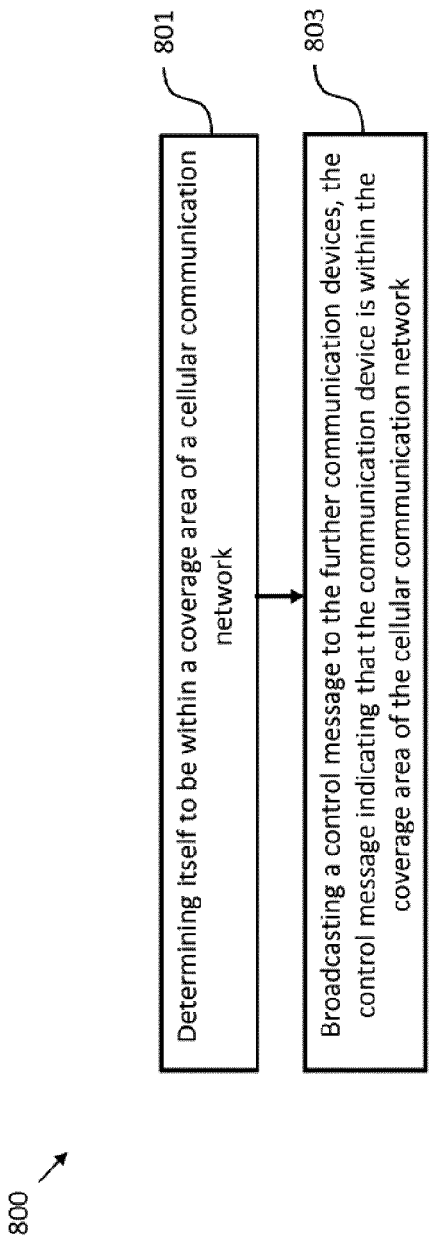
800
801
Determining itself to be within a coverage area of a cellular communication network
803
Broadcasting a control message to the further communication devices, the control message indicating that the communication device is within the coverage area of the cellular communication network

Fig. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20140133332 A1 **[0006]**

Non-patent literature cited in the description

- **G. FODOR et al.** Design Aspects of Network Assisted Device-to-Device Communications. *IEEE Communications Magazine,* May 2011 **[0005]**
- On Metric and Procedures for In/Out of NW coverage detection for D2D. **ERICSSON.** 3GPP DRAFT; R1-141389 OUT OF COVERAGE PROCEDURES, 3RD GENERATION PARTNERSHIP PROJECT (3GPP). MOBILE COMPETENCE CENTRE, 21 March 2014 **[0005]**